STATE STRATEGY
&
ACTION PLAN ON CLIMATE CHANGE

HIMACHAL PRADESH
2012

Department of Environment, Science & Technology
Government of Himachal Pradesh

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Abbreviations

ADB	Asian Development Bank
AGiSAC	Aryabhatta Geo-informatics & Space Application Centre
BEE	Bureau of Energy Efficiency
BICAT	Basin wise Integrated Catchment Area Treatment
CAMPA	Compensatory Afforestaion Management and Planning Authority
CAT	Catchment Area Treatment
CBO	Community Based Organisations
CDD	Community-Driven Development
CEIA	Cumulative Environment Impact Assessment
CERC	Central Electricity Regulatory Commission
CLAP	Community Led Assessment, Awareness, Advocacy & Action Programme
CSI	Climate Sensitivity Index
CV	Coefficient of Variation
DEST	Department of Environment, Science & Technology
DOm	Degradable Organic matter
ECBC	Energy Conservation Building Code
EF	Emission Factor
EIA	Environment Impact Assessment
EMAP	Industry Energy Management Action Programme
EMP	Environment Management Plan
EPS	Electric Power Survey
ER	Emission Reductions
ET	Evapo-Transpiration
FSI	Forest Survey of India
GCM	Global Circulation Models
GHG	Green House Gas
GHNP	Great Himalayan National Park
GIS	Geographic Information System
GLOF	Glacier Lake Outbursts Floods
GtC	Gigatons of Carbon
GWh	GigaWatt per hour
HadAM	Hadley Atmospheric Model
HadCM	Hadley Coupled atmosphere-ocean Model
HadRM	Hadley Regional Climate Model
HIMUDA	HP Housing and Urban Development Authority
HPSEB	Himachal Pradesh State Electricity Board
IAEA	International Atomic Energy Agency
IHBT	Institute of Himalayan Bio-resource Technology
IITM	Indian Institute of Tropical Meteorology
IMD	*India Meteorological Department*
INCCA	Indian Network for Climate Change Assessment

IPCC	Intergovernmental Panel on Climate Change
ISM	Indian Summer Monsoon
IWDP	Integrated Watershed Development Project
KLD	Kilo Litres per Day
kwh	kilowatt-hour
LISS-III	Linear Imaging Self Scanning Sensor
LULUF	Land-use, Land-use Change and Forestry
MHWP	Mid-Himalayan Watershed Project
MSW	Municipal Solid Waste
NAPCC	National Action Plan on Climate Change
NATCOM	National Communication
NEERI	National
NPP	Net Primary Productivity
NTFP	Non Timber Forest Products
PPE	Perturbed Physics Ensemble
ppm	Parts per million
GDP	Gross Domestic Product
PRECIS	Providing Climate Investigation Studies
QUMP	Quantifying Uncertainty in Model Predictions
RCM	Regional Climate Models
RIDF	Rural Infrastructural Development Fund
SAPCC	State Action Plan on Climate Change
SEAC	State Environment Appraisal Committee
SEIAA	State Environment Impact Assessment Authority
SEOC	State Emergency Operation Centre
SFR	State Forest Report
SLR	Sea Level Rise
SMDI	Soil Moisture Deficit Index
SRES	Special Report on Emission Scenario
SWAT	Soil & Water Assessment Tool
TFR	Total Fertility Rate
TWh	TerraWatt per hour
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
VA	Vulnerability Assessment
VFDS	Village Forest Development Societies
WB	World Bank
WBCIS	Weather Based Crop Insurance Scheme
WMO	World Meteorological Organizations

Overview

1

Climate is the long-term average weather. The typical weather (e.g. temperature, rain and snowfall, wind) on any given day tends to be most controlled by the cycle of the seasons from spring through summer, autumn and winter. Other factors, with longer time scales, can cause systematic changes to the climate.

Climate Change has undoubtedly emerged as an issue of global concern. Climate Change has a potential to completely and adversely affect the way of human life. The terms ‘global warming’ and ‘climate change’ are often used interchangeably, but there is a difference. 'Global warming' is the gradual increase of the earth's average surface temperature due to greenhouse gases in the atmosphere, whereas the 'climate change' is a broader term. It refers to long-term changes in climate, including changes in average temperature and rainfall due to global warming. Climate change phenomenon which is much more complex is the result of activities that alters the composition of atmosphere, due to undesirable and unwanted over exploitation of our natural resources.

Climate change refers to a statistically significant variation in either the mean state of the climate or in its variability, which is attributed directly or indirectly to anthropogenic activities that alter the composition of global atmosphere and which are in addition to natural climatic variability observed over comparable time periods.

Panoramic View of West Rongbuk Glacier during an analysis of Everest between 1921 and 2009 taken in 1921 (top) by Major E.O. Wheeler and in 2009 (bottom) by David Breashears.

Climate change is the result of changes in our weather patterns because of an increase in the earth's average temperature. This is caused by increases in greenhouse gases in the earth's atmosphere. These gases soak up the heat from the sun but instead of the heat leaving the earth's atmosphere, some of it is trapped, making the earth warmer.

Greenhouse gases have always been a natural part of the atmosphere. They absorb and re-radiate the sun's warmth and maintain the earth's temperature at a level necessary to support life. The problem we now face is that the human actions are increasing the amount of the gases that trap heat. This is an enhanced greenhouse effect, which is contributing to the warming of earth's surface.

Climate change emerged on the political agenda in the mid-1980s with the increasing scientific evidence of human interference in the global climate system and with growing public concern about the environment. The United Nations Environment Programme (UNEP) and the World Meteorological Organizations (WMO) established the Intergovernmental Panel on Climate Change (IPCC) in 1988 to provide policy makers with authoritative scientific information. In its first report in 1990, the IPCC concluded that the growing accumulation of human made green house gases in the atmosphere would "enhance the green-house effect, resulting in an additional warming of the earth's surface" by the next century, unless measures were adopted to limit emissions.

Climate change is a global problem that requires an internationally co-ordinated solution. 189 countries are Party to the United Nations Framework Convention on Climate Change (UNFCCC). Although the Kyoto Protocol (1997) to the UNFCCC was signed by over 170 countries requiring developed countries to reduce their emissions by 5.2% below 1990 levels in the period 2008-2012 as an essential first step towards stabilizing atmospheric concentrations of greenhouse gases, but the consensus is still eluding the international fraternity.

There will always be some uncertainty surrounding the prediction of changes in such a complex system as the world's climate. Nevertheless, the IPCC's conclusion that it is at least 90% certain that temperatures will continue to rise, with average global surface temperature projected to increase by between 1.4 and 5.8°C above 1990 levels by 2100 is a matter of concern. This increase will be accompanied by rising sea levels, more intense precipitation events in some countries, increased risk of drought in others, and adverse effects on agriculture, health and water resources.

Our country is faced with the challenge of maintaining its rapid economic growth while dealing with the associated environmental issues besides the global threat of climate change. This threat emanates from accumulated greenhouse gas emissions in the atmosphere anthropogenically generated through intensive industrial growth and high consumption lifestyles in developed countries. While engaged with the international community to collectively and cooperatively deal with this threat, our country is carving out strategies and making efforts to adapt to climate change and further enhance the ecological sustainability of country's development. Himachal Pradesh too is following the same approach to combat the looming threat of climate change which is very significant in the context of fragile Himalayan eco-systems. It is imperative that the relative position of our State warrants that we play a proactive role in the national framework. The State Government is very much conscious of importance of its strategic location in the Himalayan Region. Its ecological fragility and sensitivity and has ushered realization towards its immense responsibility for downstream populace besides for its own future generations. The State has repeatedly through actions has expressed its resolve to protect and enhance its natural resources and to follow the path of sustainable development in all sectors.

Climate change may alter the distribution and quality of natural resources of Himachal Pradesh and adversely affect the livelihoods of its people. With its economy closely tied to its natural resource base and climate-sensitive sectors such as Agriculture, Horticulture, Irrigation & Public Health, Power and Forestry etc; the State may face a major threat on account of the projected changes in climate.

The state's development path is based on its unique resource endowments, the overriding priority of economic and social development and poverty eradication, and its adherence to its legacy that places a high value on the environment and the maintenance of ecological balance.

In charting out a developmental pathway which is ecologically sustainable, Himachal Pradesh has wider spectrum of choices because it is at an early stage of development. The vision is to create a prosperous, but not wasteful society; an economy that is self- sustaining in terms of its ability to unleash the creative energies of its people and is mindful of its responsibilities to both present and future generations. The state's approach is based on a global vision of Mahatama Gandhi, *'the earth has enough resources to meet people's needs, but will never have enough to satisfy people's greed'.*

Maintaining a high growth rate is essential for enhancing the living standards of vast majority of our people and reducing their vulnerability to the impacts of climate change. In order to achieve a sustainable development path that simultaneously advances economic, social and environmental objectives, the National Action Plan on Climate Change (NAPCC) has been prepared guided by following principles:

- Protecting the poor and vulnerable sections of society through an inclusive and sustainable development strategy, sensitive to climate change.
- Achieving national growth objectives through a qualitative change in direction that enhances ecological sustainability, leading to further mitigation of greenhouse gas emissions.
- Devising efficient and cost-effective strategies for end-use Demand Side Management.
- Deploying appropriate technologies for both adaptation and mitigation of greenhouse gases emissions extensively as well as at an accelerated pace.
- Engineering new and innovative forms of market, regulatory and voluntary mechanisms to promote sustainable development.
- Effecting implementation of programmes through unique linkages, including with civil society and local government institutions and through public-private-partnership.
- Welcoming international cooperation for research, development, sharing and transfer of technologies enabled by additional funding and a global IPR regime that facilitates technology transfer to developing countries under the UNFCCC.

National Action Plan on Climate Change (NAPCC) is a consolidated account of the country's position on climate change mitigation and adaptation efforts. In line with the government's adopted policy of shared but differentiated responsibility, the plan focuses of efficiency targets through well prioritized and established eight national missions which forms the core of the plan and dictate the direction of further action.

The National Action Plan on Climate Change (NAPCC) identifies measures that promote our development objectives while also yielding co-benefits for addressing climate change effectively. It outlines a number of steps to simultaneously advance India's development and climate change related objectives on adaptation and mitigation.

Eight National Missions under the National Action Plan on Climate Change (NAPCC) are as follows:

- National Solar Mission.
- National Mission for Enhanced Energy Efficiency.
- Mission on Sustainable Habitat.

- National Water Mission.
- National Mission for Sustaining the Himalayan Ecosystem.
- National Mission for a “Green India”.
- National Mission for Sustainable Agriculture.
- National Mission on Strategic Knowledge for Climate Change.

In dealing with the challenges of climate change, there is a need to simultaneously act on several fronts in a focused manner. The National Action Plan hinges on the development and use of new technologies. The implementation of the Plan would be through appropriate institutional mechanisms suited for effective delivery of each Mission's objectives and include public private partnerships and civil society action. The focus is on promoting understanding of climate science, adaptation, mitigation, energy efficiency and natural resource conservation.

1.1 National Missions

The Eight National Missions which form the core of the National Action Plan represents multi-pronged, long term and integrated strategies for achieving key goals in the context of climate change.

1.1.1 National Solar Mission

National Solar Mission is aimed to significantly increase the share of solar energy in the total energy mix while recognizing the need to expand the scope of other renewable and non-fossil options such as nuclear energy, wind energy and biomass.

1.1.2 National Mission on Enhanced Energy Efficiency

The Energy Conservation Act, 2001 provides a legal mandate for the implementation of energy efficiency measures through the institutional mechanism of the Bureau of Energy Efficiency (BEE) in the Central Government and designated agencies in each State.

1.1.3 National Mission on Sustainable Habitats

The National Mission on Sustainable Habitats is aimed to make habitat sustainable through improvements in energy efficiency in buildings, management of solid waste and modal shift to public transport.

In addition, the Mission will address the need to adapt to future climate change by improving the resilience of infrastructure, community based disaster management, and measures for improving the warning system for extreme weather events. Capacity building is going to be an important component of this Mission.

1.1.4 National Water Mission

The National Water Mission would ensure integrated water resource management helping to conserve water, minimize wastage and ensure more equitable distribution within States. The Mission will take into account the provisions of the National Water Policy and develop a framework to optimize water use by increasing water use efficiency by 20% through regulatory mechanisms with differential entitlements and pricing. It will also seek to ensure that a considerable share of the water needs of urban areas is met through recycling of waste water and rain water harvesting systems.

The National Water Policy would be revisited in consultation with States to ensure preparation of basin level management strategies to deal with variability in rainfall and river flows due to climate change. This will include enhanced storage both above and below ground, rainwater harvesting, coupled with equitable and efficient management structures.

The mission will seek to develop new regulatory structures, combined with appropriate entitlements and pricing. It will seek to optimize the efficiency of existing irrigation systems, including rehabilitation of systems that have been run down and also expand irrigation, where feasible, with a special effort to increase storage capacity. Incentive structures will be designed to promote water-neutral of water-positive technologies, reaching of underground water sources and adoption of large scale irrigation programmes which rely on sprinklers, drip irrigation and ridge and furrow irrigation.

1.1.5 National Mission on Sustaining the Himalayan Ecosystem

The mission for sustaining the Himalayan Ecosystem is aimed to evolve management measures for sustaining and safeguarding the Himalayan glaciers and mountain eco-systems. Himalayas, being the source of key perennial rivers, the Mission would, inter-alia, seek to understand, weather and the extent to which, the Himalayan glaciers are in recession and how the problem could be addressed.

An observational and monitoring network for the Himalayan environment will also be established to assess freshwater resources and health of the ecosystems. Cooperation with neighbouring countries will be sought to make the network comprehensive in its coverage.

The Himalayan ecosystem has 51 million people who practice hill agriculture and whose vulnerability is expected to increase on account of climate change. The community based management of these ecosystems will be promoted with incentives to community organizations and panchayats for protection and enhancement of forested lands. In mountainous regions, the aim will be to maintain two-thirds of the areas under forest cover in order to prevent erosion and land degradation and ensure the stability of the fragile eco-system.

1.1.6 National Mission for a Green India

The National Mission is aimed to enhance eco-system services including carbon sink is called Green India. Forests play and indispensable role in the preservation of ecological balance and maintenance of biodiversity. Forests also constitute one of the most effective carbon sinks.

The Mission on Green India is being taken up on degraded forest land through direct action by communities, organized through Joint Forest Management Committees and guided by the State Department of Forests.

1.1.7 National Mission for Sustainable Agriculture

The Mission would devise strategies to make Indian agriculture more resilient to climate change. It would identify and develop new varieties of crops and especially thermal resistant crops and alternative cropping patterns, capable of withstanding extremes of weather, long dry spells, flooding, and variable moisture availability.

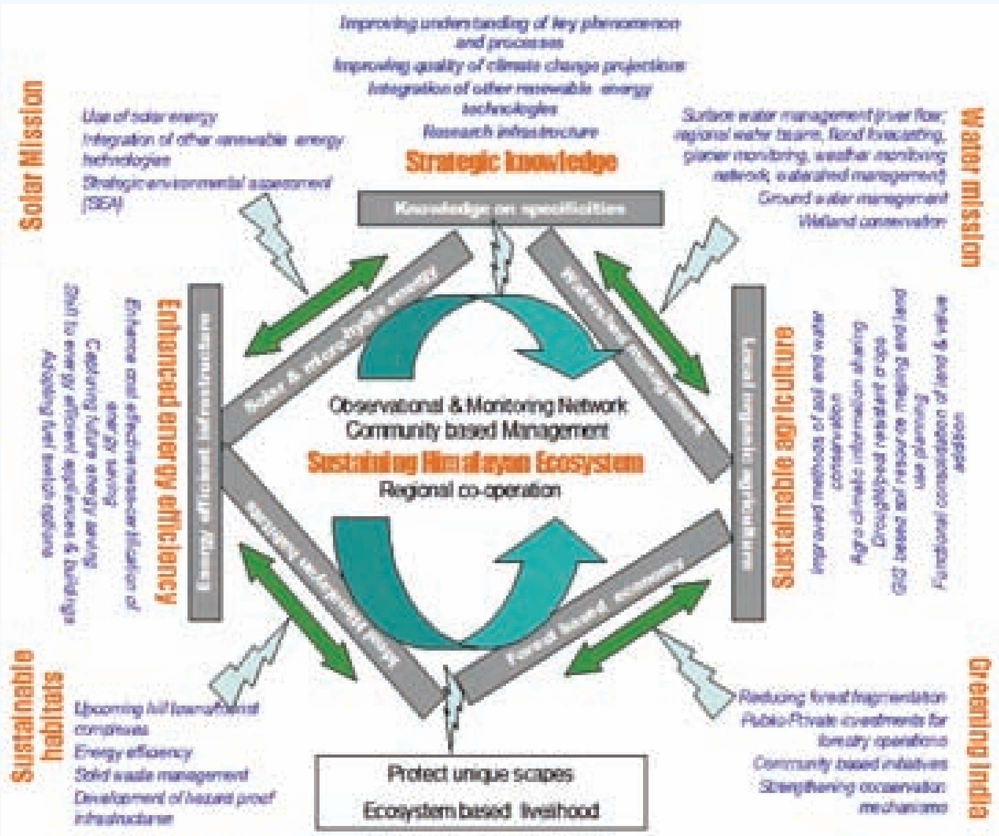
Agriculture will need to be progressively adapted to projected climate change and our agricultural research systems must be oriented to monitor and evaluate climate change and recommend changes in agricultural practices accordingly.

1.1.8 National Mission on Strategic Knowledge for Climate Change

To enlist the global community in research and technology development and collaboration through mechanisms including open source platforms, a Strategic Knowledge Mission would help to identify the challenges of, and the responses to, climate change. It would ensure funding of high quality and focused research into various aspects of climate change.

1.2 Linkages

The interlinkages amongst different missions are described below:



Source: NMSHE Document

The Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC AR4) concluded from direct observations of changes in temperature, sea level rise, and snow cover in the northern hemisphere during 1850 to the present, that the warming of the earth's climate system is unequivocal. The global atmospheric concentration of carbon dioxide has increased from a pre-industrial value of about 280 ppm to 379 ppm in 2005. Multi model averages show that the temperature increases during 2090-2099 relative to 1980-1999 may range from 1.1 to 6.4°C and sea level rise from 0.18 to 0.59 meters. These could lead to impacts on freshwater availability, oceanic acidification, food production, flooding of coastal areas and increased burden of vector borne and water borne diseases associated with extreme weather events.

India's development agenda focuses on the need for rapid economic growth as an essential precondition to poverty eradication and improved standards of living. Meeting this agenda, which will also reduce climate related vulnerability, requires large scale investment of resources in infrastructure, technology and access to energy. Developing countries may lack the necessary financial and technological resources needed for this and thus have very low coping capacity to meet threats from climate change. Only rapid and sustained development can generate the required financial, technological and human resources. In view of the large uncertainties concerning the spatial and temporal magnitude of climate change impacts, it is not desirable to design strategies exclusively for responding to climate change. Rather, the need is to identify and prioritize strategies that promote development goals while also serving specific climate change objectives.

It is imperative to identify measures that promote our development objectives, while also yielding co-benefits for addressing climate change effects. Cost effective energy efficiency and energy conservation measures are of particular importance in this connection. Similarly, development of clean energy technologies, through primarily designed to promote energy security, can also generate large benefits in terms of reducing carbon emissions. Different health related local pollution controls measures can also generate significant co-benefits in terms of reduced greenhouse gas emissions.

It also describes India's willingness and desire, as a responsible member of the global community, to do all that is possible for pragmatic and practical solutions for all, in accordance with the principle of common but differentiated responsibilities and respective capabilities. The purpose of this document is also to create awareness among representatives of the public at large, different agencies of the government, scientists, industry-in short, and the community as a whole – on the threat posed by climate change and the proposed steps to counter it.

1.3 Five Year Plans

The Eleventh Five Year Plan (2007-08 to 2011-12) had aimed at achieving faster and more inclusive growth. Rapid GDP growth, targeted at 9.0 percent per annum, was regarded necessary for two reasons: first, to generate the income and employment opportunities that were needed for improving living standards for the bulk of the population; and second, to generate the resources need for financing social sector programmes, aimed at reducing poverty at enabling inclusiveness. During the Eleventh Five Year Plan the country perused its development agenda considering environmental protection at the core of all policy formulation. The Eleventh Five Year Plan laid emphasis on environmental sustainability while pursuing development planning at all levels. A number of schemes on pollution abatement, conservation of biodiversity and habitat management were implemented. However, in the Twelfth Five Year Plan (2012-17) it has been felt that the country needs more focussed efforts not only to preserve and maintain natural resources but also to provide equitable access to those who are denied of this currently.

The Twelfth Five Year Plan (2012-17) lays adequate emphasis on environment, forestry & wildlife. Twelve monitorable targets have set for Twelfth Plan, these include three targets in the areas of Environment & Climate Change, four targets in Forestry and three targets under Wildlife, Eco-tourism & Animal Husbandry, and two under Eco-systems and Biodiversity for ushering in inclusiveness and growth.

1.4 Issues & Problems

Chirgaon after cloud burst on 11 August 1997, total causalities 124

Deforestation, landslides, land degradation, desertification and Glacier Lake Outbursts Floods (GLOF) are some of the common but critical environmental issues in the Himalayan regions. The major challenges currently faced by the Himalayan environment are the escalation of such issues through atmospheric as well as man-induced interferences. Himalayan ecosystems sustain a wide range of significant natural resources that play a critical role in the ecological and economic processes of the earth, thus it is very important that these systems are properly analyzed and taken care.

Himalayan eco-systems are predominantly sensitive to climate changes. Himachal Pradesh although a small Himalayan State, is nevertheless playing a very crucial role in sustaining the livelihoods of downstream areas. The conservation, sustenance of these ecologically fragile regions is a biggest challenge faced being faced at the moment which can get further aggravated due to financial constraints and limited resources.

Himalayan eco-systems are predominantly sensitive to climate changes. Himachal Pradesh although a small Himalayan State, is nevertheless playing a very crucial role in sustaining the livelihoods of downstream areas. The conservation, sustenance of these ecologically fragile regions is a biggest challenge faced being faced at the moment which can get further aggravated due to financial constraints and limited resources. Therefore, it can be safely stated that climate change will manifest most in Himachal Pradesh. The commonly observed events and likely ones in the State are as follows:

- State is likely to face warming, erratic rainfall and rainfall changes, floods.
- Change in precipitation pattern.
- There is likely to be a shift in snow line, agriculture /horticulture line; certain areas may open up with some good livelihood openings.
- Significant impacts on agriculture production, water resources, forests, natural wetlands.
- Health risks are likely to increase in the State. Instances as malaria, water borne disease, jaundice etc. may break along river bed predominantly.
- Impacts likely to adversely affect large percentage of population depending on natural resources.

The predicted potential impacts of climate change on Himachal Pradesh are both positive and negative. While many of the impacts would be disruptive and potentially very costly, none are likely to be on at par with the worst impacts elsewhere in the Country. Examples of the projected impacts based on scenarios generally within the range predicted in the IPCC Assessment Reports and other research findings broadly include:

- Changes in precipitation (rain and snow fall) with the average water levels in rivers, lakes less than normal with serious drought like conditions, and in rainy seasons flooding being more frequent, areas currently subject to flooding would suffer flooding of greater severity and for more duration; areas currently flood-free would suffer from occasional floods and flash floods. Lesser spring, summer rainfall causing regular water shortages, especially in the mid hills would be affecting both people and the ecosystems. There would be less recharge of reservoirs during the summer; water shortages would occur regularly and would be longer than at present. The change in rainfall patterns may further cause regular water deficits, leading to accelerated soil erosion and loss of fertility and biodiversity.

  Rising river water levels due to rapid glacier melt and more storm events and storm surge, particularly on the Satluj, Beas and Ravi rivers and their tributaries with storms of a greater severity are at risk from rising water levels, including related landslides, erosion, flooding and environmental changes with severe threat to infrastructures.
- Riverbed areas subject to human industrial development would be at risk, and could suffer loss of infrastructure. Human use of the river bed is quite intensive, and low lying areas of all valleys are highly developed with different key industries (mainly energy), and tourism, residential development along the river are under potential threat. Protective options include abandonment of land, stronger planning controls, and fiscal disincentives for river side development.
- Short-term increased agricultural production with new crops becoming viable in certain regions and agricultural production costs reduced if prolonged summer droughts do not become a problem. Grass growth could enjoy beneficial effects with a good increase with

higher temperatures and changes in rainfall patterns. Increase in man-animal conflicts in the event of decreasing quality of forest cover/area.

- New grassland and livestock management systems would be possible, with a longer grazing season and the prospect of growing additional forage crops (e.g. maize, fodder beet). There would be little or no increase in cereal yields, but increases in other crops are possible, and the area for growth of many arable crops would migrate northwards. A number of new crops (e.g. sunflower best option) may become viable in our area as well.
- Some existing forestry species may suffer badly (e.g. where availability of water and nitrogen are limiting factors), with others becoming more productive (higher temperatures and increased CO_2 concentrations in the atmosphere supporting higher rates of photosynthesis and hence higher growth rates).
- Issues associated to Glaciers and Snow fields over Himachal Himalayas: Five major perennial rivers of Northern India passes through Himachal Himalayas, which have their origin in the glaciated terrains either in the State or outside. These are Beas, Satluj, Yamuna, Ravi, and Chenab rivers. The rivers like Chenab, Ravi and Beas originate from Himachal Pradesh, whereas, the other two have their origin outside the State. In order to understand the dynamics of the glaciers, which are considered to be the direct indicators of climate change, it is important to have the systematic study of these Himalayan glaciers. Since the glaciers are located in the higher regions, where it is not possible to map them by any conventional method; therefore, the space technology has proved to be very useful for mapping these Himalayan glaciers and estimating its potential for water as well as hydro power projects development in the State.

An over view w.r.t. damages due to Droughts, Flash Floods, and widespread Rains in Himachal Pradesh:

Due to climatic extreme events Himachal Pradesh economy has faced many losses from time to time, both in terms of lives and infrastructural damages such as:

Year 2005-06 (Rabi Season): The damage due to drought conditions in Himachal Pradesh has been assessed to the tune of Rs. 366 crore which include loss of agri-horti crops, IPH infrastructure, and animal husbandry.

Year 2002-03 (Kharif Season): The estimated damage due to drought conditions in Himachal Pradesh was Rs. 707.21 crore.

Year 2000-01 (Rabi Season): The estimated damage was Rs. 360.85 crore.

Year 1999 The damage due to widespread rains, flash floods and drought were beyond imaginations about 2.423 lac ha area under agriculture and 0.447 lac ha area under horticulture (total monetary loss estimated to Rs. 23,487.00 crore)was affected due to extreme events besides physical losses estimated to Rs. 19,151.67 lacs were observed

Year 1998: The total loss (physical and crops) was assessed for an amount of Rs. 33,226.79

Year 1997: The estimated damage was Rs. 79, 865.19 lacs.

Year 1996: The estimated damage was Rs. 47,677.28 lacs

Year 1995: The estimated loss was about Rs. 50,599.82 lacs.

Climate Change – Issues of Concern

The economy of the State is dependent on sectors like the hydel power generation, horticulture, agriculture, forestry and tourism etc. and these sectors are assumed to be under threat in the present scenario of changing climate. Any change in these sectors due to climate change, in every likelihood, will not only going to affect the livelihood prospects in the agrarian economies of mountain regions, but also everyone living below in the plains. The major issues of concern due to the emerging threat of climate change in Himachal Pradesh are:

Receding Trend in Himalayan Glaciers

- Agrarian economy of 90% rural population and their livelihood.
- Dependence on rains for agrarian activities.
- Sustainability of hydro economy as dependency on snow and glaciers.
- Water sources for drinking and irrigation.
- Rural livelihood dependency on forest for fuel wood, fodder and non wood products etc.
- The role of medicinal herbs in economy.
- Climate induced and other natural hazards threat in the state.

Indicators of Climate Change in Himachal Pradesh

- Rise in temperature in the NW Himalayan Region by about 1.6°C in the last century.
- Warming rate of Shimla was higher during the period 1991-2002 as compared to earlier decades.
- About 17% decrease in rainfall in Shimla was observed from 1996 onwards.
- The decreasing trend in seasonal snowfall in Shimla is very conspicuous since 1990 and it was lowest in 2009.
- Monsoon discharge in Beas River has shown a significant decrease.
- Winter discharge in River Chenab has shown a significant increase.
- Satluj showing an increasing trend in winter and spring discharge.
- Quality of apple has been affected and the apple line has shifted upwards.
- Area under apple is being diverted to vegetable due to rising temperature.
- Incidence of pest and disease are more severe.
- Pine forest invading heights.
- Kikar, Tali (Shisham), Deodar, Ban trees are on decline.
  Water fowls, Ducks, Birds, House sparrows, Vultures

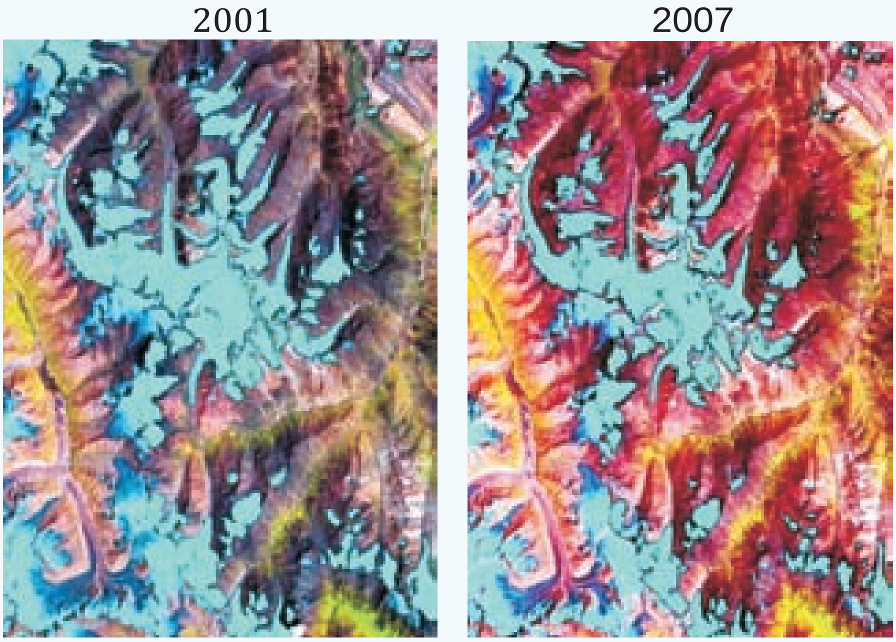
Agro-Horticulture Sector

Erratic and changing weather pattern has affected on the sustainability of marginal agriculture and horticulture in the State where average holding size is 1.07 ha and about 70% of the population depends upon these two sectors for their livelihood. Over 92% of the holdings in the State are classified as small or marginal and dependence on rain in some areas is very high. Thus, when viewed along with other specificities such as infrastructure, rugged topography, limited land for cultivation, limited livelihood choices, low productivity of land, and vulnerability to natural disaster renders the state to be highly vulnerable to the phenomena of climate change.

- Rabi crops more affected due to erratic rainfall.
- Diversion from apple to vegetables especially in the Lower Kullu valley.
- Increase in annual production of vegetables from 25,000 tonne in 3,000 ha area in 1951-52 to 1,269 thousands tonne in 65,000 ha area in 2010-11.
- The rise in temp has affected the apple production especially located on the lower altitude.
- Apple production in cold desert areas has suddenly improved.
- Change in average winter temperature has led to early flowering in Rhododendron.

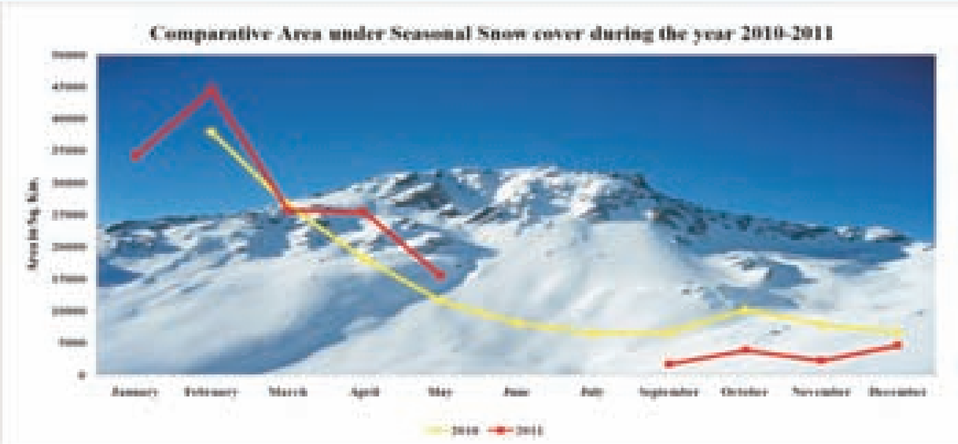
Glacier Status in Himachal Pradesh

- An overall reduction in glacier area from 2,077 sq. km. to 1,628 sq. km. from 1962-2001 in Chenab, Parbati & Baspa Basins, H.P.
- An overall deglaciation of 21% of total area in these basins.
- About 10% deglaciation is observed in Spiti Basin during 2001-2007.
- Prominent glaciers as studied by GSI in Himachal Pradesh shows:
    - Chota Sigri 6.81 m/y retreat during 1962-95.
    - Bara Sigri 29.78 m/y during 1906-1957.
    - Trilokinath as 17.86 m/y during 1968-1996.
    - Beas Kund as 18.8 m/y during 1963-2003.
    - Manimahesh as 29.1 during 1968-2005.



Temporal Monitoring of Glaciers

According to experts, glaciers in the Himalaya have been reported to be in the retreating phase and in future, this can result in water scarcity for the people living in the mountain region and in downstream area who depend on glaciers and snow as a source of fresh water. Retreating glaciers, depleting snow cover and Glacial Lake Outburst Floods (GLOFs) are of immediate concern in the mountain environment as GLOFs can have a devastating impact on the hydro power, water sources, people, livestock, forests, farms and infrastructure. Decreases in snow accumulation and glacial retreat might lead to acute water shortages in the future.

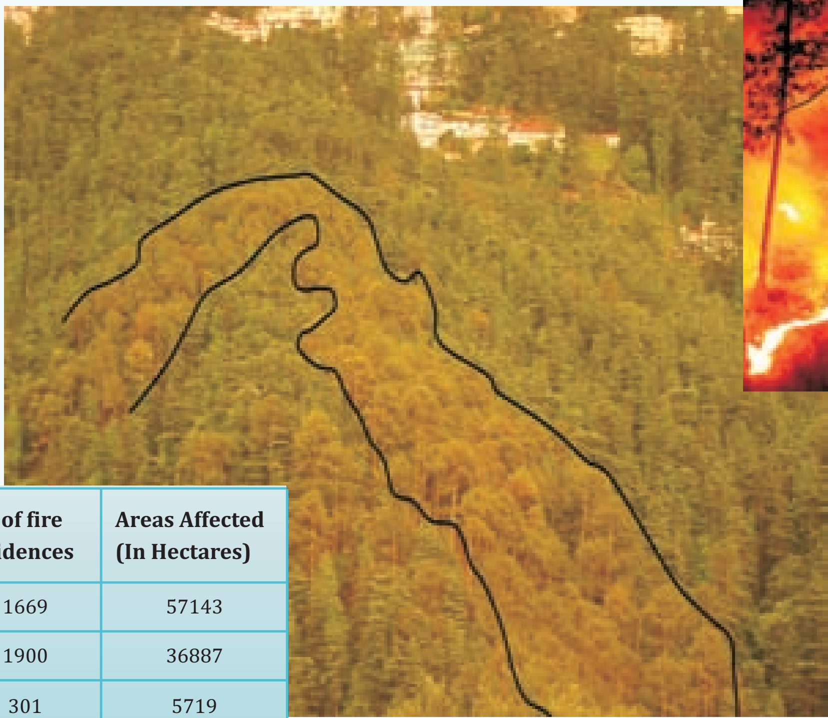


Forests

Forests in Himachal Pradesh are an important ecological and natural resource and have been aptly termed as "Green Pearl" in the Himalaya. About 26% of the State's geographical area is the repository of 3,295 species out of which 95% are endemic to the state and 5% (150) species are exotic, most of the people in rural areas in the State depend directly or indirectly on forests for their livelihood and use significant quantity of forest goods and services like non-wood forest products, ecotourism, fodder, timber etc.

The immediate repercussions of climate change on the forests are visible in the form of shifting of tree line to higher altitudes and movement of pine species to higher altitudes. Available data on climate suggested that by 2100, under the most probable scenario, temperature of the state is likely to increase by 3^{0}C and precipitation will decrease by 20% and in that situation the effects will be more visible and alarming also.

Effects of Climate Change

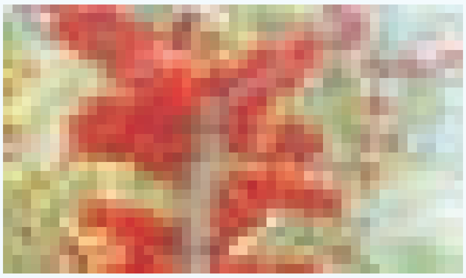


Year	No. of fire Incidences	Areas Affected (In Hectares)
1995	1669	57143
2000	1900	36887
2001-02	301	5719
2002-03	282	4204
2003-04	550	9896
2007-08	550	8393

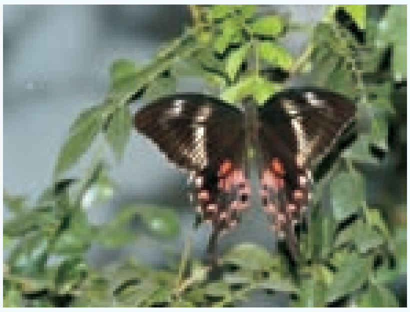
Invasion of pine into oak/deodar due to climate change affecting fodder availability for livestock & people's livelihood

Biodiversity

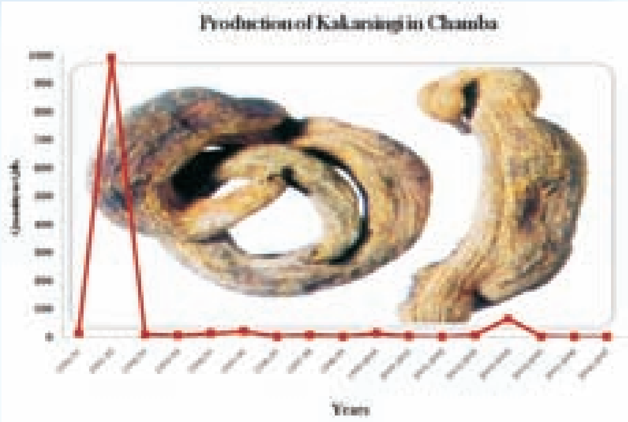
- Himachal Pradesh being a mountain State is rich in floral and faunal biodiversity. The tribal and remote areas of the state have good medicinal and aromatic floral resources which plays a major in their livelihoods.
- With the changing climate, many species are either facing the problem of extinction or declining because of rising temperature affecting health, well being and livelihood of the people who rely on such resources.
- We are committed to preserve this Himalayan reserve as it provides us with biological resources and basic goods like food, fibre, medicine, timber, fuel wood etc.

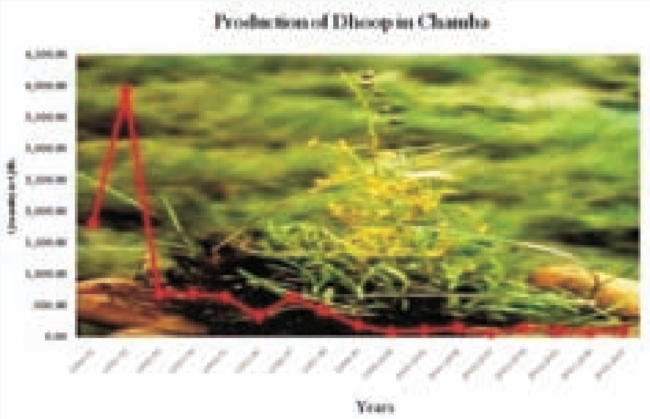


Seabuckthorn, Native of Cold Desert (Lahaul & Kinnaur)



Romulus sp. in upper Himachal





Brahm Kamal Flower (Flower of High Alpine Zone)

Water Resources

Climate Change induced weather extremes such as unprecedented drought, frequent floods, cloud bursts, erratic and changing pattern of rain and snowfall, higher temperature and milder and late winters have affected the availability of natural resources in general and the water in particular. Over the years, the water availability in all towns of the State has declined and majority of them are facing scarcity situation. The traditional water sources are either on the verge of extinction or have dried. Any change in the behaviour of water resources will have adverse impact on the overall economy of the State.

River System	Area of Catchment	Area in %
Satluj	20,398	30.69
Beas	13,663	24.50
Chenab	7,850	14.20
Ravi	5,528	9.90
Yamuna	5,872	10.60

Effects of Climate Change on the Water Resources

- Khatris are no more functional.
- Micro – hydel are under threat.
- Decreasing river discharge.
- Affects the riverine ecology.
- Dried traditional sources of water.
- Decreasing snowfall patterns.
- Perennial streams have become seasonal.

Changes in Climate and Weather Events in India

2

Certain observations in climate parameters have been observed as far as climate change from the Indian perspective is concerned. There are some changes observed in climate parameters in India as well. According to India's initial National Communication, 2004 (NATCOM 1) to UNFCCC some of the observed changes are as under:

2.1 Surface Temperature

At the national level, increase of ~ 0.4°C has been observed in surface air temperatures over the past century. A warming trend has been observed along the west coast, in Central India, the interior peninsula, and north-eastern India. However, cooling trends have been observed in north-west India and parts of south India.

2.2 Rainfall

While the observed monsoon rainfall at the All-India level does not show any significant trend, regional monsoon variations have been recorded. A trend of increasing monsoon seasonal rainfall has been found along the west coast, northern Andhra Pradesh, and north-western India (+10% to +12% of the normal over the last 100 years) while a trend of decreasing monsoon seasonal rainfall has been observed over eastern Madhya Pradesh, north-eastern India, and some parts of Gujarat and Kerala (-6% to - 8% of the normal over the last 100 years).

2.3 Extreme Weather Events

Instrument records over the past 130 years do not indicate any marked long-term trend in the frequencies of large-scale droughts and floods. Trends are, however, observed in multi-decadal periods of more frequent droughts, followed by less severe droughts. There has been an overall increasing trend in severe storm incidence along the coast at the rate of 0.011 events per year. While the States of West Bengal and Gujarat have reported increasing trends, a decline has been observed in Orissa. Goswami et al, while analyzing daily rainfall data sets, have shown (i) a rising trend in the frequency of heavy rain events, and (ii) a significant decrease in the frequency of moderate events over Central India from 1951 to 2000.

2.4 Rise in Sea Levels

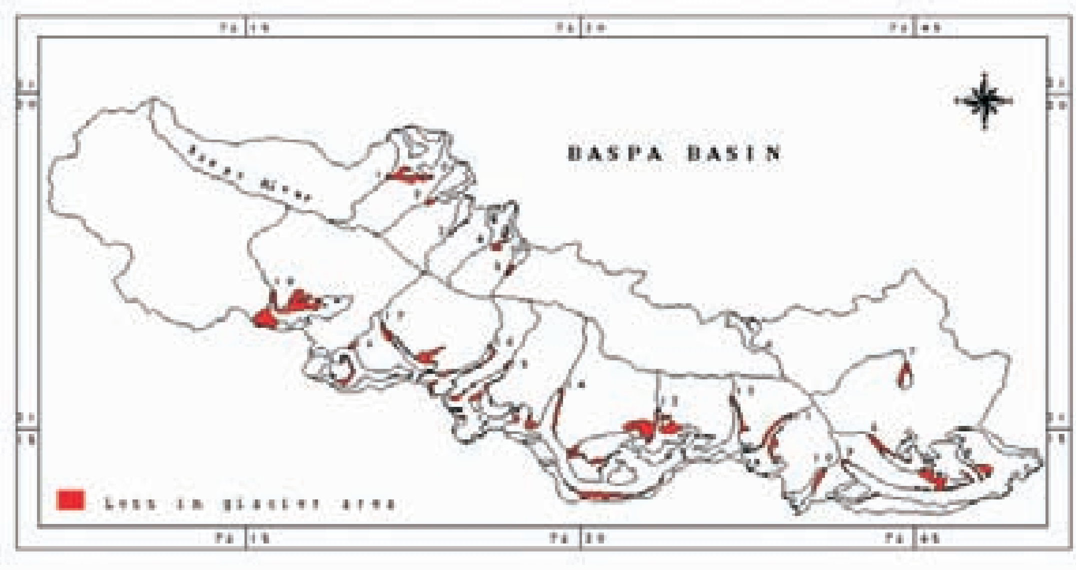
Using the records of coastal tide gauges in the northern part of Indian Ocean for more than 40 years, Unnikrishnan and Shankar have estimated, that sea level rise was between 1.06-1.75 mm per year. These rates are consistent with 1-2 mm per year global sea level rise estimates of IPCC.

2.5 Impacts on Himalayan Glaciers

The Himalaya possess one of the largest reserve of snow and ice and form a major source of water for the perennial rivers such as the Indus, the Ganga, and the Brahmaputra. Glacial melt may impact their long-term lean-season flows, with adverse impacts on the economy in terms of water availability and hydropower generation.

The available monitoring data on Himalayan glaciers indicates that while recession of some glaciers has occurred in some Himalayan regions in recent years, the trend is not consistent across the entire mountain chain. It is accordingly, too early to establish long-term trends, or their causation, in respect of which there are several hypotheses.

LOSS IN GLACIER AREA: 1962 - 2001



Glaciers are well distributed by size, type, altitude and debris cover. Area in 1962 and 2001 (LISS-III) observed as 173 and 140 sq. km., respectively. Overall 19 % loss in glacier area.

2.6 Climate Change Projections for 21st Century (India)

Based on modeling and other studies the following changes due to increase in atmospheric GHG concentrations arising from increased global anthropogenic emissions have been projected:

- Annual mean surface temperature rise by the end of century, ranging from 3 to 5°C under A2 scenario and 2.5 to 4°C under B2 scenario of IPCC with warming more pronounced in the Northern Parts of India, from simulations done by Indian Institute of Tropical Meteorology (IITM), Pune.
- Indian Summer Monsoon (ISM) is a manifestation of complex interactions between land, ocean and atmosphere. The simulation of ISM's mean pattern as well as variability on inter-annual and intra-seasonal scales has been a challenging ongoing problem. The simulations by IITM, Pune, have indicated that summer monsoon intensity may increase beginning from 2040 and by 10% by 2100 under A2 scenario of IPCC.
- Changes in frequency and/or magnitude of extreme temperature and precipitation events. Some results show that fine-scale snow albedo influence the response of both hot and cold events and that peak increase in extreme hot events are amplified by surface moisture feedbacks.

2.6.1 Impacts on Water Resources

A decline in run-off by more than two-thirds is also anticipated for the Sabarmati and Luni basins.

2.6.2 Impacts on Agriculture & Food Production

Food production in India is sensitive to climate changes such as variability in monsoon rainfall and temperature changes within a season. Studies by Indian Agricultural Research Institute (IARI) and others indicate greater expected loss in the Rabi crop. Every 1°C rise in temperature reduces wheat production by 4-5 Million Tonnes. Small changes in temperature and rainfall have significant effects on the quality of fruits, vegetables, tea, coffee, aromatic and medicinal plants, and basmati rice. Pathogens and insect populations are strongly dependent upon temperature and humidity, and changes in these parameters may change their population dynamics. Other impacts on agricultural and related sectors include lower yields from dairy cattle and decline in fish breeding, migration, and harvests. Global reports indicate a loss of 10-40% in crop production by 2100.

2.6.3 Impacts on Health

Changes in climate may alter the distribution of important vector species (for example, malarial mosquitoes) and may increase the spread of such diseases to new areas. If there is an increase of 3.8°C in temperature and a 7% increase in relative humidity the transmission windows i.e., months during which mosquitoes are active, will be open for all 12 months in 9 states in India. The transmission windows in Jammu and Kashmir and in Rajasthan may increase by 3-5 months. However, in Orissa and some southern states, a further increase in temperature is likely to shorten the transmission window by 2-3 months.

2.6.4 Impacts on Forests

Based on future climate projections of Regional Climate Model of the Hadley Centre (HadRM3) using A2 and B2 scenarios and the BIOME4 vegetation response model, Ravindranath et. al. It show that 77% and 68% of the forest areas in the country are likely to experience shift in forest types, respectively under the two scenarios, by the end of the century, with consequent changes in forests produce, and, in turn, livelihoods based on those products. Correspondingly, the associated biodiversity is likely to be adversely impacted. India's NATCOM I projects an increase in the area under xeric scrublands and xeric woodlands in central India at the cost of dry savannah in these regions.

2.6.5 Vulnerability to Extreme Events

Heavily populated regions such as coastal areas are exposed to climatic events, such as cyclones, floods, and drought and large declines in sown areas in arid and semi-arid zones occur during climate extremes. Large areas in Rajasthan, Andhra Pradesh, Gujarat, and Maharashtra and comparatively small areas in Karnataka, Orissa, Madhya Pradesh, Tamil Nadu, Bihar, West Bengal, and Uttar Pradesh are frequented by drought. About 40 million hectares of land is flood-prone, including most of the river basins in the north and the north-eastern belt, affecting about 30 million people on an average each year. Such vulnerable regions may be particularly impacted by climate change

2.6.6 Impacts on Costal Areas

A mean Sea Level Rise (SLR) of 15-38 cm is projected along India's coast by the mid 21st century and of 46-59 cm by 2100. India's NATCOM I assessed the vulnerability of coastal districts based on physical exposure to SLR, social exposure based on population affected, and economic impacts. In addition, a projected increase in the intensity of tropical cyclones poses a threat to the heavily populated coastal zones in the country (NATCOM, 2004).

Climate Change in State's Context

3

Climate change is any long term significant change in the 'average weather' temperature, precipitation and wind patterns that a given region experiences, which includes processes such as solar radiation, green house gas concentration and the effects of human activity. Recent climate change attributed to human activity, and the debate has shifted to how to reduce impact of human activity (Mitigation), and adapt to change that is already in the system (Adaptation).

Conceptually, **Adaptation**, in context of climate change is defined as the measures taken to minimize the adverse impacts of climate change, e.g. switching to crops that can withstand higher temperatures is adaptation, relocating the communities from sea shore to some other places to cope with the rising sea level.

And, **Mitigation** in context of climate change is defined as measures to reduce the emissions of green house gases that cause climate change in the first place, e.g. by switching to renewable sources of energy such as solar energy or wind energy, or nuclear energy instead of burning fossil fuel in thermal power stations.

For drawing adaptation and mitigation options for State of Himachal Pradesh it is very important to first understand the following critical and core concepts:

- State's Profile
- Past & Current Climate Change Trends in Himachal Pradesh
    - Climatic Patterns of Himachal Pradesh
    - Current Climate Trends in Himachal Pradesh
- Climate Statistics for Himachal Pradesh- Current Scenario & Projections
    - Precipitation (Rain & Snow Fall)
    - Temperature
- Climate Scenarios
    - Precipitation (Rain & Snow Fall)
    - Temperature
    - Extreme Precipitation (Rain & Snow Fall)
    - Extreme Temperature
- Impacts on Key Sectors in Himachal Pradesh & Projections
- Issues and Problems: Climate Change
- Assessment of Climate Change Vulnerability of Himachal Pradesh
- Past, Current and Projections: Exposure Level, Sensitivity and Adaptive Capacity
    - Description of Vulnerability Index and Projected Trends
    - Sectoral Analysis with respect to Climate Change Vulnerability
- Status of Green House Gas Emissions Inventory at Sectoral Level & Future Energy Need Projections
- Gap Analysis

And after observing above exercise one can safely look into the main entry points leading to description of main priority adaptation and mitigation measures reducing Sectoral and Regional Vulnerability.

3.1 State's Profile

Himachal is situated in the western Himalayas. Covering an area of 55,673 kilometers (34,594 miles), Himachal Pradesh is a mountainous state with elevation ranging from about 350 meters (1,148 ft.) to 6,000 meters (19,685 ft.) above the Mean Sea Level. Area-wise, Hamirpur is the smallest district of the Pradesh which covers an area of 1,118 sq. kilometers (2.01%) and Lahaul & Spiti has the largest area of 13,835 sq. kilometres (24.85%).

The population of Himachal Pradesh is 68,56,509 as per the Census of India, 2011 (Table-1). In terms of population it accounts for only 0.57% of total country's population. The population of the State increased by 17.53% between the years 1991–2001 and further decreased by 12.81 % in 2011.

Table-1: Distribution of Population, Decadal Growth Rate, Sex-Ratio and Population Density

State/District	Population 2011	Percentage Decadal Growth Rate of Population		Sex-Ratio (Number of Females per 1000 Males)		Population Density per sq. km.	
	Persons	1991-2001	2001-2011	2001	2011	2001	2011
Himachal Pradesh	**68,56,509**	**17.54**	**12.81**	**968**	**974**	**109**	**123**
Chamba	5,18,844	17.19	12.58	959	989	71	80
Kangra	15,07,223	14.05	12.56	1025	1013	233	263
Lahul & Spiti	31,528	6.17	-5.1	802	916	2	2
Kullu	4,37,474	26.17	14.65	927	950	69	79
Mandi	9,99,518	16.1	10.89	1013	1012	228	253
Hamirpur	4,54,293	11.8	10.08	1099	1096	369	406
Una	5,21,057	18.51	16.24	997	977	291	338
Bilaspur	3,82,056	15.4	12.08	990	981	292	327
Solan	5,76,670	30.94	15.21	852	884	259	298
Sirmaur	5,30,164	20.78	15.61	901	915	162	188
Shimla	8,13,384	17.02	12.58	896	916	141	159
Kinnaur	84,298	9.91	7.61	857	818	12	13

Note: For calculation of sex ratio total of males and others as males used

Source: Series-3 Provisional Population Totals Paper-1 of Census 2011

Urban & Rural Population of Himachal Pradesh in 2011 with Percentage Growth

Population of Himachal Pradesh has experienced a gradual increase from one Census year to the next one with the exception of 1901 to 1911 where it declined slightly. Total population of this State has increased from 19,20,294 in 1901 Census to 68,56,509 in 2011 Census.

Table-2: Growth in Urban & Rural Population in Himachal Pradesh						
State/District	Population 2011			Percentage Decadal Growth (Persons) 2001-2011		
	Total	Rural	Urban	Total	Rural	Urban
Himachal Pradesh	68,56,509	61,67,805	6,88,704	12.81	12.50	15.64
Chamba	5,18,844	4,82,653	36,191	12.58	13.21	4.77
Kangra	15,07,223	14,20,864	86,359	12.56	12.17	19.47
Lahul & Spiti	31,528	31,528	0	-5.10	-5.10	-
Kullu	4,37,474	3,96,216	41,258	14.65	12.87	35.47
Mandi	9,99,518	9,36,894	62,624	10.89	11.49	2.69
Hamirpur	4,54,293	4,22,880	31,413	10.08	10.56	4.00
Una	5,21,057	4,76,140	44,917	16.24	16.46	13.93
Bilaspur	3,82,056	3,56,930	25,126	12.08	11.91	14.46
Solan	5,76,670	4,74,592	1,02,078	15.21	15.93	11.93
Sirmaur	5,30,164	4,72,926	57,238	15.61	15.09	20.07
Shimla	8,13,384	6,11,884	2,01,500	12.58	10.20	20.49
Kinnaur	84,298	84,298	0	7.61	7.61	-

The sex ratio (i.e. the number of females per thousand males) of population was recorded as 968 to 974. The urban population has increased @ 10.04% in 2011 in comparison of 2001 when it was @ 9.80%; however the rural population has declined in the State by 0.30% and number of towns has also increased in the State (Table-2). It is noted from the census data that although the urban population is increasing at a faster pace in the State but yet the majority of population lives in rural areas of the State and is dependent on agriculture- horticulture and state's natural resources. Most of the agri-horti practices are of subsistence type and dependent on prevailing climatic conditions for yield.

The literacy of the State has increased to 83.78 % in 2011 in comparison to 76.50% in 2001 and 63.94% in 1991 (Table-3).

Table-3: Literacy Status in Himachal Pradesh						
State/ District	Literacy Rate (Persons) 2001			Literacy Rate (Persons) 2011		
	Total	Rural	Urban	Total	Rural	Urban
Himachal Pradesh	**76.48**	**75.08**	**88.95**	**83.78**	**82.91**	**91.39**
Chamba	62.91	60.63	89.50	73.19	71.63	92.90
Kangra	80.08	79.70	86.62	86.49	86.54	85.67
Lahul & Spiti	73.10	73.10	-	77.24	77.24	-
Kullu	72.90	71.55	87.99	80.14	79.12	89.75
Mandi	75.24	74.08	90.51	82.81	82.14	92.62
Hamirpur	82.46	81.90	89.34	89.01	88.67	93.48
Una	80.37	80.19	82.14	87.23	87.24	87.19
Bilaspur	77.76	76.97	89.08	85.67	85.21	92.06
Solan	76.57	73.94	87.97	85.02	83.53	91.86
Sirmaur	70.39	68.29	87.80	79.98	78.54	91.51
Shimla	79.12	75.19	91.75	84.55	81.45	93.76
Kinnaur	75.20	75.20	-	80.77	80.77	-

Literacy rates of males in the state remained highest as compared to total literacy rates and female literacy rates since 1971 to the present Census year of 2011 (Fig. 1). While literacy rates of females remained lower to both male and total literacy rates during this period the matter of a satisfaction is that the male-female gap in literacy rates is decreasing 1981 onwards, though it has increased during 1971-1981.

Himachal Pradesh has a Total Fertility Rate (TFR) of 1.9 which is one of the lowest in India, and below the TFR of 2.1 required to maintain a stable population. Overall sex ratio in Himachal Pradesh from 1981 Census to the present Census year has been eratic as it increased a little from 1981 to 1991 but decreased slightly in 2001. It increased once again in 2011. The child sex ratio remained a matter of concern from 1981 to 2001, as it nose dived from 971 in 1981 to 896 in 2001, though in the current of Census, 2011 it has shown a marignal increase as it stands at 906. (Fig. 2)

The drainage system in the State is well developed and forms the part of the Indus and the Ganges River Basins of India. The major rivers which either originate or pass through Himachal are the Satluj, Ravi, Beas, Chenab and Yamuna. Besides these, there are number of small rivers like Baspa, Parvati, and Spiti etc. which contributes to the major river systems of Himachal Pradesh (Fig. 3). These rivers are perennial and are fed by snow and rainfall. They are protected by an extensive cover of natural vegetation.

Fig. 1: Literacy Rates by Gender & Male- female Gap in Literacy Rates since 1971

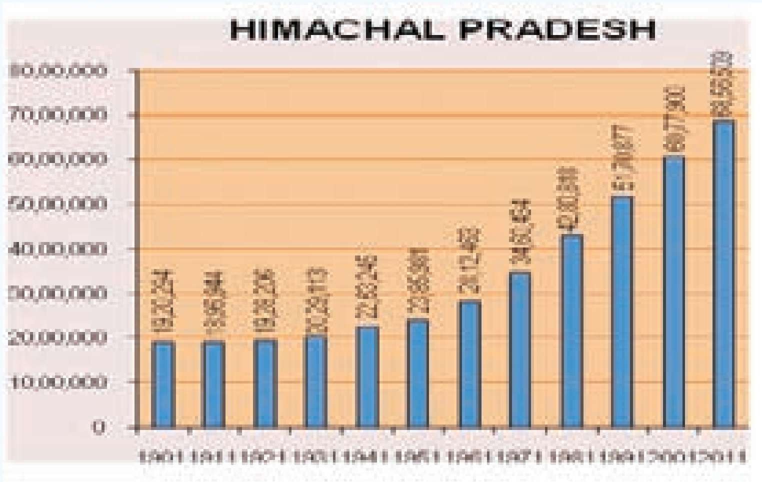


Fig. 2: Changing Trends in Sex Ratio in Himachal Pradesh

Fig. 3: Drainage Network of Himachal Pradesh

The State comprises of four different Agro-climatic Zones (Fig. 4).

1. SHIVALIK HILL ZONE: *Climate Sub Tropical, consists of foothills and valley area from 350 to 650 meters above mean sea level, It occupies about 35% of the geographical area and about 40% of the cultivated area of the State. The major crops grown in this Zone are Wheat, Maize, Paddy, Gram, Sugarcane, Mustard, Potato, Vegetables etc.*

2. MID HILL ZONE: *This zone extends from 651 meters to 1,800 meters above mean sea level. Having mild temperate climate. It occupies about 32% of the total geographical area and about 37% of the cultivated area of the State, the major crops are Wheat, Maize, Barley, Black Gram, Beans, Paddy etc. This zone has very good potential for the cultivation of cash crops like Off-Season Vegetables, Ginger and production of quality seeds of temperate vegetables like Cauliflower and root crops.*

3. HIGH HILL ZONE: *It lies from 1,801 to 2,200 meters above sea level with humid temperate climate and alpine pastures. This zone covers about 35% of the geographical areas and about 21% of the cultivated area of the State. The commonly grown crops are Wheat, Barley, Lesser Millets, Pseudo-cereals (Buckwheat and Amaranthus), Maize and Potato etc. The area is ideally suited for the production of quality seed Potato and temperate Vegetables. This zone possesses good pastures and meadows.*

4. COLD DRY ZONE: *It Comprises of Lahaul-Spiti and Kinnaur Districts and Pangi Tehsil of Chamba District lying about 2,200 meters above mean sea level. It occupies about 8% of the geographical and 2% of the total cultivated area of the State. The major crops grown are Wheat, Barley, Pseudo-cereals like Buck wheat and Amaranthus. It is ideally suited for the production of quality Seed Potato, temperate and European type of Vegetables and their Seeds, Seed Potato, Peas as green and seed purposes.*

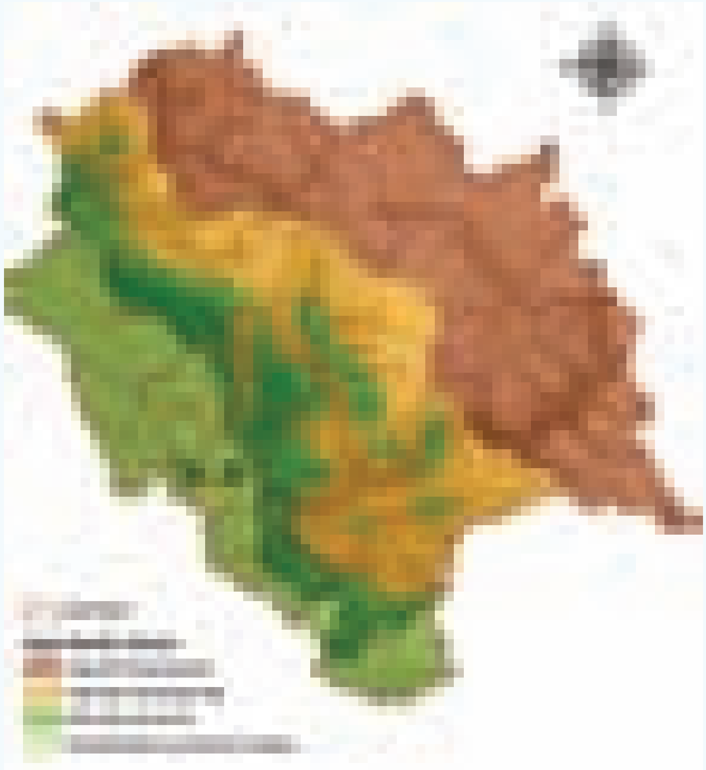


Fig. 4: Agro-climatic Zones of Himachal Pradesh

Rising into the hills, we find a mosaic of Western Himalayan broadleaf forests and Himalayan subtropical pine forests. Various deciduous and evergreen oaks are found in these broadleaf forests, while Chir pine is a dominant species in the pine forests. Western Himalayan subalpine conifer forests grow near tree line, with species that include East Himalayan Fir, West Himalayan Spruce, Deodar (State tree), and Blue pine (Fig. 5). The state has about 26.37% forest cover of total area which has great bearing on present and future climate scenario.

Fig. 5: Biological Richness in Himachal Pradesh

In the uppermost elevations, we find western Himalayan alpine shrub and meadows in the northeast and northwestern Himalayan alpine shrub and meadows in the northwest. Trees are sturdy with a vast network of roots. Alders, birches, rhododendrons and moist alpine shrubs are there as the regional vegetation. The rhododendrons can be seen along the hillsides around Shimla from March to May. The shrublands and meadows give way to rock and ice around the highest peaks

Himachal Pradesh is a well known habitat to a variety of wild life. There are around 1,200 bird and 359 animal species in the state. This includes the Leopard, Snow Leopard (State Animal), Ghoral, Musk Deer and Western Tragopan. It has 2 National Parks and 33 Wildlife Sanctuaries – the largest number in the Himalayan region. The Great Himalayan National Park (GHNP) in Kullu district was established to conserve the flora and fauna of the main Himalayan range, while the Pin Valley National Park was established to conserve the flora and fauna of the cold desert.

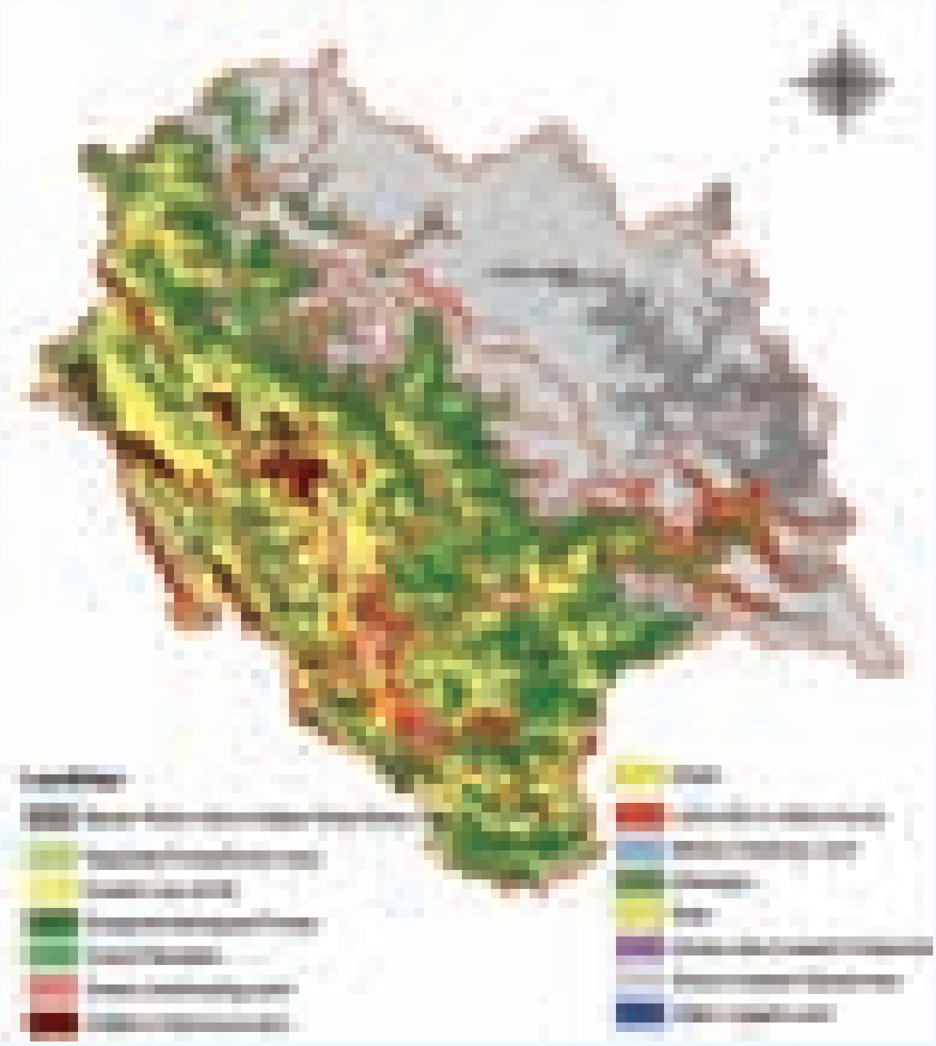


Fig. 6: Land Use/ Land Cover in Himachal Pradesh

Fig. 6 depicts the land use/ land cover pattern available in Himachal Pradesh. Based upon the satellite data analysis, the predominant land use/land cover categories available in the State are mainly the forest which is ever green or semi green in nature, forest plantation, agriculture, land with/without scrub etc.

The soils of Himachal Pradesh can be divided into nine groups on the basis of their development and physio-chemical properties (Fig. 7). These groups are alluvial soils, brown hill soils, brown earths, brown porous soils, grey wooded or podozolic soils, grey brown podzolic soils, plansolic soils, humus and iron podzols and alpine humus mountain skeletal soils. The soils of Himachal Pradesh can be divided into nine groups on the basis of their development and physio-chemical properties. These groups are alluvial soils, brown hill soils, brown earths, brown porous soils, Grey wooded or podozolic soils, grey brown podzolic soils, plansolic soils, humus and iron podzols and alpine humus mountain skeletal soils.

As far as lithological variations in the State are concerned, it is characterized by highly diversified geological formations ranging from Pre Cambrians to Holocene or Recent (Fig. 8). The low lying areas of the State comprising mainly of Kangra, Hamirpur, Una, Sirmour, parts of Mandi are characterized of Shivalik and the Tertiary group of rocks where as the Northern and North western and North eastern parts of the State are comprised of meta sediments.

Fig. 7: Soil Classification Map of Himachal Pradesh

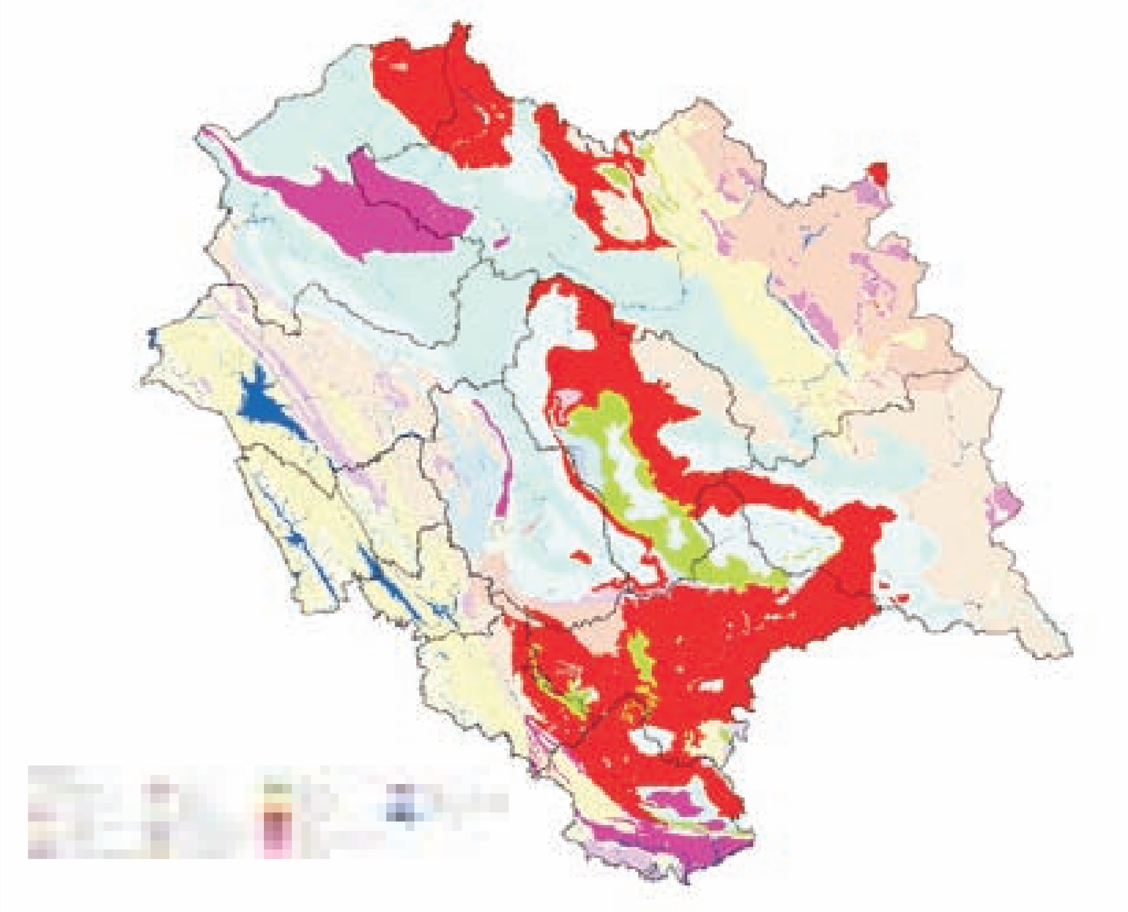


Fig. 8: Lithology Map of Himachal Pradesh

3.2 Past & Current Climate Change Trends in Himachal Pradesh

3.2.1 Climatic Patterns

The term climate is mainly determined by two variables viz. temperature and precipitation. The climate of the state varies from place to place depending on the altitude. It varies from hot and sub-humid tropical (450-900 m) in the southern low tracts, warm and temperate (900-1,800 m), cool and temperate (1,900-2,400 m) and cold alpine and glacial (2,400-4,800 m) in the northern and eastern high mountain ranges.

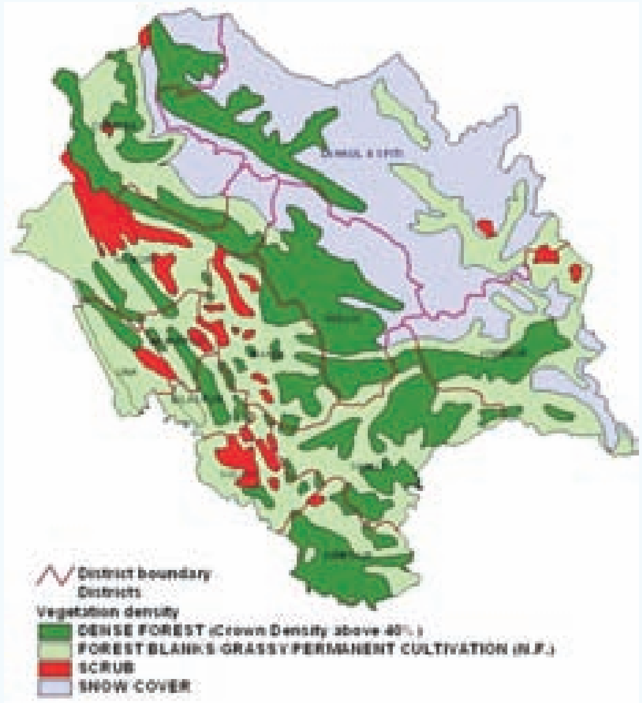


Fig. 9: Vegetation Density Map

The state is broadly divided into three physio-geographical regions, viz. Outer Himalaya, the Lesser Himalaya and the Greater Himalaya or the Alpines. The Outer Himalaya includes the districts of Bilaspur, Hamirpur, Kangra, Una and the lower parts of Mandi, Sirmour and Solan. The Lesser Himalaya includes the parts of Mandi, Sirmaur and parts of Chamba, Kangra and Shimla districts. The Alpine zone is at an altitude of 4,500 m and beyond, includes Kinnaur and parts of Lahaul and Spiti, Chamba districts. The areas of the state increase in elevation from west to east and from south to north. Therefore, geo-climatically Himachal Pradesh has three zones (i) The Outer Himalaya, (ii) The Inner Himalaya and (iii) Alpine zone. The first zone receives annual rainfall between 150 cms and 175 cms. In second zone, it varies between 75 cms to 100 cms and the Alpine zone receives solid precipitation during winters only and remains under the impact of snow for about five to six months in a year. The average annual rainfall in the State is about 160 cms. The climate varies between hot and humid in the valley areas to freezing cold in the areas of perpetual snow.

The areas in the state under each climatic pattern based on *Koppen's Classification* are shown in following Fig. 10 & Table-4. This broad classification is based on the variation of temperature and precipitation. The state as a whole mainly comes under the climatic type as stated below.

As per the study carried out by IMD Pune, the districts Bilaspur, Kangra, Mandi, Sirmour Una, Hamirpur, Solan and Chamba falls under the climatic type Cwa with Sub-tropical monsoon, mild and dry winters and hot summers. Shimla district and some parts of Chamba has been classified as climatic type Cwb with Sub-tropical monsoon, mild and dry winters and short warm summers. Chamba, major parts of Kullu and Mandi districts has been classified as a climatic type Cfa with humid subtropical mild winter, moist all seasons, long hot summer. Kullu district has a climatic type varying between Cfa and Cfb; Humid sub tropical, mild winter, moist all seasons, long hot summer and marine. As the sufficient temperature data for the districts Lahaul & Spiti and Kinnaur is not available, climatic type of these districts is not mentioned though District Kinnaur classified as type Dwb and Dfb for Lahul and Spiti.

Therefore, based on the rainfall and temperature variability criteria the climate pattern observed in the State are as follows:

Table-4: Classification based on Climate Pattern

Climate Pattern Classification		Type	Area/ Districts
Sub Tropical monsoon	Mild and dry winter, Hot summer	Cwa	*Bilaspur, Kangra, Mandi, Sirmour, Una, Hamirpur, Solan, Chamba*
Sub Tropical Monsoon	Mild and dry winter, Moderate hot summer	Cwb	*Shimla, parts of Chamba*
Sub Tropical Monsoon	Without dry winter, With hot summer	Cfa	*Chamba, Major parts of Kullu and Mandi*
Sub Tropical monsoon	Without dry winter with moderate hot summer	Cfb	*Minors parts of Kullu*
Humid continental	Severe and dry winter, warm summer	Dwb	*Kinnaur*
Humid continental	Severe winter, moist all seasons, short warm summer	Dfb	*Lahul & Spiti*

Source: IMD Pune

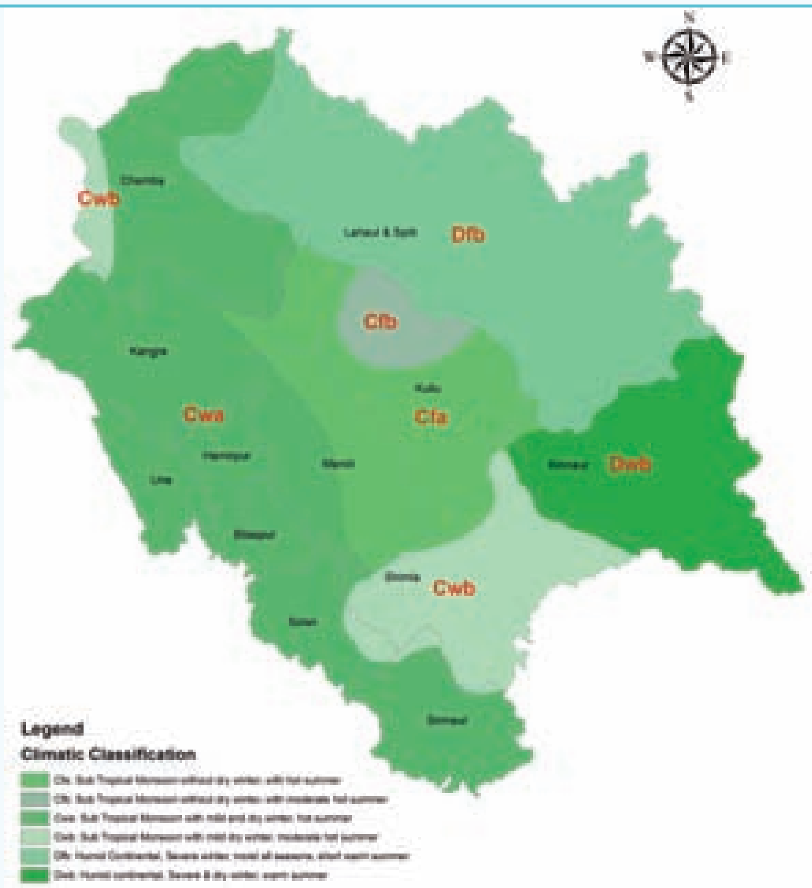


Fig. 10: District Wise Classification based on Climate Pattern

Throughout the year the State experiences four seasons (Table-5). The winter season from December to February is followed by the pre-monsoon or hot weather season from March to May. The period from June to September constitutes the southwest monsoon season and the period from October to December is the post monsoon season. During the period from January to February, generally low temperature prevails over the entire state and is generally not very pleasant due to biting cold. In this season, a series of western disturbances affect the climate of the state. Heavy snowfall occurs during this season. In the summer months from March to May, weather is very dry. In the hilly regions, due to lower temperature, the climate of the state is comfortable. Weather tends to be humid during July to September due to rise in moisture content of the atmosphere. These monsoon months are fairly comfortable due to reduced day temperature, although humidity continues to be high in comparison with the other months.

Table-5: Prevalent Seasons in Himachal Pradesh

Seasons	Pattern/ Duration/ Period
Winter	Low temperature, biting cold, snow **December- February**
Pre-monsoon/ Hot weather-Summer	Extreme dry in lower elevation/ Mild in hills and valleys **March-May**
South West Monsoon/Rainy	Heavy rains, humid, hot in lower elevations **June- September**
Post Monsoon/Autumn	Moderate temperature **October- November**

Source: IMD Pune

3.2.2 Current Climate Trends in Himachal Pradesh

In the context of understanding the climate trends in Himachal Pradesh, both precipitation (Rainfall & Snowfall) and temperature are considered significant indicators. Based on comprehensive studies carried over NW Himalayas on long term trends in maximum, minimum and mean annual air temperate by *Bhutiyani, et. al. 2007*, included observation from Shimla, HP for a period 1901-2002, at 95 % confidence level indicates that there is a significant increase in air temperature in the NW Himalayan region by about 1.6^{0}C with winter warming at a faster pace.

The rates of increase of winter, monsoon and annual air temperatures in ^{0}C in last century, computed by liner regression slope is given in the Table-6.

Table- 6: Winter Monsoon & Annual Air Temperature in Himachal Pradesh

Observation Location	Season	Winter bx100	Monsoon bx100	Annual bx100
Shimla	Mean Maximum Mean minimum Average annual	2.6 1.0 1.8	2.8 (-) .01 1.5	2.4 0.5 2.0
North West Himalayas	Mean Maximum Mean minimum Average annual	1.7 1.7 1.7	1.3 0.4 0.9	1.6 1.1 1.6

Source: Bhutiyani et.al. 2007 (95% confidence level)

As per analysis it is observed that the temperature rose at a lower rate till 1930, thereafter grew at a modest rate during the decade of 1961-1970. Warming rate was higher during the period from 1991-2002 as compared to the earlier periods and the gross rise in mean temperature during 1980-2002 was about 2.2^{0} C. According to *Bhutiyani et. al. 2007* based on short term analysis observed that in different altitudinal zones in Himachal Pradesh, the rate of increase in maximum temperature at higher altitudes was more than that at the lower altitudes and in last century north western Himalayan region warmed significantly higher than the global average.

The gross increase in winter mean air temperature in last two decades in Himachal Pradesh is given in the Table-7.

Table- 7: Increase in Winter Mean Air Temperature in Himachal Pradesh

Observation Stn (Alt)	Mean Max (^{0}C)	Mean Min (^{0}C)	Average Winter (^{0}C)
Bahang (2192)	4.0	1.8	3.8
Solang (2480)	4.4	- 2.0	3.8
Dhundi (3050)	5.6	1.0	3.2
Patseo (3800)	3.0	- 3.0	0.0
Shimla (2200)	2.8	2.2	2.4
Average	**3.2**	**0.8**	**2.2**

Source: Bhutiyani et.al. 2007 (95% confidence level)

There is clear increase observed in winter temperature in Himachal and across North West Himalayan region (Table-8).

Table-8: Observed Increase in Winter Air Temperature

Observation Stn. (Period)	Mean Max (°C)	Mean Min (°C)	Average Winter (°C)
Shimla			
(1901-2002)	2.6	1.00	1.800
(1991-2000)	1.83	0.14	0.898
(2001-2007)	3.42	0.74	2.800
Solang			
(1991-2000)	0.99	- 0.08	0.45
(2001-2007)	2.84	- 1.12	1.98
North west Himalaya (1901-2002)	1.7	1.7	1.7

As per analysis carried on different altitudes in Himachal Pradesh decreasing trend of snow fall is observed (Table-9).

Table- 9: Altitudinal Variation in Snow Fall Trends.

Observatory Stn	Time Period	Time Period
	Observations based on depth of snowfall	
Bhang	(-) 1974-2005	(-) 1991-2005*
Solang	(-) 1982-2005	(-) 1991-2005*
Dhundi	(-) 1989-2005	(-) 1991-2005
Patseo	(-) 1983-2005	(-) 1991-2005
(+) Increasing, (-) Decreasing trend		

Source: Bhutiyani et.al. 2007 (95% confidence level)

Through an analysis of data base from 1866-2006 w.r.t. climate change and precipitation, variation in the north western Himalayas (*Bhutiyani et. al. 2009*) it has been observed that the change in winter precipitation is minimum but there is significant decrease in monsoon precipitation.

Results of trend analysis of annual, winter and monsoon precipitation in Shimla & North Western Himalaya are as under in (Table-10).

Table-10: Trend Analysis of Annual, Winter & Monsoon Precipitation

Observatory Stn.	Data Period	Trend Analysis	
		Mann-Kendall's Non Parametric Text	Linear Regression Coefficient (b)
Annual Precipitation			
Shimla	1866-2006	(-)*	(-)*
North West Himalaya	1866-2006	(-)*	(-)*
Winter Precipitation			
Shimla	1866-2006	(-)*	(-)*
North West Himalaya	1866-2006	(-)*	(-)*
Monsoon Precipitation			
Shimla	1866-2006	(-)*	(-)*
North West Himalaya	1866-2006	(-)*	(-)*

(+) Increasing, (-) Decreasing trend

Source: Bhutiyani et.al. 2007 (95% confidence level)

Trend analysis of annual rainfall data (Ranbir, 2010) of last 25 years in different districts in Himachal Pradesh revels that increasing trend of about 33.5%, 54.3% and 51.5% has been observed in the State in district Kinnaur, Chamba and Lahul & Spiti respectively on one hand and decrease of about 8.7%, 13.3% and 26.6% in District Solan, Shimla and Sirmour respectively. About 0.5^{0}C rise in maximum temperature is observed for Palampur, in District Kangra.

The Annual Rainfall Variation Trend in different districts of H.P. is given in (Table-11).

Table-11: District Wise Variation in Annual Rain Fall Trends

Districts	Rainfall Variation 25 years
Kinnaur	33.5% (+)
Chamba	54.3% (+)
Lahual & Spiti	51.5% (+)
Solan	8.7% (-)
Shimla	13.3% (-)
Sirmour	26.6% (-)

Source: Ranbir, 2010

The variation observed in Mean Temperature (Max & Min) in District Kangra, H.P. is given in (Table-12).

Table-12: Observed Mean Temperature (Max. & Min.) in District Kangra

Observatory Stn.	Temperature (Max)		Temperature (Min)	
	1985	2009	1986	2009
Palampur Kangra	31.5 ^{0}C	32.1 ^{0}C	4.4^{0}C	5.2^{0}C
Net Change	0.5^{0}C		0.8^{0}C	

Source: Ranbir, 2010

It has also been observed that there has been about 40% reduction in rainfall over the last 25 years as it was 948 mm in 1987 which is reduced to about 470 mm during 2009. Another analysis with respect to climate of Shimla reveals that total precipitation and snowfall for all the season has a decreasing trend. The analysis of twenty years data by (*Bhan & Manmohan, 2011, IMD*) reveals that the season tends to end by about 10-12 days earlier per decade leaving long term impacts on agriculture-horticulture production of the State.

Table-13: Observed Decreasing Trend in Rain Fall & Snow Fall at Shimla

Month	Trend in Total Precipitation, Rainfall and Snowfall		No of Days with Snowfall	
	Trend (mm per decade)		Avg. no of days with snowfall	Max. no of days with snowfall (year)
	Rainfall	Snowfall		
December	- 3.8	- 8.4	0.8	3 (1995)
January	- 46.0	29.6	3.1	8 (1995)
February	- 20.9	14.5	3.9	12 (2000)
March	- 19.2	- 4.3	0.4	2 (1993, 2007)
Season	- 89.9	- 56.9	8.2	20 (1994-95)

Analysis of Trends of Rainfall & Snowfall of Shimla Himachal Pradesh

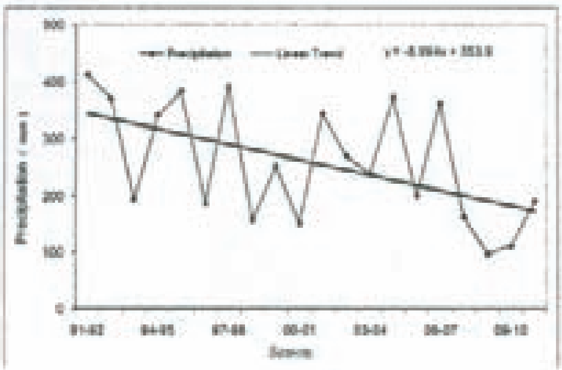


Fig. 11 (i): Total Seasonal Precipitation over Shimla

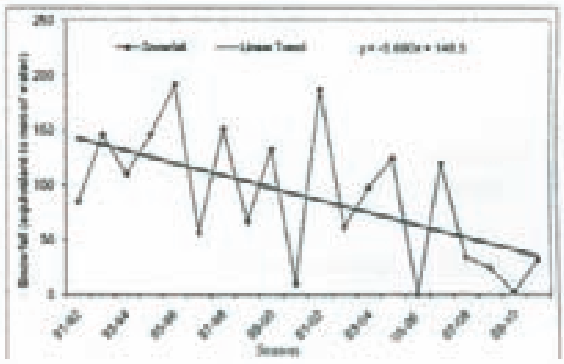


Fig. 11 (ii): Total Seasonal Snowfall (Equivalent to mm or water) over Shimla

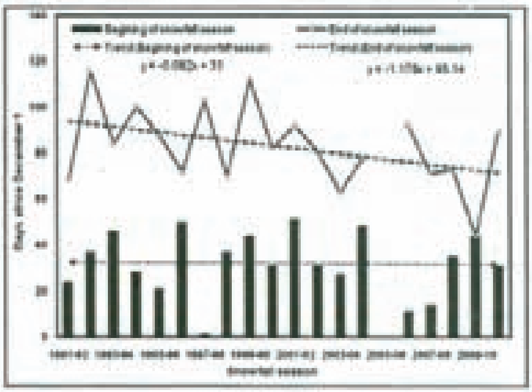


Fig. 11 (ii): Beginning and End of Snowfall Season at Shimla

Source: Bhan, Manmohan, 2011, IMD

110 years annual rainfall trend of Shimla, Himachal shows a decreasing trend which is similar for about 50 KM aerial distance around (Fig. 12).

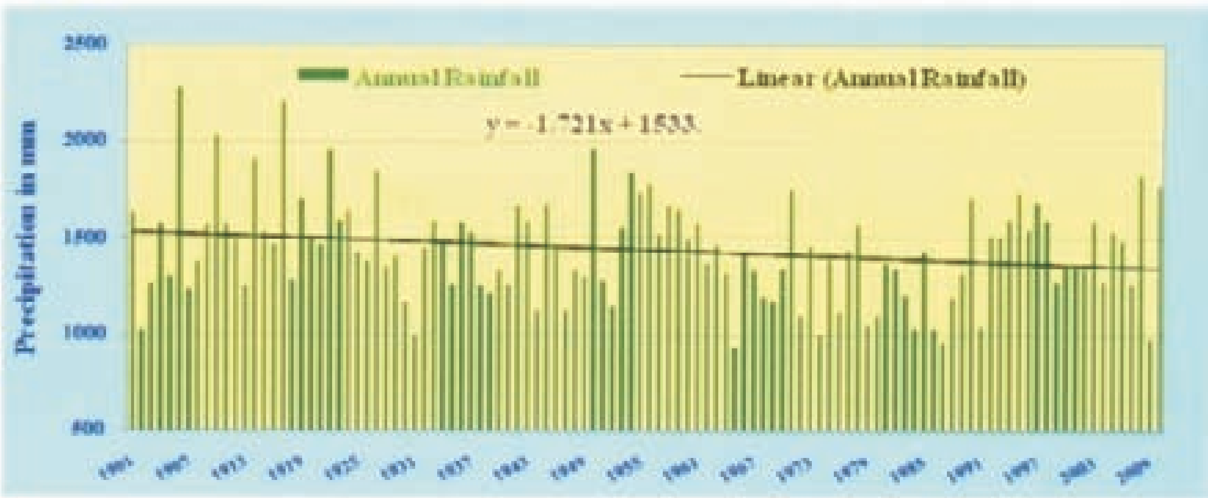


Fig. 12: 110 Years Annual Rainfall in Shimla

Source: IMD, Pune

Extreme Temperature Variations Ever Recorded (^{0}C)

Fig. 13(i): Area Affected by Drought (1951-2000)

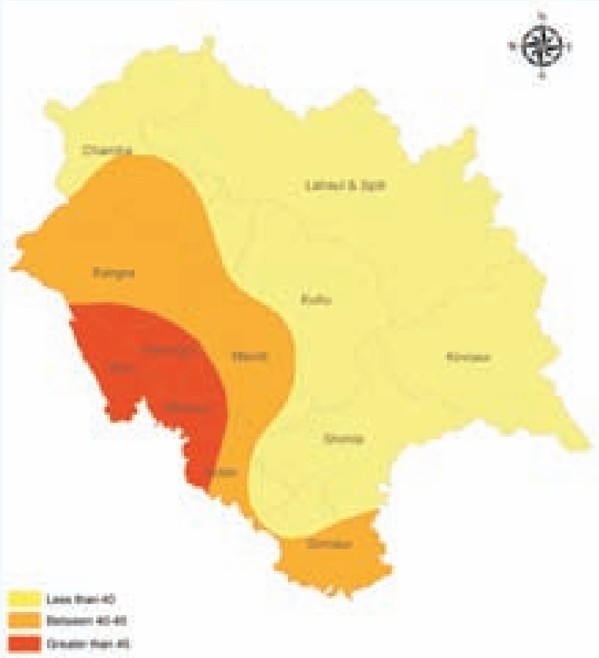


Fig. 13(ii): Highest Temperature Ever Recorded (^{0}C)

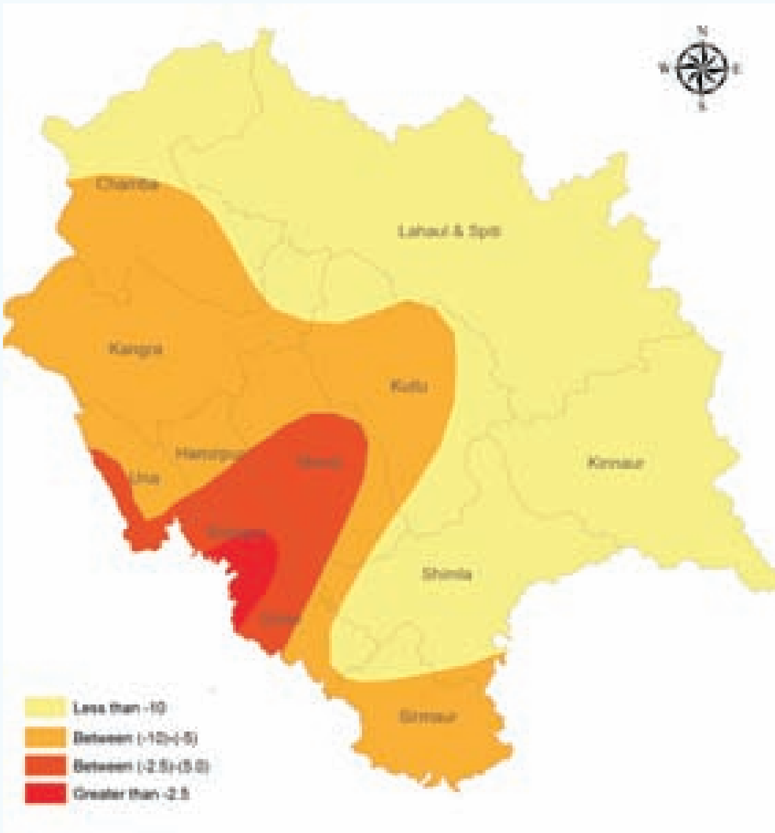


Fig. 13(iii): Lowest Minimum Temperature Ever Recorded (^{0}C)

The trend analysis of climate variables (temperature and precipitation) at various altitudes in Himachal Pradesh over more than two decades is as follows in Table-14.

Table-14: Altitude Wise Climate Variables in Himachal Pradesh

Altitude (amsl)	Obs. Stn.	Annual Mean Temp.	Annual Mean Rainfall	Data base
1,500-2,400	Theog (Shimla) High Hill Temperate wet	(+) 1.8 ^{0}C	(-) 127 mm (+) in Kharif season)	20 years
1,200-1,800	Kullu High Hill Temperate wet	(+) 2.8 ^{0}C	(-) 20.1 mm (+) in Kharif season	34 years
700-1,500	Palmpur (Kangra) Mid Hill sub Humid	(+) 1.0 ^{0}C	(-) 1,000 mm exceptional decrease (+) in Kharif season	35 years
< 700	Fatehpur (Sirmour) Low Hill sub Humid	(+)	(-) 29.4mm	23years

3.2.3 Glaciers & Snow Fields in Himachal Himalaya

As per the investigations carried out in the Himachal Himalayas, there are about total of 334 glaciers in the entire Satluj basin which includes the glaciers in Beas, Sainj, Spiti, Baspa basins and 457 glaciers in the Chenab basin in Himachal Himalaya. Out of 334 glaciers in the entire Satluj basin, 202 glaciers are located in Himachal Pradesh (Kulkarni et. al). The total area covered by these glaciers in Satluj and Chenab basins is around 2,175 sq. km. Besides, the glaciers there are about 1,826 permanent snow fields in these basins having a total area of 1,101.737 sq. km. (Table-15).

Table-15: Basin Wise Distribution of Glaciers and Snow Fields in Himachal Himalayas

Basin Name	Number of Glaciers	Aerial Extent (sq. km.)	No. of Permanent Snowfields	Aerial Extent (sq. km.)
Beas	06	15.843	47	72.442
Parvati	36	450.627	131	188.188
Sainj	09	37.255	59	51.934
Spiti	71	258.237	597	368.366
Baspa	25	203.300	66	64.964
Satluj	55	154.762	194	110.843
Chenab	457	1055.27	732	245.000
Total	**659**	**2175.294**	**1826**	**1101.737**

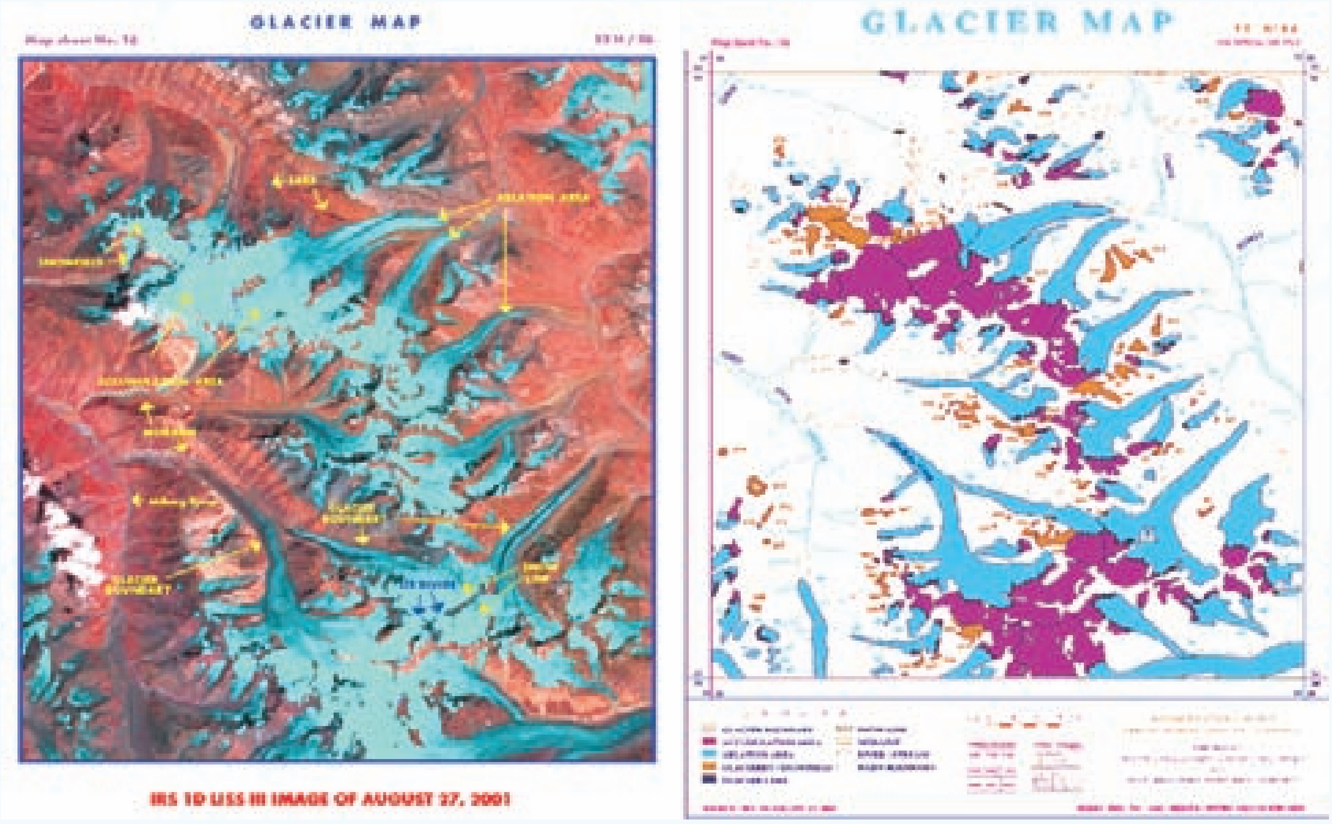
In the case of Himachal Pradesh rivers flow, the major contribution is from the snow and glacier melt which affects the discharge of the streams considerably. To understand the effect of global warming on the hydrological balance, the snow ablation studies in the Himalayas have been carried out. Initially the investigations were carried out in the Beas and Baspa basins in Himachal Pradesh.

To understand these changes snow cover an evaluation has been carried out in the Beas and Baspa basins using IRS WIFS satellite data from October to June for the period 1997 to 2001. On the basis of the study carried out by Space Application Center in the Beas basin pertaining to the period from October to June 1997-98 and 2001-2002, that snow accumulation has been observed in early winter i.e. from November to January for 1998-99 and 1999-00, in 2000 it was substantially lower than in 1997-98 and 2000-2001, which may be attributed due to low snowfall in the early winter and abnormally high temperature as the average maximum temperature in the month of November and December was higher in the year 1998 and 1999 as compared to 1997. On the other hand, the snow accumulation pattern in the year 2000-2001 was entirely different. Overall snow cover was very high in the month of Nov-December, but right from the beginning of December snow cover started retreating and this trend continued up to the middle of February. The data suggest that the snow accumulation was above normal for 1997-98 and very low for 1998-99 affecting snow ablation patterns. In May 1998, snow cover was almost 70% compared to 30% in 1999. Altitude wise monitoring of snow has also been done in the Beas basin between 1800 m to 5400 m at an interval of 600m. It has been observed that there was a substantial retreat of snow in the month of December up to 5400 m altitude in this basin. In January retreating snow was observed up to 4200 m in the Beas Basin. The melting of snow cover in high altitude region in the month of December and January is an unusual observation. Similarly, on the basis of the studies so far done on Chotta Sigri glacier in the Chandra basin, it has been observed that snout of Chotta Sigri glacier has receded by about 8m/year during 1963 to 1984 and about 23 m/year during 1984 to 1986. It has further receded by about 15 to 20 m during September 1986 to August 1987. Average melting rate calculated was 6.5 cms/day, 4.1 cms/day and 3.0 cms/ day in snout, ablation and accumulation zone. The results have proved that the rate of melting was maximum in the snout zone and minimum in the accumulation zone.

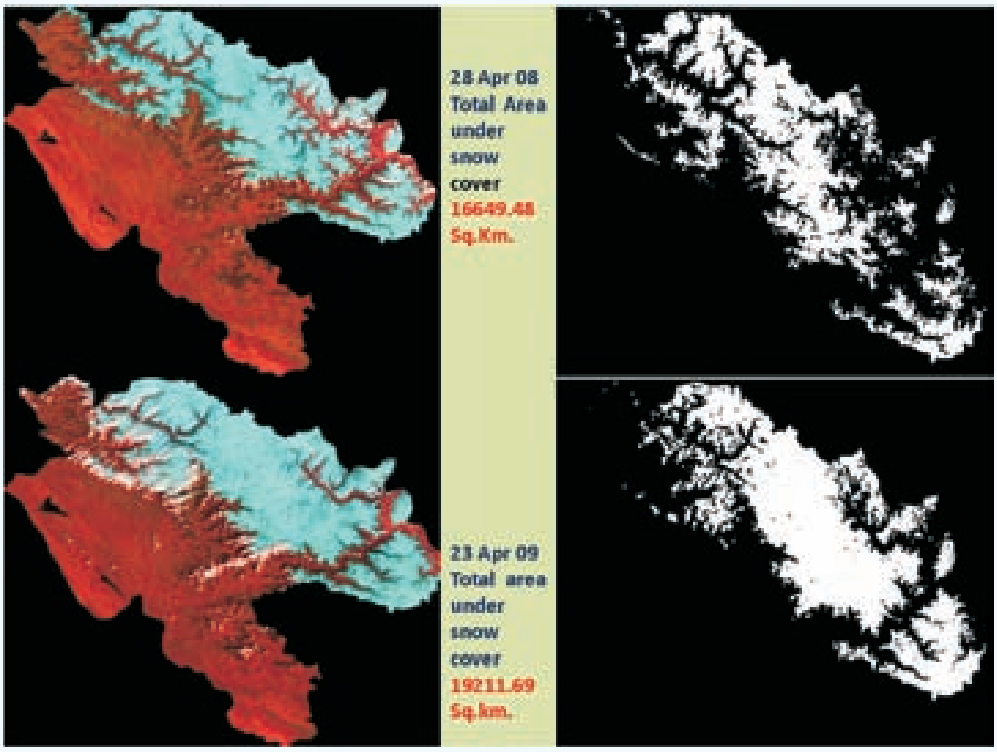
The glaciers are receding, precipitation is becoming erratic, the protection of glacier fields is emerging as an important issue and associated livelihood issue does require attention at the moment.

The analysis of data whatever available, therefore, presents that effects of climate change are likely to be become more intense by next 2-3 decades when time temperature may rise by 2-4 ^{0}C. There would be clear change in monsoon precipitation pattern which may increase by 20-25 %. Frequency of extreme events may double. Resultantly there will be snow and glacier field loss, which will affect the flow in river system, the flow in lower elevation would reduce maximum. The glacier fields may reduce by more than 50% due to rise in temperature, increased melting rate, monsoon, extreme events may further increase the issues of sedimentation, intense erosion, destabilization of slopes and the increase in events of GOLF's etc. (Kulkarni et. al).

Climate Change Impact on the Himalayan Glaciers



Impact of Climate Change on the Seasonal Snow Cover Patterns



Long Term Monitoring of Himalayan Glaciers

Nardu Glacier: Baspa Basin

3.2.4 Conclusions

From above discussions it is observed that in Himachal Pradesh the climate change variations are set to arrive in following manner:

3.2.4.1 Temperature

- The annual temperatures are set to rise.
- The rise in temperature with respect to 1970s shows a range between 1.5 ^{0}C to 2.8 ^{0}C.
- Temperatures are also showing a rising trend in all seasons.

3.2.4.2 Precipitation

- The mean annual rainfall likely to vary between 1250±225.2 and 1550±175.2 mm in Himachal Pradesh.
- The rate of increase is more in North-western parts of the State i.e. areas of district Kangra, Chamba, Kullu, Una are likely to receive rainfall with increased intensity.
- The High Hill areas like Kinnaur, Lahul & Spiti and some parts of Chamba and Kullu districts may also experience rainfall in place of snowfall with increased temperature.
- There may be staggering decrease in snowfall patterns in mid-hills temperate wet agro climatic zone.
- The number of rainy days may increase in Himachal Pradesh with decrease in average intensity.
- An increase in rainfall in the pre-monsoon and post-monsoon months with increasing incidence of storms in Himachal Pradesh.

3.2.4.3 Extreme Events

- Change in rainfall patterns with increased variability in future some regions (South-eastern parts) may be experiencing less rainfall. Drought like conditions may prevail in given projections.
- Projected increase in temperature, rainfall, rainfall variations and intensities in the State may lead to accelerated summer flows leading to situations like floods/flash floods in North-western parts of the State.
- Health risks are also associated indirectly with extreme events in sub montane, low hills, and sub humid agro climatic zones of the State.

3.3 Climate Statistics for Himachal Pradesh- Current & Projections

Long term trends in observed seasonal rainfall and temperature over State using IMD gridded rainfall and temperature at daily time scales has been performed to arrive at the current baseline climatology.

3.3.1 Rainfall

Rainfall in the state of Himachal Pradesh varies considerably both in space and time from year to year as in Table-16.

Table-16: Variation in Rainfall in Himachal Pradesh

Season	Statistics	Value	Contribution in Annual Rainfall (%)
Annual	Average (mm)	1490	
	Range-average (mm)	606.8-3722.5	
Winter	Average (mm)	134.1	9%
	Range-average (mm)	17.4-310.1	
Pre-monsoon	Average (mm)	163.9	11%
	Range-average (mm)	28.4-268.9	
Monsoon	Average (mm)	1087.7	73%
	Range-average (mm)	19.9-1275.2	
Post Monsoon	Average (mm)	89.40	6%
	Range-average (mm)	4.4-96.6	
Annual	Range-Inter-annual variation	0.93-1.25	
Winter	Range-Inter-annual variation	0.6-0.8	
Pre-monsoon	Range-Inter-annual variation	0.4-0.6	
Monsoon	Range-Inter-annual variation	0.86-0.90	
Post Monsoon	Range-Inter-annual variation	0.3-0.5	

Source: IMD Gridded Rainfall Data (1971-2005)

Fig. 14: Annual Normal Rainfall (cm)

The total annual rainfall in the state is the maximum over the region of Kangra district and neighbourhood areas (Fig. 14). The total annual rainfall for the state is 149 cm with total annual number of rainy days as 65. Kangra district receives the maximum amount of rainfall (185 cm) in a year, whereas Una receives the minimum amount of rainfall (121 cm) in a year. The figures have been plotted which show rainfall pattern during winter season (December to February) and pre-monsoon season (March to May). The rainfall over the state increases towards northeast region during winter and pre monsoon. The pattern of spatial distribution of the rainfall over the state during the southwest monsoon season generally resembles to that of the spatial distribution of the annual rainfall. In both cases, the rainfall is maximum in northwestern region which is further corroborated by fact that the isopleths are concentrated more in this region. It is observed that during the post-monsoon season, the rainfall pattern over the north and eastern parts is uniform and rainfall decreases towards west/southwest region (Fig. 15 (i-iv).

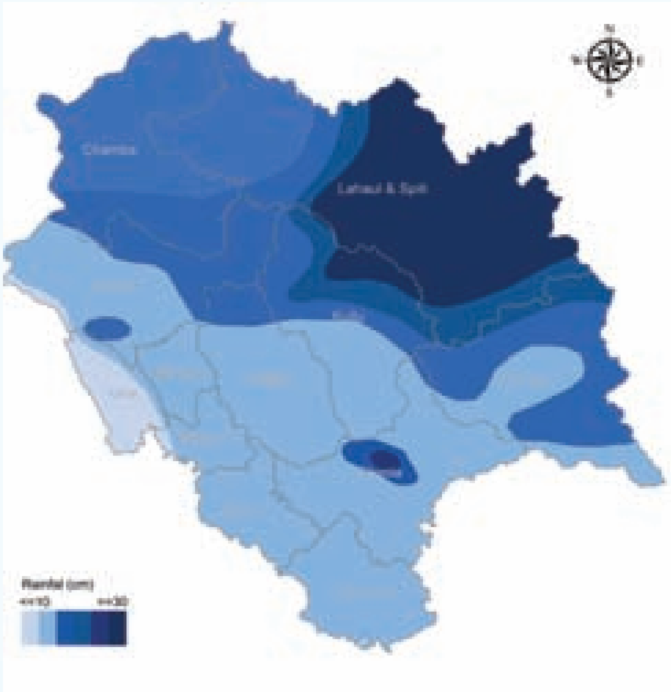


Fig. 15(i): Seasonal Rainfall(cm)- Cold Weather Season- January to February

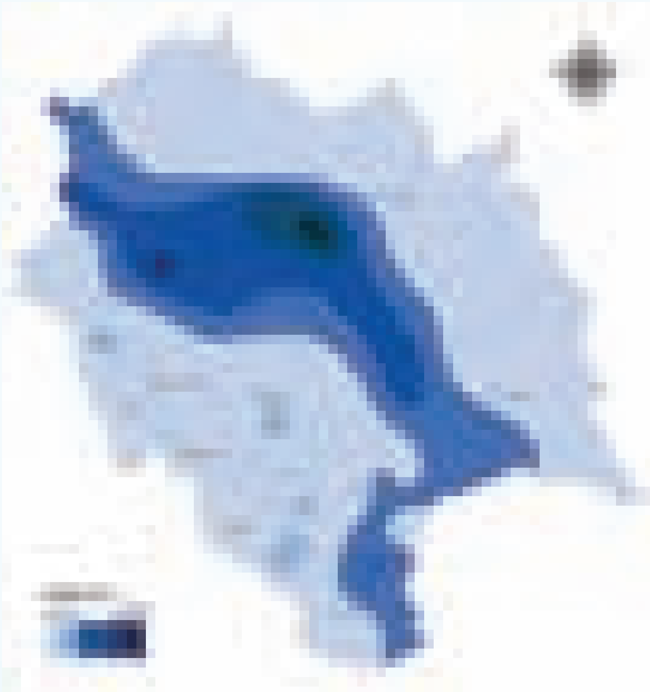


Fig. 15(ii): Post Monsoon Season- October to December

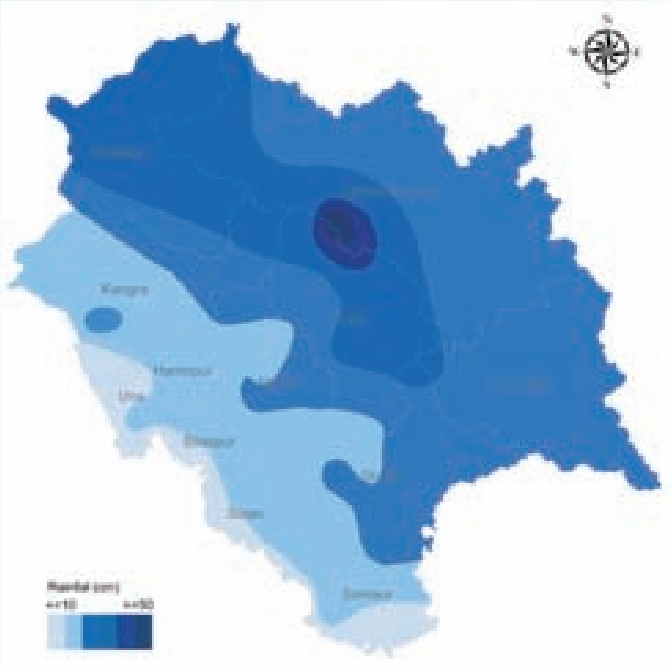


Fig. 15(iii): Pre-monsoon Season- March to May

Fig. 15(iv): Monsoon Season- June to September

The southwest monsoon season is the predominant rainy season in the state. Of the total annual rainfall, about 73% is received during the southwest monsoon season (June to September), about 9% is received in the winter season (December, January and February), about 11% is received in the pre-monsoon season (March to May) and about 6% is received in the post-monsoon season (October to November). The percentage of the seasonal number of rainy days with respect to the annual number of rainy days is 63% for the southwest monsoon season, 16% for the pre-monsoon season, 7% for the post monsoon season and 13% for the winter season. During the southwest monsoon season, the state receives rainfall mainly due to low pressure areas and monsoon depressions originating from the Bay of Bengal.

Fig. 16: Are Affected by Excessive Rainfall

The southwest monsoon extends over the entire state by the last week of June. July and August are the wettest months accounting individually to about 27% of the annual rainfall. The number of rainy days ranges from 6 to 14 during southwest monsoon season, the number being maximum (14) for the month of July and August. The most common rain-giving systems over the state during post-monsoon season are the depressions and cyclonic storms originating from the Bay of Bengal. During winter, the state receives about 14 cm of rainfall. This rainfall, though small in amount, is of utmost significant for agriculture. This rainfall generally occurs in association with induced low pressure areas over the surface due to western disturbances moving from west to east, across the northern parts of the country.

Rainfall, sufficiently in excess of the normal, is a predominant factor for the occurrence of floods, particularly in high rainfall regions. For the purpose of present description, annual rainfall of 125 % or more of the normal is considered as excessive rainfall.

The Fig. 16 shows the percentage frequency of excessive rainfall and successive years of excessive rainfall during the period 1951 to 1999. It is seen from this figure that the frequency of excessive rainfall for Chamba district in northwest region of the state is highest and the number of successive years of excessive rainfall are more.

The annual rainfall in different river catchments is as follows. It is seen from Table-17 and Fig. 17 that the river Beas has a catchment (No. 203) in the state, which receives the maximum amount of annual rainfall (182.2 cm) as well as the maximum rainfall (130 cm) during the southwest monsoon season.

Table-17: Catchment Area Wise Mean & Maximum Rainfall

River Catchment	Catchment No	Area Districts	Mean Annual Rainfall (mm)	Max. Rainfall mm(month)
Sutlej (Upto Bhkara Dam)	201	Shimla, Kinnaur, Solan, Mandi, Bilaspur	1191.9	256.6 (July)
Sutlej (Between Bhakra Dam and Beas excluding Beas)	202	Solan, Sirmour, Una	1573.8	444.9 (July)
Beas	203	Kangra, Hamirpur, Kullu, Lahul & Spiti, Mandi, Chamba	1821.9	497.9 (July)
Ravi	204	Chamba	1190.3	169.2 (July)
Chenab	205	Lahul & Spiti	1004.4	155.5 (Mar)
Yamuna	403	Shimla, Sirmour	1355.1	354.6 (July)

The spatial distribution of the coefficient of variation of annual rainfall over Himachal Pradesh is depicted as shown in Fig. 18 Coefficient of Variation (CV) which is expressed as percentage is defined as:

CV = Standard Deviation (σ) X 100 Normal (N)

It is observed that the values of CV of annual rainfall range between 30% and 50% over the entire state of Himachal Pradesh. The values of CV over northwestern and southern parts are less than 30%, while those over some parts of the northern and eastern Himachal Pradesh the values are higher than 50%.

Fig. 17: Catchment Area with Annual

The regions of extreme southern parts of the State exhibit the highest variability, with values of CV exceeding 70%. During the southwest monsoon season, the rainfall variability is low with the values of CV ranging between 20% and 50% (Fig. 19). It is observed that the values of CV of the rainfall during the post-monsoon season range between 80% and 120% (Fig. 20). During the winter season also, the variability of rainfall is very high. The values of CV range between 40% and 120% (Fig. 21). Thus, the variability of annual rainfall and rainfall during the southwest monsoon season, over Himachal Pradesh is relatively lower. On the other hand, the variability of seasonal rainfall for the other three seasons is very high. The contribution of southwest monsoon rainfall to the annual rainfall is the highest.

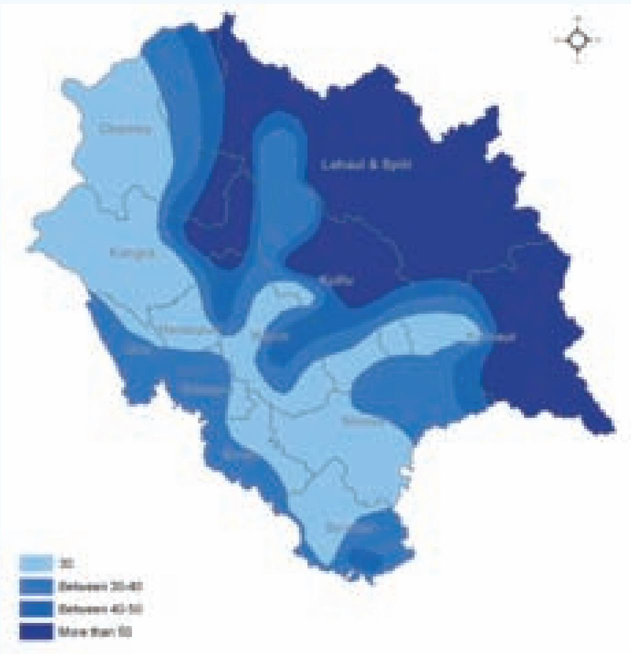


Fig. 18: Coefficient of Rainfall Variation- Annual

Fig. 19: Coefficient of Rainfall Variation- Southwest Monsoon

Fig. 20: Coefficient of Rainfall Variation- Post Monsoon

Fig. 21: Coefficient of Rainfall Variation- Winter

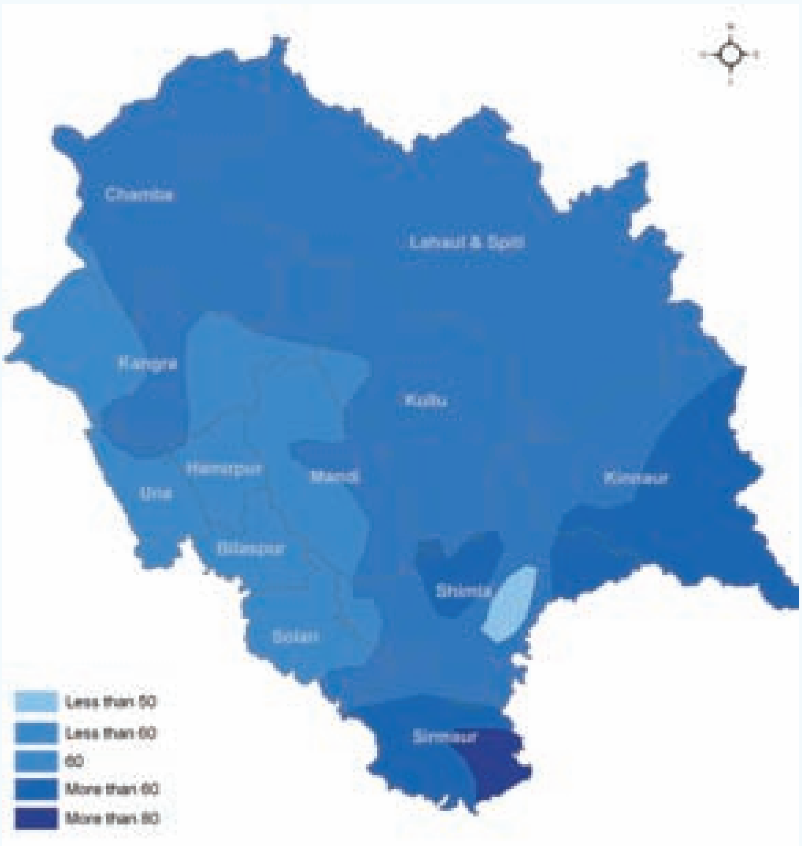


Fig. 22: Coefficient of Rainfall Variation- Premonsoon

3.3.2 Temperature

Table-18 gives the mean daily maximum and mean daily minimum temperature. The spatial distribution of the mean daily maximum temperature for the representative months of four seasons of a year is depicted (Fig. 23). It is observed that the temperatures of hilly districts with deep valleys vary considerably from place to place depending on elevation. June is the hottest month with the mean daily maximum temperature of 35.5°C in the plains and 28.7°C in hilly places. During June, the mean daily maximum temperature ranges from 24°C to 38.4°C over the state, the values increases towards southwest. The highest values are observed over the extreme south western region. With the onset of monsoon season the day temperatures falls significantly. During August, an appreciable drop in the mean daily maximum temperature is observed with the values ranging between 20.4°C and 32.6°C. The values of mean daily maximum temperature in October range between 18.8°C to 30.6°C with the values generally increasing towards southwest. It is observed that the mean daily maximum temperature of January ranges between 9.3°C and 20.3°C. The temperature pattern of January is quite similar to that of October.

Fig. 23 Annual Normal Temperature (°C)

Table-18: Seasonal Variation Max. & Min. Temperature			
Season	**Statistics**	**Max. Temperature (°C)**	**Min. Temperature (°C)**
Annual	Average	22.31	10.6
	Range-average	17.3-29.7	6.2-16.2
Winter	Average	14.6	3.1
	Range-average	9.3-22.6	-1.7-8.9
Pre-monsoon	Average	23.9	10.91
	Range-average	14.6-36.2	2.6-20.8
Monsoon	Average	27.02	17.01
	Range-average	20.3-38.4	11.1-24.5
Post Monsoon	Average	22.05	8.58
	Range-average	15.1-30.6	1.4-17.5
Annual	Range-Inter-annual variation	0.04-0.06	0.02-0.03
Winter	Range-Inter-annual variation	0.07-0.09	0.16-0.18
Pre-monsoon	Range-Inter-annual variation	0.02-0.03	0.04-0.04
Monsoon	Range-Inter-annual variation	0.01-0.03	0.03-0.05
Post Monsoon	Range-Inter-annual variation	0.06-0.08	0.04-0.06

Source: IMD Gridded Rainfall Data (1971-2005)

The spatial distribution of the mean daily minimum temperature for the representative months of four seasons of a year is also depicted. In the month of January, the minima of the mean daily minimum temperature are observed over the northeast region of the state. The values range between -1.7^{0}C to 7.3 ^{0}C (Fig.24). Over the southern region of the state, temperature higher than 5^{0}C is observed. During the winter months, cold waves associated with western disturbances may bring down night temperatures appreciably, even 5-10^{0}C below the freezing point of water. In the month of April, the values range between 6.2^{0}C to 18.4^{0}C (Fig.25). The temperature is more than 18^{0}C over the extreme southern region of the state. The lowest value of the mean daily minimum temperature is observed over the northern region of the state. In the month of July the values of minimum temperature range between 14.7^{0}C to 24.5^{0}C (Fig. 26). The values of mean daily minimum temperature over the hilly region of the state are generally lower than 20^{0}C.

During the month of October, the values of mean daily minimum temperature range between 5.3^{0}C to 17.5^{0}C (Fig. 27). The temperature over the hilly region is observed to be lower than 11^{0}C except at Dharamsala observatory.

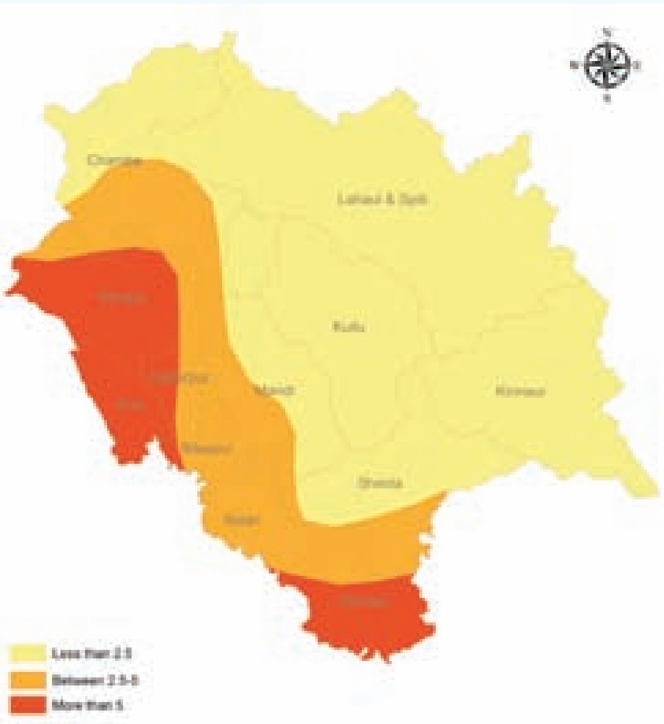


Fig. 24 Mean Minimum Temperature (^{o}C) - January

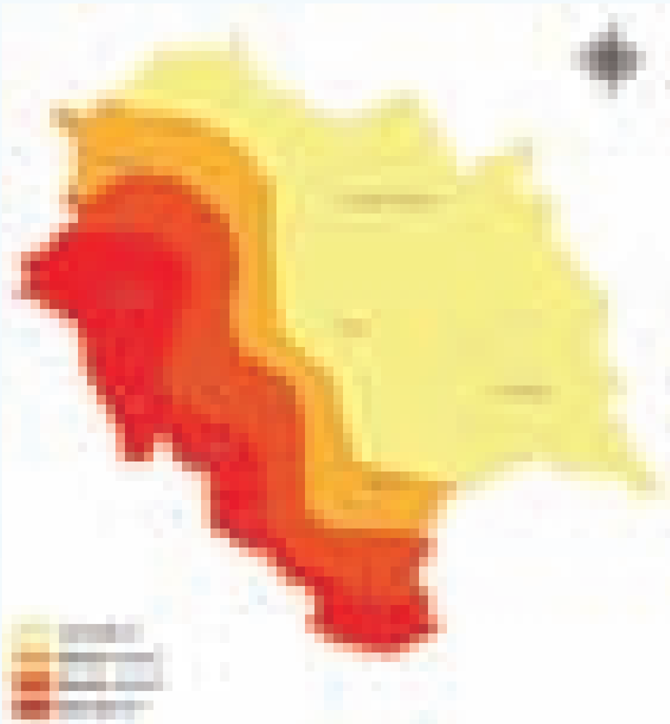


Fig. 25 Mean Minimum Temperature (^{o}C) - April

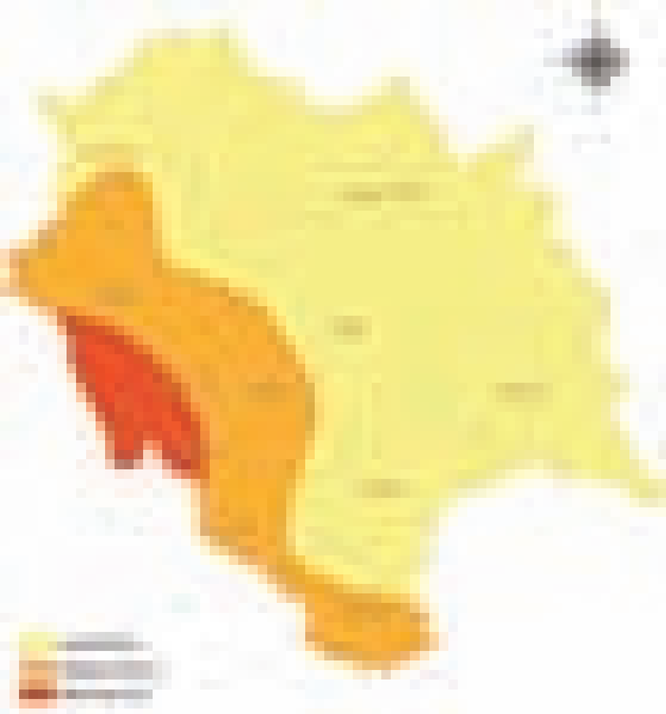


Fig. 26 Mean Minimum Temperature (^{o}C) - July

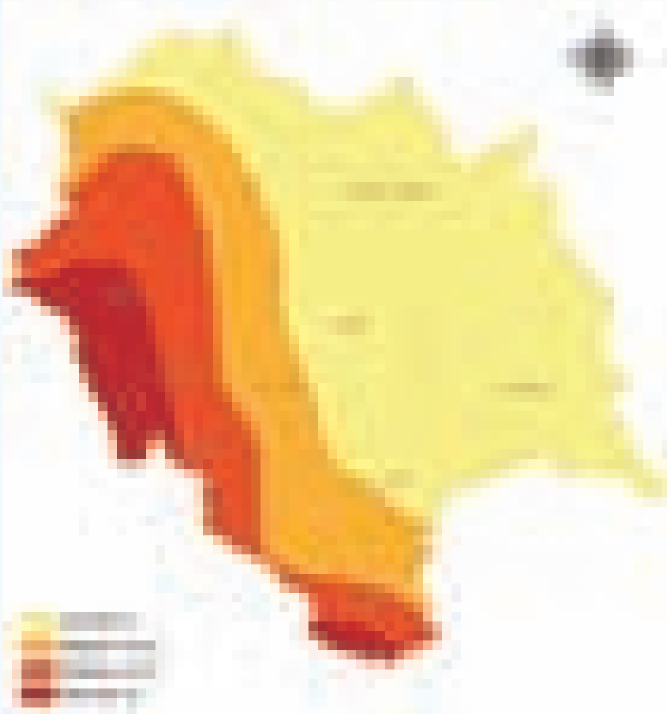


Fig. 27 Mean Minimum Temperature (^{o}C) - October

The highest maximum temperature and the lowest minimum temperature ever recorded are depicted. The highest maximum temperature ever recorded in the State is 49.9^{0}C on 8th May, 1958 at Gondla observatory and the lowest minimum temperature ever recorded in the state is -25.9^{0}C at Keylong observatory on 21st February, 1978 in Lahaul and Spiti district. Thus, day temperatures in the state increase uniformly from April to October. In general, the night temperatures are lower in the higher latitude districts. Both day and night temperatures are lower over the hilly stations than those over the plains. Maximum temperatures rise rapidly from February onwards till June and ranges from about 10^{0}C to 16^{0}C at plains and about 14^{0}C to 16^{0}C over the hilly regions, whereas minimum temperatures rise rapidly during the period from February to July and it ranges from 13^{0}C to 18^{0}C at plains and 12^{0}C-16^{0}C at hill stations. In the state, from the beginning of June to the end of July, the maximum temperature falls by about 2^{0}C to 6^{0}C whereas the minimum temperature falls by about 2^{0}C to 3^{0}C from July to September. Both day and night temperatures start falling rapidly after October onwards and attain the lowest value by January. August has the lowest diurnal range of temperature, about 9^{0}C in plains and about 8^{0}C in hilly regions. The diurnal range increases rapidly after the retreat of southwest monsoons. During the period from November to June, the diurnal range is of the order of 14^{0}C to17^{0}C at plains and 11^{0}C to 14^{0}C in hilly regions Fig. 28 (i-iv).

Fig. 28(i) Mean Max. Temperature (°C) - August

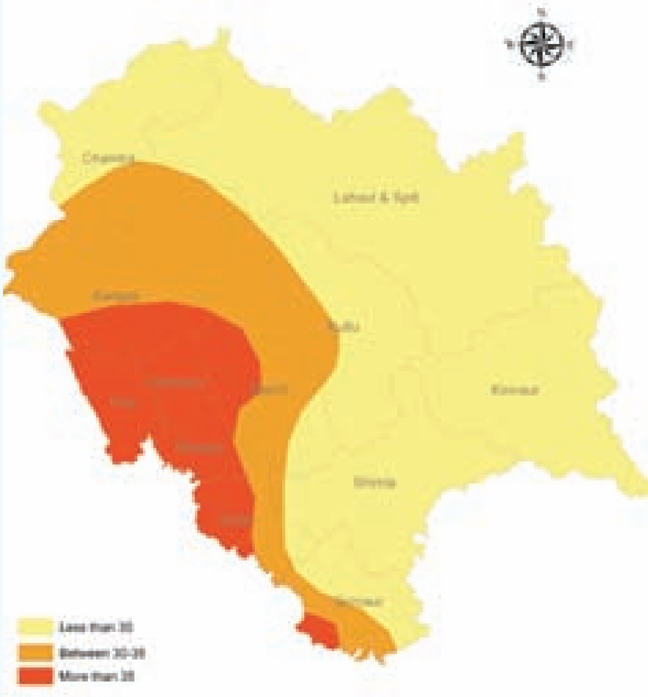


Fig. 28(ii) Mean Max. Temperature (°C) - June

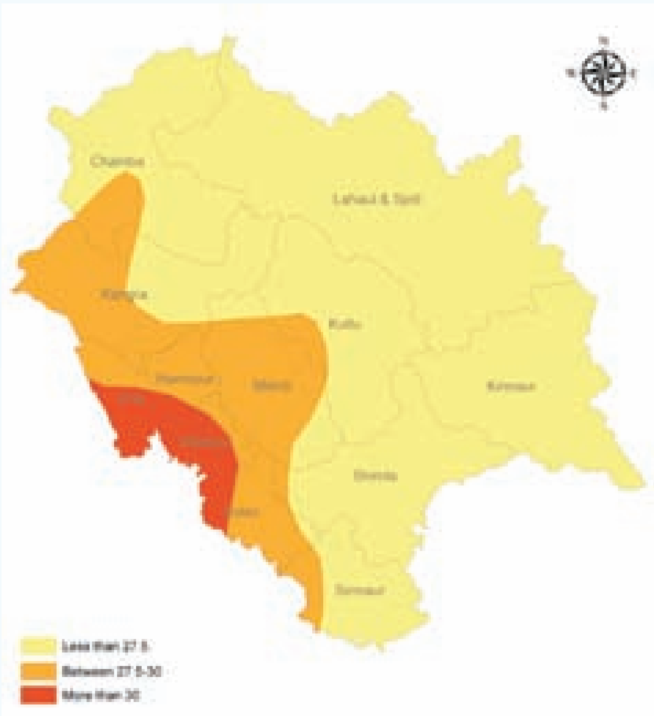


Fig. 28(iii) Mean Max. Temperature (°C) - October

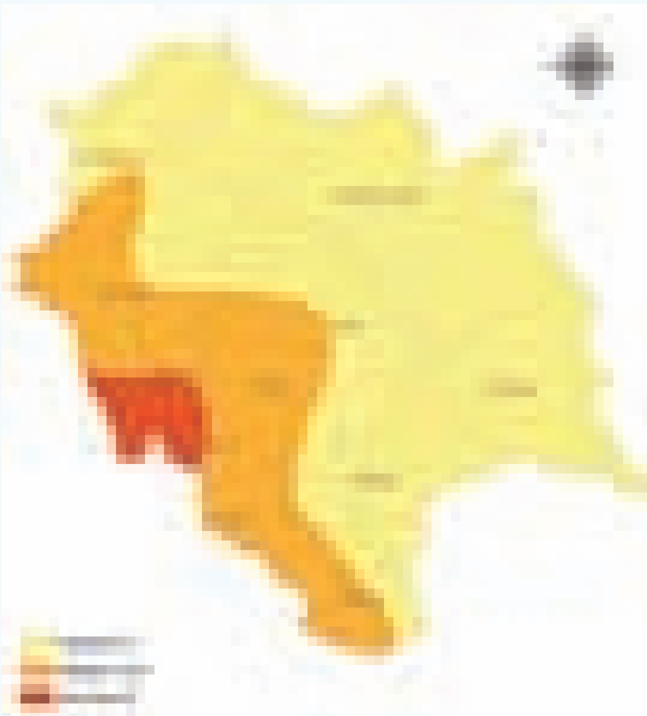


Fig. 28(iv) Mean Max. Temperature (°C) – January

3.3.3 Climate Scenarios

Third major publication of INCCA assessment is an attempt to use PRECIS (Providing Climate Investigation Studies) based on HadRM (Hadley Regional Climate Model) to generate climate change scenario for 2030s. This report provides an assessment of impact of climate change in 2030s on four key sectors of the Indian economy, viz. Agriculture, Water, Natural Ecosystems & Biodiversity and Health in four climate sensitive regions of India, viz. the Himalayan region, the Western Ghats, the Coastal Area and the North-East Region. At State level there are hardly any studies that have done a thorough analysis of the trends of climate change in Himachal Pradesh from where set conclusion can be drawn.

The climate change scenarios have been derived from a Regional climate change model PRECIS (a version of HadRM3 developed by the Hadley Centre, UK) with a resolution of 50km x 50km and forced by a Green House Gas (GHG) emission scenario emanating from A1B IPCC SRES (Special Report on Emission Scenario, IPCC, 2000). The year 2030 is the average of the period between 2021 to 2050. All the changes in this period are with respect to the average of the period 1961 to 1990, also referred to 1970s or the baseline.

3.3.3.1 Temperature

PRECIS simulations for the 2030s indicate an all-round warming over the Indian Subcontinent associated with increasing GHG concentrations. The annual mean surface air temperature is projected to rise by 1.7°C to 2.0°C in 2030s. Seasons may be warmer by around 2.0°C towards the end of 2030s. The variability of seasonal mean temperature may be more in winter months. On a regional scale, the variations in temperatures are described below [Figure: ES3 (a) for the observed mean temperatures in the 1970s and simulated by PRECIS for the same period]. Figure: ES3 (b) depicts changes in temperature in the 2030s.

Fig. ES3: (a) Mean Annual Surface Air Temperature Climatology simulated by three PRECIS runs compared with the observed climatology [upper left panel] for baseline period (1961-1990). (b) Projected changes in the Annual Surface Air Temperature in the 2030s w.r.t. 1970s.

As per PRECIS simulation the mean annual temperature of Himachal Pradesh is projected to increase from 0.9±0.6°C to 2.6±0.7°C in the 2030s. The net increase in temperature ranges from 1.7°C to 2.2°C with respect to the 1970s. Temperatures also show a rise in all seasons.

3.3.3.2 Precipitation

All the regions of Indian Subcontinent under consideration show a small increase in annual precipitation in 2030s with respect to the baseline, that is 1970s. Figure: ES4 (a) shows the summer monsoon rainfall climatology simulated by the three PRECIS simulations compared with the observed climatology (upper left panel) for the baseline period. Figure: ES4 (b) shows projected changes in summer monsoon precipitation in the 2030s with respect to the 1970s.

As per PRECIS simulation the annual rainfall in the Himachal region is likely to vary between 1268±225.2 and 1604±175.2 mm in 2030s. The projected precipitation is likely to increase by 5% to 13% in 2030s with respect to 1970s.

3.3.3.3 Extreme Temperatures

Further, analysis of the model indicates that both the daily extremes in surface air temperature, that is, daily maximum and daily minimum may intensify in 2030s. The spatial pattern of the change in the lowest daily minimum and highest maximum temperature suggests a warming of 1°C to 4°C towards the 2030s. The warming in night temperatures is more over the southern peninsular region and the Central and Northern India, whereas daytime warming is more in Central and Northern India.

As per PRECIS simulation in our region, minimum temperatures are projected to increase by 1°C to 4.5°C, and the maximum temperatures may increase by 0.5°C to 2.5°C.

3.3.3.4 Extreme Precipitation

Extreme precipitation can be defined in terms of number of rainy days if it exceeds the currently observed average number of rainy days in a year (exceeding 2.5mm) as well as the volume of rainfall in a day if it exceeds a particular threshold. Currently, the frequency of rainy days is more in East and North-Eastern India and less over Western India. Projections for the 2030s, however, indicate that the frequency of rainy days is likely to decrease in most parts of the country. Presently, the intensity of a rainy day is more along the western coast, especially in the Western Ghats, and North-East India. The intensity of rainy days increases in a more warming scenario.

As per PRECIS simulation the number of rainy days in our region may increase by 5–10 days on an average in the 2030s. The rainy days will increase by more than 15 days in the north-western part of the State. The intensity of rainfall is likely to increase by 1–2mm/day.

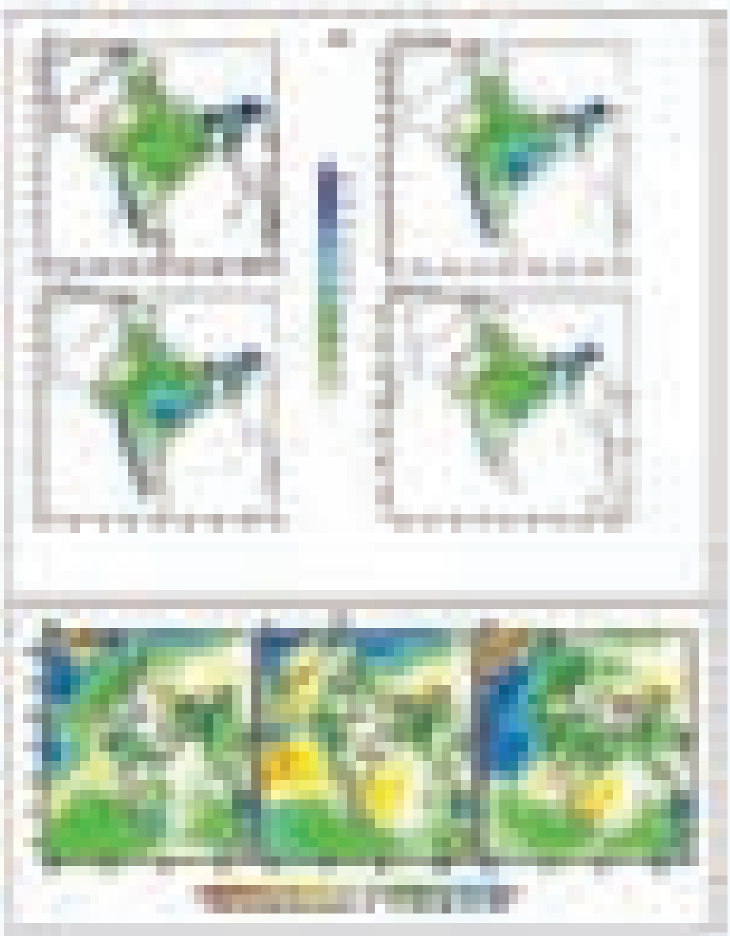


Fig. ES4: (a) Summer Monsoon Rainfall Climatology simulated by the three PRECIS simulations compared with the observed climatology [upper left panel] for the baseline period [1961-1990]. (b) Projected changes in summer monsoon precipitation in the 2030s w.r.t. 1970s.

3.4 Conclusions

Therefore, it is clear from PRECIS simulations that Himachal Pradesh is likely to experience the climate variations in following manner:

3.4.1 Temperature Variations

- The annual temperatures are set to rise.
- The rise in temperature with respect to1970s shows a range between 1.7°C to 2.2°C.
- Temperatures also show an increase in all seasons.

3.4.2 Rainfall Variations

- The mean annual rainfall likely to vary between 1268±225.2 and 1604±175.2 mm in Himachal Pradesh.
- The rate of increase is more in north western parts of the State i.e. areas of district Kangra, Chamba, Kullu, Una are likely to receive rainfall with increased intensity.
- The number of rainy days is projected to increase in Himachal Pradesh with decrease in average intensity.An increase in rainfall in the pre-monsoon and post monsoon months with increase in number of storms in Himachal Pradesh.

3.4.3 Extreme Events

- Change in rainfall patterns with increased variability in future will have some regions (south eastern parts) experiencing less rainfall. Drought like conditions may prevail in given projections.
- Projected increase in temperature, rainfall, rainfall variations, and intensities in the State may lead to accelerated summer flows leading to situations like floods/ flash floods in North-Western parts.

The changes in extreme events of rainfall and temperature will have direct or indirect bearings on different sectors of economy with changes in hydrological response of the basins including impacts on glaciers. The land use changes are expected with impact on development trends.

The following sectors will primarily be affected adversely in projected scenarios:

Directly- Agriculture, Water Resources, Biodiversity, Forests.
Indirectly- Livelihoods, Tourism, Hydropower, Health.

Climate Variable	Current Trend	Projected Trend	Impact	Uncertainty	Gap	Action Required
Temperature	Increase	Increase	Both Direct and Indirect (-ve & +ve)	High level of Confidence	Database	Research Adaptation Mitigation
Rainfall	Decrease	Slight Increase	Both Direct and Indirect (-ve & +ve)	High level of Confidence	Database	Research Adaptation
Frequency of Rainfall	Decrease	Increase	Direct (-ve & +ve)	Low level of Confidence	Database	Research Adaptation Mitigation
Intensity of Rainfall	Low	Decrease	Direct (-ve)	Low level of Confidence	Database	Adaptation Mitigation

The IPCC scenarios provide a mechanism to assess the potential impacts on climate change. Global emission scenarios were first developed by the IPCC in 1992 and were used in global general circulation models to provide estimates for the full suite of greenhouse gases and the potential impacts on climate change. Since then, there has been greater understanding of possible future greenhouse gas emissions and climate change as well as considerable improvements in the general circulation models. The IPCC, therefore, developed a new set of emissions scenarios, published in the IPCC Special Report on Emission Scenarios (IPCC SRES November 2000). These scenarios provided input into the Third and Fourth Assessment Reports and were the basis for evaluating climatic and environmental consequences of different levels of future greenhouse gas emissions and for assessing alternative mitigation and adaptation strategies. These scenarios refer to the predictions made for future conditions mainly related to precipitation, sea level rise and temperature changes based on 'story lines' of the alternate greenhouse gas emissions. There are four storylines (A1, A2, B1 and B2) identifying alternate states of future economic and technological development that takes place over the next few decades as summarized in following Table:

<table>
<tr><th colspan="2">IPCC SRES Scenarios</th></tr>
<tr><td>A1
World: Market Oriented
Economy: Rapid economic growth.
Population: Peaks in 2050 and then gradually declines.
Governance: A Convergent world-income and way of life coverage between regions. Extensive social and cultural interactions worldwide.
Technology: There are three subsets to the A1 Family
A1F1-fossil-fules intensive.
A1B: balanced on all energy sources.
A1T: non-fossil energy sources.</td><td>A2
World: Divided World
Economy: Regionally oriented, lowest per capita income.
Population: Continuously increasing population.
Governance: independently operating, self-reliant nations.
Technology: Slower and more fragmented.</td></tr>
<tr><td>B1
World: Convergent
Economy: Service and Information based, lower growth then A1.
Population: Same as A1.
Governance: Global solutions to economic, social and environmental stability.
Technology: Clean and resource efficient technologies.</td><td>B2
World: Local Solutions
Economy: Intermediate levels of economic development.
Population: Continuously increasing population, but at slower rate than in A2.
Governance: Local solutions to economic, social and environmental stability.
Technology: More rapid A2, less rapid more diverse A1/B1.</td></tr>
<tr><td colspan="2">Source: IPCC 4th Assessment Report (2007)</td></tr>
</table>

Climate models are mathematic models used to simulate the behaviour of climate system. They incorporate information regarding climate processes, current climate variability and the response of the climate to the human-induced drivers. These models range from simple one dimensional models to complex three dimensional coupled models. The latter, known as Global Circulation Models (GCM), incorporate oceanic and atmospheric physics and dynamics and represent the general circulation of the planetary atmosphere or ocean. The GCMs are usually run at very course grid (about 3^0 x 3^0) resolution whereas the processes that are of interest for studies such as this one, such as precipitation, are highly influenced by the local features namely orography and land use. These local characteristics are not properly represented at the coarse scale of GCM and contribute to prediction errors on the impact of climate change at the sub-grid scale. Therefore, these GCMs are strengthened with the incorporation of local factors and downscaled, in general with a grid resolution of about 0.5^0 x 0.5^0or less. The downscaling can be of dynamic or statistical type. These models are referred to as Regional Climate Models (RCM) and improve the quality of climatic prediction for specific local areas.

A RCM is a model of the atmosphere and land surface which has high horizontal resolution and consequently covers a limited area of the earth's surface. A RCM cannot exist without a 'parent' GCM to provide the necessary inputs. The RCMs provide an opportunity to dynamically downscale global model simulations to superimpose the regional detail of specified region. RCM provide climate information with useful local detail including realistic extreme events and also they simulate current climate more realistically.

A Regional Climate Model:

- *Is comprehensive physical high resolution (~50km) climate model.*
- *Covers a limited area of the globe*
- *Includes the atmosphere and land surface components of the climate system*
- *Contains representations of the key processes within the climate system (e.g., cloud, radiation, rainfall, soil hydrology)*

Advantages of Regional Climate Models include

- *highly resolved information*
- *physically based character*
- *many variables*
- *better representation of the mesocale and weather extremes than in GCMs.*

Disadvantages of Regional Climate Models include

- *computational expensiveness, particularly for long runs*
- *lack of two way nesting (feedback with the forcing GCM input)*
- *dependence on usually biased inputs from the forcing GCM*
- *errors in the GCM fields that could result in errors in the regional climate scenarios*
- *availability of fewer scenarios.*

Providing Regional Climates for Impact Studies (PRECIS) is an atmospheric and land surface model of limited area and high resolution which is locatable over any part of the globe. Dynamical flow, the atmospheric sulphur cycle, clouds and precipitation, radiative processes, the land surface and the deep soil are all described and lateral boundary conditions (LBCs) are required at the limits of the model's domain. Information from every aspect may be diagnosed from within the model (Noguer et al., 1998). PRECIS can be applied easily to any area of the globe to generate detailed climate change predictions and is used for vulnerability and adaptation studies and climate research.

Regional Climate Scenarios for India Using PRECIS

PRECIS is the Hadley Centre portable regional climate model, developed to run on a PC with a grid resolution of 0.44° x 0.44°. High-resolution limited area model is driven at its lateral and sea-surface boundaries by output from global coupled atmosphere-ocean (HadCM3) and global atmospheric (HadAM3) general circulation models. PRECIS captures important regional information on summer monsoon rainfall missing in its parent GCM simulations.

Noguer M, Jones R, Murphy J (1998) Sources of systematic errors in the climatology of a regional climate model over Europe. Clim Dyn 14:691–712

PRECIS A1B, which is a mid path scenario, 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 the development balanced across energy sources

Indian RCM PRECIS has been configured for a domain extending from about 1.5°N to 38°N and 56°E to 103°E. IPCC SRES A1B Scenario10– Q14 Qump (Quantifying Uncertainty in Model Predictions) for the time slices of present (1961–1990), mid century (2021-2050) and end century (2071–2100) has been made available by IITM Pune.

Simulations from a seventeen-member perturbed physics ensemble (PPE) produced using HadCM3 under the Quantifying Uncertainty in Model Predictions (QUMP) project of Hadley Centre Met Office, UK have been used as LBCs for 138 year simulations of the regional climate model PRECIS. The QUMP simulations comprise 17 versions of the fully coupled version of HadCM3, one with the standard parameter setting and 16 versions in which 29 of the atmosphere component parameters are simultaneously perturbed (Collins et al., 2006).

3.5 Impacts on Key Sectors in Himachal Pradesh & Projections

As explained above in detail on the basis of the analysis of available data base it is quite clear that in the State climate variables are showing changes in trends:

- Change in trend of rainfall.
- Change in trend of snowfall.
- Change (shift) in cropping pattern and vegetation species.
- Change (shift) in apple contour.

These trends which have been established on scientific data base are also supported by concerns expressed by local stakeholders such as:

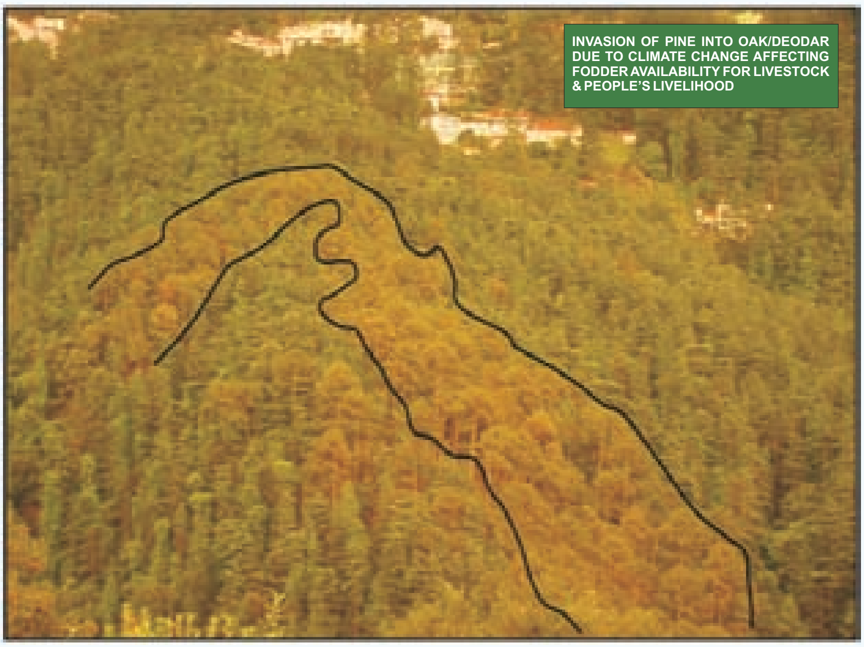
- Some of common birds, butterflies and insects have disappeared.
- Vegetation species and crops have changed and become extinct.
- Decline in normal winter precipitation.
- Natural water sources have started drying up.
- Increase in incidences of diseases, pests etc.
- Change in setting of seasons.

As per the projections explained above Himachal Pradesh is highly vulnerable to climate change. Himachal Pradesh has a high reliance on agriculture which has a direct bearing from climate variations. Climate change also poses additional challenges as higher temperatures increase the need for water, irrigation and the risk of warm stress on crops. Changing weather patterns and rising temperatures will leave the farmers of the State vulnerable to crop losses on one hand and excessive precipitation also destroy the crops on other hand. Climate change will also negatively affect the water resources with increased water scarcity in hill stations. The increase in water demands will increase the vulnerability in the State. The sector wise analysis of projections is as under:

3.5.1 Agriculture: With increasing temperatures, it is anticipated that there may be an all-round decrease in horticultural- agricultural production in the region in long-term, and the line of production may shift to higher altitudes. Apple production in the Himachal Pradesh region has decreased between 1982 and 2005 as the increase in maximum temperature has led to a reduction in total chilling hours in the region-a decline of more than 9.1 units per year in last 23 years has taken place (Fig. 29). Temperature Humidity Index (THI) is projected to rise in many parts of State during March–September with a maximum rise during April–July in 2030s with respect to 1970s will lead to discomfort of the livestock productivity and therefore will have negative impact on livestock productivity.

Fig. 29: Trend of Apple Production in Himachal Pradesh between 1980 and 2005.

3.5.2 Forests, Natural Eco-systems & Biodiversity: It has been projected that the forest vegetation type of the four eco-sensitive regions are vulnerable to projected climate change in the short term, that is, in 2030s, even under a moderate climate change scenario (A1B). The impacts vary from region to region. For Himachal Pradesh, of the 98 IBIS grids covering this region, 56% of the grids are projected to undergo change in 2030s shows a high degree of vulnerability of forests in the State. The dense forest line is expected to undergo more changes. The Net Primary Productivity (NPP) is projected to increase in the region by about 57% on an average by 2030s.



3.5.3 Water: The water resources in this analysis have been assessed in terms of water yield in the various river basins that are part of our region. The water yield is the total surface runoff, which is usually a function of precipitation, its distribution, evapo-transpiration (ET) and soil characteristics. As per PRICIS region-specific projections for 2030s, the water yield in Himachal Pradesh, mainly covered by major rivers, is likely to increase by 5%–20% in most of the areas, with some areas showing an increase of up to 50% with respect to 1970s. The impact of increase in precipitation in this region has been reflected in an almost similar pattern of increase in the ET. Increase in the water yield is more for those areas that have experienced a low increase in ET.

3.5.4 Health: A qualitative assessment of PRESIS indicates that morbidity and mortality of the population in the regions under focus are likely to increase with warming temperatures and variable precipitation as they have direct as well as indirect effects. Direct effects can manifest as heat stress and indirect effects can be in terms of vector borne diseases, water borne diseases and malnutrition etc. A quantitative assessment has been carried out for determining the transmission of malaria in 2030s. The transmission windows have been determined in terms of (a) temperature as well as (b) temperature and relative humidity requirements for transmission. It has been concluded that the projections based on Temperature (T) and Relative Humidity (RH) do not match with the observations made in the Himalayan region, and other regions, thereby indicating that even if the required humidity is not existing in the atmosphere, the mosquito vectors seek micro niche for their resting to get the required RH for survival. In Himachal Pradesh which is nestled in the North-Western Himalayas, projections of malaria transmission windows for 2030s, based on temperature, reveal introduction of new foci and an increase in opening of more transmission months in different districts of the State.

3.5.5 Frequency of Droughts: The percentage change in the spatial distribution of Soil Moisture Deficit Index (SMDI) between 1970s and 2030s has been used for defining the Drought Index. The weeks when the soil moisture deficit may start, drought development (Drought Index value between 0 and -1) as well as the areas which may fall under moderate to extreme drought conditions (Drought

Index value between -1 and -4) has been assessed. There is an increase in the drought like situations for those areas of various regions that have either projected decrease in precipitation or have enhanced level of evapo-transpiration in the 2030s. Similarly, the weeks belonging to moderate soil moisture stress, show an increase in severity of drought from baseline to the mid-century scenario, which is self-evident. It is very evident from the depiction that the moderate to extreme drought severity has been pronounced for the State, where the increase is more than 20% in many areas despite the overall increase in precipitation.

3.5.6 Floods: Possible floods have been projected using the daily out flow discharge in each sub-basin as generated by the SWAT model, ascertaining the change in magnitude of flood peaks above 99^{th} percentile flow in 1970s and in 2030s. The change in peak discharge equal to or exceeding at 1% frequency in 1970s and 2030s for various regions indicates that the flooding would vary from 10% to over 30% of the existing magnitudes in most of the regions. This has a very severe implication for existing infrastructure such as dams, bridges, roads, etc., in the areas and will require appropriate adaptation measures to be taken up.

From the analysis one can say that impact on agriculture-horticulture production will be visible in the form of change in cropping pattern and the crop productivity can be projected to decrease even at 1-2^0C rise in temperature. Whereas Himachal Pradesh is likely to experience 1.7°C to 2.2°C warming:

- Northern parts of the State at higher altitudes can witness most shifts.
- Agriculture may benefit from the increase length of growing period initially but would get adversely affected later on.
- Apple production may be affected with shift in the long term.
- Some regions may experience large reduction in yields (up to 50% by 2020).

Impact of climate change on water resources will definitely be manifested in the State, further; water stress will increase with changes in rainfall patterns and the fast melting of Himalayan glaciers.

- The rainfall is projected to increase during June to September.
- Increased occurrence of floods and increased flow in rivers and dams, increased instances of soil erosion and silt load.
- Increase in water stress for rain-fed crops due to warming (1.7°C to 2.2°C)
- Glaciers retreat may affect the discharge dependability of all rivers.

Impacts of Climate Change on the forests of State are highly uneven due to climate variance:

- The forests of the State are highly vulnerable especially the high altitude dense forests.
- Forest types shifts may occur in >80% of forested grids (2080 scenarios).
- The occurrence of forest fire may increase.
- The forest productivity may increase initially but there would certainly be long term adverse impacts.

Therefore, the water crisis, droughts and floods, agriculture-horticulture security issues, agriculture, land fertility, health impacts especially vector borne diseases, vulnerable forests, deforestation and loss of biodiversity, pollution of air, water and soil will have the most impact on the State and so on the poor and vulnerable groups and sections of the society. There is a need for further analysis, capacity enhancement to cope up with the likely climate change impacts in Himachal Pradesh and need for adaptation and mitigation measures. The assessment of vulnerable groups can only be seen as composite of the regional and local vulnerability w.r.t. climatic variables. Through this report the vulnerability assessment has been carried out at Block level so as to ascertain the exposure, sensitivity of the regions.

Forests in Himachal Pradesh are an important ecological and natural resource and have been aptly termed as "Green Pearl" in the Himalaya. About 26% of the State's geographical area is the repository of 3,295 species out of which 95% are endemic to the state and 5% (150) species are exotic, most of the people in rural areas in the State depend directly or indirectly on forests for their livelihood and use significant quantity of forest goods and services like non-wood forest products, eco-tourism, fodder, timber etc.

Avalanche

Assessment of Climate Change Vulnerability: Himachal Pradesh 4

Himachal Pradesh has a large repository of natural resources. It is the most important source of clean water for the people of Northern India. Snow and glacier melt during the summer season provide large inflows to five major river basins and their tributaries the crucial source of water supply for the people inhabiting in these basins. The availability of abundant water resources, fertile soil and suitable climate has led to the development of a highly agricultural based society in this region. In view of significance of agricultural sector and water resources for the State, its sensitivity to the vagaries climate change makes it imperative for the planners and scientists to strategize as in case of any changes in the pattern of climate in the form of shift in the time period, frequency or magnitude, there can be substantial impacts on the overall economy of the State.

Himachal Pradesh faces a number of non-climatic and climatic stressors due to several reasons including the rapid growth in industrialization, hydro-power development, increasing tourism based activities etc. There has been substantial deforestation and change in the land use. The increasing population of various towns has put a stress on water resources besides on its quality. Inadequate infrastructure such as sewage treatment plants, municipal solid waste management sites is adding to the stress in many ways. Impounding and diversion of water systems for development of hydropower is resulting in long term impacts on the ecosystems.

The widespread range of climatological and geographical features makes the State more unique. Therefore, any small alteration in the natural resources of the State has its implication on the society and the ecosystem as a whole.

Climate change projection scenarios suggest an increase in temperature, changing precipitation trends resulting in increased river water flows in the short term due to fast melting of snow and glaciers followed by substantial decrease in river flows in the long run.

From the above discussions, it is imperative to understand the current levels of risks from climate variability and changes, sensitiveness of resources and existing capacity so as to ensure compatible solutions for mitigating the likely impacts. Frameworks containing various indicators have been used to measure the vulnerability broadly based on its definition which takes it as a function of three broad factors viz. exposure, sensitivity and adaptive capacity. The current assessment at the Block* level is mainly on the secondary information in the form of reliable database gathered from different Government departments/sources.

** The selection of Block as unit for micro level assessment has been driven from the availability of required data base at different levels. Otherwise also the geographical distribution facilitated the selection of the Block as a unit for assessment.*

4.1 Climate Change Vulnerability- Literature Review

Various factors show that Himachal Pradesh possesses a high degree of vulnerability to climatic variations, which will affect millions of poor rural people. The majority of the estimated 69% poor rural people in region are subsistence farmers tilling mainly the rain-fed lands. Impacts of such disasters range from hunger and susceptibility to disease, to loss of income and human livelihoods. Climate change in fact is emerging as the pre-eminent development issue in the entire Indian Himalayan region. Some of the identified key aspects of Himachal Pradesh have been elaborated using parameters such as adaptive capacity, exposure and sensitivity that contribute to its net vulnerability to climate change in the State.

From global level assessments of vulnerability on the basis of database for the period 1960-1990 carried out by *K. O'Brien et al. / Global Environmental Change 14 (2004) 303–313* following spatial representations of adaptive capacity, sensitivity and exposure have been observed.

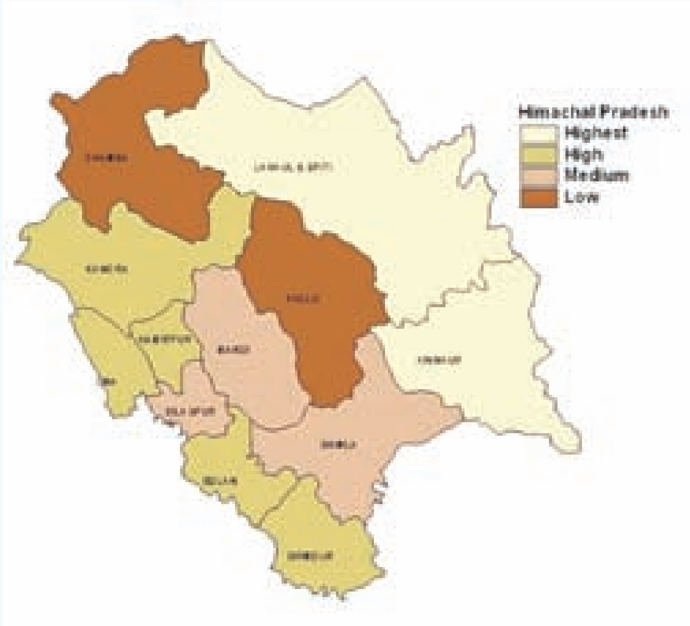


Fig. 30: District-level Mapping of Adaptive Capacity at Global Level in Himachal Pradesh

District-level mapping of adaptive capacity of Himachal Pradesh at global level measured as a composite of biophysical, social, and technological indicators (1960-1990) shows lowest adaptive capacity for Chamba and Kullu whereas higher adaptive capacity of Kangra, Hamirpur, Una, Solan and Sirmour districts(Fig.30).

Fig. 31: District-level Mapping of Climate Sensitivity Index (CSI)

District-level mapping of Climate Sensitivity Index (CSI) for India based on observed climate data (1961–1990) and based on results from the HadRM2 model is shown in the Fig. 32 and as per estimate, sensitivity is lowest for Lahaul & Spiti and low in Chamba, Shimla, Kullu and Kinnaur regions(Fig.31).

Districts in the country that rank highest under climate change vulnerability and globalization vulnerability are considered to be double exposed (depicted with hatching). It is clarified that doubly exposed districts as shown in the map depicts that districts with high Climate Change Vulnerability may not necessarily be highly vulnerable to globalization.

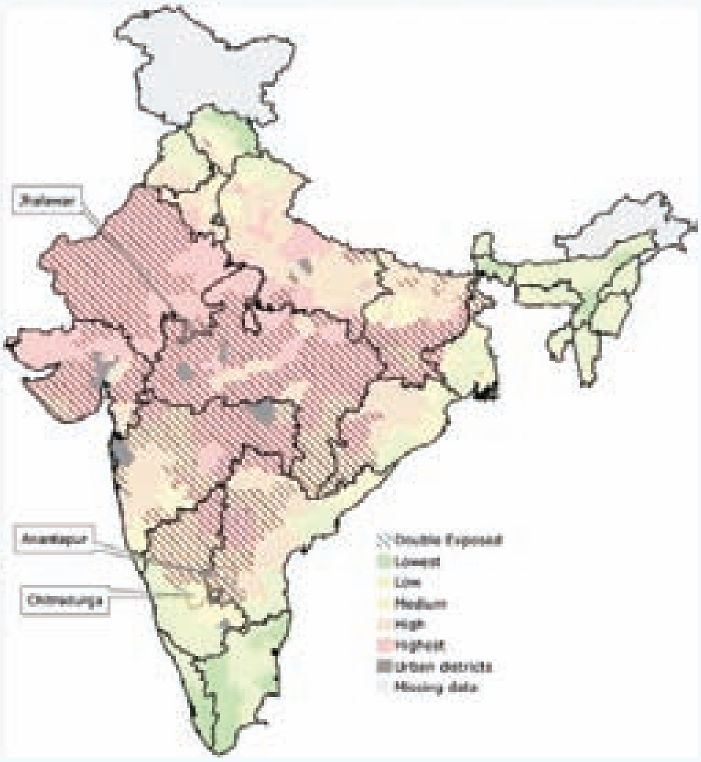


Fig. 32: District-level Mapping of Climate Sensitivity Index (CSI) for India

The districts Una, Hamirpur, Solan, Bilaspur, Sirmour have been categorized as highly exposed and vulnerable towards climate change, whereas, Kullu and Shimla have medium level of vulnerability (based on 1960-1990 data base at Global level) (Fig. 33).

The Climate Change Vulnerability has been measured as a composite of adaptive capacity and climate sensitivity under exposure to climate change. District-level mapping of globalization vulnerability is measured as a composite of adaptive capacity and trade sensitivity (for a representative basket of import-sensitive crops). Hamirpur district has been categorized as highly vulnerable with Kangra and Kullu districts at high and Solan, Mandi and Shimla districts with medium level of vulnerability (Fig. 34).

Fig. 33: District-level Mapping of Climate Change Vulnerability (Exposure)

Fig. 34: District-level Mapping of Globalization Vulnerability

The results presented in this document demonstrate a method for mapping vulnerability that can be used to assess climate impacts in the context of a range of societal changes. As such, it is important to look into and recognize both the limitations and strengths of the analytical method. As far as the limitation of this method is concerned, one limitation of the macro-profiles is that mapping vulnerability at the district level may lead to a false sense of precision. Abrupt differences in vulnerability across district boundaries might be more realistically represented as fuzzy transitions. Similarly, differences between farmers and between villages within districts are not captured in the vulnerability maps, although these differences have been tried to be looked at during the assessment of data base. The second limitation of this approach is that the uncertainties associated with regionally downscaled climate scenarios (or scenarios of trade liberalization) are not explicitly represented in the maps. Incorporation of the uncertainties associated with different climate scenarios might be addressed through application of a range of different regionally downscaled models. The third limitation of the approach concerns the time scale of the analysis, and especially the fact that our assessment does not capture changes in adaptive capacity over time, but instead holds the adaptive capacity constant to levels in a particular year. To capture potential changes over time, the adaptive capacity indicators can further be analyzed using alternative scenarios of future social and economic conditions.

4.2 Climate Change Vulnerability- Current & Future Projections

The State with its economy closely tied to its natural-resource-base and climate-sensitive sectors such as agriculture, water, and forests, today faces a major threat because of the projected changes in climate. Crucial sectors in Himachal Pradesh like agriculture-horticulture, water resources, forests, hydro power generation, health, urban waste management & sanitation, and rural development are likely to be affected by climate change. Further, a large population of the State mainly depends on climate-sensitive sectors like agriculture-horticulture and forests for their livelihood needs. Any change in these sectors due to climate change will not only going to affect the livelihood prospects in the agrarian economy of the mountain region, but also impact people living in the plains.

It is very important to understand as how and which region is exposed towards climate change, what is the level of sensitivity of these region, and what is the level of adaptive capacity to absorb the projected and existing climate change trends. Undoubtedly, the data base is a big constraint to carry out such an assessment comprehensively at micro level but still whatever and wherever possible the data has been gathered and collated to demonstrate the current levels of climate change vulnerability of different districts at the Block level.

Vulnerability Assessment (VA) provides two important contributions:

- Identify which system/region/sector/indicators are currently getting affected or are likely to get affected in the future.
- Understanding why/how various sectors are likely to be vulnerable- whether directly or indirectly, when interaction between shifts/change and existing stressors is projected.

The idea of this assessment is to prepare an indicative index to map the vulnerability among the various areas, blocks and districts of the State and rank these districts in terms of vulnerability so as to facilitate the process for actions; such as identifying and fixing priority for the vulnerable areas, components, identification of adaptation interventions and mainstreaming adaptation in policy and planning processes. Thus, **Vulnerability Assessment (VA)** is a key tool for informing adaptation planning and enabling resource managers to make such decisions. A framework has been developed for undertaking exercise to estimate the extent of vulnerability through the index based approach.

4.2.1 Methodology Adopted for Vulnerability Assessment

According to IPCC 'Vulnerability' is a function of character, magnitude and rate of variation of system, climate to which a system is exposed, its sensitivity, and it's adaptive capacity. It has also been indicated that the assessment of vulnerability could also be drawn on a wide range of physical, biological and social science disciplines, and consequently employed variety of methods and tools (*Sumana Bhattacharya et. al., 2003)*.

It is widely acceptable in terms of climate change that:

Sensitivity- refers to innate characteristics of a system, sector and considers tolerance to changes which temperature, rain fall, fires etc. alters.

Exposure- refers to extrinsic factors, focusing on the character, magnitude, and rate of change the system, sector likely to experience.

Adaptive Capacity- addresses the ability of a system, sector to accommodate with impacts with minimum disturbance.

In other terms we can say that:

Exposure

- Historic v/s future projected estimated changes.
- Basic climate, draught, hydrologic changes, changes in fire regimes, changes in CO_2 concentrations, changes in vegetation, changes in storm/event frequency and intensity.

Sensitivity

- Hydrology related, fire hazard related, wind.
- Physiological factors, dependence on sensitive habitats, ecological linkages, phenological changes, population growth rates.
- Degree of specialization, reproductive strategy, interaction with other stressors, sensitivity of component species, community structure.
- Sensitivity of component species, sensitivity of ecosystem processes to temperature or precipitation.

Adaptive Capacity

- Ability for a sector to attend change or behavior to synchronize with changing environmental conditions.
- Dispersal abilities, evolutionary potential, permeability of land use, landscape,
- Redundancy and response diversity within functional groups.

IPCC Indicators for Assessment of Vulnerability Sensitivity or Adaptive Capacity Category Proxy Variables:

Sensitivity or Adaptive Capacity Category	Proxy Variables
Settlement/ Infrastructure Sensitivity	Population at flood risk from SLR, Population without access to clean water and sanitation
Food Security	Cereals production/area, Animal protein consumption per capita
Ecosystem Sensitivity	% Land Managed, Fertilizer use
Human Health Sensitivity	Completed fertility, Life expectancy
Water Resource Sensitivity	Renewable supply and inflow, Water use
Economic Capacity	GDP (market)/ capita, Gini Index
Human and Civic Resources	Dependency Ratio, Literacy
Environmental Capacity	Population Density, SO_2/ Area and % Land Managed
	Source: IPCC, 2001

In the current analysis, the proxy variables used to determine exposure, sensitivity and adaptive capacity for the State in different districts at Block level is as per Table-19.

Table-19: Proxy Variables used at Block Level

Component	Indicator	Proxy Variable	Source
Exposure	Temperature	Annual Mean Max. Temperature(°C)	*IMD Pune*
		Annual Mean Min. Temperature (°C)	
	Rainfall	Annual Mean Rainfall (mm)	
Sensitivity	Agriculture	Agriculture Population (%)	*Government of HP, Deptts. of Economics & Statistics, Agriculture, Public Works, Forests, I,P&H, and Census.*
		Rainfed Farming (%)	
	Agro-climate Zone	Altitude (Mean) (mts).	
	Water Resources	Irrigated Area (%)	
	Health	Birth rate, Family Size (%)	
	Forests	Forest Cover (%)	
		Biodiversity richness (%)	
Adaptive Capacity	Economic Capacity	Poverty Rate (%)	
	Education	Literacy Rate (%)	
	Environmental Capacity	Population Density (persons/ sq. km.)	
	Physical Capacity	Road Network (%)	

Therefore, the basic approach for the micro level vulnerability assessment is broadly based on three components such as exposure, sensitivity and adaptive capacity with 1-2 proxy variable/indicators covering diverse dimensions of climate, population, ecosystem and socio economic conditions. The method for assessing vulnerability has been opted after reviewing varied methodologies.

Broadly, the process adopted has three major steps moving from variables to indicators and then to components and finally to the Vulnerability Index.

- Selection of possible scale, variables, indicators and components for the analysis.
- Grouping of variables in terms of indicators and components for calculations
- Normalization of data by equal weightage system.
- Combining of values under each component.
- Identify variables as how systems are already impacted.
- Deriving Vulnerability Index (Exposure- Adaptive Capacity) x Sensitivity.
- Scaling the values from 0 to 1 to indicate low to high vulnerability.

The steps can be broadly summarized as follows:

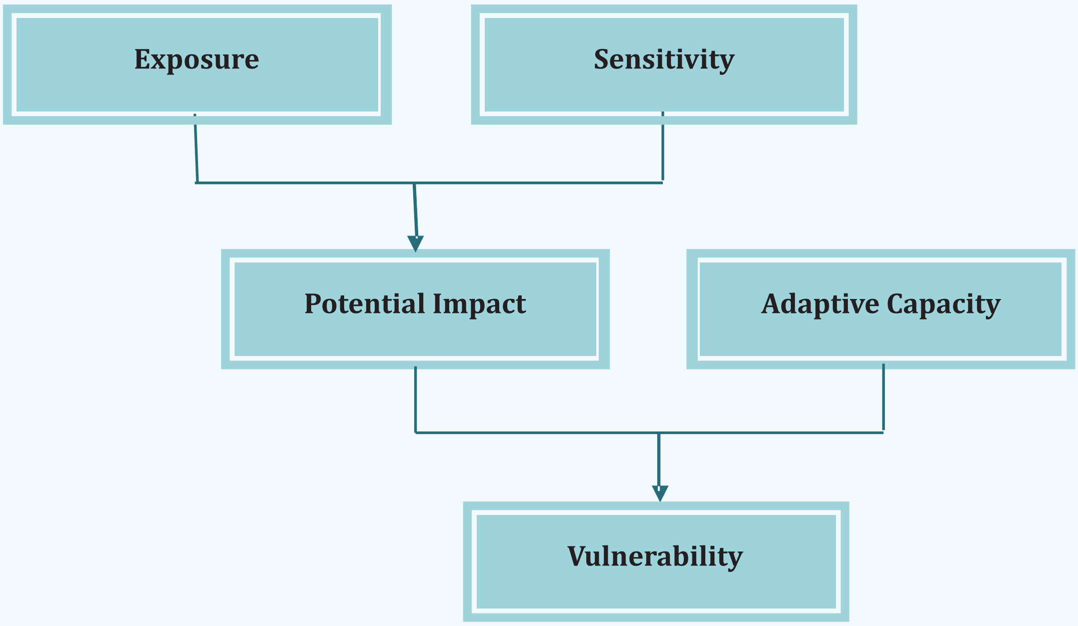
Step I Variables- Indicators

- Proxy variables/indicators are selected and quantified.
- Standardization of values; the variables value for an indicator are standardized so that the mean=0 and range=1. The proxy variable Vn have been estimated using the following equation

$$V_n = (V-V_{min})/ V_{max}-V_{min})$$

Where, Vn is the actual value of n^{th} variable, within an indicator each variable will have equal weightage between 0-1.

Vulnerability Assessment



Step II Indicator- Components

- The indicators for a component are normalized so that the mean=0 and range=1. The indicator I_n have been estimated using the following equation

  $I_n = (I-I_{min}) / I_{max}-I_{min})$

- The indicator value for each component C_b is taken by taking the average of all the indicators Average (I_n).

Step III Component- Vulnerability

- The climate related vulnerability index VI has been calculated as:

  $$V_I = (C_{b(Exposure)} - C_{b(Adaptive\ Capacity)}) \times C_{b(Sensitivity)}$$

- V_I is thereafter again normalized so that the mean=0 and range=1.

The Vulnerability Index for a particular indicator is typically based on a number of variables which are likely to determine the relative vulnerability of that indicator towards climate change scenarios.

4.2.2 Spatial Patterns of Vulnerability

The output of Vulnerability Assessment along with census data has been integrated on a Geographic Information System (GIS) platform using open source GIS software's (Quantum GIS and Map Window) for integration of the various layers on a GIS platform.

As has been explained above that the State has been distributed in four different agro climatic zones viz sub mountain, low hill, sub tropical, mid hill sub humid, high hill temperate wet and high hill temperate dry. For better comprehension it is essential to understand the distribution district wise. Following table gives an understanding to various areas falling under different zones, which are explained ahead with climate variables in terms of exposure, sensitivity and adaptive capacity:

Agro Climate Zone wise description of Different Districts

Agro Climatic Zone	Elevation (mtrs.msl)	Districts/ area
Sub mountain, Low Hill, Sub Tropical	350 to 650 meters 35% of the geographical area and about 40% of the cultivated area	Hamirpur, Una, Bilaspur, Parts of Sirmour, Kangra, Solan and Chamba
Mid Hill Sub Humid	651 meters to 1,800 meters 32% of the total geographical area and about 37% of the cultivated area	Parts of Mandi, Solan, Kullu, Chamba, Bilaspur, Sirmour Palampur & Kangra tehsils of Kangra Rampur tehsil of Shimla
High Hill Temperate Wet	1,801 to 2,200 meters about 35% of the geographical areas and about 21% of the cultivated area	Shimla, Kullu, Chamba Parts of Mandi, Kangra, Chamba
High Hill Temperate Dry	Above 2,200 meters 8% of the geographical and 2% of the total cultivated area	Kinnaur, Lahul & Spiti Parts of Chamba District

4.2.2.1 Exposure

The long term meteorological data base on various parameters is available from IMD. The exposure is determined in terms of climatic variables such as annual mean temperatures, annual mean rainfall pattern and no of extreme events, rainy days etc. Himachal Pradesh is exposed to a range of climate conditions and extreme events. In particular, some of the key features of the region's climate are the influences of monsoons, the El Niño-Southern Oscillation, and cyclones on the rainfall in the State. Most part of the State is adapted to, and thus reliant upon, the annual monsoon occurrence, which makes it vulnerable if the monsoon fails and rainfall is significantly limited/less. Meanwhile, variability associated with the El Niño-Southern Oscillation, and particularly El Niño events, contributes to cyclic droughts. Besides, much of area gets affected by tropical disturbances and their associated high winds, snow, hail storms, and extreme rainfall. These climate challenges are the permanent features of the Himachal Himalayan region, but that may be significantly altered by anthropogenic climate change in the decades ahead as well.

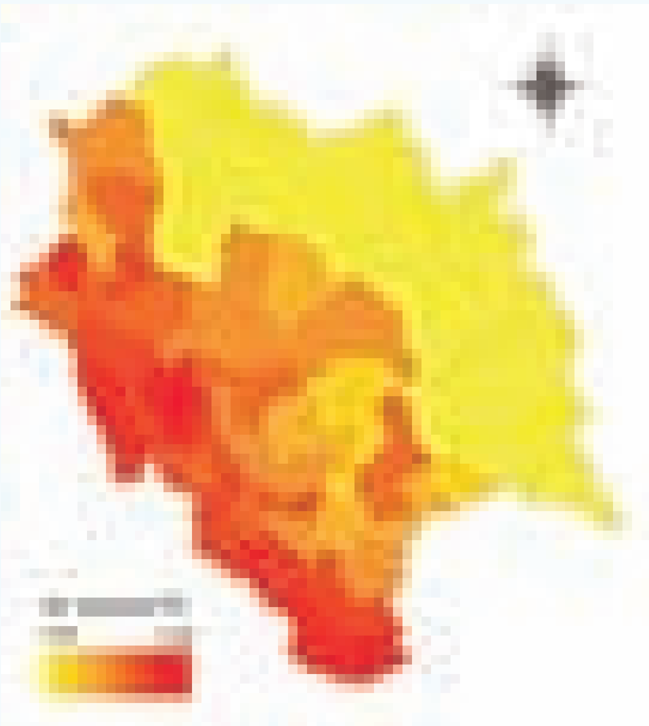


Fig.35(i): Annual Mean Min. Temperature at Block Level

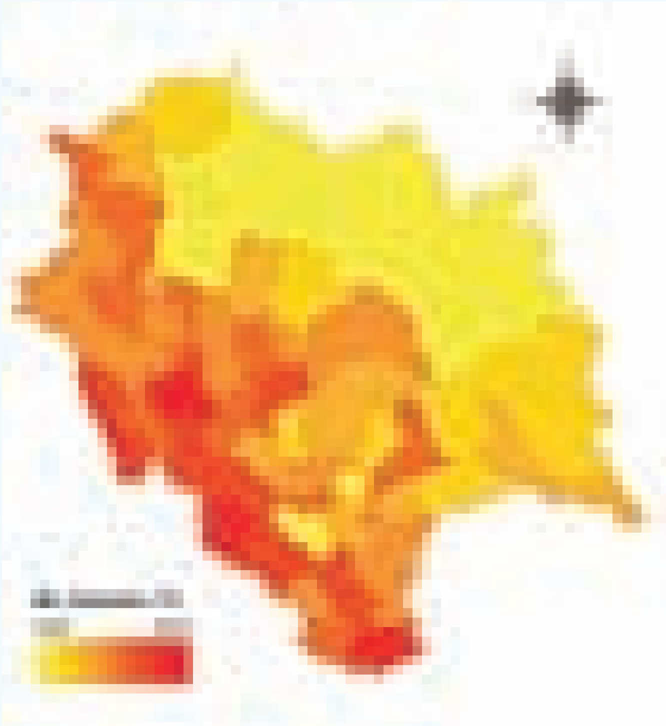


Fig. 35(ii): Annual Mean Max. Temperature at Block Level

Fig.36: Annual Mean Rainfall at Block Level

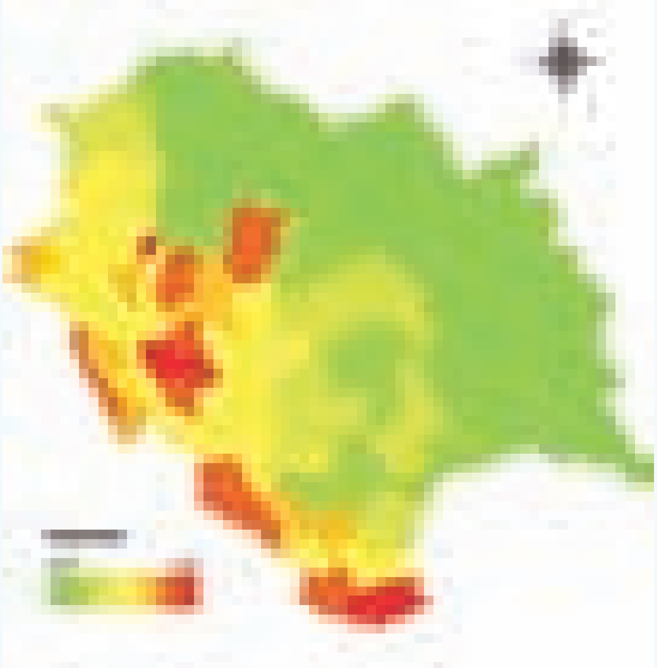


Fig. 37: Climate Change Exposure at Block Level

Temperature is a critical parameter of climate which strongly influences people, biodiversity and ecosystems, important driver of natural and man managed systems. As per the analysis, in the last few decades, the average temperatures have been found to vary from normal ranges for Himachal Pradesh and yearly variations in average temperature are indicative of this trend. Variability, leading to higher temperatures shows higher exposure level of the different Blocks in different districts Fig. 35(i-ii).

Precipitation is an important component of the water balance and ecosystem. Normally, rainfall patterns are dependent on a range of factors such as topography, local climate and wind patterns. In Himachal Pradesh, as per analysis of the long term database it is observed that during the past century, some areas have experienced an average rainfall, some areas have experienced increase in the rainfall and few areas have faced reduction with variation in frequency and intensity Fig. 36. A change in the timing of run-off impacts the water availability, which will resultantly impact progress in developing areas, crops, agriculture, livelihoods and eventually the entire economy. Average rainfall and change in pattern in different region shows higher level of exposure to climate change.

The analysis of results reveals that the low lying areas of Himachal Pradesh are highly exposed to climate change. The areas falling in Hamirpur, Sirmour, Solan and Una districts are highly exposed whereas, Kangra, Chamba and Mandi districts are also exposed but comparatively less than the above districts. Likewise areas falling in and Shimla and Kullu districts are also moderately exposed to climate change Fig. 37.

4.2.2.2 Sensitivity

Ecosystem balance profile leads to overall measurement of sensitivity of the region. The sensitivity component here includes four indictors such as Agriculture-livelihoods, Water resources, Forests and Health with 1-2 proxy variables of each indicator. Besides being exposed to a variety of climate hazards, the vulnerability of Himachal Pradesh in the Himalayan region also gets affected by the sensitivity of different neighboring States and sectors to these hazards when they occur. For example, with much of their subsistence and economic growth dependent upon agriculture, the potential for widespread adverse impacts is enhanced in these areas. Likewise, the existing water resources are limited in many areas under development, as is subsequently, access to safe drinking water, sanitation, and irrigation. In case of drought or flood, the ability to safely and efficiently manage water storage, diversion, and delivery would be easily compromised. Settlements and infrastructure in Himachal Pradesh tend to be more susceptible to the effects of climate extremes and are more likely to be damaged. The analysis shows that low-lying river bed areas, including hydro power projects, are more sensitive to the effects of water level rise and flood like situations and thus have potentially more to lose from climate change than the other regions. Statistics indicate that extreme events in the region are associated with significant financial losses as well as the loss of lives, and as explained above such disasters in the region has increased in recent decades/years.

There are few regions where forest cover has decreased and less forest cover would thus be more sensitive and vulnerable to climate change if the same trend continues. Land use change has a direct linkage with climate change. The deforestation, habitat fragmentation, urban expansion and other developmental modifications have significantly changed the land use patterns. Extensive land use changes have an impact on livelihoods of people and ecosystems. The areas where agriculture workers are more would be more sensitive to climate change. Clearing of vegetation leads to degradation of area and enhances the sensitivity towards climate variability; resultantly the biodiversity gets impacted adversely. Further, an increase in gross sown area will raise the sensitivity levels of the different areas of various districts. Higher family size or the birth rate would increase the sensitivity since there will be competition for scarce resources. The analysis depicts different levels of sensitivity with different trends of indicators.

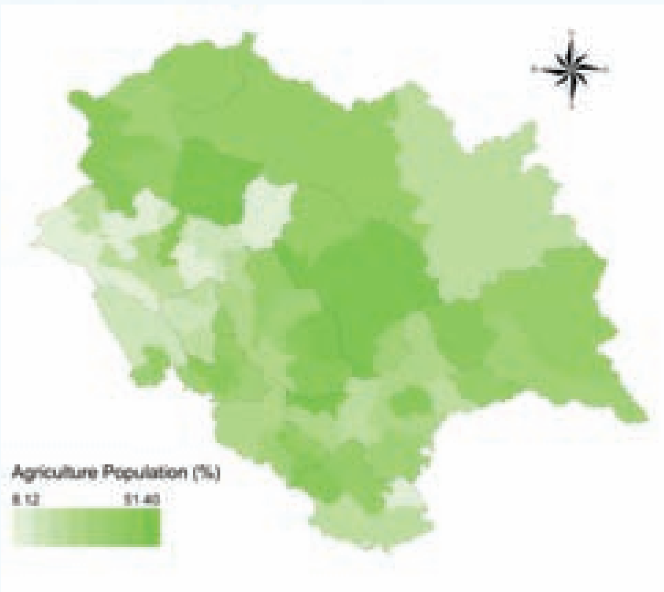


Fig. 38(i): Percentage Agriculture Population at Block Level

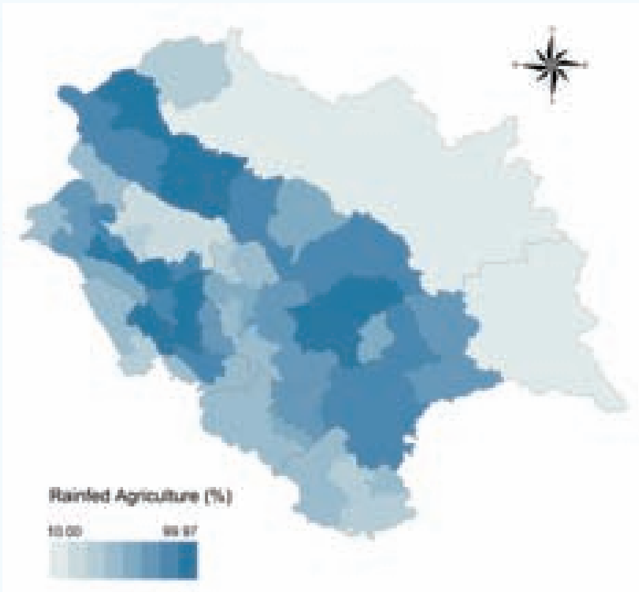


Fig. 38(ii): Percentage Rain-fed Agriculture at Block Level

Fig. 38(iii): Percentage Irrigated Area at Block Level

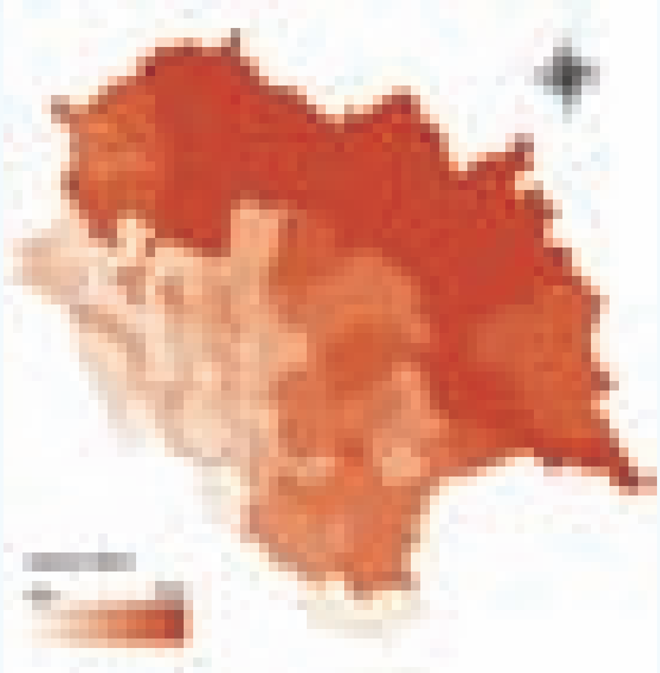


Fig. 38(iv): Altitude Distribution at Block Level

Fig. 38(v): Forest Cover at Block level (Percentage of District)

Fig. 38(vi): Family Size at Block Level

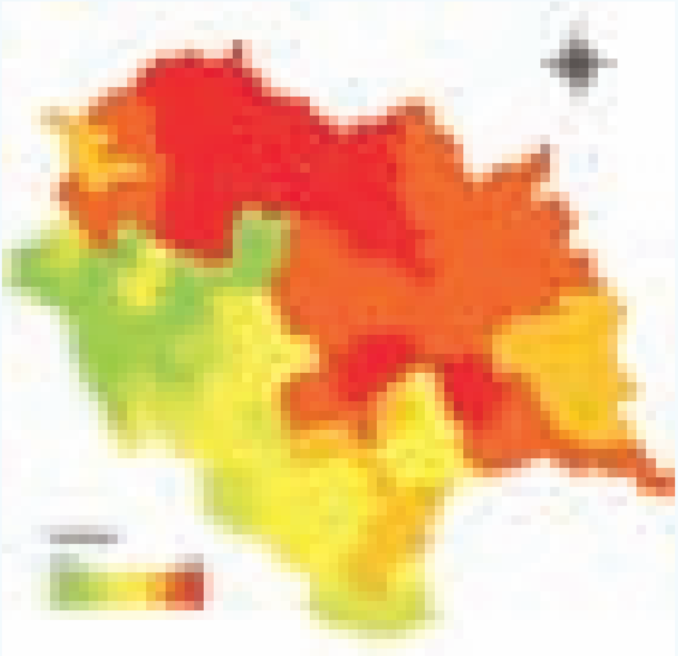


Fig. 38(vii): Percentage Biological Diversity Richness at Block level

Fig. 38(viii): Climate Change Sensitivity at Block Level

The results depicts that District Chamba, Lahul & Spiti, Kinnaur, Kullu and some areas of Shimla, Sirmour are highly sensitive towards climate change and Hamirpur, Mandi, Solan Una, and Kangra districts are moderately sensitive to climate change Fig. 38(i-viii).

4.2.2.3 Adaptive Capacity

The socio economic conditions give measures on adaptive capacity which contain economic capacity, poverty rate and, roads connectivity, literacy rate, environment management infrastructure with population density, as proxy variables Fig. 39(i-iv). Adaptive capacity is the ability or potential of a system to respond successfully to climate variability and change, and includes adjustments in both behaviour and in resources and technologies. The presence of adaptive capacity has been shown to be a necessary condition for the design and implementation of effective adaptation strategies so as to reduce the likelihood and the magnitude of harmful outcomes resulting from climate change (*Brooks and Adger, 2005*). Adaptive capacity also enables sectors and institutions to take advantage of opportunities or benefits from climate change, such as a longer growing season.

From analysis of database it is evident that the areas which have high percentage of poverty are more exposed shows low economic capacity and, therefore, has less adaptive capacity and more vulnerability. Higher literacy rate, road network shows higher adaptive capacity. More is the population, lesser the adaptive capacity in the region.

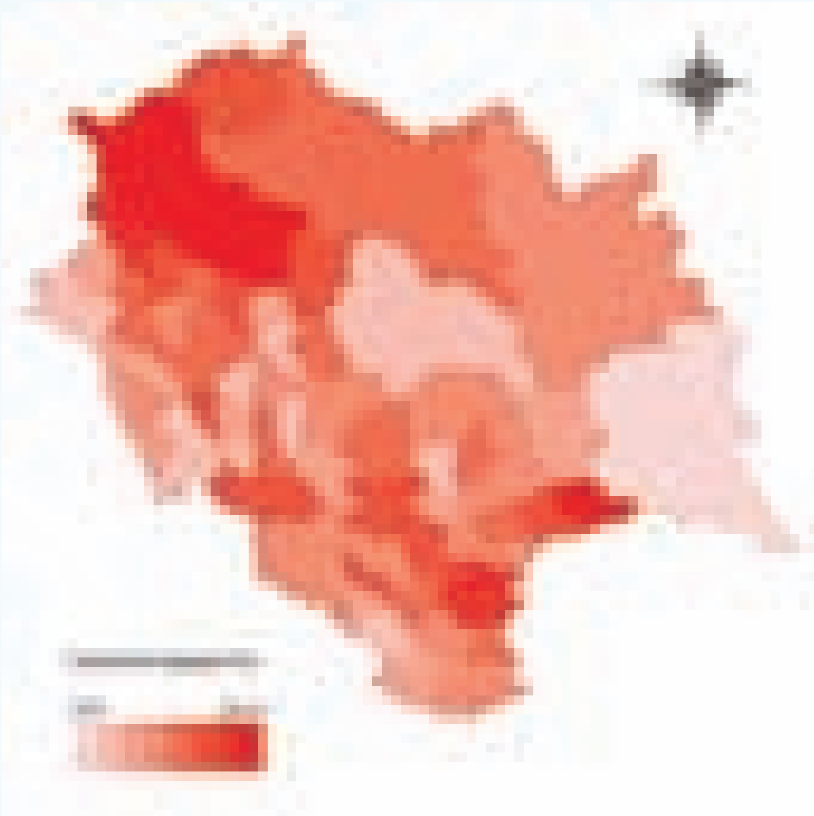


Fig. 39(i): Economic Capacity at Block Level

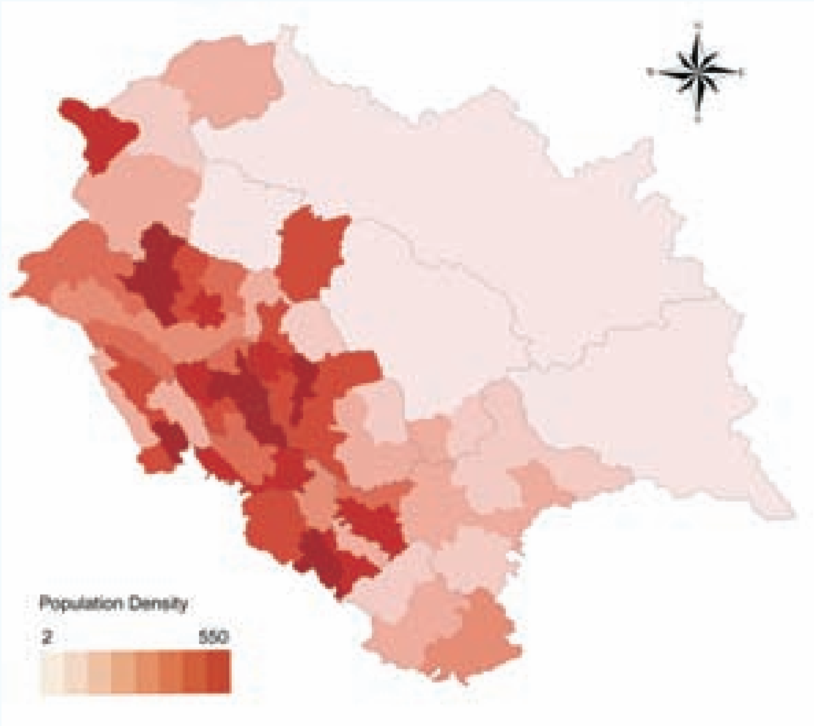


Fig. 39(ii): Environmental Capacity at Block Level

Fig.39 (iii): Physical Capacity at Block Level

Fig. 39(iv): Human Capacity at Block Level

The analysis of the index of vulnerability at the Block level of all districts of State has been calculated using index based approach which primarily is an outcome-based vulnerability measurement.

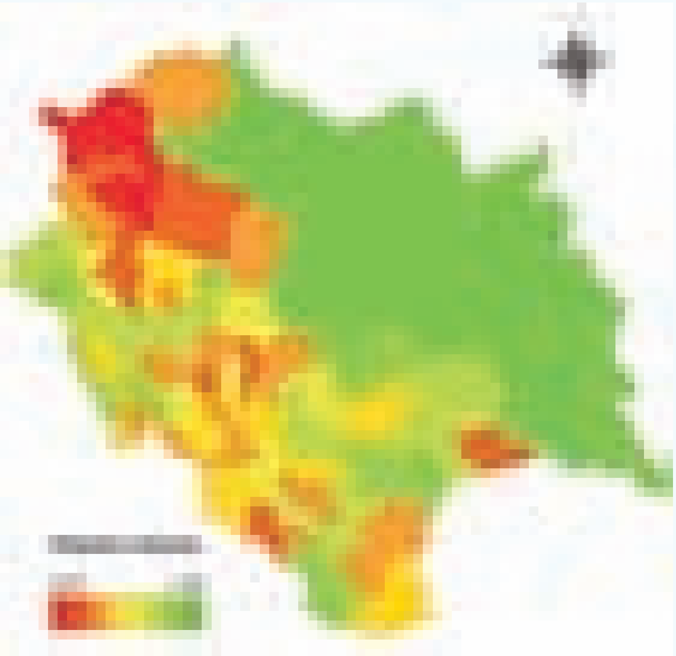


Fig.40: Adaptive Capacity at Block Level

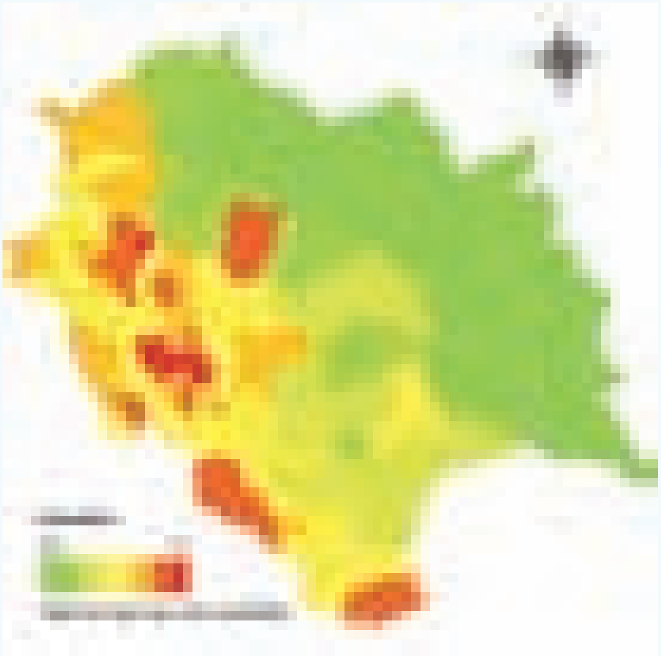


Fig.41: Climate Change Vulnerability at Block level

From the analysis it is observed that the adaptive capacity of Lahaul & Spiti, Kinnaur, some areas of Kangra, Shimla and Mandi districts is better. The adaptive capacity of District Chamba, Hamirpur, Una, Solan and Sirmour is poor to cope with the impacts of climate change.

When combined together all the three components i.e. Exposure, Sensitivity and Adaptive Capacity, the results indicates that Hamirpur, Kangra, Una, Solan, Bilaspur, Sirmour districts are highly vulnerable to climate change whereas, the districts Mandi, Shimla, Kullu, Chamba are moderately vulnerable.

The Vulnerability Index, measured here, tries to capture a more comprehensive scale of vulnerability to give composite Vulnerability Index (Table-20). It has been calculated by including many indicators that serve as proxies to look at different aspects of vulnerability. In other words, we assume that vulnerability can arise out of a variety of factors. In particular, we look at different sources of vulnerability; broadly this includes the climatic factors, demographic factors, agricultural factors and occupational factors etc.

4.2.2.4 Economic Impacts

In Himachal Pradesh climate change is projected to have likely negative effects on its sustainable development, as it compounds the pressures on natural resources and the environment associated with rapid urbanization, industrialization and economic growth. The net effect of climate change on local and regional economies is projected to be largely negative. Loss of agricultural-horticultural revenue and additional costs for managing water resources, energy, and disease and other health risks will be a drag on economic activity. Given long term, sustainable economic development and growth in per capita wealth, such economic impacts may comprise a declining portion of total economic welfare, and State's capacity to effectively manage climate risk is likely to rise more in future.

Table-20: Vulnerability Index of Himachal Pradesh (Districts at Block Level)

Sr. No.	Districts	Blocks	Components			Vulnerability Index
			Exposure	Sensitivity	Adaptive Capacity	
1	Bilaspur	Bilaspur Sadar	0.68	0.26	0.68	0.56
2		Ghumarwin	0.66	0.24	0.71	0.49
3		Jandhutta	0.67	0.24	0.65	0.61
4	Chamba	Pangi	0.37	0.38	0.51	0.18
5		Chamba	0.65	0.25	0.60	0.65
6		Salooni	0.60	0.26	0.65	0.48
7		Bharmour	0.41	0.32	0.45	0.48
8		Tissa	0.60	0.26	0.51	0.73
9		Bhatiyat	0.64	0.31	0.59	0.69
10		Mehla	0.64	0.27	0.50	0.86
11	Hamirpur	Bhoranj	0.81	0.22	0.76	0.64
12		Bijhri	0.76	0.20	0.61	0.78
13		Hamirpur	0.83	0.19	0.72	0.72
14		Nadaun	0.82	0.19	0.70	0.73
15		Taunidevi	0.73	0.20	0.65	0.69
16		Sujanpur	0.73	0.20	0.61	0.75

17	Kangra	Dharamsala	0.81	0.29	0.67	0.88
18		Kangra	0.69	0.28	0.77	0.43
19		Bhawarna	0.73	0.28	0.70	0.62
20		Panchrukhi	0.70	0.28	0.65	0.67
21		Nurpur	0.69	0.20	0.61	0.69
22		Nagrota Bagwan	0.68	0.30	0.65	0.63
23		Rait	0.69	0.25	0.74	0.48
24		Fatehpur	0.68	0.19	0.58	0.70
25		Indora	0.70	0.21	0.61	0.70
26		Pragpur	0.69	0.20	0.62	0.67
27		Lambagaon	0.69	0.19	0.61	0.68
28		Behdu Mahadev	0.68	0.27	0.58	0.76
29		Dehra	0.68	0.19	0.61	0.67
30		Nagrota Surian	0.69	0.18	0.63	0.65
31		Baijnath	0.71	0.19	0.66	0.64
32	Kinnaur	Pooh	0.36	0.39	0.44	0.34
33		Kalpa	0.40	0.42	0.45	0.41
34		Nichar	0.40	0.32	0.43	0.51
35	Kullu	Nagar	0.54	0.29	0.51	0.64
36		Banjar	0.51	0.31	0.47	0.67
37		Nirmand	0.50	0.26	0.49	0.60
38		Kullu	0.58	0.27	0.49	0.75
39		Ani	0.55	0.28	0.49	0.70
40	Lahul Spiti	Lahul	0.32	0.50	0.49	0.00
41		Spiti	0.34	0.45	0.50	0.07
42	Mandi	Dharampur	0.65	0.22	0.67	0.54
43		Sundernagar	0.66	0.23	0.68	0.53
44		Sadar	0.67	0.22	0.65	0.61
45		Balh	0.62	0.23	0.63	0.57
46		Chauntra	0.68	0.26	0.62	0.67
47		Darang	0.63	0.26	0.51	0.79
48		Karsog	0.57	0.27	0.58	0.55
49		Chachiyot	0.57	0.28	0.59	0.53
50		Seraj	0.55	0.27	0.52	0.63
51		Gopalpur	0.63	0.24	0.65	0.55
52	Shimla	Chopal	0.60	0.26	0.48	0.79
53		Basantpur	0.65	0.25	0.66	0.55
54		Rohroo	0.61	0.23	0.52	0.71
55		Nankhari	0.54	0.24	0.60	0.48
56		Chirgaon	0.49	0.28	0.56	0.43
57		Rampur	0.61	0.22	0.51	0.74
58		Theog	0.55	0.24	0.61	0.47
59		Mashobra	0.56	0.26	0.67	0.37

62	**Sirmour**	**Nahan**	0.72	0.23	0.56	0.83
63		**Pachad**	0.69	0.27	0.51	0.91
64		**Rajgarh**	0.70	0.27	0.53	0.89
65		**Sangrah**	0.68	0.29	0.48	0.99
66		**Paonta Sahib**	0.78	0.25	0.58	0.94
67		**Shilai**	0.67	0.25	0.54	0.80
68	**Solan**	**Solan**	0.69	0.28	0.68	0.60
69		**Dharampur**	0.72	0.26	0.68	0.63
70		**Kandaghat**	0.71	0.26	0.61	0.76
71		**Nalagarh**	0.73	0.22	0.64	0.71
72		**Kunihar**	0.67	0.24	0.59	0.71
73	**Una**	**Una**	0.70	0.26	0.69	0.59
74		**Haroli**	0.69	0.26	0.63	0.67
75		**Gagret**	0.73	0.23	0.58	0.81
76		**Amb**	0.71	0.21	0.63	0.70
77		**Bangana**	0.67	0.20	0.57	0.72
						Higher the value, high is the vulnerability

4.3 Analysis of Results

The vulnerability assessment for this report has been carried out for a total of 77 blocks of 12 districts of the State (Table-20) The analysis of large data sets for the variables of different indicators for all these blocks is as under:

4.3.1 Sectoral Analysis w.r.t. Climate Change Vulnerability

The climate change has direct bearing mainly on agriculture-horticulture, water resources, forests & biodiversity. Like the rest of the northwest region of India and other Himalayan regions, Himachal Pradesh is extremely vulnerable to climate change. Himachal Pradesh has a high reliance on agriculture and horticulture. Climate change poses a huge challenge as rising temperatures, raises the need for irrigation and the risk of heat stress or crop failure. Shift in weather patterns, erratic rainfall, rising temperatures leave farmers vulnerable to crop losses.

The sectoral analysis of vulnerability amongst these sectors is as follows:

4.3.1.1 Agriculture- Horticulture

In Himachal Pradesh, agriculture and horticulture activities have high dependency on precipitation and temperature. It has direct impact on crop production and food security. From the above analysis, it is observed that with the rise in temperature, crop productivity will slightly increase in tropical regions but will decrease in sub tropical areas. The agricultural families are highly exposed in changing climate scenarios since rainfed dependency is high. In the State, there will be an impact on crop performance in sub tropical region. Based on ICAR recent findings, the apple belt is shifting upwards due to rise in temperature and decrease in chilling period. Due to this reason, the apple area between 1500-1800 msl is decreasing and increasing between 2200-3000 msl.

As per study carried out by Verma et. al. (2009), in higher altitudes of Shimla Districts, the farmers have already started shifting from high chilling requirement crops to less chilling requirement crops such as kiwi, pomegranate and vegetables etc.

Another study carried out by IHBT observed that the quality of tea has been adversely affected due to less rainfall in Palampur area as it has affected the accumulation of a compound responsible for giving colour and briskness to the tea. Over all one can say that the agriculture-horticulture sector is vulnerable and require adaptive and mitigative steps.

4.3.1.2 Water Resources

The snow depository and glaciers support water supply to the major rivers and their tributaries. The analysis shows change in patterns of rain fall in different areas differently. There is drought like conditions in almost every or alternate years. The areas located in Kangra, Bilaspur, Hamirpur districts have received rainfall below the normal though Kangra receives maximum rainfall in the State. The change in rainfall will impact most the natural springs of rural and semi urban habitations where there is no glaciated or wetlands in uplands. Water conservation, distribution, recharging and storage are required to be developed in such areas.

Over the period, the water requirement has gone up where as water availability has declined. The situation in summer months is even worse. The irrigated area is very less in comparison to the potential available. The major source of water supply in the State is surface water, which is augmented by rainfall, snow and glaciers and in case of any change in the pattern of temperature and rainfall; the water supply system will get badly affected.

The Asian Development Bank (ADB, 2010) has carried out a detailed analysis of impacts of climate change on water eco-system and has suggested a strategic framework for the State.

4.3.1.3 Forest & Biodiversity

About 26.37% area of the State's geographical area having spread of 14,679 sq. kms. is covered with forests. The State is having unique forest and diverse habitat with large altitudinal variations. The State is a repository of about 3,295 species of plants (7.32% of total of Country) and 5,721 species of animals (7.4 % of Country total). Three altitudinal strata of the State i.e. Shiwalik, Middle and Himdaris support about 35 types of forests which vary from dry scrubs forest to alpine pastures. Any change in temperature or rainfall pattern will adversely impact the entire ecosystem. The consequences of change in climate will cause change in distribution of floral species, forest areas, forest productivity, shift in tree line, mortality during transient, threatened species will be highly exposed.

From the analysis, it is observed that the forests of High Hill Temperate Wet zone will be highly vulnerable. Species composition may change. With higher temperatures, the production of species such as deodar and oak may decline. Decline in snow fall may result in greater mortality of species. Change in climate conditions in sub tropical regions will favour expansion of certain species upwards.

As per study carried out by Rana et. al. (2009), states that many temperate species such as Lilium polyphyclum, Sorbus, Lanata, Swertia chirayita, Androsco, Aconitum heterophyllum which were frequently found in Shimla (Collet, 1902) are no longer observed in the localities as mentioned by him. As per data Pinus longifolia which was 100 years ago was recorded at 1800 mtrs. but is now it is recorded above 2200 mtrs altitude. Similarly, Woodfordia fructifose earlier located at 1500 mtrs has now shifted to 2000 mtrs altitude. Over all the tree line is highly vulnerable which will resultantly affects the habitat of many other species from Mid Hill Sub Humid to High Hill Temperate Wet and to Temperate Dry zones subsequently. Interventions are required to be taken well in time to sustain these unique ecosystems of the Himalayan region.

To counter the severe impacts of climate change, varied developmental interventions are required at different levels, since significant variations are observed among various Blocks within the district itself. Interventions are required in agriculture, water resources, forests & biodiversity energy, health, tourism and urban planning as to minimize the exposure and improve the adaptive capacity.

4.3.2 Climate Change Vulnerability under different Agro Climatic Zones

The climate change vulnerability of different districts and blocks under different agro climatic zones is described as follows Fig. 42(i-xv):

4.3.2.1 Exposure

The temperature and rainfall depicts moderate variations over small distances. The north (some parts), west, south and partially central parts of the State which has low elevation and is a drought prone area is observed to be highly exposed. The local community perception and the trends of climate change are also corroborating the current analysis e.g. shift in cropping pattern and shift in floral and faunal species etc. Based on the trends, the same are the concerns which are invariably expressed by the local communities such as change in setting of season, extinction of birds, butterflies, vegetation species, decline in snow fall, and drying up of natural water sources etc.

Some of the regions of districts Kangra, Una, Hamirpur, Solan, Sirmour, which are falling in sub-mountain low hills, sub tropical region and mid hill sub humid regions are having higher exposure conditions w.r.t. Climate Change variations as depicted in Fig. 42 (i). Areas of districts Chamba, Kullu, Shimla, Sirmour, Palampur falling under high hill temperate wet zone are also more exposed in comparison of districts Lahul & Spiti & Kinnaur, Chamba falling in high hill temperate dry zone.

4.3.2.2 Sensitivity

The Sensitivity Index evaluated on the basis of different indicators indicate that High Hill Temperate Wet and High Hill Temperate Dry zones of the State are highly sensitive to any kind of variation in climate and they also represents the biodiversity richness of the State. It is observed that even a small variation in temperature or timing of precipitation has significant impacts. The rising temperatures will affect the cropping patterns in High Hill Temperate Wet Zone.

The regions of Districts Lahul & Spiti, Kinnaur, Kullu, Chamba, Kangra which is biodiversity rich zone are highly sensitive towards Climate Change, the majority of area of this region falls within the high hill temperate dry & high hills temperate wet zones, besides some adjoining parts of District Mandi and Shimla, which falls within the mid hill sub humid zone and also has rich biodiversity is expected to face changing patterns due to Climate Change variations. However, the sub mountain low hill sub tropical region is not that sensitive in view of its lesser biodiversity and growing pattern as depicted in Fig. 42 (ii).

4.3.2.3 Adaptive Capacity

The High Hill Temperate Wet and Dry zones have high adaptive capacity in comparison to Sub montane, Low Hill, Sub Tropical Mid Hill Sub Humid, which are found to be having moderate-low adaptive capacities in view of the better physical connectivity and infrastructure. Certain areas with high literacy and poverty rate but with poor connectivity displayed low adaptive capacity. The Block with urban centres having better infrastructural facilities depicts high adaptive capacity.

The adaptive capacities of majority of areas of districts Chamba, Lahual & Spiti, Kinnaur, Kullu, Manali, Shimla, Una, Sirmour, Solan are better in comparison to other areas as shown in Fig. 42(iii). The adaptive capacity is better in high hill temperate dry, partially in high hill temperate wet due to less exposure, however, in sub mountain low hills sub tropical zone it is better due to better infrastructure, or for the one or the other reasons despite higher exposure.

Over all the vulnerability of the 77 Blocks of the State as a combination of exposure, sensitivity and adaptive capacity observed to be high in Sub montane, Low Hill areas and Sub Tropical regions of the State and in case of Mid Hill Sub Humid, it ranges from moderate to high, As far as High Hill Temperate Wet regions of the State are concerned, the vulnerability varies from low to high where as in case of in case of in High Hill Temperate Dry regions it is reasonably low due to better adaptive capacity as shown in Fig. 42(iv). The areas where the climate sensitive livelihoods are practices have least adaptive capacities and at the same time have high exposure resulting into higher vulnerability. The trends of climate change depicts that the vulnerability of all the zones are likely to show an increase and therefore there is a need to strengthen the adaptive capacity of such areas so as to offset the exposure and sensitivity. There is need for adaptation and mitigation measures in Sub montane, Low Hill, Sub Tropical, Mid Hill Sub Humid and High Hill Temperate Wet zones of Himachal Pradesh.

4.3.3 Projection of Scenarios 2020 & 2030

The HADCM3 simulations downscaled with PRECIS indicate an all around warming over the Indian sub continent associated with increasing GHG concentrations. It is observed that both maximum and minimum temperatures are projected to rise under the PRECIS A1B scenario. Increase in the monsoon season would be lower than in the dry season.

Himachal Pradesh receives most of its rain during the monsoon season, which starts in the late June. The mean seasonal precipitation simulated by PRECIS shows variations for Indian sub continent. Under A1B scenario, mean annual rainfall is projected to increase marginally for the State by about (5% to 13%) i.e. 70-200 mm by 2030. Increase in monsoon season, and marginal increase in other seasons with increase in rainy days.

Besides, on the basis of available data base w.r.t. temperature (max & min) and precipitation form IMD Pune and after working out the decadal variation on average basis, decadal scenarios for climate variations i.e. variations in rain fall and temperature for 2020 and 2030 have been projected (No specific PRECIS or HADCM simulations have been worked out for Himachal Pradesh separately) and have been further analyzed for deriving Vulnerability Index while assuming that the sensitivity and adaptive capacity would continue to show the same pattern*(The adaptive capacity & sensitivity could not be analyzed for decadal scenarios in view of lack of data base for specific variables and also that the adaptive capacity or sensitivity will not show any change in its pattern in case projected on simple average methods).

* (Even if the increase in biodiversity or growth in infrastructural facilities is observed)

Therefore, the projections only w.r.t exposure based on decadal variations have been plotted on spatial maps to see the likely/ possible changes in 2020 & 2030.

The exposure scenario for 2020 is depicted in Fig. 42 (v) and further overlaid with agro climate zone layers, Fig. 42 (vi), reveals that the different regions of district Sirmour, Solan, Una, Shimla, Bilaspur, Hamirpur, Kangra, Mandi, Kullu which are falling under sub mountain low hill sub tropical region and mid hill sub humid zones are likely to have greater exposure in comparison to high hill temperate dry & high hill temperate wet agro climatic zones.

Further, when the same exposure scenario is applied to derive projections with respect to Vulnerability Index for 2020, we observed variations in current levels. By examining Fig. 42 (vii) one can see that the Vulnerability Index spatial distribution projected for 2020 in various blocks. While overlaid by agro climatic zone wise layers to observe the different zone wise variations, it is observed that the Climate Change vulnerability in 2020 scenario the areas of districts Sirmour, Solan, Bilaspur, Una, Kangra, Mandi, Kullu, Chamba will be at risk, that means the regions falling under sub mountain zone will be at risk while other will have lower risk, Fig. 42 (viii).

Similarly, the decadal scenarios projections have been worked out for 2030 as well and the Fig. 42 (ix), 42 (x), 42 (xi) & 42(xii) shows the spatial distributions of scenario projections of Exposure Projections 2030, Agro Climate Zone Wise Exposure Projections 2030, Climate Change Vulnerability Projections 2030, Agro Climate Zone Wise Climate Change Vulnerability Projections 2030 respectively, with the indication that the vulnerability of low lying areas i.e. sub mountain low hills sub tropical region, mid hills sub humid will be at higher risk and high hill temperate wet will be under moderate risk while dry region will be continue to have lower risk even in 2030.

Furthermore, while drawing spatial maps the Climate Change vulnerability maps have also been overlaid through climate classification layers to observe that how the current Climate Change vulnerability in different regions emerges, Fig. 42 (xiii), similarly the layer have been overlaid on 2020, 2030 as well, Fig. 42 (xiv) & 42 (xv) respectively.

It is observed that currently, the region classified as sub tropical monsoon with mild and dry winter, hot summer (CWa) is highly vulnerable with some adjoining regions sub tropical monsoon without dry winter, with hot summer (CFa), while plotting the spatial distribution projection scenarios, it is observed that vulnerability of these area will continue to increase further in 2020 & 2030 see Fig. 42 (xiii), Fig. 42 (xiv) & 42 (xv) and thus the adaptive capacities of the area needs to be enhanced to counter the impact of exposure besides sensitiveness of the region falling in sub tropical monsoon with mild and dry winter, hot summer (CWa).

In view of climate classification, the regions having sub tropical monsoon with mild dry winter, moderate and hot summer are highly exposed and are highly vulnerable to climate change. This region of the State is quite significant from economic point of view as it represents about 86% area of total cultivated area and 67% of total geographical area.

The results have been summarized in Table-21 along with projected trends.

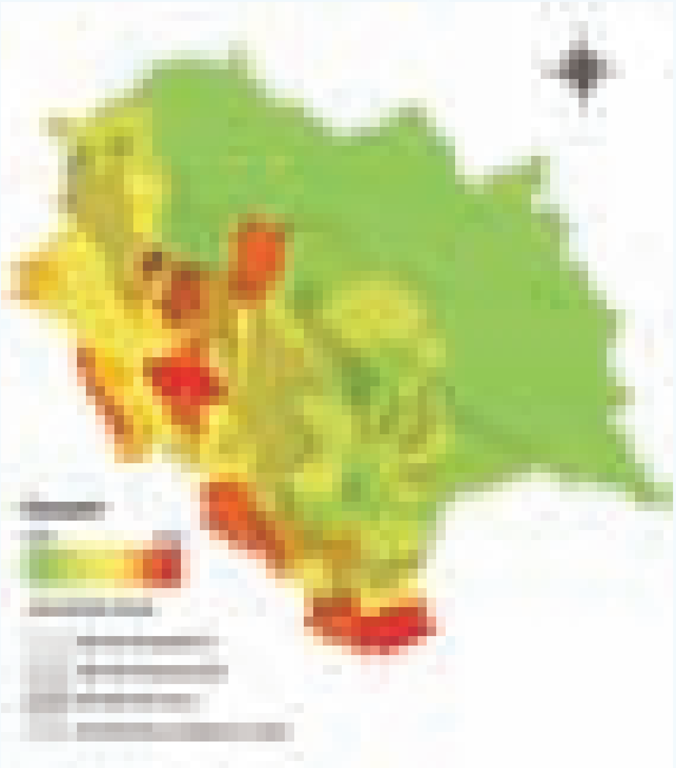


Fig. 42 (i): Climate Change Exposure as per Agro-climatic Zones at Block Level

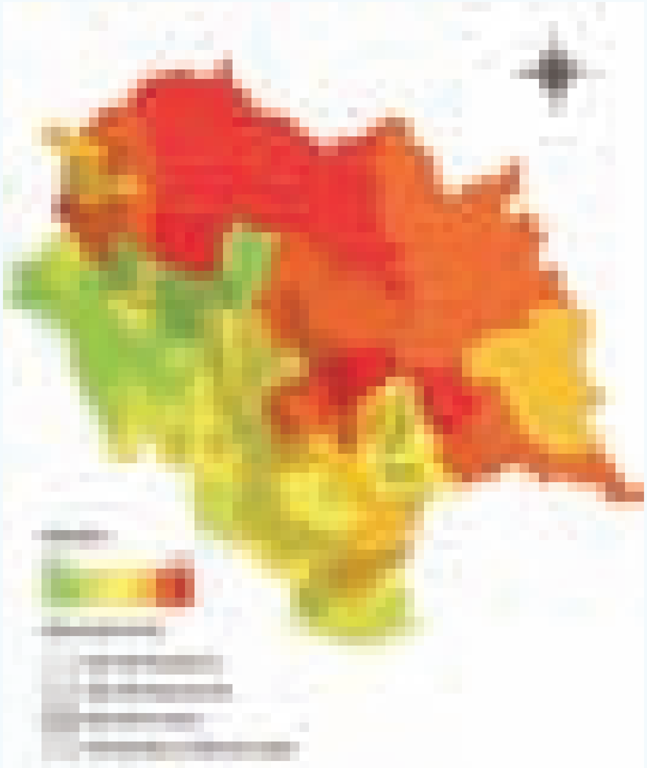


Fig. 42 (ii): Climate Change Sensitivity as per Agro-climatic Zones at Block Level

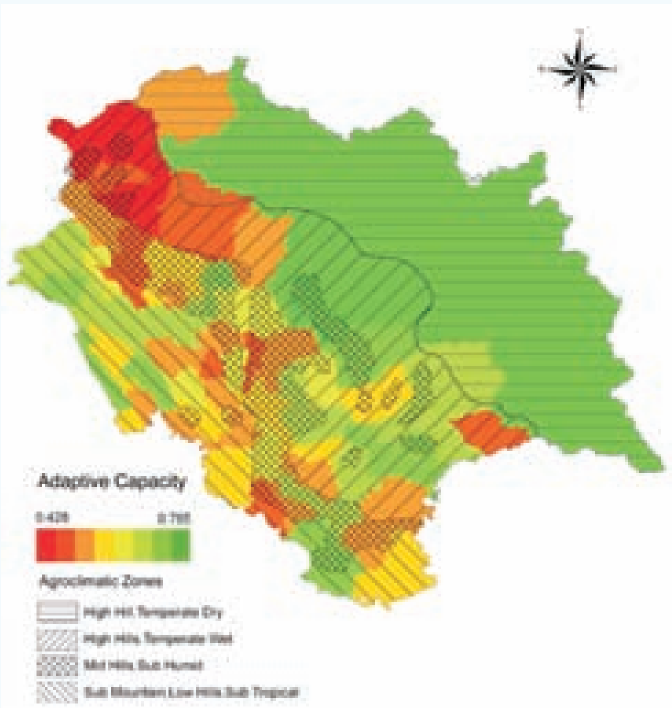


Fig. 42 (iii): Adaptive Capacity as per Agro-climatic Zones at Block Level

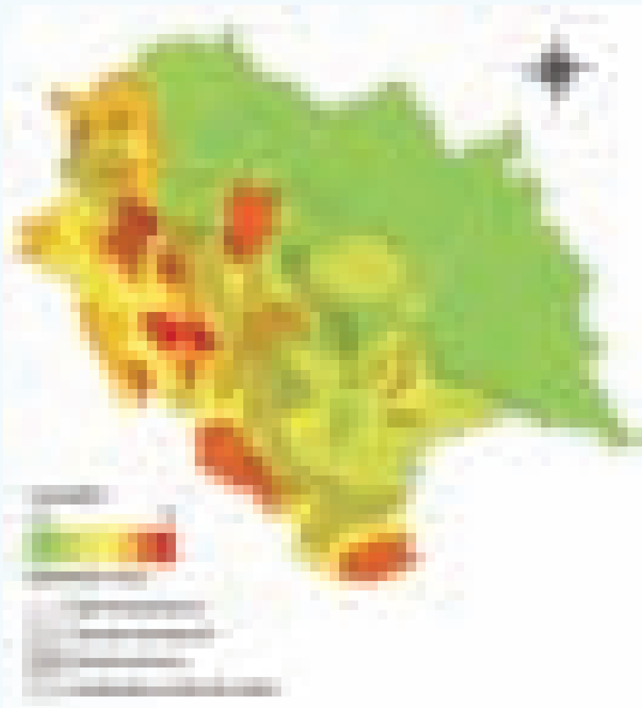


Fig. 42 (iv): Vulnerability Variation as per Agro-climatic Zones at Block Level

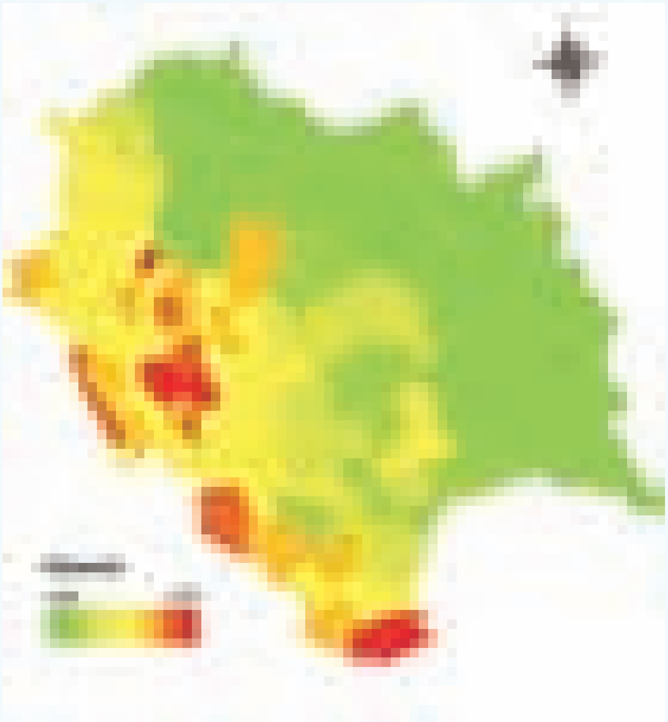


Fig. 42 (v): Climate Change Exposure at Block Level (2020)

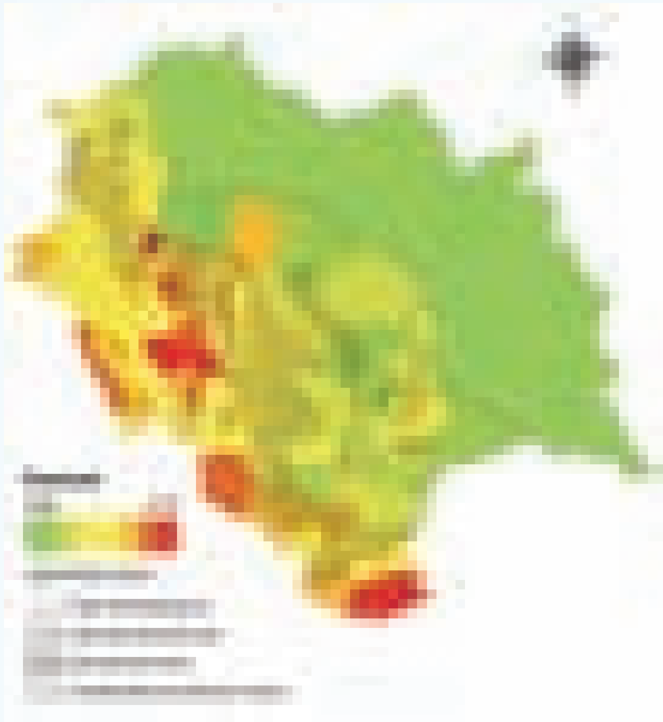


Fig. 42 (vi): Climate Change Exposure as per Agro-climatic at Block Level (2020)

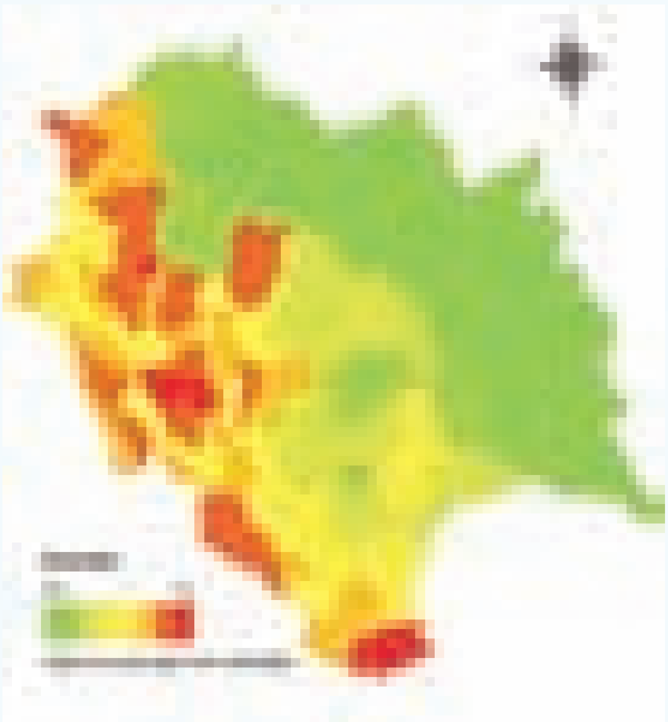


Fig. 42 (vii): Climate Change Vulnerability at Block Level (2020)

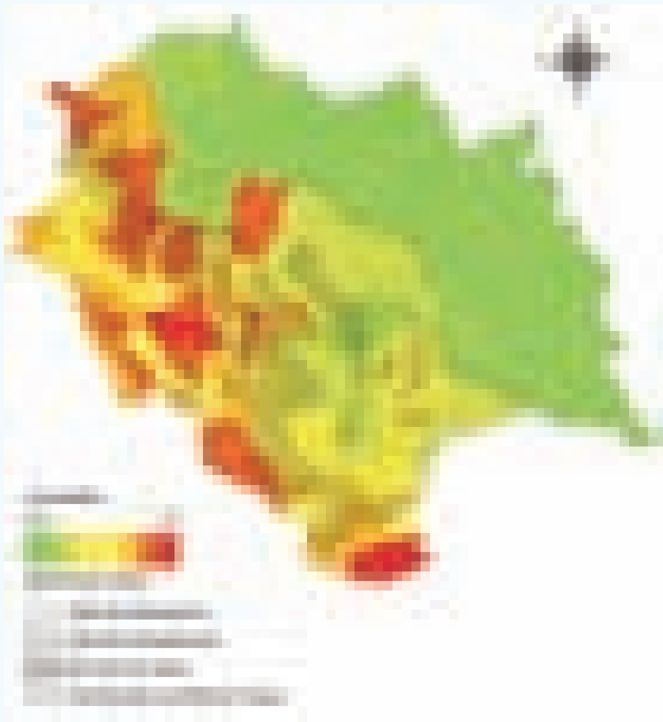


Fig. 42 (viii): Vulnerability Variation as per Agro-climatic Zones (2020)

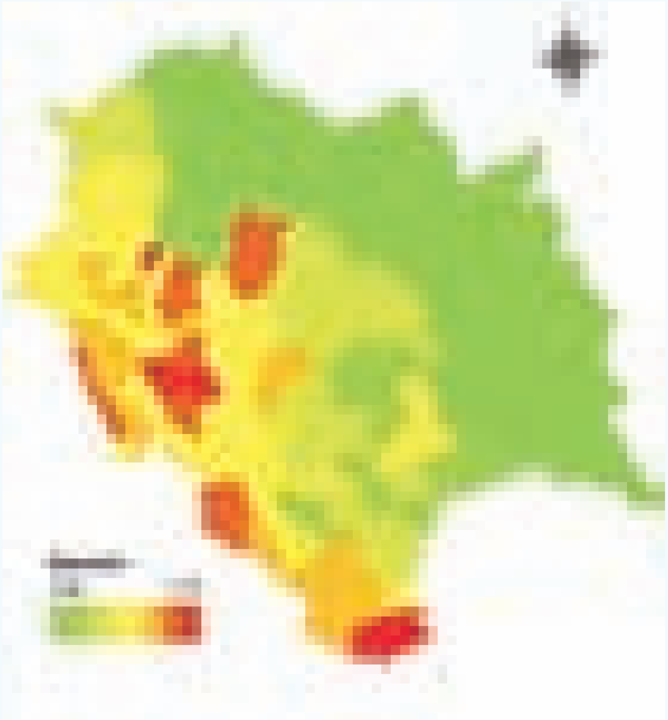


Fig. 42 (ix): Climate Change Exposure at Block Level (2030)

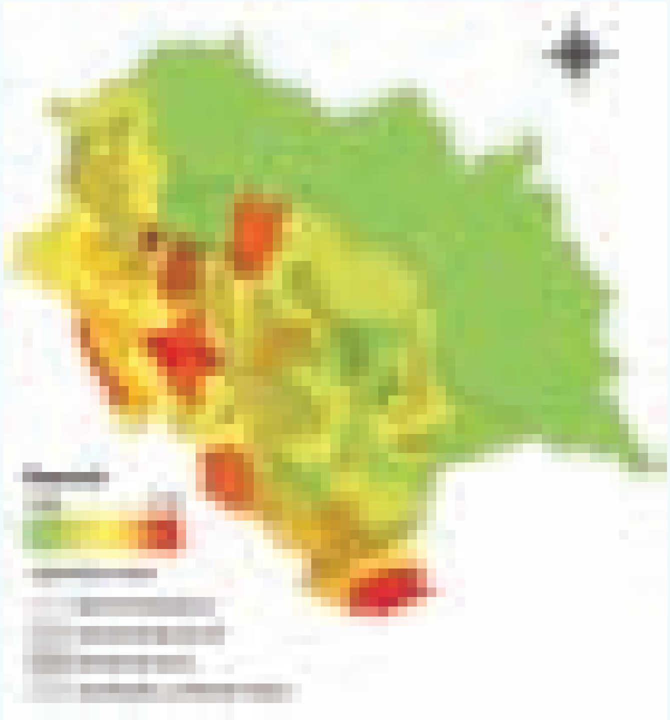


Fig. 42(x): Climate Change Exposure as per Agro-climatic Zones (2030)

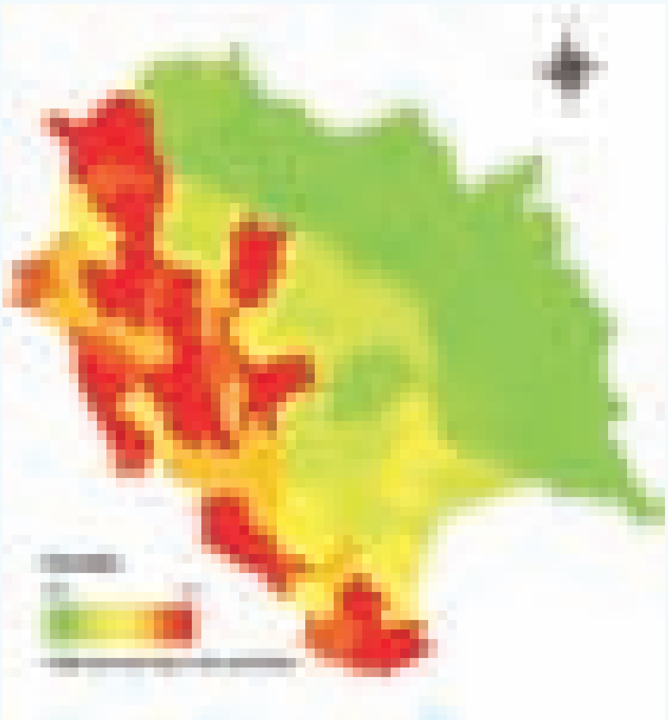


Fig. 42 (xi): Climate Change Vulnerability at Block Level (2030)

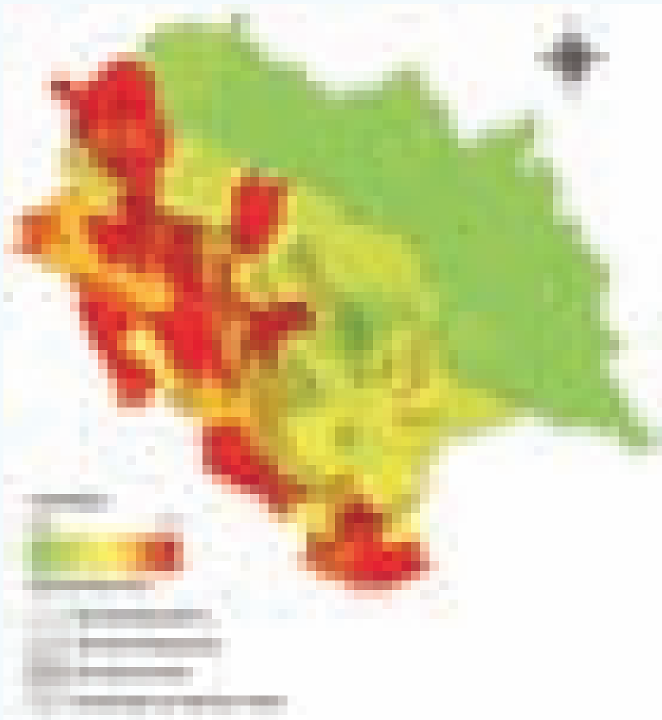


Fig. 42 (xii): Vulnerability Variation as per Agro-climatic Zones (2030)

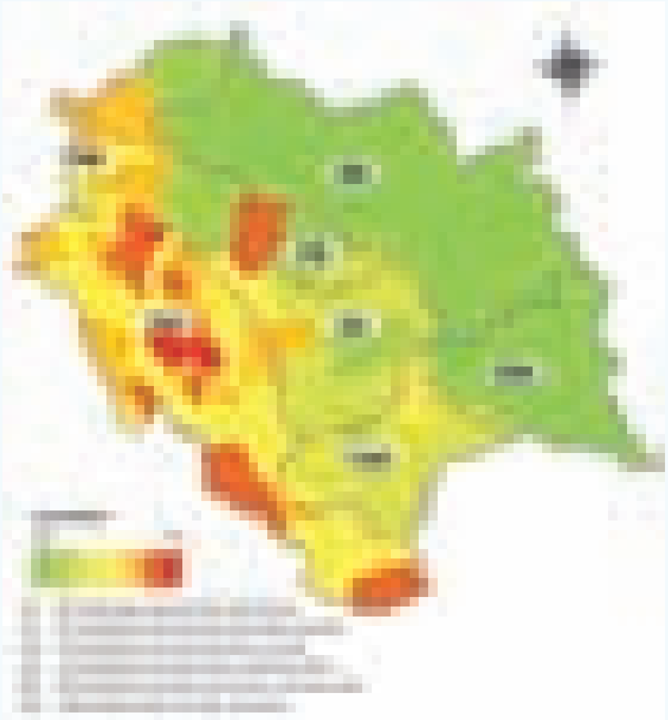


Fig. 42 (xiii): Vulnerability Variation as per Climate Classification

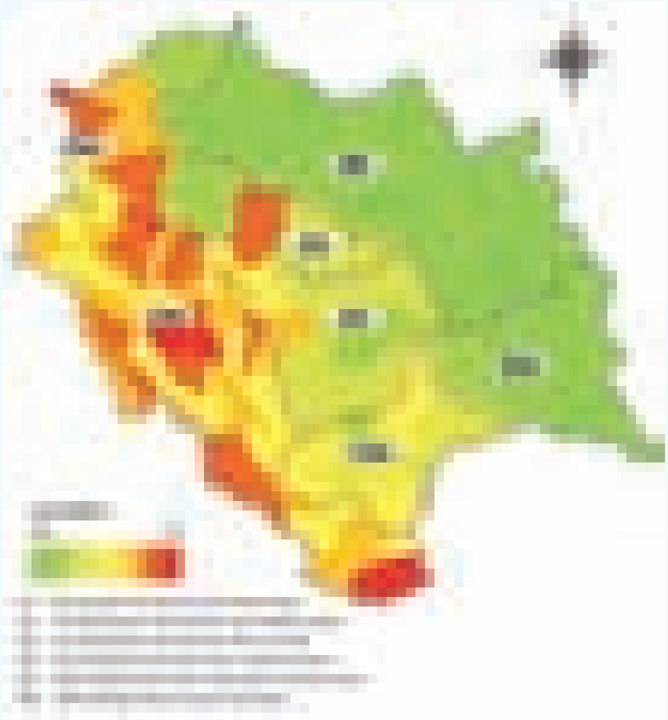


Fig. 42 (xiv): Vulnerability Variation as per Climate Classification (2020)

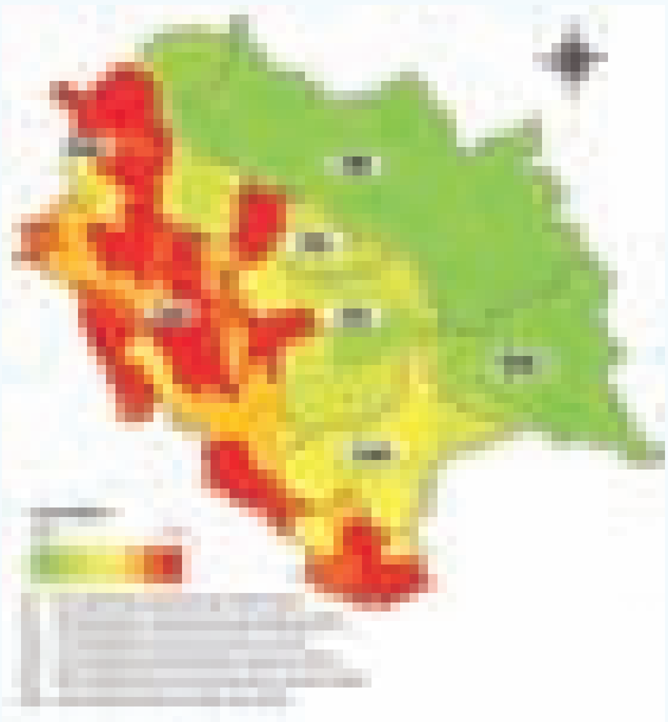


Fig. 42 (xv): Vulnerability Variation as per Climate Classification (2030)

Table-21: Agro Climate Zone Wise Description of Vulnerability Index & Projected Trends

Agro Climatic Zone	Elevation (mtrs.msl)	Districts/ area	Climate Change Impact Component			Vulnerability Index	Trend as per projections of climate change
			Exposure	Sensitivity	Adaptive Capacity		
Sub mountain, Low Hill, Sub Tropical	350 to 650 meters 35% of the geographical area and about 40% of the cultivated area	Hamirpur, Una, Bilaspur, Parts of Sirmour, Kangra, Solan and Chamba	High	Moderate	High	High	(+)
Mid Hill Sub Humid	651 meters to 1,800 meters 32% of the total geographical area and about 37% of the cultivated area	Parts of Mandi, Solan, Kullu, Chamba, Bilaspur, Sirmour Palampur & Kangra tehsils of Kangra Rampur tehsil of Shimla	High	Moderate	Moderate	Moderate to High	(+)
High Hill Temperate Wet	1,801 to 2,200 meters about 35% of the geographical areas and about 21% of the cultivated area	Shimla, Kullu, Chamba Parts of Mandi, Kangra, Chamba	Moderate	High	Moderate	Low to High	(+)
High Hill Temperate Dry	Above 2,200 meters 8% of the geographical and 2% of the total cultivated area	Kinnaur, Lahul & Spiti Parts of Chamba District	Low	High	High	Low	(+)

Adaptation & Mitigation

5

Climate change is any long term significant change in the 'average weather' (temperature, precipitation and wind patterns) that a given region experiences, which includes processes such as solar radiation, green house gas concentration and the effects of human activity. The recent climate change manifestations are attributed to human activity, and the debate has now shifted to reduce impact of human activity (Mitigation), and adapt to change that is already in the system (Adaptation).

Vulnerability can be reduced either by mitigation and/or adaptation. Mitigation basically involves reducing the causes of damage – in particular the GHG emissions and concentration in the atmosphere - with the aim to reduce the probability of occurrence of adverse conditions for socio-economic and environmental systems. The adaptation, however, reduces the severity of many impacts when/if adverse conditions prevail.

In its broader sense, adaptation to climate change can be defined as any adjustment in ecological, socio-economic system in response to actual or expected climatic stimuli, impacts or effects. The adjustment depends partially on climate change per se, but mostly on the vulnerability of the impacted system. As per IPCC 2001 report, "*vulnerability is the degree to which a system is susceptible to, or unable to cope with, adverse effect of climate change including climate variability and extremes*. [It] is a function of the character, magnitude and rate of climate change and variation to which a system is exposed, its sensitivity and its adaptive capacity".

Adaptation is a process taking place through space and time that can take the most diverse forms. Its characterization depends on different factors. The most important are: the subject of adaptation (who or what adapts), the object of adaptation (what they adapt to), the way in which adaptation takes place (how they adapt). The last aspect includes e.g. what resources are used, when and how they are used and with what results.

Adaptation to climate change has the potential to substantively reduce many of the adverse impacts of climate change and enhance beneficial impacts - though neither without cost nor without leaving residual damages…nevertheless…current knowledge of adaptation and adaptive capacity is not sufficient for reliable predictions of adaptations; it also is not sufficient for rigorous evaluation of planned adaptation options, measures and policies of governments.

Presently, the research on adaptation tries to reduce the veil of ignorance surrounding this strategy. The research should focus on the following:

- How effective the adaptation is in reducing climate-change damages?
- How much will it cost (in absolute terms as compared with other strategies)?
- When – where and what adaptation strategies should be adopted (should damage be anticipated?

Or simply awaited and then accommodated? Should resources for adaptation be addressed where they can be more effective or where they are more needed?

- Who should adapt and bear the costs (private agents or public agencies)?
- How can adaptation be harmonized with other strategies, first in line, mitigation? In particular is mitigation and adaptation complement or substitute? What is the optimal balance between them? What determines this balance?

The different objectives of planned adaptation can be summarized by the following:

- increasing the robustness of infrastructural design and long term investments,
- increasing the flexibility of vulnerable managed systems,
- enhancing the adaptability of vulnerable natural systems,
- reversing the trends that increase vulnerability ('mal adaptation'),
- improving societal awareness and preparedness.

Adaptation: Possible Criteria for Classification	
Concept or Attribute	
Purposefulness	*Autonomous - Planned*
Timing	*Anticipatory - Responsive*
Temporal Scope	*Short term - Long term*
Spatial Scope	*Localised - Widespread*
Function/Effects	*Retreat – accommodate – protect – prevent*
Form	*Structural – legal – institutional*
Valuation of Performance	*Effectiveness – efficiency – equity – feasibility*
	Source: Smit et. al., 1999

The objective of adaptation is to reduce vulnerability to climate change, thereby, reducing its negative impacts. It should also enhance the capability to capture any benefits of climate change. Hence, adaptation, together with mitigation, is an important response strategy. The mitigation of greenhouse gas emissions in order to prevent dangerous interference with the climate system is one plan. Some climate change is, however, inevitable due to historic and current emissions of greenhouse gases, and for this reason, adaptation can no longer act as a policy option – it has to be a fundamental element of the global response to climate change.

The issue of global warming is much influenced by the greenhouse gas emissions, and is considered to be the primary source of climate change. As a result, the policies are necessary to slow down the climate problem and to limit global warming. Therefore, it is very essential to understand clearly the potential of Green House Gas Emissions from the State form various sectors so as to draw options/measures for mitigation of climate change impacts besides assessing the energy needs inventory for the State.

A detailed Green House Gas Emissions Inventory has been worked out for the State of Himachal Pradesh using the standard norms adopted at National level. The details of which are as follows:

5.1 Green House Gas Emissions- India

The Indian Network for Climate Change Assessment (INCCA), a nation-wide network comprising 127 research institutions working on science and impacts of climate change for the Ministry of Environment & Forests, Union of India, filed a report on India's Greenhouse Gas Emissions, 2007 in May,

2010. The said report was released by Deputy Chairman, Planning Commission, Mr. Montek Singh Ahluwalia at an INCCA meeting, which made India the first “non-Annex I” (developing) country to publish such updated numbers on global warming and climate change.

According to the latest report, India's ranking in 2007 w.r.t. aggregate GHG emissions in the world is 5^{th}, behind USA, China, European Union and Russia. The report also points out that the 2007 emissions of USA and China are almost 4 times that of India. What is also highlighted in the report is that the emissions intensity of India's GDP declined by more than 30% during the period 1994-2007, which is largely attributed to the proactive efforts and policies being put in place by the Ministry of Environment & Forests, Union of India from time to time. The report mainly focuses on emissions from different sectors such as Energy, Industry, Land-use, Land-use Change and Forestry (LULUF) and Waste.

As per INCCA report, the net Greenhouse Gas (GHG) emissions from India, that is emissions with LULUCF, are reported to be 1727.71 million tons of CO_2 equivalent (eq) in 2007. Out of this, CO_2 emissions were 1221.76 million tons; CH_4 emissions were 20.56 million tons; and N_2O emissions were 0.24 million tons. The largest percentage of GHG emissions (58%) is from the Energy sector followed by Industry, Agriculture and Waste sectors in that order. Within the Energy sector, 65.4% of total CO_2 eq were emitted from electricity generation while the transport sector contributed to 12.9 % of the total CO_2 eq. The report also points out that for the estimation year 2007, LULUCF sector was a net sink. It sequestered 177.03 million tons of CO_2.

The report calculates India's per capita CO_2eq emissions including LULUCF for the assessment year 2007 at 1.5 tons/ capita. The report is also a step further towards incorporating the 3 M's” – Measurement, Modeling and Monitoring in the essence of formulating policies on climate change. By releasing such updated figures well before the COP at Cancun in Mexico, the Union of India has indicated its seriousness on the issue of climate change and its willingness to take on global leadership.

Existing GHG Emissions by Sector (Transport, Buildings, Industry, Waste, Agriculture & Forests) and Sub-sectors.

	Annual CO_2 emissions (eq) (In thousands of metric tonnes) Giga Gram	**Percentage of Global total**
India	17,27,706.10	<5% of global

Carbon dioxide Emissions (CO_2), metric tons of CO_2 per capita (CDIAC)

Rank	***Country***	***1990***	***1991***	***1992***	***1993***	***1994***	***1995***	***1996***	***1997***	***1998***	***1999***	***2000***	***2001***	***2002***	***2003***	***2004***	***2005***	***2006***	***2007***
145.	*India*	*0.8*	*0.8*	*0.9*	*0.9*	*0.9*	*1*	*1*	*1.1*	*1.1*	*1.1*	*1.1*	*1.1*	*1.1*	*1.2*	*1.2*	*1.2*	*1.3*	*1.4*

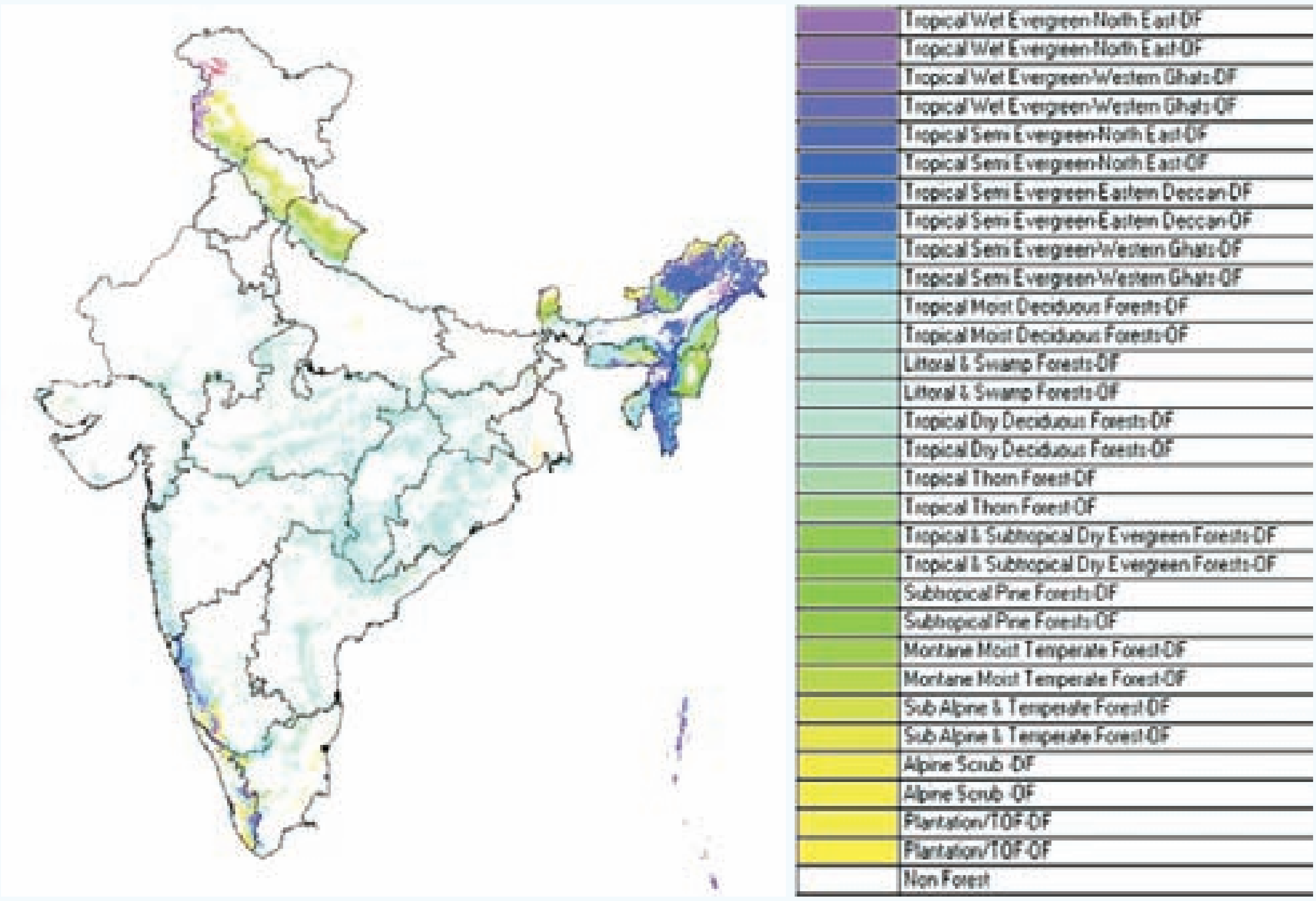
Rank of India (out of total 215 countries) *the data presented above corresponds to emissions in 2007. The data was collected in 2008 by the CDIAC for the United Nations. The data only considers carbon dioxide emissions from the burning of fossil fuels and cement manufacture, but not emissions from land use such as deforestation.*

(By Sources & Removal by Sinks during 2007 (In thousand tons)

	CO_2 emissions	CO_2 removal	CH_4	N_2O	CO_2 equivalent
GRAND TOTAL	**1497029.20**	**275358.00**	**20564.20**	**239.31**	**1727706.10**
ENERGY	**992836.30**		**4266.05**	**56.88**	**1100056.89**
Electricity generation	715829.80		8.14	10.66	719305.34
Other energy industries	33787.50		1.72	0.07	33845.32
Transport	138858.00		23.47	8.67	142038.57
Road transport	*121211.00*		*23.00*	*6.00*	*123554.00*
Railways	*6109.00*		*0.34*	*2.35*	*6844.64*
Aviation	*10122.00*		*0.10*	*0.28*	*10210.90*
Navigation	*1416.00*		*0.13*	*0.04*	*1431.13*
Residential	69427.00		2721.94	36.29	137838.49
Commercial / Institutional	1657.00		0.18	0.04	1673.18
Agriculture / Fisheries	33277.00		1.20	1.15	33658.70
Fugitive emissions			1509.40		31697.30
INDUSTRY	**405862.90**		**14.77**	**20.56**	**412546.53**
Minerals	130783.95		0.32	0.46	130933.27
Cement production	129920.00				129920.00
Glass & ceramic production	277.82		0.32	0.46	427.14
Other uses of soda ash	586.12				586.12
Chemicals	27888.86		11.14	17.33	33496.42
Ammonia production	10056.43				10056.43
Nitric acid production				16.05	4975.50
Carbide production	119.58				119.58
Titanium dioxide production	88.04				88.04
Methanol production	266.18				285.37
Ethylene production	7072.52		0.91		7270.64
EDC & VCM production	198.91		9.43		198.91
Ethylene Oxide production	93.64				97.71
Acrylonitrile production	37.84		0.19		37.98
Carbon Black production	1155.52		0.01		1156.07
Caprolactam			0.03		336.22
Other chemical	8800.21				8873.97
Metals	122371.43		0.56	1.08	122736.91
Iron & Steel production	116958.37		0.95	0.20	117315.63
Ferroalloys production	2460.70		0.85	1.11	2462.29
Aluminum production	2728.87		0.08	1.09	2729.91
Lead production	84.13		0.01		86.38
Zinc production	76.11		0.00	0.00	77.99
Copper	63.25		0.00	0.01	64.70
Other Industries	123969.17		0.01	0.01	124530.44
Pulp and paper	5222.50		2.37	0.00	5248.35
Food processing	27625.53		0.05	1.65	27717.25
Textile and leather	1861.11		1.12	0.08	1867.94
Mining and quarrying	1460.26		0.03	0.22	1464.62
Non-specific industries	87799.77		0.06	239.31	88232.28
Non energy product use	849.49				849.49
Lubricant					776.75
Paraffin wax					72.75

AGRICULTURE		**275358.00**	**13767.80**	**146.07**	**334405.50**
Enteric fermentation		67800.00	10099.80		212095.80
Livestock Manure management		207520.00	115.00	0.07	2436.70
Rice cultivation			3327.00		69867.00
Burning of crop residue		275358.00	226.00	6.00	6606.00
LULUCF		67800.00			-177028.00
Forestland		207520.00			-67800.00
Cropland	98330.00				-207520.00
Grassland		38.00			10490.00
Settlement		275358.00			-38.00
Wetland					NE
Other land	10490.00				NO
Fuel wood use in forests					87840.00
Waste	NE				57725.18
Municipal Solid waste	NO				12694.71
Domestic waste water	87840.00		2515.58	15.80	22980.47
Industrial waste water			604.51		22050.00
Bunkers*			861.07	15.80	3484.45
Aviation Bunkers			1050.00		3355.31
Marine bunkers			0.03	0.10	129.14
					Source: INCCA Report-2007

Note: LULUCF: Land Use Land Use Change & Forestry, * Not included in the National totals, NE: Not estimated; NO: Not Occurring.



Distribution 30 Forest Strata Across India

5.2 Green House Gases (GHGs) Emissions Inventory- Himachal Pradesh

The existing GHG emissions have been worked out for sector and sub-sectors viz. Transport, Buildings, Industry, Waste, Agriculture and Forests. The assessment provides an in site on the predominant emissions of Green House Gases (Carbon Dioxide (CO_2), Methane (CH_4) and Nitrous Oxide (N_2O) emitted as a result of anthropogenic activities at the State level from sectors like Energy, Industry, Agriculture, Waste, and Land Use Land Use Change & Forestry (LULUCF).

	Annual CO_2 emissions (eq) (in thousands of metric tonnes) Giga Gram	**Percentage of Global total**
India	17,27,706.10	<5% of global
Himachal Pradesh*	**10082.87*** ~0.00147 per capita 000'tones*	~0.67% of India*

** Without taking into consideration emission/ removals due to hydro power generation 6,419 MW contributed to grid as clean energy. ~ (-)* 15,397.191 000'tons CO_2 eq @ ~ 50% operational capacity.

The source of the activity data taken for deriving calculations is primarily from the published documents of different organizations in the State and the studies carried out by HPSCST&E, HPSPCB, Departments of Transport, Economic and Statistics, HPSEB, Forests and Agriculture etc. The methodology, emission factors used in calculations has been drawn from the INCCA country specific references available in IPCC publications. The methodology tier level presented is also a 'mix type'.

5.2.1 Methodology Adopted for Estimation of GHGs Emissions

In Himachal Pradesh the estimated volume of the Greenhouse Gas emissions have been worked out as per the standard methodologies contained in IPCC Guidelines (IPCC 1997, 2000 and 2003):

$$\text{Emissions}_{gas} = \Sigma_{category} A \times \text{Emission Factor (EF)}$$

Where; Emission_{gas} is the emissions of a given gas from all source categories.
A is amount of individual source category utilized that generate emissions.

EF is the emission factor of a given gas as per type of source category.
Following sectors have been considered in the State contributing for GHGs emissions:
Energy, Industry, Agriculture, Land Use, Land Use Change * Forest (LULUCF) and Waste.

<u>Methodology Tiers</u>

Tier 1 approach employs activity data that are relatively coarse, such as nationally or globally available estimates of deforestation rates, agricultural production statistics, and global land cover maps.

Tier 2 use the same methodological approach as Tier 1 but applies emission factors and activity data which are defined by the country.

Tier 3 approach uses higher order methods are used including models and inventory measurement systems tailored to address national circumstances, repeated over time, and driven by disaggregated levels.

The emission reductions by the project activity (ER_y) during a given period of year y are the product of the baseline emissions factor (EF_y, in tCO_2e/MW) times the electricity supplied by the project to the grid at the same period of year y (EG_y, in MW), as follows: *(*ref. Cachoeira Encoberta*).

$$ER_y = EF_y . EG_y$$

As in all scientific endeavors; any estimate provided is necessarily contingent upon the availability of data and information. Over time the coefficients will be refined, methodologies and data sources improved therefore, it is anticipated that there will be adjustments in future iteration, to keep pace with scientific convention and good practice.

Green House Gas Emissions by Sources & Removal by Sink (with LULUCF) from Himachal Pradesh in 2007-08- 09 (000'tons) Giga Grams (Table-22)

(Following IPCC convention in calculating GHGs footprint at source of production and not consumption)

Table 22: GHGs Emissions from different sources in Himachal Pradesh

Sr. No.	Type	GHG (000'tones) G grams			
		CO_2	CH_4	N_2O	CO_2 eq
A.	Electricity/ Energy				
1.	Captive Generation and Consumption	358.056	0.01823	0.000742	358.670
2.	**Transport**				
a.	Road	655.14	0.012	0.0032	667.28
b.	Railways	0.0012	-	-	0.0014
c.	Aviation	0.0011	-	-	0.0012
3.	**Others**				
a.	Residential	911.525	3.555	0.4765	1809.72
b.	Industrial/ Commercial/ Institutional/ Bulk mics.	3183.27	0.346	0.0768	3213.984
c.	Agriculture	15.66	0.00056	0.000555	15.840
Total	A	**5123.6533**	**3.93179**	**0.557797**	**6065.497**
B.	Industry				
1	**Mineral**				
a.	Cement Production	5170.39	-	-	5170.39
b.	Glass Production	0.971713	0.0012	0.00161	1.49397
2	**Chemical**				
a.	Carbide Production	26.488	-	-	26.488
b.	Methanol	4.775	0.00163903	0.007906	5.11925
3	**Metal**				
a.	Ferroalloys	82.170	0.00396	-	82.2231
b.	Aluminum	170.399	0.000624	-	170.464
C.	Lead (Secondary Production)	28.192	-	-	28.946
d.	Zinc production	0.0191	-	-	0.0191
4	**Other Industries**				
a.	Pulp & Paper	0.02312	0.00000022	0.000000354	0.02323
b.	Textile & Leather	0.042	0.00000049	0.000000096	0.01204
c.	Food Processing	0.012	0.00000068	0.000000451	0.042154
d.	Mining and Quarrying	0.0022	-	-	0.00221
Total	B	**5483.484**	**0.007424**	**0.009517**	**5485.223**

A. Agriculture					
1.	Enteric fermentation	-	0.1134	-	2.3814
2.	Manure management	-	0.00129	0.00000076	0.02733
3.	Rice cultivation	-	7.0445	-	147.9936
4.	Crop residue	-	0.478	0.0399	13.972
5.	Soils	-	-	0.00152	0.475
Total	**C**	**-**	**7.63719**	**0.04142**	**164.84933**
D Land Use, Land Use Change & Forestry					
1.	Forestland	(-) 2917.70	-	-	(-) 2917.70
2.	Cropland	(-)69.68	-	-	(-)69.68
3.	Grassland	(+)36.27	-	-	(+)36.27
4.	CO_2 loss due to fuel wood use	(+) 1318.41	-	-	(+) 1318.41
Total	D	**(-)1632.70**	-	-	**(-)1632.70**
E Waste					
1.	MSW	-	0.0271471	-	-
2.	Industrial Waste Water	-	0.0001366	-	0.006129
Total	**E**		**0.0272837**		**0.006129**
Grand Total A+B+C+D+E		**8974.437**	**11.60369**	**0.608734**	**10082.87**

5.2.2 Key Results

- The net Green House Gas (GHG) emissions from Himachal Pradesh that is emissions with LULUCF, for activity data base for year 2009 were 10.083 million tons of CO_2 equivalent (eq) of which
  - CO_2 emissions were 8.97 million tons;
  - CH_4 emissions were 0.116 million tons; and
  - N_2O emissions were 0.0061 million tons.
- GHG emissions from Energy, Industry, and Agriculture sectors constituted 51.77% (6065.497 Gg), 46.82% (5485.223 Gg), 1.41% (164.85 Gg)) of the net CO_2 eq emissions respectively. The contribution of Waste sector is quite marginal.
- Energy sector emitted 6.07 million tons of CO_2 eq, of which 3.21 million tons of CO_2 eq were emitted from electrcity consumption in Industrial, Commercial and Institutional sectors and 1.81 million tons of CO_2 eq were emitted from energy consumption in Residential sector.
- Industry sector emitted 5.49 million tons of CO_2 eq.
- LULUCF sector was a net sink. It seqestrated 1.63 million tons of CO_2 eq.
- Himachal Pradesh per capita CO_2 eq emissions including LULUCF were 1.47 tons/ capita in 2009.

From the analysis it is concluded that in Himachal Pradesh, the majority of emissions are from energy consumption by industry, commercial, tourism, institutions etc. besides the emissions from cement manufacturing industry. The sector wise description is as under:

1. Energy: The Energy sector emitted 6.066 million tons of CO_2 eq due to fossil fuel combustion in electricity generation in captive plants, transport, commercial/institutional establishments, agriculture, and energy intensive industries such as cement, steel and secondary metallurgical processing plants, including energy demand from Residential sector. Fugitive emissions from vehicles also accounted for in the Energy sector.

a. **Energy consumption for Industry, Tourism, Commercial, Institutional etc.:** The energy demand/ consumption in industry, tourism, commercial, institutional etc. activities emitted 3.214 million tons of CO_2 eq. which is about 52.99 % of the total CO_2 eq. emissions from Energy sector.
b. **Residential:** The Residential sector in Himachal Pradesh is one of the major consumers of electricity, fuel, LPG etc. outside the energy industries. Total green house gas emissions from this sector were 1.81 million tons of CO_2 eq. about 29.84 % of the total CO_2 eq emissions for Energy sector.
c. **Transport:** The Transport sector emissions are reported from road transport, aviation, railways. In Himachal Pradesh, the Transport sector emitted 0.667 million tons of CO_2 eq. Road transport being the dominant mode of transport in the State, emitted 99.99% of the total CO_2 equivalent emissions from the Transport sector. The railway and aviation in comparison only emitted 0.01%% of the total CO_2 eq emissions.
d. **Captive Power Generation and Consumption:** The total greenhouse gas emissions from captive power generation and consumption by industries were 0.358 million tons CO_2 eq. The CO_2 eq emissions from electricity generation were 5.91% of the total CO_2 eq emitted from the Energy sector. It has been assumed that coal use constituted about 55% of the total fuel mix used.
e. **Agriculture:** The energy demand/ consumption in agriculture activities emitted 0.0158 million tons of CO_2 eq. which is about 0.26 % of the total CO_2 eq. emissions from Energy sector.

2. Industry: In Himachal Pradesh of 11.707 million tons of CO_2 eq Industrial activities together emitted 5.486 million tons of CO_2 eq of GHG. Industry sector emissions have been estimated from data base for production process manufacturing of cement, glass, metals, chemicals, other specific industries. The emissions covered in the Industry sector include the process based emissions.

a. **Cement and Glass Production:** The cement industry emitted 5.17 million tons of CO_2, which is 94.26% of the total CO_2 eq emissions from the Industry sector. The emissions cover all the large, medium and mini cement plants, grinding plants. The other ones like glass production emit 1.494 000' tons of CO_2 eq.
b. **Metals:** The metal industry viz. aluminium, ferroalloys, lead, zinc and copper production lead to an emission of 0.282 million tons of CO_2 eq. about 5.14% of the total of CO_2 eq emissions.
c. **Chemicals:** The chemical industries together emitted 0.0316 million tons of CO_2 eq. about 0.57% of the total of CO_2 eq emissions.
d. **Other Industries:** Other industries comprising of pulp/paper, leather, textiles, food processing , mining and quarrying, and non specific industries comprising of rubber, plastic, watches, clocks, transport equipment, furniture etc., together emitted 0.0796 000' tons of CO_2 eq. which constitute very little about 0.002% of total emissions from this sector.

3. Agriculture: The Agriculture sector estimated to be emitting 0.165 million tons of CO_2 eq. Estimates of GHG emissions from the Agriculture sector arise from enteric fermentation in livestock, manure management, rice cultivation, on field burning of crop residue and agricultural soils.

a. **Livestock:** Enteric fermentation in livestock released 2.3814 000' tons of CO_2 eq (0.1134 000 tons of CH_4). This constituted 1.45% of the total GHG emissions (CO_2 eq) from Agriculture sector in the State. The estimates cover all livestock, namely, cattle, buffalo, sheep, goats, donkeys, horses and others. Manure management emitted 0.02733 000' tons of CO_2 eq.

b. **Rice Cultivation:** Rice cultivation emitted 0.148 million tons of CO_2 eq or 7.0445 000' tons of CH_4. The emissions cover both type of rice cultivation, namely, irrigated, rainfed and upland rice cultivation. The upland rice is zero emitters and irrigated fields are only emitter of methane per unit area.

c. **Agricultural Soils and Field Burning of Crop Residue:** The total CO_2 eq emitted from these two sources were 14.45 000' tons about 8.77% of total CO_2 eq emissions. Agricultural soils are a source of N_2O, mainly due to application of nitrogenous fertilizers in the soils. Burning of crop residue leads to the emission of a number of gases and pollutants. Amongst them, CO_2 is considered to be $C_{neutral}$, and therefore not included in the estimations. Only CH_4 and N_2O are considered in this report.

4. **Land Use Land Use Change and Forest:** The LULUCF sector in Himachal Pradesh was a net sink. It sequestered 1632.70 000' tons of CO_2. The estimates from LULUCF sector include emission by sources and or removal by sinks from forest land, crop land, and grassland. Wet lands have not been considered due to lack of database.

a. **Forest Land:** Analysis indicate that forest land sequestered 2917.17 000' tons of CO_2 in Himachal Pradesh. However, deforestation due to developmental activities, fuel wood extraction in non-sustainable manner from forests led to an emission of 1318.41 000' tons of CO_2 in the State. This includes estimates of emissions and removal from biomass in very dense, moderately dense, open forests, and scrub lands.

b. **Crop Lands:** The crop land sequestered 69.68 000' tons of CO_2 in Himachal Pradesh. The emission estimates have been made from net sown area as well as fallow land.

c. **Grassland:** Pasture, grassland resulted in the emission of 36.27 000' tons of CO_2 due to changes in grass land area over a period of time.

5. **Waste:** The Waste sector emissions were 0.2728 000' tons of CH_4 from municipal solid waste management and industrial waste water management.

a. **Municipal Solid Waste (MSW):** It has been estimated that the MSW generation and disposal resulted in the emissions of 0.02715 000' tons of CH_4 in Himachal Pradesh. Systematic disposal of solid waste is carried out only in the major towns resulting in CH_4 emissions due to aerobic conditions generated due to accumulation of waste over the periods. It is observed that the municipal solid waste is the major nuisance in emission of GHGs in the State.

b. **Waste Water:** The waste water generation emissions are estimated only for waste water disposal from industries. Waste water management from industries emitted about 0.006129 000'tons of CO_2 eq.

5.2.3 Sector Wise Description of Green House Gas Emissions

5.2.3.1 Energy

In Himachal Pradesh the Energy sector emitted 6.0655 million tons of CO_2 equivalent. Out of this, 5.124 million tons were emitted as CO_2, 0.00393 million tons as CH_4 and 0.0006 million tons as N_2O. This does not include emission/ removals from electricity generation from hydro projects for distribution through grids. Of above, about 52.99% (3213.98 Gg) of the total CO_2 equivalent emissions from the Energy sector were due to electricity consumption by Industry, Commercial, Institutions and Tourism. The Residential sector has a rural and urban spread, and therefore it combusts both fossil fuel as well as biomass which together emitted 29.84% (1809.72 Gg) of the total GHG emitted from the Energy sector. The Transport sector emitted 11% (667.2826 Gg) of the total CO_2 equivalent emissions. Emissions due to captive power generation by various industries contributed about 5.91% (358.67 Gg). Rest of the 0.26% (15.84 Gg) GHG emissions were from energy consumption for agriculture.

Following the procedures laid in estimation of emissions by IPCC, in Himachal Pradesh the key constituent of GHGs emissions from energy sector are the electricity generation, combustion of fossil fuels, transportation, energy consumption by commercial, tourism, institutional, residential and agriculture sectors. The emission factor of the fossil fuels such as coal, oil and natural gas are the most important considerations in the country but in case of Himachal Pradesh it is very minute contributor.

Based on above activity data the GHGs emission 000' tones (or Giga Gram) from Energy sector in Himachal Pradesh is as under:

Sr. No.	Type	GHG emission 000' tones (or Giga Gram)			
		CO_2	CH_4	N_2O	CO_2 eq
1. Electricity					
	Captive Generation and Consumption	358.056	0.01823	0.000742	358.670
2. Transport					
	Road	655.14	0.012	0.0032	667.28
	Railways	0.0012	-	-	0.0014
	Aviation	0.0011	-	-	0.0012
3. Others					
	Residential	911.525	3.555	0.4765	1809.72
	Industrial/ Commercial/ Institutional/ Bulk Mics./Tourism	3183.27	0.346	0.0768	3213.984
	Agriculture	15.66	0.00056	0.000555	15.840
	Total:	**5123.6533**	**3.93179**	**0.557797**	**6065.497**

5.2.3.2 Emissions/ Removals from Hydro Power Generation

The equivalent GHGs emission form hydro power generation to the State assuming that the operational capacity is only @50% of total capacity annually:

Sr. No.	Type	GHG emission 000' tones (or Giga Gram)			
		CO_2	CH_4	N_2O	CO_2 eq
Hydro Power Generation					
1.	Power Generation (Hydro Power only) Estimated CO_2 removals are equivalent to kwh power to be replaced by hydro power contributed to the grid.	(-) 15322.795	-	-	(-)15397.191

Himachal Pradesh has been blessed with vast hydroelectric potential in its five river basins, namely Yamuna, Satluj, Beas, Ravi and Chenab. Through preliminary hydrological, topographical and geological investigations, it has been estimated that about 23,194.95 MW of hydel potential can be exploited in the state by constructing various major, medium, small and mini/micro hydel projects on these five river basins. Out of this hydel potential so far only 6,419 MW has been harnessed by various agencies. Although the requirement of energy in the State is not so huge but in the national interest the State is committed to contribute the clean energy to the national grid. The Government of Himachal Pradesh is promoting run-of-river projects which are environmentally benign.

A paper reports on the findings of a recent IAEA (International Atomic Energy Agency) expert meeting on the assessment of greenhouse gas (GHG) emissions from the full 'lifecycle' of hydropower. It discusses the different categories of hydropower plants in view of the two main sources of GHG emissions: first, direct and indirect emissions associated with the construction of the plants; second, emissions from decaying biomass from land flooded by hydro reservoirs.

In terms of GHG emissions, this report shows that, in most cases, hydropower is a good alternative to fossil fuelled power generation. For hydropower plants in cold climate, a typical GHG emission factor is 15 g CO_2 equivalent/kWh, which is 30-60 times less than the factors of usual fossil fuel generation. For some hydropower plants in tropical climates, theoretical calculations have shown that reservoir emissions could be very high. However, no measurements of emissions were taken from tropical reservoirs and the current level of research does not allow for a reliable evaluation. Research is urgently needed in humid tropical climates.

Hydropower's contribution to GHG emission control is related to avoided emissions (i.e., emissions that would occur if hydroelectricity had to be replaced by another fossil-fuelled energy source). The estimation of an appropriate value for avoided emissions is complicated, because there is not a single equation to calculate the emissions that are *not* produced at hydropower projects. The characteristics of avoided emissions depend on the type of power that is displaced by hydropower generation. If a kilowatt-hour (kwh) were not generated at the hydro plant, what plant would have generated it? The answer depends on a range of factors: the time of day, the plants already on the system, the plants available, their variable costs, the type of fuel they use, their efficiencies, even the transmission losses and constraints. The production of hydroelectricity is associated with significant reductions in the nation's GHG emissions, although the specific amount of this benefit is difficult to measure directly.

In a specialized documentation it is stated that impoundment of hydroelectric reservoirs induces decomposition of a small fraction of the flooded biomass (forests, peat lands and other soil types) and an increase in the aquatic wildlife and vegetation in the reservoir. The result is higher greenhouse gas (GHG) emissions after impoundment, mainly CO_2 (carbon dioxide) and a small amount of CH_4 (methane). However, these emissions are temporary and peak two to four years after the reservoir is filled. During the ensuing decade, CO_2 emissions gradually diminish and return to the levels given off by neighboring lakes and rivers. Hydropower generation, on average, emits one-thirty-fifth of the GHGs that a natural gas generating station does and about one-seventieth the GHGs that a coal-fired generating station does. (Ref. Hydro- Quebec's- Sustainable Development a specialized documentation).

The details of Generation, Consumption of Energy in the State of Himachal Pradesh is as follows:

Sr. No.	Type	Quantity
1.	Total Generation (2008-09) (Hydro Power only)	6419 MW
2.	Captive Generation and Consumption	~ 100 MW
3.	Electricity purchased from BBMB & other States	6047.497MU
4.	Energy Consumed by the State:	**6958.716MU**
	(a) Domestic	1089.118
	(b) Non Domestic & Non-Commercial	80.585
	(c) Commercial	274.663
	(d) Public lighting	13.013
	(e) Agriculture	28.738
	(f) Industries	3385.303
	(g) Govt. Irrigation & Water Supply Scheme	389.331
	(h) Temporary Supply	22.705
	(i) Bulk & Misc.-Tourism	1675.26
5.	Fuel Consumption	
	(a) Diesel *	**~530400 KL**
	(b) Petrol*	**~244800 KL**
	(c) Kerosene*	**~86000KL**
	**As per total sale/ consumption in Himachal Pradesh*	
6.	Transport (Vehicles registered) ± Tourist Taxis.	~5,38,341Nos.
7.	LPG (including DBG) Approx.	
	Indian Oil Corpn.	**~76800 MT/annum**
	Hindustan Petroleum	**~56100 MT/annum**

Source: HP Statistics Department, Indian Oil Corpn, HP Oil Corpn, and Transport. Department

5.2.3.3 Industry

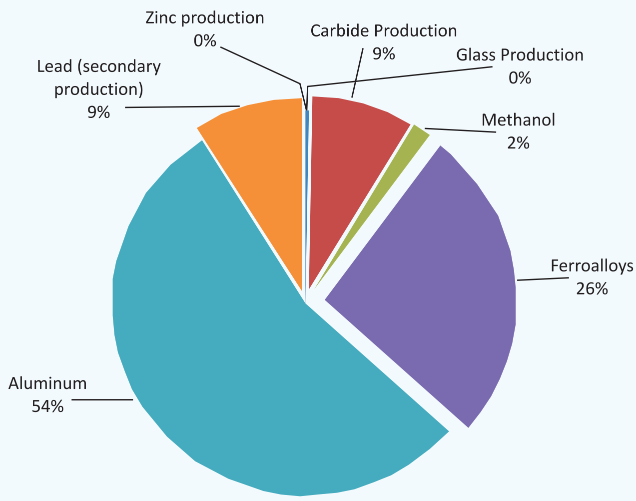
GHG emissions from the Industry sector in brief are as the total CO_2 equivalent emission from this sector was 5.485 million tons. Of which 5.484 million tons were of CO_2, 0.007424 000'tons of CH_4 and 0.00952 000'tons of N_2O. It is indeed a matter of concern that 94.29% of the total CO_2 equivalent emissions from Industry sector were from Cement production under Mineral industries categories, whereas, Glass production industries under this category emitted only 0.02%. 5.12% of the total GHG emissions were from Metal industries and about 0.57% of the total GHG emissions were from chemical industries. The Other industries consisting of pulp and paper, food & beverage, non-specific industries, textile & leather, and mining/ quarrying together emitted 0.0015% of the total GHG emission from the energy sector. The Industry sector includes emissions due to various processes involved and burning of fossil fuels. Broad categories which have been covered are Mineral, Chemical, Metal, Other including viz. Textile, Pulp and Paper, Food processing units.

Category	Emission Factor	Gas	Source
Cement	0.537 tCO_2 / t Clinker produced	CO_2	CMA 2010
Glass Production	0.21 tCO_2/ t glass (Container Glass); 0.22tCO_2/t glass (Fiber Glass); 0.03tCO_2/t glass (Specialty Glass)	CO_2	IPCC, 2006
Carbide Production	1.1tCO_2/$tCaC_2$ produced	CO_2	IPCC 2006
Methanol	0.67 tonsCO_2/tons TiO_2 produced 2.3 kg CH_4/tons Methanol produced	CO_2 CH_4	IPCC 2006
Ferroalloys	4.8 tonsCO_2/ton Ferrosilicon produced; 1.5 ton CO_2/ton Ferromanganese produced; 1.1 kg CH_4/Ferrosilicon produced	CO_2 CH_4	IPCC 2006
Aluminum	1.65 ton CO_2/ton Aluminum produced	CO_2	IPCC
Lead (Secondary Production)	0.58 ton CO_2/ton Lead produced (Imperial Smelting Furnace); 0.25 ton CO_2/ton Lead produced (Direct Smelting); 0.2 ton CO_2/ton Lead produced (Secondary Production);	CO_2	IPCC 2006 (Avg. EF)
Zinc production	0.53 ton CO_2/ton Zinc produced (Pyro-metallurgical Mrocess)	CO_2	IPCC 2006

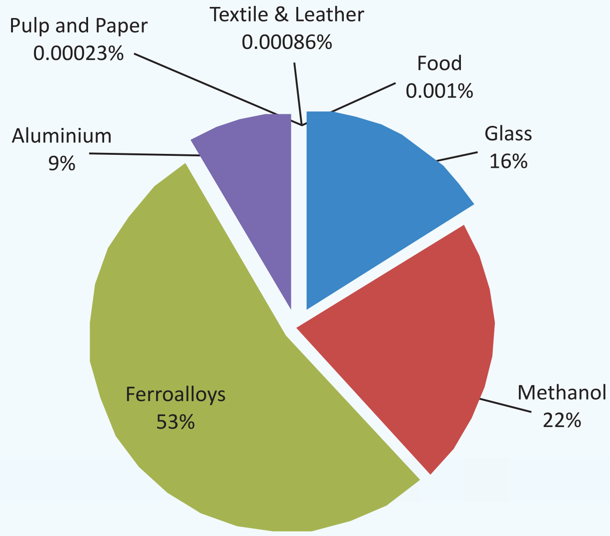
Source: IPCC & NICCA Report 2007

Type	**GHG emission 000' tones (or Giga Gram)**			
	CO_2	**CH_4**	**N_2O**	**CO_2 eq**
Mineral				
Cement Production	5170.39	-	-	5170.39
Glass Production	0.971713	0.0012	0.00161	1.49397
Chemical				
Carbide Production	26.488	-	-	26.488
Methanol	4.775	0.00163903	0.007906	5.11925
Metal				
Ferroalloys	82.170	0.00396	-	82.2231
Aluminum	170.399	0.000624	-	170.464
Lead (secondary production)	28.192	-	-	28.946
Zinc production	0.0191	-	-	0.0191
Other Industries				
Pulp & Paper	0.02312	0.00000022	0.000000354	0.02323
Textile & Leather	0.042	0.00000049	0.000000096	0.01204
Food Processing	0.012	0.00000068	0.000000451	0.042154
Mining and Quarrying	0.0022	-	-	0.00221
Total	**5483.484**	**0.007424**	**0.009517**	**5485.223**

Activity database Source: HPSPCB & Industries Department



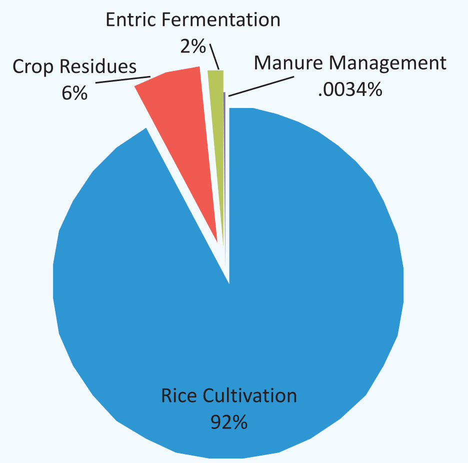
CO_2 Emissions from Industrial activities other than Cement in Himachal Pradesh



CH_4 Emissions from Industrial production in Himachal Pradesh

5.2.3.4 Agriculture

Agriculture sector emitted 0.164 million tons of CO_2 equivalent, of which 0.0076 million tons were CH_4 and 0.414 thousand tons were N_2O. The majority of emissions i.e. about 89.78% were from rice cultivation. Burning of Crop residue emitted 8.48% of the total CO_2 equivalent emissions from this sector; where as 1.45% of the emissions were due to enteric fermentation. However, Crop soils emitted 0.29% of the total CO_2 equivalent emission from Agriculture and 0.017% of the emissions were from Livestock manure management.



CH_4 emissions from Agriculture Sector in Himachal Pradesh

The emissions from Agriculture sector are mainly in the form of CH_4 from rice paddy cultivation and enteric fermentation. However, the N_2O emissions are due to use of fertilizers in the agricultural fields. The sources included for calculations in Himachal Pradesh are Livestock; Enteric fermentation, Animal manure, Rice cultivation; Irrigated & Rainfed, Agriculture soils; direct emissions & indirect emissions, and Field burning of agriculture crop residue etc.

5.2.3.4.1 Enteric Fermentation

In Himachal Pradesh the livestock nurture is an integral part of hill culture and is also an important component of the agricultural activities. Live stock which includes cattle, buffaloes, sheep, goat, horses, ponies, mules, donkeys, pigs, dogs, yaks, and other live stock are the major source of methane emissions (CH_4). Cattle and buffalo are the main milk producing animals in the State and constitute about 56 % of the total live stock population. In order to estimate the CH_4 emission from livestock, the cattle population has been divided into

dairy and nondairy categories. The emission factors provided in the report (NATCOM, 2004) have been used to calculate the emissions.

5.2.3.4.2 Animal Waste/Dung

In Himachal Pradesh the waste –dung is mainly converted into manure, little percentage in to dung cake for energy purposes in the rural areas. The dung management practices vary in different districts depending upon the need of the fuel and manure. Due to availability of fuel wood, the dung cake practice is less practiced in the State. The manure is major way of use of dung. To convert the cattle and buffalo dung into manure, the dung is collected on the heap nearby to the animal shed. The residual feed and ash (available from kitchen etc.) are also put on the heap.

The dung, thus collected is exposed to the weather conditions and methane emission is expected from the inner core of the heap due to the anaerobic fermentation of organic matter. IPCC (1997) also attributed this fact. The manure thus prepared is generally taken to the fields, orchards at the time of soil preparations after the monsoon season or at the time of need.

Part of the dung of cattle and buffaloes goes directly to the soil and deposited on the soil during the course of grazing. In Himachal Pradesh, large forest areas and natural pastures are available for grazing and animals not only survive on grazing in such areas but also are allowed to graze on road side, canal bunds, fellow lands and harvested fields. The excreta of grazing animals dry up quickly due to the mixing with soil during the trampling by the animals and do not produce methane as suggested by IPCC (1997).

Type	GHG emission 000' tones (or Giga Gram)	
	Methane (CH_4)	N_2O
Enteric fermentation	0.1134	-
Manure: Animal Waste/ dung	0.00129	0.00000076

The dung of goat and sheep goes directly to the soil and farmer's value for this source of Nitrogen (N), Phosphorous (P), and Potassium (K) for their soil. Normally in winters (from Nov- Feb) in most of the areas, farmers invite the nomadic shepherds along with their flock after the harvesting is over so that the flock can sit on the harvested field and consume the stubble and provide the nutrients from their dung and urine to the field. Traditionally shepherds are obliged with food and shelter till their flock sits on the field. The dung of other species such as donkey, horses directly goes to the soil deposition due to their daily mobility.

5.2.3.4.3 Rice Cultivation

In our country, rice is cultivated under various water management options, depending on the availability of water across the country. In the mountainous regions, rice is grown in terraces created along the side of the mountains. In most of the northern plains and some parts of the eastern region, rice is cultivated by irrigating the fields intermittently or continuously, for a considerable period of time. In other parts of the country, however, rain-fed rice cultivation is predominant where water is only available in the fields during rains. Deep-water rice cultivation, with a water depth ranging from 50-100 cm. is also practiced in the coastal regions of West Bengal and Orissa. In coastal areas two or three crops are taken annually.

The rice cultivation is under taken in about 79,000 hectare area. The State is primarily dependent on rains and river water and takes single crop. The rain fed area is around 45% and irrigated area is 55% of the total cropped area. The emissions from the sector are as follows:

Eco system	Rice cultivation area ha	Methane (CH_4) (000'tons)
Rain fed (upland only)	35,550	-
Irrigated	43,450	7.0445
		Source: HP Agriculture Department

The CH_4 emissions from rice cultivation have been estimated by multiplying the seasonal emission factors by the annual harvested areas. The annual amount of CH_4 emitted from a given area of rice is a function of the crop duration, water regimes and organic soil amendments. The total annual emissions are equal to the sum of emissions from each sub-unit of harvested area using the following equation.

$$Ch_4\,Rice = \sum_{i,j,k} (EFi, j, k \times Ai, j, k \times 10^{-6})$$

Where,

CH_4 Rice = Annual methane emissions from rice cultivation, Gg CH_4/yr;

EFijk = A seasonal integrated emission factor for i, j, and k conditions, kg CH_4 /ha;

Aijk = Annual harvested area of rice for i, j, and k conditions, ha /yr;

i, j, and k = Represent different ecosystems, water regimes, type and amount of organic amendments, under which CH_4 emissions from rice may vary.

Separate calculations were undertaken for each rice ecosystems (i.e., irrigated, rainfed upland rice production).

The upland rice area is 35,550 ha and is a net sink of CH_4, as no anaerobic conditions are generated at these heights.

5.2.3.4.4 Agriculture Soils

N_2O emissions are estimated using details of human-induced net N additions to soils (e.g., synthetic or organic fertilizers, deposited manure, crop residues, sewage sludge), or of mineralization of N in soil organic matter following drainage/ management of organic soils, or cultivation/land-use change on mineral soils (e.g., Forest Land/Grassland/Settlements converted to Cropland). Nitrous oxide is produced naturally in soils through the processes of nitrification and denitrification. Nitrification is the aerobic microbial oxidation of ammonium to nitrate, and denitrification is the anaerobic microbial reduction of nitrate to nitrogen gas (N_2). Nitrous oxide is a gaseous intermediate in the reaction sequence of denitrification and a by-product of nitrification that leaks from microbial cells into the soil and ultimately into the atmosphere. One of the main controlling factors in this reaction is the availability of inorganic Nitrogen (N) in the soil.

In Himachal Pradesh the distribution of fertilizers (in nutrients) N, P & K:

Nitrogen (N) = 31042 MT

Source: HP Economics & Statistics Department

The emissions of N_2O that result from anthropogenic N inputs or N mineralization occur through both a direct pathway and through two indirect pathways: (i) following volatilization of NH_3 and NO_x from managed soils and from fossil fuel combustion and biomass burning, and the subsequent re-deposition of these gases and their products NH_4^+ and NO_3^- to soils and waters; and (ii) after leaching and runoff of N, mainly as NO_3^- from managed soils. Therefore, total N_2O emitted from soils can be represented as:

$$N_2O\text{-}N_{TOTAL} = N_2O\text{-}N_{DIRECT} + N_2O\text{-}N_{INDIRECT}$$

Using the above methodology, the total N_2O emissions from Himachal Pradesh are estimated to be 0.00152 (000' tons). The emission factors used for rice–wheat systems are 0.76 for rice and 0.66 kg ha^{-1} N_2O –N for wheat for urea application.

5.2.3.4.5 Burning of Crop Residues

Crop residue is burnt in the fields in many districts of the State such as Kangra, Mandi, Una, Kullu, Shimla, Hamirpur, Bilaspur, Solan producing CO, CH_4, N_2O, NO_x, SO_2 and many other gases. We have calculated only the CH_4 and N_2O emissions by using the equation given below.

EBCR = Σ crops (A x B x C x D x E x F)

Where, EBCR= Emissions from Residue burning
A = Crop production
B = Residue to crop ratio
C = Dry matter fraction
D = Fraction burnt
E = Fraction actually oxidized
F = Emission factor

The estimation of emission of targeted species was arrived at by first estimating the amount of biomass actually burnt in the field using the IPCC Revised Inventory Preparation Guidelines (IPCC, 1996). Currently, wastes from three crops viz., rice, wheat, maize are subjected to burning. The state's crop production figures for 2007 have been used as the basic activity data.

The dry matter fraction of crop residue is taken as 0.8 (Bhattacharya and Mitra, 1998), 0.25 as fraction burned (IPCC, 1997) in field and 0.9 as the fraction actually oxidized (IPCC, 1997). Crop specific values of carbon fraction were as per IPCC default values. The default N/C ratios were taken from IPCC (2006). Further, the emission ratio was calculated using emission factors given by Andreae and Merlet (2001) which are the default factors mentioned in IPCC (2006) National Inventory Preparation Guidelines.

Using this methodology, it is assumed that in Himachal Pradesh 0.478 (000' tons) of CH_4 and 0.0399 (000' tons) of N_2O was emitted from burning of crop residue in the fields.

The GHG emission (000'tons) from the sector is as under:

Sr. No.	Type	CO_2	CH_4	N_2O	CO_2 eq
1	Enteric fermentation	-	0.1134	-	2.3814
2	Manure management	-	0.00129	0.00000076	0.02733
3	Rice cultivation	-	7.0445	-	147.9936
4	Crop residue	-	0.478	0.0399	13.972
5	Soils	-	-	0.00152	0.475
	Total	**-**	**7.63719**	**0.04142**	**164.84933**

5.2.3.5 Land Use, Land Use Change & Forest (LULUCF)

Land Use, Land Use Change & Forest (LULUCF) are one of the key components of the Greenhouse Gas Emission summary. It involves estimation of carbon stock changes, CO_2 emissions and removals and non-CO_2 GHG emissions. For estimating GHG emissions from this sector, the GHG inventory guidelines followed at National level i.e. *IPCC – 2003 GPG* approach due to advantages of reporting tables, the Himachal Pradesh has followed the same procedure.

Methodology: *IPCC GPG 2003* adopted six land categories to ensure consistent and complete representation of all land categories, covering the total geographic area of a country or a State.

The GPG 2003 adopted three major advances over IPCC 1996 guidelines, such as:

- Introduction of three hierarchical tiers of method that range from default data and simple equations to use country specific data.
- Land use category based approach for organising the methodologies.
- Provides guidelines for all the 5 carbon pools.

Methods adopted in Good Practice Guidelines (GPG 2003) are as under:

1. Land category based approach covering forest land, cropland, grassland, wetland, settlement and others.
2. These land categories are further sub divided into; - land remaining in the same use category differently - other land converted to this land category.
3. Methods given for all carbon pools; AGB, BGB, dead organic matter and soil carbon and all non-CO_2 gases.
4. Key source/sink category analysis provided for selecting significant land categories; - sub-land categories- C-pools - CO_2 and non-CO_2 gases.
5. Three tier structures presented for choice of methods, Activity Data and Emission Factors.
6. Biomass and soil carbon pools linked particularly in Tier 2 and Tier 3.

5.2.3.5.1 Carbon Stock Changes

Carbon stock change is the sum of changes in stocks of all the carbon pools in a given area over a period of time, which could be averaged to annual stock changes. A generic equation for estimating the changes in carbon stock for a given land use category is as follows:

$\Delta C_{LUi} = \Delta C_{AB} + \Delta C_{BB} + \Delta C_{DW} + \Delta C_{Li} + \Delta C_{SC}$

ΔC_{LUi} is the carbon stock change for a land use category,

AB is above ground bio mass, BB is below ground bio mass, DW is dead wood, Li is litter and SC is the soil carbon.

For the purpose of this equation the stock change has been estimated for each pool by using following method- Carbon 'stock-change' or stock difference'

$$\Delta C = (C_{t2} - C_{t1}) / (t_2 - t_1)$$

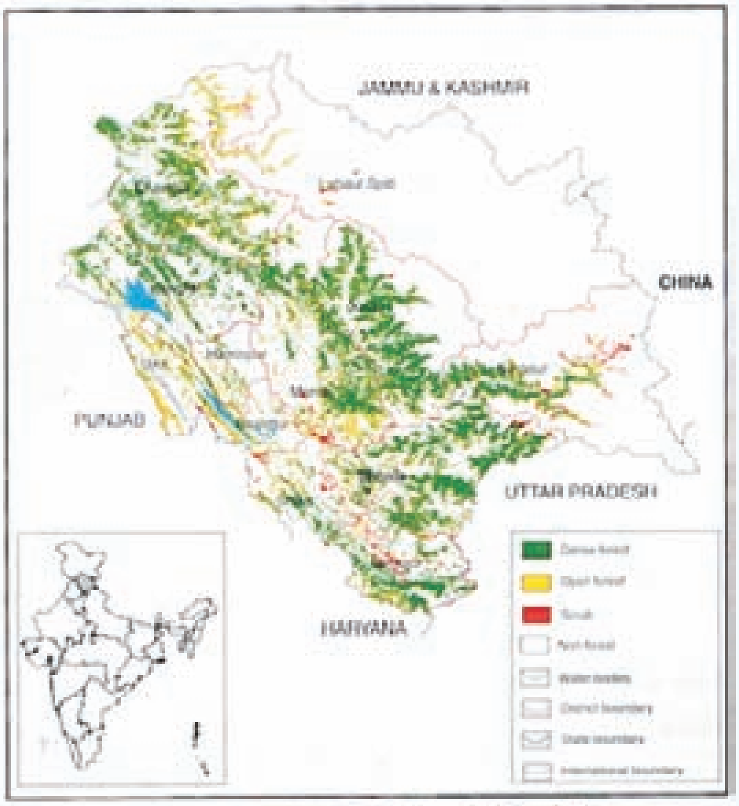
Where: ΔC is the annual carbon stock change in the pool, C_{t1} is at time t_1 and C_{t2} is at time t_2 in the same pool.

In Himachal Pradesh GHG inventory has been prepared by taking the activity data available at National and State level. Land use change matrix has been prepared using land use data for 2005 and 2007. The area under forest has been obtained from Forest Survey of India Report, 2009 and area under other land categories has been sourced from Directorate of Land Record reports for the years 2005 and 2007.

Land Use Pattern of Himachal Pradesh (*Source FSI, 2009*)		
Land Use	**Sub Category**	**Area ha**
Forest	Very dense	3,22,400
	Moderately dense	6,38,300
	Open	5,06,100
	Total	14,66,800
Crop Land	Net sown area	54,300
	Fallow	7,400
	Total	61,700
Grass land	Grazing land and pastures	1,50,100
	Scrubs	33,100
	Total	1,83,200
Other land	Other land	38,45,600 ha

Himachal Pradesh, Predominantly a mountainous State in the Western Himalayas, has a geographical area of 55,673 km^2. The altitude of the State varies from 350 m to 6,975m above the mean sea level. It is located between latitude $30^0$22' to 33^0.12' N and longitude75^0 45' to79^0 04' E. The State has three distinct regions viz the Shiwaliks with altitudes up to 1,500 m, Middle Himalayan region between 1,500 m to 3,000 m and the *Himadris* higher than 3,000m.

About one third of the State is permanently under snow glaciers and cold deserts where tree growth is minimal due to harsh conditions. The overage annual rainfall is about 1,800 mm. The temperature varies from sub-zero to 35°C. The major rivers are Satluj, Beas, Ravi, Chenab and Yamuna. The land use pattern of the State is given in Table. As per Census 2011, the total population of the State is 6.85 million of which the rural population constituted 89.96%. The population density is about 120 persons per km^2. The Scheduled Tribes constituting around 4.02% of the population ore mainly distributed in three districts. The livestock population as per Livestock Census 2003 is 5.12 million, which has increased marginally since the previous Census (1992).



Forest cover of Himachal Pradesh

5.2.3.5.2 Land Use Change Matrix

The recorded forest area of the State is 37,033 km^2. Reserved Forests constitute 5.l3%, Protected Forests 89.27% and Un-classed Forests 5.60% of the total forest area. About two third of the State's geographical area is under recorded forests. But a substantial part of this is not conducive for tree growth, being under permanent snow, glaciers and cold deserts. The forest cover in the State, based on interpretation of satellite data of Oct 2006 - Jan 2007, is 14,668 km^2, which is 26.35% of the State's geographical area. In terms of forest canopy density classes, the State has 3,224 km^2 very dense forest, 6,383 km^2 moderately dense forest, and 5,061 km^2 open forest. As per data there has been a decrease of 3 km^2 in the moderately dense forest and an increase of 5 km^2 in open forest.

Land Use Change Matrix of Himachal Pradesh

Land Use	Sub Category	Area ha 2005-06	Area ha 2007	Change in area ha
Forest	Very dense	3,22,400	3,22,400	-
	Moderately dense	6,38,600	6,38,300	(-)300
	Open	5,05,600	5,06,100	(+)500
Crop Land	Net sown area	54,140	54,300	(+)160
	Fallow	7,520	7,360	(-)160
Grass land	Grazing land and pastures	1,50,100	1,50,100	-
	Scrubs	33,100	32,700	(-)400
Other land	Other land	38,45,600	38,45,800	(+)200

(*Source FSI, 2009 and Agriculture, Land Records Reports*)

5.2.3.5.3 Assessment of Carbon Stock from Forests

An assessment of Growing stock, Biomass and Carbon stock of Indian forests strata wise have been made by FSI based on SFR, 1997 data base, as per the 2002 report the Forests carbon stocks are as under:

Particulars	India (1997)	HP (1997)
Forest Cover (KM^2)	6,33,357	12,521
Growing Stock (000, m^3)	43,40,027.96	2,47,483.99
Bio Mass (000, tons)	23,95,373.45	1,06,442.18
Carbon (000 tons)	10,83,809.74	48,909.11

Similarly, the estimates for year 2005 and 2007 for Carbon stock under Forest sector are as under:

Particulars	India		HP	
	2005	2007	2005 (Based on 2003 assessment)	2007
Forest Cover (KM^2)	6,90,200	6,91,600	14,353	14,668
Growing Stock (000, m^3)	47,29,540.05	47,39,133.67	2,83,694.41	2,89,920.50
Bio Mass (000, tons)	26,10,357.11	26,15,651.95	1,22,016.18	1,24,694.03
Carbon (000 tons)	11,81,080.31	11,83,479.75	56,065.21	57,295.65
				Source: FSI Report

5.2.3.5.4 Soil Carbon Stock

As per Forest Survey of India, 2005 the forest cover in the State was spread over 14,35,300 ha which was 14,66,800 ha in 2009 and the agriculture-crop area was 61,660 ha in 2005 and 61,700ha in 2009. Based on an assessment w.r.t. carbon store in Giri catchment of the State conducted by Forest Research Institute, Dehradun, it has been inferred that on an average HP Forests have 61.68 t/ha soil carbon store and 53.74 t/ha average soil carbon store in agriculture sector. Therefore, applying these averages the soil carbon stock has been estimated for H.P. as follows:

Particulars	HP in hectare		C stock in million tons/ ha	
	2005 (Based on 2003 assessment)	2007	2005	2007
Forest Cover (ha)	14,35,300	14,66,800	88.52	90.47
Crop Land (ha)	61,660	61,700	3.314	3.316
Total estimated area	14,96,960	15,28,500	91.834	93.786

The carbon stock estimates combined in terms of

- Above ground biomass
- Belo ground bio mass and
- Soil Carbon.

Himachal Pradesh estimated emissions from Forest sector during 2007, based on 2003 and 2007 stock changes is given as below:

Carbon Pools	C stock in million tons 2005 (Based on 2003 assessment)	C stock in million tons 2007	Change in C stock in million tons (2003-2007)	CO_2 removal in million tons during 2007
	A	B	C=A-B	D= C x 44/ 12
Above ground biomass	56.065	57.296	-0.3078*	-2.1284
Below ground biomass				
Soil Carbon	91.834	93.786	-0.488	-1.7893
Total	147.899	151.082	- 0.7958	-2.9177

The emissions and removals for biomass and soil carbon for land categories with land remaining in the same categories based on National Mean Annual Increments are detailed as follows:

Land Use categories	MAI in perennial above ground biomass (t/ha/y)	MAI in perennial below ground biomass (t/ha/y)	MAI in total perennial biomass (t/ha/y)	MAI in soil carbon (t/ha/y)	MAI in total Carbon (t/ha/y)	Net DC (Mt C)	Net Change in CO2 (Mt)
	A	B	A+B	C	D=(A+B)/2 +C	E= DxArea	F= E x 3.6666 (+ is Emission, - is Removal
Crop Land	0.130	0.046	0.176	0.220	0.308	0.019004	- 0.0696801
Grass Land	0.003	0.001	0.004	-0.056	-0.054	0.009893	+0.036273

The net CO_2 emission/ removal for LULUCF sector is given below. This includes CO_2 net emissions and removals from land categories. The net CO_2 emissions include gain and loss of CO_2. The loss of CO_2 is largely due to extraction and use of fuel wood from felling of trees which is not very large amount. Over all, the net CO_2 emissions / removal estimate shows that the sector is a net sink of 1,632.70 (000' tons) CO_2. The sector is a net sink due to uptake of CO_2 by the cropland followed by forest land. This is a preliminary estimate and may change with improved activity data and emission factor estimates.

Emissions in 000'tons			
Land use categories	**CO_2 emissions/ removals**	**CO_2 loss due to fuel wood use**	**Net CO_2 emissions/removal**
Forestland	(-) 2,917.7	(+) 1,318.41	(-) 1,632.70
Cropland	(-)69.68		
Grassland	(+)36.27		
Total	(-) 2,951.11	(+) 1,318.41	(-) 1,632.70
Removal (-) Emission (+)			

Green Felling of tree etc. is completely banned in Himachal Pradesh; therefore the use of fuel wood in the State is much lower than the assumed National level %age. Source of fuel wood is also not known, so assumed to come from all land categories. About 2-3% of the fuel wood consumption is estimated to come from felling of trees leading to net CO_2 emission.

5.2.3.6 Solid Waste & Waste Water (Industrial)

The total GHG released from waste sector in Himachal Pradesh 6.129 tons of CO_2 equivalent, of which, 27.284 tons were emitted as Methane (CH_4). Municipal Solid Waste is the dominant source of Methane (CH_4) emission in Himachal Pradesh it emits almost 99.50% of total emissions from this sector. About 0.50% of the total CO_2 equivalent emissions from the waste sector were from disposal and treatment of Industrial waste water.

We know that the methane ($CH_{4)}$ Gas is the main gas which produced and released into the atmosphere as a by-product of the anaerobic decomposition of solid waste, in fact methanogenic bacteria break down organic matter in the waste. Similarly, wastewater is also a source of Methane (CH_4) when treated or disposed anaerobically. It also releases Nitrous oxide (N_2O) emissions due to protein content in waste water generated from activities at domestic level.

The total GHG released from waste sector in Himachal Pradesh 6.129 tons of CO_2 equivalent, of which, 27.284 tons were emitted as Methane (CH_4). Municipal Solid Waste is the dominant source of Methane (CH_4) emission in Himachal Pradesh.

The greenhouse gases and their source categories considered in this sector include:

- Municipal solid waste disposal resulting in CH_4 emission.
- Domestic waste water disposal emitting CH_4 and N_2O.
- Industrial waste water disposal leading to CH_4 emissions.

Effluent Treatment System for Treatment of Industrial Waste Water

5.2.3.6.1 Municipal Solid Waste

In Himachal Pradesh, there are 56 urban local bodies viz. 1 – Municipal Committee, 20- Municipal Councils, 28- Nagar Panchyats and 7- Cantonment Boards of which 33 have provided the MSW dumping facility where waste is partially collected and disposed in a systematic way at waste disposal sites under these ULBs in various towns, resulting in CH_4 emission from anaerobic conditions. In rural areas, waste is scattered and as a result the aerobic conditions prevail with no resulting CH_4 emission. In towns, the municipal solid w aste is disposed in landfills by means of open dumping; however, a small fraction is used for composting in some of the disposal sites. In the major towns such as Shimla, Kullu, Dharamsala, Solan, Baddi the rate of generation of MSW is high due to tourists and the population growth rate. The rate of disposal of MSW varies from place to place; therefore, the estimation of CH_4 generated from MSW State level also becomes highly uncertain unless year wise data on MSW generation is incorporated in the estimates. In the present calculations IPCC 2000 guidelines have been used. Average CH_4 Emission Factor derived from a study by NEERI in 69 cities (NEERI, 2005) has been applied to calculations.

For calculating the amount of degradable organic matter (DOm) in waste method used is as per following equation:

$$DOm = W \times DO \times DO_f \, X \, MCF$$

Where;

DOm = mass of decomposable DO deposited m Gg

W = mass of waste deposited, Gg

DO = degradable organic carbon in the year of deposition, fraction, Gg C/Gg waste

DO_f = fraction of DO that can decompose (fraction)

MCF = CH_4 correction factor for aerobic decomposition in the year of deposition (fraction)

The methane generated in a year has been calculated as per following method:

Methane generated in year Y

$$CH_4 = DOm\ decopom_Y \times F \times 16/12$$

Where;

F = Fraction of CH_4 by volume

16/12 = molecular weight ratio, CH_4/C

$$CH_4\ Emitted_Y = (\Sigma\, CH_4 generated_{X,Y} - R_Y) \times (1 - OX_y)$$

Where;

RT = recovered CH_4 in year Y, Gg

OX_Y = Oxidation factor in year Y, (fraction)

On an average for towns waste generation rate is 0.350kg/capita/day and that 60% of the waste is reaching the landfill site.

IPCC default factor (IPCC, 2002) such as the methane correction factor of 0.4, fraction of degradable organic carbon that decomposes (DO_f) as 0.5, fraction of methane in landfill gas as 0.5, rate constant (K) as 0.17 year -1 are used in the estimation. The factor related to degradable organic carbon fraction (DO) in the waste disposed is taken as 0.11 (NEERI, 2005). Considering that the amount of recovered methane is zero and oxidation factor is zero, the total methane CH_4 emitted from solid waste disposal site is estimated to be 17.17 (tons) in the State.

Component	Quantity
Urban population	6,88,704
Waste generation rate (kg/capita/day)	0.350
MSW generated (tons)	2410.464
Quantity of waste reaching the landfill site(tons)	1408.68
DOm disposed (tons)	45.12
DOm accumulated (tons)	142.00
DOm decomposed (tons)	24.00
Estimated Methane (CH_4) emitted (tons)	27.14

Source: HP Economics & Statistics Department, HP SPCB

5.2.3.6.2 Waste Water

In Himachal Pradesh the wastewater originates from a variety of domestic, commercial and industrial sources. In industrial, commercial hotel etc. waste water is treated on site, however, for waste water being generated from domestic sources in towns where the treatment facility is available it is collected in centralized treatment plants but the %age is very low. As per information obtained from HP State Pollution Control Board there are about 30 Sewage Treatment Plants installed in the State by various Urban Local Bodies out of which only 6 have been granted permission by the State Board for operation. About 34 more STPs are being installed in the State which will definitely enhance the capacity of State to treat the waste from domestic sources and so far majority of waste water is disposed untreated nearby. The methane (CH_4) is emitted from waste water when it is treated or disposed anaerobically. Here for Himachal Pradesh the calculations have been carried out in following manner:

- CH_4 and N_2O from domestic waste water
- CH_4 from Industrial waste water


Treatment System for Treatment of Domestic Waste Water (Source-SPCB)

In Himachal Pradesh, it is estimated that about 4,476.98 K litres per day (KLD) of domestic wastewater is generated from urban area against 49,144.97KLD industrial wastewater. The waste water generated from rural areas is not treated in any way, therefore, as it decomposes in an aerobic condition, it is considered as not a source of CH_4. Domestic wastewater have been categorized under urban and rural, since the characteristics of the municipal wastewater vary from place to place and depend on factors, such as economic position, food practice of the area, water supply status and climatic conditions of the area.

Waste water treatment and discharge pathways for the wastewater generated in the urban areas is partial and about 70 % of the wastewater generated from the urban centres is not collected and treatment is provided to only 10% of what is collected is not very significant. The waste water gets disposed of in aerobic conditions. Therefore, no specific calculations have been made.

The CH_4 emission from waste water generated from Industry has been estimated based on data available with SPCB. The industries have been included for estimating CH_4 from industrial waste water are given in following table:

Waste Water Generated in Major Industries in Himachal Pradesh

Sector	Waste Water generated
Industrial	49,144.97 KLD
Domestic	4,476.98 KLD
	Source: HPSPCB

The emissions have been calculated using as per IPCC approach by incorporating country specific emission factors and State specific data. The general equation followed to estimate CH_4 emissions from industrial wastewater is presented in equation below:

Ti = i (TOWi – Si) EFi – Ri

Where;

- Ti — CH_4 emission in inventory year, kg CH_4/yr;
- i — Industrial sector.
- TOWi — Total organically degradable material in waste water for industry i in inventory year, kg COD/year.
- Si — Organic component removed as sludge in inventory year, kg COD/year (Default Value 0.35).
- EFi — Emission factor for industry i, kg CH_4 kg/CODfor treatment/discharge pathway or system used in inventory year.
- Ri — Amount of CH_4 recovered in inventory year, kg CH_4/year.

Tertiary Level Treatment by provision of Reverse Osmosis (Source-SPCB)

GHG Emitted from Waste Water Sector ('000 tons)

Activity	CH_4	CO_2 equivalent
Industrial	0.0001366	0.006129

Root Zone Biotech plant at ACC Gagal

5.3 Future Energy Needs & GHG Emissions Trends in Himachal Pradesh

In Himachal Pradesh, power is one of the most important inputs for economic development. In addition to its widely recognised role as a catalyst to economic activity in different sectors of economy, the power sector makes a direct and significant contribution to State's economy in terms of revenue generation, employment opportunities and enhancing the quality of life.

In our country total energy consumption per capita, as published by the *World Resources Institute for the year 2003 is about 512.4 kge/a which is in our case about 225 kgoe/a*. The data is given in kilograms of oil equivalent per year, and gigajoules per year, and in watts, as average equivalent power. Undoubtedly the energy consumption projections is an important input for planning growth in industry, agriculture, domestic, commercial and other related sectors but at the same it is quite significant from environment conservation point of view. As per CERC Electric Power Survey (EPS) Committee Report year wise electric demand has been given for each State for the terminal years of 12th and 13th Five Year Plans i.e. 2016-2017 and 2021-2022.

The yearly energy requirement detailed out and projection are as follows:

Years	**2004-05**	**2005-06**	**2006-07**	**2007-08**	**2008-09**	**2009-10**	**2010-11**	**2011-12**
Power in TWh	4.516	5.022	5.585	6.212	6.909	7.684	8.545	9.504

Long Term Projections:			
Years	**2011-12**	**2016-17**	**2021-22**
Power in GWh	9503.91	13135.52	17657.40
Ref. CERC			

It is pertinent here to mention that the population of Himachal Pradesh has been increasing continuously over the years. However, the growth rate of total population has shown a decreasing trend over the last three decades. In 2001, the total population of the State was about 60,77,900 which during the year 2011 has increased to 68, 56, 509. The percentage share of urban population has been increasing continuously over the years. Population growth scenario in urban areas likely in Himachal Pradesh is as under:

Component	**Year 1991**	**Year 2001**	**Year 2011**	**Year 2021**	**Year 2031**	**Year 2041**
Total Population	51,70,877	60,61,849	68,56,509	79,14,736	88,40,647	97,66,913
Urban Population Growth	8.69%	9.79%	10.04%	11.29%	12.09%	13.23%

The energy demands also show an increasing trend which undoubtedly indicates need for mitigative and adaptive measures.

Scenario of Energy Demand Projections

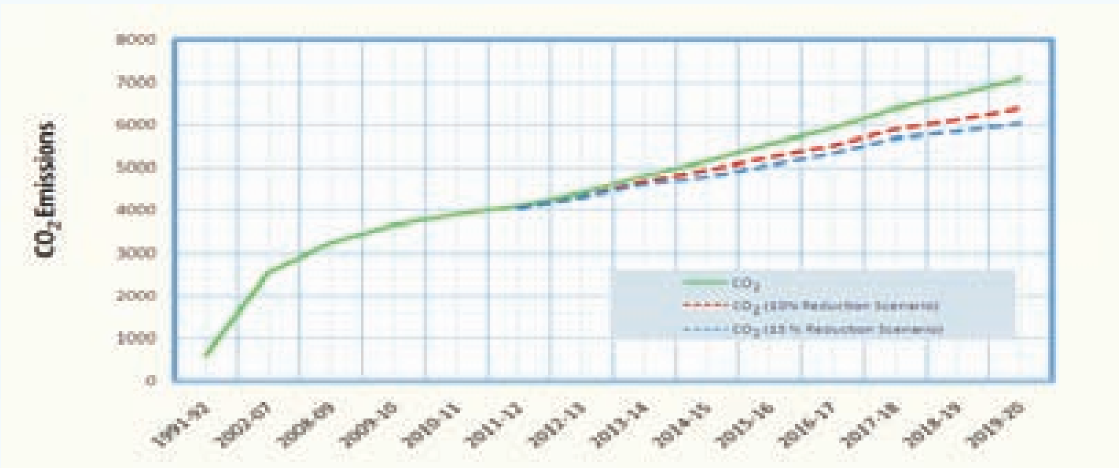
The simple method of projecting aggregate energy demand is to assume constant energy intensity for future years. This is adjusted for changes through conservation by estimating the likely conservation potentials for future years (Table-22, Fig. 43).

Table-22: Future Energy Demand Projections

Year 1991-92	Years 2002-07	Year 2008-09	Year 2009-10	Year 2010-11	Year 2011-12	Year 2012-13
1002.00	4300.439	5460.50	6200	6641	6950	7450
Estimated CO_2 Emissions		3225	3662	3923	4105	4401

Ref: HPSEB, Energy in million units

Year 2013-14	Year 2014-15	Year 2015-16	Year 2016-17	Year 2017-18	Year 2018-19	Year 2019-2020
8150	8741	9450	10050	10850	11400	12050
4814	5163	5582	5936	6409	6734	7118



Ref: HPSEB, Energy Consumption in million units

Fig. 43: CO_2 Emissions as per Energy Demand Projections

As per the current analysis carried out in case of Himachal Pradesh it depicts a higher emissions scenario for the State. The scenario represents a more competitive economy that lacks cooperation in development and portrays a future in which economic growth is uneven, which may be lead to a growing income gap. It is important to here that mention that this scenario does not bracket the entire range of possible future emissions and resulting climatic changes, as even higher emissions or lower emissions scenarios are possible depending upon the actions adopted.

5.4 Some Current Actions for Adaptation & Mitigation

The Government of Himachal Pradesh is already taking various initiatives to adopt the path of sustainable development and inclusive growth and has initiated various programmes and actions which would be further strengthened and made well equipped to deal with the challenges of climate change. The various actions have already been initiated in the State to streamline actions towards expected changes in various sectors viz. Agriculture, Water Resources, Forests, Biodiversity, Ecosystem, Energy (Hydro Power), Health, Tourism, Urban Development, Transport, Industry (Mining), and Disaster Management etc. The State Government has demonstrated its commitment by taking various initiatives for reductions of GHG emissions by way of bringing energy efficiency in the State.

5.4.1 Agriculture – Horticulture

The Department of Agriculture is working with responsibility for the economic up-liftment of farming community of the State through planned agriculture development with a strategy for future sustainable agriculture and production and improvement in productivity and quality through various adaptive measures such as setting up of 21 Seed Multiplication Farms where Foundation Seeds of Kharif and Rabi crops are being produced. Annually about 3,500 to 4,000 qtls. seed of Cereals, Pulses and Vegetables are produced. Besides this, the department has established 11 Soil Testing Labs and 4 Mobile Soil Testing Labs to provide free soil testing facilities to the farmers.

The Department of Agriculture is also keeping an eye on the pest situation in the State. To overcome this, about 160-168 M.T. of pesticides through Departmental Sale Outlets are being supplied to the farmers. For quality control of pesticides, a State Pesticides Testing Laboratory has been set up with an annual capacity of 500 samples. One Bio Control Laboratory has been set up at Palampur, where conservation and augmentation, rearing and multiplication of bio-agents are being carried out. Farmers Field Schools (FFS) are also organized to train farmers/ extension workers etc. The plant protection material including Plant Protection equipments are supplied to the SCs/ STs/ IRDP families and farmers of the backward areas at 50% cost.

There are 13 Potato Development Stations in the State where Foundation Seed Potato is being produced. More area is being diversified for undertaking production of cash crops and market maximum potato as table variety and produce only that much seed potato which can easily be marketed outside the State. The diversification is towards market oriented demand of high value cash crops/vegetables.

Three Vegetable Seed Farms have been set up in the State where Quality Seed is being produced. Besides this, two Training Centers one at, Mashobra in District Shimla and other at Sundernagar, District Mandi have been established. Further, farmers training camps are organized at Village, Block and District levels.

Weather Based Crop Insurance Scheme (WBCIS) has been introduced for different crops. Two risk-financing programmes have been started which support adaptation to climate impacts. The Crop Insurance Scheme supports the insurance of farmers against climate risks, and the Credit Support Mechanism facilitates the extension of credit to farmers, especially for crop failure due to climate variability.

The Department of Agriculture also is participating in RIDF for creation of irrigation potential through Minor Irrigation/ Water Harvesting Structures.

The programme for the production of cash crops through adoption of precision farming practices through poly house cultivation and Project on Diversification of Agriculture through Micro-Irrigation and other related infrastructure is also being implemented in the State.

"Seed Village Programme" by which sufficient seed multiplication can be achieved in order to meet local seed requirements is being implemented besides facilitating supply of seeds at reasonable cost and ensuring quick multiplication of new varieties in a shorter time. Under this programme, areas of better seed production will be identified and a compact area approach will be followed.

The adoption of organic agriculture on one hand, is expected to provide sustainability, while on other hand, it will help in increasing the income of the farmers. The Government of India has launched a National Project on Agriculture in order to promote organic farming in the State. Under this project, financial assistance was being provided for setting up of Model Farms, training of farmers, setting up of vermin composting units, hatcheries etc. For promoting organic farming a project was taken up in Shimla District in collaboration with Morarka Foundation and District Rural Development Agency, Shimla.

The current programmes aims to minimize the adverse effects of drought on production of crops and livestock, and on the productivity of land, water and human resources, so as to ultimately lead to drought proofing of the affected areas. It also aims to promote overall economic development and improve the socio-economic conditions of the resource poor and disadvantaged sections inhabiting the programme areas or affected areas.

The Horticulture Technology Mission programme funded by Government of India is taking care of adaptation actions to combat climate change impacts as well as capacity building of extension workers, farmers and NGOs to support better vulnerability reducing practices.

5.4.2 Water Resources

In view of vital importance of water for the sustenance of human and animal life for maintaining the ecological balance and for economic and developmental activities of all kinds, and considering its increasing scarcity, the planning and management of water resource and its optimal, economical and equitable use is treated as a matter of utmost urgency. Concerns of the community are taken into account for water resources development and management. The State Water Policy has been prepared in the State and is being currently revised.

In order to provide permanent drinking water supply and to avoid deployment of tankers/tractors, the Rehabilitation and Source Level Augmentation of various schemes are being implemented. Through such schemes percolation wells are being developed (6 Nos. along right bank of River Beas and discharge is 30 LPS of each percolation well.) The villages/habitations proposed to be covered under these schemes are water scarcity areas and huge number of tankers and tractors are being deployed to supplement the drinking water demand in summer season. On implementation of such schemes, sufficient drinking water supply is likely to be available to all habitations maximum number of Panchayats without deploying tankers/tractors in the summer seasons. Although Hand Pumps are being installed throughout the State, but it does not cover the areas which has no road connectivity.

These hand pumps are supplementing the existing piped water supply and have been installed in drought prone areas, areas of acute water scarcity and other problematic areas and the areas where tankers are being deployed during the peak season in recent years at a huge financial cost.

The demand – driven, participatory approaches is being adopted in the State on water allocations. The Village Panchayat / community are delegated with powers to plan, implement and manage various schemes. An integrated approach to water, sanitation & hygiene, ground water conservation and rain water harvesting is being adopted. Capacity development of the community to plan, implement and manage the Rural Water Supply Schemes of their own choice is being undertaken.
The Hand Pump programme is quite successfull in mitigating the people's misery due to shortage of drinking water in different pockets of drought prone and acute water scarcity areas. The programme was started during 1991-92 and a total of 23,371 hand pumps have been installed in the State up to March-2011.

As towns in the State mostly serve as health resorts, environment improvements assume special significance particularly to avoid pollution of the rivers and other water bodies of the State. To abolish carrying of night soil on head load and scavenging system in the country/states, the Government has given top priority to connect dry latrine system into water pour system. Hence, the sewerage programme has assumed immense importance to contain the water pollution problem. Under this programme sewerage facilities are proposed to be provided in all towns of the State.

13 sewerage schemes have been completed viz. Shimla,Palampur, Mandi, Jawalamukhi Shri Naina Devi Ji, Chamba, Bilaspur, Rohroo, Ghumarwin, Manali, Jogindernagar, Arki, Rampur, Reckong-Peo and Sarahan. The work on 24 schemes is in progress viz. Una, Solan, Sundernagar, Paonta, Sarkaghat, Kullu, Mehatpur, Santokhgarh, Dalhousie, Chowari, Bhuntar, Dharamsala, Hamirpur, Kangra, Nagrota, Jubbal, Sujanpur, Nadaun, Kotkhai, Narkanda, Theog, Nurpur, Suni and Dehra.

The non-conventional methods for utilization of water, including inter-basin transfers, artificial recharge of groundwater, as well as traditional water conservation practices like rainwater harvesting, including roof-top rainwater harvesting, are being practised to increase the utilizable water resources. The rain water harvesting has been made mandatory in Himachal Pradesh.

5.4.3 Forests & Biodiversity

India has a strong and well diversified afforestation programme. The impetus to afforestation process was accelerated by the enactment of the Forest Conservation Act, 1980, which aimed at stopping the clearing and degradation of forests through a strict, centralized control of the rights to use forest land and mandatory requirements of compensatory afforestation in case of any diversion of forest land for any non-forestry purposes. In addition, an aggressive afforestation and sustainable forest management programme resulted in annual reforestation of 1.78 mha during the period 1985-1997, which is currently 1.1 mha annually. Due to this, the carbon stocks in forests of the country have increased over the last 20 years to 9 -10 gigatons of carbon (GtC) during 1986 to 2005. The State of Himachal Pradesh is known for its forest wealth and has demonstrated its commitment to afforestation with an increase in open forest of 13 sq. kms. Traditional methods are promoted for conservation of bio resources.

Mid Himalyan Watershed Development Programme:

The Project has become operative in 10 districts of Himachal Pradesh w.e.f. 1st October, 2005 with the financial assistance of the World Bank. The Project builds on the successful experience of the Integrated Watershed Development Project (IWDP) (KANDI PROJECT) which culminated on 30th September, 2005. MHWDP Project aims at scaling up the successes of IWDP with two main differences. First, it expands upwards from the Shivaliks to the Mid-Hills, a region which covers about one-third of the State and over half of the cultivated land. Second, it entrusts the responsibility for most Project implementation with the local governments (Gram Panchayats) rather than with Village Development Committees, which were created for the purpose of IWDP implementation.

Project Goal & Objectives:
The overall goal of the project is to reverse the process of degradation of the natural resource base and improve the productive potential of natural resources and incomes of the rural households in the project area in Himachal Pradesh (using the Community-driven Development (CDD) approach). A secondary objective is to support policy and institutional development in the State to harmonize watershed development projects and programs across the State in accordance with best practices.

Project Scope:
The project covers around 272 Micro-watersheds spread over 602 GPs, 42 blocks and 10 districts (viz., Bilaspur, Chamba, Hamirpur, Kangra, Kullu, Mandi, Shimla, Sirmaur, Solan, and Una). The project benefits are expected to reach to around 25,000 poor families in the project area.

Project Area:
The project covers the Mid Hill and High Hill zone of the State within the altitude range of 600-1800 metres. Shiwalik Hills areas up to an altitude of 600 meters has not been considered as it has been covered in IWDP (Hills-1 and II). Accordingly, 11 sub-watershed divisions (falling in 10 districts except Tribal Districts) have been selected while covering 602 Gram Panchayats for implementation.

The project is of 7 years duration. The project became operational in October, 2005 and will culminate in March 2013.A key feature of the Project is the proactive involvement of village level institutions of self - governance i. e. the Gram Panchayats (GP). It is envisaged that substantial Project activities, and the Project funds, would be channelized directly through the GPs.

Guiding Principles:
1. *An integrated Watershed Management framework as a strategy.*
2. *Conservation planning, while using water as the nucleus for a community-based program of rural development.*
3. *Decentralization of PRIs and making them sustainable instrument of natural resource management.*
4. *Cost sharing for promoting ownership.*
5. *Transparency in decision making and resource allocation.*
6. *Targeting vulnerable groups such as women, landless and nomads with special programmes.*
7. *Value addition to agricultural production.*
8. *Improving accessibility.*
9. *Communities being empowered through capacity building, partnership and accountability mechanism.*

Bio-Carbon Sub-Project:
(BC Sub-Project) is proposed as an additional component of the Mid-Himalayan Watershed Project (MHWP). Both projects (MHWP & BC) focus on different approaches and implemented on different lands – at the same time complement each other in all respects. The objective under the BC sub-project has been developed through a series of consultations with Mid-Himalayan Watershed Project (MHWP) partners, Forest Department, Govt of HP (GoHP) and World Bank wherein a consensus for three guiding principles for the project were reached:

- i) *identify locally grown and accepted species in the MHWP areas,*
- ii) *involve small and marginal formers in plantation activities that will bring value addition to the ongoing watershed interventions/activities,*
- iii) *the plantation activities should support for livelihood enhancement. However, it is also important to understand the context of MHWP through which it is proposed to implement the BC sub-project as an additional component and use its institutional base without which it would not be possible to develop this initiative.*

The interventions proposed under the BC sub-project makes the villagers a strategic seller of Carbon Credits under the Kyoto Protocol as well as in response to global demand for Certified Emissions Reductions under the Clean Development Mechanism. The BC sub-project is a good opportunity for value addition to the marginal farmers as majority of them will be receiving additional cash benefits by selling carbon credits that is over and above ecological and livelihood benefits through MHWP. Besides selling Carbon Credit, the villagers in general will also get direct benefit of fuel wood and NTFPs (Non Timber Forest Products).

Flow of Benefits		
Economic	*Ecological*	*Socio-Economic*
NTFPs	*Watershed protection*	*Involvement of the poorest of poor*
Fuel wood	*Biodiversity conservation*	*Capacity building of communities particularly women in management of carbon finance*
Fodder	*Soil quality improvement*	*Institutional development*
Carbon revenue	-	*Increased crop productivity*
Indicative carbon revenue: Rs. 3000 to 4000/ha at US$ 4/tonne of carbon besides reduction of GHG globally.		
		(Ref: HP Forest Department website)

5.4.4 Health

The State has a better public health care infrastructure and better health status than many other Indian states e.g., infant mortality rate in the State is less than two-third of the all India average. The people of the State also appear to find higher value in the care provided by government facilities many Indians in other states.

The Department of Health has played an important role in this success through such activities in improving government health facilities and implementing the targeted disease reduction campaigns.

As the State is developing economically, there is also a need for the Department of Health to engage in greater depth on the issue of insurance and the challenges of providing financial protection against catastrophic losses. The current insurance mandate in the State represents a step forward. A robust regulatory mechanism needs to be in place in order to mitigate effectively.

There are various programmes which are being carried out extensively in the State. The prime objective of these programmes is the surveillance and control of vector borne diseases such as Malaria. The health programmes also provide for emergency medical relief in the case of natural calamities, and to train and develop human resources for these tasks.

There are other programmes to promote the role of Gram Panchayats in providing basic health care to their residents and as a part of the decentralization planning processes, the basic health functions are also being provided by the Gram Panchayats.

5.4.5 Disaster Management

The flood prone area in the State has been estimated as 2.31 lakh ha. The Government of Himachal Pradesh is making strenuous efforts to protect private properties and culturable land by providing emergent flood protection measures in the shape of embankments, spurs and wire crates etc. Up to March, 2011 the Irrigation & Public Health Department was able to protect an area of 17,602 ha from the fury of floods.

A Disaster Management Authority has been setup in the State to combat the emerging threat of natural disasters. The State provides grants-in-aid to victims of weather related disasters. It also supports proactive disaster prevention programmes, including dissemination of information and training on disaster-management personnel. The State Disaster Management Plan is also being finalized wherein the vulnerability assessment of the State would be carried out and various mitigation measures would be suggested. Besides his, District Disaster Management Plans have been prepared by most of the districts and District Disaster Management Authorities have been established. The State Emergency Operation Centre (SEOC) has also been established.

5.4.6 Actions Relevant to GHG's Mitigation

Himachal Pradesh has in place a detailed policy to programme level structure that relates strongly to GHG mitigation. The State has in place its own Power Policy which ensures sustainable development of hydropower and promotes run-of-river projects, release of minimum discharge downstream the diversion structures etc. The major initiatives are:

- Promotion of CFL bulbs, energy efficiency in all sectors.
- Promotion of ropeways.
- Emphasis on use of renewable sources of energy including biofuel plantations.
- Accelerated development of Hydro power through run-of river projects.
- Adoption of several clean energy related technologies.

A number of economic activities are required to prepare Environment Impact Assessments (EIA), and Environment Management Plans (EMP), which are appraised by SEAC/ SEIAAs before the commencement of work. The provisions under the Environment (Protection) Act, 1986 strongly promote environmental sustainability. The mitigation of impacts is ensured through implementation of Environment Management Plans. The State is also undertaking preparation of basin wide Cumulative Environment Impact Assessment (CEIA) and basin wide integrated catchment Area Treatment Plan (CAT).

5.4.7 Other Initiatives

- A "**Community Led Assessment, Awareness, Advocacy & Action Programme** (**CLAP**) for Environment Protection and Carbon Neutrality" in Himachal Pradesh has been started in the State. This programme has been envisioned to assess the carbon and environment footprints at Panchayat level, the smallest unit of governance and through advocacy usher in sustainable development and low carbon economy in partnership with the citizenry through environment awareness, awareness, advocacy, action and improvement activities.

The programme at the grass root level would comprise of the following activities:

- **Assessment:** Facilitate systematic assessment and documentation of the existing environmental quality and carbon foot prints of Panchayats, Urban Local Bodies, Blocks, and Districts through network of Eco-clubs, Mahila Mandals, NGOs etc. by Participatory Appraisal Techniques and build requisite capacity for these purposes on an ongoing basis.

- **Awareness:** Facilitate generation of systematic awareness through network of Eco-clubs, Mahila Mandals, NGOs etc. of amongst among citizens, decision makers, communities and other stakeholders in the society on the state of environment, environmental issues and causes of degradation and possible ameliorative action.

- **Advocacy:** Facilitate mobilization of communities and panchayats through network of Eco-clubs, Mahila Mandals, NGOs etc. for to promote environmental advocacy for policy change at district and state level.

- **Action:** Based on environmental assessment help Panchayats and communities through network of Eco-clubs, Mahila Mandals, NGOs etc. to undertake environmental improvement actions at the local level to improve environment and reduce their carbon foot prints.

- The State Government has introduced use of CFL for energy conservation through '***Atal Bijli Bachat Yojna'*** by distributing 4 CFL bulbs at free of cost to every family in Himachal Pradesh aimed to achieve sizable reduction in energy consumption. The State is also encouraging run-of-river hydel power projects and is striving to meet 100% of its energy requirements from the hydel sector. The State is discouraging use of fossil fuels and other traditional materials for space heating and has banned use of coal for purposes of space heating. This has led to a sizable reduction in the GHG emissions in this environmentally sensitive Himalayan state. The State has also initiated the processes of energy efficiency, waste audit and water audit etc. The State is promoting use of energy efficient devices and making efforts to reduce the consumption of energy and promoting use of solar passive technologies. The solar passive designs have been made mandatory in the State. By following Energy Conservation Building Code (ECBC), the space heating load of Government building can be reduced by 40%. By replacing the existing 40 W tube lights with energy efficient T-5 tubes and by providing daylight controls, energy consumption can be reduced by 70%. By integrating solar hot water system with existing heating system, 10 % load on the central heating can be reduced.

Gaps in Understanding the Impacts of Climate Change 6

Based on the available data and its assessment clearly indicates that that there is a considerable gap in our knowledge about the natural resources and their vulnerability to climate change of the entire Himalaya in general and State in particular. There is no systematic monitoring, documentation, or research to have an update on the status of biodiversity in the region. Despite various projections and observed changes, the region lacks adequate scientific evidences to understand the impact of climate change on various aspects of human well being. Across the entire region, most of the limited research that is available focuses on the adverse impacts of climate change and overlooks the adaptation mechanisms that local people have developed themselves, and have evolved the potential new opportunities. There is also a lack of trained human resource and institutional set up and policy imperatives to tackle climate change issues. The present analysis and assessment experienced shortcomings mainly as a result of lack of reliability in observed trends and model projections in later parts resulting from the lack of consistent sector wise data in relation to climate change. Three broad areas stand out as knowledge and data gaps that need to be addressed:

- First, there is much to learn about the potential magnitude and rate of climate change at the regional and local levels, and subsequent impacts on the full range of biodiversity endpoints and ecosystems.
- Second, there is need to develop a consolidated biodiversity conservation techniques (both traditional and natural), or climate adaptation techniques, targeted on Himachal Pradesh or Himalayan region.
- Third, detailed analysis needed at the moment to be developed for each of the priority vulnerable sector specifically to agriculture and horticulture, ecosystems and to biodiversity and other natural resources.

Based on available data base and the current/prevalent conditions, analysis have been carried out for Himachal Pradesh to demonstrate that how the State is vulnerable w.r.t. climate change risks and what are the indicators/scenarios. An attempt has been made to undertake the district level mapping of adaptive capacity in the State as a composite of bio, social and technological indicators. But certainly inadequate data base and the knowledge gaps indicate towards strengthening of capacity of State on account of this.

6.1 Actions on Gaps for Projections

In Himachal Pradesh there is exists a significant data gap for drawing projections. Climate change is an interdisciplinary subject that cuts across physics, chemistry, biology, earth sciences, economics, technology development, etc. Therefore, multiple data sets are required even to simulate the current situations by different models; for which the current data on climate, natural ecosystems, soils, water from different sources, agricultural productivity and inputs and socio-economic parameters amongst others are continuously and consistently required. It is essential to have accessibility to databases that reflect local and regional concerns. Various agencies in State are presently collecting such data on a regular basis; however, efforts are required to be made to establish an effective mechanism for sharing and accessing this data in formats that can be easily deciphered.

6.2 Systematic Observations

Systematic observations that have the long term effects must be taken up on a regular basis in the State which adds to the database on physical and biological systems for example, data on forest vegetation types. In Himachal Pradesh, forest observation plots were established in the late 19th century to observe the changes in forest vegetation patterns in different areas. However, most of these plots have not been continuously monitored, and as a result, we do not have adequate data on the vegetation types, forest soil characteristics etc. which could have been effectively used for modeling. The Forest Survey of India (FSI) is now making efforts to revive these plots, so that they can be observed and monitored for a longer period of time to attribute the effects of climate change on various systems.

6.3 Building Capacities

A rapid building up of capacities is essential to enhance the level of climate change research in Himachal Pradesh. In this context scientific cooperation and collaboration is essential in the area of climate modeling, impact assessment, integrated impact assessments, research on mitigation of climate change concerns and adaptation to impacts of climate change. Extensive networking of researchers within country to carry forward the work on science, impacts and mitigation of climate change in the State is required.

Main Entry Points with Eight National Missions

7

The Government of Himachal Pradesh has already decided to undertake the path of sustainable development and inclusive growth and have taken various initiatives and programmes which would be further strengthened to deal with the challenges of climate change.

7.1 Sector wise Description of Ongoing Activities

7.1.1 Himachal Pradesh Solar Energy Programme

In the State 'Himurja' is set up to significantly increase the use of solar energy in the total energy mix while recognizing the need to expand the scope of other renewable and non-fossil options such as thermal energy, wind energy and biomass.

Himachal Pradesh is a tropical Himalayan State, where sunshine is available for longer hours per day and in great intensity. Solar energy, therefore, has an enormous potential as future energy source. It also has the advantage of permitting a decentralized distribution of energy, thereby empowering people at the grass root levels.

Solar Trombe Wall at Tabo Monastery Sarai

Subsidies are being given on the purchase of solar heaters, cookers, photovoltaic cells which are becoming cheaper with new technology. There are newer reflector-based technologies that could enable setting up of megawatt scale solar heaters for hot water.

Awareness programmes are being conducted for the use solar water heating, streetlights systems to save energy and reduce GHG emissions in the State.

While dealing with environmental NOCs, directives are there to ensure that the project developers shall install solar space heating systems, use solar street lighting systems in the State.

It has been emphasized that the projects would be prepared which could draw upon international cooperation as well to enable the creation of more affordable, more convenient solar heating systems, and to promote innovations that enable the storage of solar power for sustained, long-term use.

Himachal Pradesh is the first state in the country to introduce Solar Passive Building technology for the design and construction of Governmental & Semi Governmental buildings on a large scale. H.P.

State Council for Science, Technology & Environment has formulated a Solar House Action Plan for Himachal Pradesh in May 1994, which is being supported by Ministry of Non-Conventional Energy Sources, Govt. of India.

The State Council is also coordinating the Solar Passive Building Programme in Himachal Pradesh in collaboration with HP Public Works Department H.P. (PWD), HP Housing and Urban Development Authority (HIMUDA) Board & other organizations.

A Solar House Action Plan for Himachal Pradesh has been formulated under which it has been made mandatory that all Govt./ Semi Govt. buildings be designed and constructed as per solar passive housing technology in a phased manner.

Solar passive building technology has been made mandatory in Himachal Pradesh under which all the departments including Corporations, Boards, Universities, HP Housing Board and HPPWD are required to incorporate features of solar passive technology in their designs at places above 2000 meters (msl)

7.1.2 Himachal Pradesh Energy Efficiency/Saving Programme

The Energy (Conservation) Act, 2001 provides a legal mandate for the implementation of energy efficiency measures through the institutional mechanism of Bureau of Energy Efficiency (BEE) not only in the Central Government but also in each State. A number of programmes have been initiated and it is anticipated that these would result in saving of 500 MW in overall consumption of the energy in Himachal Pradesh.

In the State Government has initiated various programmes to enhance energy efficiency.

- Launched 'Atal Bijli Bachat Yojna' in the State by distributing CFL to the people of State at free of cost to promote saving of energy as a shift to energy efficient appliances/equipments.
- Complete ban on use of coal for space heating etc.
- Developing economic instruments to promote energy efficiency in Himachal Pradesh.
- Committed to harness the entire potential of 22,000 MW of Hydro Power available in State though the demand of the State is far less than the available potential, so as to contribute to the country's clean energy demand for meeting the set goals for reduction in the GHG emissions.
- Encourage the use of solar passive heating systems and promote the use of biogas plants.
- Discourage the energy intensive industries that contribute large to GHG emissions.

7.1.3 Himachal Pradesh Sustainable Development Programme for Urban & Rural Areas

The State Government is committed to develop in a sustainable manner so as to conserve its beautiful environs through improvements in management of solid waste, waste water, modal shift to public transport, construction of buildings and roads, energy efficiency in buildings etc. The State Government is firm to promote sustainable development, energy efficiency as an integral component of urban and rural planning through various initiatives.

i. The State Government has completely banned the use of polythene carry bags, cups, plates and glasses in the State.
ii. Emphasis has been made for recycling of waste materials.
iii. Municipal Solid Waste Management is a major component of ecologically sustainable economic development. Our country already has a significantly higher rate of recycling of waste in the context of *'kabaris' system* as compared to many countries.
iv. The waste water treatment plants are installed and the use of waste water and recycling options are exercised wherever possible.
v. To save potable water, rainwater harvesting in new buildings has been made compulsory.
vi. The Energy Conservation Building Code, the green buildings which addresses the design of new and large commercial buildings to optimize their energy demand has been promoted.
iii. Initiatives have been made for better urban planning and sustainable rural development having effective waste management facilities.
iv. The public transport systems have been strengthened by providing more infrastructures such as energy efficient vehicles and good road network.
v. Master Plan for the transport shall be prepared for Himachal Pradesh focusing long term transport plans to facilitate the growth of medium and small towns in ways that ensure efficient and convenient public transport in tourist seasons.
vi. State Disaster Management Plans are being prepared to address issues associated with extreme weather eventualities in the State such as cloud burst, floods, health hazards etc.

7.1.4 Sustainable Water Management

In Himachal Pradesh availability of water is highly uneven in both space and time. Precipitation is confined to only about three to four months in a year and varies from about 600 mm in Lahaul & Spiti district to around 3200 mm in Dharamshala, District Kangra. However, in spite of heavy rains and snow during the rainy season and the winters, the summer months are periods of water scarcity in many areas as the flow in the rivers and nallahs is quite low and the traditional sources also dry up. This results in migration of humans and animals to the banks of rivers with perennial flows. On the other hand, heavy rains regularly cause havoc due to floods. Flash floods also cause damage in the higher reaches of the State. Thus, to address the issues of drought management in some areas and flood control in others, the State Government has framed a State Water Policy. Planning and implementation of water related projects has many socio-economic aspects and issues such as environmental sustainability, resettlement and rehabilitation of project-affected people and livestock, public health concerns of water impoundment, dam safety etc., clear guidelines are, therefore, necessary in these matters in the State.

As a scarce and precious resource its usage has to be planned, along with conservation and management measures, on an integrated and environmentally sustainable basis, keeping in view the socio-economic needs of the State. In the 21st century, efforts to develop, conserve, utilize and manage this important Himalayan resource in a sustainable manner have to be guided by the State's perspective and vision.

The State Government will work in consonance with the National Missions on Climate Change to ensure integrated water resource management to conserve water, minimize wastage and ensure more equitable distribution both across and within the State.

The State's Water Policy is being revisited in consultation with the line departments such as Urban & Rural Development, MPP & Power, State Ground Water Authority to ensure basin level management strategies to deal with the variability in rainfall and river flows due to climate change.

The demand of water for industrial use has so far largely been concentrated in or near the towns. However, the domestic and industrial water demand in rural areas is expected to increase sharply as the development programmes improve economic conditions as more and more industry comes up there. Impounding of water for hydropower generation will also increase, as the potential in this sector is harnessed. This underscores the need for the utmost efficiency in water utilization and public awareness of the importance of conservation and maintenance of water quality.

Water quality is impacted by untreated or inadequately treated hotel, industrial effluents and sewage flowing into *nallahs* and rivers or affecting the surface and ground water. Since it has potential to adversely affect the health of the populace, special attention needs to be paid to these aspects. Improvements in existing strategies, innovation of new techniques resting on a strong science and technology base are needed to eliminate the pollution of surface and ground water resources to restore the pristine quality.

7.1.5 Sustainable Development to Save the Himalayan Ecosystem

The sustainability of Himalayan Eco-system is of utmost importance. Himalaya has the largest concentration of glaciers outside the Polar Regions. Geological history of the earth indicates that the glacial dimensions are constantly changing with the changing climate. Last glaciations took place in the Pleistocene Time. During the peak glaciations, 46 million sq. km., area was covered by glaciers which are more than three times the present ice cover. The data indicates that during the Pleistocene Time, the earth experienced four or five glaciations period separated by an interglacial period. During an interglacial period, the climate was warm and the de-glaciations occurred on a large scale. This suggests that glaciers are constantly changing with time and these changes can profoundly affect the runoff from Himalayan Rivers. In order to assess the changes in the runoff from these Himalayan reservoirs, systematic studies of the glaciers and snow covers is required to be undertaken.

Himachal Pradesh is a small hilly state which lies in the North western Himalaya, the youngest mountain chains in the world. A scientific study carried out on the evolution of the Himalaya suggests that these mountain chains are rising at the rate of 2 cm per year. The State of Himachal Pradesh can broadly be categorized into three major physiographic sub divisions The Outer Himalaya (the Shiwaliks), the Middle Himalaya (Lower Himalayas) and the Inner Himalaya (Higher or Great Himalayas). The Higher Himalaya predominantly is the snow-clad peaks and remains under thick cover of snow throughout the year.

Five major perennial rivers of Northern India pass through Himachal Pradesh. The major rivers are Ravi, Chenab Beas, Satluj & Yamuna. The rivers Ravi, Chenab and Beas originate from the glaciated areas in the State and all the five rivers which passes through the State depends largely on the snow and glaciers for their discharge dependability during the peak and lean seasons. In order to understand the runoff from these Himalayan Rivers, systematic studies on snow and glaciers have been carried out in Himachal Himalaya to estimate the snow and glacier cover available in the Satluj and the Beas basins. The investigation suggests that there are about 334 glaciers in the entire Satluj and Beas basins covering a total area of 1515 sq. km. Besides this, 1987 permanent snow fields could also be mapped from the satellite data covering a total area of 1182 sq.km. Out of the 334 glaciers identified, 202 glaciers fall in the Himachal Himalaya, whereas the remaining glaciers are in the Tibetan Himalaya.

The State Government is to evolve management measures for sustaining and safeguarding the Himalayan glaciers and mountain eco-systems. An observational and monitoring network for the Himalayan environment is required to be established to assess freshwater resources and health of the ecosystems. Cooperation with neighbouring States will be sought to make the network comprehensive in its coverage.

In Himachal Pradesh, about 90% of rural people practice hill agriculture and their vulnerability is expected to increase on account of threats of climate change. Community-based management of these ecosystems will be promoted with incentives to community organizations and panchayats for protection and enhancement of forested lands. In rural, tribal and mountainous regions, the aim will be to maintain two-thirds of the areas under forest cover in order to prevent soil erosion and land degradation and to ensure the stability of the fragile Himalayan eco-system.

There is an urgent need to conduct a study on the existing snowfields and glacial fluctuations all along the Himachal Himalaya and their expected life spans from future perspectives.
In order to undertake studies pertaining to Himalayan eco-system, a Regional Centre for Glacial Monitoring and Management needs to be established in the State.

7.1.6 Programme for Greening of Himachal

There is a clear indication of climate change having a direct impact on the vegetation both natural and cultivated, and also on the availability of water in the rivers and streams. At the same time, land which is not presently available for forestry being under permanent snow cover could gradually convert in to grassland/forests.

Himachal Pradesh provides an unmatched contribution to 'national interest' in sustaining life support systems, on the basis of which sustainable development can be realized downstream in the plains of Northern India. Attention is shifting to environmental services provided by the forests. These include critical watershed services, biodiversity conservation, carbon sequestration and off course maintaining the landscape beauty. The State has a repository of rich floral and well as faunal bio-diversity. The floral bio-diversity has become a part of livelihood practices of our rural as well as tribal populace in the State. The State also has a significant area above 3000 meters from sea level. Although trees do not grow much above this altitude, but these unique eco-system supports precious Himalayan biodiversity. To conserve this exceptional bio-diversity, which include several globally threatened species, like the Snow Leopard, the Himalayan Ibex, Himalayan Brown Bear, Himalayan Lynx, Himalayan Tahr etc., Himachal Pradesh has setup a network of national parks and wildlife sanctuaries, covering approximately 14% of its geographic area.

Ecosystem services, human welfare and economic systems are intrinsically connected. Sustainable forest management, the new mantra, has emerged to meet societal concerns and tackle conservation and land-use issues, providing for multifunctional landscapes and looking to eco-regions rather than boundaries as the unit of analysis and management. It is a movement away from the conventional, commodity production orientation, towards a holistic, people- centric ecosystem-level approach. This shift has been necessary to address State's depleting drinking water sources, global warming and biodiversity losses. Sustainable forest management represents a new look at forests and forest management in order to meet two major commitments:

1. Protect and restore the forest ecosystem—improve biological diversity, enhance water supplies, make possible carbon sequestration, meet recreation needs and provide for the forest dependent communities through improved non-wood forest produce;
2. Encourage profitable enterprises, attracting the investor who sees sustainability as a viable economic venture.

The role of woody vegetation in sequestering carbon is well recognized. Research to study vegetation shifts in the forestry sector, to establish whether the crop compositions are changing, or there is the effect of climate change on biodiversity is urgently required in Himachal Pradesh. Such studies will ultimately help define the policy on raising and maintenance of forests in the State. The possible mitigation strategies in forestry that would evolve would be implemented to reduce GHG emissions and enhance carbon sinks in soils and forests. These would extend to finding of proper energy solutions to a low-carbon energy economy, explore options to leap-frog to cleaner development paths and work towards enhancing de-carbonizing potential. Under adaptation, the issues that are in focus are the vulnerability of higher altitude forests in Himachal Pradesh and possible forest-type shifts occurring in more than 80% of the forestry grids, likely increased forest fire occurrences and the anticipated water stress and scarcity in the region that would come under water resource management.

The State Government has successfully initiated the Sanjhi Van Yojna Scheme by the involvement of grass root level institutions such as Gram Panchayats, Mahila Mandals, Yuvak Mandals, Ex-servicemen's bodies, Schools, Village Forest Development Societies (VFDSs), User Groups, other Community Based Organisations (CBOs) and NGOs in sustainable management of forest resources. This involves giving grant of 100 % income from plantations to the VFDSs and Panchayats; grant of total usufruct rights to the VFDSs; regeneration of degraded forest areas and conservation and sustainable use of better forests through community involvement. Involvement of local communities in the choice of species to be planted under the scheme; creation and enhancement of social, physical and financial capital of the participating communities for poverty reduction; special emphasis on the involvement of women in the scheme; recognising that participatory processes are critical to Sustainable Forest Management in the State. Recognising the link between rural poverty reduction and the sustained and increasing availability of forest resources and access to them for the rural communities particularly the poor; the scheme targets pockets of poverty in the state.

Forests of Himachal Pradesh known for their grandeur and majesty are like a green pearl in the Himalayan crown. This life supporting systems are presently under stress due to impact of modern civilization, economic development and growth in human and cattle population. According to National Forest Policy, 1988, at least two third i. e. 66% of the total geographical area should be under forest in the hilly states like Himachal Pradesh. However, keeping in view that about 20 % of the area is inaccessible and beyond the tree limit, the State Government aims to bring 50% of the geographical area under the forest cover. The forests of the State have been classified on an ecological basis as laid down by Champion and Seth, and can be broadly classified into Coniferous Forests and Broad-leaved Forests. A State wide programme has been launched to enhance ecosystem services including carbon sinks. Rural campaign for the afforestation through MNREGA has also been undertaken.

The programme on Green Himachal will be taken up on degraded forest land through direct action by communities, organized through Joint Forest Management Committees and guided by the Department of Forests, Himachal Pradesh. Financial assistance for the programme shall be drawn through the Compensatory Afforestaion Management and Planning Authority (CAMPA) to commence work.

7.1.7 Sustainable Agriculture

Himachal Pradesh is predominately an agricultural State where agriculture provides direct employment to about 71 percent of the total population. The Agriculture sector contributes nearly 30 percent of the total State Domestic Product. The Department of Agriculture is serving the farming community by implementing various developmental programmes and disseminating the relevant technology to increase productivity, production and profitability of field crops. The natural endowments like soil, land, water etc. are being harnessed in such a way that cherished goals of ecological sustainability, economic up-liftment of farming community are achieved. About 18-20% area in the State is irrigated and rest is rain fed. The agriculture research is being undertaken State's Agriculture University, Palampur. The Department of Agriculture is, therefore, now concentrating on agriculture production and soil water conservation aspects and practices. Thrust areas identified for future agriculture development in Himachal Pradesh are as under:

- Diversification of area from traditional crops to commercial crops where irrigation potential has been created. The farmers are being motivated to produce organic vegetables without the use of pesticides and chemical fertilizers.
- Development of rainfed areas through watershed approach on a large scale for efficient and judicious use of natural resources is being undertaken. Increased funding is being arranged under the RIDF.
- Rainwater harvesting is another area, which not only provides life saving irrigation to the crops but also recharges the ground water and checks the erosion. The Department is seeking financial assistance from Govt. of India for small irrigation tanks/shallow wells and pumping sets etc.
- Increase in maize productivity through high yielding hybrids.
- Adoption of precision farming practices (Poly House and Micro Irrigation).
- Organic farming is being promoted as the thrust area.
- Post harvest management and efficient marketing system is being encouraged.
- Farm mechanization with special reference to hill agriculture is being given major thrust. This is necessary to reduce cost of cultivation in view of high cost of labour. A Technical Working Group has been constituted to identify new farm implements and machinery, which can be introduced in the State.
- A strong research extension interface directed towards problems oriented research programmes is being undertaken. Research projects are being identified and funded in the problem areas.
- Extension reforms through public-private partnership are under way.
- Agro processing and value addition is being encouraged.
- Emphasis is on increase in productivity and quality.
- Application of Biotechnology in the field of agriculture is being explored.
- Soil testing and issuance of Soil Health Cards has been undertaken.

The State Government is committed to impart latest technology to the farmers for increasing agricultural production in view of climate change threats. This includes ensuring timely supply of all types of agricultural inputs like improved seeds, agricultural implements, pesticides and fertilizers etc. The capacity building of the farmers in the sustainable use of irrigation water, soil and water conservation technologies, trainings on Integrated Pest Management, use of farmers friendly bio fertilizers, diversified farming systems and to create irrigation facilities to the farmers through minor/tank irrigation schemes so as to obtain maximum returns from their land even in the challenges emerging from climate change in the State are being undertaken.

The State Government is revisiting the functions more effectively to make agriculture more resilient to climate change. It would identify and develop new varieties of crops especially the thermal resistant crops and alternative cropping patterns capable of withstanding extremes of weather, long dry spells, flooding, and variable moisture availability.

Agriculture is progressively adapted to projected climate change and our agricultural research systems will be reoriented to monitor and evaluate climate change and recommend changes in agricultural practices accordingly.

This will be supported by the convergence and integration of traditional knowledge and practice systems, information technology, geospatial technologies and biotechnology. New credit and insurance mechanisms will be devised to facilitate the adoption of desired practices. Focus would be on improving productivity of rainfed agriculture. India will to spearhead efforts at the international level to work towards an ecologically sustainable green revolution.

7.1.8 Strategic Knowledge for Climate Change - Towards Carbon Smart Growth

Geological history of earth indicates that the glacial dimensions are constantly changing with changing climate and these changes can profoundly affect the runoff of the Himalayan Rivers. On the basis of study carried out, total 23,315 sq. km. area is under snow in India and the runoff from these glaciers contributes significantly to the stream flow of the rivers originating in the higher Himalaya. Therefore, it is important to study the glacial aerial extent and possible changes for proper management of Himalayan water resources with an aim is to develop of a model to assess the effect of climatic variation on Himalayan glaciers and to assess changes in the glacial-melt runoff due to climatic variations. The studies are being carried out in the Spiti and Baspa basins of Himachal Pradesh. On monitoring the glaciers of Spiti river basin, it has been found that a de-glaciation of about 10% has occurred between 2001 and 2007 in the entire Spiti river basin. Likewise de-glaciation of about 22% has been reported in the Baspa river basin. The inventory of glaciers and permanent snow fields has been prepared for the Chenab river basin which suggests the presence of 454 numbers of glaciers and 768 number of snow fields in Chenab river basin in Himachal Pradesh only. Complete data base for the glaciers and snowfields in Satluj & Beas basins is available in digital format.

A “Community Led Assessment, Awareness, Advocacy & Action Programme (CLAP) for Environment Protection & Carbon Neutrality in H.P.” has been launched in the State for a period of three years with the aim to develop Himachal Pradesh as sustainable and climate resilient State by mobilising community's responsibility for environmental assessment, environment protection and carbon neutrality. The programme would ensure knowledge of high quality and focused approach into various aspects of climate change, socio-economic impacts of climate change including impact on health, demography, migration patterns and livelihoods of rural communities.

An 'Environment Fund' has been created by the State Government to facilitate and support the environmental protection activities. Private sector initiatives for development of innovative technologies for adaptation and mitigation would be encouraged through environment fund.

7.2 Sector wise Glimpse of Initiatives Taken

Watershed Development

The fragile Himalayan ecosystem in Himachal Pradesh forms the catchment of major Indian rivers the Satluj, Beas, Ravi, Chenab and Yamuna. It is an important source of water that supports about 200 million people in Punjab, Haryana, Uttar Pradesh and Rajasthan. In addition, these rivers are crucial in sustaining livelihoods and assuring food and water security (for irrigation and domestic use) across much of the northern India besides enhancing agricultural productivity and natural resource base in Himachal Pradesh.

The watershed development programmes in the State aim at enhancing livelihoods of rural inhabitants while ensuring sustainable management of land and water resources and furthering progress on fiscal, administrative and political decentralization to Gram Panchyats (GPs) for strengthening local governance and participatory development.

The Watershed Development Programmes (WDP) have become a trusted tool for the overall development of the villages and people living within a watershed area. The Watershed Development Programme initially envisaged as a measure for poverty alleviation and improved livelihoods has gained even greater importance in the light of the worldwide recognition of its effectiveness in combating climatic change.

Through Watershed Management Programmes, the State is striving to improve the productive potentials of watersheds and their associated natural resource base through soil moisture conservation, rain water harvesting, afforestation, pasture development, sustainable agriculture and horticulture activities and development of the degraded land. It also develops and strengthens community based institutional arrangements for sustainable natural resource management, imparts skills and employment opportunities for non-farm sectors, ensures involvement of village communities in participatory planning, implementation as well as social and environmental management.

Soil & Moisture Conservation

Step Towards Green Cover

Nursery Raising

Contour Trenching

Growing Vegetables by Lifting Water from Check Dam

An End to Fodder Problem through Watershed Development

Pasture Development , Watershed – Bamned Khad

Rural Participation

It is felt that people's participation is not only critical during the implementation phase of watersheds but also ensures conservation and development of Common Property Resources. The State has consciously created a scenario where the Government is acting as a facilitator and the people at the grass root level become the real executioner and beneficiary of the programme.

Glimpses of Rural Prosperity- MNREGS

This programme has not only enhanced livelihood security of households in rural areas of the State but has also helped in strengthening natural resource management through works that address causes of chronic poverty like drought, deforestation and soil erosion and therefore has encouraged sustainable development in rural areas.

Total Sanitation Campaign is another mile stone for the State. The State has strategized holistic concept of sanitation including generation of awareness on the 'need' for sanitation amongst people individually and also as a community.

Rs. 353 crore **'Pandit Deen Dayal Kisan Bagwan Samridhi Yojna'** envisages construction of polyhouses and bringing maximum area under minor irrigation for which State Govt. is providing 80 percent subsidy to the beneficiaries.

'Himachal Pradesh Crop Diversification Project' at the cost of Rs. 321 crore has been taken in hand to ensure organic farming and production of vegetables besides creating infrastructure for agriculture development. It is being implemented in collaboration with Japan International Co-operation Agency (JICA).

Organic Himachal

The National Mission on Sustainable Agriculture Development emphasizes on promotion of good agriculture practices as necessary components of the agriculture development approaches for which organic farming is the best known tool. The State has formulated the **Organic Farming Policy** which takes into account whole gamut of organic farming such as vision, mission, strategy about desired policy revision, awareness raising among stakeholders, organic technological and extension support to the farmers, quality assurance of State produce, organic inputs, demand and supply issues, developing organic supply chains as well as governance and implementation.

'Horticulture Technology Mission' programme is being implemented in the State with an objective of integrated development of horticulture in Himachal Pradesh.

Cold Desert turns into a Green Apple Orchard on the Altitude of 9,400 feet

Amongst fruit production, "Apple" has given Himachal Pradesh the status of "Apple State of the Country". To make apple cultivation viable in the face of growing environmental and global challenges, the State is implementing Rs. 85 crore **'Apple Re-plantation Scheme'**, wherein it is envisaged to replace the old and low yielding varieties with value productive varieties in the area of 12,500 acres during next five years.

Mid Himalayan Watershed Development Project

The Mid-Himalayan Watershed Development Project is operational in the mid and high hill range of 600 to 1800 metres covering 11 sub watershed divisions falling in 10 districts. The project is aimed at reforestation of protect watersheds, improve livelihoods and to generate carbon revenue. The total outlay of the project is Rs. 365 crores.

All these schemes are promoting inclusive growth in the rural sector. Adequate livelihood opportunities are being created in rural sector so that the tendencies of population migration to urban areas is checked and environmental problems associated with urban sprawl are contained.

Agriculture

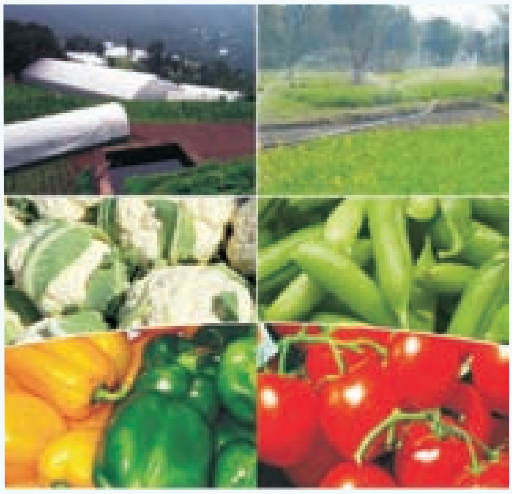
- The Department of Agriculture is serving the farming community by implementing various Developmental Programmes and disseminating the relevant technology to increase productivity, production and profitability of field crops.
- The natural endowments like soil, land, water etc. are being harnessed in such a way that cherished goals of ecological sustainability and economic upliftment of farming community are achieved.

Himachal Pradesh is mainly an agrarian economy based upon rain fed agriculture. The average cultivated land is about 5.42 lac hectares in the State out of which 80% is rain-fed. The land holdings are not only small but fragmented and 86.4% farmers fall in the category of marginal and small farmers. Their survival depends upon subsistence farming.

The Government of Himachal Pradesh is laying special emphasis on strengthening of rural economy by giving priority to Agriculture Sector. The focus is on diversification of crops, production of high value crops and raising productivity by dissemination of technology in the fields. About 12 per cent of the total budget of the State is being spent on this sector, which is highest in the country.

'Pandit Deen Dayal Kisan Bagwan Samridhi Yojna' is an all embracing scheme being implemented by Government of Himachal Pradesh for creating self-employment opportunities and diversification of farming for strengthening the economic status of farmers.

- 16,500 poly houses would be constructed in 15 lakh square meter area.
- 20,000 hectare area to be brought under micro irrigation.
- The farmers are being provided 80 percent subsidy for construction of poly houses. BPL families are being given 90 per cent subsidy for construction of bamboo based polyhouses.
- An assistance of Rs. 82.74 crore has been provided as subsidy to the farmers under this scheme so far.



Under the **'Himachal Pradesh Crop Diversification Project'** activities like promotion of organic farming, vegetable production and transfer of technology are being undertaken.

The State is also participating in Rashtriya Krishi Bima Yojna (RKBY) with a purpose to provide comprehensive risk insurance against yield losses from drought, hailstorm, floods and pests disease etc in Wheat, Barley, Maize, Paddy and Potato.

Under **Biogas Development Programme** Rs. 4,000 and Rs.10,000 is provided as subsidy on Biogas Plants upto 1 cubic meter and more than 1 cubic meter to 4 cubic meter.

Organic Policy

- Giving recognition and encouragement to the organic sector in the State.
- Creating enabling environment for organic farming in the State through developing appropriate policies, plans, and support services for organic production.
- Develop favourable policies and plans to make Himachal an organic compost rich State.
- Undertake steps to make forests, grazing lands and pastures recognised as organic, certified/ uncertified areas.
- Create investment environment for organic agribusiness and organic agro tourism.

Changing Scenario in Agriculture Sector through Organic Farming

The organic farming is emerging as future farming technique in the State of Himachal Pradesh. This endeavour would not only help in promoting sustainable agriculture production but would also mitigate the climate change effects by way of reduced GHG emissions, lesser use of chemical fertilizers and lesser requirements for irrigation. Series of awareness programmes on organic farming are being organized with an objective to provide one vermi-compost unit to each house hold farming family. About 4.0 lakh vermi compost units have been set up. 25,160 farmers have been registered for organic farming.

Soil Health Card

Under the Soil Health Management Programme of the State, Soil Health Cards are prepared and distributed amongst farmers based on tests of their soil samples by District Soil Testing Labs. This will help farmers to plan cultivation of flowering plants, medicinal herbs or other cash crops as per the fertility status of the soil.

Horticulture

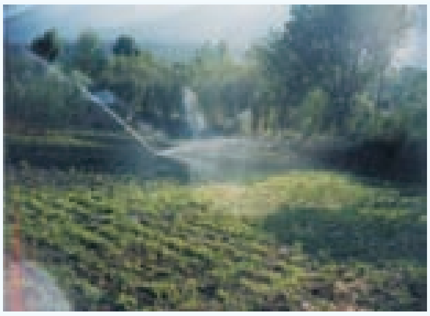
The endeavor is to make Himachal Pradesh **'Fruit Bowl'** of the country by adopting sustainable horticultural practices which will help to raise the economy of the State while protecting the environment.

- Sustainable development of horticulture by harnessing the natural resources in the hilly areas.
- Generation of sources for cash income to the rural people.
- Generation of employment opportunities in the pre and post harvest sectors of the horticulture industry.
- Provision of nutritive foods in the form of fruits, vegetables, nuts, mushrooms, honey.
- Satisfaction of the aesthetic needs of the people.

Horticulture is being practiced in suitable areas and only about 2.18 lac hectares area is under fruit cultivation. Sizable part of the horticulture produce is lost for want of proper storage and processing facilities. The State Government is aware of the potential and challenges for the development of horticulture in the State and treats horticulture as a priority area in the development plans.

Horticulture Technology Mission Programme is all embracing programme to address issues related to production and productivity, post harvest handling, marketing and processing of horticultural crops as well as backward and forward linkages.

HTM Contributing to Prosperity



Transfer of Technology

Realizing the utmost need to make farmers aware regarding latest technologies and interventions in the horticulture sector as well as about the threats emerging from climate change on horticulture crops, the Department of Horticulture has training cum awareness camps.

To make Apple cultivation viable in the face of growing economic, environmental and global challenges, the State is implementing Rs. 85 crore **'Apple Re-plantation Scheme'**, where it is envisaged to replace the old and low yielding varieties with value productive varieties in the area of 12,500 acres during the next five years.

Glimpse of RKVY Activities

- To provide financial assistance to the farming community for development of infrastructure supporting horticultural activities for generating self employment, bring in efficiency and increase farm income.
- To improve the production and productivity of horticultural crops through hi-tech, diversified, mechanized and organic horticulture.

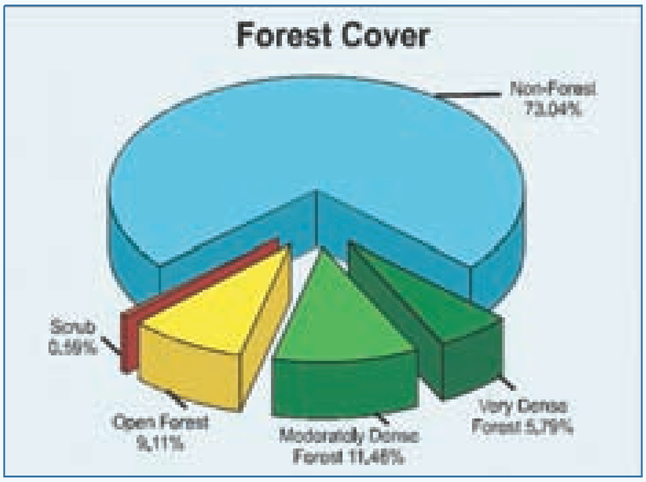
'Anti Hail Radar and Gun' has been established at Khara Pathar in Shimla District on experimental basis to protect the crops from hail. On success, such Radars and Anti Hail Guns would be established in other parts of the State.

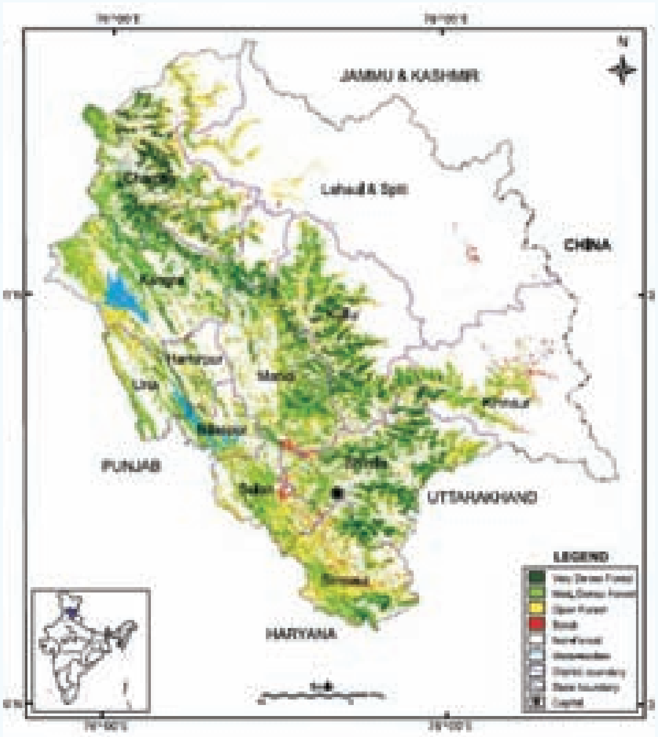
Forests

The Forests of Himachal Pradesh, known for their grandeur and majesty are like a green pearl in the Himalayan crown. The forests in Himachal Pradesh which host 7.32% of flora and 7.4% fauna of the Country are presently under great stress due to impact of modern civilization, economic development and growth in human and cattle population.

Forests at a Glance

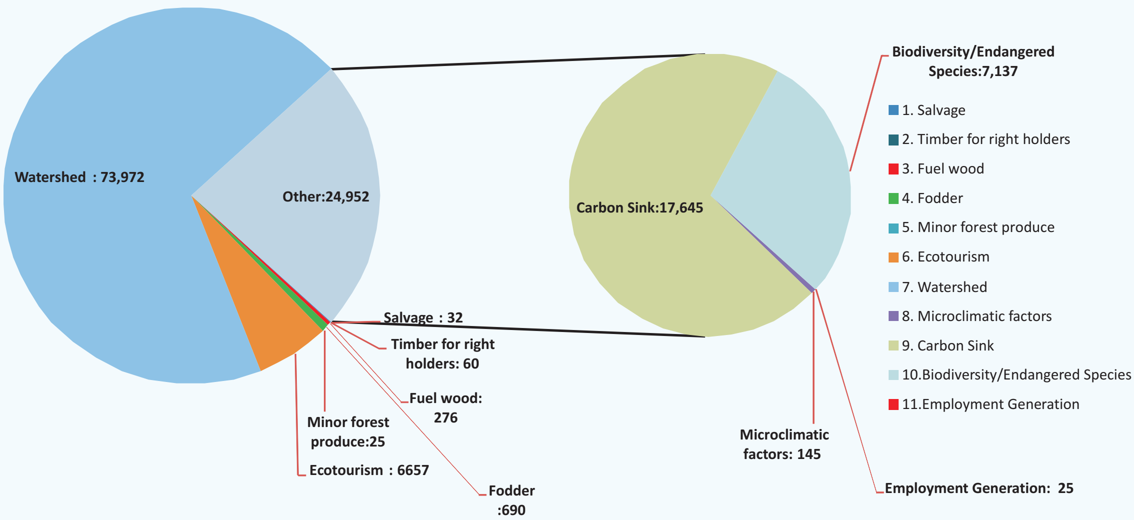
The Forest cover in the State, based on interpretation of satellite data of October-December 2008, is 14,679 sq Kms. which is 26.37% of the State's geographical area.





The state has 38 Forest Types which belong to 8 Forest Type Groups, viz. Tropical Moist Deciduous Forest, Tropical Dry Deciduous Forest, Subtropical Pine Forest, Himalayan Moist Temperate Forest, Himalayan Dry Temperate Forest, Sub Alpine Forests , Moist Alpine Scrub and Dry Alpine Scrub.

Economic Valuation (In crores)



Direct Benefits: 7,740 crores
Indirect Benefits: 98,924 crores
Total Economic Value: 1,06,664 crores

Himalayan States need to be compensated for the environmental services provided to the downstream regions.

The sustainable forestry, which judiciously manages renewable natural resources and provides food, income and livelihood for present and future generations while maintaining or improving the economic productivity and ecosystem services of these resources is need of the hour. The State Government stands by unequivocal commitment to long-term support of sustainable forestry and promotion of the stewardship and use of forests and forest lands in a way, and at a rate, that maintains their biodiversity, productivity, regeneration capacity, vitality and potential to fulfill, now and in the future, relevant ecological, economic and social functions at local, national, and global levels.

Promoting Carbon Neutrality

- The State has undertaken many programmes for preserving the pristine Himalayan ecology and enhancing the forest cover in the State. The efforts of afforestation have resulted in achieving an ever largest recorded forest cover in the State during the year 2009 that was 14,679 sq. km covering 26.37% of geographical area of the State.
- 'Jan- Jan Sanjeevani Van Abhiyan' in the year 2008 ensured the distribution of more than 15 lacs medicinal plants to the rural and urban households of Himachal Pradesh through 5,000 distribution points.
- To internalize the Jan Jan Sanjeevani programme, the State has further launched two new people centric plantation schemes, 'Sanjha Van Sanjeevani Van' and 'Apna Van Apna Dhan' for planting on private land and community land. Under the , 'Sanjha Van Sanjeevani Van Programme, 51 lac, 46.5 lac and 45 lac plants were planted in the year 2009-10, 2010-11 and 2011-12 respectively.

Peepal –Bargad Plantation

For involvement of elderly people in the plantation drive, the Forest Department has initiated another scheme "Peepal – Bargad Plantation" where Peepal and Bargad plants are being planted in the villages by elderly people in the lower and middle zones of the State. In the year 2009-10, 8,539 plants (Pipal-5,073 and Bargad-3,466) were planted in 4,436 villages.

Carbon Revenue: Generating Income through Carbon Credits

HP Mid Himalayan Watershed Development Project (MHWDP)

After learning from past experiences and considerable success of Integrated Watershed Management Programme, Mid Himalayan Watershed Development Project with an objective of reforestation to protect watersheds, improve livelihoods and generate carbon revenue is being implemented in the State.

- Operative in 10 districts of Himachal Pradesh including around 272 Micro-watersheds spread over 602 Gram Panchayats.
- The project benefits are expected to reach to around 25,000 target poor families in the project area.

Bio-carbon, Clean Development Mechanism (CDM) Project

Bio-carbon-sub project will go long way in protection and supporting our commitment for preservation and protection of environment through sequestration of Green House Gases (GHG) by expanding forestry plantations on mostly degraded land.

The impact area of project is 4,003.07 ha covering:

- Forest land of 3,176.86 ha.
- Community land of 203.06 ha.
- Private land of 533.15 ha.

The CDM agreement will fetch carbon revenue of around Rs. 20 crores for the first crediting period of 20 years. The Community and private land holders would be benefitted and will earn about Rs. 2,500/- per ha.

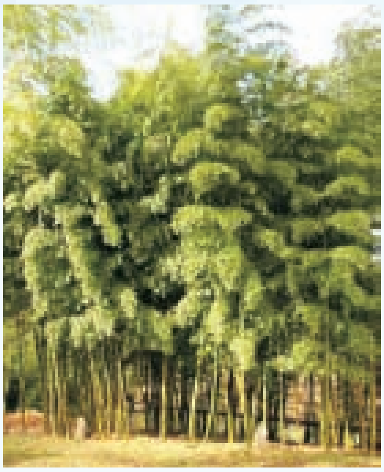
First Asian State to Sell Carbon Credits

Himachal Pradesh is the first Indian State to sell carbon credits from community lands under the UN-mandated Clean Development Mechanism (CDM). Implementation of Clean Development Mechanism will generate CDM revenues. The revenue from degraded forest and community lands and will be shared with the Gram Panchayats and in turn with the individual families. The carbon revenue is likely to be significant at about Rs. 20 crores for the first crediting period of 20 years. The project is expected to sequester the emission of 8,00,000 tonnes of carbon dioxide from 2006 to 2025.

Integrated Watershed Development Project, Swan, Una

The State Government is conscious and concerned about damage caused to land, property, human and cattle living along its banks due to reoccurring flash floods. Integrated Watershed Development Project (IWDP), Swan, Una targets to implement watershed catchment treatments of the 73 tributaries of the Swan River.

National Bamboo Mission



The State is also participating in National Bamboo Mission and has got approved a plan of Rs. 1.49 crores for planting of bamboo species in Nahan, Bilaspur, Mandi, Hamirpur and Kangra districts which also include interventions in non-forest areas for generating employment opportunities for skilled and un-skilled persons and promoting marketing of bamboo and bamboo based handicrafts.

Green India Mission

Under Green India mission which aims to improve the quality and quantity of forest cover with the help of Gram Sabhas, Women Self-Help Groups and Forest Management Committees and the technical assistance of State Forest Department, a bridge plan for Rs. 1.26 crore has been approved for Himachal for Mandi, Bilaspur, Hamirpur and Kangra districts for the year 2012-13.

Van Sarovar

The State has taken steps to revive the traditional model of water bodies as well as to recharge the ground water and enhancing soil and water conservation. This will also help in controlling forest fires and act as a source of water to wild animals.

- 148 Van Sarovars have been constructed during 2011-12 under the National Flagship programme NREGA.
- 100 Van Sarovars will be constructed during 2012-13.

Programmes through National Medicinal Plant Board

To conserve and develop the medicinal wealth of the State, conservation and propagation of medicinal species is also being done.. A medicinal plant project has been got sanctioned from "National Medicinal Plants Board" (NMPB) for Kangra, Kullu, Chamba and Sirmaur districts for Rs. 400.80 lacs.

Under the project, 1.96 crores medicinal plants over an area of 1,257 hectares area will be planted in four years with the active involvement of Joint Forest Management Committees and Village Forest Development Societies.

Towards 'Herbal' State

Realizing potential of medicinal herbs as a source of income generation for the people of the State. The State Government is providing impetus to the cultivation of medicinal plants to make Himachal **'Herbal State'** of the country. The State Government has established herbal gardens at Jungal Thalera, Bilaspur and Neri, Hamirpur (Sub Tropical zone), Jogindernagar (Mid-Hills/Sub temperate Zone) and Dhumrera, Rohroo (High Hill Temperate wet zone).

Further, Rs. 969.06 project on "Cultivation, Value Addition and Marketing of Medicinal and Aromatic Plants for Rural Upliftment in HP" under SGSY component of the Ministry of Rural Development, GOI is being undertaken.



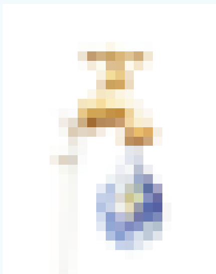



Water Resources, Irrigation & Public Health

Himachal Pradesh is endowed with a rich and vast diversity of natural resources, water being one of them. Its development and management plays a vital role in agriculture production. Irrigation & Public Health Department envisages integrated water management for poverty reduction, environmental sustenance and sustainable economic development.

Water is the elixir of life. As a scarce and precious resource, its usage has to be planned along with conservation and management measures on an integrated and environmentally sound basis. Keeping this in view and the socio-economic needs of the State, a revised Water Policy is being drafted so that safe and portable drinking water supply to all and community participation in conservation of water resources is ensured.

Managing Water: A Challenging Task



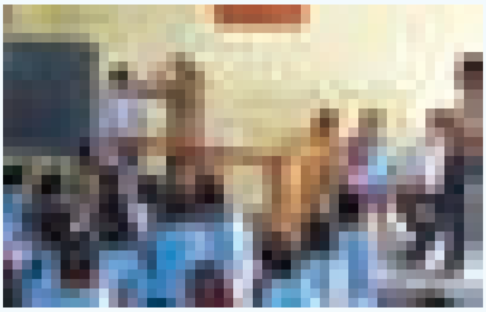
- 7,940 Water Supply Schemes under Rural Water Supply have been completed in the State. Out of these ,1,526 are lift , 234 tubewells and 6,180 are gravity schemes.
- Augmentation of Urban Water Supply Schemes of 43 towns prominently viz; Shimla, Kangra, Manali, Kullu, Hamirpur, Mandi, Dalhousie Solan, and Dharamshala have been completed.
- 26,132 hand pumps have been installed in the water stressed areas of the State.
- 2,217 irrigation schemes have been completed.

Flood Protection

Flood Protection measures in the shape of embankments, spurs and wire crates etc. has been undertaken at critical/flood prone areas. Till now 17,602 hectare area has been protected from the fury of floods.

To meet the challenges of ensuring quality water supply, the State is implementing National Rural Drinking Water Programme (NRDWP) focusing on area coverage, sustainability, water quality and natural calamity. Under this scheme, 219 habitations with an expenditure of Rs. 67.56 crore in State Sector and 1,596 habitations with an expenditure of Rs. 69.44 crore under Central Sector have been covered.

Another Water Supply programme Jalmani aims at providing safe drinking water in adequate quantity to all rural habitations in the State including rural schools and Anganwadis. Under this programme Simple Stand Alone Water Purification System based on UV technology are being installed in rural schools. For implementation of this programme, the Government of India has released a total sum of Rs. 749.05 lacs for providing Simple Stand Alone Drinking Water Purification system in rural schools.



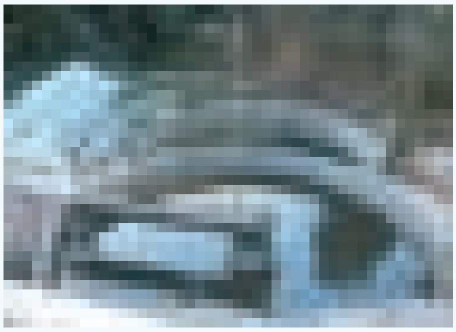
Irrigation

Out of the total geographical area of 55.67 lakh hectare of State, only 5.83 lakh hectares is the net area sown. It is estimated that ultimate irrigation potential of the State is approximately 3.35 lakh hectares. Out of this, 0.50 lakh hectares can be brought under irrigation through major and medium irrigation projects and balance 2.85 lakh hectares of area can be provided irrigation through minor irrigation schemes of different agencies. 23,197 hectares has been brought under irrigation in the last four years. Financial provision has been made for minor irrigation schemes under major and medium irrigation projects.

COMMAND AREA OF SAHANEHAR MAJOR IRRIGATION PROJECT

Sewage Disposal

Environment improvement assumes special significance particularly to prevent water pollution of the rivers and other water bodies and to abolish carrying of night soil on head load and scavenging system in the State. The State Government has given top priority to connect dry latrine system into water pour system. Under this programme, sewerage facilities are proposed to be provided in all the towns of the State. Sewerage schemes of 15 towns have been completed and work on sewerage schemes of 24 towns is in progress.



Sewage Treatment

Towns in the State mostly serve as health resorts, environment improvement, therefore, assume special significance particularly to avoid pollution of the rivers and other water bodies of the State. The sewage treatment is of immense importance. The State Government has initiated installation of 38 Sewage Treatment Facilities covering 9 Districts of the State considering the population load in their respective townships.

Implementation and Strengthening of Rain Water Harvesting Structures (RWHS)

The State Government took initiatives in the year 1999 to conserve its water resources. A decision was taken to make compulsory the collection of rainwater from the rooftops of buildings in the State. With a view to review the ground realities and assess the implementation level in the State, the Government constituted a task force for "Strength-ening of Rain Water Harvesting Operation and Management System in Himachal Pradesh".

Department	No of Buildings provided with RWHS
Public Work Department	62
HIMUDA:	
Public	23
Tourism :	
HPTDC	18
Private Hotels	137
Forest	2
Agriculture/ Rural Development	5
Health	3
Town & Country Planning :	
Public Buildings	115
Private buildings	2,441
Urban Development :	
Public Buildings	33
Private Building	2,371
Irrigation & Public Health	66
Total	5,276

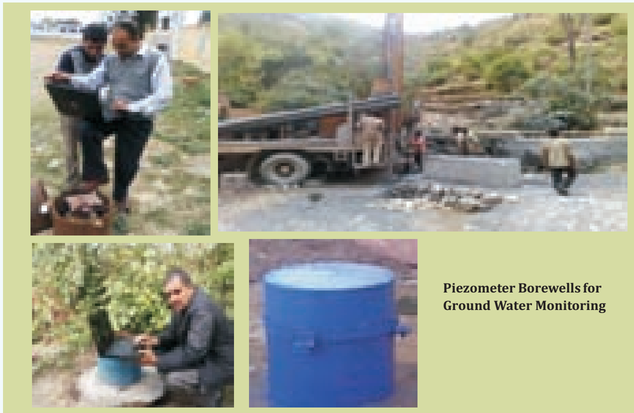
Integrated & Comprehensive Hydrological Database - Hydrology Project II

World Bank funded Hydrology Project – II (HP-II) is being executed in the State to develop an integrated and comprehensive hydrological data base. Total cost of the Project is US$ 135.01 million and the World Bank has approved a credit (IBRD Loan) of US$ 104.98 million to the Govt. of India for the same.

The Project envisages to establish:

- Hydrological Information System (HIS) network comprising of 80 piezometer borewells for ground water monitoring.
- 35 River Gauge sites, 136 Standard Rain Gauges (SRG) and Autographic/Automatic Rain Gauges (ARG).
- 6 Climatic Stations and 16 Snow Gauge Stations.
- Network of 16 Water Quality Laboratories.
- 1 State Data Centre, 8 Divisional Data Centres and 40 Sub-Divisional Data Centres.

Monitoring of Climatic Parameters for Building Strong Meteorological Data Base



Piezometer Borewells for Ground Water Monitoring

Animal Husbandry

Livestock is integral to the sustainability of economy of Himachal Pradesh. The Government of Himachal Pradesh has taken several steps to strengthen Animal Husbandry sector.

- Development of requisite infrastructure in State for improving animal productivity.
- Preservation and protection of livestock through provision of health care.
- Strengthening of central livestock farms (Cattle, Sheep and Poultry) for development of superior germplasm for distribution to States.

Doodh Ganga Scheme

The State Government is implementing Rs. 300 crore 'Doodh Ganga Scheme' in the State with an objective to increase income of the farmers and to provide self employment opportunities. Soft loans up to Rs. 15 lakh are being made available under the scheme. A 25 % subsidy is being given to general category and 33.33% to scheduled caste/ scheduled tribe beneficiaries.

Mukhya Mantri Arogya Pashudhan Yojana

The Animal Husbandry Department has launched 'Mukhya Mantri Arogya Pashudhan Yojana' to ensure opening of at least one veterinary Institution in each left out Panchayat in the State. Under this scheme 1,272 veterinary Institutions will be opened in a period of three years in a phased manner. 1,012 Veterinary Institutions have been opened this year.

Feed & Fodder Development Scheme

Rs. 517.50 lacs have been sanctioned for this scheme and Rs. 258.75 lacs have been released for the year 2011-12 to provide power driven chaff cutters at 75 percent subsidy. 6,900 hand chaff cutters have been provided under this scheme.

Bhed Palak Samridhi Yojana

The Department has started this scheme for Sheppard of Mandi, Kangra, Chamba, Kullu and Shimla Districts. Loan upto Rs. One lacs is being made available for purchase of sheep and lambs. A 33% subsidy is being given for this purpose.

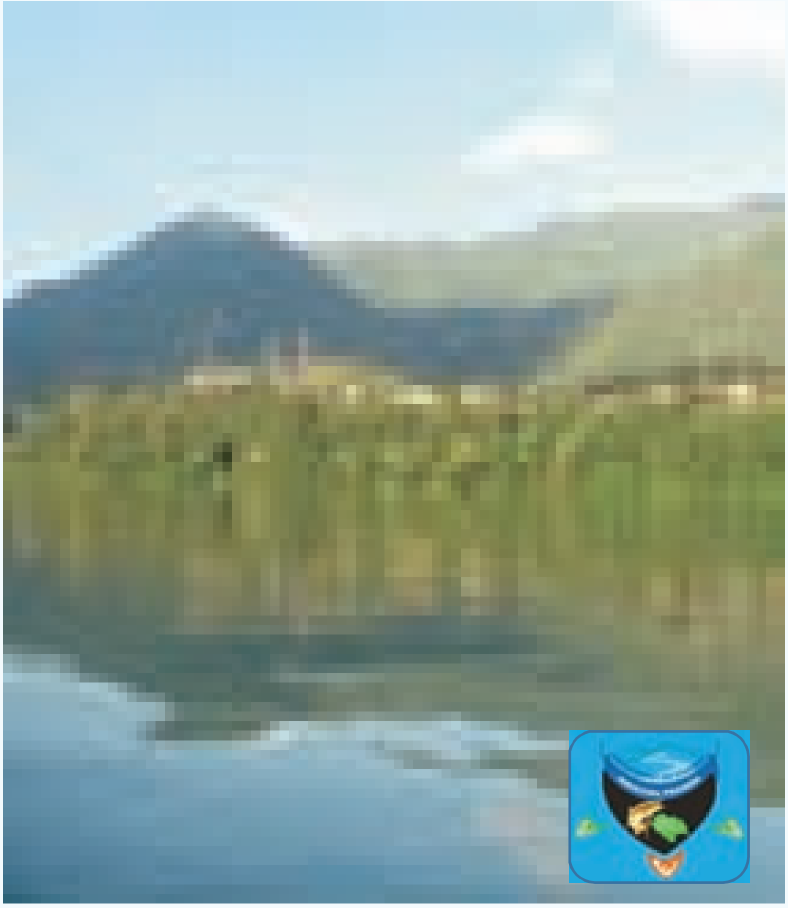
The State Government is committed to Socio-economic upliftment of Gujjar community and has constituted community specific Welfare Boards to advise State Government in formulation of policies and programmes for the upliftment of the community.

- Gujjars have been provided tribal status keeping in view their avocation of rearing animals while moving from one place to other round the year.
- 15 hostels has been constructed at a cost of Rs. 22.50 crore at education concentrated non-tribal towns for the benefit of the tribal students.

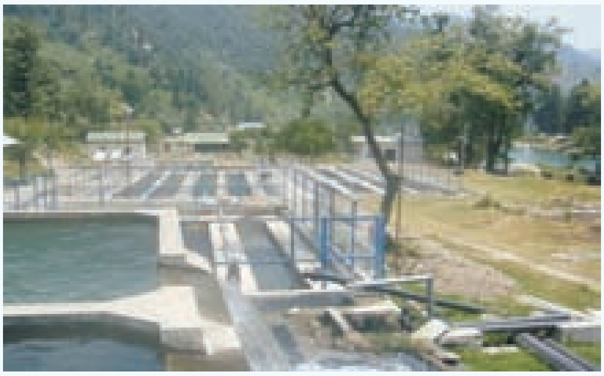
Embryo Transfer Technology Lab and Hilly Cattle Breeding Farm established at Palampur. A State of the Art Multidisciplinary Veterinary Hospital is being established at Palampur. Under the 'Shepherd Insurance Scheme' 17,000 shepherds have been given insurance cover. Intake capacity of Gosadan at Khajjian increased to 500 by spending Rs. 1.75 crore. More Gosadans are being set up in the State.

Fisheries

Goals & Objectives:



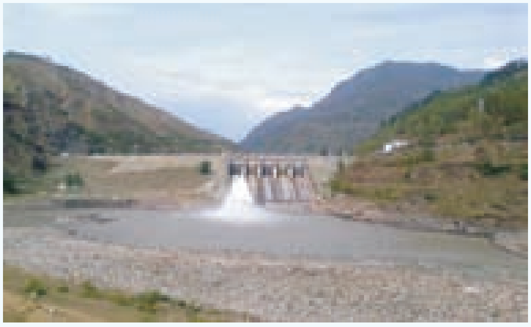
- To increase fish production in the State by judicious management of all the culturable water resources.
- To develop reservoir fishery of the State with an aim to increase per hectare production from the open impoundments.
- To protect and conserve reservoir and lacustrine fisheries resources of the State.
- To promote game fishery in the State with particular emphasis on promotion of Tourism.
- To promote commercial farming of Rainbow Trout in the high altitude areas.
- To promote aquaculture in the State.
- To generate employment opportunities in fishery sector.



Sustainable & Renewable Energy

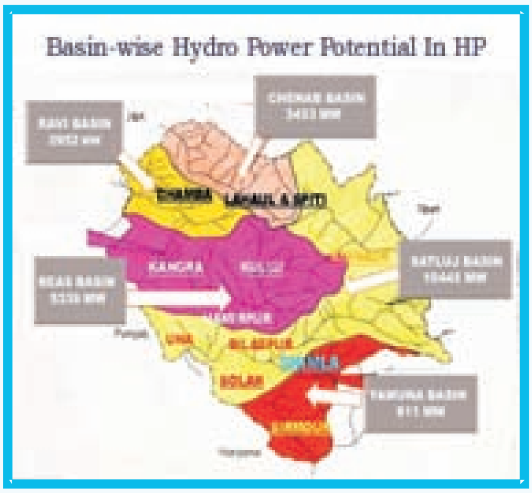
Coal remains a predominant energy source for power production in India, catering to production of 70% of total domestic electricity. Energy demand in India is expected to continue increasing over the next 10-15 years. The oil and gas fuel has also started contributing towards power generation, even though the coal is expected to remain dominant fuel for power generation. India currently has a peak demand shortage of around 14% and an energy deficit of 8.4% and to cope up with that India is contemplating to achieve a overall target of 215,804 MW power generation. To manoeuvre these shortages, the State Government is keen to optimally produce the hydro-power, known to be cleaner form of energy.

The State is the major provider of clean energy–hydropower for the country. The State has an identified hydro-power potential of around 23 GW (15% of the total hydro potential in the country) out of which around 8 GW has already been harnessed. This corroborates the national objective of realizing 40% of the total installed capacity through renewable energy in the country. This low carbon 'green energy' will further help to alleviate power shortage in India's northern power grid while being a vital source of non-tax revenue for the State. The State Government is striving to develop Himachal Pradesh as a power surplus and climate resilient State of the country.



Hydropower Potential of State

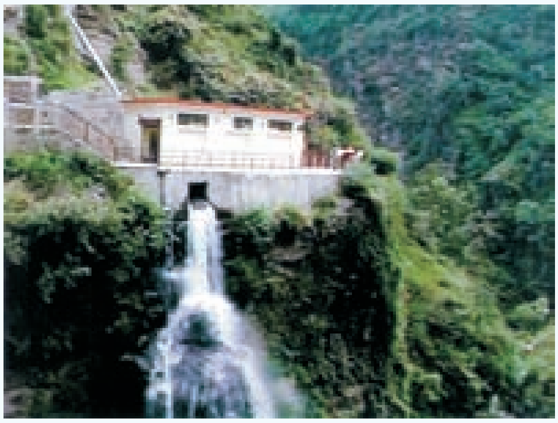
State Government is targeting to tap over 70% of hydropower potential of the State by 2020, essentially adding 10 GW to the current potential. The State has already identified projects for commissioning on Satluj, Yamuna, Beas, Chenab & Ravi basins during 12th and 13th Five Year Plans which will add 5,621 MW to the existing capacity.



Hydro Power of about 8,000 MW against total potential of 23,000 MW in five River Basins has been harnessed.

River Basin	Assessed Potential
Yamuna	811
Satluj	10,355
Beas	5,339
Ravi	2,952
Chenab	2,973
Others/self identified	570
Total	**23,000**

Small, Micro & Mini-Micro (572) Projects are being promoted to produce about 10,131 MW of Hydro-power.



Sustainance through Ecological Flows

- Himachal Pradesh is the only state to have mandated the release and maintenance of 15% minimum lean flows downstream of diversion structure to maintain riverine ecology.
- Real Time On-Line Continuous Flow Measurement & Data Logging Devices for the implementation of ecological flows and managing erosion, sedimentation & catchment degradation.
- Global Positioning System (GPS) based photo monitoring of muck dumping of the hydel projects.

Scientific Environment Management in Hydel Projects

The environment management, by and large, of hydro projects mainly lays focus on scientific Muck Disposal and implementation of Environment Management Plan

Scientific Muck Management

Management of muck and restoration of muck disposal site is implemented as a part of Environmental Management Plans of the hydro power project s and is monitored by the State Pollution Control Board and State Department of Environment, Science & Technology.

Ushering Local Area Development

- Local Area Development Fund (LADF) is currently being implemented in about 25 projects with an estimated Rs. 1600 million (33 million USD) that has been either spent or deposited with Local Area Development Committees (LADC) by the developers as per Ministry of Environment & Forest, Govt. of India provisions of 1.5% project cost for LADF.
- The investment in hydro sector in last 5 years has been around Rs. 10,000 crore and out of this Rs. 1,500 crore is spent/being spent on the local area development activities in the project affected areas.
- Provisions have been made for mandatory expenditure of more than 5% project cost towards Catchment Area Treatment (CAT) plans, afforestation activities and environmental protection & management.
- Cash transfers of 50 million rupees (or $1 million) to project affected peoples by 2014. The benefits due to this will be spread in 8 Districts of Himachal Pradesh and it is estimated that this benefit will be ranging from Rs. 3,000 to Rs. 1,50,000 depending upon the density of projects and population in the area.

A Novel Initiative

On social sustainability, the Government of Himachal Pradesh has undertaken action to adopt a new revenue sharing scheme that pays annuities to the local communities living in the affected villages during the operational life of hydropower projects.

This is a bold policy where the Government of Himachal Pradesh, leads, perhaps globally. Under this new policy, annual revenue equivalent to 1 percent of power sales from the project will be distributed to households in the project affected area.

This will be in the form of annuity payments through cash transfers made directly into bank accounts, to minimize risks of leakage. The Bank accounts will be created for households who do not possess an account at an established financial institution. The funds will be given to project affected persons (PAPs) and there would be additional transfers to "Below Poverty Line" (BPL) families. The scheme involves distributing 85 percent of the available funds to all affected families (PAPs). The remaining 15 percent would be transferred as an additional supplement to BPL families.

Integrated Catchment Area Treatment Plan

As a step forward to existing Catchment Area Treatment (CAT) Plans and institutionalization of CAMPA, the State Government has switched over to integrated and basin catchment area treatment approach, among other things:

- To ensure a scientific and need based approach to the treatment of catchments wherein all the stakeholder can contribute to catchment area development.
- Cumulative mitigation measures for the soil erosion and landslide hazards.
- To cumulatively redress the problem of silt and debris load.
- Checking the sediment load from the tributaries directly discharging into the reservoir.
- Combining protection of the direct draining catchments from scouring/ sloughing and slips.

Cumulative Environment Impact Assessment (CEIA) Studies

Realizing that the isolated impact assessments do not provide a sustainable answer to the environmental impacts emanating out of developmental activities, the State Government has prudently moved ahead for undertaking cumulative impact studies for redressal of environmental concerns in totality by taking river basin as a unit.

Carbon Credits

Green Houses Gases and phenomenon of Global Warming impacts our Glaciers, Agriculture and Horticulture, Forest wealth, Hydro- Electric Projects and Tourism. Through various initiatives we expect to earning Carbon Credit revenue through CDM from the following projects.

Project	Expected CER's
Mid Himalayan Water Shed Development Project	41,979 Annually
Public Sector Hydro - Power Projects	
a) Sawra Kuddu Hydroelectric Project	26,41,660 Expected in 10 Years
b) Integrated Kashang HEP	55,83,918 Expected in 10 Years
27 Private Hydroelectric Projects	31,63,014 Annually for a period of 10 Years

Optimising Renewable Energy in the State

Government is committed for harnessing renewable sources of energy in the State. Wind Solar Hybrid System of 12 KW (10 KW Wind Aero-generators and 2 KW Solar Photovoltaic Panels; investment of Rs. 41.30 lacs) has been installed at Pooh, District Kinnaur during 2008-09 with an objective to facilitate the Military Operations at high altitude near Line of Control (LOC), China.

- Two sites for establishment of Solar Power Plant of 3 MW have also been identified.
- The proposal for establishment of Wind Power Plant as joint venture with the Independent Power Producers is in pipeline.

Atal Bijli Bachat Yojna (ABBY)- A Step Towards Energy Saving & Efficiency

The State Government has introduced CFL for energy conservation through the 'Atal Bijli Bachat Yojna' by distributing 4 CFL bulbs free of cost to every family in Himachal Pradesh, which consequently resulted in saving of 270 MU power every year and earned an additional revenue of Rs. 109 crore to the State. The State Government is creating awareness in masses about the energy conservation need.

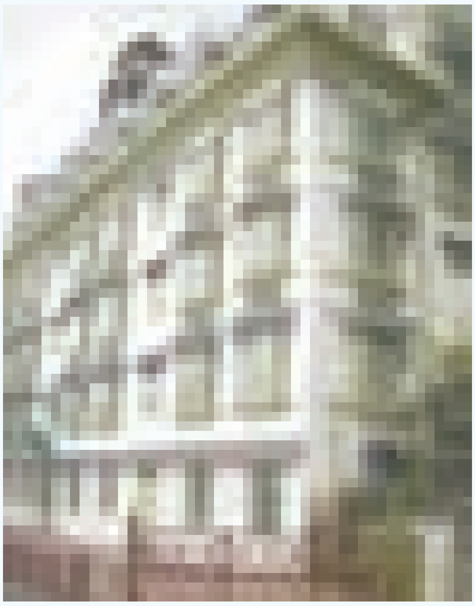
"Energy Saved is Energy Generated"concept mooted by the H.P. Government has helped in energy conservation and its alternative usage.

Use of Solar Energy

The traditional energy source for heating purposes has been the fuel wood, coal or the electricity, the demand of which is considerably large. The carbon emissions resulting out of use of coal & fuel wood for heating during winters causes environmental degradation. The State Government is discouraging the use of fossil fuels for the purpose of space heating during winters due to environmental concerns. Use of Solar Energy is being prioritized in the State to off load the pressure on hydro energy and as a safeguard to carbon emissions.

Solar Initiative

- Himachal Pradesh is the first State in the country to introduce Solar Passive Building Technology for the design & construction of Govt. & Semi Govt buildings in the State.
- The State Council for Science, Technology & Environment is co-ordinating the Solar Passive Building Programme in Himachal Pradesh in collaboration with HP Public Works Department, H.P. (PWD), HP Housing and Urban Development Authority (HIMUDA), TCP & other organisations.
- Through an institutionalised mechanism, the State Government is ensuring mandatory inclusion of solar energy techniques in all construction works in the State before making recommendations for Environment Clearance.



Solar Thermal Programme

The State has so far distributed 32,548 box type solar cookers, 83 dish type solar cookers and installed 9,53,640 LPD capacity solar water heating system on subsidized rates especially in the remote and far flung areas.

Solar Photovoltaic Programme

- Solar Photovoltaic Street lights are provided to far flung areas where grid connected electricity is not available or is insufficient or where it is not economical to provide grid connected street lights and to the areas which are socially & economically remote.
- A Solar Power Plant of 6.5 kWp and 2x 1000 LPD Solar Water Heating System is being installed at H.P. Secretariat, Shimla.

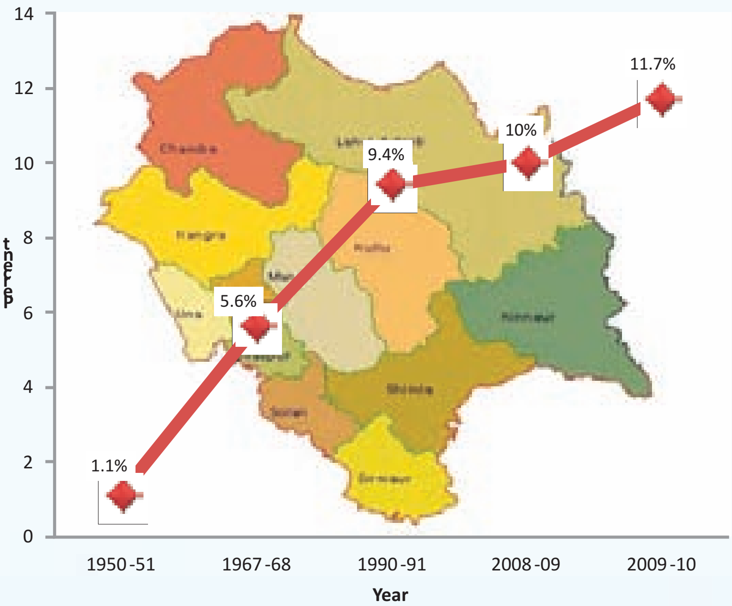
Carbon Smart Industrial Growth

The vision of Sustainable Industrial Growth of Himachal Pradesh envisages an industrial development, which is inclusive and is in harmony with the environment. During last few years, the State Government has initiated several policy amendments, provided concessions, offered incomparable services/infrastructures and created investment friendly environment, which have started yielding results in terms of setting up of more industrial units and enhancing employment opportunities for the local people.

Contribution to Economy

- The emphasis has been laid on a faster growth of manufacturing sector, which is a key area of employment generation. The manufacturing sector today employs more than 2.66 lakh persons and contributes to 11.7 percent (2009-10) of State Domestic Product.
- During the last few years, the industrialization in the State has made significant progress. Today, Himachal Pradesh has about 38,790 (38,302) Small Scale and 488 Medium & Large Scale) Industrial Units with an investment of about Rs. 16,287.27 crores.
- Till 1977-78 there were only about 5,700 SSI units and about 10 Large and Medium units employing just a few thousand people.
- The share of industries in SDP has increased from 1.1 percent in 1950-51 to 5.6 percent in 1967-68, 9.4 percent in 1990-91, 10 percent in 2008-09 and 11.7 percent in 2009-10.

Growth in Industrial Share to SDP in Himachal Pradesh



Red, Orange & Green Types of Industry

Types of industrial units falling under Red, Orange & Green categories as per their environmental pollution potential.

Category	Small	Medium	Large	Total
Red	747	75	182	1004
Orange	2274	189	134	2597
Green	2689	108	91	2888
Total	5710	372	407	6489

Note: The table excludes a number of industries exempted from environmental consent mechanism.

Thrust Industrial Enterprises

Major industrial enterprises in this category include enterprises of non-polluting nature such as horticulture produce including hops and tea, mineral water bottling, electronic enterprises including computer software and information technology except assembling, medicinal herbs and aromatic herbs, handicrafts, enterprises to manufacture industrial products by any biotechnology processes and processing laboratories or research & development activity related to processing, scale-up, other innovations and products in the field of biotechnology, and precision industries etc.

Negative List of Industries

Major industrial enterprises in this category are of polluting type including tobacco and tobacco products including cigarettes and pan masala, thermal power plant (coal/oil based), coal washeries/dry coal processing, inorganic & organic chemicals, tanning and dyeing extracts, cement clinker and asbestos raw including fibre, manufacture of pulp-wood pulp, mechanical or chemical (including dissolving pulp), plastics and articles thereof, production of firewood and charcoal, mini steel plants induction/ arc/submerged furnaces, and/or rolling mills etc.

Environment friendly Policy Amendment

Translating the above vision into action, the State Government amended the Industrial Policy in December 2011 to promote environment friendly development in the State and encourage cleaner production. Salient features of the amendment are as under:

- Promotion of cleaner production and environmental management system consistent with internationally recognized standards.
- Disincentive to industries on negative list.
- Promote public disclosure of pollution status at the unit and cluster level .

The focus of the Industrial Policy is now on dispersal of eco-friendly & local skill and raw material based industries to the interior areas of the State by granting incentives, depending on their location.

In Support of Traditional Industry

Geographical Indicators

In order to protect the traditional products of Himachal Pradesh, the State Govt. has obtained registrations for Kullu Shawl, Kangra Tea, Chamba Rumal and Kinnauri Shawl under Geographical Indications (Registration and Protection) Act, 1999.

The registration under GI Act will check the unauthorized use of these products, which will result in socio-economic growth of thousands of weavers/ farmers/ artisans and traders of Himachal Pradesh. The Geographical Indications (GIs) right can be used by all the producers from the geographical region covered by the particular geographical indication.

Kullu Shawls (GI No. 19)

Kinnauri Shawl (GI No. 149)

Chamba Rumal (GI No. 79)

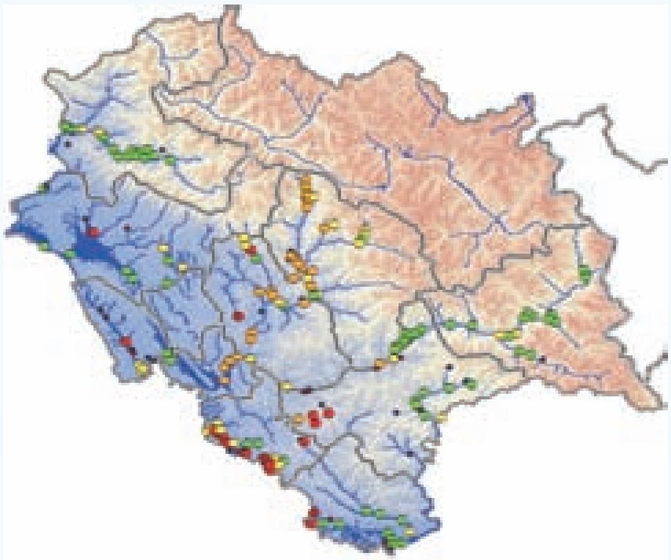
Kangra Paintings

Kangra Tea (GI No. 26)

Treatment of Industrial Effluents

- The State Government is according top priority for setting up of a Common Effluent Treatment Plant (CETP) through a Special Purpose Vehicle (SPV) namely M/s Baddi Infrastructure Ltd, formed by Baddi Barotiwala Nalagarh Industrial Association (BBNIA), Baddi, Disrtrict Solan, Himachal Pradesh.
- The CETP shall serve 990 industries present in 9 industrial areas in Baddi-Barotiwala industrial corridor.
- The proposed site of CETP is present near the industrial area at village Kainduwal in Solan District. The total cost of the project is around Rs. 53.80 crores.
- Setting up of the CETP is a step towards reducing and abating environmental pollution in the area and because of this infrastructure, more and more industrial units including ancillary units will strive to set up their units in this industrial area. This will give further impetus to growth process resulting to greater employment opportunities to the local people.
- The environmental clearance for the CETP project has been received from the MoEF, GOI and work will now be started.

Monitoring of Water Quality

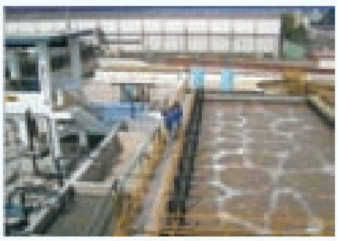


- Surface water quality monitoring is conducted four times a year for 189 locations selected on major rivers viz. Satluj, Beas, Ravi, Yamuna, Parvati, Sirsa, Markanda & Sukhna and their tributaries in the State.

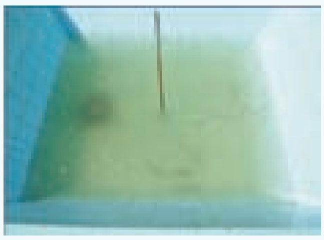
- These locations include 116 points on major rivers and its tributaries, 18 locations in major industrial towns for the monitoring of ground water and 55 locations on Hydel projects.

Zero Discharge Plant 100% of plant waste water is treated on site and used for gardening in a Baddi Plant

Waste Water in...



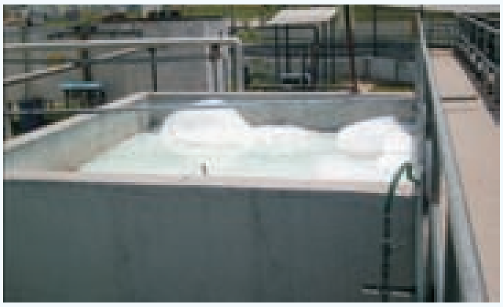
Treatment Done...



Fish Pond..

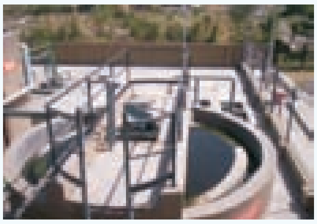
Landscaping...

Treatment of Industrial Effluents

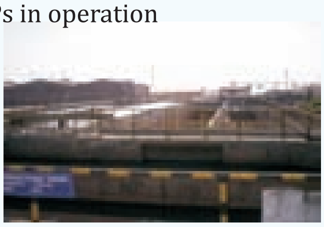


Primary Clarifier

ETPs in operation



Biological Treatment



Secondary Clarifier

Tertiary Treatment

In addition to the three conventional treatment comprising of physico-chemical and biological treatment, initiative has been taken to introduce tertiary level of treatment in the industrial units particularly those in Baddi-Barotiwala area.

Treatment of Sewage

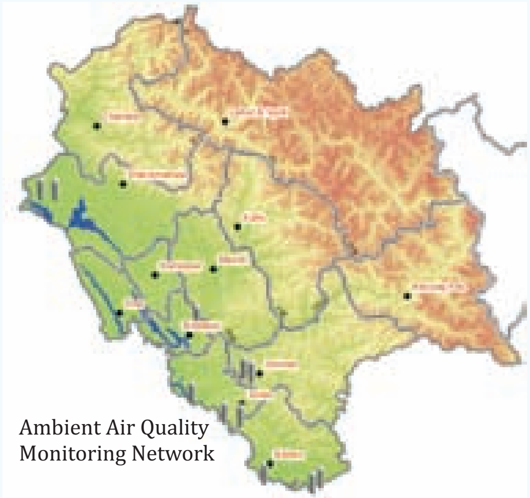
So far 35 sewage treatment plants with cumulative treatment capacity of 79.66 mld have been commissioned and provided. In all, 10 municipal solid waste processing facilities are being set up at different towns for better disposal and management of sewage and municipal solid wastes in the State. The Sewage Treatment Plants have been installed in hotels above 25 rooms capacity outside the municipal limit.

A Water Conservation Initiative by a Textile Unit at Nalagarh

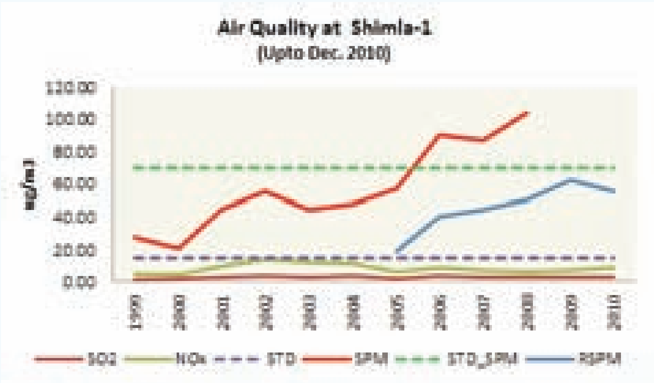
Monitoring of Air Quality

It has been ensured that air polluting industries comply with the air quality standards, which are being monitored regularly under Air Quality Monitoring Network

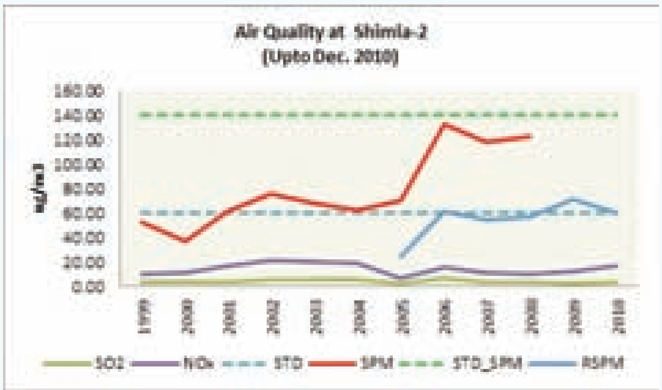
- The Ambient Air Quality Programme is operational with the objective to find the current status of pollution, to study the trends and to undertake remedial action as a result of increasing industrialization/urbanization.
- The parameters such as Suspended Particulate Matter (SPM), Respirable Suspended Particulate Matter (RSPM), Oxides of Nitrogen (NOx) and Sulphur Dioxide (SO_2) are being monitored with the help of Respirable Dust Sampler on the basis of three days per station per week for 24 hours at 8 Towns/Cities covering 14 numbers of locations in the State.



Ambient Air Quality Monitoring Network



RSPM recording partial decline after 2009 at the Bus Stand

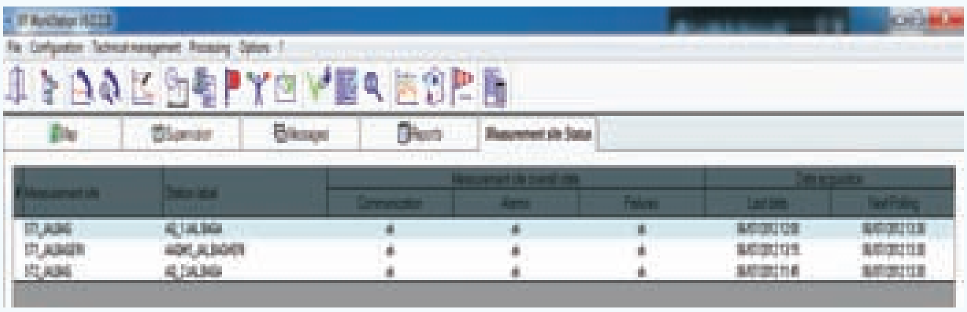


RSPM recording partial decline after 2009 at the Ridge

Online Continuous Ambient Air Monitoring Station (CAAQMS) by ACC Plant Gagal

- Installation of Continuous Ambient Air Quality Monitoring Station (CAAQMS). It has helped in measuring the continuous online ambient air conditions and helped in taking the pollution mitigation steps as and when required.
- Continuous Ambient Air Quality Monitoring Stations are contemplated in all major cities and industrial towns of the State.

Online Monitoring Locations in HP



Air Pollution Control

Wet Scrubbers and Cyclones

Air Pollution Control System in a Boiler

Bag House Filter

Bag Filters

Dust Collector

Cyclones

Pressure Filters

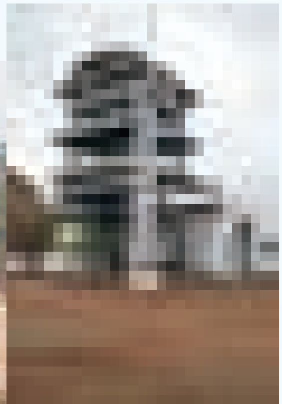
Laminar Decanter

Hazardous Waste Management

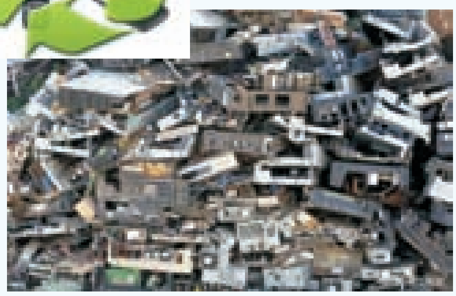
The Common Treatment, Storage, Disposal Facility (TSDF) at village Majra, Tehsil Nalagarh, District Solan is operational since June, 2008 for scientific disposal of landfillable hazardous waste.

Till March 2011, about 2427 units generating hazardous waste have been identified. Out of which 1862 are operational as on 31st March 2011 and responsible for generating hazardous waste under Hazardous Waste (Management, Handling & Trans-boundary Movement) Rules, 2008. Of them authorization was granted to 1862 units.

A total of 27,786 MT of landfillable hazardous waste has been disposed off in TSDF by various landfillable hazardous waste generating industries.



Management of E-wastes



- Guidelines for the Environmentally Sound Management of E-Wastes and Guidelines for Environmentally Sound Mercury Management in Fluorescent Lamp have been issued by the MoEF/CPCB in 2008. This is being pro-actively implemented.
- The aspect of E-waste generation in the state and its management is being taken up on priority, beside the management of mercury from the CFL lamps and its disposal requires awareness and proper central disposal facility.

Bio-medical Waste Management

Till March 2011, 555 Health Care facilities were inventorised and covered under Biomedical Waste (Management & Handling) Rules, 1998 which includes 233 Government and 322 Private health institutions.



Incinerator

Syringe Destroyer

Deep Burial pit at a Civil Hospital

Incinerator at MC Shimla

Municipal Solid Waste processing facilities towards Green Himachal

- Eight number of waste processing facilities (composting plants) are functional, wherein approx., 80-90 tons of municipal solid waste from 10 number of municipalities is processed/ day.
- Total waste generation is approx. 300-350 tons/day within the area of jurisdiction of municipal limits.
- The establishment of composting plants of five more municipalities has also been proposed.
- Besides technical assistance, financial assistance was also provided for establishment of waste processing facility at MC Nahan.

Municipal Waste Management

Root Zone Technology

Redressal of Public Complaints/Representations

- The State Government ensured that surveillance and monitoring becomes a regular event to maintain a constant vigil on the environmental quality and impact thereof on the people.
- The concerned regulatory authority not only keep liaison with the people but also take prompt action for mitigation of the public grievances.
- During the years 2008-11, the State Pollution Control Board took remedial action on 641 public complaints/representations that were received during these years.

Surveillance and Monitoring of Industrial Pollution (Compliance)

- This part of the function is very crucial for the operation and maintenance of the pollution control systems installed by the industrial units. This assumes greater significance because if the pollution control systems are not properly operated and maintained, this will cause water and air pollution due to release of effluents and emissions.
- As part of surveillance & monitoring activity, the State Board collected samples and inspections were conducted to ensure compliance to norms and environmental standards.

Application of e-Governance in Industrial Pollution Control

HIM-XGN web-portal has been launched to facilitate the entrepreneurs for online application and data uploading for effective and transparent environmental governance:

- Fully web enabled consent mechanism adopted since 5-06-2009 to introduce transparency and accountability in consent administration.
- Online real time monitoring of emissions and air quality in Cement Plants.
- Online real time monitoring of 15 % minimum flow in the rivers mandated for Hydro power units.
- GIS based Surveillance & Monitoring for Hydro projects is being conceived.
- Video Conferencing facility with the Regional offices.

Initiatives by the Industry

- Entrepreneurs are also coming forward to help us to achieve our stated objectives of effective environmental governance.
- ACC Gagal (Barmana) has adopted Root Zone technology, which is the nature's answer to the modern industrialized world's water pollution problems.
- Wetland plants called reeds have been grown in specially designed beds, which provides eco-friendly mode to use nature to "Protect Nature" as the net work of Rhizomes and naturally occurring bacteria associated with their root structure help in breaking down of organic solids present in the waste water.
- Gujarat Ambuja, Darlaghat & ACC both have started co-processing solutions to local municipalities and industries alike to dispose off their hazardous and non-hazardous wastes in kilns in the most environmental friendly and ecologically sustaining manner.

Dumping Sites

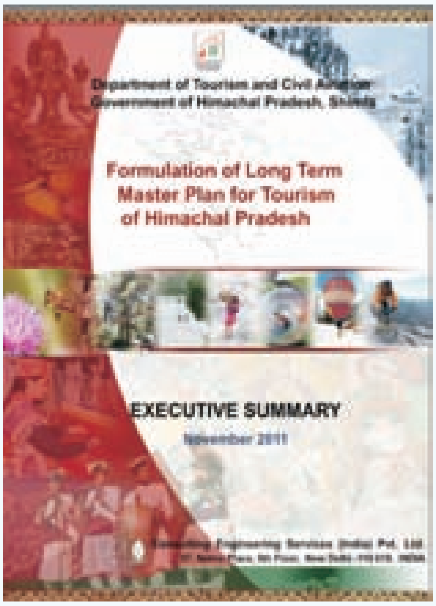
In order to promote green roads, the State Government has prioritized the identification of dumping sites for scientific disposals of road debris/muck. In total 273 such dumping sites have been identified and are being put to use.

Eco-Tourism

In order to to achieve the dual objective of resource generation and the protection of our fragile Himalayan ecology, the efforts are to encourage tourism in the relatively lesser explored parts of Himachal Pradesh. The involvement of local community would help in keeping the natural pristine environs intact while enabling tourists to enjoy the exclusive natural Himalayan retreat.

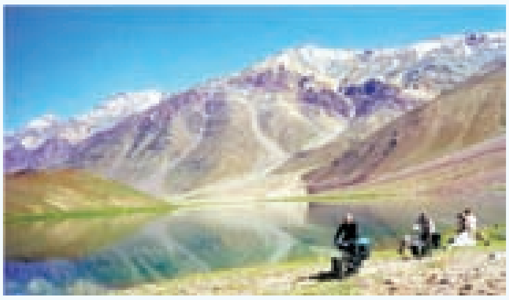
Home Stay Scheme, is a unique environment friendly scheme, which provides secure and comfortable Home Stay facilities of standardized services to the tourists and to supplement the availability of accommodation in the rural tourist destinations, besides generating employment opportunities and adding economic values in the interior, remote and rural areas. 'Home Stay' scheme is pivotal for promoting rural tourism in the State. Himachal is now being recognised as 'A Destination for All Seasons & All Reasons'.

Towards Sustainable Tourism Development-Tourism Master Plan



Recognizing the potential of the tourism sector and the contribution it could make in the State's GDP, the GoHP in extension to its Tourism Policy has set a mission of making tourism the prime engine of economic growth. The State Government, in its endeavour of becoming a carbon neutral state, has focused at expanding tourism activities having low carbon footprints. The Government of Himachal Pradesh is in the process of formulating a long term Tourism Master Plan so that tourism development remains in harmony with the environmental conservation. We aim to develop sustainable and environment friendly high-end tourism in the State. The Tourism Master Plan would suggest strategic interventions required to de-congest the present tourist destinations by diverting the tourism traffic to new places with higher revenue yield.

Effective Environment Management Practices



Actions for Present and Future Generation

The State is very much conscious of importance of our State's strategic location in the Himalayan Region. In view of State's ecological fragility and sensitivity the State has realization towards our immense responsibility for downstream populace besides for our own present and future generations.

The State Government is committed for promotion of sustainable development in the State in an economically, socially and environmentally sound manner and has repeatedly through real actions expressed its resolve to protect and enhance its natural resources and followed the path of GREEN GROWTH in all sectors of governance.

The State Government through participatory governance is dealing with issues related to environment degradation and pollution including impacts of climate change on various sectors of our economy.

In order to have the status of environment of our eco system and environment at the macro-level, the Government prepared and released its State of Environment Report during the year 2009.

‘**State of Environment Report (SoER)**’ of Himachal Pradesh is an innovative interactive report. It allows the user to view data on environmental issues and challenges.

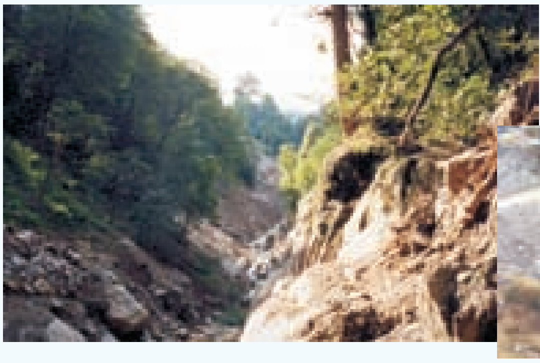
Key Objectives

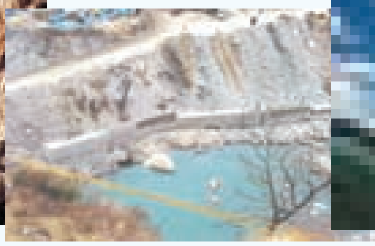
State of Environment reporting has been undertaken in order to understand, describe, analyze and communicate information on the conditions and trends in the environment and accordingly frame strategies to mitigate challenges. The objectives have been:

- To identify gaps in the State of knowledge of environmental conditions and trends, and recommend strategies for research and monitoring to fill these gaps.
- To provide early warning of potential problems, as well as allowing for the evaluation of the possible scenario for the future.
- To report on the effectiveness of the policies and programmes that has been designed to respond to the environmental changes.
- To assess the State's progress towards achieving ecological sustainability.

Following Themes have been included in the Report:

- Physiography of Himachal Pradesh.
- Agriculture and Allied Activities (Horticulture and Animal Husbandry).
- Bio-Diversity.
- Energy.
- Land Use.
- Forest.
- Health Transport.
- Industries and Mining.
- Tourism and Culture.
- Water Resources.
- Environmental Pollution. and Management.
- Society & Environment.
- Natural Disasters and Climate Change.





Environment Master Plan for Himachal Pradesh

In order to ensure the sustainability of environmental heritage and natural resources and to develop a long term perspective of achieving environmentally sustainable development, the Government of Himachal Pradesh has undertaken the preparation of Environment Master Plan (EMP) for the State. The key objectives of the Environment Master Plan are to enable the State of Himachal Pradesh to:

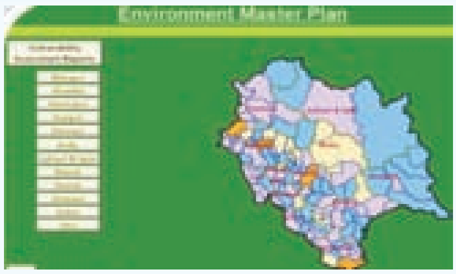
- Simultaneously address issues of ecological and environment restoration and bring convergence along with the development activities taking place in the state;
- Engage and ensure close coordination with all the concerned development departments, both at the state and Government of India level;
- Decide future financing of investments for development in a sustainable manner, and
- Develop suitable institutional arrangements in order to implement the Government of Himachal Pradesh's policies and strategies.

Through this initiative, the State Government is able to achieve following:

- Establish Baseline conditions.
- Conduct a Spatial Vulnerability Assessment and formulate Planning Principles.
- Develop Public Consultation and Communication Strategy for the Department of Environment.
- Develop Sectoral Guidelines for High Foot Print Sectors.
- Develop an Institutional Mechanism for implementation of the EMP.
- Establish need for Training and Capacity Enhancement.
- Develop Monitoring and Evaluation Protocols.

It is one of the unique initiatives in the Country towards Sustainable Development and Planned Green Growth. Overall, the Environment Master Plan has been envisioned as guide tool to provide strategic direction with respect to all encompassing environmental issues. This plan would be a platform for engagement among implementing agencies, developmental agencies and the local government, to take action w.r.t. environmental issues of local concern on priority. The Environment Master Plan would also act as a tool for monitoring environmental performance and progress.

Vulnerability Assessment of Himachal Pradesh



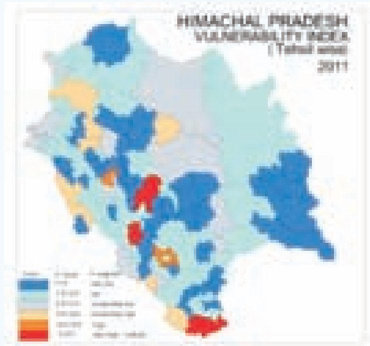
The Vulnerability Assessment of all the districts at tehsil and sub tehsil level has been carried out with the objective of correlating the baseline data and information and identify critical and vulnerable areas / issues at tehsil level. Perhaps this study was the first of its own kind, which the Government of Himachal Pradesh ensured during the year 2009-2011, as to formulate planning approach, as an optimal combination of "bottom up" (inclusive of community inputs) and "top down".

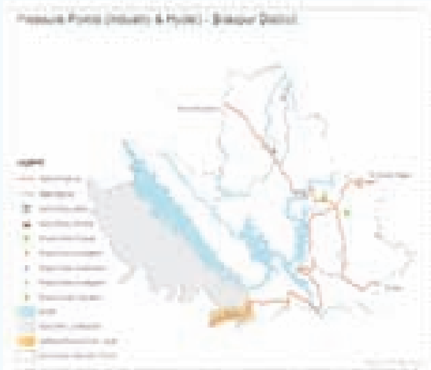
The assessment of vulnerability in the context of natural systems and quality of life is an important and integral part of the Environment Master Plan.

A spatial vulnerability assessment has been carried out and accordingly the planning principles have been formulated.

While deriving the vulnerability assessment our experts have correlated the baseline data and information and identified critical and vulnerable areas/ issues related to the specific sectors viz; infrastructure, natural resource management and services besides their associated sub sectors:

- Priorities have been fixed for optimal decision-making.
- Vulnerable areas or hotspots have been Identified.
- Mapping of hot spots have been done with identification of trade offs.
- Planning approach has been formulated.



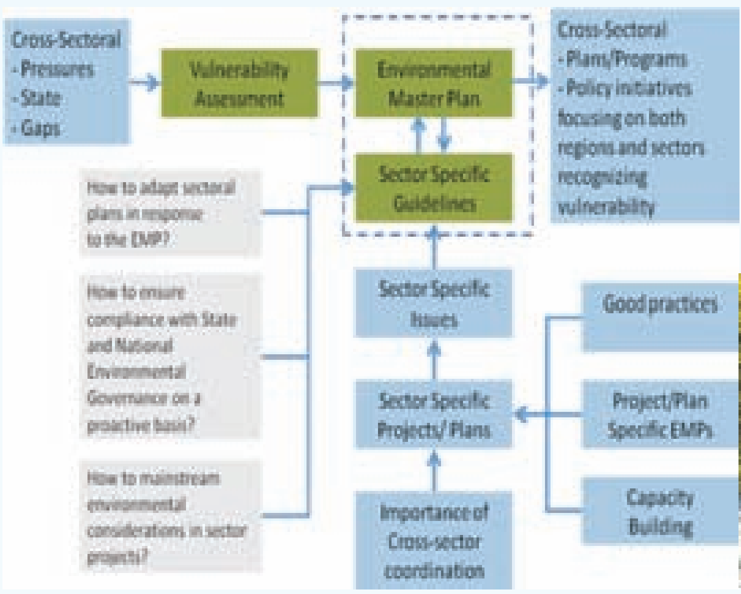


Current Environmental Vulnerability Status

The scenario projection is quite helpful, acts as healthy source of information for deriving the priorities for optimal decision-making, identification of vulnerable areas i.e. physical areas or hotspots; and policies which exacerbate environment deterioration in these areas. Mapping of hot spots and identification of tradeoffs, Categorization of areas based on impacts and associated environmental risks and establishing criteria for the same has been set through this endeavour.

Environmental & Social Sectoral Guidelines

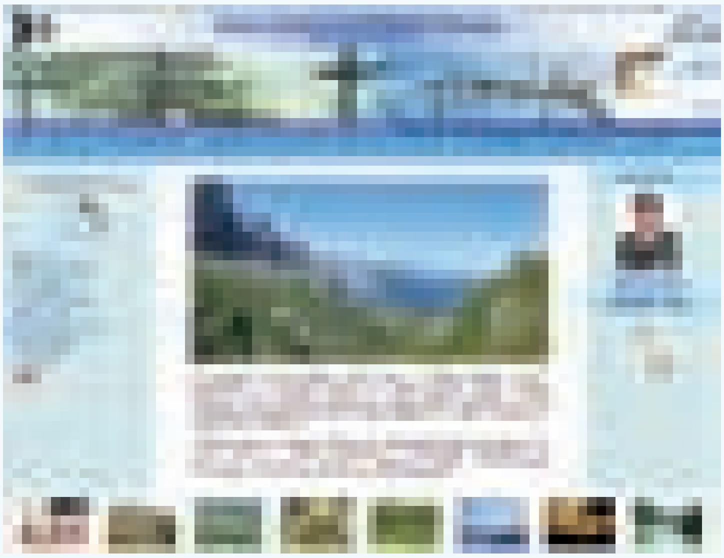
Based on environmental status and vulnerability assessment out comes, action plan has been given for each and every sector for Policy level, Plan level and Programme level interventions to be taken by the various stakeholders to ensure sustainable development of the State and to usher the State on path of Green Growth.To mainstream environmental concerns into the State's development agenda in the next three decades and beyond and to attend the emerging environmental challenges for achieving the green growth; environmental and social sectoral guidelines have been prepared for 16 major sectors in Himachal Pradesh.



State Centre on Climate Change, Himachal Pradesh

The Centre endeavours to achieve the following objectives:

- Guide State growth through a qualitative change in direction that enhances ecological sustainability leading to further mitigation of greenhouse gas emissions.
- Recommend appropriate technologies for both adaptation and mitigation of greenhouse gases.



- Protect, preserve and enhance the forest cover and the biodiversity for effective carbon sinks.
- Monitoring of glaciers, mass balance, retreating trends & up-dation of inventories.
- Coordination with different universities, research institutions, Govt. departments, NGOs etc. to pursue theme based specific research on climate change and its impacts.
- Awareness amongst various stakeholders for taking appropriate measures in combating the impact of climate change.
- Evolve strategies and policies for implementation through public and private institutions.
- Awareness modules at the different platforms for the mitigation of natural disasters.
- Strengthen capacity building in disaster management.
- Polices and inputs to the State government in the field of disaster management.

Actions Being Taken

The Government of Himachal Pradesh has initiated many programmes for dealing with the challenges of climate change. The initiatives and action can be categorized into the following broader areas as:

- State specific Action Plan on Climate Change.
- Institutional framework to deal with different facets of climate change.
- Catalyzing research on critical areas on developmental & livelihood.
- Strategy and action plan for generating awareness and education.
- Adaptation measures to combat the impact of climate change.
- Creation of centralized database.
- Managing water sources.
- National and international initiatives for dealing with the impacts of climate change on livelihoods of people.
- Working towards achieving and sustaining the goal of making Himachal Pradesh the first Carbon Neutral State of Country.
- Use of remote sensing technology for the better management of climate induced, other natural hazards and the natural resources.

A Step towards Prevention of Forest Fire and Reduction of Green House Gas Emissions

Dry Pine needles are susceptible to fire and poses fire hazard to the forests.

- Every year thousands of hectares of forests are turned into ashes because of Pine needles incidents.
- Pine needles also obstruct the green grass to grow as natural phenomena.
- Removal of Pine Needles from the forest will help to save our National Property.
- Encourage regeneration of new growth.
- Fulfill the grazing needs.
- Prevent the forest fire.
- Create the Income generation activity for community earning on an average Rs. 150/- per quintal (Rs. 800/- per day) for collection of bio–mass.

Forest Department through Ambuja Cement Foundation has taken initiative and identified 3,000 ha area in Kunihar Forest Division for collection of pine needle bio mass mobilizing Self Help Groups, Women Groups/Yuvak Mandals and local rural communities for collection.

Steps for building Green Economy

Himalayan Chief Minister's Conclave- for 'Himalayan Advocacy'

In view of the fact that the 'hilly states' lacks in collective 'advocacy' at National level on issues concerning sustainable hill development and that such issues do not receive attention at the national level due to geographic, demographic, political reasons, we decided and acted to convene a 'Himalayan Chief Ministers' Conclave -Indian Himalayas: Glaciers, Climate Change and Livelihoods at Shimla to create a common plate form to resole and create collective advocacy on Himalayan issues at the national level. A resolution - 'Shimla Declaration' on Sustainable Himalayan Development was released with the aim to protect and conserve Himalayan eco system.

Release of State of Environment Report, H.P. by Sh.J airam Ramesh, the then Hon'ble Union Minister for Environment & Forests (Independent Charge), Govt. of India.

Shimla Declaration:

- Establishment of a Himalayan Sustainable Development Forum (HDSF);
- Setting up State Councils for Climate Change;
- Catalyzing research for policy action;
- Payment for ecosystem services;
- Managing water resources for sustainable development;
- Challenge of urbanization;
- Green transportation;
- Dealing with impacts of climate change on livelihoods;
- Decentralized energy security;
- Managing growth of eco-friendly tourism and pilgrimage.

ESTABLISHMENT OF STATE CENTRE ON CLIMATE CHANGE to better comprehend the dynamics of climate change, coordinate the research and to evolve management measures with the active involvement of experts.

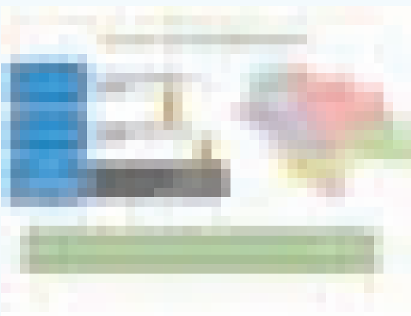
Foundation Stone Ceremony of State Centre on Climate Change
Dr. R. K. Pachauri, D.G. ,TERI: Guest of Honour.

The State Government has introduced CFL bulbs for energy conservation through the **'Atal Bijli Bachat Yojna'** by distributing 4 CFL bulbs free of cost to every family in Himachal Pradesh. This would result in a sizable reduction in energy consumption.

COMMUNITY LED ASSESSMENT, AWARENESS & ADVOCACY PROGRAM (CLAP) for Environment Protection & Carbon Neutrality.

- Environment and carbon footprint assessment.
- Environment protection / improvement and carbon footprint reduction.

Thematic Areas under Clap



1. Pawan TARA Air Testing Kit
2. Biodiversity Survey
3. Jal TARA Water Monitoring Kit
4. Laboratory Support
5. Paper Recycling Plant

Achievements

- Environment Assessment exercise in about 400 Panchayats undertaken.
- Carbon footprint for Panchayats calculated and advocacy issues identified and advocacy undertaken.
- Selection of Eco–Sensitive Panchayats in all the Districts on following criteria:
    - High Population
    - Nearness to Highway
    - Industrial Area
    - Number of Villages
    - Eco-Sensitivity of area (like Dumping area, water quality and Protected areas)

Afforestation Scheme viz. **Sanjeevani Van- Sanjha Van** for the promotion of medicinal herbs for the conservation of biodiversity.

To make Himachal a Herbal State, a new ambitious programme 'Jan-Jan Sanjivni Van Abhiyan-2008' was launched in the State. Under the programme medicinal plants have been distributed.

Journey of Plastic from Waste to Wealth

A Way Forward – To make the State Carbon Neutral

The Delhi Sustainable Development Summit (DSDS), organized annually by The Energy and Resources Institute (TERI) since 2001, is an international undertaking that provides a platform for the exchange of knowledge amongst important heads of the State and Central Governments, academicians, and policy makers on all aspects of sustainable development.

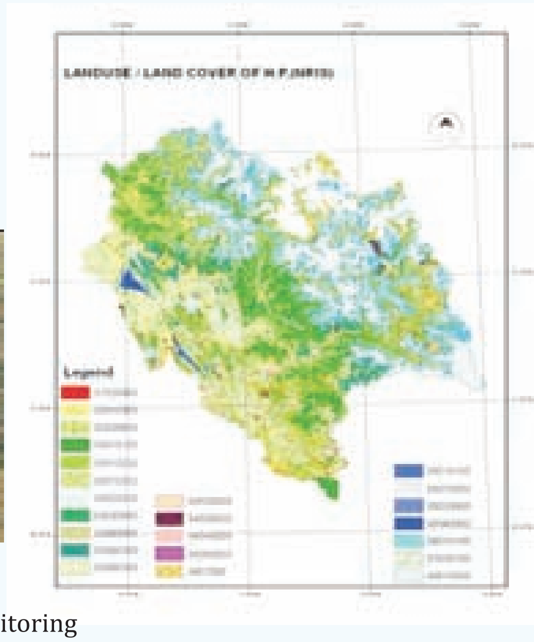
The theme of DSDS 2012 was protecting the Global Commons: 20 years post Rio. The debates at this DSDS revolved around the commons and took stock of the situation since the Rio summit of 1992.

New Partners

TERI will establish a Regional Centre in Himachal Pradesh in collaboration with State Centre on Climate Change, Government of Himachal Pradesh to study the various facets of climate change.

Application of Remote Sensing in Environment Management

Natural Resource Mapping



Disaster Management-Parechhu Lake Monitoring

Environment Awareness & Education

In order to preserve, maintain and enhance the pristine environment of the State, the Government has acted very proactively and initiated number of programmes for the conservation and protection of our environment.

The State Govt. initiated School Environment Audit Scheme for Eco-Clubs to improve their environmental performance. To sensitize the general public about menace of littering, State Government launched a Eco– Monitoring Scheme. The State Council is also effectively implementing National Green Corps programme through 3000 Eco-clubs across the state and National Environment Awareness Campaign through NGOs, Mahila Mandals, Gram Panchyats etc.

Climate Induced Hazards & Other Natural Disasters

The State of Himachal Pradesh, which forms a part of the Western Himalaya, is environmentally fragile and ecologically vulnerable. The State being part of the Himalaya is seismically very active and is highly vulnerable since 32% of the total geographical area of the state falls in very high damage risk zone as Zone -V and the remaining in Zone -IV. Occurrence of natural hazards emanating from the effects of climatological variations are a matter of immediate concern to the State, as every year the State experiences the fury of nature in various forms like cloud bursts, flash floods, landslides, snow avalanches, and droughts.

Hazard Vulnerability of the State	
Natural Hazards	Man-Made Hazards
Earthquakes	Accidents
Landslides	Electric Fires
Snow Avalanches	Forest Fires
Droughts	Building Collapse
Hailstorms	Serial Bomb Blasts
Flash floods/Cloud bursts	Festival related Disasters

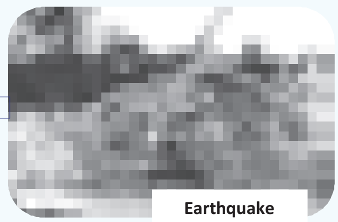
History of Disasters in Himachal pradesh

Landslide Area	History of Damage
Maling (1968).	This slide damaged 1 Km NH-22 and is still active.
Kinnaur (Dec.1982)	This occurred at Sholding nala collapsing 3 bridges and 1.5 of road was vanished.
Jhakri (March 1989)	At Nathpa about 500 m of road was damaged due to this slide and is still active
Luggarbhati on 12 Sept.1995	65 (39 as per official record) were buried alive during the slide

Landslide

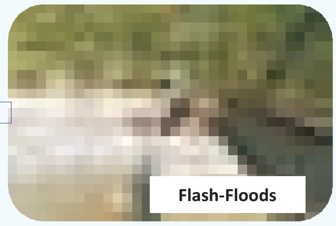
Location	32°15´ N, 76°15´ E
Date	4th April, 1905
Time	06:20 hrs., IST
Magnitude	8.0 Richter Scale
Intensity	X on MM Scale
Causalities	20,000 persons
Area Shaken	4,16,000 sq.km

Earthquakes in the State in last 100 years	
No. of Earthquakes	Magnitude
141	3-3.9
22	4-4.9
45	5-5.9
7	6-6.9
1	8.0
1130	Less than 3.0



Earthquake

Date & Place	Damage
08-Jul-73	Formation of lake in Satluj River due to Nathpa rock fall. Revenue loss of Rs.45 million.
4th & 5th Sept.1995, Kullu valley	Flash Floods & Landslides in Kullu valley. Damage to the tune of Rs.759.8 million.
On the night of 31st July & Ist August 2000, Satluj valley	Flash flood in the Satluj valley, water level increased upto 60 feet above the normal. The flash flood was termed as the one that occurs once in 61,000 years. 135 people and 1673 cattle lost their lives. The total loss was Rs.1466.26 crore.
16th July 2003, Gharsa valley in Kullu district	Due to these flash floods, 21 people lost their lives, 21 people suffered major injuries and 9 were reported missing.
26th June 2005, Satluj river due to breach in the Parechhu lake in Tibetan catchment.	10 km stretch of NH-22 between Wangtoo and Sumdo was washed away. Total loss was Rs. 610 crore.



Year	Road Accidents	Persons Killed	Injured persons
2001-02	2,226	804	3,798
2002-03	2,830	695	3,917
2003-04	2,607	867	4,188
2004-05	2758	920	4674
2005-06	2807	863	4833
2006-07	2756	886	4688
2007-08	2906	945	4867
2008-09	2846	838	4637
2009-10	3409	1196	5560

District	Accidents	Persons involved	Persons killed	Persons injured
Chamba	12	59	53	0
Kinnaur	32	144	129	9
Kullu	6	13	9	4
Lahaul & Spiti	21	397	298	53
Shimla	2	6	1	5

Air Crash

Punjab Governor Shri Surendra Nath and nine members of his family were killed when the Government's Super-King aircraft crashed into high mountains in bad weather on July 9, 1994 in Himachal Pradesh.

Other Hazards

Stampede

A human stampede at the temple of Naina Devi occurred on 3rd August 2008. 162 people died when they were crushed, trampled, or forced over the side of a ravine by the movement of a large panicking crowd. Possibility of such instances is always there if there is any laxity on the part of the management.

Actions being taken for Managing Disasters

In order to reduce the vulnerability of State, the Government of Himachal Pradesh is committed towards disaster management as one of its topmost priority area. Considering the topographical conditions, the Government is working to strengthen the preparedness level so that the post disaster effects are not only minimised but also reduced to a great extent. The actions which are being taken to fulfil the mandate of disaster management are:

- Hazard Risk Vulnerability Assessment (HRVA) of the state.
- Formulation of State Disaster Management Plan.
- Finalisation of Distt. Disaster Management Plan (DDMP).
- Establishment of State Emergency Operation Centre (SEOC) & District Emergency Operation Centre (DEOC).
- Assessment of current level of knowledge, aptitude & practices in DM of various stakeholders.
- To examine the current construction practices in Hamirpur Distt. & suggestions of mitigation measures.
- Constitution of State Disaster Response Force (SDRF).

Initiatives taken by the Government for Disaster Management

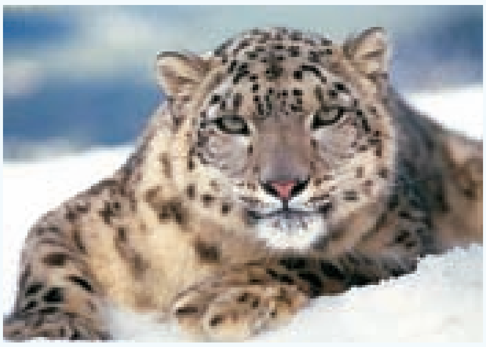
As far as Disaster Management in India is concerned, there is a paradigm shift from the earlier charity approach to a professional way of handling Disaster Management. The Government of Himachal Pradesh has already taken various initiatives for handling disaster at pre disaster level for better management.

- State Disaster Management Authority (SDMA) & State Executive Committee (SEC) to coordinate response in the event of any disaster situation or disaster in the State.
- District Disaster Management Authority (DDMA) to coordinate response at District Level.
- Awareness material developed and circulated throughout the State.
- Training Need Assessment for all stakeholders in DM
- State DM Policy.
- Strengthening of 100 Companies of Home Guards with Search & Rescue (SAR) Equipments.
- Strategy for capacity building for Masons, Bar benders & Carpenters for safe construction practices at Panchayat level.
- Capacity building throughout the State at various platforms for different stakeholders.
- Issuing of guidelines to all departments about:
  - Training officer/officials in DM.
  - Preparation of DM Plans.
  - On -site & Off -site Emergency Plans for industrial units.
  - Mock-drills in schools for Fire & Earthquakes.

Protection and Expansion of Protected Area

To conserve the entire range of biodiversity *in situ*, the state has established a network of protected areas, comprising 2 National Parks and 33 Wildlife Sanctuaries. Regulatory mechanism for wildlife conservation has also been put in place.

The State has about 13.6% of the total geographical area under Protected area, which is significantly higher when comparison is made with other States and with national percentage.



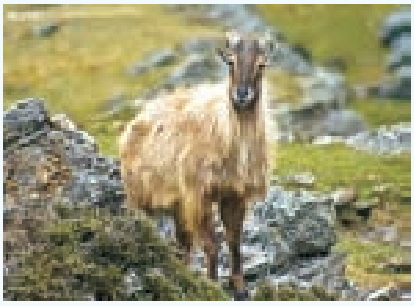
Area under Protected Area in Network	
National Parks (2)	**1440 km^2**
Wildlife Sanctuaries (33)	5562 km^2
Recorded taxa of higher plants	>3500
Recorded species of mammals	77
Recorded species of birds	463
Recorded species of reptiles	44
Recorded species of fishes	80
Recorded species of aquatic fauna	436

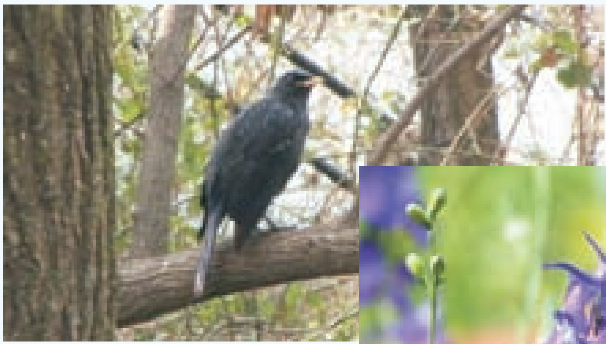
With a view to conserve the total range of wildlife available in the state, the Government of Himachal Pradesh has declared 32 areas, covering all the agro-climatic zones in the state and having significant ecological, geomorphological and biodiversity value as Wildlife Sanctuaries . The State also has two prestigious National Parks.

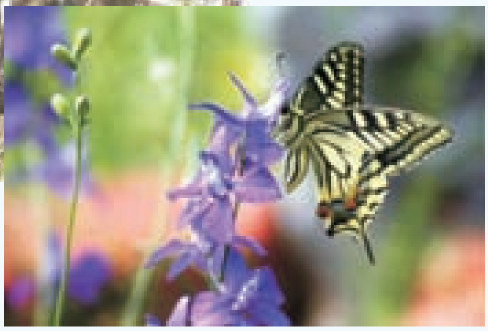
Some of the important Wild life Sanctuaries of the State

Sanctuary	District	Area (Km^2)
Govind Sagar	Bilaspur	100
Shri Nainadevi	Bilaspur	123
Kugti	Chamba	379
Kalatop-Khajjiar	Chamba	69
Pongdam Lake	Kangra	307
Dhauladhar	Kangra	944
Rakchham-Chhitkul	Kinnaur	304
Rupi-Bhaba	Kinnaur	503
Kibber	Lahaul & Spiti	1400
Nargu	Mandi	278
ShikariDevi	Mandi	72
DaranghatiI & II	Shimla	167
Talra	Shimla	40
Water Supply Catchment	Shimla	10
Churdhar	Sirmour	66
Simbalbara	Sirmour	19
Renuka	Sirmour	4
Chail	Solan	109

National Park	District	Area (Km^2)
Great Himalayan National Park	Kullu	765
PIN Valley National Park	Lahaul & Spiti	675
Total Area National Parks		**1440**



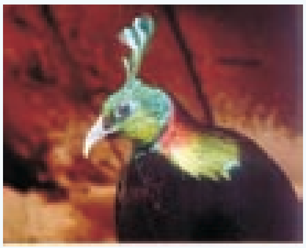




Due to the conservation and protection efforts of State Government, many floral and faunal species are flourishing in protective and safe environment of the state.

Cold Desert Faunal wealth-
Snow Leopard, Ibex and Snow Cock.

Cold Temperate regions of the state form natural habitat of Musk Deer, Himalayan Tahr, Brown Bear, Monal and Western Tragopan.

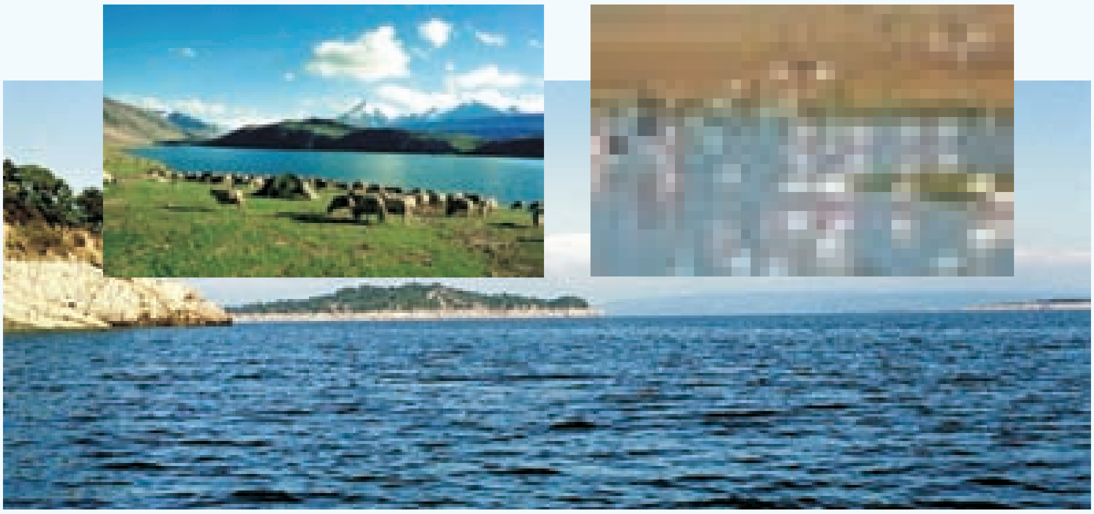


The lower reaches of the state abound with Sambhar Deer, Barking Deer, Wild Boar, Ghoral and Leopard amongst mammals and pheasants including Cheer and White Crested Kaleej.

Wet Lands

Management and development of lakes has been given priority by the State. Lakes in Himachal Pradesh, besides being a favorite tourist destination attract thousands of tourists, not only acts as natural resource for the local people but also the source of income. These lakes are in peril due to anthropogenic pressure and overall deterioration of surrounding environment, therefore, the efforts have been made to prepare and cover the major lakes under the lake conservation programme of Ministry of Environment & Forests. Initiatives for lake conservation are being undertaken through education and mass awareness.

The State Government has ensured and established good practices viz. compulsory door to door household waste collection in and around the lake areas. Carrying of polythene carry bags, plastic items, chips packets etc. has also been banned in and around the lake area.



Wetland Conservation Programme Strengthened

Wetlands in Himachal Pradesh

92 Wetlands(>2.25 ha)
- 88 Natural Wetlands
- 7 Man made wetlands

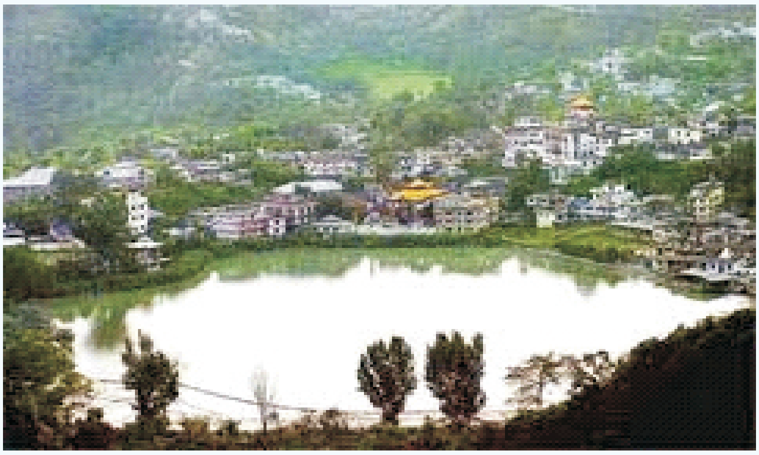
- These Wetlands covers about 1% of the total geographical area.
- Majority of Wetlands are high altitudes wetlands.

Designated Wetlands of HP

Ramsar Sites
- Renuka (Sirmour)
- Pong Dam (Kangra)
- Chandertal (Lahaul & Spiti)

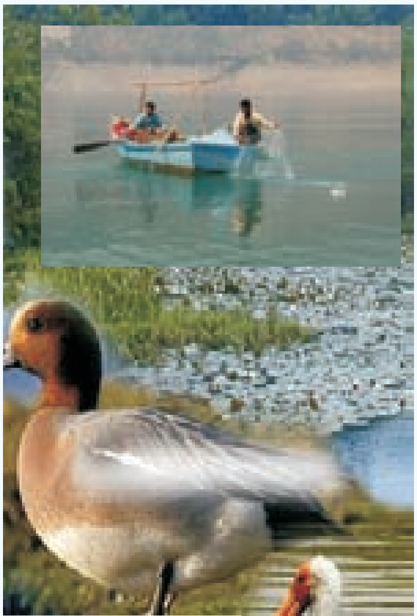
National Wetlands
- Rewalsar (Mandi)
- Khajjiar (Chamba)

- Formulation of Management Actions Plans for Renuka, Chandertal, Khajjiar and Rewalsar with the active participation of the local community and different organizations /stakeholders.
- Organized experts visits to the wetlands and to enhance the capacity building of stake holders.
- Initiated the process for generation of base line information with spatial and non spatial techniques.
- Soil conservation works through Forest Department.
- Deweeding and desilting works.
- Awareness and education through NGO's and local bodies.
- Awakening of local community on importance of maintaining wetlands and encouraging feed backs for improvement.



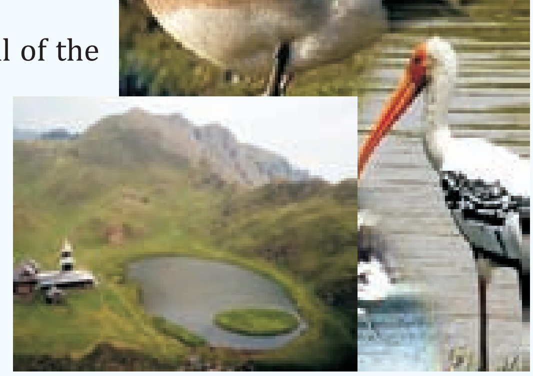
Values of Wetlands

- Recharge of Ground Water
- Habitat for Wild Life & Aquatic life.
- Source of Economical activity.
- Socio-cultural, aesthetic and recreational value.
- Irrigation Purposes.



With the active participation of the local community at the planning, implementation and monitoring levels :

- We are conserving and restoring the habitats for migratory & resident species of birds in the area.
- We are conserving the indigenous fish species to make the fishery sustainable livelihood for the local community.
- Adopting the organic farming practices in the peripheral of the wetlands.
- Generating livelihood practices and enhancing the incomes of the local people from wetlands.
- Conserving soil and water as the major components of environment.
- Evolving practices of eco-tourism in the region.
- Making the tourists more sensitive to the values of nature.



Sustainable Wetland Management Practices ensured

In view of threats to Wet land Eco system in the State, the Government has initiated various programes and steps to protect the pristine wetlands in the State. These include preparation of Guidelines for Camping in the Wetland regions, Do's and Don'ts for Tourists, Guidelines for 'Mindful Travel' in the State sensitive areas, banning of vehicles in eco sensitive zones etc.

Threats to Wetlands:

- Unplanned and Unregulated Tourism
- Tourist season coincides with peak biological activity
- Infrastructure
- Tremendous Grazing pressure
- Lack of awareness among the stakeholders
- Emerging Threat of Climate Change
- Lack of Coordination among various developmental agencies

New Programmes initiated in Himachal Pradesh

In order to build-up environment consciousness in the young minds of Himachal, the Govt. of Himachal Pradesh has launched two flagship programmes - Environmental Audit Scheme & Eco-Monitoring Scheme for eco-clubs. The Schemes have been introduced in 346 Eco Clubs of the State.

Environmental Audit Scheme

- Encourage schools to improve their environmental performance.
- Monitor the existing environmental performance in a participatory and transparent way.
- To help school to prepare an inventory of their resources and systematically collect information about their environmental performance.
- Train and build capacity of students, teachers w.r.t. environment Audit of the school.

Eco-Monitoring Scheme

- Sensitize the public on the menace of littering through eco clubs members of schools.

- Generate awareness amongst general masses about littering and prohibition of the use of polythene bags.
- Provide aid in effective implementation of ban on littering under H.P. Non Biodegradable Garbage Control Act, 1995.

Strengthened National Green Corps Programme (Eco-Club)

To sensitize students on environment conservation and protection, the State Government has established, 3,000 Eco-Clubs in the schools evenly spread in all districts of the State. The objective of the programme is to spread environmental awareness and carry out action based programmes for protection and improvement of environment.

Inculcating Environmental Protection in Building Blocks of Our Society

Nine Point Environment
Protection Code- Morning Oath

NINE POINT 'ENVIRONMENT PROTECTION CODE'

I, hereby, pledge to conserve and protect the natural resources and environment of Himachal Pradesh and in doing so:

- I will respect all living things.
- I will plant, conserve and protect trees and I will conserve paper by doing my rough work on slate or black board.
- I will conserve water at all times by ensuring that no one in my house keep taps unnecessarily open during brushing, washing hands, shaving and bathing.
- I will conserve energy by always switching off the lights and appliances when not required.
- I will never use plastic carry bags and shall go for shopping only with a cloth or jute bag.
- I will avoid use of non-biodegradable disposable items like disposable cups, plates and spoons.
- I will dissuade people and the safai karamcharis from burning dry leaves, garbage and request them to use leaves, biodegradable waste for composting or mulching.
- I will not litter on streets, hill slopes, in neighborhoods, gardens, into our rivers, nallas, and water bodies and request all to dispose-off the waste in dustbins or at designated places.
- I will ensure segregation of waste and to give only segregated waste to the door step collectors.

I will follow 'Environment Protection Code' and say with pride that 'I am building a Clean, Green & Beautiful Himachal.'

Aryabhatta Geo-informatics & Space Application Center (AGiSAC)

Establishment & inauguration

The State Government has taken the initiatives of setting up Aryabhatta Geo-informatics & Space Application Centre (AGiSAC) under the aegis of State Council for Science, Technology & Environment with an objective to facilitate the use of Geo–informatics for developmental planning and decision making in the State.

Objective

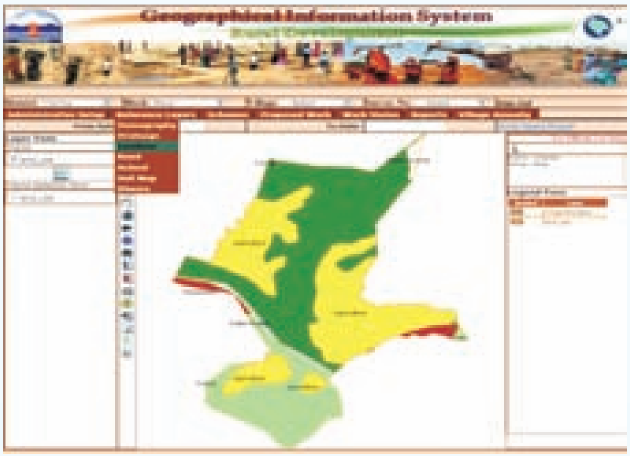
The objectives for setting up this State Centre is to facilitate decentralized planning, objective decision making, Monitoring & Evaluation of Government Schemes & Programmes, to set up integrated natural resources data management system, to provide services/consultancy based on specific user needs in the field of Remote Sensing and GIS and to promote the use of SATCOM networks for distant interactive training and education in the State.

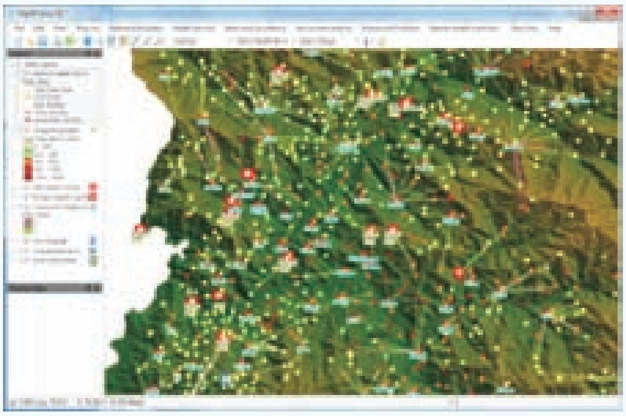
Key Functions

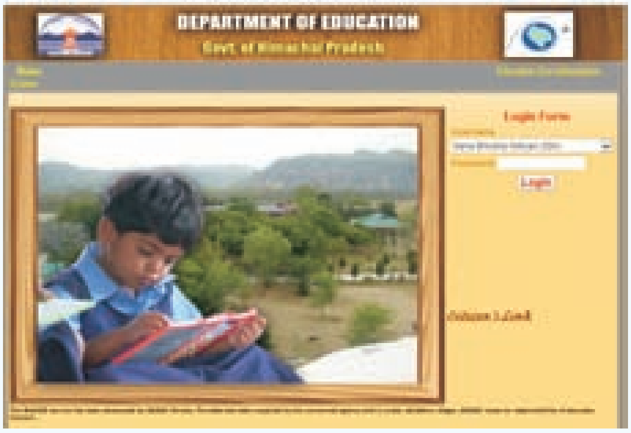
- Developmental Planning/ Decision Support Applications/Yes/No Decision
- Advisories/Alerts
- Surveillance /Regulatory Applications
- Monitoring & Evaluation of Developmental Works/ Schemes

Applications for Departments

Applications under various level of development for Departments of Agriculture, Education, Energy, Environment, Fisheries, Horticulture, Food & Civil Supplies, Forests, Industries, Health, Social Justice & Empowerment, Irrigation & Public Health, Tribal Development, Public Works Department, Rural Development, Tourism, Town & Country Planning, Urban Development, Revenue and Himurja etc.







Himachal Pradesh Environment Fund

Objectives:

- Environment protection, conservation, restoration and mitigation works etc. Including efforts to reduce carbon footprints in the environmentally vulnerable areas.
- Development of environment infrastructure for environment protection, eco restoration, mitigation etc.
- Awards to individuals, organizations institutions etc. of proven track record that have rendered/rendering valuable services to the Nation/ State in protection of environment for recognition of their contribution for the cause of environment protection.
- Relief for environment protection in exceptional cases for the following categories

  - Environmental losses sustained as a result of natural calamities.
  - Grants to villages proactive for environment protection and reducing carbon foot prints.
  - Grants to schools, institutions, organizations showing proactive role in environment protection and conservation.

- Environmental educational activities, awareness programmes.
- Any other case not covered by any of the above categories and where the Environment Fund Administering Committee is satisfied with regard to the genuineness of the demand of grant for environmental protection, conservation, mitigation and restoration.

- Rs. 51 lacs have been received as voluntary contribution towards H.P. Environment Fund.

- Two proposals have been short listed for funding under H.P. Environment Fund during 2010-11 namely "Restoration and revival of traditional watermills through up-gradation" by WWF India for Rs. 4.96 lacs and Malana Ajeevika Vikalp Agro-Hort Growers Marketing and Development Co-operative Society for Rs. 6 lacs.

Adaptation & Mitigation Measures for Reducing Sectoral and Regional Vulnerability

8

As explained above, the major sectors of State's economy are likely to be affected to some extent by the impacts of climate change. This framework focuses on sectors and regions where there is a significance for social, economic, biophysical or cultural outcomes; decisions to be made in the next few years, which could be affected in the long term by climate change impacts; and actions which have a high level of potential to capture the benefits from early adaptation planning.

There are many inter-relationships within and among the vulnerable sectors and regions. For example, impacts of climate change on water resources will further affect environmental flows for biodiversity, agriculture, irrigation for agriculture and water supply for urban settlements and industry, hydro power etc. Early adaptation will be influenced by the extent to which climate change factors are incorporated into sectoral and regional planning.

Sectors dependent on natural resources are particularly vulnerable to climate change. Increasing temperature, changing precipitation patterns and water resources availability, increasing atmospheric levels of CO_2 and water acidification will impact on sustainability of major sectors like agriculture, forestry and fisheries. The impacts will vary across regions and among the different industry subsectors.

8.1 Agriculture- Horticulture

The Agri- Horticulture sector of the State is highly dependent on climate. About 90% of rural population in the State depends on this sector for their livelihood. Seasonal weather variability in conjunction with climate change will have long-term effects on agricultural production, agribusiness investments, and regional prosperity.

The costs of the impact of climate change on agriculture could be considerable; for example, should there be an increased frequency of severe drought this would leave considerable social impact on rural communities. Adaptation can reduce these costs building on the experience of dealing with climate variability.

Effective adaptation actions would provide farmers with added resilience and coping ability in circumstances of a changed climate system. Information on how seasonality will alter due to climate change will also assist the agriculture industry to adapt.

Potential Areas of Action:

a) Implement the relevant components of the National Agriculture Mission, as has been released by the Government of India.

   In particular:
   - support research to improve understanding of the implications of climate change for agriculture at the State, sectoral and regional levels, including:
     a. vulnerability assessments of regions and agricultural activities;

b. effects of climate change on seasonal variability and reliability, and on climate extremes (e.g. droughts, rainfalls) affecting agricultural production; and
c. understanding barriers to adaptation and opportunities to adapt.

- increase resilience of farming systems and regions to climate change, and help agribusinesses identify where changes may be needed for the long-term investment strategies;
- enhance current programmes and structures to incorporate climate change adaptation considerations into natural resource management, rural support and adjustment, research and development and plant and animal health, pest and weed policies and programmes, and environmental management systems.
- develop decision support tools, pilot adaptation options, inform and encourage adaptation, and engage industry in participatory research, communication and review.

Important ongoing development initiatives need to be strengthened to reduce vulnerability to climate change, including developing agricultural markets, reducing distortions and subsidies in agricultural policies, continuing trade liberalization policies, enhancing social protection and microfinance, preparing for disasters and, critically, mainstreaming climate change in agricultural policies.

Though these aforesaid initiatives may not be enough instead, the adaptation will require improvements that take existing development policies above and beyond their current capacity.

Innovative policies include:

- changing investment allocation within and across sectors,
- increasing the focus on risk-sharing and risk-reducing investments,
- improving spatial targeting of investments,
- eliminating existing detrimental policies that will exacerbate climate change impacts, and
- reducing greenhouse gas (GHG) emissions from agriculture and increasing the value of sustainable farming practices through the valuation of carbon and other forms of agricultural ecosystem services such as water purification and biodiversity.

Key components of new and innovative adaptation measures to climate change include:

- changes in agricultural practices to improve soil fertility and enhance carbon sequestration;
- changes in agricultural water management for more efficient water use;
- agricultural diversification toward enhanced climate resilience;
- agricultural science and technology development, agricultural advisory services, and information systems; and
- risk management and crop insurance.

8.2 Water Resources

Himachal Pradesh is not only important water source for its own habitats but is also serving other States for the purpose of drinking water supply, irrigation and power generation. Rainfall and stream flows are highly variable. The climate change presents significant additional challenges for the managers of water resources in Himachal Pradesh. In a changing climate, droughts are expected to become more severe in the State. The potential for replenishment of groundwater is expected to continue to decline and water quality is also likely to be affected. Rainfall is likely to be concentrated more in extreme rainfall events affecting water availability (both surface and groundwater), water quality, the balance between environmental and consumptive demand and allocation, as well as the design and the safety of dams.

Improved knowledge is needed to assist water managers to understand the wide range of impacts the climate change will have on surface and groundwater resources and the demand for water. The adaptation to changed water availability could require the sourcing of additional water supply and retrofitting water infrastructure, with the associated costs. It could also mean new ways of managing water.

The National Water Mission and other water management frameworks are central to dealing with reduced water availability due to climate change. Information on climate change will be essential for the water managers.

Potential Areas of Action:

a) Research to address key knowledge gaps, current and projected demographic changes, and socio-economic analysis of impacts about climate and water resource, initiatives needed to implement the National Water Mission and other water management initiatives.

   This will include research on:
   - high quality projections of climate variables relevant to demand and supply/ allocations of water resources;
   - understanding of impacts of climate change on water resources and dependent ecosystems; and methods and approaches for integrating climate change related risks into water management.
   - identify vulnerable river bed areas and apply appropriate planning policies, including ensuring the availability of land, where possible, for migration of ecosystems.

b) Work with the water intensive industry to ensure that climate change impacts and risks are incorporated into water resource and infrastructure planning and management including:
   - assessing the implications of changes in extreme rainfall events for water infrastructure;
   - preparation of hand book on rainfall, precipitation and updating estimates of probable maximum precipitation and rainfall extremes for use and to reflect likely climate change;
   - jurisdiction of dam safety authorities to review major dam safety policies to accommodate the impacts of climate change.
   - assess the vulnerability of infrastructure, settlements, and environments of significance using biophysical and socio-economic scenarios and inundation modeling.

8.3 Forests

Climate change could have significant impacts on the forests of the State, through slower growth rate due to reduced water availability, raised temperatures, increased bushfires and wind damage and disease pressures and through growth fertilization by higher atmospheric CO_2 levels. Frequent or extensive damage to production forests can significantly reduce the sustainable supply of timber to capital intensive processing industries with consequences that last for many years. Climate change may also impact on the species that can be grown productively in plantations in different regions influencing costs involved. Much forest land has multiple uses, and climate change may also impact on water yields and biodiversity and ecotourism values of forests.

Potential Areas of Action:

a. Develop a Climate Change and Forestry Action Plan under the National Green India Mission. This would include:
   - identifying key impacts, vulnerabilities and research priorities;
   - developing strategies in collaboration with hydro industry; and
   - developing communication strategies.

b. Support research to address major knowledge gaps about the impact of climate change on forestry and the vulnerability of forest systems. This may include assessing implications of climate change for native and plantation forests used for timber production; the capacity of forest systems to sequester carbon; the role and impacts of forests in natural resource management; and social and economic aspects of forests and forestry.

8.4 Bio-diversity

Ecosystems are likely to be adversely affected by increasing temperatures, changes in rainfall patterns, the spread of pests and weeds, changed fire regimes etc. Higher temperatures, possible changes in precipitation patterns, glacial chemistry are likely to affect Himalayan ecosystems. The impacts on bio-diversity will affect ecosystem services such as water, soil quality and cover.

Reducing other stresses on bio-diversity, such as overuse and pollution, is likely to ameliorate species loss, system degradation and range contraction due to climate change. Healthy ecosystems are more resilient to climate change impacts and are able to 'bounce back'. Some ecosystems are particularly vulnerable such as high altitude wetlands, alpine areas, rainforests, fragmented terrestrial ecosystems, pastures etc. Environmental flows of key riverine systems for the sustenance of ecology are also vulnerable, with increased competition for diminishing water resources. However, there has been no systematic analysis of this vulnerability across the whole set of assets.

Potential Areas of Action:

1. Review of the State Biodiversity Policy, functioning of the State Biodiversity Board.
2. Establishing a State Specific programme of research on the impacts of climate change on biodiversity and ecosystem processes. The research will address:
   i. Terrestrial, aquatic and riverine ecosystems with a focus on:
      - analysis of changing distribution and phenology;
      - the interactions and combined impacts of climate change and other threatening processes;
      - identification of critical thresholds for natural ecosystems and approaches to increase their resilience to the impacts of climate change including connectivity; and

   ii. The implications of climate change for existing strategies, such as the planning for threatened and migratory species and ecological communities.
3. Provide practical guidance on how to integrate existing and emerging knowledge about climate change into management of disturbance regimes (for example, fires, floods, invasive species) in areas managed for biodiversity conservation.
4. Assess the vulnerability of State forest cover, Ramsar Wetlands to the impacts of climate change. Regular reviews of management plans for each reserve, wetland will explicitly

consider vulnerability to climate change impacts and plans will include actions, where necessary, to reduce vulnerability or manage impacts.

5. Finalize and implement key steps in the Climate Change Action Plan.

8.5 Ecosystems

Climate change is likely to affect perennial aquaculture, fisheries through increasing temperatures, changes to water currents and nutrients, changed rainfall patterns. There are specific and different threats to local fisheries and aquaculture. Aquaculture is likely to be impacted by climate change through higher temperatures, water availability and river bed township impacts. Greater precision in assessing vulnerability of trout fish stocks to climate change is needed to ensure sustainability of commercial fisheries. Initial estimates show that the trout species could be particularly vulnerable. Climate change is expected to make interpretation and use of historical fisheries management data more difficult.

Potential Areas of Action:

a. Develop a Climate Change and Fisheries Action Plan, to be considered under Himalayan Eco System Mission that includes:
    - identifying risks associated with climate change for the sustainable use of trout fish stocks;
    - determining ways of distinguishing climate change impacts from the impacts of other environmental and management factors;
    - developing strategies in collaboration with industry and community stakeholders; and assessing the impacts and risks of climate change on aquaculture.

b. Support research, in association with hydro industry and research providers, to address major knowledge gaps about the impact of climate change on fisheries and aquaculture. This may include analysis of the impact of changing climate, rising temperatures, river water quality, currents on the distribution and abundance of riverine species; vulnerability and resilience of riverine systems; productivity; and social and economic systems using riverine environments.

8.6 Health

Risks to the health from climate change include increased transmission of vector-borne, food-borne and water-borne diseases. Floods, bushfires, and changes to industry, land use and climate events such as drought can result in adverse mental health consequences within rural communities, along with a range of other health risks (e.g. from freshwater shortages, increased exposures to heat and dust, and changes in local food availability and affordability).

The vulnerability assessment indicates that changes in climatic conditions can have three kinds of health impacts viz. health consequences of changes to ecosystems and biological processes (e.g. mosquito-borne infections, agricultural food yields), direct impacts (e.g. cold and heat-waves), and the many health consequences that occur when populations are disrupted or displaced. Health impacts due to climate change will affect some regions, socioeconomic groups and demographic groups more than others. For example, older people are more susceptible to extremes of temperature. Many rural and remote communities have less capacity than larger settlements to deal with the health impacts of climate change. Any geographic extensions of mosquito-borne infections are likely to impinge more on majority of populations.

Potential Areas of Action:

a. The Health Department to develop and implement a State Action Plan on Climate Change and Health that includes:
    - research on climate change impacts on physical and mental health and identify key vulnerabilities;
    - identifying the capacity of the public health system and hospital system to plan for and respond to these vulnerabilities including links to emergency services and health disaster management policies; and
    - incorporating the potential for climate change impacts on health into community and public health education programs.

b. Develop and implement heat/ cold wave warning and response systems.

c. State health institutions to carry out research activities with a focus on research on climate change and health.

d. To assess, and develop strategies to address, the impact of climate change on water borne diseases.

8.7 Tourism

The impact of climate change on infrastructure and the natural environment has the potential to affect the tourism industry. In some cases this could result in social and economic impacts in regions with a high dependency on tourism as a source of income and employment. However, the impacts will depend on the relative attractiveness of different destinations and the potential for alternative attractions in the current tourism areas. As tourist attractions, areas such as the snow, wetlands, the landscape, pastures, alpine areas, are particularly vulnerable.

Potential Areas of Action:

a. The Tourism Department to develop action plan in partnership with hotel industry and other stakeholders which would include:
    - assessment of the impacts of climate change on tourism and tourism values (physical, social and economic) and on the relative impact of climate change on the different forms of tourism; and
    - developing adaptation strategies for nature based tourism including tourism based on the use of natural and cultural resources, specific tourism regions, and the industry more broadly.

8.8 Urban Planning

The physical infrastructure and the social and economic fabric of settlements are likely to be affected by climate change, especially by changed frequency of intensity of extreme weather events. Urban infrastructure such as buildings, roads, bridges, railways are normally designed for a life span of 20-50 years. Planning decisions for development and the replacement or restoration of long-lived infrastructure, need to take account of the different climate in the future including higher temperatures and changes to precipitation, water tables and humidity.

Increasing urbanization in river bed areas, hilly areas and urban expansion into regional areas are likely to increase the exposure of people and infrastructure to the impacts of climate change. People living in remote areas may be more vulnerable. The impacts will vary depending on the form of the settlement, geographic considerations and the nature of the local economy.

Adaptation measures include planning to reduce vulnerability and/or increase resilience, and using codes and standards that take into account the impact of climate change on frequency and duration of rainfall, storm water handling capacity, changes in snow fall patterns. The finance and insurance industries will help to manage society's risk from weather related damages.

Climate change impacts on settlements will depend upon a wide range of local factors, including the form of the settlement, the nature of the local economy, and geographic considerations such as elevation and proximity to the terrain. Integrated assessment is an approach to understanding climate change impacts and adaptation options at the local scale.

However, decision makers need additional information about the vulnerability of major infrastructure, including energy systems, transport systems, communication networks and building stock, in order to develop adaptation strategies.

Potential Areas of Action:

a. Research to address key knowledge gaps about human settlements and climate change impacts, including information needed to effectively implement actions in relation to planning, codes and standards and major infrastructure.
b. All jurisdictions to evaluate and share relevant information about the extent to which planning and development systems promote decisions that increase resilience to the impacts of climate change.
c. Discourage decisions that increase vulnerability, and consider changes where appropriate.
d. Analyze and revise urban planning systems including revision and development of green codes, standards and guidelines to increase resilience to climate change including:
    - To consider climate change as part of periodic reviews;
    - Review standards used for building, plumbing and electrical standards and specification for the development. Include a particular focus on green standards related to green buildings and utilities.
    - Review information used to determine vulnerability of settlements, land to climate related hazards (flash floods, forest fires, landslides) and develop new or revised risk management guidance to take into account any projected changes as a result of climate change.
    - Review to also take into account the contribution of 'urban forests' to modify the impact of climate change in the urban environment; and
    - Revision of guidelines for management treatment, disposal, storage of rain water and sewerage.
e. Identify and address the impact of climate change on major infrastructure including hydro power dams etc:
    - Identifying priority infrastructure assets that may be vulnerable to climate change and coordinate with the owners on business continuity plans take this vulnerability into account; and
    - Analyze the vulnerability of electricity, transport, communications, water

infrastructure and other key infrastructure to climate change, and develop appropriate risk management strategies to reduce this vulnerability. For example, the review could consider road connectivity and encompass existing transport infrastructure, planned transport infrastructure and transport infrastructure management and planning. A review of the electricity supply infrastructure could consider possible effects from projected increases in temperature and changes in rainfall patterns and the changes in energy demand due to climate change.

f. Develop capacity and tools for the planning sectors including insurance etc.

8.9 Disaster Management

Climate change is likely to increase the risk of natural disasters in Himachal Pradesh. Flash floods and GLOFs, landslides are a feature of State's variable climate. However, climate change is likely to increase the frequency and/or severity of extreme events. The high concentration of people and infrastructure in urban areas, especially along the river and river bed lowlands are likely to result in severe economic losses with changing exposure to extreme events. Remote settlements can be particularly vulnerable to natural disasters due to inadequate health infrastructure, road connectivity.

Natural disasters already cost very heavily excluding death and injury costs. It is likely that climate change will increase the frequency or intensity of some climate-driven weather extremes.

Climate change impacts need to be factored into natural disaster management risk reduction, emergency services planning, and recovery management, especially for areas more vulnerable to extreme events. Community awareness and developing a culture of preparedness in conjunction with emergency services will contribute to effective adaptation responses.

Potential Areas of Action:

a. Set up State Level Disaster Management Authority and make it functional with suitable TORs addressing Climate Change risks.
b. Undertake research to improve knowledge on the nature and expected extent of changes to existing risk profiles as a result of climate change for key events such as, flash flooding, GLOFs, hail damage, forest fires and landslides.
c. Incorporate climate change impacts into planning for natural disaster response management, in particular the risk and changing behavior flash flooding, GLOFs, hail damage, forest fires, landslides and extremes in temperature. This may include:

    - Incorporating climate change issues in the review of the Natural Disaster Mitigation Programme and proposals submitted under the Programme; and
    - Improving information for emergency services and communities to encourage awareness of climate change and adaptation responses.

Climate Change Strategy for Himachal Pradesh

9

In view of past and current scenarios as explained w.r.t. losses due to extreme events and climate change, the State's immense geographic diversity append to the complexity of developing and implementing appropriate climate risk management strategy. Within the country the impacts will vary across States, sectors, locations and populations. The climate projections for the country suggest that impacts are likely to be diverse and mixed, with some regions experiencing more intense rainfall and flood risks, while others will encounter sparser rainfall and prolonged droughts. Among the more substantial effects is a projected spatial shift in the pattern of rainfall towards the areas under snow line or already having heavy rains, while in some regions water scarcity may increase thereby affecting land fertility and unproductiveness. The climate variability and climate change poses huge risks to life and threat to endanger the sustainability of the country's fast growing economy.

The Himalaya has the largest concentration of glaciers outside the Polar Regions and some of the prominent rivers of the Northern India originate from these Himalayan reservoirs. Geological history of the earth indicates that the glacial dimensions are constantly changing with the change in climate. Monitoring of seasonal snow cover depicts the melting and the retreat of snow in the month of December at an altitudinal range of more than 4,800 mts., in Baspa valley implying thereby that global warming has actually started affecting the snow glacier melt and run off patterns in the Himachal Himalaya as well.

An analysis has been carried out on various sectors viz. agriculture-horticulture, water resources, forests, biodiversity, energy, health, tourism, urban development, transport, industries, mining etc. which indicates that the trends are not favorable and the climate risk management actions are not sufficiently met due to lack of knowledge and resources, but still the steps are being taken at different levels to adapt to the existing trends and mitigate the adverse impacts to the possible extent.

Being the most eco sensitive and fragile nature, the impacts of Climate Change manifest most, leading to significant impact on agriculture and horticulture production, water resources, forests and these impacts are likely to adversely affect large percentage of population depending on these natural resources/activities in future as well. There is in fact a greater need for sustained efforts for the adaptation measures in the State.

Himachal Pradesh is known for its dominant rural/ tribal population, traditions and culture. To retain and sustain traditional cultural originality of the people of State and to maintain their developmental graph is indispensable for the State. The options available are to be realized through various strategic interventions by different public authorities at the State and Local levels. The purpose of Climate Change Strategy for Himachal Pradesh is twofold:

- Taking into account the prevailing developmental process- its achievements and losses.
- Identification of solutions and actions, as may be required at various levels such as regulatory, institutional, programme, policy, and plan.

As the climate changes, so must the State respond. To effectively address the challenges that a changing climate will bring, climate adaptation and mitigation actions must complement each other, efforts within and across sectors must be coordinated. These approaches have been viewed as alternatives, rather than as complementary and equally necessary approaches.

The Department of Environment, Science & Technology has worked out strategies for climate change adaptation and mitigation, and to develop the necessary tools to effect adaptation protocols. Now closer coordination is needed to implement these approaches. The strategy for Himachal Pradesh has been developed using a set of guiding principles:

- Involvement of all related stakeholders in identifying, reviewing, and cultivating the State's adaptation strategy.
- Give priority to adaptation strategies that initiate, encourage, and enhance existing efforts that improve economic and social well-being, public safety and security, public health, environmental justice, species and habitat protection, and ecological function.
- Prioritizing adaptation strategies that modify and enhance existing policies rather than solutions that require new funding and new staffing.
- Recognizing the need for adaptation policies that are effective and flexible enough for circumstances that may not yet be fully predictable.
- Use the effective reliable data base in identifying climate change risks and adaptation strategies.
- Recognize sustainable scientific data base collection and knowledge about climate change is evolved continuously.
- Establish and retain strong partnerships with central, state, and local governments, tribes, private business and landowners, and non-governmental organizations to develop and implement adaptation strategy recommendations over time.

9.1 Approach

A collaborative approach is proposed to deal with the emerging situation. The climate change impacts cuts across jurisdictional boundaries of various sectors and will require governments, businesses, nongovernmental organizations, and individuals to minimize risks and take advantage of potential planning opportunities in a collaborative manner. This is the simple means by which the far reaching effects of climate impacts can be addressed efficiently and effectively while avoiding potential conflicts. The Comprehensive State Adaptation Strategies explained subsequently emphasize the need for collaboration and identifies issues where cross-sector relationships are necessary.

9.2 Goals & Objectives

The fundamental purpose and goal of the strategy is to begin a state wide, ongoing, and committed process of adapting to a changing climate in the context of other changes in the environment, economy, and society. To achieve this goal, the adaptation strategy pursues the following specific objectives:

- **Identification and synthesis of climate change risks:** We need to synthesize to the greatest extent possible how temperature rise, extreme weather events, precipitation changes, seasonal shifts, will exacerbate existing water supply and quality, air quality, habitat loss, human health risks, fire and floods etc. and to assess how these changes will impact the state's economy, infrastructure, society and environment.

- **Develop criteria for prioritizing identified adaptation strategies:** The applicability of these criteria may vary across sectors, and should ideally include but not be limited to social, environmental, technological, manpower, institutional, policy, and financial /economic considerations.

- **Identification of sector-specific and cross-sectoral adaptation strategies to reduce vulnerabilities and built climate resilience:** To make strategies which helps to (a) improve preparedness for climate change impacts and extreme events, (b) avoid, prevent, or minimize climate change impacts to agriculture, public health, biodiversity, land, forests, and infrastructure, (c) enhance the state's response capacity in case of extremes, and (d) facilitate recovery from impacts and extremes in order to enhance the state's resilience.

- **Cross-cutting supportive strategies:** Identify governance efforts (such as policy or changes in regulations, procedural adjustments, etc.) and resources needed to enable the development and implementation of identified adaptation strategies.

9.3 List of Prioritized Adaptation & Mitigation Options

9.3.1 Adaptation

"*To develop a package of adaptation measures, aimed at protecting the health of people, water resources, agri-horti production, urban and rural infrastructure and hydropower generation.*"

To achieve this, it is essential to first define future climate change vulnerability scenarios in State's priority sectors, with the aim of assessing the environmental, socioeconomic and health impacts of this phenomenon. This information will allow climate change adaptation measures to be defined on the regional and sector levels. Described below are the actions set out under this vision that will be undertaken to establish and execute measures to adapt to the climate change impacts in the State.

Adaptation, Mitigation to the Impacts of Climate Change

- Analysis of Climate Scenarios at the Local/ Regional Level.
- Determination of Impacts and Climate Change Adaptation Measures in following sectors:

Direct:	Agricultural- Horticulture
	Water Resources
	Forest,
	Biodiversity
Indirect:	Energy, Hydro Power
	Health.
	Tourism
	Housing, Urban Infrastructure

- Formulation of a Regional Plan for Climate Change Adaptation and Related Sectoral Plans.

9.3.2 Mitigation

"To work toward becoming a low-carbon/carbon neutral economy as a means of promoting sustainable development in Himachal Pradesh as well as a means of contributing to national efforts to reduce GHG emissions."

To achieve this goal, the State must first analyze its options for reducing greenhouse gas emissions and then assess various mitigation scenarios. Options for reducing GHG emissions include increasing the availability of carbon sinks (biological absorption of GHGs) or reducing the level of emissions released into the atmosphere, ideally in sectors such as energy generation, transport, mining and agriculture, which contribute the large amounts of emissions in the State. This being the case, and with the objective of evaluating Himachal Pradesh potential for GHG mitigation, the Action Plan recommends the guidelines detailed below:

- To carry out/update Greenhouse Gas Emissions inventory.
- Mitigation Assessment Studies & Implementable Actions.
- Generation of mitigation scenarios in Himachal Pradesh.
- Formulation of a State Plan for mitigation of Green House Gas Emissions and related Sectoral Plans.

9.3.3 Capacity Building

General Guidelines for Capacity Building: *"To inform the population about environmental problems and, in particular, to raise awareness about the effects of climate change and to encourage education, awareness and research on this subject in Himachal Pradesh."*

The above vision for the production of quality and accessible information on climate change will help formulate the State's position on this issue.

The actions described below will be carried out under these general guidelines in order to build capacities for comprehensively addressing climate change in the long-term as well as to reinforce capacities already present in the State.

- Creation of a State Fund for research on biodiversity and climate change.
- Evaluation of the technical and economic feasibility of establishing a basic Comprehensive Regional Network (Atmospheric and Terrestrial) for Monitoring and Studying Climate Change.
- Creation of a state level Glacier Registry.
- Strengthening the institutional framework in Himachal Pradesh for addressing climate change.
- Design of instruments to promote the development, transfer and adoption of technologies for climate change mitigation and adaptation.

A core element of the implementation strategy is that all research studies that will be conducted in the State, weather funded through State Action Plan on Climate Change or through other sources, will be coordinated by State Centre on Climate Change.

9.4 Strategic Framework for Adaptation & Mitigation

The Strategic Framework for Adaptation & Mitigation worked out is as per Table-23 & 24.

Table-23: The Strategic Framework for Adaptation & Mitigation

Area	Objectives
Adaptation to the Impacts of Climate Change	1. Evaluate environmental and socioeconomic impacts of climate change in Himachal Pradesh. 2. Define adaptation measures. 3. Implement and follow-up on adaptation measures.
Mitigation of Greenhouse Gas Emissions	1. Analyze alternatives for mitigating greenhouse gas emissions in Himachal Pradesh. 2. Define mitigation measures. 3. Implement and follow-up on mitigation measures.
Creation and Promotion of Capacities in the Area of Climate Change	1. Promote public information and awareness about climate change. 2. Encourage education and research on climate change. 3. Improve systematic climate observation. 4. Generate high-quality, accessible information for decision-making. 5. Build institutional capacities for mitigation and adaptation. 6. Develop and transfer technologies for mitigation and adaptation. 7. Prepare, regularly review and update State's greenhouse gas inventory. 8. Actively participate in the National Climate Change agenda. 9. Support national cooperation on climate change. 10. Establish synergies with other conventions being implemented at national level.

9.5 Short Term Adaptation Strategies

Table-24: Short Term Adaptation Strategies

Sr. No.	Strategic Entry Point	Action	Indicator
A.	**Comprehensive State Level Adaptation Planning**	- Institutionalization of adaptation to climate change and reducing greenhouse gas emissions into state planning processes, budgets, and policy development. - Establish a framework for promoting collaboration within and among different sectors to implement climate change adaptation strategies and to promote comprehensive state adaptation planning. - Set up three levels of coordination- Implementation, Monitoring & Evaluation, and Coordination.	- Efficiencies are realized and impacts are minimized. - Level of coordination set up in each line organization.
B.	**Integration of Land Use Planning and Climate Adaptation Planning**	- Prepare guidelines to guide agencies to evaluate the impacts of locating developmental projects in areas susceptible to disastrous conditions. - Incorporate climate adaptation considerations into the urban and rural planning processes. - Incentives to communities that are most vulnerable and are prepare them for likely climate change impacts. - Make land use planning integral part of development process. - Address climate change in the long-term vision and development goals of general plans. - Coordination and consultation mechanisms need to be established and/or strengthened. - Effectively address the vulnerability, resilience, and future growth of areas prone to climate change impacts. - Identify critical infrastructure such as roads, power projects, and water/wastewater pipelines that may be affected by climate change extreme events. - Inventorize sources of water that may be reduced due to increased temperatures, decreased glacial snow pack and dependent wetland storages. - Prepare state blueprint for planning process that identify areas vulnerable to climate change.	- Regulation in urban, rural expansion in sensitive areas. - Road map identified to address local level vulnerabilities in an integrated and comprehensive manner. - Local, state, and other jurisdictions do not work at cross purposes.
C.	**Improve Emergency Preparedness and Response Capacity for Climate Change Impacts.**	- To assess emergency response capacity, minimize exposure to climate extremes. - To undertake anticipatory planning (prevention and preparation). - To update the State Disaster Management Plan, to strengthen consideration of climate impacts to hazard assessment in planning, implementation priorities, and emergency response.	- Sectors starts periodically reviewing their changing capacity needs. - Limited consequences of unforeseen events. - Preparedness and emergency response capacity built. - Reduced strain on emergency services.

Sr. No.	Strategic Entry Point	Action	Indicator
D.	**Strengthen the climate change research and science programs**	- To develop a strategic plan that identifies priority state climate adaptation research and monitoring needs; proposed resources and timeframes to implement the plan; and potential for research co funding and collaboration with local, state, and national agencies, universities and other research institutions. - To develop a comprehensive research project catalogue and continue to biannually publish key state sponsored climate research. Such as on glacier-society-economic sector interaction. - To develop a Local Level Climate Vulnerability Index to ensure the best available science informs climate adaptation decision making. - To develop a more systematic approach to funding risk reduction efforts.	- Centre on Climate Change research and development set up. - Planning process linked to climate change research and science. - Enhanced adaptive capacity of sectors developed.

Himachal Pradesh has a unique opportunity to confront the problem of climate change synergistically with sectoral development agendas that will create opportunities to address local needs such as:

- Formulating and strengthening the State Environmental Policy by reducing local pollutants and other negative environmental externalities and implementing measures to reduce greenhouse gas emissions and adapt to climate change. Based on the potential synergy between national issues and the local agenda, a major challenge for the State Government is to integrate climate change into its public policies and management instruments that address issues such as:
    - conservation and sustainable use of biodiversity and natural resources,
    - water resources management through river basin management, among other important issues in this area,
    - glacier protection,
    - energy generation and use,
    - public health impacts, and
    - education for sustainable development.
- Advancing sustainable development and poverty reduction through the transfer of technologies that mitigate greenhouse gas emissions and enable adaptation to their expected impacts. This will help to improve the socio-economic and environmental conditions of communities or parties directly affected by this phenomenon.
- Increasing participation in the carbon market through the Clean Development Mechanism, which is crucial for accelerating the introduction of environmentally friendly technologies that reduce emissions of greenhouse gases and local pollutants.

9.6 Recommendations

The recommendations outlined below have been developed based on substantive feedback drawn from review of various policies, drawing on the expertise of different sectors and individuals offering different perspectives on effective approaches to climate adaptation.

It is recognized that implementation of the proposed strategies will require significant collaboration among multiple stakeholders to ensure that these are carried out in a rational, yet progressive manner over the long term. These strategies distinguish between near-term actions that should be done by the end of 2012-15 and long-term actions to be developed over time.

Key recommendations include:

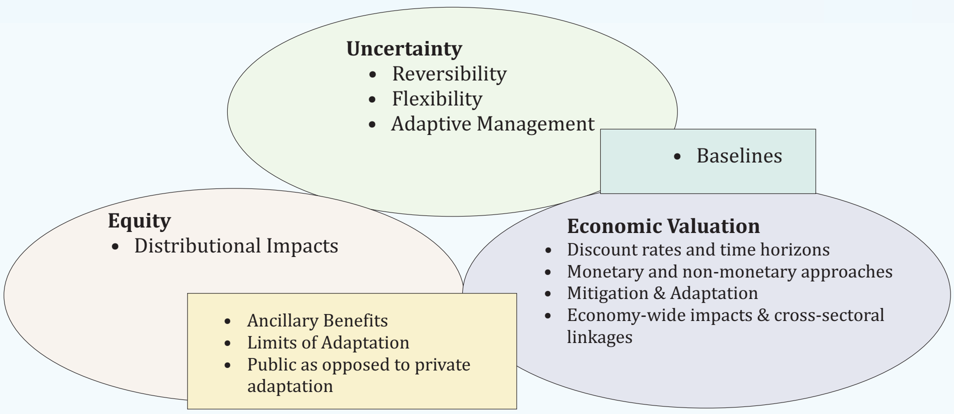
1. Promote sustainable development through climate change related adaptation and mitigation actions.
2. Prepare sector specific adaptation plans, guidance manuals, or criteria for the management and regulation of urban and rural development, health, water supply, hydropower development subject to significant climate change by 2017.
3. To assess the risks to the State from climate change and recommend strategies to reduce those risks building on State's Climate Adaptation Strategy.
4. Empowering local communities and stakeholders to promote integrated watershed management as an instrument for rural poverty reduction through improvements in the productivity and climate resilience of natural resources.
5. To develop a plan for expanding existing protected areas or altering land and water management practices to minimize adverse effects from climate change induced phenomena. Extensive research activities w.r.t. land and aquatic habitats which significantly susceptible to climate change need to be undertaken.
6. Reviewing of its water management practices and uses as the climate change is likely create bigger competition for limited water supplies required for the drinking water supply, agriculture, ecology & environment, and hydropower. To work out and implement strategies to achieve at least 5-10 percent reduction in per capita water consumption by 2015.
7. To expand surface and groundwater storage, implement efforts to fix water supply, quality, and ecosystem conditions, support agricultural water use efficiency, improve state-wide water quality, and improve ecosystem conditions and stabilize water supplies.
8. Soil conservation activities are required to be enhanced in the State.
9. All significant state development projects, including township, hydropower, industry projects, must consider the potential impacts of locating such projects in areas susceptible to hazards resulting from climate change.
10. To develop plans for an increased use of renewable energy; harnessing solar, wind power to meet out the energy demand from projected population growth with greater energy conservation.
11. To adopt alternatives study approach that avoids significant new development in areas that cannot be adequately protected (planning, permitting, development, and building) from extreme events of climate change. The most risk-averse approach for minimizing the adverse effects of temperature rise, river bed water level rise and storm activities is to carefully consider while developing new areas which are vulnerable to these aspects.
12. To assess mitigation and adaptation strategies that includes impacts on vulnerable populations and communities and assessment of cumulative health impacts including

assessments of land use, urbanization, hydropower development, industrial development and transportation proposals that can impact health.

13. To prepare long term plans for dealing with health impacts which are likely to increase with climate change with a view to develop and to build resilience to increased spread of disease and temperature increase.
14. Ecosystems evaluation analysis and issuance of state policy on payment for environmental services based on pilots.
15. Sustainable Management of forests as per agreed methodology for REDD+.
16. Preparation and implementation of Basin wise Integrated Catchment Area Treatment (BICAT).
17. To develop effective fire fighting plans in view of emerging extreme climate change risks. Enhanced fire risk in forest areas from climate change will likely increase and impact on the biodiversity, public health and safety risks, property damage, fire suppression and emergency response costs to government, watershed and water quality impacts, and vegetation conversions and habitat fragmentation.
18. Expansion & consolidation of Community Led Assessment, Awareness, Advocacy and Action Program (CLAP) for Environment Protection and Sustainable Development in the State.
19. To broaden and fund the research beneficial to policy makers, planners on climate change impacts in Himachal Pradesh, focusing on linkages with international, central funding resources, developing vulnerability studies, and synthesizing the latest climate information into useable information for local needs through different tools.

9.7 Cost-benefit Analysis to Assess Environmental, Social & Economic Costs of Identified Options

Cost–benefit analysis is often used in government systems to evaluate the desirability of a given intervention or for selecting an option. It is heavily used in today's government systems. It is an analysis of the cost effectiveness of different options in order to see whether the benefits outweigh the costs. The aim is to gauge the efficiency of the option relative to the status quo. The costs and benefits of the impacts of an intervention are evaluated in terms of the public's willingness to pay for them (benefits) or willingness to pay to avoid them (costs).



For example, the adaptation options proposed include improving water resources management, optimizing agricultural production and increasing the efficiency of irrigation systems. The water allocations from water resources, covering generation of hydropower, water for human consumption, water for agricultural production, water discharges control. Identified adaptation options include improving infrastructure to enhance water quantity and quality, improving storm and sanitary sewers, domestic and industrial wastewater treatment, raising public awareness and integrated watershed management.

Options have been categorized as policies, strategies, planning or operations. While the first two groups of options are assumed to have minimal costs and could be part of the regular budget, the second two are expected to have considerable costs in the short, medium and long term. The costs of immediate actions to enhance integrated water resources management are estimated to be higher but certainly have potential to deliver cost effective later.

Biodiversity and ecosystems is one area of action in Himachal Pradesh where consideration of externalities and non-monetary values is paramount in an assessment of costs and benefits. For example, the construction of hydro power, irrigation dams does bring significant short term benefits to communities living upstream, such dams constrain the development opportunities for communities living in downstream of such area, downstream communities not paid in part to their effects on local ecosystems. Once all projected costs (losses in fisheries habitat, in quality of agricultural land and in water purification capacity of downstream) and benefits (irrigation and hydropower generation upstream) are taken into account, a net economic cost could be workout.

9.8 Assessment of Adaptive Capacity & Feasibility of Implementing the Options

Key components of adaptive capacity include the ability to generate, access and interpret information about climate change and its likely impacts; suitable methods for identifying and assessing potential adaptation strategies; appropriately skilled people; adequate financial and other resources; governance systems with sufficient flexibility and foresight to embrace adaptation planning; and willingness to adapt. Knowledge and methods will need to span a range of disciplines, including climate science, biophysical sciences, engineering, social sciences and economics, and planning. Inter-disciplinary studies shall also be important.

There are substantial gaps in our knowledge and we need to improve the synthesis and dissemination of information for decision-makers. Decision makers need improved information, guides and tools which are tailored to their field and scope of operation to enable effective adaptation. Based on the adaptive capacity of various regions of the State, general anticipatory adaptation options have been indicated which should be adopted as per the local level circumstances. The response matrix for these options is summarized in a Table-25.

Complementary and Conflicting Adaptation and Mitigation Actions

Favourable Actions	⟷		Unfavourable Actions
Favourable for Adaptation and Mitigation Efforts	**Favourable for Mitigation, but Unfavourable for Adaptation Efforts**	**Favourable for adaptation, but Unfavourable for Mitigation Efforts**	**Unfavourable for Adaptation and Mitigation Efforts**
• Energy Demand Management • Energy Efficient Buildings • Water Conservation • Biodiversity-Oriented Forestry • “Smart Growth” • Development in Cooler Regions	• Forestry with Non-Native Species • Urban Forestry (shade trees) with High Water Demand) • Some Bio-fuels Production	• Meeting Peak Energy Demand with Fossil Fuels • Wastewater Recycling and Desalination • Groundwater Banking • Increased Air Conditioner Use • Use of Drainage Pumps in Low Lying Areas	• Development in Floodplains • Traditional “Sprawl” Development • Development in Hotter

Source: Bedsworth and Hanak (2008)

9.9 Response Matrix for Anticipatory Adaptation Options in Himachal Pradesh

Table 25: Response Matrix for Anticipatory Adaptation Options in Himachal Pradesh

Sector	General Policy Options for Adaptation	High Priority*			Irreversible or Catastrophic Impacts*	Long-term Decisions*	Unfavorable Trends*	Net benefits are independent of Climate Change*
		Short Term	Medium Term	Long Term				
Agriculture	Develop new crop types			✓	✓			✓
	Enhance seed banks		✓		✓			✓
	Avoid monoculture and encourage farmers to plant a variety of heat- and drought-resistant crops		✓					✓
	Avoid tying subsidies or taxes to type of crop and land	✓	✓			✓		✓
	Increase efficiency of irrigation					✓		✓
	Disperse information on conservation management practices	✓						✓
	Liberalization of agricultural trade					✓		✓
	Promote agricultural drought management practices	✓			✓			✓
	Land consolidations		✓			✓		✓
	Avoid Land Use Change especially agriculture land		✓			✓		✓
Water Resources	Use river basin planning and coordination		✓		✓		✓	✓
	Adopt contingency planning for drought prone area	✓			✓			✓
	Make marginal changes in construction of infrastructure	✓				✓		
	Use inter basin transfers for responding to regional droughts or other problems of water supply					✓		✓
	Avoid inter basin transfers for hydro power generation			✓	✓	✓	✓	✓
	Maintain options to develop new dam sites for irrigation and water supply			✓			✓	
	Conserve water	✓						✓
	Encourage efficient water use		✓			✓		✓
	Spread awareness, education, increase voluntary compliance	✓	✓					✓
	Introduce market based pricing policies, legal restrictions on water use, rationing of water, or the imposition of water conservation standards on technologies		✓	✓		✓	✓	✓
	Allocate water supplies by using market-based system, market-based allocations are able to respond more rapidly to changing conditions of supply and also tend to lower demand		✓			✓		✓
	Control of water pollution	✓			✓	✓	✓	✓
Forests	Enhance forest nurseries, seed banks	✓	✓		✓			
	Encourage diverse management practices	✓				✓		
	Encourage participatory forest management, incentives to the communities	✓				✓		✓
	Ensure effective timely implementation of CAT plans	✓	✓			✓		✓
	Establish flexible criteria for interventions		✓		✓			✓
	Restoration of degraded sites	✓	✓		✓			✓
	Avoid excessive diversion of forest land for long term			✓	✓	✓	✓	✓
	Reduce habitat fragmentation and promote development of migration corridors		✓				✓	✓

Biodiversity & Eco System	Integrated ecosystem planning and management		✓	✓	✓			
	Protect and enhance migration and buffer zones		✓		✓		✓	
	Enhance methods to protect biodiversity off site		✓		✓			
	Preserve vulnerable wetlands		✓		✓			✓
	Restrict, avoid interference with sensitive ecosystem	✓			✓	✓		✓
Energy - Hydro	Promote run of river projects	✓				✓		✓
	Minimum discharge regulation enforcement	✓	✓			✓		
	Avoid inter basin transfers for hydro power generation		✓		✓	✓	✓	✓
	Dam safety measures in all hydropower dams/ reservoirs structures		✓		✓	✓	✓	✓
	Conserve energy- efficient use of energy	✓			✓		✓	✓
	Create awareness, education, increase voluntary compliance	✓	✓		✓			✓
	Promote solar energy use	✓			✓			✓
Health	Improve medical health services		✓		✓			✓
	Greater accessibility to medical health services		✓	✓	✓			✓
	Identification of vulnerable areas by developing vector-specific regional maps		✓		✓	✓	✓	✓
	Development of a robust predictive model linking climate and incidence		✓		✓			✓
	Improved surveillance and monitoring systems		✓		✓			✓
	Improved infrastructure to avoid breeding		✓		✓		✓	✓
	Develop Integrated Environmental Management Plans		✓					✓
	Public awareness, education programmes	✓				✓	✓	✓
Tourism	Enhance, conserve natural assets closely associated to tourism activities	✓						✓
	Regulate hydraulic stress and ecosystems degradation		✓			✓		✓
	Creating adequate infrastructure for meeting pressure in peak events					✓		✓
	Promoting ecotourism, traditional –culture based activities		✓			✓	✓	✓
	Efficient solid waste and waste water treatment system, recycling provisions	✓						
Urban Development	Plan urban growth	✓					✓	✓
	Reduce subsidies/ incentives for undertaking development in and around sensitive lands		✓				✓	✓
	Use set-backs for housing development	✓					✓	
	Discourage permanent river bank line stabilization		✓			✓	✓	
	Incorporate marginal increases in the height of urban infrastructure			✓		✓		
	Discourage urban shift towards river bed areas		✓			✓		✓
	Enhance capacity to manage solid waste, waste water	✓					✓	✓
	Enhance rain water harvesting system		✓					✓
	Encourage community based system for waste management		✓			✓		✓
Climate Change in General	Incorporate climate change in long-term planning				✓	✓	✓	
	Inventorize existing practices and decisions used to adapt to different climates		✓	✓	✓	✓	✓	
	Disaster relief to hazard-reduction programs		✓		✓	✓	✓	✓
	Promote awareness of climatic variability and change	✓			✓	✓	✓	✓

- ***High Priority:*** Some adaptation options need to be implemented in anticipation of climate change because they would be significantly less or not effective if implemented as reactive policies. Adaptation options that fall into the following sub-categories may be considered as high priority.
- ***Irreversible or Catastrophic Impacts:*** These options are policies concerning potentially irreversible or catastrophic impacts of climate change; for example, loss of life or of species, extensive loss of property, or destruction of resources may be irreversible or catastrophic. Such policies warrant consideration because reactive measures will probably be unsuccessful in mitigating the impacts of climate change.
- ***Long-term Decisions:*** Decisions on many long-term issues, such as the construction of dams, reservoirs, bridges, have long useful lifetimes and may be affected by climate change. Policies affecting the construction of such structures warrant consideration because the initial costs of making the structures less vulnerable to climate change are likely to be significantly less than the costs of adapting the structures after climate changes.
- ***Unfavourable Trends:*** Certain trends in growth or resource use may make some types of adaptation more difficult; for example, the fragmentation of habitats is a trend that is unfavourable to wildlife. As climate changes, fragmentation could become an even greater problem as species need to migrate to cooler areas. Policies affecting such trends warrant consideration before climate change, because adaptation may be more difficult in the future or because opportunities to implement low-cost or politically feasible options may be lost.
- ***Other Terms*:*** *As given below:*

Term*	***Goals***	***Planning***
Short Term	Definitions vary on what makes up a short-term goal, but most people feel that a short-term goal is something that will take less than one year to accomplish. Of course, they can be shorter term, such as a weekly sales or fitness goal, or longer term, such as taking a family vacation to a popular theme park in the summer. Short-term goals require minimal planning; often you only need to book time in your schedule to do what needs to be done. Short-term goals are often unwritten, and exist only in your mind.	Short-term planning addresses goals that can be obtained within a short period of time. Short-term usually refers to anything that can be done within a week, such as getting a website up for the company, to a year, like expanding the customer base by 50 percent. Other short-term plans include selling a certain amount of products each day, publishing a newsletter on a monthly basis and hiring new employees for marketing.
Medium term	Goals that will take longer than one year to accomplish, but less than five to 10 years, are usually considered medium-term goals. With these goals, the planning becomes more critical, as most of these goals will need to be broken down into a series of smaller, short-term goals. Often, people pay more attention to their short-term goals and tend to forget or ignore medium-term goals. It is important to review your mid-term goals frequently, so that you don't lose sight of these important objectives.	Medium-term planning refers to the plans that may take anywhere from a year to five years to implement and complete. Examples of medium-term planning include increasing the income from the products sold, increasing the product line with 10 new products over a five-year period, letting third-party manufacturers go to build products on company plant and stabilizing the net worth of the business by gaining more assets and paying liabilities.
Long Term	Goals with a completion date longer than 10 years into the future are generally classified as long-term goals. A long-term goal can become more fuzzy and unclear than shorter term goals, but the more specific you can make it, the more likely you are to obtain your objective. Some long-term goals become more of a vision. While visions are important, they should be kept separate from goals. A happy life in retirement may be a vision, but purchasing a lake house to enjoy summers when you retire, and to complete the purchase within 15 years with cash, is a goal.	Long-term plans are those that take anywhere from five years and up to complete. At the time of business launch, long-term plans can appear unrealistic; so many business owners go back and adjust long-term plans to suit the direction of the company. Long-term plan examples include getting shareholders in the business, expanding the company to several states or internationally and having a net worth triple that of liabilities. All loans and liabilities can also be paid off as part of the long-term plans, especially if the loans are large.
Other	The more specific you make your goal, the more likely you are to achieve it. One should write down all of your goals in a personal journal or record them where you can review them regularly. Hold yourself accountable for the steps to meet your goals. As you plan each of your tasks for the day or week, ask yourself how this fits into your goals, and how that action is helping you reach one or more of your goals.	Business planning is an important aspect of growing a business, whether they are short-term plans that can be obtained within a few weeks or long-term plans that take 10 or more years to implement. Business planning allows you to do extensive research and evaluate each risk associated with a plan before you actually execute it. Some business owners simply do what seems enjoyable at the time without an actual plan, but consequences of acting before thinking can lead to loss in profits or overall failure if the decision tarnishes the company's credibility.

9.10 Instruments to Supplement Implementation- A Roadmap

In view of the current financial and economic positions, emerging crisis such as pressure on water and natural resources etc. shall create even greater challenges due to climate change in times to come. These problems shall make more evident than ever the need to transform the way in which we live, produce, operate and consume. There is a necessity to move towards green economy, sustainable patterns of agriculture practices and consumption and sustainable growth. Green economy represents a genuine opportunity to positively input the system of national economic relations to promote long-term sustainable growth and make the financial and economic systems face environmental reality, through the integration of environmental considerations into these systems.

The State of Himachal Pradesh has always taken the challenges ahead critically and has initiated various programmes, activities for sustainable and inclusive growth. The State has adopted a strategy for sustainable growth by way of promoting a resource efficient, greener and competitive economy. Developing Himachal Pradesh as a green economy is an effort to enhance the environmental pillar of sustainability.

In order to move the State on the path of green economy, the actions are needed at all levels, by all stakeholders. There is a need of commitment and understanding at local level as well. Developing State as a 'green economy' can be achieved by integrating number of interlinked elements such as:

- **Green Public Procurement:** It represents a clear opportunity for the Governments to show in a very practical way their political will to move towards a green economy. Adopting it as a modern policy instrument has a huge potential to catalyze change towards greening all sectors of economic activity, mainly industry and services.

- **Green Jobs:** It represents a huge opportunity to reduce unemployment while enhancing the protection of the environment. It requires an enhanced support and commitment both from governments and from the private sector.

- **Promote Small Scale and Medium Scale Industries:** This has a potential to be a key factor in the process of expansion of green economy. Because of their size and dynamism, these are more likely to adapt faster than large companies to the new environmental standards. Improved regulatory frameworks, easier access to international markets and supporting incentives with cleaner technologies.

- **Enhance Corporate Social and Environmental Responsibility:** This needs to be further promoted at the local level as a key element in ensuring long term public and user reliance, poverty reduction and reduction of the environmental impacts of economic activities.

- **Conservation of State Biodiversity and Ecosystem:** These services are important fundamental basis for a greener economic and social development. There is a need to recognise the value of biodiversity and ecosystem services reflected in the marketing of goods and services.

- **Resource Efficiency:** It aims at supporting the shift towards a resource efficient and low carbon economy that is efficient in the way as it uses all resources, in order to decouple economic growth from resource and energy demand, reduce CO_2 emissions, enhance organic agri-horti produce and ensure greater clean energy contribution to grid.

- **Research and Eco-innovation:** It aim at R&D activities, policy on the likely climate change challenges that our State shall face, such as hydropower, natural resource efficiency, health, tourism, agriculture and land use and demographic changes.

- **Sustainable Consumption Patterns and Agriculture Production:** it is a very important issue, which can make a substantial difference in moving towards sustainable patterns of production and consumption.

- **Promotion and Consumption of Locally Grown/Manufactured Products:** Traditional products and their cultural values must be conserved, bringing in a policy level intervention. It must be further promoted as a way to both alleviate poverty and contribute to the reduction of $Co_{2.}$

- **Payment on Eco services:** Keeping in view the fact that the state is facing numerous challenges on the fronts such as green house gas emissions, deteriorating air quality, increasing trends of pollution of its rivers and water bodies, melting glaciers, deforestation and land fragmentations etc because of various developmental initiatives, introduce new market based concept which is coming to the forefront whereby the beneficiaries of the environmental commodities and services have to pay for their use.

- **Introduce Green Tax for Tourism:** The State is looked upon as a storehouse of the natural wealth, lush green meadows, mountain peaks clad under thick layer of snow, enriching picturesque, dense forests and clean air and water, population expanse and tourist influx has to some extent taken its toll on the environmental health of the hill states, therefore, options of instruments like Green Tax need to considered for the State.

- **Hydropower Generation Taxing to be linked with development of catchment's:** Hydropower, by the nature of its resource (water) and the non-combustion way in which it captures and converts the energy of falling water into electrical energy via the water turbine and generator set, lowers the amount of carbon dioxide emitted during the production of electricity. One can easily assess the annual reduction in carbon dioxide emissions and identify the potential hydropower capacity that can be developed further given the various environmental, legal, and institutional development constraints for levying the Carbon Tax in the State besides linking it with development of catchment's areas.

A-2-S-2	**Water Resources**	- Evaluation of the effects of climate change on different phases of the water cycle. - Perform an analysis of the vulnerability and adaptation potential of water resources. - Updating of hydrological balances in the most critical areas. - Determination of the availability of water in the future for consumption by humans, agriculture and electricity generation, considering the effects of climate change and demand forecasts. - Forecasting of hydrological trends (flows) based on climate evolution predictions. - Design of a state level aquifer monitoring program. - Progress toward commitments set out in the State Strategy for Integrated Watershed Resources Management and development. - Study of water resources and how efficiently they are used, in order to adapt them to climate change in Himachal Pradesh. - Application of calibrated hydrologic balance models to various unregulated watersheds. - Creation of the Environmental Research Centre, which will focus on the study of the region's water resources. - Encourage the construction of rain water harvesting structures. - Implement the processes for technical improvements for the effective irrigation. - Carry out a multidisciplinary study of glaciology and meteorological aspects of rich biodiversity in remote geographical regions, through research. - Set up a multipurpose centre equipped for researching water resources and biodiversity in order to advance research in the State. - Enhance rain water harvesting installations coverage in time bound manner. - Regulate and target to reduce water storage systems in industrial, commercial activities.	IPH, SCSTBE, HPSPCB, University of Agricultural/ Horticulture Research, UD, DEST, CWC, CCC, Power, Forests, AGiSAC, District Administration etc.	2012-2017	-	1,100
A-2-S-3	**Forests**	- Perform an analysis of the vulnerability and adaptation potential of the Forest sector resources. - Assess and summarize national policies and strategies for adaptation in the Forest sectors and water resources. - Conduct a socioeconomic assessment of the impact of climate change on the Forestry sector. - Perform studies to identify climate change adaptation measures and projects in Forest sector of Himachal Pradesh, especially in alpine areas, reserves. - Implement a Genetic Improvement Program to develop new plant varieties that have been adapted for new climate change scenarios. - Foster and promote the efficient use of rain water in forests. - Forest fire management and control. - Target annual basis forest area enhancement- community participation. - Target CAT plan implementation and physical achievement. - Target to create nurseries with new varieties.	Forests, IPH, Rural Development, IIT, IHBT, SCSTBE, Fire Deptt., DEST, UD, AGiSAC, CCC, District Administration, etc.	2012-2016	-	1,400

A-2-S-4	**Biodiversity-Ecosystems**	- Evaluation of the effects of climate change on areas of high environmental value/ eco sensitive areas. - Analysis of the effects of climate change on species in conservation categories. - Strengthening of ecological restoration programs in degraded systems. - Undertake out climate change impact studies using existing information on public land of significant patrimonial value such as glaciers that encompass entire watersheds, glaciers or those that form an oasis in absolute desert ecosystems. - Develop the Integrated Observatory Project in order to precisely measure terrestrial factors that influence climate change. - Wetland conservation, restoration programmes. - Protection of glaciers.	Forests, SCST&E, Biodiversity Board, Ayurveda, IHBT,UHF Nauni Univ; NBPGR, Forests (Wildlife), DEST, District Administration etc.	2012-2016	-	550
A-2-S-5	**Health Sector**	- Create probable climate change impact scenarios that could be used to establish the needs for health infrastructure and personnel. - Establish criteria for adapting to contingencies and other needs in the Health sector. - Carry out an economic assessment of preventive measures and infrastructure and personnel needs. - Strengthen the capabilities of health personnel to address prevention and care of adverse effects caused by climate change. - Identify vulnerable areas or those with the greatest health risks due to different factors. The affected population should also be considered. - Improve monitoring of environmental health indicators. Trends in these indicators as well as any stark changes can reveal effects of climate change. - Interact with other sectors in order to identify the current or future effects of climate change on the health of the population. - Create and develop capacities to address the potential introduction of yellow fever, dengue fever, malaria and vectors such as mosquitoes. - Adapt monitoring systems and emergency plans by including in risk management practices, any climate change related health effects.	Health, IPH, DEST, SPCB, Disaster Management Authority, UD, AGiSAC, CDC, District Administration etc.	2012-2016	-	1050
A-2-S-6	**Tourism- Eco Tourism**	- Incorporate the results of climate change impact studies into tourism plans to avoid the expansion of urban areas into rural and riverside areas that are already susceptible to climate change risk. - Check infrastructure development related to tourism activities in areas prone to disasters. - Assess the economic impact of preventive measures to prepare for extreme events and of repairs or reconstruction that could result necessary from such events. - Promote programme related to traditional culture based tourism. - Eco tourism expansion. - Roads/ transport networking. - Regulating interferences with eco sensitive zones.	Tourism, Forests, Health, IPH, Transport, PWD, UD, District Administration etc.	2012-2017	-	650

A-2-5-7	**Housing, Urban Infrastructure**	- Develop scenarios to model the impacts of climate change on major infrastructure in low-lying and river bed areas susceptible to climate-related damage. - Assess the economic impact of preventive measures to prepare for extreme events and of repairs or reconstruction that could result necessary from such events. - Develop criteria for adapting regional emergency plans to prepare for the potential destruction of major infrastructure. - Adapt the design for new bridges and hydraulic infrastructure so that these would account for changes to Himachal Pradesh's hydrology caused by climate change. - Expand the infrastructure and defence program designed to protect the lives of citizens and safeguard public and private property in remote areas and riverside areas. - Improve the capacity to predict and respond to hydrological emergencies caused by destructive rises in river levels due to the new hydrology caused by climate change. - Incorporate the results of climate change impact studies into zoning plans to avoid the expansion of urban areas into rural and riverside areas that are already susceptible to climate change risk. - Improve the link between the process for developing urban planning instruments and the incorporation of background information from available studies on rural areas and watersheds. - Check infrastructure development related to tourism activities in areas prone to disasters. - Develop building energy efficiency design guidelines- (retrofitting as well as new constructions)	UD, RD, IPH, PWD, TCP, SPCB, Tourism, Transport, District Administration etc.	2012-2016	-	1,250
A-3	**Formulation of a Regional Plan for Climate Change Adaptation and Related Sub-sectoral plans**	- Develop the regional level Adaptation Plan and the respective Sectoral Adaptation Plans for the period 2015-2045. - Their implementation will be monitored over time and the sectoral impact scenarios will be updated, as needed.	DEST, SCST&E, Stakeholder Organizations etc.	2012-2013	-	850
					Total (I)	**8,450**

Action Code	Component	Action Proposed	Implementing Institution	Implementation Period	Budget Rs. (million)	
					Existing	Additional
Mitigation						
M-1	**Carry out/ Update Greenhouse Gas Emissions Inventories**	- Update and publish the State Inventory of Greenhouse Gases for the Energy and Non-Energy Sectors. - Design a structure for collecting and handling information needed for ongoing inventory preparation. - Formulate procedures for handling data uncertainties in the inventories and GHG emission calculations. - Develop local emission factors. - Sign institutional agreements to establish coordination on the periodic updating of the State GHG inventory. - Determine annual emissions from tourism, industries, cement industry, hydropower, given that these are the principal activities in the States economy and accounts for major% of the State's consumption of electricity.	DEST, Industry, Energy, Tourism, Transport, SPCB, AGiSAC, CCC, GB Pant etc.	2012-2014	-	150
M-2	**Mitigation Assessment Studies & Implementable Actions**					
2-S-1	**Agriculture, Animal Husbandry and Forests**	- Evaluate the department of Agriculture's development programs in terms of their contribution to carbon capture and any resulting decrease in the use of fossil fuels. - Promote native forest management and recovery. - Promote afforestation. Analyze the agriculture, livestock and forest energy market. - Conduct studies on the use of waste for the production of bioenergy, either by individual companies or collectively, in Himachal Pradesh's agriculture, livestock and forestry sectors. - Promote a program to calculate the carbon footprint of agricultural, livestock and forestry products exported by State. - Create and implement consortia for applied research on next generation biofuels. - Carry out a technical and economic assessment of the production and use of biofuels. - Implement the "Policy for Biofuels in Himachal Pradesh", which will consider the use of biofuels as an alternative to fossil fuels. - Estimate the carbon captured by plantations, as promoted by Forest department. - Ecosystems evaluation analysis and issuance of state policy on payment for environmental services based on pilots. - Sustainable Management of forests as per agreed methodology for REDD+. - Preparation and implementation of basin wise integrated Catchment Area Treatment (CAT). - Promotion of diversification of farming systems. - Certification protocol for organic farming in the State.	Energy, Transportation Housing and Urban Development, Industry, Agri Univ. UHF Nauni Animal Husbandry Deptt., Agri. Deptt. Horti. Deptt. GB Pant, District Administration etc.	2012-2017	-	550
M-2-S-2	**Energy Efficiency and Renewable Energies**	- Improve estimates of potential savings and energy efficiency on a State and regional scale, by consumption sector. To achieve this, the potential for reducing greenhouse gas emissions through implementation of the 2009-2014 Action Plan of the National Energy Efficiency Mission will be quantified. The objective of this plan is to limit increases in energy consumption in sectors such as transport, industrial, cement mining, public and residential. In addition, this program's potential for reducing baseline emissions will be established.	Energy, Himurja, UD/ RD/ TCP, Transport, Industry, Agriculture, Forests,	2012-2016	-	750

		- Strengthen the National Energy Efficiency mission based on results of the potential for savings and energy efficiency. The purpose of this is to intensify energy efficiency initiatives in sectors such as construction, commercial, residential, industrial and transport and to evaluate their potential for future mitigation. - Study the potential for renewable energy generation. To do this, the potential for limiting the increase of greenhouse gas emissions will be calculated and quantified. This potential is a result of new investments being made in this field that have resulted from actions taken to promote the development of non-conventional renewable energies in the State and also of regulatory modifications. - Ongoing monitoring of the evolution of the current and projected baseline, for the purpose of tracking the natural evolution of growth in demand, as well as the new energy supply options that are available. - To undertake Cumulative Environmental Impact Assessment (CEIA) studies - Establish the Centre for Renewable Energies to create policies that guide and create incentives for investors. Implement a government-backed fund for investments in renewable energies and energy efficiency. - Encourage the installation of solar systems for heating water or generating electricity in the public, commercial, residential and industrial sectors, to make maximum use of Himachal Pradesh's solar resources. - Provide the necessary infrastructure and safety features for the large-scale use of bicycles, pooled transport as an everyday means of transport in urban areas. - Improve estimates of potential savings and energy efficiency on a State and regional scale, by consumption sector. To achieve this, the potential for reducing greenhouse gas emissions through implementation of the 2009-2014 Action Plan of the National Energy Efficiency Mission will be quantified. The objective of this plan is to limit increases in energy consumption in sectors such as transport, industrial, cement mining, public and residential. In addition, this program's potential for reducing baseline emissions will be established. - Strengthen the National Energy Efficiency mission based on results of the potential for savings and energy efficiency. The purpose of this is to intensify energy efficiency initiatives in sectors such as construction, commercial, residential, industrial and transport and to evaluate their potential for future mitigation. - Study the potential for renewable energy generation. To do this, the potential for limiting the increase of greenhouse gas emissions will be calculated and quantified. This potential is a result of new investments being made in this field that have resulted from actions taken to promote the development of non-conventional renewable energies in the State and also of regulatory modifications. - Ongoing monitoring of the evolution of the current and projected baseline, for the purpose of tracking the natural evolution of growth in demand, as well as the new energy supply options that are available. - Establish the Centre for Renewable Energies to create policies that guide and create incentives for investors. Implement a government-backed fund for investments in renewable energies and energy efficiency. - Encourage the installation of solar systems for heating water or generating electricity in the public, commercial, residential and industrial sectors, to make maximum use of Himachal Pradesh's solar resources. - Provide the necessary infrastructure and safety features for the large-scale use of bicycles, pooled transport as an everyday means of transport in urban areas.	Animal Husbandry, SCST&E, District Administration etc.			

M-2-S-3	**Energy, Hydro Power, Industry Sector**	- Evaluate the potential energy generation scenarios in Himachal that take into account the expected impacts of climate change on water resources. This information will be central to any assessment of different alternatives and opportunities that, in the future, could allow for the establishment of a more diverse and sustainable energy matrix. - Assessment of the Power sector's hydrological vulnerability and its effect on Himachal Pradesh energy security. This will be carried out by developing future hydroelectric generation scenarios. - Transmission and evacuation plan. - Target energy conservation through market based instruments. - Target solar energy coverage in urban rural areas. - Bio-energy- waste to energy pilot-model projects. - Discourage energy intensive industrial development. - Regulating diversion of river flows, courses for power generation. - Target to achieve minimum discharge required for downstream floral-faunal sustenance. - Target revival of water mills, Design of economic instruments to address of one priority pollutant and incentives for cleaner production based on economic efficiency criteria.	Energy, Power Corporation, HPSEB, CWC, DEST, IPH, SCST&E, SPCB, HIMURJA, Industry, District Administration etc.	2012-2017	-	450
M-3	**Generation of Mitigation Scenarios in Himachal Pradesh.**	- Development of mitigation scenarios for the next 15 or 20 years, which includes creating scenarios up to 2025 or 2030 for those sectors making significant contributions to State's GHG emissions. These future scenarios will be based on the new energy sector baseline and will include the most up-to-date State specific supply and demand conditions.	DEST, CCC Energy, Agriculture, Transport, Industry, Forests, Revenue, District Administration etc.	2012-2016	-	250
M-4	**Formulation of a Regional Plan for Mitigation and Related Sectoral Plans.**	- Creation of the 2015-2025 Regional Action Plan for Mitigation of GHG Emissions and its related Sectoral Plans	DEST Sectoral Institutions etc.	2012-2016	-	150
					Total (II)	**2,300**

C-5	**Strengthening the Institutional Framework in Himachal Pradesh for Addressing Climate Change.**	- Review the current membership of the State Steering Committee on Climate Change, with the aim of incorporating other important sectors such as health, public works, industry-mining and transport, among others. - Review the institutional arrangements in different sectors for combating climate change, and implement recommendations of the institutional assessment as per outcomes of Environment Master Plan. - Strengthen State Centre on Climate Change through staff, training and capacity building.	DEST, Sectoral Organizations etc.	2012-2013	-	950
C-6	**Design of Instruments to Promote the Development, Transfer and Adoption of Technologies for Climate Change Mitigation and Adaptation.**	- Design instruments to promote the development, transfer and adoption of technologies for climate change mitigation and adaptation. - These instruments should complement measures included in the respective regional and sectoral plans. - Provide incentives for the development of alternative energy projects and evaluate mechanisms to facilitate their implementation. - Implement the Integrated Climate Change Project, which seeks to create technologies for climate change mitigation and/or adaptation in the agriculture and forestry sectors. - Implement an environmental labeling system to inform consumers about the performance and emission levels of new vehicles, including CO_2 emissions. - Develop incentives for the promotion of more energy-efficient transportation, such as hybrid or electric vehicles. - Support the Mechanism, an instrument that supports the development and transfer of technology and sustainable development. - Proposed Studies: - Natural capital cost accounting targeted at the forestry sector. - South -South Exchange on sub national environmental and climate change management. - Analysis of monitoring and institutional mechanisms for appropriate in-stream flows, sharing of international experience on good practices for cumulative environmental impact assessment. - Poverty and social impact analysis / monitor and evaluate innovations in benefit sharing. - Sharing of international experience on water policy. - Assessment of economic instruments to promote cleaner sources of growth and to reduce pollution from existing industrial plants. - Strategic Environment Assessment of Sustainable Tourism Practices.	DEST, Energy Institute, Agricultural Research, Natural Resources Forests, Transport and Telecommunications	2012-2016	-	1,200
					Total (III)	**4,850**
					Grand Total (I+II+III)	**15,600**

*** The budget presented above are indicative and worked out in context of geographic condition of State and current price and may alter/ change in future. The State Strategy & Action Plan on Climate Change is a dynamic process and will be reviewed annually and necessary corrective steps/ measures will be undertaken.**

9.12 Cost of Implementation

The Government of India has indicated and committed in various national communications that the adaptation and mitigation measures shall have to be implemented all throughout the country without any compromise. The Government of India has specifically asked to furnish the State Action Plan on Climate Change (SAPCC) for consideration under the 12th Five Year Plan for funding.

Where possible, the strategy and action plan identifies the indicative costs associated with specific measures but it is recognised that the overall costs of the strategy will be spread across the economy as a whole associated with adaptation and mitigation and indeed are likely to impact in some way on every household. It would clearly be impossible to attempt to quantify the total cost.

However, the measures in the strategy also present opportunities for savings across the economy, right down to the individual household. Energy efficiencies, in particular, will reduce living costs for households and improve the profitability of enterprises, competitiveness and employment opportunities. More importantly, it is quite certain that, for society as a whole, the costs of inaction would greatly outweigh the cost of action. It, therefore, makes economic sense to invest now in placing ourselves on a low carbon path or carbon smart path for the future. Guidance manual can be prepared for the Government Departments and Offices on appraising the costs and benefits of greenhouse gas mitigation policies. These will be used in conjunction, where appropriate, with existing guidelines for departments and Offices on other issues.

9.13 Institutional Arrangements for Steering Climate Change Strategy & Action Plan

In Himachal Pradesh in order to respond effectively to the challenges of climate change, the **State Government has constituted a State Level Governing Council on Climate Change, under the chairmanship of Chief Minister**. The Council has broad based representation from key stake-holders departments to monitor the targets, objectives and achievements of the Eight National Missions specified under National Action Plan on Climate Change. The State Governing Council also provides guidance on matters relating to coordinated national action on the State's agenda and review of the implementation of the National Action Plan on Climate Change. The State Level Governing Council chaired by the Chief Minister also provides guidance on the matters relating to national level negotiations including bilateral, multilateral programmes for collaboration, research and development in the State of Himachal Pradesh (Annex-I).

Besides, an Executive Council under the chairpersonship of Chief Secretary, Himachal Pradesh has also been setup having involvement of almost all stake holder line Departments with the objective of implementation and monitoring of the directives of the State Governing Council on Climate Change.

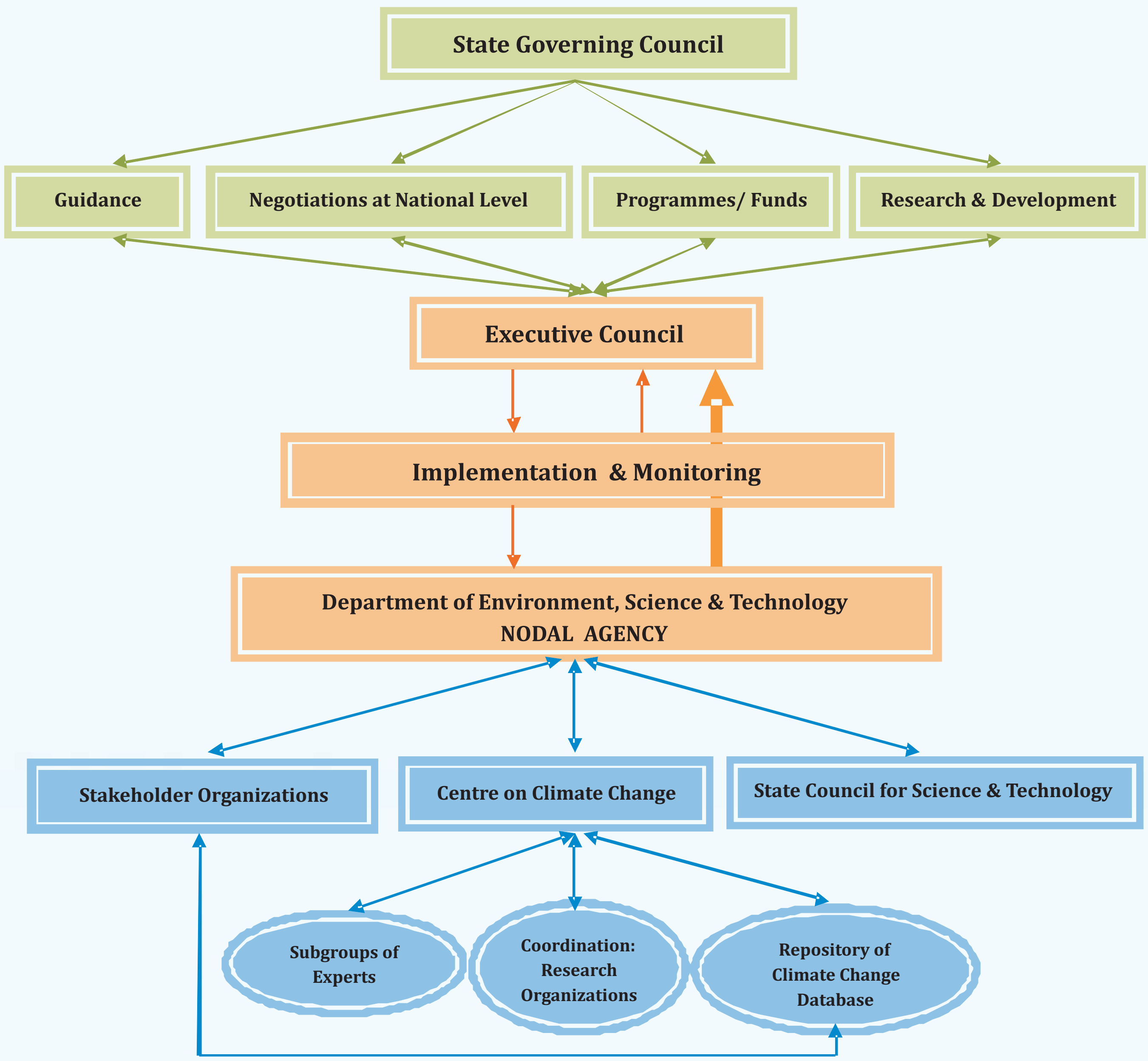
The Department of Environment, Science & Technology to the Government of Himachal Pradesh acts as a Nodal Agency to coordinate and deal with the climate change issues. The Department of Environment, Science & Technology, the State Council for Science, Technology & Environment, State Centre on Climate Change would continue to evolve strategies and programmes, based on new scientific and technical knowledge as they emerge and in response to the evolution of the multilateral climate change regime including arrangements for national and international cooperation. Further, the Department shall monitor and assess State's progress in addressing climate change issues and to increase awareness in all sectors of the opportunities and challenges presented by the transition to a carbon neutral economy.

The Government would ensure that the implementation of measures at sectoral level will be the responsibility of the relevant Government Departments and agencies. On Climate Change, a team comprising of senior officials from relevant Government Departments will be notified to coordinate the implementation of the Strategy.

A Centre on Climate Change has already been established in Himachal Pradesh which will act as a nerve centre for climate change data base and actions. This Centre is being catered and supported for its GIS applications need by the Aryabhatta Geo-informatics & Space Application Centre (AGiSAC). Further, Working Groups and Sub-groups will be established, as necessary, to secure implementation of specific measures that require enhanced policy coordination across sectors and may involve appropriate expertise from State level agencies. Other existing cross-departmental arrangements and structures will also be utilised as appropriate, to secure the implementation of this Strategy and Action Plan on Climate Change.

The Department of Environment, Science & Technology (DEST) will work in close coordination with Local and Regional Authorities, through existing coordination arrangements, to secure implementation of specific aspects of this Strategy and Action Plan at the local level.

Institutional Framework for Steering Climate Change Strategy & Action Plan



Annex-I

Government of Himachal Pradesh,
Department of Environment and Scientific Technologies
H.P. Secretariat, Shimla-2

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No. STE-F[1]-12/2008 **Dated: Shimla-2, 29-08-2008**

NOTIFICATION

There is a global threat of climate change is being felt strongly and India is not unaffected. This threat emanates from accumulated greenhouse gas emissions in the atmosphere, anthropogenically generated through long-term and intensive Industrial growth and high consumption lifestyles in developed countries. The climate change may alter the distribution and quality of India's natural resources and adversely affect the livelihood of its people and also the State of Himachal Pradesh.

The Government of India has prepared a NATIONAL ACTION PLAN ON CLIMATE CHANGE (NAPCC) which would address the impacts of climate change. It would also focus on sustainable development with emphasis on environmental objectives.

In order to achieve the objectives of the above mentioned NATIONAL ACTION PLAN ON CLIMATE CHANGE (NAPCC) and dovetail State's initiatives with the Centre, the Governor, Himachal Pradesh is pleased to constitute the State Level Governing Council on Climate Change in the following manner:-

1.	Hon'ble Chief Minister, Himachal Pradesh	Chairperson
2.	Hon'ble Minister for (Power & Non-Conventional Energy Sources), H.P.	Executive Member
3.	Hon'ble Minister for (PWD and Revenue), H.P.	Executive Member
4.	Hon'ble Minister for (TCP and Housing), H.P.	Executive Member
5.	Hon'ble Minister for (Urban Development), H.P.	Executive Member
6.	Hon'ble Minister for (Irrigation & Public Health), H.P.	Executive Member
7.	Hon'ble Minister for (Agriculture & Horticulture), H.P.	Executive Member
8.	Hon'ble Minister for (Transport), H.P.	Executive Member

Contd... P-2/-

9.	Hon'ble Minister for (Forest, Env. & Scientific Technologies) H.P.	Executive Member

In addition to above, it would comprise of following members:-

10.	Secretary (Forests), H.P.	Member
11.	Secretary (Urban Development), H.P.	Member
12.	Secretary (Agriculture & Horticulture), H.P.	Member
13.	Secretary (MPP & Power) to the Govt. of H.P.	Member
14.	Secretary (Irrigation & Public Health), H.P.	Member
15.	Secretary (PWD and Revenue) to the Govt. H.P.	Member
16.	Secretary (TCP and Housing), H.P.	Member
17.	Secretary (Transport), H.P.	Member
18.	Secretary (Env. & Sci. Technologies), H.P.	Member Secretary

The overall objective of the Governing Council would be to monitor the targets, objectives and achievements of the National Missions specified NATIONAL ACTION PLAN ON CLIMATE CHANGE (NAPCC). The respective Missions shall be taken care of and attended by the individual departments who shall strive to attain the listed objectives with in a stipulated time frame and ensure its vertical integration with the National Missions. The Governing Council shall meet twice in a year.

The Governor, Himachal Pradesh is further pleased to constitute Executive Council which will monitor the directions and other related matters of Governing Council in the following manner:

1.	Chief Secretary, Himachal Pradesh	Chairperson
2.	Secretary (Forests), H.P.	Executive Member
3.	Secretary (Urban Development), H.P.	Executive Member
4.	Secretary (Agriculture & Horticulture), H.P.	Executive Member
5.	Secretary (MPP & Power) to the Govt. of H.P.	Executive Member

Contd... P-3/-

6.	Secretary (Irrigation & Public Health), H.P.	Executive Member
7.	Secretary (PWD and Revenue) to the Govt. of H.P.	Executive Member
8.	Secretary (TCP and Housing), H.P.	Executive Member
9.	Secretary (Transport), H.P.	Executive Member
10.	Secretary (Env. & Scientific Technologies), H.P.	Executive Member
11.	Pr. Chief Conservator of Forests, H.P.	Member
12.	The Director, (MPP & Power) to the Govt. of H.P.	Member
13.	The Engineer-in-Chief, PWD, U.S. Club, Shimla, H.P.	Member
14.	The Director, Town & Country Planning Deptt., Shimla-9	Member
15.	The Chief Executive Officer-cum-Secretary, H.P. Housing & Urban Development Authority, Shimla-2	Member
16.	The Engineer-in-Chief, Irrigation & Public Health Department, Shimla-1	Member
17.	The Director, Department of Agriculture, Shimla	Member
18.	The Director, Department of Horticulture, H.P. Shimla	Member
19.	The Director, Department of Transport, H.P. Shimla	Member
20.	The Director (Urban Development), Shimla-2	Member
21.	The Director, Department of Environment & Scientific Technologies, H.P.	Member Secretary

The Executive Council shall meet at least once in quarter but can also meet as per the need and contingencies.

By Order

[Harinder Hira]
Pr. Secretary [Env. & ST] to the
Government of Himachal Pradesh

Endorsement No. : As above. Dated: Shimla-2. 29-08-2008

Copy forwarded for information and necessary action to:

1. The Secretary to Governor, Himachal Pradesh, Shimla-2.
2. The Pr. P.S. to the Chief Minister, H.P. Shimla-2.
3. The P.S. to the Cabinet Ministers, H.P. Shimla-2.

Contd... P-4/-

4. The P.S. to the Chief Secretary to the Government of H.P., Shimla-2.
5. All Executive Members and Members of the above-mentioned Governing Council and Executive Council.
6. The Director, Environment & Scientific Technologies, Narayan Villa, Shimla-2.
7. The Member Secretary, H.P. State Environment Protection and Pollution Control Board, Paryavaran Bhawan, Below BCS, New Shimla-9
8. The Member Secretary, H.P. State Council for Science, technology and Environment, SDA Complex, Kasumpti, Shimla-9.
9. Guard file.

Joint Secretary [Env. & ST] to the
Government of Himachal Pradesh

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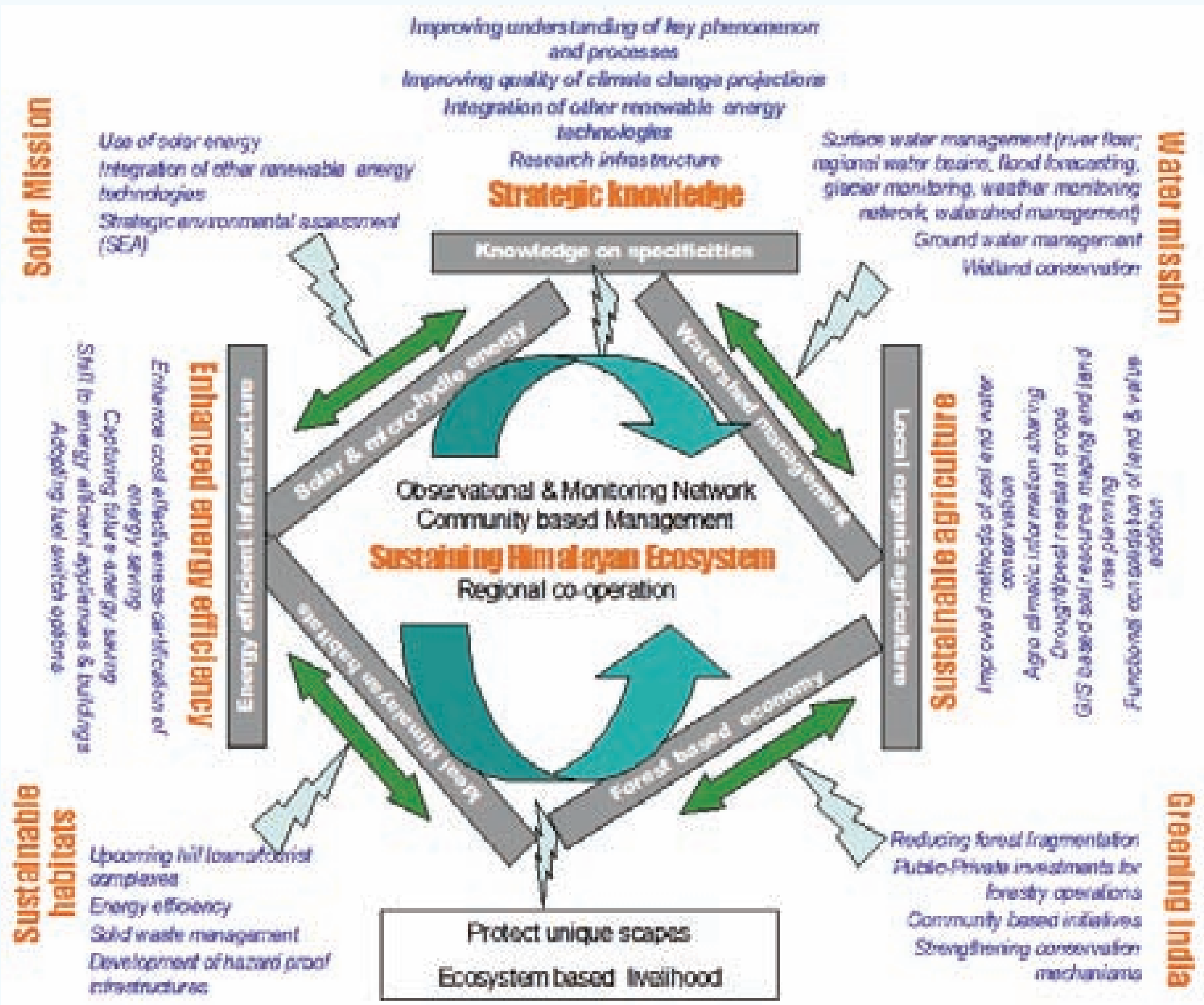
The Way Forward

10

The anthropogenic interventions in pursuit of developmental activities are necessary for coping up employment, energy and resource utilization pressures needs to be curbed with matching compensation as opportunity cost. The regional cooperation (among Himalyan States in IHR) and where needed cooperation with countries in the area of Himalayan ecology would certainly help mitigate the vagaries of climate change in a holistic sense.

The experience gained so far enables the State to embark on an even more proactive approach. The previous section presented the strategy that Himachal Pradesh will undertake for implementing its State Action Plan. However, implementation would require effective cooorditnation and cooperation with other National Missions under National Climate Change Action Plan (NAPCC) and move specifically with NMSHE:



Source: NMSHE

Although the Vulnerability Assessments have been carried out at block level but in order to give an orientation towards action, it would be necessary in the times to come to expand this Vulnerability Assessment format to the panchayat level so as to facilitate the comprehension of cause and effect relationship amongst different components and implement actions at the ground level.

Various programmes that can be taken up in consonance with the National Action Plan on Climate Change are as follows:

10.1 National Solar Mission

Under National Solar Mission, use of solar energy for power generation and related applications is emphasized. Where ever necessary for the purpose of system balance or ensuring cost-effectiveness and reliability, the promotion to integrate other renewable energy technologies such as wind, biomass etc. is proposed. Himachal Pradesh is a tropical Himalayan State, where sunshine is available for longer hours per day and in great intensity. Solar energy, therefore, has a great potential as future energy source. It also has the advantage of permitting a decentralized distribution of energy, thereby empowering people at the grass root levels.

The Government may also initiate to provide support for research, development and deployment of emerging technologies such as solar and wind power. Other constraints to the development of renewable energy need to be also addressed. The Government may also support co-firing of biomass in power generation as a means of reducing greenhouse gas emissions and introducing additional diversity into power generation.

10.1.1 Solar Thermal Power Generation

Electricity generation from renewable sources provides the most effective way of reducing the greenhouse gas emissions from power generation in the State. The Government of Himachal Pradesh has to, therefore, targets for the contribution of renewable energy for power generation. To promote the use of renewable energy sources in the State, R&D collaboration, technology transfer, and capacity building with respect to use of renewable source of energy needs to be encouraged.

10.2 National Mission for Enhanced Energy Efficiency in Industry

The Industry sector contributes to greenhouse gas emissions mainly through heavy consumption of energy, direct fossil fuel combustion for heating and emissions that arise in the course of various industrial production processes. The sector is also the main source of emissions of industrial gases, in particular through use in refrigeration, air conditioning and in the electronics sector.

A number of programmes have been initiated and it is anticipated that these would result in a saving of 500 MW in overall consumption of the energy in Himachal Pradesh. Analysis needs to be also made to assess the potential for various forms of distributed electricity generation, and the implications for the electricity transmission and distribution networks.

The natural gas network needs to be explored for the Industrial areas, wherever it is cost-effective and economic to do so. A programme for the natural gas transmission and distribution network not only needs to be put in study but also there is a need to prepare an action plan in this regard.

There is also a need for a comprehensive Energy Efficiency Action Plan to deliver a significant reduction in energy demand for Himachal Pradesh. Programmes need target energy efficiency across all sectors, including industries, with the public sector setting example with energy efficiency.

There is a need to work with stakeholders to ensure the smooth implementation of the environmental regulations in Himachal Pradesh. The use of vehicles with air-conditioning units that use a refrigerant known as HFC-134 a (which has a global warming potential of 1300 times that of CO_2) is a particular concern and needs to be phased out.

The Industry Energy Management Action Programme (EMAP) needs to be evolved for those industries that have no mechanism for energy audits. There is often significant untapped potential for energy efficiency gains in this sector that are not being realised due to less awareness, ignorance, resource and time constraints. IEMAP shall provide advice for management of such sources and will reduce energy consumption to engage industry in energy efficiency actions with profits.

The Industry sector is increasingly recognising that strong environmental performance makes a good business sense and firms may wish to communicate that their adoption of the superior energy performance practices also demonstrates their commitment to addressing climate change.

The Government may also examine options to enable the planning system to play a more active role in encouraging renewable energy uptake in the industrial, commercial and agricultural sectors. As a general rule, it is intended that where possible, exemptions from planning requirements will be provided. Where planning considerations relating to specific technologies or sectors preclude exemption, there is a need to provide guidance to planning authorities. Where exemptions are provided, the Government may ensure that these complement existing supports provided for the installation of renewable technologies.

Increasing consumer awareness of climate change and the greenhouse gas emissions associated with products placed on the market will require businesses to address changing expectations of the environmental impact of their products and services. The integration of environmental considerations into business planning shall be made fundamental to the future success of the business sector.

To support the adoption of eco-efficient technologies and practices in industry with the aim at improving the strategic capability of unit, in particular in the management of their environmental issues, and developing and exploiting the market opportunities that improved environmental performance needs to be encouraged.

To support a wide range of projects to improve the level of research and development work on environmental technologies and eco-innovation in Himachal Pradesh needs to be encouraged in Industry sector to prevent and minimise the impact of industrial activities on the environment.

Himachal Pradesh needs to work towards implementation of various GHG Mitigation Options in the Industry(s) viz.

- Sector Specific Technological Options
- Cross-cutting Technological Options
- Fuel Switch options

In view of this, there is also a need to work out potential for emissions reduction, apply policy and regulatory options to achieve the set goals.

10.3 National Mission on Sustainable Habitat

The Government's endeavour is to develop in sustainable and inclusive manner so as to conserve its beautiful environs through improvements in management of solid waste, waste water, by undertaking modal shift to public transport, construction of green buildings and roads, energy efficiency in buildings etc. Further, the State Government is committed to promote sustainable development, energy efficiency as an integral component of urban and rural planning through various initiatives.

Furthermore, development strategies, plans and programs cause environmental impacts which, in some extreme cases, may even undermine development efforts. It is, therefore, of utmost importance to integrate environmental concerns from the earliest stages of the definition and programming of development cooperation all the way through implementation, monitoring and evaluation.

The State is also working to integrate environmental concerns into its development policy and planning processes in the past few years.

10.3.1 Promoting Energy Efficiency in Residential & Commercial Sector

The Govt. of India and/or Government of Himachal Pradesh can think to incentivize the installation of mirco-renewable technologies for homeowners. These include solar panels, heat pumps, wind turbines, and biomass etc.

There is a need for expeditious switch over to low-energy light bulbs from traditional incandescent light bulbs which are extremely efficient as CFL bulbs use 80% less energy for equivalent light and last up to 15 times longer. Although its initial cost is high, they are more economical for the consumer in the long run.

To deal with GHG's emissions, the option of introducing an environmental levy on the use of incandescent bulbs can be though to reduce their price advantage and to encourage consumers to switch over to CFL bulbs. The intention is to alter consumer behaviour rather than to generate revenue, but any income from this environmental levy can be channelled through the State Environment Fund to support climate change awareness and action initiatives. It is estimated that emissions savings of up to 230,000 tonnes or more could be achieved if every household replaces 6 conventional bulbs with CFL bulbs. Further, such savings could be achieved in non-residential buildings as well through energy audits.

Electronic smart meters have demonstrable potential to deliver benefits for energy consumers, including more flexible tariffs offering greater choice and energy saving opportunities, and remote meter reading resulting in reduced costs and full accuracy. These meters can also facilitate the incorporation of on-site generation at consumer premises, including renewable generation. Installation of smart meters for all electricity consumers in both new and existing housing sectors can be explored.

Consumer information plays a key role in driving energy efficient behaviour. The energy savings awareness initiatives can be initiated through sustainable energy campaigns. These campaigns can be organized and sustained over regional and community level as well as across other economic sectors.

Efficiency of appliances and energy labelling of appliances enables consumers to compare energy consumption of product alternatives. This will encourage the consumers to go for more energy efficient appliances.

Suppliers and distributors need be directed to produce the labelling material and to ensure accuracy. Retailers are also required to ensure that all display models carry the correct energy labels. Energy labelling needs to be underpinned as the eco-design directive, which provides a formal mechanism for establishing product standards for energy efficiency. Energy efficiency improvements, including water heaters and boilers, computers, fridges, freezers, dishwashers and washing machines needs to be promoted.

Low income households require coordinated action to ensure that homes which are subject to fuel poverty have access to cost-effective heating, hot water and lighting through the installation of energy efficiency measures necessary interventions in this sector needs be initiated.

A special derive to reduce energy consumption and thereby to reduce greenhouse gas emissions needs to be adopted as:

- To convert the heating systems in some large State buildings from their existing electric, fossil fuel burners (oil/natural gas) to possibly solar systems.
- Energy awareness –Pilot staff energy awareness campaign in some office buildings with a target to reduce energy consumption at least by 10% through local energy conservation campaigns, energy workshops and close monitoring of the performance of heating/air conditioning equipments.
- Energy efficient design for new buildings – The scope for improving energy efficiency in new buildings is very significant and by having energy efficient designs in new buildings can considerably improve the energy efficiency of the building over their entire lifetime with little or no additional construction costs.

10.3.2 Management of Municipal Solid Waste

There is a need to regard waste as a useful resource. This can be reflected in our commitment to develop a recycling option for plastic, papers etc. and the priority are given to the diversion of waste from the landfills. The adoption of such techniques has a positive side-effect in reducing greenhouse gas emissions.

Emissions from the waste sector consist mainly of methane from the anaerobic decomposition of solid waste that has been deposited in landfill sites. Small amounts of methane and nitrous oxide arise from wastewater treatment. Improved landfill gas management/capture for power generation can be explored which may contribute in the reduction of methane emissions.

Management of non-biodegradable waste is regulated through a set regulation in the State. The strategy for biodegradable municipal waste is required as an integrated waste management approach. Through this approach, the preferred options for dealing with biodegradable municipal waste are required to be put in place with a specific focus on the prevention and minimisation – avoiding generating the waste; recycling – mainly of paper and cardboard but also of textiles; biological treatment – mainly of kitchen and garden waste including composting; and residual treatment – thermal treatment with energy recovery or by way of mechanical-biological treatment. Significant energy savings derive from recycling activity can also be explored.

10.3.3 Promotion of Urban Public Transport

Transport plays a pivotal role in supporting economic growth and balanced regional development and there has been a strong correlation between economic growth in and energy, fuel consumption and greenhouse gas emissions in the transport sector.

There is a need to develop a sustainable transport system that will promote economic competitiveness by removing infrastructural bottlenecks and to achieve a diverse fuel mix, while increasing social cohesion, access to peripheral rural areas and reducing environmental impacts, including greenhouse gas emissions.

10.4 National Water Mission

In Himachal Pradesh, the availability of water is highly uneven in both space and time. The precipitation in the form of rains is confined to only about three to four months in a year and varies from about 600 mm in Lahaul & Spiti district to about 3,200 mm in Dharamshala, District Kangra. However, in spite of heavy rain and snow during the rainy season and winters, the summer months are periods of water scarcity in many areas as the flow in the rivers and nallah is quite low and traditional sources also dry up.

10.4.1 Management of Surface Water Resources

River Basin Planning & Coordination: Comprehensive planning across a river basin may allow coordinated solutions to problems of water quality and water supply in the State; for example, enhanced coordination of facility system operations or expansion of the conjunctive use of groundwater and surface water can improve water yields, which can help to alleviate droughts. Planning can also help to address the effects of population, economic growth, and changes in the supply of and demand for water. The MPP & Power Department of the State and IPH Departments need to improve their coordination and planning for allocation of river water to anticipate climate change.

Further, there is a need to adopt contingency planning for drought management. Plans for short-term measures to adapt to water shortages could help mitigate droughts. Planning could be undertaken for droughts of known or greater intensity and duration. The cost of developing contingency plans is relatively small compared with the potential benefits. Additionally, plans could be effective in managing current climatic variability, as well as future climate change.

There is also a need to use desirable inter river basin transfers. Transfers of water between water basins may result in more efficient water use under current and changing climate scenario. Transfers are often easier to implement than fully operating markets for water allocation. Transfers also can be an effective short-term measure for responding to regional droughts or other problems of water supply.

Maintain options to develop new dam sites. Keep options open to develop new dam sites, should they be needed. The number of sites that can be used efficiently as reservoirs is limited, and removing structures once an area has been developed may be very costly. Thus, development in potential dam sites should be limited or only allowed under terms that would permit conversion to dam sites.

10.4.2 Management & Regulation of Water Resources

In the present times, there is a need to allocate water supplies by using market-based systems which allows water to be diverted to its most efficient use. Other mechanisms, such as prior appropriation, may result in inefficient allocation of water supplies. Market-based allocations are able to respond more rapidly to changing conditions of supply and also tend to lower demand, thus conserving water. Consequently, market-based allocation increases both the robustness and the resiliency of the water supply system. In addition, it improves the economic efficiency of the allocation system under the current climate scenario.

Reducing demand can increase excess supply, creating a greater margin of safety for future droughts. Demand for water may be reduced through a range of policies that encourage efficient water uses including education, voluntary compliance, pricing policies, legal restrictions on water use, rationing of water, or the imposition of water conservation standards on technologies. Reduced demand may increase current capacity to cope with drought.

10.4.3 Up-gradation of Storage Structures for Fresh Water & Drainage System for Waste Water

Marginal changes may be made in the planned construction of water resources infrastructure such as reservoirs and flood control works to adapt to increased variability in runoff or to a need for greater storage capacity. In planned construction, a marginal increase in the size of dams or marginal changes in the construction of canals, pipelines, pumping plants and storm drainages can be considered. This change may be much less expensive than adding capacity in the future.

Polluting water that is unfit for drinking or for other uses can, in many respects, have an effect similar to reducing water supply. Reducing water pollution effectively increases the sustainable and healthy use of water. In turn, a larger water supply increases the safety margin for maintaining water supplies during droughts. In addition, reduced runoff from climate change will most likely increase concentrations of pollutants in the water column. If pollutant load are lower, water quality standards are less likely to be violated.

Redirecting growth away from sensitive lands and towards less vulnerable areas is one option to reduce the risks associated with a river basin, and also to reduce vulnerability to severe cloud bursts, storms that happen under current climate conditions.

10.4.4 Conservation of Wetlands

Efforts should be made to maintain wetlands that are more likely to be affected by less rains and water tables. Wetlands are valuable natural areas that are difficult to re-create; therefore, current and future efforts are warranted to protect these areas. In setting priorities for protecting wetlands, the likelihood of surviving a wetland, migrating landward should be considered. Protecting wetlands will also improve water quality, flood control and fish and wildlife habitat under the current climate conditions.

Permanent shore-hardening structures, such as protection walls need to be banned or discouraged in moderately developed areas. Limiting permanent stabilization of the shoreline will allow a gradual retreat in a natural way.

Permanent or temporary camping structures, such as huts, tents may be banned or discouraged around moderately developed areas and as well as in eco sensitive zones. Limiting trafficking near to the wetlands will allow a gradual natural maintenance of the wetlands. Exposure of the wetland to pollutants due to solid wastes, vehicles etc. may destroy the natural retreat systems of the wetlands.

Public participation can help the authorities, in preventing the waste from entering the lake. They can generate income and employment by converting the waste in to manure. The schools are educating their students about waste management practices.

Lakes in Himachal Pradesh, besides being a favourite tourist destination attract thousands of tourists and serves as a natural resource for the local people. The lakes are in peril due to anthropogenic pressure and overall deterioration of surrounding environment. The efforts should be made to prepare and cover the lakes in the lake conservation programme of Ministry of Environment & Forests, GoI, besides the initiatives for lake conservation through education and mass awareness. An establish practice of compulsory door to door household waste collection can also be introduced in and around the lakes areas. Carrying of polythene carry bags, plastic items, chips packets etc. can also be banned in the lake area.

10.5 National Mission for Sustaining the Himalayan Ecosystem

Himachal Pradesh is a small hilly state lies in the North-western Himalaya, the youngest mountain chains in the world which are still in the building phase. A scientific study carried out on the evolution of the Himalaya suggests that these mountain chains are rising at the rate of 2 cm per year. The Himalayan ecosystem is vital to the ecological security of the Indian landmass, through providing forest cover, feeding perennial rivers that are the source of drinking water, irrigation and hydropower, conserving biodiversity, providing a rich base for high value agriculture and spectacular landscapes for sustainable tourism.

It is imperative on parts of States to continue and enhance monitoring of Himalayan ecosystem, in particular the state of Glaciers. It is also important to empower local communities, in particular through the Panchyats to assume greater responsibility for conservation of mountain ecosystems and management of ecological resources.

Emphasize can be given on following measures:

- Adopt appropriate land use planning and watershed management practices for sustainable development of mountain ecosystem.
- Adopt best practice norms for infrastructure construction in mountain region to avoid or

minimize damage to sensitive ecosystem and despoiling of landscape.
- Encourage cultivation of traditional varieties of crops and horticulture by promotion of organic farming enabling farmers to realize a price premium.
- Promote sustainable tourism through adoption of best practice norms for tourism facilities and access to ecological resources, and multi-stakeholder partnership to enable local communities to gain better livelihoods while leveraging financial, technical, and managerial capacities of investors.
- Take measures to regulate tourist inflows into mountain regions to ensure that these remain within the carrying capacity of the mountain ecology.
- Consider these unique mountains as entities with "incomparable values", in developing strategies for their protection.

10.6 National Mission for Green India

Himachal Pradesh provides unmatched contribution to the 'national interest' in sustaining life support system, on the basis of which sustainable development can be realized downstream, in the plains of North India. Attention is shifting to environmental services flows provided by the pristine forests of the State. These include critical watershed services, biodiversity conservation, carbon sequestration and of course maintaining landscape beauty.

Gender specific policies are required to help cope with the loss of control over natural resources, technologies and credit to deal with seasonal and episodic weather and natural disasters. There is a need to re-design the existing tourism policy to produce alternative mountain specific tourism models focusing on environmental sustainability. Forest departments need to be more proactive in influencing policies of other sectors such as road construction, transportation, power and industries which impinge on conservation issues.

10.6.1 Forest Cover & Density

There is a need to formulate a separate and distinct forest policy for Western Himalayan States in view of their vulnerability to climate change, critical role as watershed States for the northern India plains; and unique ecosystem and forested landscapes rich in biodiversity.

There is an urgent need to establish long term monitoring plots across representative eco-zones, together scientific data on climatic and biological parameters, especially in Reverine, Alpine and Shivalik ecosystems.

There is a need to map climate change driven adaptation in natural resource use and livelihood patterns across eco-zones and for developing of a database on carbon sequestration potential of forest flora in these forests.

Further, there is a need for periodic assessment of carbon stock including soil carbon under different ecosystems and effective deployment of new and advanced technologies, such as, GIS remote sensing, climate change modelling in natural resources management.

There is an urgent need to incentivize the community involvement in some mainstream Forest department activities, including forest protection, afforestation and fire fighting etc.

10.6.2 Biodiversity Conservation

Conservation of biological diversity needs to guide afforestation programmes and not carbon sequestration potential alone. Re-orienting afforestation programmes with a focus on species that help mitigate man-animal conflict. Furthers, there is a need to revisit forestry operations to realize full water conservation potential of forests leading to development of “water sanctuaries”.

10.6.3 Payment for Ecosystem Services

By not integrating and extending the concept and practice of Payment for Ecosystem Services (PES) within the States to compensate for forgone land use and occupation options can adversely impacting the environment. There is a need to impress upon the Government of India to move beyond 'Green Bonus' to adequately compensate these States for ecosystem services flows. There is a need to re-orient the developmental interventions by adopting watershed as the unit for planning and fund flows.

10.7 National Mission for Sustainable Agriculture

Himachal Pradesh is predominately an agricultural State where agriculture provides direct employment to about 71 percent of the total population. The Agriculture sector contributes nearly 30 percent of the total State Domestic Product. The actions in accordance with National Missions shall be taken up in following manner:

10.7.1 Increase Efficiency of Irrigation

Improvements allow greater flexibility by reducing water consumption without reducing crop yields. This will also help in adapting water resources. Many farming technologies, such as efficient irrigation systems, provide opportunities to reduce direct dependence on natural factors such as precipitation and runoff. In evaluating an improvement to irrigation systems, the additional benefit of reducing vulnerability to climatic variations and natural disasters can be considered.

10.7.2 Dry land Agriculture

The new mantra is to avoid monoculture and encourage farmers to plant a variety of heat- and drought-resistant crops. Further, growing of single crops such as maize increases farmers' vulnerability to climate variability. If the probability of droughts and heat waves increases with climate change, such vulnerability can also increase. One adaptation option is for farmers to plant a wider variety of crops so as to reduce the risks of crop failure.

10.7.3 Risk Management

Encourage management practices that recognize drought as a part of a highly variable climate, rather than treating drought as a natural disaster. Farmers can be given information on climatic conditions, incentives can be offered to adopt sound practices of drought management, and farmers can be discouraged from relying on drought relief. This type of policy is particularly useful if farm disaster relief and other government subsidies distort the market and encourage overly risky expansion of farming into marginal lands. Review tying subsidies or taxes to type of crop and land. Commodity support programs or tax policies may discourage switching from one cropping system to another that is better suited to the changed climate.

Therefore, efforts to stabilize farm supply and to maintain farm incomes should avoid disincentives for farmers to switch crops, rotate crops, and use the full land normally planted. This policy approach will increase the efficiency of current farming practices and will also increase the ability of the system to quickly recover from the climate change.

Seed banks that maintain a variety of seed types provide an opportunity for the farmers to diversify, allowing them to both counter the threat of climate change and develop a profitable specialization.

Development of more and better heat- and drought-resistant crops will help fulfil current and future food demand by enabling production in marginal areas to expand. The improvements will be critical because the State and Country's population continues to increase, with or without climate change.

10.7.4 Access to Information

Many practices, such as conservation tillage, channel dykes, terracing, contouring, and planting vegetation to act as windbreaks, will protect fields from water and wind erosion and can help to retain moisture reducing evaporation and increasing water infiltration. Using management practices that reduce dependence on irrigation will reduce water consumption without reducing crop yields and will allow greater resiliency in adapting to future climate changes.

10.7.5 Liberalize Agricultural Trade

Lowering trade barriers will result in higher levels of State agricultural production both under the current climate and under the projected climate change scenarios. Farmers will receive information on changes in National market conditions faster than if trade barriers are not lowered.

10.8 National Mission on Strategic Knowledge for Climate Change

The State of Himachal Pradesh intends to take forward the areas as envisaged under this National Mission for a broad based effort that would include the following key themes:

- Research in key substantive domains of climate science.
- Regional Climate Modelling.
- Strengthening of observational networks and data generation.
- Creation of research infrastructure.

10.8.1 Climate Modelling & Access to Data

The IPCC-AR4 addressed the global trends on climate change, but detailed analysis is lacking for India and its regions due to difficulties in obtaining database related to climate change. For this purpose the State make intervention in following areas:

10.8.1.1 Enhanced Research on Climate Modelling

There is a need to develop high resolution regional climate models that simulate regional climate change, in particular monsoon behaviour by pooling institutional capabilities and computational resources. The State needs to encourage regional data re-analysis projects.

10.8.1.2 Promoting Data Access

Different line organisations, research institutions are carrying out various climate change related studies and generating data. It needs to be ensured that all such institutions may appoint a nodal officer who should be made responsible to provide access to such data base. The concept of 'registered users' also needs to be introduced in the State.

10.8.1.3 Human Resource Development

Institutional assessment with respect to required skill needs to be carried out at State, regional and local levels so that necessary measures can be undertaken for enhancing the quality and quantum of human resource which would be required in future.

11 Reporting & Review

A detailed reporting template will be developed to monitor implementation of the measures in this Strategy and Action Plan. This will form the basis of an Implementation Status Report which will be published annually.

The Department of Environment, Science & Technology (DEST) through State Centre on Climate Change (SCCC) and the State Council will coordinate the preparation of this annual report. It is also proposed to lay the report before the State Legislative Assembly. This report will also update emission projections and quantifications of emission reduction measures and detail the further measures which have been introduced or which are in the process of development.

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