PUNJAB
STATE ACTION PLAN ON CLIMATE CHANGE

February 2014

Prepared by:

Punjab State Council for Science & Technology

With Technical support from GIZ

On behalf of:

Department of Science, Technology & Environment

Government of Punjab

Citation
Jerath, Neelima; Ladhar, Satnam Singh; Kaur, Simrandeep; Sharma, Vidushi; Saile, Peter; Tripathi, Priya; Bhattacharya, Sumana and Parwana, H.K. 2014. *Punjab State Action Plan on Climate Change.* Punjab State Council for Science and Technology and GIZ (Deutsche Gesellschaft for Internationale Zusarnmenarbeit GmbH - German International Cooperation, India), pp 329.

PSCST, 2014

Acknowledgements

The Punjab State Council for Science and Technology is the focal point for climate Change matters in the Punjab government. It has been entrusted with the preparation of the State Action Plan on Climate Change. The Action Plan has been prepared with support and contributions of multiple stakeholders in the state, namely the line departments, universities, scientific institutions, industry associations and NGOs. The Council sincerely appreciates and acknowledges their cooperation. It is also thankful to the GIZ for providing technical support and for facilitating the preparation of the Action Plan.

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FOREWORD

Climate change has unequivocally been considered as one of the most serious threats to sustainable development with possible adverse impacts on natural resources thereby affecting food security, human health and economic activities.

The state has reasons to be concerned about climate change, as a large share of its population is engaged in climate sensitive sector of Agriculture. Also Punjab being traditionally the granary of India, the sustenance of this sector vis a vis climate change is a key to the food security of the Nation. Further, as Punjab is thrusting ahead in investing in infrastructure (especially up scaling rural habitats), industries and new technologies, climate change concerns need to be kept in view while ensuring the sustainability of these systems.

The Punjab SAPCC provides a platform to integrate climate change into the policies and programmes of the state to ensure the ultimate objective of sustainable development with inclusive growth. The strategies have been drafted keeping in view the existing concerns, on-going developmental programmes in different sectors, the institutions that are managing these programmes, and the assessed vulnerabilities of the various sectors to climate change.

The strategies in the document are in line with the eight missions of the National Action Plan on Climate Change. The SAPCC assigns state specific targets for each strategy and the actions are geared towards achievement of these targets. The targets as well as the strategies and actions have been developed in consultation with the stakeholders concerned from government departments, universities, industry association and other experts. The actions in the strategies have been budgeted for the 12th and the 13th plan.

It is envisaged, that the multidisciplinary institutional arrangement set up for implementation of SAPCC will ensure climate proofed actions at the ground level to ensure food and economic security of the state in a changing climate scenario. A preliminary implementation arrangement and a monitoring and evaluation framework for the same also have been designed to assess the progress of actions and make course corrections mid way if maladaptation is noticed.

Since this is the first version of the SAPCC, it is expected that it will undergo changes as science progresses and policy needs modify and change. However, the present document forms a strong base and provides guidance to the state to enable it to address its climate change concerns.

The Punjab SAPCC has been prepared by the Punjab State Council for Science and Technology (PSCST) under the aegis of Department of Science, Technology & Environment, Government of Punjab (which is the focal point for Climate Change matters in the Punjab government) with the technical support of GIZ and financial support of Ministry of Environment & Forests, Government of India. Therefore, Department of Science, Technology & Environment will continue to play a pivotal role in integrating climate change in planning.

I hope that this Action Plan would be implemented successfully and shall prove to be of immense benefit to the state.

Rakesh Singh, IAS
Chief Secretary,
Government of Punjab

PREFACE

On behalf of the Department of Science, Technology and Environment, Government of Punjab, I have great pleasure in presenting Punjab's State Action Plan on Climate Change. It is for the first time such a document has been prepared in the State which is in response to and in line with the overall National Policy on Climate change and the National Action Plan on Climate Change (NAPCC). Climate change being a global phenomenon, Punjab is also affected by it and therefore this action plan is a timely effort indicating strategies to address such concerns.

The NAPCC through its eight missions suggests measures to address and adapt to the projected impacts of climate change, as the impacts are making our natural resources vulnerable and threatening our food and economic security. Further the NAPCC suggests measures to abate the drivers of climate change i.e. the greenhouse gases emanating from anthropogenic activities through energy efficiency measures and use of solar technologies.

The Punjab State Action Plan on Climate Change (PbSAPCC) has been prepared through a rigorous procedure involving participation of a broad base of stakeholders drawn from the Punjab government line departments, associated Institutions, Universities, Industry associations and NGOs. The strategies suggested are envisaged to provide necessary guidance towards adaptation and mitigation to the likely adverse impacts of climate change on Punjab agriculture sector, water resources, Forests, Himalayan ecosystem and biodiversity, the Urban and Rural habitats, Human health, and Energy. This, in turn, is expected to ensure food security and a sustainable economic development of the state.

The PbSAPCC is different from the other action plan documents of the Punjab government as it takes into account the climate change concerns for each sector and tries and integrates the adaptation strategies, which are an addition to the elements of the various programmes being implemented to manage the various sectors. I understand that this is an organic document, as with changes in science and technology, adaptation and mitigation strategies will also be realigned.

Further as per the decision of the Planning Commission, all plan funds for programmes allocated to various states, need to have climate change integrated into their respective developmental programmes. This document, therefore, is a step towards that direction. Also, the document provides an opportunity to all departments in the government to build their capacity to address the future likely impacts of climate change and gear their programmes in line with it.

I hope the implementation of this Action Plan will help the State to address its Climate Change concerns. I also take this opportunity to appreciate the work put in by the Punjab State Council for Science & Technology, the State nodal agency for Climate Change, our consultants GIZ, and through them the Consulting Engineering Services, New Delhi, in preparing this document on behalf of the State Government and the Ministry of Environment & Forests, Government of India for their sustained technical and financial help.

Seema Jain, IAS
Secretary
Department of Science, Technology & Environment,
Government of Punjab

PRELUDE

The Punjab State Council for Science & Technology was designated by the State Government as Nodal Agency for assessing, identifying and implementing programmes related to Climate Change in the State of Punjab. Taking cognizance of the potential impact of Climate Change on all sectors of development and the ramifications of this Action Plan, the Council adopted a unique participatory approach while preparing this document. Nodal Officers from all concerned departments were identified and stakeholder workshops and one-to-one meetings were held from time to time to obtain data, seek inputs and authenticate information obtained from secondary sources. Published studies were extensively referred to. Draft documents were extensively shared and updated/modified from time to time. Public comments were also invited by placing the draft document on the website of PSCST and ENVIS Centre and conducting a public hearing-cum-workshop which was attended by the experts, officers from line departments, NGOs and academicians. The GIZ which was identified as the Consultant for Punjab by the Ministry of Environment & Forests, Govt. of India, provided major technical support in data collection and preparation of draft document through Consulting Engineering Services, New Delhi. Financial assistance & technical comments were provided by Ministry of Environment & Forests, Government of India. The comments of TERI (a leading Climate Change expert agency), were also obtained.

The present document is, therefore, the result of a consultative process drawn over eighteen months. The Council recognises that addressing Climate Change is a dynamic process warranting modifications as actions progress to make it responsive to the state's needs. It is hoped that the document will facilitate suitable action through appropriate allocation of resources.

Neelima Jerath

Dr. Neelima Jerath
Executive Director
Punjab State Council for Science & Technology

CONTENTS

LIST OF BOXES

LIST OF TABLES

LIST OF FIGURES

ABBREVIATIONS

ADB	Asian Development Bank
AgriCoop	Agriculture Cooperation
AOGCM	Atmosphere-Ocean coupled General Circulation Model
BEE	Bureau of Energy Efficiency
BLY	Bachat Lamp Yojana
BOD	Biochemical Oxygen Demand
BOO	Build Own and Operate
BP	British Petroleum
C	Carbon
CDM	Clean Development Mechanism
CDM	Clean Development Mechanism
CEA	Central Electricity authority
CERC	Central Electricity Regulatory Commission
CERES	Crop Environment Resource Synthesis
CETP	Common Effluent Treatment Plants
CFLs	Compressed Fluorescent Lamps
CH_4	Methane
CO_2	Carbon dioxide
COD	Chemical Oxygen Demand
CSO	Central statistical Office
DACNET	Department of Agriculture Cooperation Network
DAHDF	Department of Animal Husbandry, Dairy development and Fisheries
DARE	Department of Agriculture Research and Education
DoA	Department of Agriculture
DOC	Degradable Organic Carbon
DoI	Department of Industries
DoIrr	Department of Irrigation
DoFWP	Department of Forests & Wildlife Preservation
DoH	Department of Horticulture
DoRDP	Department of Rural Development and Panchayats
DoSWC	Department of Soil and Water Conservation
DoTr	Department of Transport
DoWS&S	Department of Water Supply & Sanitation
DSSAT	Decision Support System for Agrotechnology Transfer
DSTENCE	Department of Science, Technology, Environment and Non-Conventional Energy
EESL	Energy Efficiency Services Limited
EWS	Economically weaker section
FAO	Food and Agriculture Organisation
FEEED	Framework for Energy Efficient Economic Development
FRI	Forest Research Institute
FSI	Forest survey of India
GCM	General Circulation Model
GDP	Gross Domestic Product
GHG	Green House Gas
GSDP	Gross State Domestic Product
IBIS	Integrated Biosphere simulator
ICAR	Indian Council of Agriculture Research

IDSP	Integrated Disease surveillance Programme
IEA	International Energy agency
IHSDP	Integrated Housing and Slum Development Programme
IMD	India Meteorological Department
INCCA	Indian Network for Climate Change Assessment
INFOCROP	INFOrmation on CROP
IPCC	Intergovernmental Panel on Climate Change
ISFR	India State of the Forest Report
IUCN	International Union for Conservation of Nature
JF	January February
JJAS	June July August September
LPA	Long Period Average
M&E	Monitoring and Evaluation
MAM	March April May
MNRE	Ministry of New and Renewable Energy
MODIS	Moderate Resolution Imaging Spectroradiometer
MoEF	Ministry of Environment and Forests
MoHUPA	Ministry of Housing and Urban Poverty Alleviation
N_2O	Nitrous Oxide
NAMAS	Nationally Appropriate Mitigation Actions
NAPCC	National Action Plan on Climate Change
NATCOM	National Communication to UNFCC
NDDB	National Dairy Development Board
NHB	National Horticulture Board
NO_X	Oxides of Nitrogen
NRESE	New and Renewable Sources of Energy
NSSO	National Sample Survey Organisation
NWP	National Water Policy
OND	October November December
PAT	Perform achieve and Trade
PbSAP	Punjab statistical Abstract
PEDA	Punjab Energy Development agency
PRECIS	Providing Regional Climates for Impact Studies
PRGF	Partial Risk Guarantee Fund
PSCSTE	Punjab state Council for science and Technology and Environment
PSERC	Punjab State Electricity Regulatory Commission
PSPCL	Punjab State Power Corporation Limited.
PSPCL	Punjab State Power Corporation Limited
QUMP	Quantifying Uncertainties in Model Prediction
RE	Renewable Energy
REC	Renewable Energy Certificates
SAPCC	State Action Plan on Climate Change
SEEP	Super Energy Efficient Products
SO_2	Sulphur dioxide
SPM	Suspended Particulate Matter
STPs	Sewerage Treatment Plants
UNFCCC	United Nations Framework Convention on Climate Change
VCFEE	Venture Capital Fund for Energy Efficiency
WHO	World Health Organisation
WMO	World Meteorological Organisation

Executive Summary

1. BACKGROUND

Scientific studies synthesized by the Intergovernmental Panel on Climate Change (IPCC Assessment Report no. 4, 2007) have unequivocally confirmed that warming of the climate globally is mainly driven by greenhouse gases emitted from anthropogenic activities. Studies indicate that the mean air temperature over the Indian region has increased at the rate of 0.56^{o}C/100 year during the period 1901–2007. Accelerated warming has been observed in the recent period (1971–2007). This warming is mainly due to increase in temperatures in winter and post-monsoon periods (NATCOM2, 2012).

The deleterious impacts of warming were recognized globally in the late 1980s. In 1992, countries joined an international treaty, the United Nations Framework Convention on Climate Change (UNFCCC), to together limit average global temperature increase and the resulting climate change and to cope with whatever impacts are inevitable. It urged the nations to reduce GHG emissions in the atmosphere based on the principle of common but differentiated responsibilities as laid out in the Convention. Further it urged the parties to the UNFCCC to communicate to its secretariat regularly the status of attainment of the actions taken to mitigate the concerns of climate change. UNFCCC presently has 195 parties as its members.

India being concerned about the impacts of climate change signed the UNFCCC as early as in June 1992 and ratified it in November 1993. The Ministry of Environment & Forests (MoEF) is the nodal agency for climate change issues in India. India reported its 1st National communication to UNFCCC secretariat in 2004 and the 2nd National communication was submitted in May 2012.

In 2008 the Government of India released its policy on climate change enshrined in its National Action Plan on Climate Change (NAPCC) having 8 missions - (i) National Solar Mission, (ii) National Mission for Enhanced Energy Efficiency, (iii) National Mission on Sustainable Habitat, (iv) National Water Mission, (v) National Mission for Sustaining the Himalayan Ecosystem, (vi) National Mission for a Green India, (vii) National Mission for Sustainable Agriculture, and (viii) National Mission on Strategic Knowledge for Climate Change. Now the Missions are live, and some of them have launched different programmes and schemes to achieve their objectives.

The National government also has undertaken a voluntary domestic commitment for reducing its emission intensity of GDP by 20-25% by 2020 with respect to 2005, which it hopes to achieve through the missions that are focused on mitigation.

Impacts of climate change manifest locally. Also the point sources of emissions that can be targeted to achieve the domestic goals of reducing emission intensities are spread all across the country in different states. The Indian government through the MoEF has, therefore, directed each state to identify their Climate Change concerns and prepare an Action Plan to combat the local impacts and devise mitigation strategies, taking advantage of the various Missions of the NAPCC. The strategies thus being formulated as a part of the State Action Plan on Climate Change (SAPCC) are as per the state specific circumstances. The SAPCC of every state is required to formulate and prioritize financeable strategies and actions that can be made operational.

2. PUNJAB CONTEXT

Punjab is located in the North Western region of India and is bounded on the West by Pakistan, on the North by the state of Jammu & Kashmir, on the North East by Himachal Pradesh and on the South by Haryana and Rajasthan.

The state is subdivided into three parts namely Malwa, Majha and Doaba. Malwa region covers major part of the state and comprises of cities like Ludhiana, Patiala, Sangrur, Bathinda and Mohali. The main districts of the Majha region include Amritsar, Gurdaspur and Tarn Taran. Doaba is one of the most fertile regions in the state and was the centre of the Green Revolution in India. This region includes the cities such as Jalandhar, Kapurthala, Hoshiarpur, Nawanshahr and Phagwara.

The state is an exquisite land with lush green fields, has monuments and religious sites of historic significance, and enchanting scenic areas of natural beauty particularly in Shivaliks. As of 2011, Punjab has 22 districts and a population of 27.7 million. More than 62% of the population lives in rural areas. Though the share of agriculture in the total GDP of the state is lowest (23.5% in 2010-11), the state remains predominantly agrarian.

Figure E1: Districts of Punjab as of 2008.
Source: Punjab Remote Sensing Centre, PAU

3. CURRENT CHALLENGES

Water and agriculture: Punjab has been the top food producer in the country for a very long time. In order to maximize grain productivity vast areas have been put under intensified rice and wheat cropping system. These have become synonymous with excess use of chemical fertilizers, over extraction of ground water, and burning of crop residue to quickly get the field cleared for the next seasonal crop. However, over a period of time, these practices have caused soil and water degradation leading to saturation in agricultural productivity and hence drop in agricultural incomes. Further indigenous biodiversity of crops that are climate resilient are less and less being grown.

The government is striving to overcome these challenges by putting in place various policies and acts. For example it is successfully implementing the Punjab Preservation of Subsoil Water Act, 2009, that encourages paddy planting in consonance with onset of monsoon thus avoiding extraction of ground water if planted earlier.

Forests: To extend area under forests as per the draft Forest policy is a challenge for the state because of limited land availability. It is trying to reach the target by planting more and more trees outside the forests. As a result the total tree cover in the state has increased by 100 square km between the period 2007 and 2009. However, there are indications of increase in open forest cover, reflecting that the forests are degrading. High levels of disturbance index in the Shivaliks hills have been noted through assessments carried out in 2001 and 2008 indicating fragmentation of forests.

***Ecosystem and Biodiversity*:** Biodiversity of forest species, crops and that of wetlands in the state are threatened largely by pressures of development. Many species of flora and fauna within and outside forests in Punjab are in different threat categories as per IUCN or are lost. Punjab is also facing some kind of natural threat leading to reduction in distribution and spread of its state tree – *Dalbergia sissoo* (Tahli). Besides the pressures of development, the other drivers include invasion of exotic species such as *Lantana* and neglect of native forest species due to extensive plantation of

poplar and *Eucalyptus*, grazing pressures, forest fires and over exploitation of forest resources. Wetland biodiversity are threatened by over diversion of water, pollution, encroachment, invasion of exotic weeds, soil erosion and wetland reclamation and due to silting and sedimentation.

Establishment of Protected Area (PA) Networks, Wildlife Sanctuaries and Community Reserves, Biodiversity Management Committees (BMCs) and Technical Supporting Groups (TSGs), preparation of People Biodiversity Register, Declaration of biodiversity heritage sites, Crop diversification activities, Soil and Water Conservation, and Wetland Conservation are some of the ongoing activities of the state that are towards addressing the mentioned challenges.

Urban Habitats: Urban Habitats are essentially a function of the people living in them and the facilities built to sustain the same through appropriate urban planning. The planning is made in such a way so as not to degrade the environment and to withstand the vagaries of climate. The urban population in Punjab is concentrated in its 4 main cities, namely in Ludhiana, Amritsar, Patiala and Jalandhar, with high rates of rural –urban migration. City amenities though being upgraded continuously, are not adequate vis a vis housing, waste disposal, water supply and sanitation coverage especially in the slums and peri urban areas. Poor water and air quality is prevalent due to industrial activities. Further, the roads and parking spaces are not enough for the ever increasing passenger vehicles .

Energy: The gap in energy supply and demand has been brought down significantly as the Transmission and distribution losses of electricity have gone down from 30.82% during 1999-2000 to 20.12% during 2010-11. However, increasing energy demand and inefficient energy use in industries especially in SMEs and for pumping water in the agriculture sector are some of the causes that continue to create deficit of electricity especially during peak demand periods. The CEA estimates indicate that the deficits in peak electricity demand in Punjab can be as high as 14%.

Energy conservation, improvement in energy efficiency and impetus to renewable energy development are some of the policies being promoted by the government. This addresses energy deficit concerns having a co-benefit of mitigating GHG emissions due to generation of electricity from conventional energy.

4. OBSERVED AND PROJECTED CLIMATE

Data analyzed by the Indian Meteorological Department indicates that the temperatures over Punjab have been rising over the years as it is elsewhere in India and the world, and in 2010 the maximum and minimum temperatures in the Punjab region have increased by 0.5-1.0^{o}C with respect to the base line 1971-2000. There have been spatial variations in precipitations across the years with some years experiencing more than normal rain fall and some years experiencing deficit rainfall.

Using the regional Climate model PRECIS developed by the UK meteorological department, the projections of climate for

Box E1: Tool for assessing Climate change PRECIS- Model and driver scenario

Climate projections for 2021-2050s and 2071-2098 for Punjab have been derived from PRECIS (**P**roviding **R**egional **C**limate for **I**mpact **S**tudies). The simulation dataset is provided by the Indian Institute of Tropical Meteorology, Pune. PRECIS is a portable version of the HadRM3 regional climate change model, developed by the Hadley Centre UK. The model outputs have a spatial resolution of 0.44° x 0.44° (50km x 50km).

The climate change scenarios are driven by the IPCC GHG emission scenarios - A1B (IPCC, SRES, 2001), which assumes a future world of very rapid economic growth, a global population that peaks in mid-century and declines thereafter, and assumes rapid introduction of new and more efficient technologies.

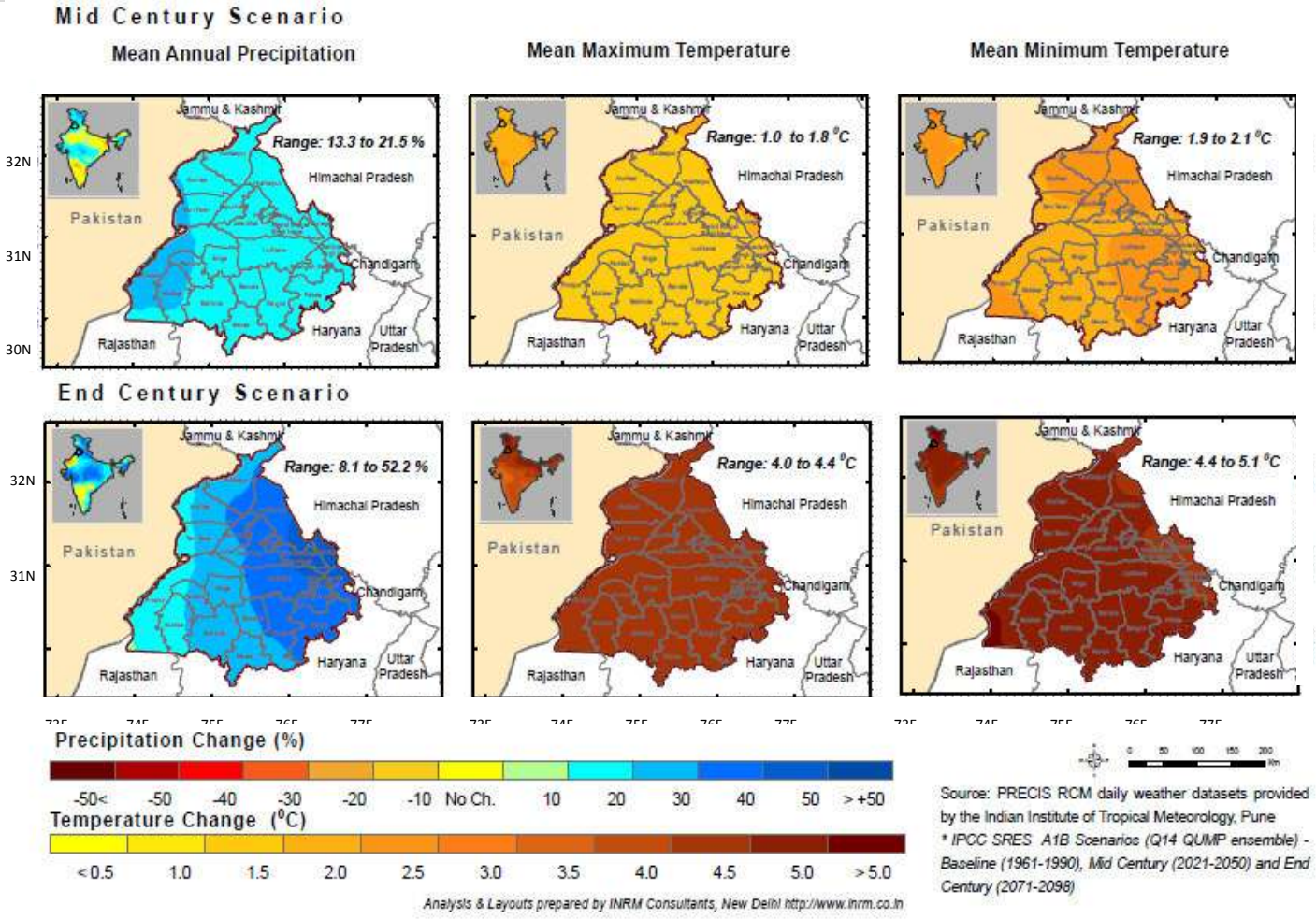

Figure E2: Projected changes by mid-century (2021-2050) and end century (2071-2098) in mean seasonal precipitation (left panel), mean maximum temperature (middle panel), and mean minimum temperature (right panel) with respect to base line (1961-1990).

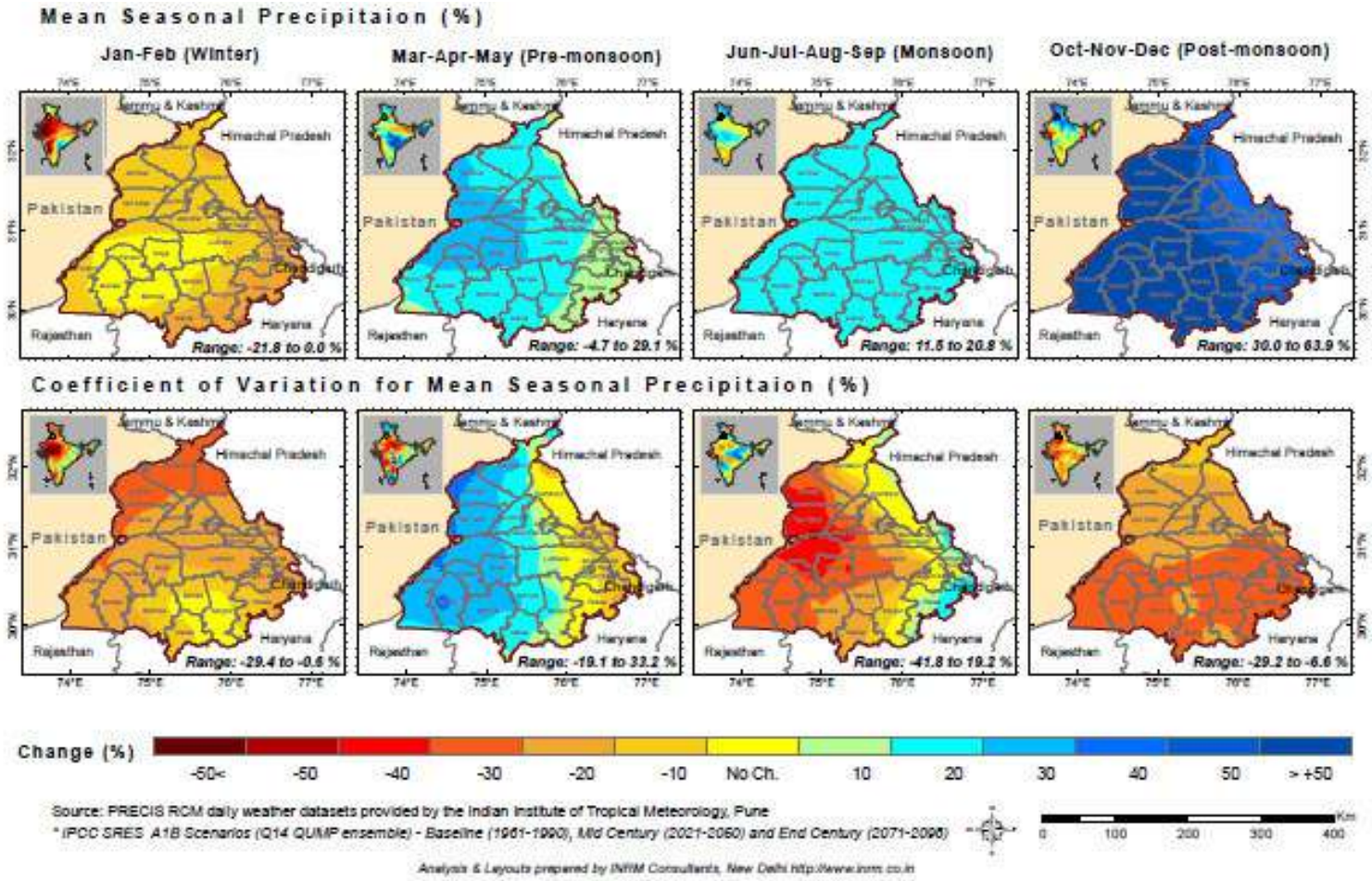

Figure E3: Projected changes in mean seasonal precipitation by mid-century (2021-2050) and end century (2071-2098) with respect to base line (1961-1990)

India have been made, which is run on A1B IPCC GHG scenario (for brief see **Box E1**), The annual mean maximum temperature is projected to increase by 1.0-1.8oC with respect to the base line in all parts of Punjab by 2021-2050 (**Figure E2**, middle panel). By the end of the century, however, the mean maximum temperature may increase further by 4.0 to 4.4oC. The annual mean minimum temperature is also projected to rise by 1.9-2.1oC by mid-century (see **Figure E2**, right panel), with respect to base line (1961-1990), and it is likely to increase further by 4.4 to 5.1oC at the end of the century.

An overall increase in annual precipitation is projected in the mid (2021-2050) century by about 13.3%-21.5% with respect to base line 1961-1990. On a seasonal basis (**Figure E3**), in the mid-century (2021-2050), the precipitation is likely to increase by 11.5-20.8% during the monsoon period (June-July-August-September) in the entire state with respect to the base line. The increase is likely to be higher in the post- monsoon period (October-November-December) ranging between 30.0-63.9%, with precipitation increasing from east to west. In the winter period (January-February), the precipitation shows a decrease in most areas of the state by upto 21.8%with respect to base line. In the pre-monsoon period (March-April-May), all parts of Punjab are likely to experience a mixed trend, with change ranging between -4.7 to 29.1% with respect to base line.

5. APPROACH TOWARDS PREPARATION OF SAPCC

The Punjab State Council for Science and Technology – PSCST is the focal point for climate change issues in the Punjab Government and for preparation of the Punjab State Action Plan on Climate Change. A Steering Committee has been constituted for this purpose with Chief Secretary, Government of Punjab as its chairman. Members in the Steering Committee are drawn from relevant line departments, universities and scientific institutions. Steps for preparation of SAPCC are schematically enumerated in **Figure E4**.

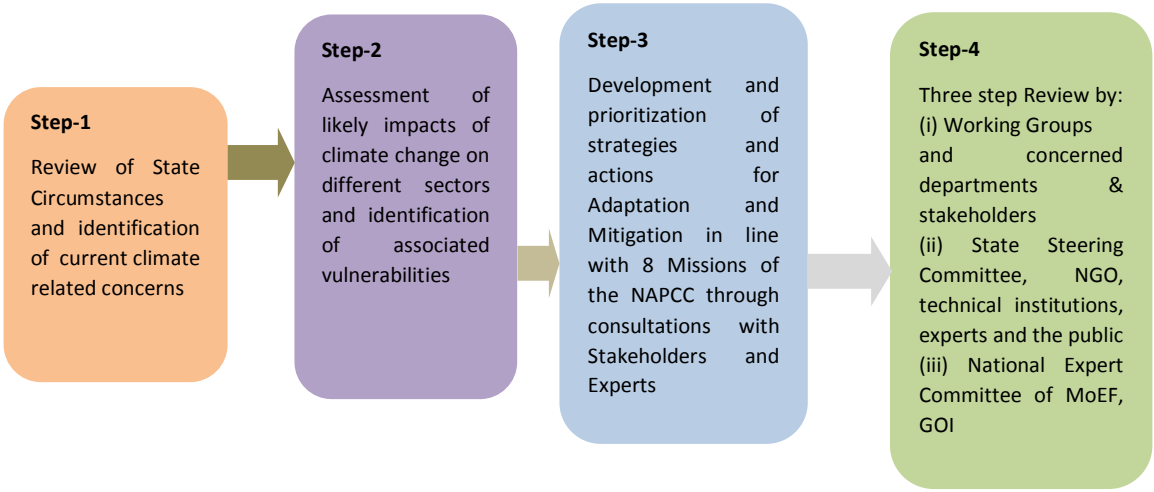

Figure E4: Steps towards drafting the Punjab SAPCC

Punjab has drafted the strategies for addressing the concerns of climate change through **Mission Based Approach** which is in line with the eight Missions of the National Action Plan on Climate Change. The summary of the state Mission objectives vis a vis the eight national missions is shown in **Table E1 below.**

Table E1: State Objectives and Targets vis a vis the Eight National Missions

Missions	National Objective	State Objectives and Targets
Water Mission	Water conservation and river basin management	The state aims to undertake an integrated approach for conservation and management of its water resources, improve water use efficiency, control water pollution, minimize wastage and ensure equitable distribution of water across the state by addressing the impacts of climate change on water resources.
Sustainable Agriculture Mission	Develop agriculture plans at agro-climatic zone level, Link research with practice to maximize productivity, Encourage innovation, Promote dry land agriculture, Risk Management through insurance, enhance livelihood opportunities, seek convergence with other missions	Usher in 2nd green revolution through sustainable management of agricultural practice, and hence ensure food security in a changing climate scenario. Approach to include crop diversification, efficient resource utilization, appropriate use of technologies and inputs from new research. Promote power generation from agricultural residue.
Green India Mission	20 million ha area to be afforested/ eco-restored by 2020.	Increase green cover in the state to 15% of the area of the state by 2022, enhance plantation in degraded forests and increase the incomes generated from ecosystem services provided by the forests.
Sustainable Himalayan Mission	Conservation, adaptation, glacier monitoring	Conserve flora, fauna, wetlands, along with agriculture and forest biodiversity to sustain the Shivalik Ecosystem.
Sustainable Habitats Mission	Efficient buildings, transport system and Solid Waste Management	The state aims to develop policies and strategies that enable the habitats to adapt to climate change concerns. Identify and implement strategies in urban areas to reduce enhanced heat island effect and sustainably manage municipal solid waste and transport.
Solar Mission	20,000 MW by 2022	Increase the solar energy mix by at least 2000 MW by 2022.
Mission on Enhanced Energy Efficiency	10,000 MW savings by 2012	To achieve 3-7% energy efficiency improvement in large energy consumers designated by BEE and 15-20% in SME sector.
Mission on Strategic Knowledge	Vulnerability assessment, Research and Data management, knowledge sharing	The Punjab Mission on Strategic Knowledge aims to build a greater understanding of the climate change processes, its implications on various sectors, and vulnerabilities associated with the same to enable it to sustainably adapt to climate change and mitigate drivers of climate change.

6. KEY CLIMATE CHANGE CHALLENGES AND STRATEGIES

Punjab Water Mission

The Sutlej basin in Punjab encompasses more than 60% area of the state (see Figure E5). The climate change projections for this river basin indicate a rise in temperature of the order of 1.7 to 2.0^{O}C by 2021 to 2050s with respect to the baseline 1961 to 1990. Though the temperature is likely to increase, however, a nominal change in evapo-transpiration is anticipated. As regards precipitation, an overall increase in rainfall of about 32% with respect to base line is projected for the mid century. The rainfall may vary between 960 mm in sub-mountain region and 460 mm in the plains. The western parts of the basin, may receive up to 50% more precipitation by the end of the century. This also means that the water logging conditions in the south western region of the state may intensify. Projections indicate increase in heavy precipitation events of the order of 100mm/day and 150mm/day level for the entire basin. Smaller increases are projected to occur in the central region of the basin, and some regions could see the numbers of such days double from about 3 per year to 6 per year. Mountainous regions are less affected.

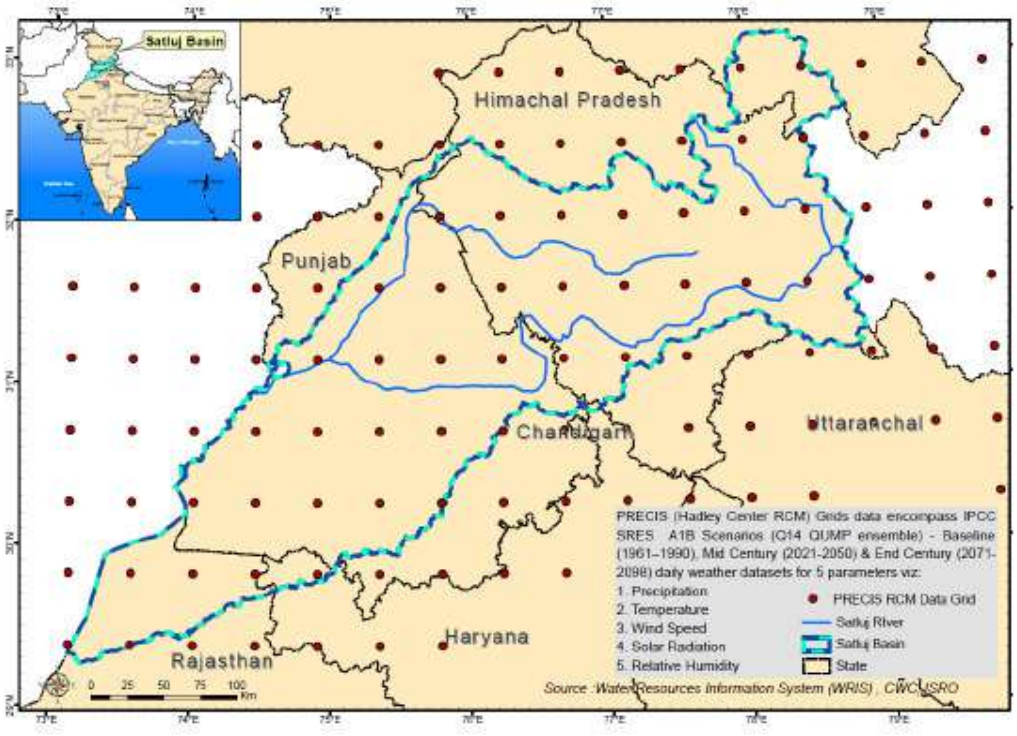

Figure E5: The boundary of the Sutlej basin (dashed line) and the PRECIS Grid points at 1^{o}x1^{o}resolution (*Source: ADB, 2011)*

With increase in heavy precipitation events, likelihood of increase in flash floods can be anticipated. An increase in annual average surface runoff of the order of 1.6 times more than the annual precipitation is projected with largest increase likely to occur during the southwest monsoon period (June, July, August and September -JJAS). Higher runoffs can be attributed to more precipitation falling on saturated soils.

Increase in glacier melt and precipitation in the form of snow is expected upto mid-century thereby increasing the availability of river water. However, after 2050s glacier melt as well as snow precipitation is likely to reduce, thereby affecting river flow/ inflow into Bhakra. In the Sutlej basin increased air temperature result in shifting of snowmelt to earlier in the snowmelt season leading to more significant decrease of snowmelt runoff in June & July. In the Beas basin studies during 1976 to 2011 indicate that there is increasing trend in maximum and minimum temperatures with corresponding decreasing trend in snowfall.

An analysis of drought durations with a 10 mm precipitation threshold in the Kharif (JJAS) and Rabi (October, November, December, January and Fenruary - ONDJF) indicates that the mean annual drought durations may vary from 23 days in the north east of the state to 46 days in the southwest in the period 2021-2050s, where potential evapo-transpiration is also highest. The range in drought durations during the Rabi season is less significant, and clearly periods of over 3 months with virtually no precipitation in the Rabi season are common throughout the lower basin.

Given this background, the Punjab Water Mission envisages to undertake an integrated approach for conservation and management of its water resources, improve water use efficiency, control water pollution, minimize wastage and ensure equitable distribution of water across the state by integrating strategies to combat climate change. The Strategies are summarized in **Box E2**.

Box E2: The Punjab Water Mission

1. Draft a State Water Policy to undertake an integrated water resource management at a basin level within the state for conserving water, minimizing wastage and for ensuring equitable distribution of the resource.
2. Undertake a focused approach to augment ground water especially in problematic/over exploited areas taking advantage of continued projection of excess rainfall with respect to base line scenario.
3. Enhance water use efficiency by at least 20% with respect to the present.
4. Augment surface water resources to accommodate excess rainfall and runoff projected for mid-century.
5. Manage floods in a future erratic and excess extreme rain fall scenario.
6. Contain likely enhanced water logging situation in the south west districts of Punjab due to the projected rain fall exceeding 50% of the base line scenario in this region.
7. Abate continued pollution of underground and surface water sources which is likely to increase due to increase in industries and population.
8. Establish adequate institutional support for efficient water resource augmentation, conservation, distribution and governance through development of basin level Integrated Water Management plans.
9. Suggested Research and monitoring activities for effective decision making.

Punjab Mission on Sustainable Agriculture

Studies carried out in Punjab, indicate that the productivity of rice is likely to decline by -0.16% to -9.6% as the temperature rises from +0.5^{0}C to +2.0^{0}C in the future. For similar rise in temperature the wheat yields are likely to decline further by -4.6% to -32% with respect to current normal yields. Already wheat yields in some areas are on the decline with increase in winter time temperatures. Cotton also shows a decline in yields with increase in temperature. With simultaneous increase in concentration of CO_2, the yields of these crops show a slight increase in yields with increase in temperature upto 2^{0}C, but beyond 2^{0}C, their yields decrease. However, the C4 plants such as Maize show a gain in yields, even upto 3^{0}C and its yields decline only beyond 3^{0}C. Horticulture crops in general show a decline in yields with rise in temperature. However, studies carried out in the Punjab region indicate a likely increase in potato yields by 7.2% by 2030s (2021-250) if temperature increases upto 1^{0}C and CO_2 concentration is maintained at 440 ppm.

In the case of livestock, temperature increase beyond the tolerance levels of the animals affects them negatively. Milk yields and reproductive capacity of cross bred cows and buffalos are likely to be affected negatively more than the indigenous varieties which can tolerate higher temperatures. Studies show that when Holstien and Sahiwal cows are exposed to 40-45^{0}C temperature for above 4 hours, Holstien released more HPS72 protein than Sahiwal, indicating greater susceptibility of Hosltein than Sahiwal at these temperatures. Similarly, poultry fertility and hatchability capacities decrease at temperatures nearing 40^{0}C and they die if exposed to temperatures nearing 45^{0}C.

Similarly, Increase in temperature may cause thermal stress in aquatic animals, leading to reduced growth, sub- optimal behaviors and reduced immune competence resulting in changes in the distribution and abundance of their hosts. However, spawning of some of the species may get shifted to cooler seasons or some of them may migrate to higher altitudes enabling Punjab to produce some species which could be grown only in lower latitudes.

Factoring in the impacts of climate change, Punjab intends to usher in a 2nd green revolution through sustainable management of agricultural practices, and hence ensure food security in a changing climate scenario (See Box E3, E4 and E5).

Box E3: Punjab Mission on Sustainable Agriculture - Agriculture and Horticulture Crops

1. Promote crop diversification in the state as per the suitability of production in its different agroclimatic zones and take advantage of efficiency of C3 vs C4 crops in the enhanced CO_2 environment
2. Sustainably manage agriculture crop residue to avoid the ill effects of on farm burning of crop residue in Punjab and also benefit from management of the same.
3. Promote resource conservation of soil, water and energy.
4. Formulate Agriculture Market Intelligence Cell within the Department of Agriculture in order to adjust the production systems each year which have to be aligned according to the variable climate as well as to the demands of the markets after meeting the basic demand of food security of the state.
5. Develop cultivars and enhance germplasm base that are (a) thermal resistant, (b) can withstand water stress, (c) Can grow in water logged areas, (d) withstand emerging pests and diseases and (e) withstand enhanced levels of CO2.
6. Manage new and emerging pests, diseases and weeds in crops.
7. Diversify into value addition activities to avoid waste of agriculture produce and increase storage capacity of grains to ensure farmer incomes in a changing climate scenario.
8. Promote cooperative farming amongst marginal, small and medium farm land owners to reduce input costs, and maximize productivity and farm incomes and hence ensure livelihood security and income for farmers.
9. Manage Climate Risk through insurance and by assessing the socio economic impacts of Climate change on Agriculture

Box E4: Punjab mission on Sustainable Agriculture – Livestock

1. Manage heat stress and ensure sustainable productivity of livestock in a climate change scenario.
2. Recover energy from livestock waste
3. Manage livestock health in the emerging pest and disease scenario.
4. Ensure adequate feed for livestock – green fodder.
5. Ensure cover for Climate Risk to livestock.

Box E5: Punjab Mission on Sustainable Agriculture - Fisheries

1. Ensure sustainable production of Fish in the state to withstand the impacts of climate change and ensure livelihood security of people dependent on this sector
2. Renovation/rehabilitation of village ponds and development of new ponds/tanks in saline affected waterlogged land in the south-western district sof Punjab.
3. Develop Saline affected waterlogged area in the south-west districts of Punjab to make fisheries to grow there and become a major livelihood activity for the farmers.
4. Assess impacts of climate change on fisheries in Punjab.
5. Determine the hydrological and physico-chemical characteristics of water bodies and correlate them with fish productivity.
6. Supply of quality fish seed for table fish production.
7. Develop information and knowledge base *vis a vis* measures for water conservation, water use efficiency and disseminate the same amongst farmers.

Green Punjab Mission

A study carried out using IBIS dynamic vegetation model with inputs of climate scenario from PRECIS run on A1B IPCC socio economic scenario, indicates that of the 41 grids of size 2.5'x2.5' that extend over the forest cover in Punjab, only 2 are likely to face changes in vegetation type by 2050s and the Net Primary Productivity(NPP) of the forest vegetation is set to increase by 0.6 to 1.2 kgC/m^2/year in

2021-2050. Further, the hilly tracts of the state in the Shivalik region are likely to experience heavy soil erosion with projected increase in heavy precipitation intensities.

Currently the green cover (trees inside and outside forests) in Punjab extends over 3463 sq km or 6.87% of the total geographical area of the state. Of this, 1028 sq km is open forests, 37 sq km is scrub forests and about 736 sqkms constitute medium dense forests. The area of tree cover outside forests is 1699 sqkms. It is estimated by the Forest Department that about 500 sq km forest area in the state is in degraded condition.

Keeping in view the current situation and the climate change projections, the Punjab Green Mission intends to increase green cover to 15% of the area of the state by 2022, enhance vegetation and tree cover in degraded forests and increase the incomes generated from ecosystem services provided by the forests (see Box E6).

Box E6: Green Punjab Mission

1. Add at least 8.13% more area under forest and tree cover by 2022 to the existing area bringing the total area under forest and tree cover in the state to 15% of its total geographical area leading to additional CO_2 sequestration over and above the current base line.
2. Enhance forest density in the Shivaliks. The aim is to improve green cover in the degraded forest area in this region by the end of 2020 and stabilise Shiwalik tracts to prevent soil degradation, avoid unsustainable agriculture and empower communities enabling them to undertake diversified income generation activities.
3. Undertake capacity building activities to integrate scientific principles of forest management in working plans and management plans.
4. Strengthen biodiversity conservation measures in the forests.

Punjab Mission on Sustaining Himalayan Ecosystems

As per the 4th Assessment Report of the IPCC published in 2007, over the past three decades, the lines marking regions in which average temperatures prevail (isotherms) have been moving pole-ward at a rate of about 56 km per decade. Consequently, changes in flowering seasons, migratory patterns and the distribution of flora and fauna have been detected. Some of the floral and faunal species in Punjab are also seen to be under various threat conditions, but long term observations are not available to draw the linkage with climate change. However, broadly speaking if the pace of climate change is too rapid, or when natural barriers block migration routes, extinction threat looms. According to the IPCC, 20-30% of plant and animal species are likely to be at increased risk of extinction if global average temperature increases exceed 1.5-2.5°C (medium confidence). At temperature increases in excess of 2°C, rates of extinction will start to increase. Environmental degradation will gather pace, with wetland and forest systems suffering rapid losses.

In view of the likely impacts of climate change, the Punjab government envisages to conserve flora, fauna and wetlands, in the Shivalik region of the state along with its agriculture biodiversity and forest diversity to sustain the ecosystem. See Boxes E7, S8, E9, and E10.

Box E7 : Punjab mission on Sustaining Himalayan Ecosystems – Understand the response of Himalayan glaciers to climate change and Protect, Preserve & Conserve Biodiversity of Shivalik Forests

1. Undertake micro level assessment, analyse remote sensing data, undertake perspective planning and address livelihood issues.
2. Conserve existing forest resources and plantations through natural and artificial regeneration in degraded areas and also conserve soil and moisture in these areas
3. Analyse satellite maps at regular intervals to keep a check on the progress of the mission. Undertake insitu studies to check status of biodiversity of forest vegetation type, crops, wetlands, forest cover-density, soil Carbon, etc.
4. Continue maintenance of biodiversity registers by the communities.

Box E8: Punjab mission on Sustaining Himalayan Ecosystems- Wetlands

1. Conserve natural wetlands to enhance the capacity of wetlands to withstand the impacts of climate change by involving the communities. It is proposed to set up an Interpretation Centre on wetlands.
2. Continue conservation of manmade wetlands that include Ramsar sites and also nationally important wetlands by involving the communities.

Box E-9: Punjab mission on Sustaining Himalayan Ecosystems- Crop Biodiversity

1. Promote crop diversification in Shivaliks by promoting indigenous crops having significant commercial value.
2. Support soil and water conservation activities in these areas.

Punjab Mission on Sustainable Habitats

The heat island effect in urban areas is likely to be enhanced with increase in ambient temperature and the demand for energy for space cooling will be on the rise. With extreme precipitation events (>150mm) becoming frequent, and number of days of rainfall<100-150 mm decreasing, urban areas lying within flood plains of Punjab are likely to face flash floods due to more built up area and less area that can percolate water into the soils, unless drainage systems are streamlined and are retrofitted or designed to accommodate the excess runoff. Increasing ambient temperatures also have implications on capacity of water to absorb pollutants, which increases even if pollutant discharge into river water or drains is as per the regulated limits. High incidences of heat stress, respiratory diseases, water borne diseases and enhanced incidences of vector borne diseases, are expected as the windows of transmission of the vectors is likely to extend with rise in ambient temperatures in the future.

Keeping in view the current concerns and the impacts of climate change that are likely to manifest themselves in habitats, the state aims to develop policies and strategies that enable the habitats to adapt to climate change. Climate proofing through building envelops, rainwater harvesting, increasing recharge capacities of soils, enhancing monitoring of disease prevalence, promoting energy efficiency, conservation of energy and harnessing energy from waste will be some of the key tools towards developing sustainable habitats. Boxes E10 – 15 enumerate the outline of strategies for the same.

Box E-10: Mission on Sustainable Habitats- Avert heat island effect and promote self-sustainability in cities

1. Develop policy and implement mandatory pursuance of ECBC norms for climate proofing building envelops of both old and new commercial, public and residential buildings in cities.
2. All housing programmes/schemes of the government for the EWS's to make provision for compulsory inclusion of building designs with ECBC/GRIHA norms to protect this section from extreme heat and also to introduce energy efficiency in their houses.
3. Undertake capacity building/training activities for architects, builders, residence owners and other stakeholders including suppliers of material for making them aware about material to use for reducing energy absorption capacities of envelop of buildings.
4. Develop incentives for retrofitting building envelopes – subsidy in building material such as glasses, roof covering material, wall coatings.
5. Promote higher share of renewables in total energy consumed (e.g. solar, recycle waste, wind) in cities in its residential, commercial areas and public utilities.

Box E-11: Mission on Sustainable Habitats- Protecting habitats from extreme rainfall and ensuing floods

1. Undertake a study to analyse the likelihood of recurrence of extreme events and their intensities
2. Reduce surface run off in urban areas by increasing infiltration.
3. Assess and address deficit in drainage system.
4. Increase drainage capacities of existing storm water drainage systems in towns in the flood plains.
5. Ensure mechanisms to separate sewer and storm water drainage.

Box E12: Mission on Sustainable Habitats- Contain pollution in river water and air pollution in urban areas in a warming scenario

1. Devise policy to ensure enough water flows at various check points to reduce the enhanced pollutant loadings with warming of river water in the river systems.
2. Revise, if necessary, the standard levels of pollutants that can be released from the industrial and domestic waste water discharges in order to make rivers less polluted in a climate change scenario.
3. Ensure cleaner air in a climate change scenario by assessing the saturation concentrations of air pollutants at higher temperatures, develop revised standards for air pollutant in order for it to be safe for breathing, strengthen air quality monitoring protocol, assess the requirement and Deploy APCDs.

Box E 13: Mission on Sustainable Habitats - Ensure human health security vis a vis impacts of climate change

1. Punjab IDSP to cover all medical health units including rural health centres, government and private hospitals and private clinics in all urban centres.
2. Create a State programme on heat and cold stress management in line with the other national programmes such as the National vector borne disease programme, Revised National TB programme, etc.
3. Develop capacities to generate short, medium and long term climate forecasts and different diseases occurrence probabilities keeping in view the topography and land use.

Box E14: Mission on Sustainable Habitats – Developing sustainable Transport systems

1. Policy shift to integrated public transport system as per the National Transport Policy, 2006
   - Extend Metro to 4 cities (Amritsar, Jalandhar, Ludhiana and Mohali) and provide Integrated feeder bus services to and from the proposed metro stations
   - Enhance density of public bus transport system
   - Create additional parking spaces based on projected passenger vehicle density by 2030s
   - Decongest roads by building separate tracks for non motorised transport.
2. Reduce congestion, improve operational efficiency, reduce noise and air pollution by Introducing intelligent traffic management systems
   - Develop real time passenger information systems
   - Install dynamic traffic lights that can operate on the basis of level of congestion on the roads at different times of the day and hence can divert traffic in advance and can adjust times for stopping traffic at signals according to the traffic flow.
3. Promote low C Transport system
   - Develop a fast moving freight corridor between the industrial towns of Punjab (Amritsar, Ludhiana and Jalandhar) to connect to the dedicated rail freight corridor being constructed linking Ludhiana to Kolkata in the east and Mumbai in the west.
   - Introduce battery operated/SPV operated/ alternate fuel operated small bus services to travel small distances
   - Raise awareness about better driving practices and maintenance of trucks to enhance fuel efficiency
   - Promote car free days in different zones
   - Declare markets and heritage areas as no fossil fuel driven vehicle zones.
4. Enhance fuel efficiency and reduce emissions from transport sector
   - Replace 700 old buses of Punjab Roadways with engines that can accept fuel with latest EURO—IV norms
   - Conduct training on Bus Simulator and other infrastructure in all workshops
   - Raise awareness of better driving practices and maintenance of buses to enhance fuel efficiency.

Box E15: Mission on Sustainable Habitats – Avail energy from municipal solid waste

1. Realize 20% of 100 MW energy generation potential from waste in Punjab by 2022.
2. About 10 solid wastes to energy plants of 2 MW each can be installed in Punjab depending on the degradable organic content available in each of the disposal sites.

Renewable Energy Development and Solar Mission

The state is endowed with vast potential of solar energy estimated at 4-7 KWH/sqm of solar insulation levels. Already about 9.325 MW of solar power has been completed/commissioned in the state. Further exploiting this resource in the state will enable the state to be less and less dependent on conventional fossil fuel driven energy sources. The state, therefore, based on the assessments carried out so far, aims to increase the solar energy in its total energy mix 2022 (See Box E16).

Box E16 Punjab Solar Mission (upto 2017)

1. Increase the share of solar Power in the grid electricity - Target: At least 4 % of GOI target of 20000 MW i.e. 800 MW.
2. Use unproductive land in the state to generate 300 MW of electricity using SPV in line with the Charnaka model of Gujarat.
3. Use of International Border (553 KM) to generate 9 MW of solar power using Solar Photo Voltaics.
4. Promote Roof Top Solar PV Power to generate 200 MW of power.
5. Develop solar cities.
6. Increase coverage of solar street lightening in rural areas putting 3000 solar lighting systems each year.
7. Provide incentive for solar thermal water heating system in Urban/Rural residences.

Enhanced Energy Efficiency Mission

As per the sale statistics of electricity in Punjab, the total consumption of electricity by different sectors in 2010-11 was 32231.72 million KWH. The top 3 consumers of electricity were the industrial sector, agriculture sector and domestic sector that consumed 34.22% (or 11030.57 Million KWH), 31.38% (or 10116.89 Million KWH) and 24.56% (or 7915.24 Million KWH) of the total sales of electricity in the state respectively. In these three sectors lies a large scope of reducing electricity consumption through enhancement in energy efficiency. To improve energy efficiency in the state the detailed strategies and quantitative energy efficiency targets by different energy consumers are provided in Box E17.

Box E17: Punjab Mission on enhanced energy efficiency

1. Achieve 15-20% energy efficiency in small and medium enterprises (SMEs).
2. Achieve energy efficiency of the order of 15-35% in buildings (Commercial & Institutional buildings such as hotels, malls and government buildings) based on ECBC/GRIHA norms.
3. Achieve energy efficiency in street lighting by replacing conventional street lights with LEDs.
4. Promote energy efficiency in consumer appliances.
5. Achieve 3-7% improvement in energy efficiency in large energy consumers not designated by BEE under PAT scheme such as food processing, Chemicals and Ceramics.
6. Create demand for energy efficient appliances, technologies and programs by educating the public and private sector on their options.
7. Conduct education and training of key stake holders on implementation of energy conservation measures, e-filing on annual reporting energy data and e-learning in consonance with BEE's mission on the Energy Conservation Act, 2001 and for monitoring and evaluation.

Mission on Strategic Knowledge Management

The Punjab Mission on Strategic Knowledge aims to build a greater understanding of the climate change processes, its implications on various sectors, and vulnerabilities associated with the same to enable sustainable adaptation to climate change and mitigation of drivers of climate change (greenhouse gases emitted from anthropogenic sources). Punjab being an agriculture intensive state, the focus will be mainly on agriculture and water issues. However, other related climate change issues will also be addressed to facilitate the development of a climate proofed society. The strategies for this mission are shown in Box E18.

Box E18: Punjab Mission on Strategic Knowledge

1. Develop a Centre of Excellence in an existing R&D body to address all research and technology development and demonstration issues related to climate change. And establish a climate change cell within the government that will coordinate and provide policy guidance on climate change in the state.
2. Develop a deeper understanding of climate change issues by running new climate projections that are based on plausible developmental scenarios of Punjab in the future and carry out impact and vulnerability analysis in priority sectors.
3. Undertake Research and Development of new and innovative Climate Friendly Technologies.
4. Undertake technology demonstration, field implementation & extension.
5. Address IPR issues.
6. Manage, interpret and disseminate data and information.

7. INSTITUTIONAL ARRANGEMENT FOR IMPLEMENTATION OF PUNJAB SAPCC

The PbSAPCC Steering Committee headed by the chief secretary will oversee the implementation of the SAPCC activities. Eight Working Groups with experts drawn from various line departments, universities, technical institutions and industry associations will provide technical guidance to the SAPCC activities. Further, a nodal agency/department has been identified for coordinating the action programmes for the respective Missions and a number of institutions/agencies have been assigned responsibilities for undertaking activities designed to attain the objectives of the strategies of each Mission (See **Figure E6**). For example, for Water Mission, Department of Irrigation is the nodal agency which will coordinate all activities related to the said mission in partnership with about 13 institutions which will implement various activities under each strategy that address climate change concerns in the state related to water as a resource and its utilization.

The budget for each of the missions and the total budget for implementing the Punjab state action Plan on Climate Change is summarized below:

Mission	**12th Plan**	**13th Plan**
	Rs in Crores	**Rs in Crores**
Water Mission	10,865.74	13,978.35
Sustainable Agriculture Mission	8,979.07	10,729.93
Green Punjab Mission	2,810.50	3,101.60
Sustaining Himalayan Ecosystem and Biodiversity	169.50	168.00
Sustainable Habitat Mission	32,547.32	33,255.47
Solar Mission	1,465.00	1,565.00
Enhanced Energy Efficiency Mission	1,877.25	1,867.50
Knowledge Mission	82.00	65.00
GRAND TOTAL	**58796.38**	**64730.85**

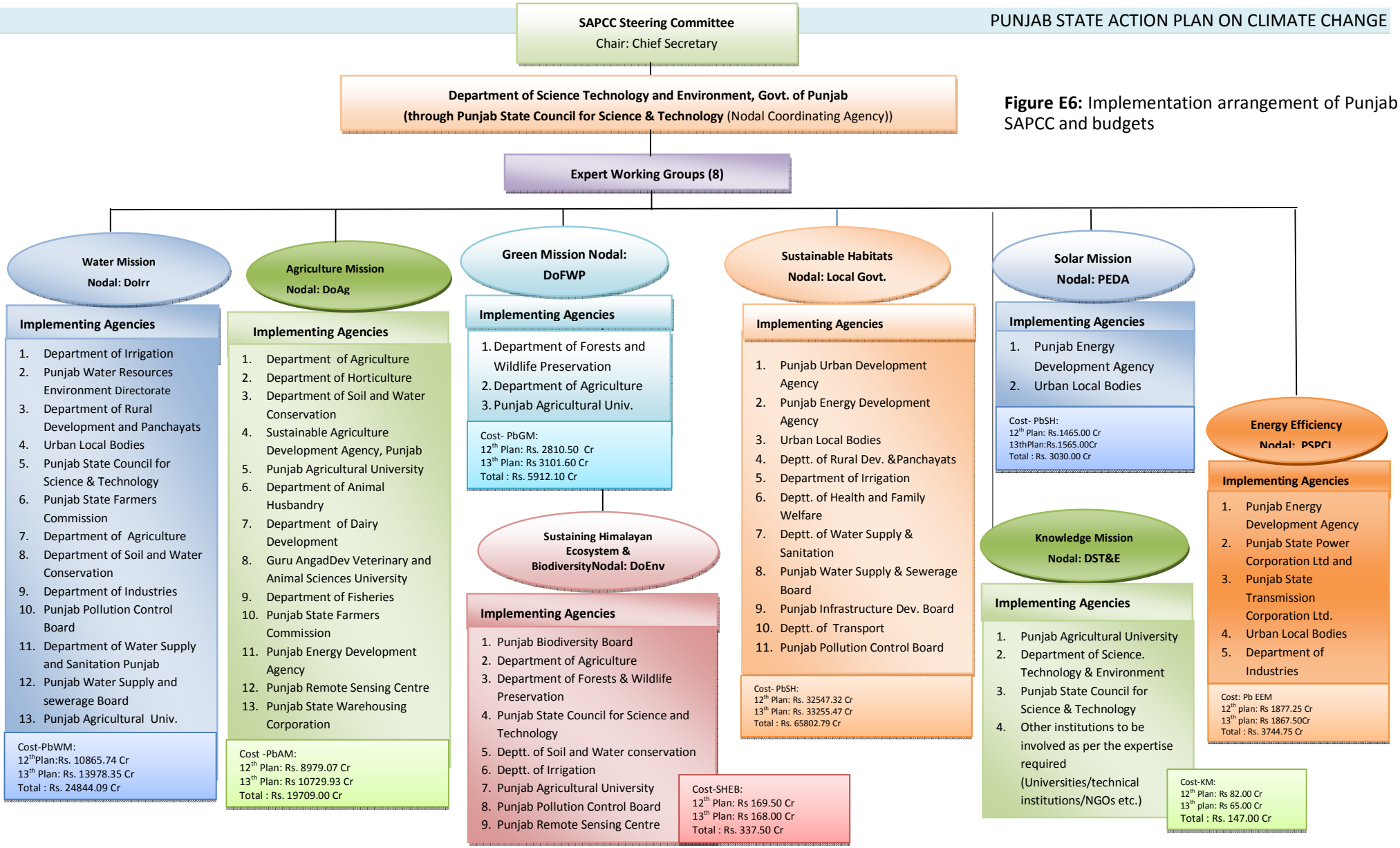

Figure E6: Implementation arrangement of Punjab SAPCC and budgets

8. MONITORING AND EVALUATION FRAMEWORK

To ensure fulfillment of climate change adaptation objectives, a conceptual Monitoring and Evaluation (M&E) framework has been designed along with its implementation arrangement (See **Figure E7**). The M&E process will again be *overseen by the Steering Committee of the SAPCC*, and will be guided by a *Technical Committee* which will review the technical aspect of the projects for implementing different activities. *Inter-sectoral departmental committees/Working Groups* for each of the 8 missions will be set up by nodal agency of the respective missions (as identified in Figure E6- Implementation arrangement of PbSAPCC). The working of the inter-sectoral Departmental Committee's will monitor the progress of achievement against targets and report the same to the Technical Committee.

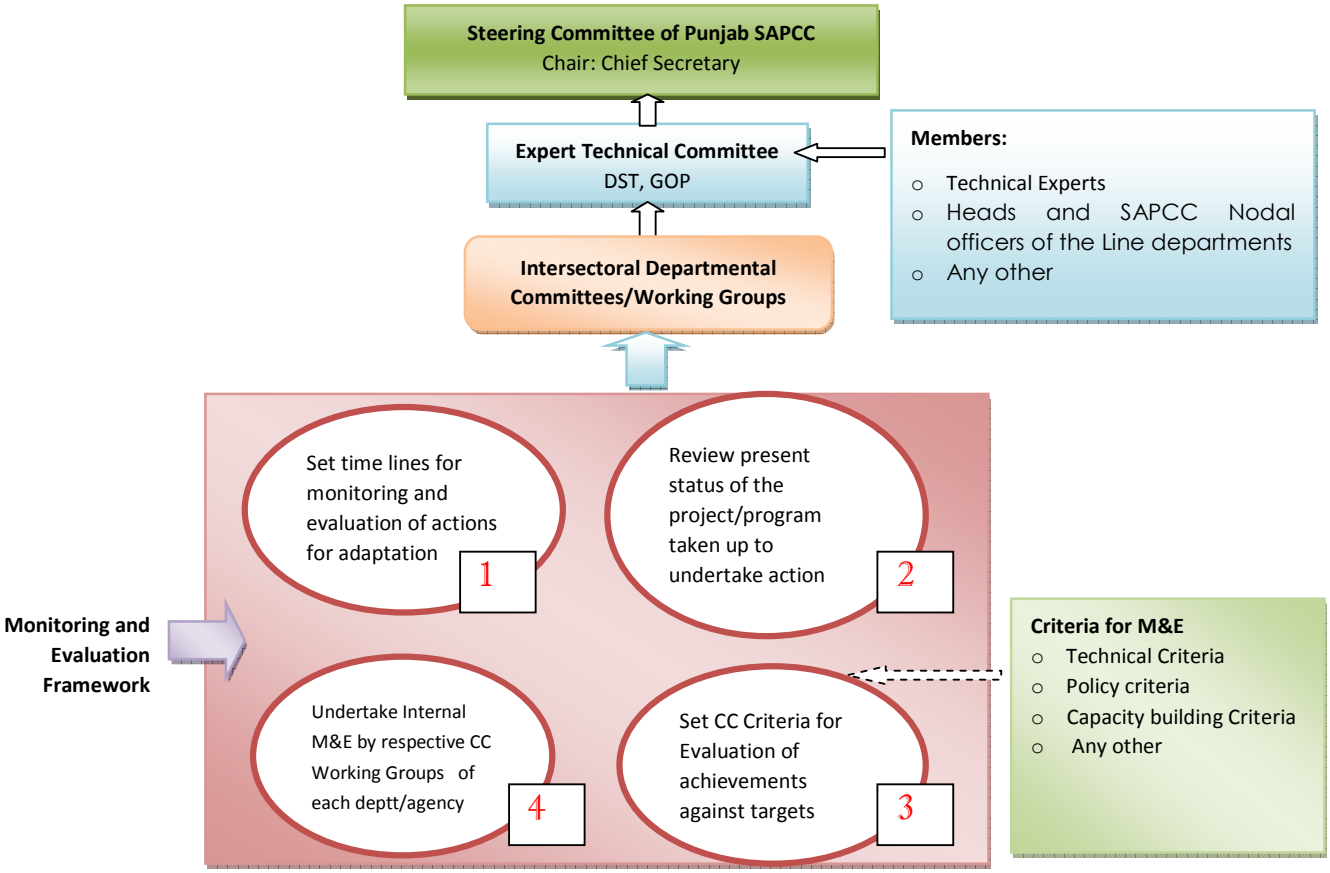

Figure E7: Monitoring and Evaluation Framework and Implementation Arrangement

9. ROAD AHEAD

Addressing climate change concerns is now a matter of immediacy for all governments as it is affecting their developmental goals as well. Considering the magnitude of the escalating impacts, the government needs to forthwith (i) build capacity to enhance scientific knowledge for informed decision/policy making on climate change, (ii) establish administrative capacity to successfully coordinate the climate change agenda of the state through an integrated approach as any solution would involve multiple sectors, (iii) establish technical capacity to implement projects to ensure adaptation to climate change, (iv) formulate project design documents for priority activities, estimating concrete budgets, establishing implementation arrangements and (v) seek technical collaboration to access state of the art technology for successful implementation of activities envisaged in the SAPCC.

The SAPCC is the first document of its type, whereby the climate change concerns of the state have been identified and strategies developed for adaptation. However, as science progresses and knowledge expands, the strategies identified in this document will certainly need to evolve. Therefore, it is essential that this document undergoes review periodically to accommodate the cost effective traditional as well as new and emerging science and technological interventions for adaptation and mitigation in the future.

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1. Introduction

CONTENT

1.1 BACKGROUND

Scientific studies synthesized by the Intergovernmental Panel on Climate Change (IPCC) have unequivocally confirmed that climate change is mainly driven by greenhouse gases emitted from anthropogenic activities. Widespread increase in average air and ocean temperatures, causing changes in rain fall and rise in global mean sea level have been observed. The combined changes have impacted water resources, agriculture, forest vegetation, human health, etc. Continuous warming may jeopardize sustainable development and food security of the population on earth.

Earth has resuscitation capacities to a certain extent but its rejuvenation from the damage caused due to continuing adverse anthropogenic activities needs human intervention through implementation of long and short-term programs. Curative and rehabilitative measures are required to be specifically designed and implemented to check any further damage to our environment on one hand and to improve overall ecological sustainability on the other.

1.2 THE INTERNATIONAL PROCESS

United Nations Frameworks Convention on Climate Change

In 1992, countries joined an international treaty, the United Nations Framework Convention on Climate Change (UNFCCC), to together consider what they could do to limit average global temperature increase and the resulting climate change, and to cope with whatever impacts were, by then, inevitable. It urged the nations to reduce GHG emissions in the atmosphere based on the principle of **common but differentiated responsibilities**. There are now 195 Parties to the Convention.

Kyoto Protocol

By 1995, countries realized that emission reductions provisions in the Convention were inadequate. They launched negotiations to strengthen the global response to climate change, and, two years later, adopted the Kyoto Protocol. The Kyoto Protocol which came into effect in 1997, legally binds developed countries, which have been industrialized since the last 150-60 years, to emission reduction targets. The Protocol's first commitment period was from 2008 to 2012. Further negotiations are on for extending this period.

Bali Road Map

The scientific evidence brought forth in the 4th Assessment Report (FAR) of the IPCC, in 1997, confirmed that deep cuts in global emissions will be required over and above the emission reduction targets set out in the Kyoto Protocol to achieve the ultimate objective of the Convention. The Bali Road Map, adopted in COP 13, in 2007, charted the course for a new negotiating process designed to tackle this issue. It created (i) Ad Hoc Working Group on Further Commitments for Annex I Parties

under the Kyoto Protocol (AWG-KP) and the (ii) Ad hoc Working Group on Long-term Cooperative Action under the Convention (AWG-LCA).

The Cancun Agreement

In 2010, the Cancun agreement (COP 16), established clear objectives for reducing human-generated greenhouse gas emissions over time to **keep the global average temperature rise below2^{o}C with respect to pre-industrial times (1880s)**. **All Parties to the Convention agreed to reduce emissions, in accordance with each country's different responsibilities and capabilities**. The agreement ensured international transparency through timely review of actions that will be taken by countries. The accord agreed to ensure (i) transfer of clean technology to the right place at the right time for the best effect, (ii) mobilize and provide scaled-up funds in the short and long term to enable developing countries to take greater and effective action, and (iii) assist the particularly vulnerable people in the world to adapt to the inevitable impacts of climate change.

The Road Ahead

At COP17 in Durban, governments of the Parties to the Kyoto Protocol decided that a second commitment period, from 2013 onwards, would seamlessly follow the end of the first commitment period. The length of the second commitment period is to be determined: it will be either five or eight years long.

1.3 INDIA'S RESPONSE TO CLIMATE CHANGE

National Communication

India signed the UNFCCC as early as in June 1992 and ratified it in November 1993. The Ministry of Environment & Forests is the nodal agency for climate change issues in India. As a Party to the UNFCCC and taking into account its common but differentiated responsibilities and specific national and regional development priorities, objectives and circumstances, India is required to develop, periodically update and publish (i) national inventory of anthropogenic emissions by sources and removals by sinks of all greenhouse gases not controlled by the Montreal Protocol, (ii) information on national programmes containing policies and measures to mitigate climate change, (iii) programmes on climate change research and observations, education, research and training, and (iv) measures to facilitate adequate adaptation to climate change. India submitted its first National Communication to UNFCCC, in June 2004 and submitted its second National Communication in May 2012.

Taking Advantage of the Kyoto Protocol

The Kyoto Protocol offered developed countries additional means over and above their domestic actions, to meet their legally binding targets by way of three market-based mechanisms, namely, emissions trading – known as "the carbon market", Clean development mechanism (CDM), and Joint implementation (JI). The mechanisms help stimulate green investment and help parties meet their emission targets in a cost-effective way.

Under Clean development Mechanism (CDM), developed country parties can participate jointly with developing countries towards meeting their GHG emission reduction targets laid out in the Article 12 of the Kyoto Protocol of the Convention. It allows Public or Private Companies in the Annex-1 countries to invest in GHG mitigation projects in non-Annex–I countries to the Convention. In return the Annex-1 parties

Box 1.1: A successful CDM project operational in India – The Bachat Lamp Yojana (BLY) Experience

The Bachat Lamp Yojana programme is a public-private partnership programme introduced by the Bureau of Energy Efficiency (BEE) to hasten market transformation towards energy efficient lighting in domestic households. Under the programme, households are charged Rs. 15/- per CFL, which is a substantial discount from the CFL market price of Rs. 120/-. The difference in costs is covered through the associated CDM. The BEE is the overall coordinating and managing entity (CME) for the programme, which is expected to save upto 4000 MW per year. The programme is the world's largest registered Programme of Activities by population coverage.

receive credits or Certified Emission Reductions (CERs) which they can use to meet their targets under the Kyoto Protocol.

So far India has approved 2230 projects that had a Certified Emission Reductions (CER) potential of 73, 08, 50,588.65till 2012. The projects cover the sectors of afforestation and reforestation, agriculture, chemical industries, energy demand, energy distribution, energy industries, fugitive emissions, manufacturing industries, mining and mineral production, transport, and waste handling and disposal.

National Action Plan on Climate Change

To address climate change domestically, the Government of India drafted its National Action Plan on Climate Change in 2008that focuses on adaptation and mitigation actions through 8 missions: National Solar Mission, National Mission for Enhanced Energy Efficiency, National 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, and National Mission on Strategic Knowledge for Climate Change.

India's Domestic Target

India has already announced a domestic goal under the Copenhagen Accord and Cancun agreements. The goal is to achieve 20-25% reduction of emission intensity of GDP in comparison with 2005 level till 2020. This is a voluntary goal and does not need any further revision till 2020. The goal is to be achieved through a sustainable development strategy including promotion of energy efficiency in several sectors of industry, and solar and other forms of renewable energy. This is to be achieved depending on the financial outlays and technology support available from domestic and international sources.

The PAT Scheme

The ambitious PAT scheme (Perform Achieve and Trade), of the GoI, is a national scheme aimed at increasing the energy efficiency in energy intensive industries in India. It sets out Specific Energy Consumption (SEC) reduction targets. These targets, however, do not intend to put any overall cap on energy consumption, consistent with the Indian stand in the ongoing climate change negotiations. The scheme involves trading of Energy Saving Certificates (ESCerts) to those designated consumers who achieve and also exceed their SEC reduction targets through a transparent regulatory framework, monitoring and verification. The savings due to PAT mechanism will be 9.78 mtoe (million tons of oil equivalent) and 26.21 million tons of GHG emissions, resulting in expected avoided capacity addition of 5263 MW, in the first 3 years of the implementation of the scheme. An investment of about Rs. 30,000 crores is expected to be made by the industry.

Preparing for NAMAs

Nationally Appropriate Mitigation Actions (NAMAs) are one of the cornerstones of the international climate negotiations at the Durban climate change talks. The term NAMA was first introduced in the Bali Action Plan of 2007, where all countries that are Party to the United Nation Framework Convention on Climate Change (UNFCCC) agreed to negotiate on "Nationally Appropriate Mitigation Actions by developing country Parties in the context of sustainable development, supported and enabled by technology, financing and capacity-building, in a measurable, reportable and verifiable manner".

Towards preparedness for NAMAs India, has started to identify, select and prepare proposals for potential NAMAs. NAMAs can potentially upscale the CDM projects that are not under the purview of PAT. One such project that is being conceptualized is to achieve energy efficiency improvement of furnaces and burners in energy intensive SME industries throughout India, which should reduce the overall energy consumption by at least 20% per unit of production.

State Action Plan on Climate Change

Realizing that the implementation of the National Action Plan will be best realized at sub-regional level, as climate change impacts manifest locally, the Indian Government through the MoEF has directed each state to identify their Climate Change concerns and prepare an Action Plan on Climate Change to mitigate climate change and adapt to the impacts of state specific climate change vulnerabilities. In this context the states are prioritizing financeable strategies and actions based on assessment of impacts of climate change on the local natural resources and economic sectors that are operational.

1.4 OBJECTIVE OF THE PUNJAB SAPCC

Punjab has experienced a dramatic improvement in its economy since independence, which is mainly agriculture driven. However, its natural resource base is shrinking because of over-exploitation due to population pressure and developmental needs. Changes in climate may be a hindrance in the future in pursuing a sustainable economic growth, as economic activities such as agriculture are overtly climate sensitive. For example, climate change modeling studies carried out by Siddhu *et al*., 2011, indicate, a reduction in yields of rice and wheat by 3 to 10% with respect to current yields in Punjab if temperatures rise by even 1^{o}C. Therefore integrating climate change in its policies and programmes is imperative. This necessitates formulation of State specific strategies and action plans, which also follow the basic principles of equity and sustainability as ingrained in the NAPCC. The principles being:

- Protecting the poor and vulnerable sections of society through an inclusive and sustainable development strategy, sensitive to climate change.
- Achieving national growth objectives by enhancing ecological sustainability and mitigation of greenhouse gases.
- Devising efficient and cost-effective strategies for end use Demand Side Management
- Developing appropriate technologies for both adaptation and mitigation of greenhouse gases.
- Engineering new and innovative mechanisms to promote sustainable development.
- Effective implementation of programs.
- International cooperation for technology transfer.

Through the formulation of the Punjab Action Plan on Climate Change the state envisages to address the impacts of climate change within the framework of the eight missions of the NAPCC. The state objectives are summarized in **Table 1.1**

Table 1.1: State Objectives and Targets vis a vis the Eight National Missions

Missions	National Objective	State Objectives and Targets
Water Mission	Water Conservation and river basin management	The state aims to undertake an integrated approach for conservation and management of its water resources, improve water use efficiency, control water pollution, minimize wastage and ensure equitable distribution of water across the state by addressing the impacts of climate change on water resources.
Sustainable Agriculture Mission	Develop agriculture plans at agro-climatic zone level, Link research with practice to maximize productivity, Encourage innovation, Promote dry land agriculture, Risk Management through insurance, enhance livelihood opportunities, seek convergence with other missions	Usher in 2nd green revolution through sustainable management of agricultural practices, and hence ensure food security in a changing climate scenario. Approach to include crop diversification, efficient resource utilization, appropriate use of technologies and inputs from new research. Promote power generation from agricultural residue.

Missions	National Objective	State Objectives and Targets
Green India Mission	20 million ha area to be afforested/ eco-restored by 2020.	Increase green cover in the state to 15% of the area of the state by 2022, enhance conditions of degraded forests, and increase the incomes generated from ecosystem service provided by the forests.
Sustainable Himalayan Mission	Conservation, adaptation, glacier monitoring	Conserve flora, fauna, wetlands along with agriculture and forest biodiversity to sustain the Shivalik Ecosystem.
Sustainable Habitats Mission	Efficient buildings, transport system and Solid Waste Management	The state aims to develop policies and strategies that enable the habitats to adapt to climate change concerns Identify and implement strategies in urban areas to reduce enhanced heat island effect and sustainably manage municipal solid waste and transport.
Solar Mission	20,000 MW by 2022	Increase the solar energy mix by at least 2000 MW by 2022.
Mission on Enhanced Energy Efficiency	10,000 MW savings by 2012	To achieve 3-5% energy efficiency improvement in large energy consumers designated by BEE and 15-20% in SME sector.
Mission on Strategic Knowledge	Vulnerability assessment, Research and Data management, knowledge sharing	The Punjab Mission on Strategic Knowledge aims to build a greater understanding of the climate change processes, its implications on various sectors, and vulnerabilities associated with the same to enable it to sustainably adapt to climate change and mitigate drivers of climate change.

1.5 APPROACH TOWARDS PREPARATION OF PUNJAB SAPCC

The Punjab State Council for Science and Technology – PSCST is the focal point for climate change issues in the Punjab government, and it is coordinating the preparation of the Punjab State Action Plan on Climate Change.

A Steering committee has been constituted for this purpose, chaired by the Chief Secretary, Government of Punjab and the members in the committee are drawn from relevant line departments, universities, scientific institutions, industry associations and nongovernmental organizations. The composition is attached in ***Annexure 1*** to this document. The institutional framework for preparation of the SAPCC is shown in **Figure 1.1** indicating that the process of formulation of the SAPCC has been a broad based participatory approach involving all concerned stakeholders. Mission wise working groups contributed towards the preparation of the SAPCC.

The State Steering Committee provided an overall guidance and supervised the process of preparation of the State Action Plan on Climate Change (SAPCC). The PSCST coordinated the entire process of preparation of the SAPCC through a broad based participatory approach involving all major stakeholders as indicated in **Figure 1.1.**

The SAPCC has been formulated in line with the 8 National Missions of the National Action Plan on Climate Change. The entire exercise of compiling SAPCC has been done through mission wise discussions with all concerned stakeholders identified for each mission in the state. A series of consultative meetings and working group discussions were carried for preparing the SAPCC.

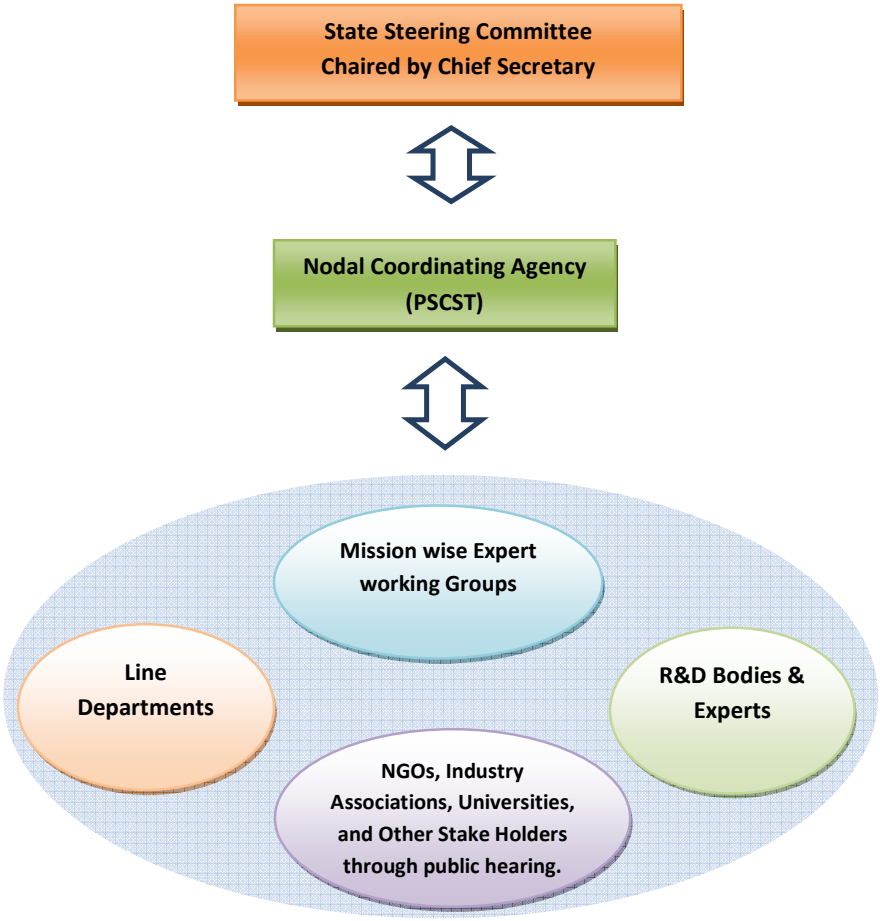

Figure 1.1: Implementation Arrangement for Preparation of Punjab SAPCC

The steps towards drafting the Punjab SAPCC included:

Step1: *A review of the state profile vis a vis its physiographic setting, natural resources available in the state, the various economic activities carried out by it, and the social and physical infrastructure that it has created.* This step was undertaken by reviewing the latest population census, economic and statistical reports. The justification of doing this exercise was to understand the circumstances within which the state is managing its resources and using the same towards a sustainable development.

Step 2: *An analysis of the observed trends of climate in the state and implications of projected climate change.* The observed temporal and spatial trends of climate have been ascertained from publications of the IMD as well as by analyzing climate data across various stations in the state. The projected climate scenarios have been obtained as outputs of the PRECIS regional model run on A1B IPCC SRES scenarios. Also as the Satluj river basin occupies more than 60% area of the state, a review of the projected climate for this basin has also been undertaken as it has implications on future water availability and sustainability of agriculture in the state.

Step 3: Formulation of background papers for the Punjab SAPCC on:

- State profile
- Punjab State Water Mission
- Sustainable Agriculture Mission
- Green Punjab Mission

- Punjab Mission for Sustaining Himalayan Ecosystem and Biodiversity
- Sustainable Habitat Mission
- Renewable Energy development and Solar Mission
- Enhanced Energy Efficiency Mission
- Mission on Strategic Knowledge Management

Each of the Mission based chapters discuss the (i) current status of the resources and sectors, (ii) current concerns (iii) the institutions managing them, (iv) the policies governing them and programmes implemented to manage the same, (v) a review of impacts of climate change on the resource/sector and associated vulnerability and (vi) Formulation of strategies and actions to adapt to the identified impacts of climate change.

Step 4: *Prioritization of the strategies and actions.* This has been done through stakeholder consultations with inputs from experts, whereby the following criteria were considered.

Importance: How important are the predicted climate change impacts addressed by this adaptation option? What is the level of severity of the impacts on unique or valuable species, ecological functions, or other natural resources under consideration? What is at stake if we do nothing?

Urgency: What are the costs of delaying action? Is it likely to cost more to implement later rather than now? Will there be loss in species, resources, or options by delaying action? Are the consequences of not acting now irreversible?

Feasibility: How feasible is the proposed action given existing laws, regulations, and policies? How technically feasible is it? Is there an opportunity to adapt existing strategies/actions, or will entirely new initiatives be needed?

Robustness and sustainability: What is the likelihood that the proposed action will be effective across a long time line over which the climate projections are made? Does it allow for adaptive management over a long time period?

Equity: The impacts of climate change will be experienced unevenly, both spatially and temporally and the consequences of climate change will also vary as a result of the differing vulnerability of individuals, communities, different age groups and gender. Thus equity and justice are important factors when considering adaptation interventions.

Consistency with national/state laws/policies: Any strategy that is aligned with existing policies and programmes has a higher chance of being implemented.

Cost effectiveness: Cost effectiveness is one of the key criteria for chosing any action, across all sectors even when they are taken up as a developmental programme. Therefore, while designing the strategy-wise actions this criteria was also kept in view.

Environmental benefits: Also environmental benefits of the different strategies and actions suggested have been kept in view with respect to the recent trends in resource utilisation. For example, soil erosion due to higher rain fall projections along with soil degradation due to over intensification of cropping is one of the areas where adaptation options have been suggested. Obviously the environmental benefits due to implementation of the adaptation options would include, soil conservation, increase in soil fertility, increase in biomass, possibility of increase in biodiversity, higher water flow in streams, and others.

Social Benefits: Social benefits that might accrue due to implementation of a strategies or actions leading to increase in cash flow in rural households as crop productions increase, creation of opportunities for diversified income generating livelihoods, improvement in housing and sanitation conditions, reduction in malnutrition and diarrheal incidences, etc. were also considered.

The draft SAPCC thus prepared has been reviewed by the National Expert Committee on Climate Change (ECCC) meeting held on 18.09.12 at MoEF in Delhi. Observations of the ECCC have been addressed in the revised draft. Subsequently, a stakeholders' workshop-cum-public hearing was also carried out on 24th Dec 2012, for seeking inputs/comments from all stakeholders including the departments, industry association, NGOs and the public on the revised draft SAPCC that was uploaded on the websites (www.pscst.gov.in and www.punenvis.nic.in) of Punjab State Council for Science & Technology. Advertisement regarding stakeholders' workshop-cum-public meeting, list of participants in this meeting and its proceedings are at Annexure 2. The response to the comments received in this stakeholders' workshop-cum-public hearing have been incorporated in the revised SAPCC.

Participants in Stakeholders' workshop-cum-public hearing at Chandigarh on 24-12-2012

1.6 KNOWLEDGE GAPS

The consultative meetings carried out with various stakeholders identified knowledge gaps that can be classified in the following broad categories:

Data Gaps

Climate change being a new subject area, data gaps vis a vis multiple climate change scenarios are lacking. Similarly assessments of impacts specific to climate change at local level are also not always available. For example, likely impacts of climate change on agricultural crop productivity in different agro-climate zones are yet to be assessed though some studies indicating impacts on specific crops like rice and wheat in general for the state are available.

Observation gaps

Long term observational gaps exist that can ascertain the clear impacts of climate change. For example, biodiversity and climate change linkages though understandable theoretically, however, the changes in biodiversity that have been observed in the state have been due to a combination of socio economic drivers and climate change. Long term systematic observations are required to understand the exact changes occurring in biodiversity due to climate change.

Understanding climate projections and their impacts on different sectors

The climate projections available are at 50kmx50km resolution and are only for a particular developmental paradigm (IPCC A1B scenario) and are available at two time slices 2021-2050 and 2071-2098. The stakeholders expressed that it would be worthwhile to have more set of climate scenarios to understand the range of climate impacts that Punjab might face in the future and the projections need to be available at least for every 10 years. Also most of the times the CC impacts are highly local, therefore projections at higher resolutions are required for certain aspects of planning. Further, the stakeholders felt that there need to be awareness campaigns for the stakeholders to interpret the climate change and impact scenarios.

Understanding vulnerabilities due to climate change

Vulnerability of the various sectors has been identified in the document in terms of the current concerns which are a result of a combination of socio economic drivers and climate variability. Projections of vulnerability of the sectors in the future would require assessing the future scenario of development as well as the climate projections. Therefore, it might be worthwhile to take up modeling/other exercises to evaluate the future vulnerabilities of various sectors due to climate

change at different spatial scales. This will be useful for developing appropriate solutions for adaptation to climate change.

Capacity building needs to mainstream climate change in projects and programmes

Climate change being a new area of concern, the developmental programmes has not yet taken into account this aspect. However, through the implementation of the SAPCC, it is envisaged that the climate change concerns will be integrated. However, in order to do so it is essential to have capacity building programmes for various levels including the policy level, the scientific and technical levels and at the grass root level. Additionally, women centric capacity building programmes will be required to enable effective water and natural resource conservation.

Broadcasting of scientific and technical development

Certain technical developments exist that can be a breakthrough in large scale adaptation but are yet to be tested on ground to stand the test of large scale implementation. For example, research is on to develop the thermal and water stress resistant cultivars of rice and other crops. However, they are yet to be tested on ground not only to test their survival in a changing climate scenario but also to see if these can produce enough to ensure food security and survive in the markets.

REFERENCES AND SUGGESTED READING

1. Bali Road Map, 2007. http://unfccc.int/key_documents/bali_road_map/items/6447.php. Accessed on Dec1, 2012.
2. Clean Development Mechanism, CDM. http://cdm.unfccc.int/. Accessed on Dec1, 2012.
3. Decision 2/CP.17, 2010. (FCCC/CP/2011/9/Add.1). Addendum Part Two: Action taken by the Conference of the Parties at its seventeenth session. A Report of the Conference of the Parties on its seventeenth session, held in Durban from 28 November to 11 December 2011. Published by the UNFCCC.
4. INCCA 2011.National Carbonaceous Aerosol Programme. INCCA Report # 3. Published by the Ministry of Environment and Forests, Government of India.
5. INCCA, 2010. Climate Change and India: A 4X4 Assessment. A sectoral and regional Analysis for 2030s. INCCA Report #2. Published by the Ministry of Environment and Forests, Government of India.
6. INCCA, 2010. India's Green House Gases Inventory: 2007 May 2010. INCCA Report #1. Published by the Ministry of Environment and Forests, Government of India.
7. Kyoto protocol, 1997. Source: http://unfccc.int/resource/docs/convkp/kpeng.pdf. Accessed on Dec1, 2012.
8. MPSAPCC, 2012. Madhya Pradesh state Action Plan on Climate Change. moef.nic.in/downloads/public-information/MP-SAPCC.pdf. Accessed on Dec 1, 2012.
9. NAMAs. Nationally appropriate mitigation actions of developing country Parties, http://unfccc.int/home/items/5265.php. Accessed on 21st feb 2013.
10. NAPCC 2008.http://india.gov.in/allimpfrms/alldocs/15651.doc. Accessed on Dec1, 2012.
11. NATCOM1, 2004. India's initial national communication to the UNFCCC. Published by the Ministry of Environment and Forests, Government of India. http://unfccc.int/resource/docs/natc/indnc1.pdf. Accessed on Dec1, 2012.
12. NATCOM2, 2012. India's 2nd national communication to the UNFCCC, Published by the Ministry of Environment and Forests, Government of India. http://envfor.nic.in/downloads/publicinformation/2ndNational_Communication_2_UNFCCC.pdf.

13. PAT, 2012.Perform Achieve and Trade. BEE, GoI. http://beenet.gov.in:90/downloadbooks.aspx?fname=BEE_PAT_Booklet. Accessed on Dec1, 2012.

14. The Cancun Agreement, 2010. http://unfccc.int/meetings/cancun_nov_2010/items/6005.php. Accessed on Dec1, 2012.

15. UNFCCC, 1992. United Nations Framework Convention on Climate Change. http://unfccc.int/resource/docs/2011/awglca14/eng/inf01.pdf. Accessed on Dec1, 2012.

16. WBSAPCC. 2012. West Bengal. State Action Plans on Climate Change. http://moef.nic.in/downloads/public-information/West-Bengal-SAPCC.pdf. Accessed on Dec 1, 2012.

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2. State Profile

HIGHLIGHTS

- Administrative units and Population
- Administrative Units and Population
- Physiography
- Climate
- Land Use
- Natural resources
- Socio Economic Profile
- Agriculture
- Physical Infrastructure

2.1 INTRODUCTION

The word Punjab is a combination of the Persian words Punj and Ābthat means Five and Water respectively, thus Punjab means Land of Five Rivers. The five rivers are the Beas, Sutlaj, Ravi, Chenab and Jehlum (also spelled Jhelum). The name is also sometimes spelled as Panjab.

The Indian Punjab historically forms a part of the larger Punjab region, which includes some parts of Afghanistan, the Pakistani province of Punjab and the North-West Frontier Province, the Indian states of Haryana and Himachal Pradesh, parts of J&K and Delhi. A large part of undivided Punjab became a part of Pakistan in 1947. The Indian Punjab was trifurcated in the year 1966 leading to the formation of Haryana and Himachal Pradesh and present day Punjab.

Punjab is a State in North-West India. It shares its 553 km international boundary with Pakistan in the west, and state boundaries with Jammu and Kashmir in the North, Himachal Pradesh in the North East and Haryana and Rajasthan in the south. It extends from 29.30° North to 32.32° North latitude and 73.55° East to 76.50° East longitude covering an area of 50,362 sq. km which is 1.54 % of country's total geographical area.

2.2 ADMINISTRATIVE UNITS AND POPULATION

The state of Punjab has been divided into 5 divisions, 22 districts, 81 sub divisions, 81 tehsils, 86 sub tehsils and 145 blocks. It has 143 towns, 14 cities and 12581 inhabited villages (*Punjab Economic Survey, 2012)*.

Box 2.1: The Districts of Punjab

1. Amristsar	2. Barnala	3. Bathinda	4. Faridkot	5. Fazilka
6. Fatehgarh Sahib	7. Ferozepur	8. Gurdaspur	9. Hoshiarpur	10. Jalandhar
11. Kapurthala	12. Ludhiana	13. Mansa	14. Moga	15. Ajitgarh (SAS Nagar)
16. Muktsar	17. Patiala	18. Pathankot	19. Rupnagar	20. Sangrur
21. SBS Nagar(Nawanshahr)	22. Tarn Taran			

The state capital of Punjab is Chandigarh. The major cities in Punjab are Ludhiana, Jalandhar, Amritsar, Patiala, Ajitgarh, Bathinda, Barnala, Phagwara, Pathankot, Moga, Ferozepur, Faridkot, Hoshiarpur, and Gurdaspur.

Punjab as of 2011, has a total population of 27.7 million (Census, 2011), which is 2.29% of India's population. Of this, 62.51% live in rural areas. The population density is high with 550 persons/sq km

as compared to the national average of 327 persons/sq km. Ludhiana is the most populous district with a population of 3.5 million people and a density of 975 people per sq km. Barnala district is the least populous with 0.6 million people. The sex ratio in Punjab has improved from 798 in 2001 to 893 in 2011. The child sex ratio in the age group 0-6 years has also improved from 798 in 2001 to 846 in 2011.

2.3 PHYSIOGRAPHY

Though Punjab appears to be a predominantly alluvial plain, but on a closer look it becomes clear that the whole state is not a flattish alluvial plain. Towards the east and north east, the plain rises to form hills – the outer flank of the Himalayas and towards the south, it becomes uneven due to the presence of a large number of sand dunes and sand flats. Within the plains also the low lying flood plains of various rivers passing through the state are separated from the main plain by bluffs (Dhaiyas). The change from flattish alluvial plains to Shivalik hills is not abrupt, it is rather slow and gentle, through uneven dissected and rolling edges called Kandi. Thus, the main physiographic subdivisions of the state are:

(a) Shiwalik Hills (b) Kandi

(c) Flattish Alluvial Plain (d) South Western Dune Studded Plain.

The state is also divided into three zones, namely Malwa, Doaba and Majha on the basis of their location with respect to the Satluj and Beas rivers (**Figure 2.1).**

Malwais a region of Punjab and parts of Haryana between the Sutlej and Yamuna rivers. The Malwa area makes up majority of the Punjab region,and has the most fertile land. Important cities such as Ludhiana, Ajitgarh, Sangrur, Moga, Barnala, Bathinda and Ferozepur are located in this region.

Doaba is the region of Punjab bounded by the two major rivers Beas and Sutlej. The name "Doaba" literally translates to "land of two rivers" ("Do" two, "Ab" river). It is one of the most fertile regions, and was the centre of the Green Revolution in India. Jalandhar is one of the most famous cities of Doaba.

Majha is a historical region of Punjab comprising of Amritsar, Gurdaspur, TaranTaran, and Pathankot.

2.4 CLIMATE

The State of Punjab lies in the sub-tropical belt and is situated in the North-west of Indian sub-continent. It lies over 1600 Km. away from the Bay of Bengal. The Shivaliks are on its North-Western boarder and Rajasthan in the South. These factors determine its climatic conditions. The climate of Punjab is determined by the extreme hot and extreme cold conditions. The region lying near the foot hills of Himalayas receive heavy rainfall whereas in the region lying at a distance from the hills, the rainfall is low and the temperature is high.

The average annual rainfall ranges from 580mm in the plains to 960mm in sub-mountain regions, and decreases from North to South. The temperature ranges from minus 2° to 40° C (min/max) in Punjab. Climatically, Punjab has three major seasons: (i) hot weather (April to June); (ii) rainy season (July to September); and (iii) cold weather (October to March) (*Source: ADB, 2011*).

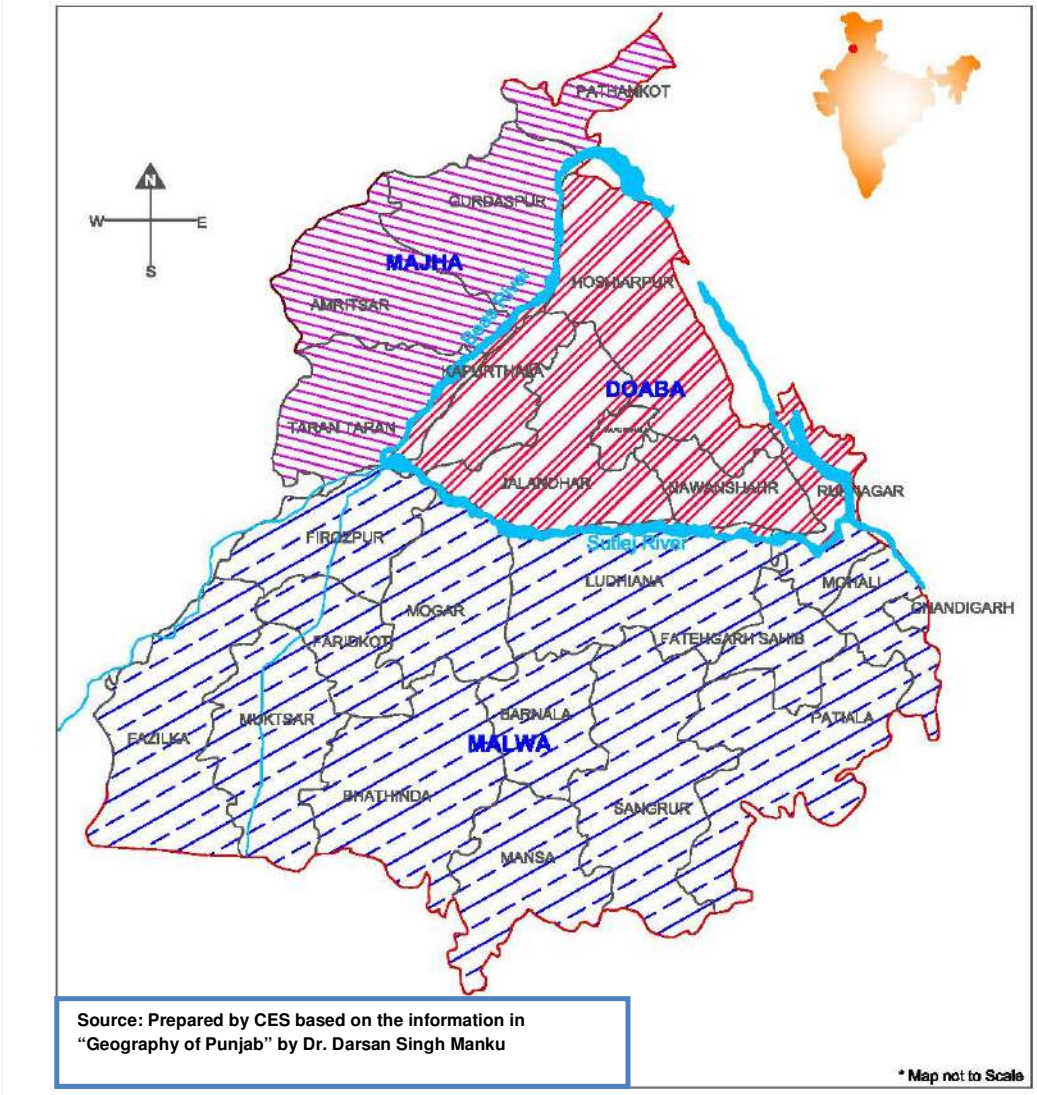


Figure 2.1: Physiographical regions of Majha, Doaba and Malwa in Punjab

2.5 LAND USE

Punjab is a small state with 50,362 sq. km geographical area. The land is primarily formed of the alluvium deposited by rivers of Indus system. About 83% of the total land is under agricultural activities including plantation, as compared to national average of 40.38%.The state land is poor in mineral resources.

The use of land in Punjab under various categories in present and past decades is shown in **Table 2.1**. The share of present land use categories in the total geographical area of the state is shown in **Figure 2.2**. Over the last two decades (1980-81 and 2008-09), the forest area in the state has increased by 37.0%, while there is a marginal decrease in net sown area. Barren and unculturable wasteland has decreased by 76.0% while the proportion of non-agriculture land has increased by 13.3% in last two decades.

Table 2.1: Land use statistics (Thousand ha)

Category	19801-81	1990-91	2000-01	2010-11	% change between 1980-81 to 2010-11
Forests	216	222	280	294	36.1
Barren and unculturable land	96	83	28	24	-75.0
Non Agricultural land use	436	343	410	508	16.5
Culturable waste land	41	35	15	4	-90.2
Permanent pasture & grazing land	4	10	4	4	0
Land under miscellaneous tree crops	4	12	3	4	0
Fallow Land (Current fallow + other fallow)	45	110	43	37	-17.8
Newt sown area	4191	4218	4250	4158	-0.8
Total Geographic area*	5033	5033	5033	5033	-

Source: Director, Land Records, Punjab; PbSAP, 2012

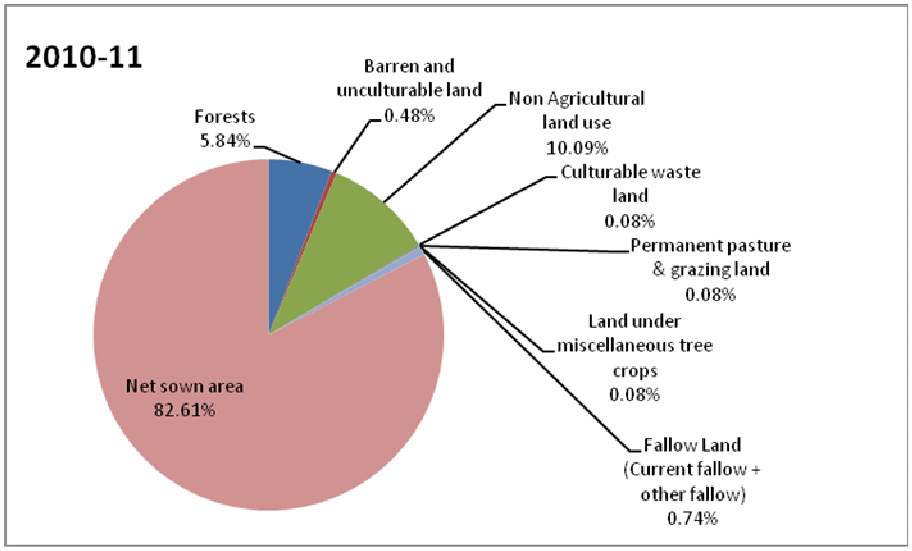


Figure 2.2: Land use distribution in Punjab, 2010-11

Source: Director, Land Records, Punjab; published in PbSAP, 2012

2.6 NATURAL RESOURCES

Soils

On the basis of the area, soils of Punjab can be grouped into three major categories namely Soils of Shivalik Hills, Piedmont Plain and Alluvial Plain and four orders i.e. Entisols, Inceptisols, Alfisols&Aridisols (*Jerath et al, 2010*).

The soils of Shivalik Hill region are found in the northern and north-eastern parts of the State in northern parts of Gurdaspur, Pathankot, Hoshiarpur, Nawanshahr and Rupnagar districts, at an elevation of 300 to 900 MSL. It covers a total area of 1,47,083 ha (2.9%) of the state. The soils of Shivalik Hills are barren or wastelands supporting bushy type of vegetation, however, some soils support horticultural crops. These soils face erosion hazards and require intensive conservation and plantation measures.

The soils of the Piedmont plains occur on nearly level to moderately sloping trasitional hills between Shivalik and river terraces and occupy a total area of 3,50,437 ha accounting for 6.9% area of the state, covering parts of Gurdaspur, Hoshiarpur, and Rupnagar, Pathankot and Nawanshahr districts. The soils are severely dissected by seasonal streams. The soils of Piedmont Plain are mostly barren & supporting bushy type of vegetation, however, some soils support horticultural & oil crops. These soils face erosion hazards and require immediate conservation measures.

Alluvial soils are most extensively spreadacross the state and occupy an area of 45,38,230 ha representing 90% of the state area. The soil type extends over the north eastern, central and south western parts of the state. The soils occur in two regions,

- Hot semi-arid agro ecological sub region (Ustic zone) and
- Northern Plain, Hot, Arid agro-ecological sub region (Aridiczone).

Surface Water

There are three perennial rivers in the State - Ravi, Beas & Sutlej and one non-perennial river namely Ghaggar. Besides several Choes, Nadies&Khads also traverse the sub mountainous & alluvial plains before joining the respective parent rivers.

The rivers are mainly glacier and snow fed and partially rain fed. Eighty percent of the Indian Sutlej river catchment in Himachal Pradesh has been observed to be snow fed at some stage or the other during the year. The average number of glaciers that feed the Sutlej river is estimated to be 935 covering an area of 1234 sq.kms. with an estimated ice volume of 77 NCM (*Source: ADB, 2011*, Averaged from studies carried out by the Geological Survey of India and by Palampur University, Himachal Pradesh).

The state also has dams built on its rivers. On river Beas there is Pong dam. On Ravi there is the RanjitSagar dam. Besides there are three major barrages on River Sutlej at Nangal, Ropar and Harike for diverting the river water into canals for irrigation in the states of Punjab, Haryana and Rajasthan. There is very less flow of water in the River Sutlej after Ropar head works.

About 14500kms long interlinked canal system criss-crosses the state (*Source: Irrigation Department*). Apart from these, the villages are dotted with 4952 ponds (*State Punjab Remote Sensing Centre, 2012*) and other traditional water harvesting structures.

Wetlands

In Punjab there are 12 natural and 8 man-made wetlands created due to construction of dams. Of the man-made wetlands, Harike, Kanjli and Ropar have been declared as Ramsar Sites. In addition two wetlands in Punjab namely RanjitSagar and Nangal have been declared as wetlands of national importance.

The wetlands provide habitat to diverse flora and fauna and provide flood protection, and many economic benefits to local population such as through fisheries and tourism. Wetlands also enable delivery of potable water by intercepting surface runoff and by filtering pollutants, processing organic wastes and reducing sediments in water before the flow reach open water and by recharging the groundwater (*Source:* PSCST, 2010*).*

Ground Water

The entire alluvial plain within the Punjab region acts as a single ground water body. The ground water levels in most of Punjab range between 5 to 20 m below ground level. The Net Annual Ground Water Availability is 20.35 BCM (billion Cubic meter) and the Annual Ground Water Draft is 34.66 BCM, with stage of ground water development standing at 170% (*Source: Central Ground Water Board and Deptt. of Irrigation, Punjab*). Ground water exploitation in Punjab is high as it provides 72% of the total water required for irrigation. In Punjab about 110 out of the 138 blocks (now spread over all the 145 blocks in the state) are over exploited for ground water, of these 3 blocks are critical and 2 blocks are in semi critical condition. (*Source: Central Ground Water Board and Deptt. of Irrigation, Punjab*)

Forests

The Punjab state was reorganized in the year 1966 and was left with only 1875 Sq. Km of recorded forest area in that year which has now increased to 3058 sq.km. The larger part of the State is a flat plain with Shivalik Hills having general summit line occasionally rising above 600 m in the north east. Only DharKalan block of Pathankot district in the extreme north has the high altitude rising above 900 msl. Therefore, most of the forests of Punjab are tropical and sub-tropical in nature. They are open, stunted and dry and mostly broad-leaved hardwoods. Sub-moist Himalayan forests are found only in the extreme north DharKalan Block of Pathankot district.

The recorded forest area in the state is 3058 km^2 which is 6.12% of the total geographical area of the state. Of this 1.43% of the area is reserved forest, 36.87% of the area is protected forest, and the rest of the forest area constitutes of unclassed forests.

Since the State has around 83% of its geographical area under agriculture with intense competition among different land-uses, there is limited scope to increase the area under forests except for bringing the available vacant wastelands/degraded lands under tree cover by the application of Agroforestry and Social Forestry in farmlands and institutional vacant lands.

Satellite measurements as of Nov 2008 indicate that the forest cover in the state has increased by 100 km^2 with respect to the interpretation made using satellite imagery for the period Oct 2006 to Feb 2007. The increase in forest area is attributed to the aggressive plantation activities undertaken by the Forest Department. Currently the state forest cover stands at 1764 km^2 (*ISFR-Punjab, 2011*). See **Figure 2.3** for the extent of forest in Punjab. This is 3.50% of the total geographical area of Punjab. About 41.7% of this forest area is moderately dense and 58.3% of the area is open forest.

The tree cover outside forests in the state extends over an area of 1699 km^2. This is 3.37% of the geographical area of the state. Adding the forest cover to the tree cover, the total area is 3463 km^2 (*ISFR, 2011*).

As can be interpreted from the forest cover map in Figure 2.3, the main forest area in the state are the **Shivalik forests** in the districts of Ropar, Nawanshahr, Gurdaspur; The **Bir Forests**are in Pathankot& Hoshiarpur; In the sitricts of Patiala and a small area in district Kapurthala which constitute the**,** and **Mand Forests**in the **d**istricts Amritsar, Tarn Taran&Kapurthala around the wetlands called the**.**

The forests in Punjab can be classified as:

- Coniferous (Lower Shivalik Chir Pine) forests
- Bamboo forests
- Scrub forests
- Broad leaf forests

Coniferous forests: These forests are found in the Shivalik hills of the state where Chir is the main species, along with Amla, Khair and some scattered trees of *Terminalia.*

Bamboo forests: These forests are also found in the Shivalik hills, mainly in the Dasuya Forest Division and in certain pockets of Hoshiarpur and Gurdaspur Forest Divisions in Dholbaha and Salidhar forests respectively. In the Dasuya Forest Division, Bindravan, Karanpur and NanadBir areas are almost pure bamboo forests. The main species is *Dendrocalamusstrictus*associated with Rajain, Khair, etc.

Scrub forests: Scrub forests are found in the Shivalik hills and in various Birs of Punjab. *Acacia catechu* is the main species found here. *Acacia nilotica*and*Dalbergiasissoo*are found along riverine areas and in the plains. In the past few years, economically more important tree species have been introduced in these scrub forests, both in the hills and in the plains. These include *Eucalyptus*, Drek, *Ailanthus*, Tun, Poplar, etc.

Broad leaf forests: *Eucalyptus*, Sheesham, Poplar, Mango, Neem, Toot, Teak, *Ailanthus* and Tun are some of the important species of the broad leaf forests. These types of forests are mainly found in the plains and are being managed under the prescriptions given in the working plans.

Figure 2.3: Forest Cover of Punjab.
(Source: ISFR-Punjab, 2011)

BOX 2.2: Diminishing population of *Acacia nilotica* and *Dalbergia sissoo*

The state tree Tahli/Sheesham (*Dalbergia sissoo*) and Kikar (*Acacia nilotica*) are commonly found in Punjab, but fully grown trees of these species are fast diminishing. The trees are dying a slow death, but the decline in numbers from 82,183 to 30,000, in Bathinda district alone in eight years is alarming.

The Kikar tree tolerates a wide range of soil types and when used in land reclamation, can be planted onto degraded saline/alkaline soils with a soluble salt content below 3 per cent. It adapts itself to annual rainfall of between 300 and 2,200 mm and tolerates extremes of temperatures.

The causes of large scale demise of sheesham or tahli trees have been linked to (i) changing climatic conditions, (ii) altering soil conditions; and (iii) water-logging. This needs to be further investigated and remedial measures taken.

Biodiversity

The typical climate, physiography and natural resources in the state have supported its unique biodiversity. The natural forests in the Shivalik hills covering the districts of Ropar, Gurdaspur,

Pathankot and Hoshiarpur and in the form of Bir forests in districts of Patiala and Mand forests around Wetlands are highly biodiversity rich regions. Also the natural and manmade wetlands support rich biodiversity in the state.

To protect the forest biodiversity of this region, 12 areas have been protected by declaring as wildlife sanctuaries covering an area of 317.79 sqkms. Important sanctuaries include Abohar wild life sanctuary, Harike sanctuary and sanctuaries in the Shivaliks.

In total about 3408 floral species have been reported from Punjab (Jerath*et al.*, 2002, Jerath *et al.,* 2006). **Table 2.2a** lists the floral species reported from Punjab. The floral elements represent Indian, Eastern (Indo-Malaysian), Western (African, Sudo-Sindian, Tropical African, Mediterranean-Oriental-European) and General (Tropical, Temperate & Cosmopolitan) elements. Five angiosperm taxa recorded in the state are unique in the world, whereas 8 species are new discoveries from India.

More than 2645 faunal species have been reported from the biodiversity rich areas of Punjab. **Table 2.2b** lists reported species of fauna. Amongst faunal diversity the state is especially rich in birds (428 species) and fishes (131 species) population. Two faunal species have been listed in the IUCN Red list of threatened animals, namely, Testudine Turtle and Smooth Indian Otter or Smooth-coated Otter, which are found in the wetlands of Punjab.

Table 2.2a: Types and number of floral species reported from Punjab

Type	Number
Algae	397
Fungi	948
Lichens	21
Bryophytes	34
Pteridophytes	48
Gymnosperms	21
Angiosperms	1939

Source: Jerath *et al., 2002, 2006*

Table 2.2b: Faunal Species

Group	No. of Species
Invertebrates	
Protozoa	86
Platyhelminthes	41
Nematoda	188
Annelida	56
Arthropoda	1389
Mollusca	94
Vertebrates	
Pisces	131
Amphibia	20
Reptilia	43
Aves	>500
Mammalia	97

Source: Jerath *et al., 2002, 2006*

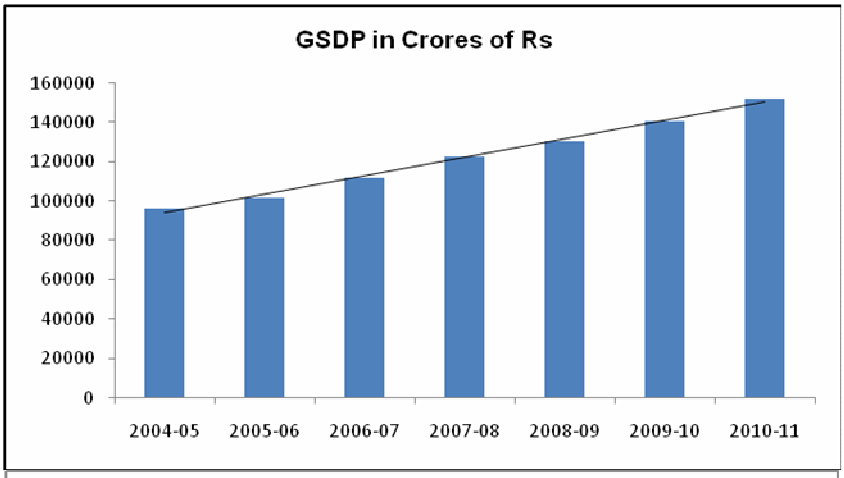
2.7 SOCIO ECONOMIC PROFILE

Economy

Punjab is one of the fastest developing states in India. The state has posted a steady growth during the last decade. The average real Gross State Domestic Product (GSDP) of the state has grown at around 7.8% during the period 2004-05 to 2010-11and has increased more than one and a half times from around Rs.96694 Crore in 2001-02 to around Rs.151941 Crore in 2010-2011. See **Figure 2.4a.**

The share of the primary sector has decreased from 37.54% to 23.45% during this period indicating the fatigue of the agriculture sector. During the same period however, the share of the secondary sector i.e. the industrial sector in the GSDP has increased significantly from 24.72% to 32.32%. The share of the tertiary sector comprising of the services sector including IT has increased from 42.69% to 44.19% during the same period. See **Figure 2.4b.**

(a)



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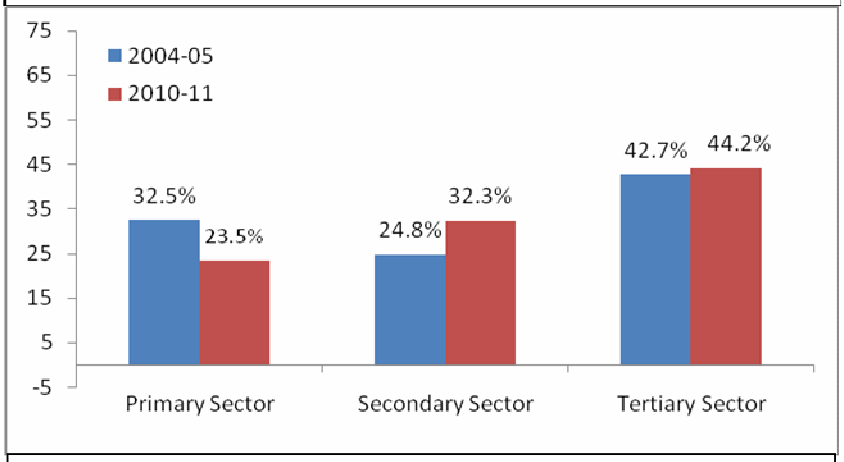

Primary sector: constitutes of Agriculture, horticulture, livestock, fisheries, forestry and logging, and mining and quarrying
Secondary sector comprises of Manufacturing, construction, electricity, gas and water supply
Tertiary sector: comprises of the service sector including transport, communication, IT, Banking, hotel industry amongst others

Figure 2.4 (a): Annual trend of Gross State Domestic Product of Punjab, (b) The changing share of sectors in GSDP between 2004-05 and 2010-11.
Source: Annual Plan 2011-2012, Department of Planning, Govt. of Punjab

2.8 AGRICULTURE

Punjab is the forerunner in the agriculture revolution in India that started in 1960s and relieved the country from importing food grains from abroad and making it a food secure nation. Consequently, agriculture and allied services play a significant role in Punjab's economy, it constituted 26.9% of the Punjab GSDP in 2010-11 (This figure includes GSDP of only agriculture and fisheries (source: *Punjab Annual Plan 2011-2012*). 70% of the population of Punjab is engaged in agricultural activities. The state government has accorded top priority to the development of Agriculture Sector. Sustenance of cereal production and productivity is not only important for the state but also for the food security of the nation.

Agriculture in Punjab is highly intensive in terms of agricultural inputs, such as, water, energy, nutrients, machinery, including the land value and capital invested. The state has about 83% of its total geographical area (50.362 lakh hectares) under cultivation. The cropping intensity is around 189% with over 98% of the cultivable area being under assured irrigation. Fertilizer consumption at 235 kg/ha is almost 1.84 times higher than the national average of 128 kg/ha. The State's farm

economy is highly mechanized. 18% of the country's tractors are in Punjab *(Punjab Annual Plan, 2011-12*).

Cereals

Punjab in 2011, produced 17224 thousand tons of food grains which was 11.26% of the total food grains produced in India. Punjab ranks 2nd and 3rd respectively amongst all states in production of wheat and rice. The key crops are rice and wheat, and Punjab produced 11.36% and 18.41% of total rice and wheat produced in the country (*PHD Chamber, 2011*). Between 1990 and 2010, the yields of rice and wheat have increased by 23.12%, and 13.26%, respectively (see **Figure 2.5**). However, in the recent years the productivity of both rice and wheat are plateauing.

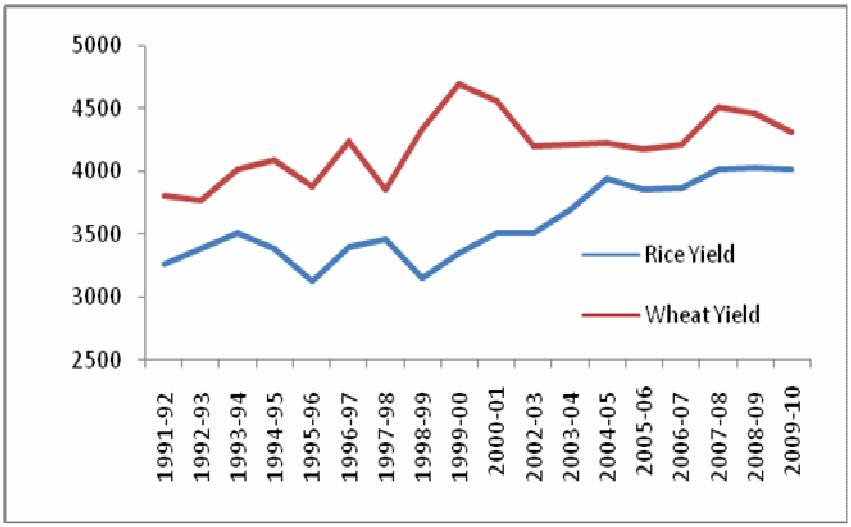

Figure 2.5: Trends of rice and wheat yields in Punjab

Source: Annual Plan 2011-2012, Department of Planning, Govt. of Punjab

Horticulture

Major horticulture and vegetable crops in the state include Citrus, Guava, Mango, Grapes, Potato, Sweet peas, Tomatoes etc. The production of fruits and vegetables between 1990-91 to 2010-11 in the state has grown from 663.8 to 1373.2 thousand Metrictonnes and 1450.0 to 3585.8 thousand Metric tonnes respectively. The production of lose flower, is however, reported to have remained the same at 82 thousand Metric tonnes through the period (*NHB, 2011)*.Though the production of fruits in the state in the 20 years has grown by about 106%, however, its share in total national production remains at 1.8% in 2010-11 (**Figures 2.6a**). Similarly, growth in production of vegetables during this period is also on the increase, however, its share in the national production in 2010-11 remains at 2.4% **(Figure 2.6b).**Never the less, the ecological conditions and availability of extensive irrigation cover, being one of the highest in the country, provides a conducive opportunity to profitably diversify further into horticulture production from rice-wheat cropping system in Punjab.

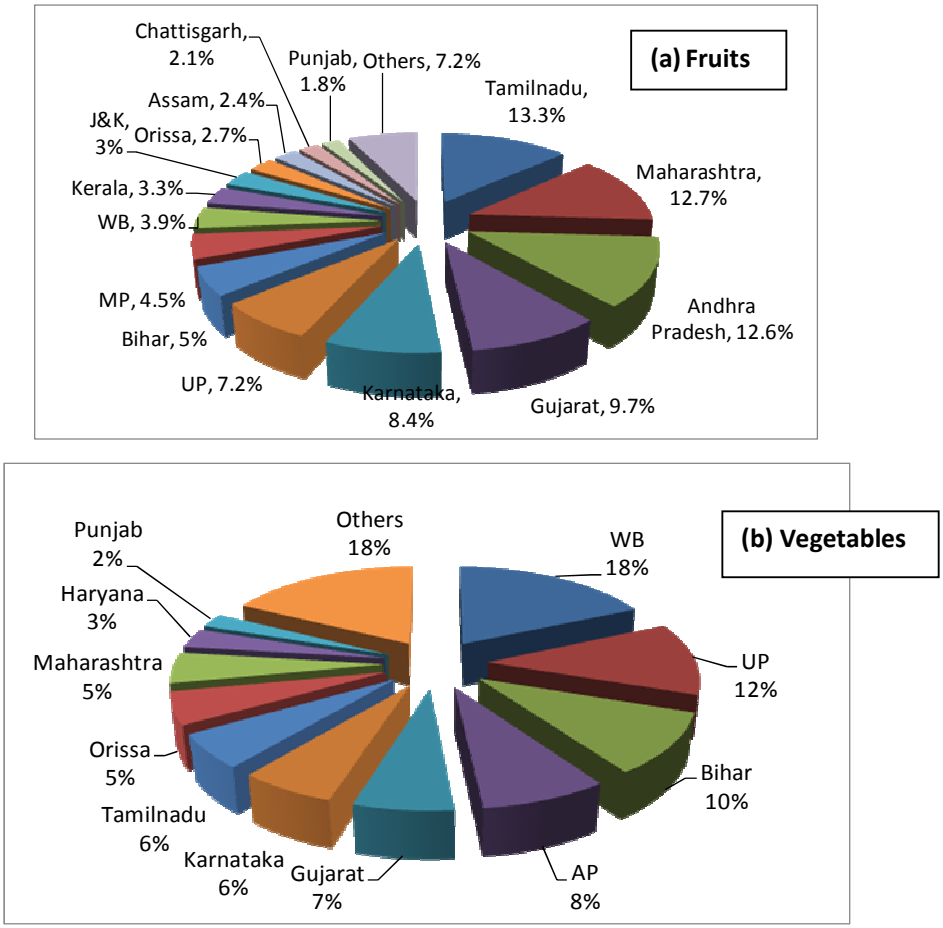

Figure 2.6: A comparison of share of production of (a) Fruits and (b) vegetables amongst different states in India

Source: NHB, 2011

Animal Husbandry and Dairying

Animal Husbandry and dairying augments income from agriculture significantly in Punjab. In 2012-13, Punjab ranked 5th in milk production amongst all states in India after Uttar Pradesh, Andhra Pradesh, Gujarat and Rajasthan, producing 9724 thousand tons of milk which is 8% of the total milk produced in India during that year (*DAHDF, 2010*)

There has been a decline (-13.9%) in total livestock population in the state from 8606 thousand to 7409 thousand with marginal increase in goat population (+4.3%) during the inter-census period of 2003 to 2007, indicating its increasing use as livelihood support for the small and marginal farmers (see **Table 2.3**).

It is interesting to note from **Table 2.4**, that though the numbers of cattle and buffalo have reduced between 2003 and 2007, the indigenous milch and breedable cattle and buffalo numbers have increased significantly. It is well known that indigenous animals can tolerate higher temperatures more than the cross bred and still be productive (*Aggarwal and Upadhyay, 1997*).Therefore the rising trends of indigenous varieties is an encouraging sign indicating that the gene pool of the indigenous cattle will be readily available in a changing climate scenario. See **Box 2.3** listing indigenous varieties of cattle in Punjab.

Table 2.3: Trends of Livestock in Punjab

Livestock	2003 ('000)	2007 ('000)	% Change
Cattle	2038	1777	-12.8
Buffalo	5995	5062	-15.6
Sheep	220	208	-5.5
Goat	278	290	4.3
Pigs	29	26	-10.3
Horses /Ponies	29	33	13.8
Mules	9	6	-33.3
Donkeys	5	5	0.0
Camels	3	2	-33.3
TOTAL	8606	7409	-13.9

Source: DAHDF, 2010

Box 2.3: Indigenous species of Livestock in Punjab

- Buffalo breeds –Murrah&Nili Ravi
- Cattle Breed- Hariana&Sahiwal
- Sheep Breed - Lohi, Nali, &Desi breeds of sheep
- Goat breeds - Beetal breed of goat
- Endangered- Sahiwal, Nilli Ravi, Lohi and Beetal

Table 2.4: A comparison of trends of indigenous and cross bred cattle and livestock in Punjab.

Livestock	2003 ('000)	2007 ('000)	% Change
Indigenous Cattle	508	498	-2.0
Breedable cattle indigenous	136	178	30.9
Cross bred Cattle	1531	1278	-16.5
Breedable cattle cross bred	782	714	
Buffalo	5995	5062	-15.5
Milch Buffalo	3106	2779	-10.5
Milch crossbred cows	741	683	-7.8
Milch Indigenous cows	124	166	33.9

Source: DAHDF, 2010

Fisheries

The state of Punjab is bestowed with vast lotic and lentic aquatic resource. Aquaculture sector is contributing more than 6 tonnes/ha/yr with an annual growth of 10%. The existing resources are the rivers Sutlej (280 km), Beas (160 km), Ravi (150 km) and Ghaggar (39 km), 14500 kms of canals, 4370 hectare small reservoirs/ wetlands and ponds. In Punjab, at present 10,856.60 hectare area is under fish culture and there are around 7500 fish farmers having fish farming units of 0.1 hectare to 5.0 hectare.

Punjab fish farmers have made the concept of industrial fisheries a reality. Besides earning a net profit of more than Rs. 2.0 lakhs per hectare per year from fish farming, they are using their fish pond fertile water as source of assured irrigation for the agricultural fields for cost effective agricultural produce. The major fish species which are being promoted for pisciculture in the state are *Labeorohita* (Rohu), *Catlacatla* (Katla), *Cyprinuscarpio* (Common carp), *Ctenopharyngodonidella* (Grass carp) and *Hypophthalmichthysmolitrix* (Silver carp) [*Source: Inputs for SAPCC from Deptt. of Animal Husbandry, Dairying and Fisheries*].

Punjab has recorded tremendous growth in the fisheries sector in the last three decades. Fish production has increased from 28 thousand tonnes in 1980-81 to 122.86 thousand tonnes in 2009-10. In 2010-11, the production however reduced to 97.04 thousand tons. See **Figure 2.7** (*Source: Annual Report, 2011-12; Department of Animal Husbandry, Dairy Development and Fisheries,*

Ministry of Agriculture, GoI). At present, aquaculture productivity of the state is 6.04 t/ha/yr, which is more than double the national productivity of 2.60 t/ha/yr (*Source: The Tribune, Fishing for Success by KanchanVasdedv, Dec, 2009.*)

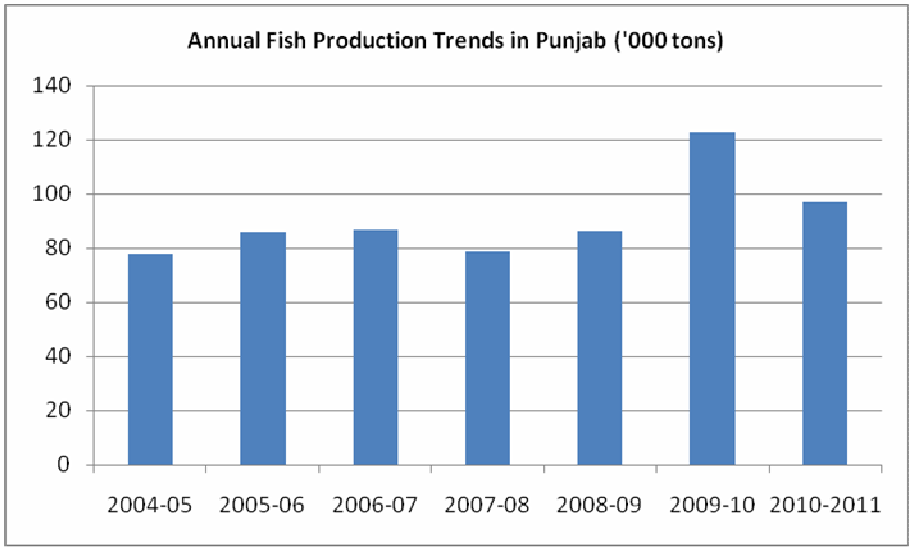

Figure 2.7: Trends of Fish production in Punjab
Source: DAHDF, 2012

2.9 PHYSICAL INFRASTRUCTURE

The state has been ranked first amongst the big states in terms of infrastructure. Punjab has also been declared as one of the best states in India in terms of irrigation facility, rail, road and transport network, and waste management (*Debroy and Bhandari, 2010)*.

Irrigation and Drainage

The irrigation infrastructure in the state mainly comprises of surface irrigation and ground water irrigation. About 72% of the requirement of irrigation (30 MAF) is met through the tube wells dotting the Punjab landscape. As of 2009-2010, 13.15 lakh tubewells were operational in the state (Pb*SAP, 2010*).

The rest (14 MAF) is met from surface water sources which mainly comprise of the 14500 km long canals and distributaries. There are 10 main canal systems, and they are the Sirhind Canal system, Bist Doab Canal system, Bhakra Main Line (BML) Canal System, Upper Bari Doab Canal system, Kashmir Canal, Ferozepur Feeder/Sirhind Feeder system, Eastern Canal system, Makhu Canal System, Shahnehar Canal system and the Kandi Canal system. Additionally, the Rajasthan Feeder and Bikaner Canal which carry Ravi-Beas & Sutlej water exclusively for Rajasthan, also run a considerable length within the Punjab Territory (*Source: Department of Irrigation, Gov. of Punjab*). See **Figure 2.8**. All draw water from reservoirs created due to construction of three major dams, namely, the BhakraNangal dam on river Sutlej, RanjitSagar dam on river Ravi and the Pong dam on river Beas. The estimated value at the present price level of Water Resource Infrastructure in the State is more than Rs.50,000.00crore (*Source: Department of Irrigation, Government of Punjab*).

The lower part of the Sirhind Command area suffers from problems of drainage and salinity. The problems arise due to the flat terrain and inadequacy of natural drainage. An extensive programme was started to minimize groundwater recharge by improving surface drainage, lining canals and distributaries, and more recently, tertiary canals and watercourses. In contrast, in the northern parts of Punjab the groundwater is fresh. The Punjab government has announced a Rs. 1441 Croresproject for re-lining of the Rajasthan and Sirhind feeder canals to prevent seepage into ground which is one of the causes of water logging in this area. Relining will also address salinity issues.

Figure 2.8 Canal Network in Punjab (*Source: ADB, 2011)*

Access to Safe Drinking Water

Punjab tops the chart among Indian states in the availability of safe drinking water to 97.6% households, which is significantly high as compared to the national average of 77.9% (*Economic Survey, 2010-11*). The water is sourced from canals, tube wells and percolation wells and from hand pumps. See the status of coverage by source as of February 2012, in **Table 2.5.**

Table 2.5: Water source, no. of schemes, and status of coverage of rural drinking water as of 29th Feb. 2012.

	Scheme	Major Habitats	Other Habitats	Total Habitats
Canal Water	762	1061	653	1714
Tube well	5872	9730	1075	10805
Hand pumps	1456	1036	458	1494
TOTAL	8090	11827	2186	14013

Source: Department of Water Supply and Sanitation

In the urban areas, the Punjab Water Supply and Sewerage Board and the Punjab Water and Sanitation department are together responsible for providing potable water in the state. The water supply in urban areas has so far covered 88 urban centres (cities and towns) and reached 103.87 lakh population or 88% of the total urban population. Water is supplied through 11868 kms network

of pipes, 1972 tube wells and through 354 overhead storage reservoirs (*Source: Punjab Water Supply and Sewerage Board*).

Clearly, Punjab has made great strides in making drinking water available to its population. However, accessibility of safe drinking water is still an issue. Water pollution due to discharge of industrial waste water, untreated discharge of municipal waste water in some towns and leaching of chemicals from synthetic fertilizers and pesticides into the soil, causes both surface water and ground water pollution. In addition to this the state is facing fluoride, chloride, nitrate, iron, and Uranium contamination in ground water in areas where over extraction is taking place and also the problems of salinity in the southern parts of the state.

The Punjab government is carrying out a number of activities to maintain water quality and abate water pollution, such as identifying sources of pollution, regular water pollution monitoring through its various departments, setting up CETP (Common Effluent Treatment Plants) in various industrial areas to clean industrial waste water, putting up Reverse Osmosis systems to combat the impacts of fluoride and salinity, undertaking major programmes for cleaning up river waters amongst others. For details see chapter 4.

Housing

Despite a quantitative increase in the housing over successive decades, it continues to be insufficient. As per the Census 2001, the State had a housing shortage of 3 lakh units of which 2.10 lakh units shortage was in urban areas and 90,000 units in rural areas. However, the number of dilapidated houses in the State was 1.81 lakh units both in urban and rural areas. Besides, the state had houseless population of nearly 47,000. As of 2007, the urban housing shortage in the State was 6.90 lakh units (MoHUPA, 2006) and requirement for 2007-12 was about 12 lakh additional units (PHHP, 2008).

Municipal Solid Waste Management

Municipal Solid Waste includes commercial and residential wastes generated in municipal or notified areas in either solid or semi-solid form excluding industrial hazardous waste, but including treated bio-medical waste (*MoEF, 2000 a and b*).

As per the study carried out by Punjab Pollution Control Board (PPCB, 2006, as quoted in Tiwana*et al.,* 2007), in the highly populated cities of Ludhiana, Amritsar, Patiala and Jalandhar, it was found that the per capita waste generation ranged between 460 g/capita/day to 610 g/capita/day, Ludhiana being the highest per capita generator of MSW. The total solid waste collected in Punjab during 2009-10 was 1007 thousand tonnes as per the PPCB data quoted by Punjab State Council for Science &Tehnology (PSCST, 2011).

The total waste generation in the state is continuously increasing with growth in population, urbanization, high per capita income, increase in construction and commercial activities, increase in slaughter houses and shift towards western lifestyles. However, urbanization is the key driving factor amongst all. See **Box 2.4** showing the urban population characteristics in 2011 in Punjab.

Box 2.4: Key Population facts influencing waste generation in Punjab in 2011

- 37.49 percent of Punjab population is urban by residence.
- Ludhiana (59.14%), SAS Nagar (55.17%), Amritsar (53.64%) and Jalandhar (53.18%) are predominantly urban and the most urbanized in Punjab; Tarn Taran is the least urbanized district (12.63%).
- 49.2 percent of the urban population is concentrated in four districts, namely, Ludhiana, Amritsar, Jalandhar and SAS Nagar. Ludhiana is the most urbanized.
- Every 5th urban dweller in Punjab is residing in Ludhiana.
- Between 2001 and 2011, the urban population in Punjab has increased by 25.72% which is twice the overall population growth rate and 3 times the growth rate of rural population.

Source: Census, 2011

Based on average per capita generation of 532 g/day (derived from *Tiwana et al., 2007*), and using the 2001 and 2011 urban population it is estimated that the total waste generated in Punjab increased from 1604.4 thousand tons to 2015.6 thousand tons annually during this period. Hence MSW generation increased from 4395.6 tons/day to 5526 tons/day between 2001-2011. The district wise trend of waste generation is shown in **Figure 2.9.**Waste generation in all the districts have increased substantially, in commensuration with the rise in population. However, drastic increase in MSW generation is seen in SAS Nagar (>100%), SBS Nagar (54%) and in Bathinda (42%).Rest of the districts show a rise in MSW generation by 12-26% between 2001 and 2011.

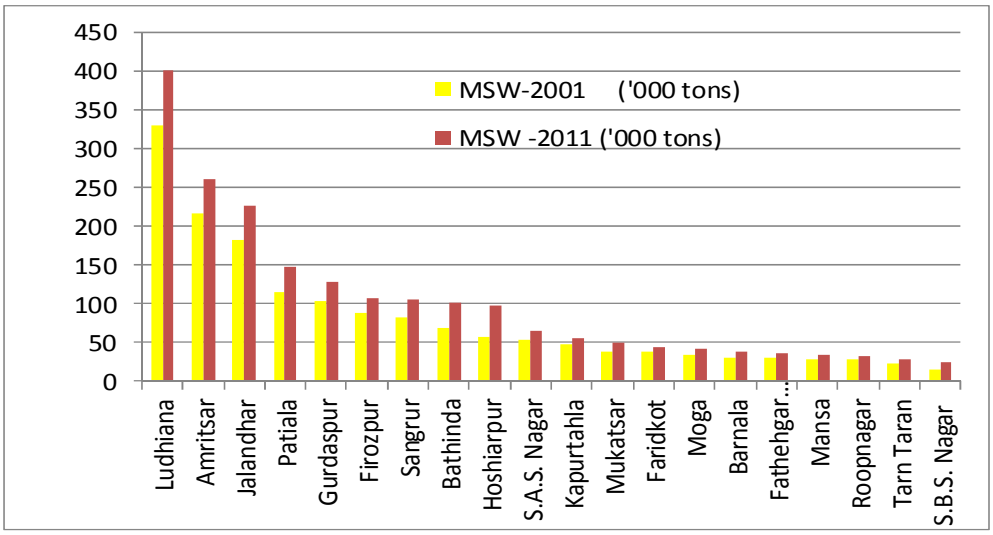

Figure 2.9: Changing trends of MSW generation in different districts of Punjab

Box: 2.5 Integrated Waste Management Programme

Considering the waste generation and waste management situation, the Punjab government has started an Integrated Waste Management Programme across the state in 8mega clusters (Jalandhar, Ludhiana, Bathinda, Ferozepur, Patiala, Amritsar, Pathankot and Greater Ajitgarh Area Development Authority-GMADA) covering 15-30 cities and towns, thereby including 137 towns in the state. Solid waste generated of the order of 4000-5000 tons per day from these towns would be utilized for producing power, compost or other useful products and finally remaining residual material will be disposed in landfills. This project would be operated and maintained by public private partnership for 25 years.

Roads

Roads form the major infrastructure for surface mode of transportation services in Punjab. The state has an extensive 60881 km network of roads comprising of 1749 km of national highways, 1479 km of state highways, 2112 km of major district roads, 4482 km of other district roads and 51059 km of village link roads. Several initiatives and road upgradation projects have been undertaken by the state. A sum of Rs. 428.07 crores have been allocated by the state for the development of road infrastructure and transport for the fiscal year 2012-13 *(Punjab Planning, 2012)*

Between 1980 and 2010, the volume of passenger vehicles on the roads of Punjab have increased by 21 times, with maximum increase in two wheelers (22 times), three wheelers (20 times) and cars and station wagons (19 times). Comparatively the goods vehicles have only registered growth by 8 fold. The growth of total number of vehicles (passenger and goods) on Punjab roads is depicted in **Figure 2.10.**

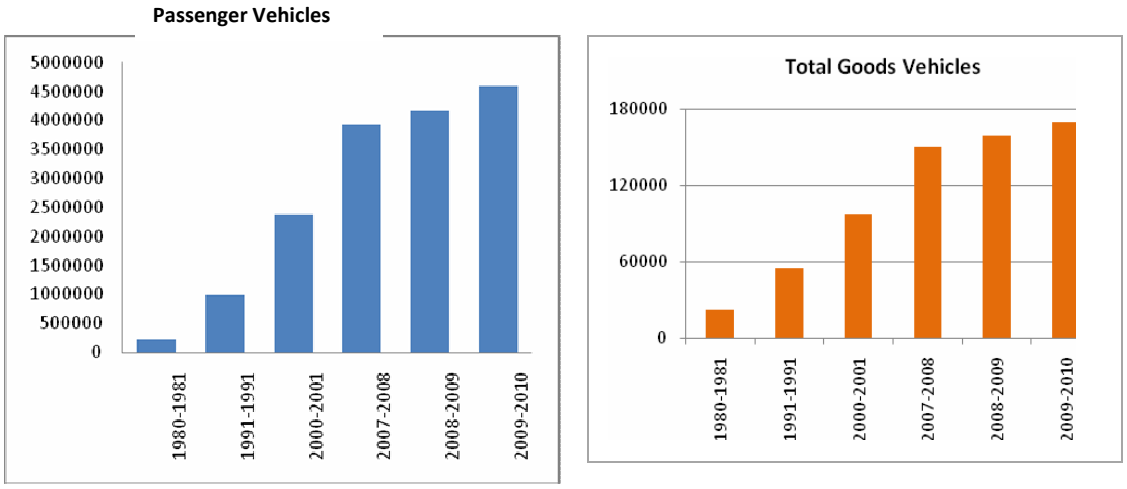

Figure 2.10: Growth of passenger and goods vehicles in Punjab between 1980 and 2010.

Source: PbSAP 2011.

Railways

The railways play a significant role in the state. It connects major industrial units such as oil refining, cement, fertilizer, thermal power and manufacturing sectors to suppliers and markets. Punjab offers good railway infrastructure and its network spans over 2,098 km. The main inter-state railway routes are

- Amritsar-Ambala-Delhi,
- Sriganganagar-Ambala-Delhi,
- Ferozepur-Ludhiana-Ambala,
- Pathankot-Rupnagar-Fatehgarh Sahib and
- Sriganganagar-Bathinda-Narwana.

Aviation

The state has made considerable progress in the field of civil aviation. Punjab has three domestic airports which are located in Chandigarh, Ludhiana and Pathankot. The International flights operate from the Raja Sansi International Airport at Amritsar. Upgradation and extension of air terminals and aerodromes is ongoing. The new Greenfield Ludhiana airport is proposed to be developed by the state as an aerotropolis. Also construction of new airports is in progress at Ajitgarh, Bathinda and Ludhiana.

Power

The installed capacity for power generation in Punjab was 5180 MW in 2010-11, and it generated 27464.57 Million KWH of electricity (CSO, 2012; PbSAP, 2011). Table 2.6 gives the conventional power infrastructure created in Punjab as of March 2011. In addition, 28.5 MW of biomass power is being generated in the state (*Source, Punjab Energy Development Agency)*. The trend of installed capacity is depicted in **Figure 2.11a**.

The highest consumer of electricity is the Industry (34.22% of total electricity consumed in the state in 2009-10, see **Figure 2.11 b**). All urban centres have 100% coverage and according to Census 2011, 95.5% of the rural households in the state have direct electricity connection.

Table 2.6: Power infrastructure created in Punjab as of 2010-2011.

Installed Capacity (Own) (Including Common Pool)	4878 MW	Length of 11KV line	177419 Ckt km
Share from Central Sector Projects	1940 MW	No. of grid Sub Stations	775
Total Installed Capacity	6900 MW	No. of Distribution Transformers	47223811
Maximum Demand Met Within 2010-11	8007 MW	Length of LT Lines	164093 Ckt km
Energy Sent Out	46985.57MU	No. of Connections	7320631
Connected Load	27385.044 MW	(i) General	6056471
Per Capita Consumption	1236 kwh/yr		
No. of Villages with Urban Pattern Supply including Deras and Dhanis	18866 Nos.	(ii) Industrial	117844
T and D Losses(Including Commercial)	20.12%	(iii) Agriculture	1143267
Length of Transmission Lines	16424 Ckt km	(iv) Others	3049

Source: Punjab Annual Plan, 2011.

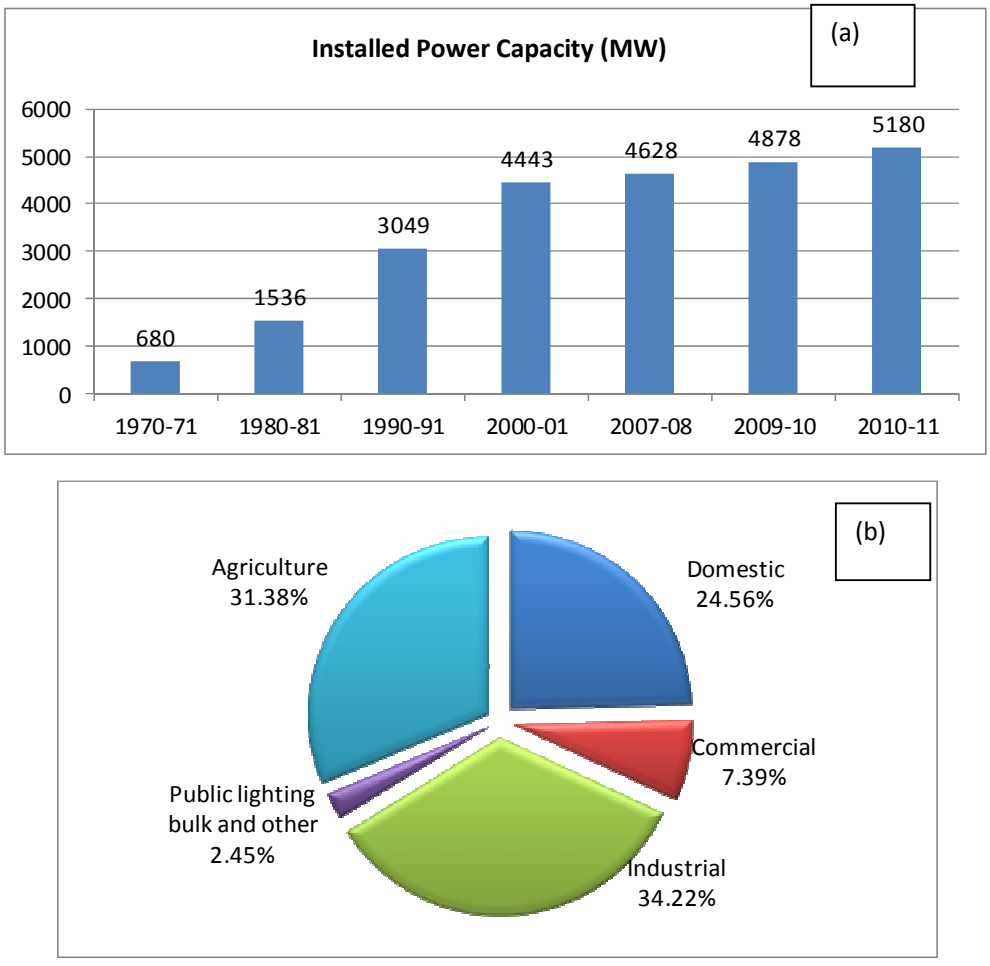

Figure 2.11: Trends of (a) installed power capacity in Punjab between 1970-71 and 2009-10; and (b) Share of electricity consumption by various sectors in Punjab in 2010-11.
Source: PbSAP, 2011

The per capita electricity consumption is 271 KWH by Domestic sector, 81 KWH by Commercial sector, 377 KWH by the Industry, 27 KWH by Public lighting and 346 KWH by agriculture. The total

per capita consumption being 1102 KWH which is almost 1.5 times the national average of 779 KWh (PbSAP 2011).

The demand for power in the State is rising sharply on account of rapidly increasing use of electrical energy for agricultural operations, progressive industrialization, high living standard of residents and intensive rural electrification programme. With a view to make the state self-reliant and power surplus, four new thermal plants namely Talwandi Sabo 1980 MW, Rajpura 1400 MW, Goindwal Sahib 540 MW and Gidderbaha 2640 MW have been undertaken. The state has also proposed to set up 1000 MW gas based power plant at Ropar.

Telecom

As of end of July 2011, Punjab telecom circle had 30517574 wireless subscribers which are 3.55% of total wireless subscribers in India. About 1543842 wire line subscribers existed, which is 4.51% of the total wire line subscription in India (TRAI data base, July 2011). The tele-density in the state is 75.4 per cent, significantly higher than the national average of 52.7 per cent. The state has 3,904 post offices, 24 telegraph offices and 1,510 telephone exchanges. The telecom operators in the state include BSNL, BhartiAirtel, Idea Cellular, Vodafone Essar, Reliance Communications, Tata Teleservices, Tata Docomo and Videocon.

Industry

As of March 2009, the state had 944241 small scale industries, 1196 units of medium scale industries and 207895 units of large scale industries (*Source: Department of Industries and Commerce*). These are well diversified and include production of food and beverage, tobacco, leather, wood products, chemicals, metals, non metallic minerals, machinery and tools, cycles, textiles, Coke, Refined Petroleum Products, Tourism, Handicrafts, agribusiness, IT etc.

GSDP from secondary sector that includes manufacturing industries has increased 2.75 times between 2000-01 to 2009-10 from Rs. 16145 Cr to Rs. 44473 Cr. The GSDP from secondary sector accounted for about 31.55% of the total GSDP of the state in 2009-10. In comparison, the share of tertiary sector which includes IT and other service industry was 43.53% and that of agriculture was 24.92%. (*Source: Punjab Annual Plan, 2011*). See **Figure 2.12.**

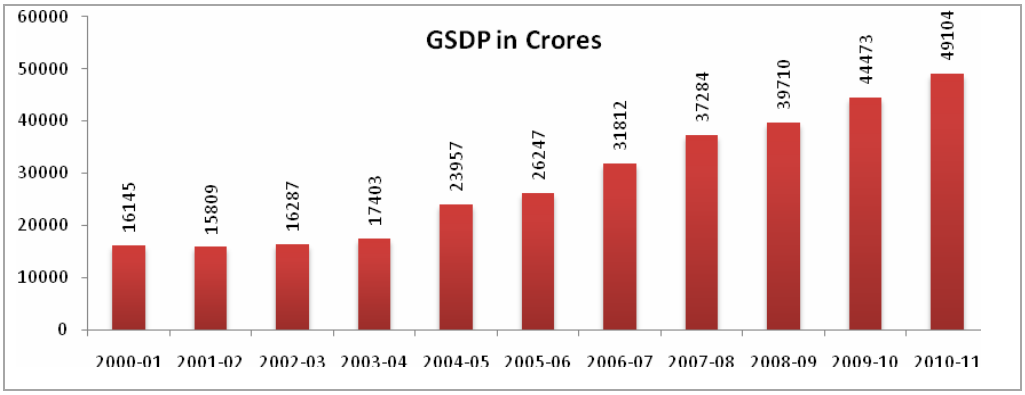

Figure 2.12: Indicator of trends of Growth of Industry in Punjab in terms of growth of GSDP of the secondary sector that includes manufacturing. *Source: Annual Plan, 2011*

The state offers a wide range of subsidies, fiscal and policy incentives and excellent infrastructure, to provide conducive milieu to foster investments and development for industries. The state has emerged as a key hub for textile based industries including yarn, readymade garments and hosiery. The state has successfully established IT Park and Electronics Township (ELTOP) at Ajitgarh for promotion and growth of IT and electronics industry in the state. The process for development of Biotechnology Park is underway.

To boost industrial output, the state government announced its new industrial policy, 2009 which focuses on creating favorable destination for investment and to establish synergy between

agriculture and industrial sectors and to rejuvenate small scale sectors. Further, it has formulated an Agro Industry Policy in 2009, to take advantage of its strong agro base and encourage investment in this sector. Also an IT/Knowledge Industry Policy 2009 of the govt. aims to harness the opportunities and the resources offered by the Information Technology and Knowledge Industry for the comprehensive social and economic development of the State.

This sector also provides an opportunity for energy saving. An estimate made by the BEE indicates that the total amount of energy that can be saved in this sector is equivalent to 4.76 BU, representing 15.63% of the annual energy sold in the state. The SMEs are being targeted for energy saving at a cluster level for energy efficiency by BEE in association with PEDA. The larger industries are being targeted under the EC Act and the PAT scheme of the GoI.

Small and medium enterprises (SMEs) face the challenge of extracting the latent value of their intellectual property (IP) and using it effectively in their business strategies. The Punjab State Council for Science & Technology (PSCST) has identified 18 micro, small and medium enterprise (MSME) clusters across the state for creating IP rights-related awareness. In order to help MSMEs the ministry has set up the IPFC at the Patent Information Centre (PIC), PSCST, in Chandigarh, under the National Manufacturing Competitiveness Programme (NMCP). The basic objective of the PIC is to enhance MSMEs awareness of their IPRs. **See Table 2.7.**

Table 2.7: List of SMEs identified for raising awareness on IPR

	Cluster Name	Location		Cluster Name	Location
1	Machine Tools	Ludhiana and Batala	10	Electroplating	Ludhiana
2	Hosiery	Amritsar and Ludhiana	11	Dyeing	Ludhiana
3	Agricultural Implements & Machines	In and around Moga	12	Ball Bearings & Auto Parts	Jalandhar(Goraya)
4	Pipe Fittings	Jalandhar	13	Textiles	Amritsar (Batala Road)
5	Switchboards	Phagwara	14	Leather Bags & Leather Tanning	Jalandhar
6	Bathroom & Sanitary Fittings	Ajitgarh	15	Wooden Inlay Handicrafts	Hoshiarpur
7	Automobile Parts & Industrial Components	Ajitgarh	16	Tractor Ancillary Units	Ajitgarh
8	Hand Tools	Jalandhar	17	Foundaries	Batala
9	Sports Goods	Jalandhar (BastiNau)	18	Drug and Pharma	DeraBassi

Source: PSCST, 2010

2.10 SOCIAL INFRASTRUCTURE

Education

In Punjab, the male literacy rate is 81.5% and the female literacy rate is 71.3% and average literacy rate is 76.7% as per the census 2011. The literacy rate of Punjab has grown at the rate of 6.99% between 2001 and 2010 and in2011 it lies above the national average literacy level of 74.0%. It has an all India rank of 21st on literacy scale among all Indian states and UTs and 14th among the states.

The state has 9 universities which includes a Central University at Bathinda, and 234 graduate colleges. School education system in the state consists of 14160 primary schools, 3920 middle schools and 5146 high schools. In 2010, 38.17 lakh students were enrolled in schools and 271791 students were enrolled in colleges (*Source: Basic Statistics of Punjab, 2010*).

Some of the world class institutions in Punjab in various fields are:

- Medicine- The state has a number of medical colleges and some of them are Christian Medical College, Ludhiana; Baba Farid University of Health Sciences, Faridkot; Government

Rajindra Medical College, Patiala; Govt. Medical College, Amritsar and Adesh Medical College, Bathinda.

- Engineering and IT- National level Engineering and IT institutions include The Indian Institute of Technology, Ropar; National Institute of Technology, Jalandhar.
- Agriculture and Animal Husbandry- Punjab Agriculture University, Ludhiana; Guru AngadDev University of Veterinary and Animal Sciences, Ludhiana.

Besides, the government has many institutions for technical education, 5 government promoted engineering colleges, 89 self-financed engineering colleges, 33 B. Pharmacy, 139 management institutions, 18 government/aided polytechnics and 119 self-financed polytechnic colleges in the state, one fashion institute (NIFT), and 2 Hotel Management Institutes.

The government has issued the Punjab Private University Policy 2010, for the purpose of setting up of self-financed private universities. Permission has already been granted to DAV University at Jalandhar, Lovely Professional University Jalandhar, and Chitkara Institute of Engineering and Technology, Patiala.

Health Infrastructure

Government of India in its 4th Common Review Mission Report has rated health infrastructure of the state as excellent and placed the state at number one position. Around 90 per cent of non-hospital healthcare and 67 per cent of hospital care cases are handled by private healthcare services. **Table 2.8** summarizes the Punjab state health indicators and infrastructure.

Table 2.8: Health indicators and Health Infrastructure in Punjab

Population served per doctor	1,225
Population served per institution	1,3698
Per Capita health expenditure	Rs.1359
Infant mortality rate	41 per thousand live births
Birth rate	17.2(2010)per thousand per annum
Death rate	7.0(2010)per thousand per annum
Infant mortality rate	34 (2010)
Life expectancy at birth (years) -Male -Female	 69.8 72.0
Hospitals	63
Community health centers	129
Dispensaries	1309
Primary health care	446
Ayurvedic and Unani Institutions	529
Homeopathic institutes	107
Medical Institutes	1942
Number of beds	20,375

Source: Punjab Economic Survey, 2010-2011

References

1. ADB, 2011.Appendix 2- Lower Sutlej Sub Basin. Published as a Part of the Final Report- TA 7417- IND: Support for the National Water Mission - National Action Plan on Climate Change. Prepared for Govt. of India and state govt. of Punjab by Asian Development Bank.
2. Aggarwal,A. and R. C. Upadhyay, 1997.Pulmonary and cutaneous evaporative water losses in Sahiwal and Sahiwal X Holstein cattle during solar exposure. Asian Australasian J. Anim. Sci.10, 318-323.
3. Basic Statistics of Punjab, 2011.Published by Punjab Planning Board. http://pbplanning.gov.in/pdf/basicStat2011in_eng.pdf. Accessed on Dec 5, 2012,
4. Census,2011. Directorate of Census Operations, Punjab Government, Government of India. http://punjabcensus.gov.in/ Accessed on Dec 5, 2012.
5. CSO, 2012. Energy Statistics 2012. Central Statistical Office, National Statistical Organisation, Ministry of Statistics and Programme Implementation. Government of India.
6. DAHDF, 2010.Basic Animal Statistics, 2010, Department of Animal Husbandry, Dairying and Fisheries, Ministry of Agriculture, Government of India.
7. DAHDF, 2012. Annual Report, 2011-12; Department of Animal Husbandry, Dairy Development and Fisheries, Ministry of Agriculture, GoI
8. Debroy, B. and L. Bhandari, 2010. The State of the state's study, Published by India Today.
9. Economic Survey, 2012.Punjab Economic Survey.Punjab Planning Board, Government of Punjab.
10. ISFR, 2011.India State of the Forest Report.Published by Forest Survey of India, Ministry of Environment and Forests, Government of India.
11. ISFR-Punjab, 2011. Report for the Punjab State Published in India State of the Forest Report. Published by Forest Survey of India, Ministry of Environment and Forests, Government of India.
12. Jerath, N., P. Nangia, A. Kaur, and J. Chaddha (eds.), 2002. *Strategy and Action Plan for the Conservation of Biodiversity in Punjab*. Punjab State Council for Science & Technology, Chandigarh, pp. 338.
13. Jerath, N., Nangia, P. and Chadha, J. (Editors), 2006. Biodiversity in the Shivalik Ecosystem of Punjab; Published by Punjab State Council for Science and Technology, Govt. ofPunjab.
14. Jerath, N., S. K.Saxena, K. K.Gangwar, R. Singh (eds.), 2010.Soils of Punjab, ENVIS News Letter, vol. 7, no.4.
15. MoEF, 2000a.Notification on Bio-Medical Waste Rules (Management and Handling) Second Amendment. Notified by Ministry of Environment & Forests, Govt. of India.
16. MoEF, 2000b.Notification on Municipal Solid Wastes (Management and Handling) Rules, 2000.Notified by Ministry of Environment and Forests, Government of India,2000.
17. MoHUPA, 2006. Estimation of urban housing shortage.Report of the Technical Group – 11th Five year plan 2007-12; GoI, Ministry of Housing and Urban Poverty Alleviation, Government of India.
18. NHB, 2011. Indian Horticulture data base, 2011, Published by National Horticulture Board, GoI.
19. PbSAP, 2010. Statistical Abstract of Punjab, 2010.Published by the Department of Economic and Statistics, Government of Punjab
20. PbSAP, 2011. Statistical Abstract of Punjab, 2011.Published by the Department of Economic and Statistics, Government of Punjab.
21. PbSAP, 2012. Statistical Abstract of Punjab, 2011.Published by the Department of Economic and Statistics, Government of Punjab.

22. PHD Chamber, 2011. Punjab State Profile: 2011; Published by PHD Research Bureau. Chandigarh, Punjab.

23. PHHP, 2008. Punjab Housing and Habitat Policy, 2008. Accessed from www.nhb.org.in/Urban_Housing/PUNJAB%20HP.pdfon Jan 2013,

24. PSCST, 2010. Wetlands of Punjab. ENVIS Centre News letter, Vol. 7, Issue 3.Punjab ENVIS Centre, Punjab State Council of Science and Technology, Govt. of Punjab.

25. PSCST, 2011. Status Report on Municipal Solid Waste Management in Punjab. Punjab State Council for Science and Technology, Chandigarh, Punjab.

26. Punjab Annual Plan, 2011.Planning Board, Government of Punjab.

27. Punjab Annual Plan, 2012.Punjab State Planning Board. Government of Punjab

28. Punjab Planning, 2012. Punjab 12thFive year Plan and Annual Plan, 2012-13, Vol. I- Statements and Vol II- Write up, Dept. of Planning, Govt. of Punjab, GoI

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3. Observed and Projected Climate

HIGHLIGHTS

- Observed Climate Trends in Punjab
- Examples of Spatial Variation in Observed Trends Within the State
- Basin level trends of Observed Climate- Sutlej Basin
- Climate change projections for the state level
- Climate Change Projections at the Sutlej River Basin Level

3.1 OBSERVED CLIMATE TRENDS IN PUNJAB

Temperature

The Annual Climate summary for 2010, published by the Indian Meteorological department (IMD, 2011), indicates that the maximum and minimum temperatures in the Punjab region have increased by 0.5-1.0°C and by 0.5 to 1.5°C respectively in 2010 with respect to the base line 1971-2000 (see **Figure 3.1).**The trend of annual rise in temperature has been observed.

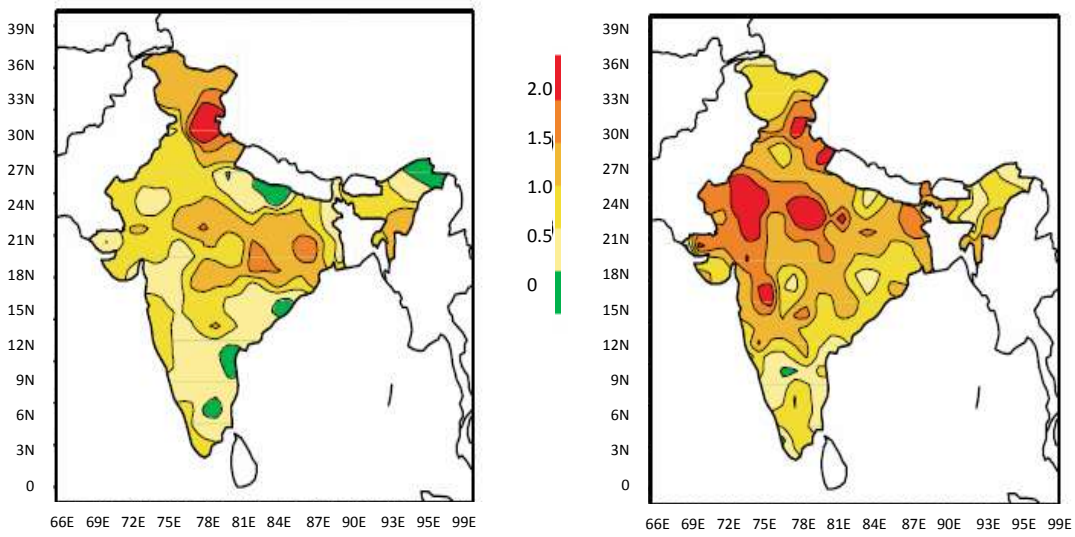


Figure 3.1: Spatial pattern of Annual (a) Maximum temperature and (b) Minimum Temperature anomalies in 2010 with respect to (1971-2000).

Source: IMD, 2011

Precipitation

In 2010, Punjab experienced deficit in rain fall with respect to its long term average. This was mainly due to scanty rainfall received during winter, summer and monsoon periods. The departure of rainfall with respect to long term averages is presented in **Figure 3.2.**

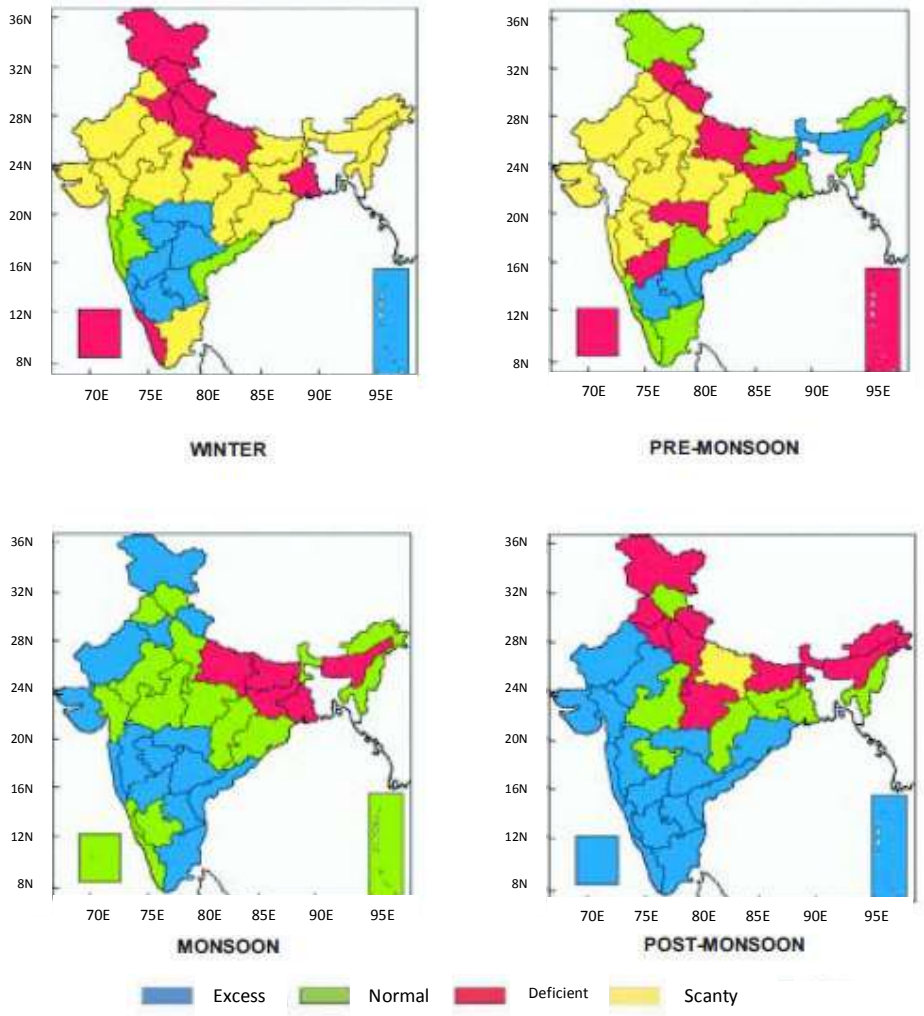


Figure 3.2: Division wise departures in rainfall in 2010 in India with respect to the Long Period Average (LPA).

Source: IMD, 2011

Analysis of inter-annual variability of area weighted seasonal monsoon rainfall expressed as the percentage departures from long period average (LPA) for the period 1901-2011 for Punjab indicates that during the period 1901 -2011, the lowest and second lowest seasonal rainfall in Punjab have occurred in 1911 (-51.0%) and in 1987 (-67.6%) respectively. Highest and second highest seasonal rainfall in Punjab have occurred in year 1950 (+ 91.2%) and in 1988 (+ 119.1%). The most significant characteristic of this rainfall series of Punjab is that the magnitude of highest positive anomaly is relatively higher than that of the highest negative anomaly in. This could be due to the fact that apart from large-scale vertical motion, the influence of moisture convergence of extra tropical weather on monsoon regime may be responsible for enhancing rainfall over the area. Out of the 30 deficit years

during the period of 1901-2011, 23 were drought years in Punjab and 13 years were associated with El Nino events. Similarly out of the 29 excess monsoon years, 6 years were associated with La Nina.

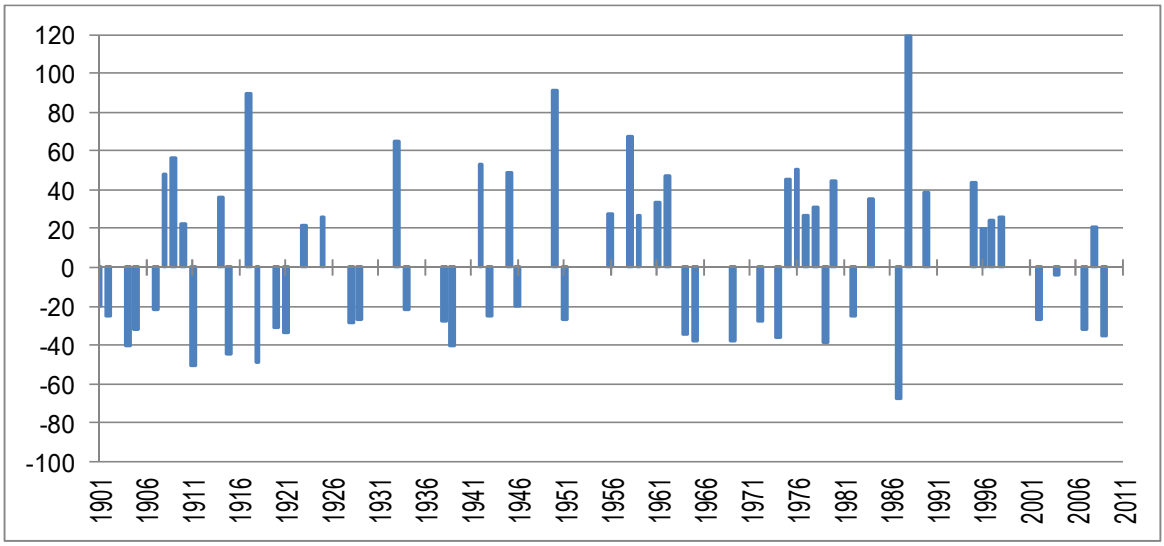


Figure 3.3: Percentage departure of rainfall in mm between 1901 and 2011 in Punjab with respect to the corresponding Long Period Average (LPA)

Source: IMD, Chandigarh Centre, 2012

Extreme precipitation events

Extreme events are categorized by IMD as i) light to rather heavy rainfall ($0 < R \leq 64.4$ mm), ii) heavy rainfall ($64.4 < R \leq 124.4$ mm) and iii) very heavy to exceptionally heavy rainfall ($R > 124.4$ mm). Rainfall events> 124.4 mm are referred as extreme rainfall events (Pattanaik and Rajeevan, 2010). The frequency of extreme rainfall (Rainfall ≥ 124.4 mm) shows increasing trend over the Indian monsoon region during the southwest monsoon season (June-July-August-September). It is also found that the increasing trend of contribution from extreme rainfall events during June-July-August-September is balanced by a decreasing trend in category-i (rainfall ≤ 64.4 mm/day) rainfall events. Like the frequency of extreme rainfall events, the contribution of extreme rainfall to the total rainfall in a season is also showing a highly significant increasing trend during the monsoon season from June to September.

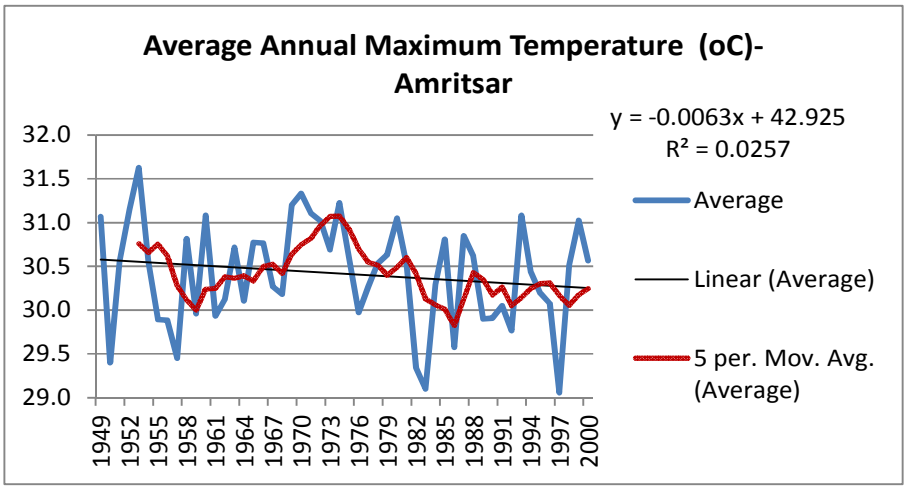
3.2 EXAMPLES OF SPATIAL VARIATION IN OBSERVED TRENDS WITHIN THE STATE

Amritsar

Analysis carried out for Amritsar district based on monthly mean data on temperature and rain fall available for the period 1949 to 2000, from the IMD website (http://www.imd.gov.in/section/nhac/mean/Amritsar.htm), indicates an overall decrease in maximum and minimum temperatures (**Figure 3.4**). The average maximum temperature decreased by -0.32°C during the 41 year period at the rate of -0.02°C annually and the annual average minimum temperature decreased by -0.8°C during the same period at the rate of -0.1°C annually.

The annual average rainfall increased in Amritsar by +150mm between 1949 and 2000, indicating an increase of +3.7 mm per year. However, there are distinct variations in changes in rainfall across the seasons over the 41 year period (see **Figure 3.5**). The pre-monsoon rainfall, the monsoon rainfall and the winter rainfall all show an increase during this period, except for the post monsoon rainfall.

On an average, the pre monsoon rainfall, monsoon rainfall and winter rainfall increased by about +18 mm, +14 mm, and +8 mm respectively between 1949 and 2000. The post monsoon rain fall decreased by about 10mm.



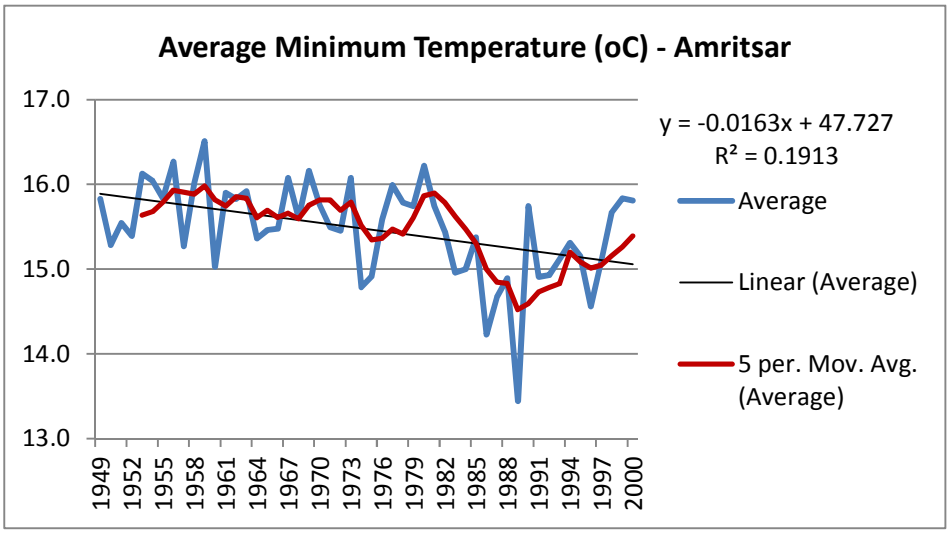


Figure 3.4: Annual average Temperature trends in Amritsar (Data *source: IMD Climate data of important stations in India, Accessed from http://www.imd.gov.in/section/nhac/mean/110_new.htm) in Feb 2013.*

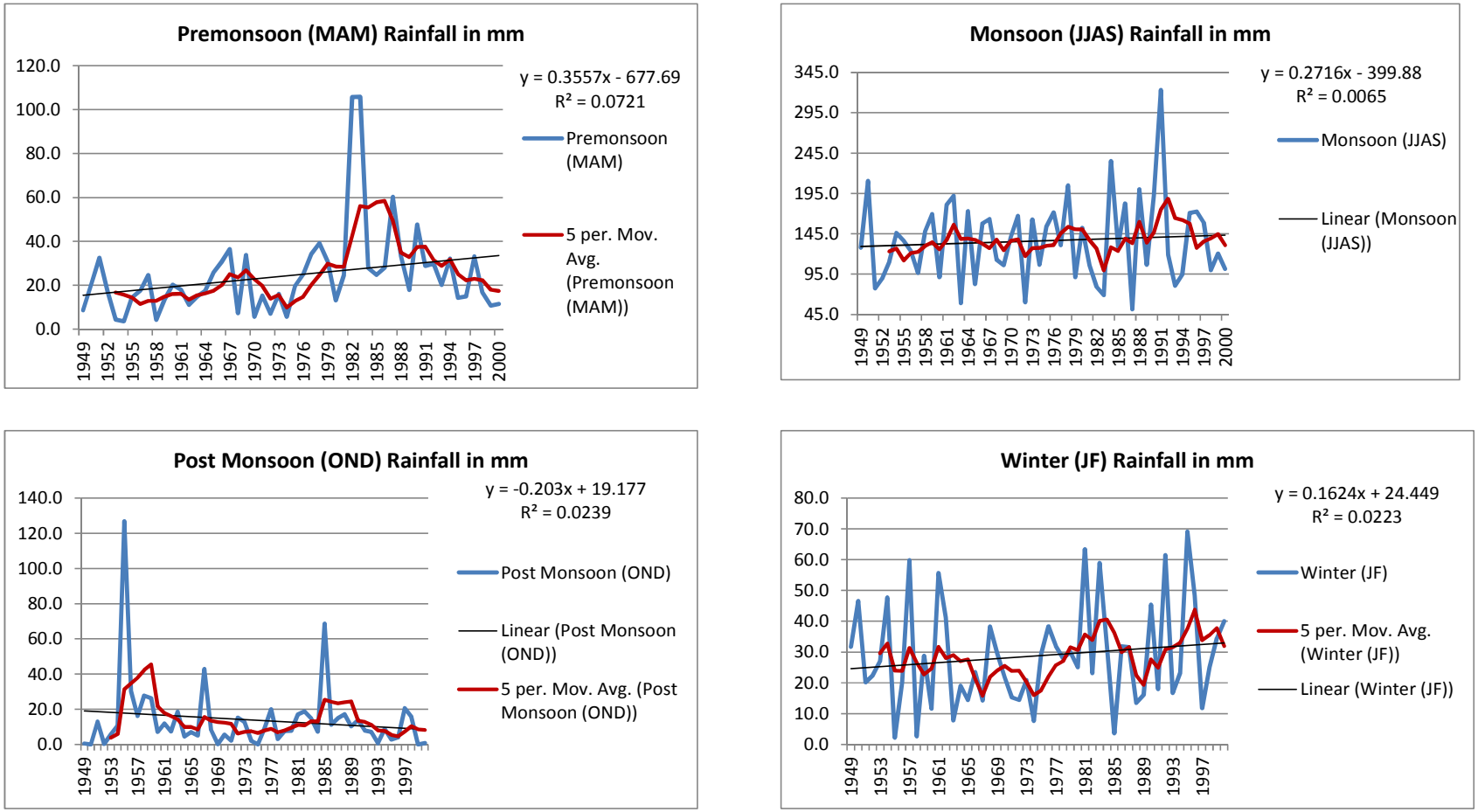


Figure 3.5: Trends of Seasonal Rain fall in Amritsar between 1949 to 2000.
Data Source: As in Fig 3.4

Ludhiana

The daily maximum and minimum air temperature data analysed from 1970-2004 for Ludhiana (*Prabhjyot Kaur et al., 2006*), indicates a decrease in mean annual maximum temperature though no significant trend could be observed (**Figure 3.6a**). On the other hand, the annual minimum temperature has increased at the rate of 0.07°C/yr during the same three decades at Ludhiana (**Figure 3.6b**). The annual rainfall analysis revealed that the annual rainfall has increased significantly at the rate of 6.6 mm/year over the past three decades (**Figure 3.7**).

The above trends studied in Ludhiana & Amritsar are sub sectoral and need to be understood in the larger context of trends of observed climate in Sutlej Basin.

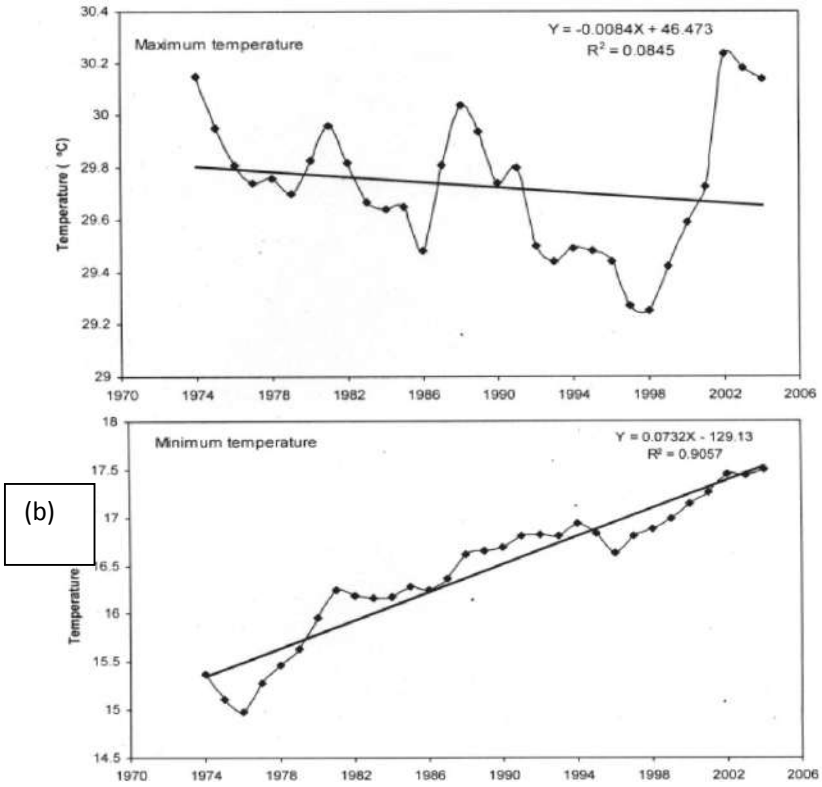


Figure 3.6: Trends in annual maximum and minimum temperatures (5 yr moving averages) in Ludhiana. *Source: Prabhjyot Kaur et al., 2006*

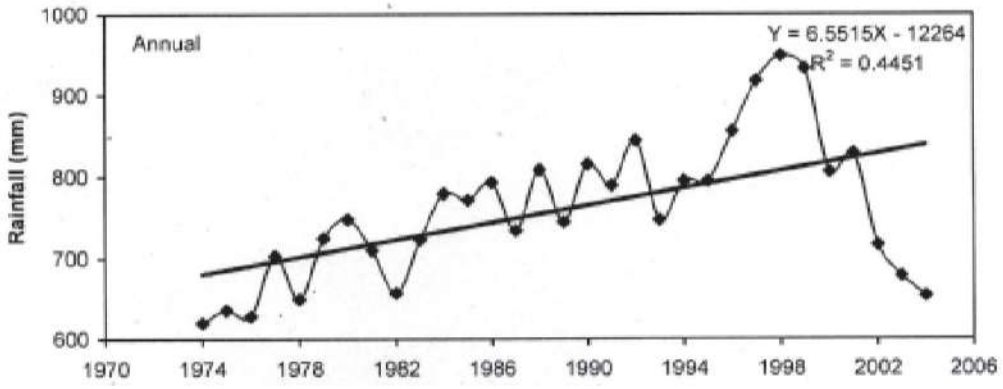


Figure 3.7: Trends in annual changes in Rainfall in Ludhiana (5 yr average)

Source: Same as Figure 3.6

3.3 BASIN LEVEL TRENDS OF OBSERVED CLIMATE – SUTLEJ BASIN

The Sutlej River is the longest of the five rivers that flows through north-western India. The lower end of the basin covers a substantial part of Punjab. Water from this river contributes significantly to make per ha food grain production in Punjab, which is one of the highest in the country at 4144 kg/ha (*MoA, 2011*). This is largely due to the combination of conducive climate, natural resources, namely, soil and water and skilled farmers. Since the last one decade production of wheat has remained stagnant around 15 million tons (*PHD Chamber, 2011*).This can be attributed to maintenance of intensive agriculture practices inspite of higher winter temperature, which are detrimental to the wheat crop. Therefore, any change in the climate of the region is likely to have profound effect on the agricultural productivity of Punjab.

Temperature

The Sutlej river basin is partly located in the Indian state of Punjab. The annual temperature range in Punjab is from -2 to 40 °C (min/max), but can reach extremes of 47 °C in summer and -5 °C in winter. Climatically, Punjab has three major seasons. Hot season is from April to June when temperature rises as high as 43°C. The rainy Monsoon season is from July to September. The monsoon onset tends to be quite late. The cold season is between October to March when minimum temperatures can fall below 0 °C.

Rainfall

The Sutlej basin with spatial variation in precipitation is shown in **Figure 3.8.** It is clear that towards the lower end of the basin, the precipitation is <400 mm, compared to the Shivalik region where it is greater than 950mm. There is an indication that droughts in the southwest of Punjab or at the lower end of the basin may be becoming more extreme (Source: ADB, 2011). The variation in the changes in rain fall can be derived from the observations made in Ludhiana which lies at the centre of the Basin in the Punjab region and Amritsar which lies partially within the basin at the North West end.

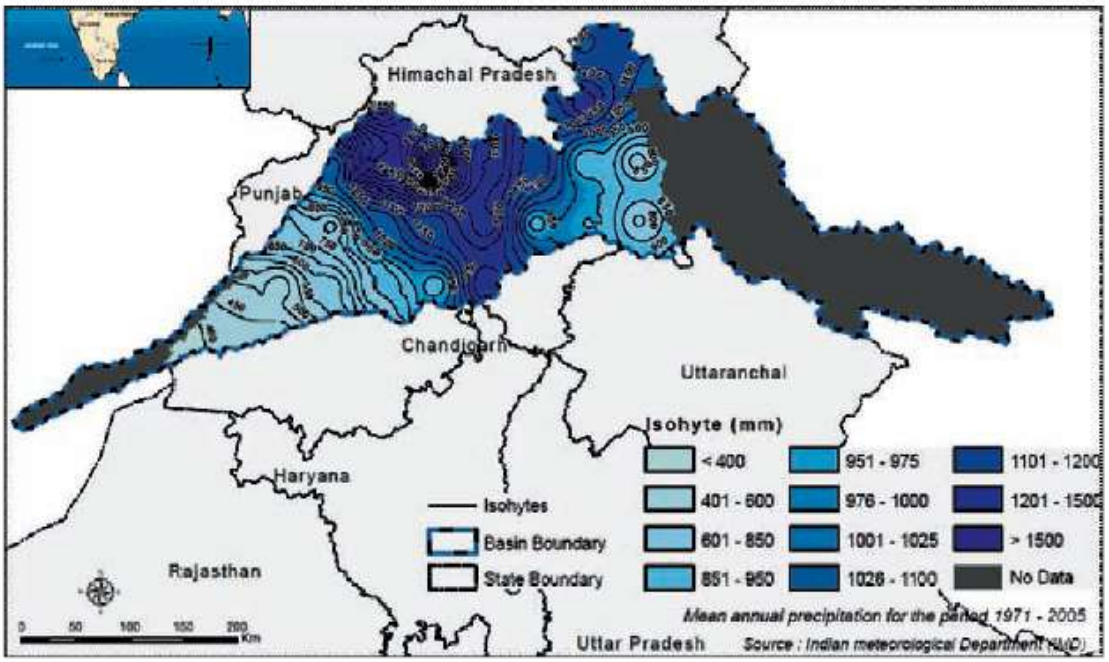


Figure 3.8: The Sutlej basin and spatial variation of rainfall within.
Source: ADB, 2011 with data from IMD.

Snowfall

The snow fall data is taken into account as the perennial rivers of Punjab are snow fed. Although snow falls in the Western Himalayas are reported to be reducing, no specific significant trend has been observed in the Sutlej basin. On an average the snow fall ranges between 5000 to 7000mm (ADB, 2011). Studies by ICIMOD show a small rising trend between 2000 and 2010 (**Figure 3.9**). About 65% of the basin area is covered with snow during winter, which reduces to about 11% after the ablation period. There are already reports of earlier melts especially at lower levels.

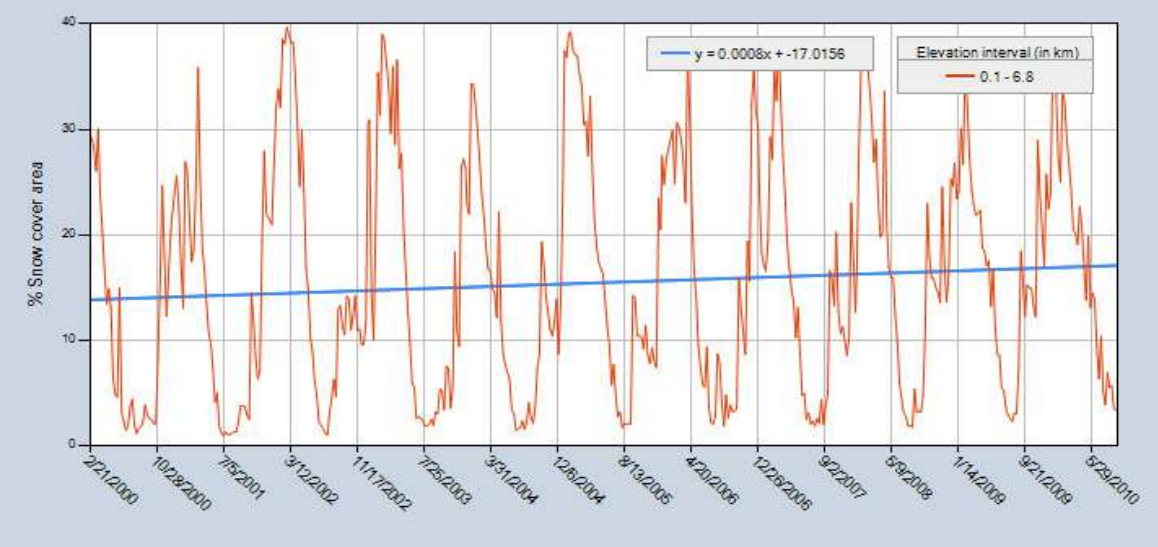


Figure 3.9: Rising trends of snow cover in the Sutlej basin between 2000-2010.
Source ADB, 2011

Glaciers

The number of glaciers feeding into Sutlej are estimated to be 935 in number spread over 1234 km^2, which have an average estimated ice volume of 77BCM (*ADB, 2011*). There is good evidence and local report of glacier decline especially in the lower catchments. Example, shrinking of Baspa glacier and increase in water levels due to GLOFs in Parechu river and hence increase in silt flow in Naptha Jhakri Chamera II and Baspa dams etc. which are in the Sutlej basin in the upstream in Himachal Pradesh (Source: Project Location and Environmental Context; www.*sjvn.nic.in/projects/rampurpdf/CEIA-PartI.pdf.)* The situation in the higher catchments are less clear; visual indications indicate quite large variations with some glaciers showing very high levels of loss and others quite robust with little change (ADB, 2011).

Inflow into Bhakra

The records of inflows to Bhakra reservoir from the Sutlej River are available since 1962. The mean annual inflow from the Sutlej River in the period April 1962 to March 2009 is recorded to be 14,450 Mm^3. The mean annual inflow from the Bhakra Sutlej Link in the period April 1978 to March 2009 was 4345 Mm^3. The coefficient of variation in annual inflows from the River Sutlej is 0.16. The variance in annual inflows is significantly lower than the variance in annual precipitation, and this will be as a result of the influence of snow and glacier melt. (Source: ADB, 2011).

3.4. CLIMATE CHANGE PROJECTIONS AT THE STATE LEVEL

Projected changes in Precipitation

An overall increase in annual precipitation is projected in the mid (2021-2050) by about 13.3%-21.5% with respect to base line 1961-1990 (**Figure 3.10a**). On a seasonal basis (**Figure 3.10b**), in the mid-century (2021-2050), the precipitation is likely to increase by 11.5-20.8% during the monsoon period (June-July-August-September) in the entire state with respect to the base line. The increase is likely to be higher in the post- monsoon period (October-November-December) ranging between 30.0-63.9%, with precipitation increasing from east to west. In the winter period (January-February), the precipitation shows a decrease in most areas of the state by upto 21.8%with respect to base line. In the pre-monsoon period (March-April-May), all parts of Punjab are likely to experience a mixed trend, with change ranging between -4.7 to 29.1% with respect to base line.

An important aspect which needs to be understood is that though the total precipitation increases, most of it will be lost as runoff during flood like situations and will not significantly help to improve ground water table unless adequate harvesting structures are in place.

Box 3.1: Tool for assessing Climate change
PRECIS- Model and driver scenario

Climate projections for 2021-2050s and 2071-2098 for Punjab have been derived from PRECIS (**P**roviding **R**egional **C**limate for **I**mpact **S**tudies). The simulation dataset is provided by the Indian Institute of Tropical Meteorology, Pune. PRECIS is a portable version of the HadRM3 regional climate change model, developed by the Hadley Centre UK. The model outputs have a spatial resolution of 0.44° x 0.44° (50km x 50km).

The climate change scenarios are driven by the IPCC GHG emission scenarios - A1B (IPCC, SRES, 2001), which assumes a future world of very rapid economic growth, a global population that peaks in mid-century and declines thereafter, and assumes rapid introduction of new and more efficient technologies.

The boundary conditions for the model are driven by the outputs of the Hadley Centre HADCM3 GCM with the Q14 member of the QUMP (Quantifying Uncertainty in Model Predictions) ensemble.

Changes in mid-century (2021-2050) and end of the century (2071-2098) have been derived with respect to base line simulations for the period 1961-1990.

Projected changes in Temperature

The annual mean maximum temperature is projected to increase by 1.0-1.8^{o}C with respect to the base line in all parts of Punjab by 2021-2050 (**Figure 3.11a,** middle panel). By the end of the century, however, the mean maximum temperature may increase further by 4.0 to 4.4^{o}C. The annual mean minimum temperature is also projected to rise by 1.9-2.1^{o}C by mid-century (see **Figure 3.11 a**, right panel), with respect to base line (1961-1990), and it is likely to increase further by 4.4 to 5.1^{o}C at the end of the century.

At a seasonal scale (**Figure 3.11b**), the mean maximum temperature is likely to rise by 1.8 – 2.2^{o}C during the pre- monsoon period (March-April-May) with respect to the baseline (1961-1990). In the monsoon season, the mean maximum temperature is projected to rise between 1.1-1.8^{o}C. In the post monsoon period (October-November-December) and winter period (January-February), the mean maximum temperature is projected to increase by 0.3-1.6^{o}C and 0.6-2.3^{o}C respectively. The mean minimum temperature is also projected to rise, with maximum rise in the pre and post monsoon periods.

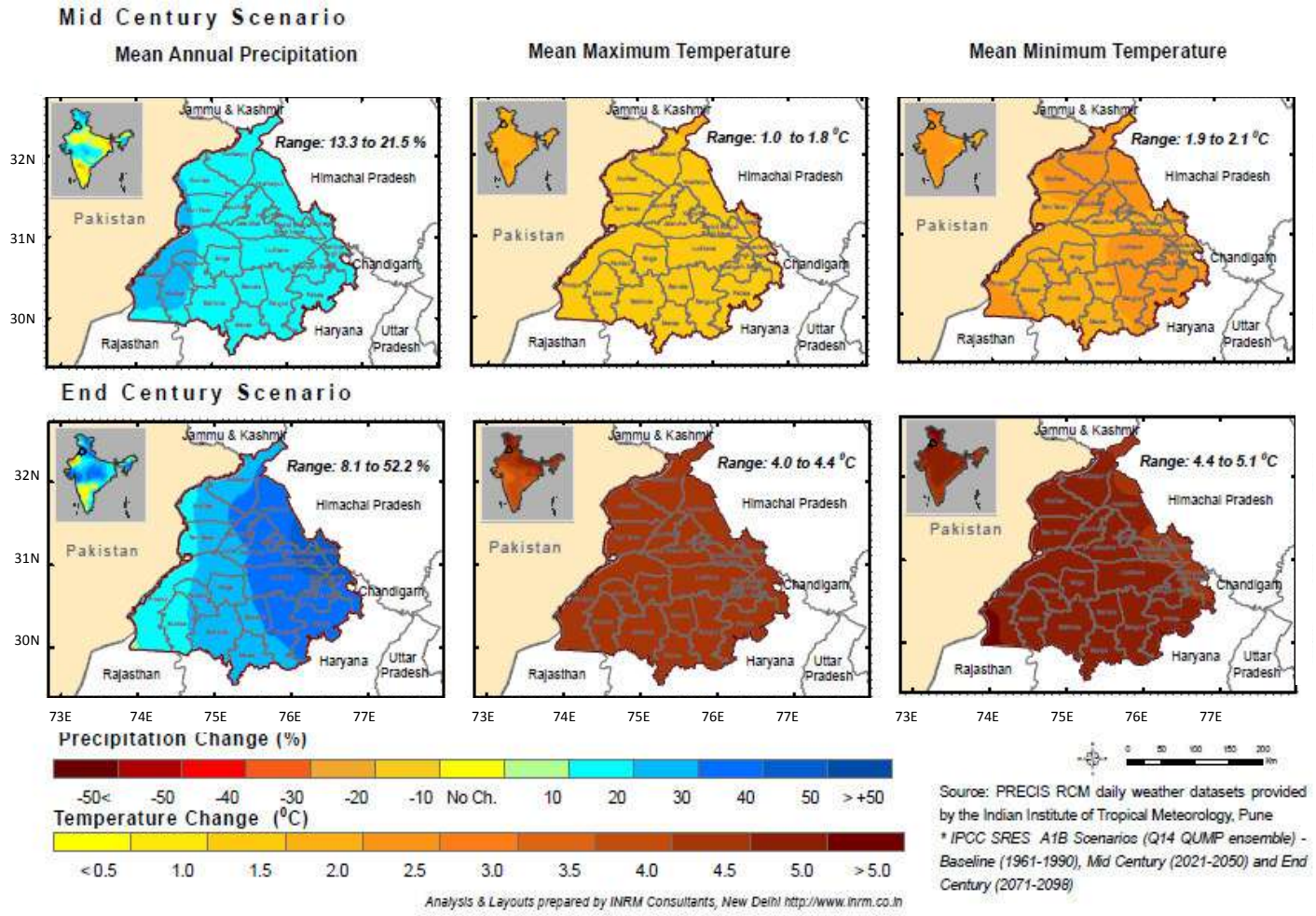


Figure 3.10a: Projected changes by mid-century (2021-2050) and end century (2071-2098) in mean seasonal precipitation (left panel), mean maximum temperature (middle panel), and mean minimum temperature (right panel) with respect to base line (1961-1990).

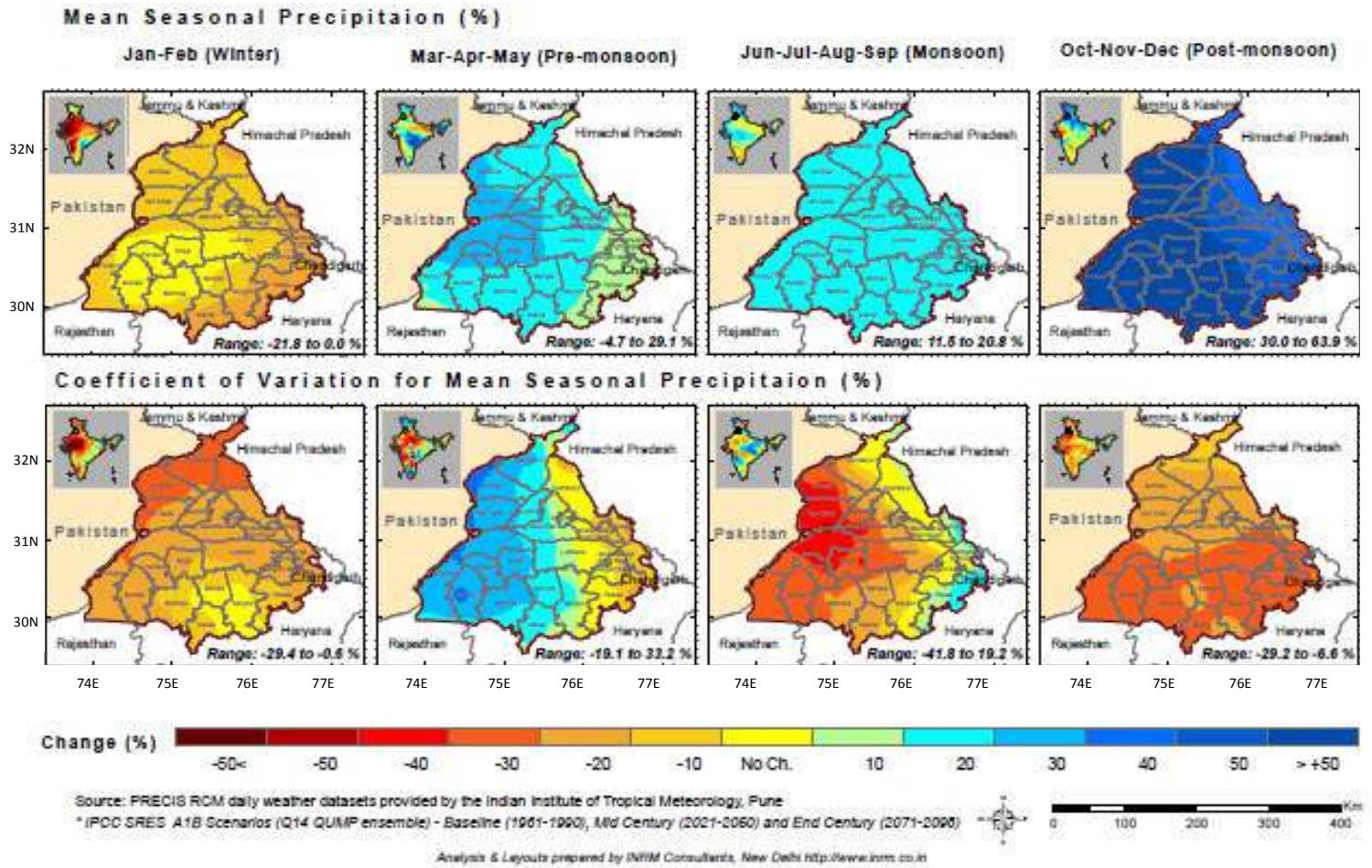


Figure 3.10b: Projected changes in mean seasonal precipitation by mid-century (2021-2050) and end century (2071-2098) with respect to base line (1961-1990)

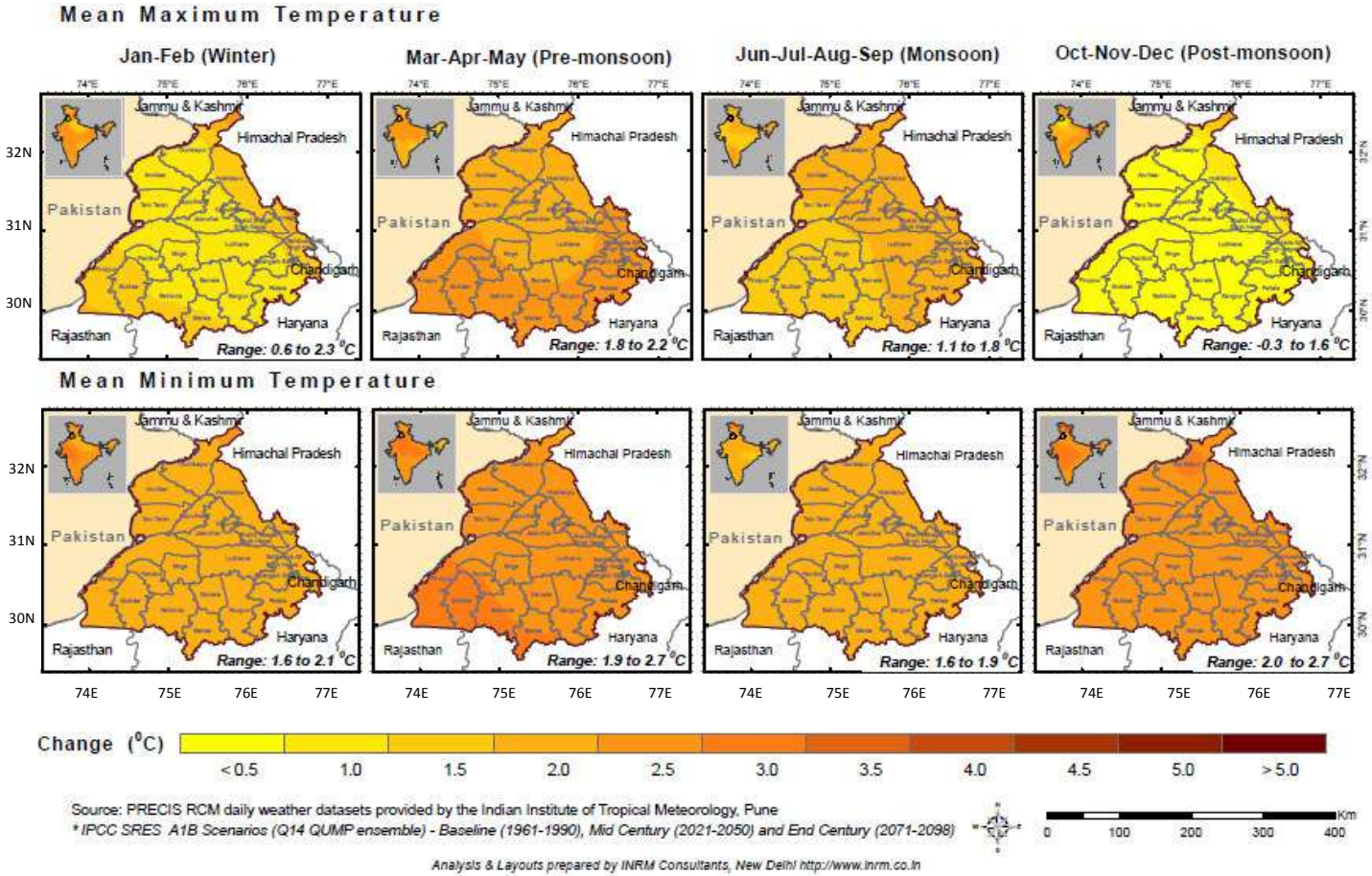


Figure 3.11a: Projected future changes in mean seasonal maximum and minimum temperatures by mid-century (2021-2050) with respect to base line (1961-1990)

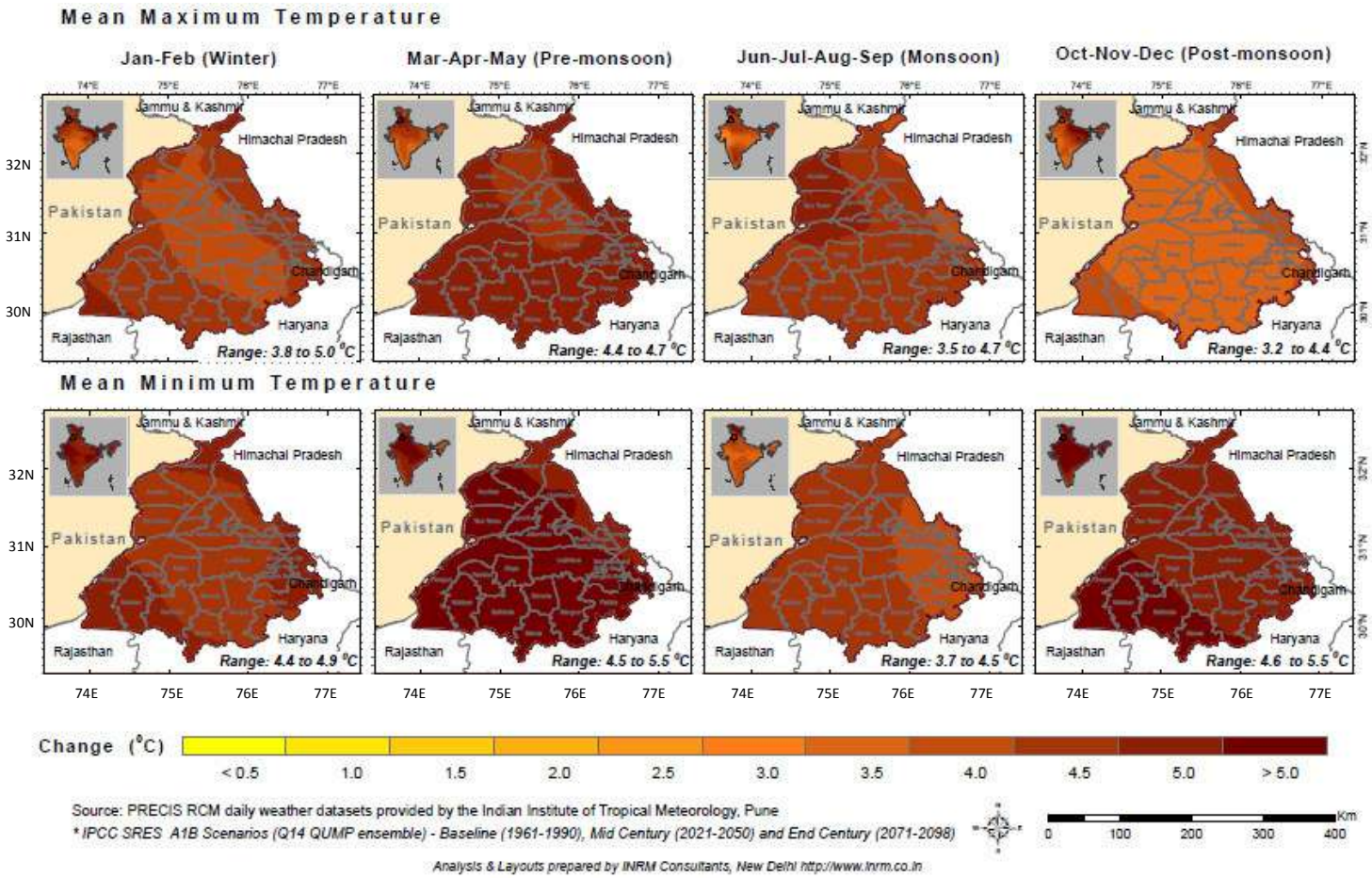


Figure 3.11b: Projected future changes in mean seasonal maximum and minimum temperatures by end of century (2071-2098) with respect to base line (1961-1990).

3.5 CLIMATE CHANGE PROJECTIONS AT THE SUTLEJ RIVER BASIN LEVEL

A study has been carried out by ADB in 2011, to assist the water mission in the National Action Plan in Climate Change. This section summarises the climate change projections made in this study.

Temperature

Projected temperature range (max & min) for the basin from downscaled Quantified Uncertainty Model Projection (QUMP) results for the A1B emissions scenario are shown in **Table 3.1**. The whole basin is projected to warm significantly, with minimum temperatures rising most pronouncedly in some of the high altitude regions in the north and east of the basin. Under the A1B scenario the projected increase in minimum temperatures in the winter months is double that of the maximum temperatures. The changes in minimum temperatures projected under the A1B scenario would have a significant impact on snow accumulation and glacial melt in the upper Sutlej. The distribution of temperature changes under the A2 and B2 scenarios is very similar to that of A1B. Spatial spread of changes in temperature is shown in **Figure 3.12**.

Table 3.1: Projected Daily Minimum and Maximum temperatures (°C) in 2021-2050s A1B scenario with respect to base line (1961-1990)

	JF	MAM	JJAS	OND	Annual
Mean daily maximum					
Base line	5.3	19.7	25.0	11.0	15.3
2021-2050s	7.0	21.8	26.6	12.3	16.9
Mean daily minimum					
Base line	-9.6	5.6	11.9	-7.1	0.2
Mean Daily Minimum	-2.9	12.0	13.8	-4.3	4.7

Source: ADB, 2011

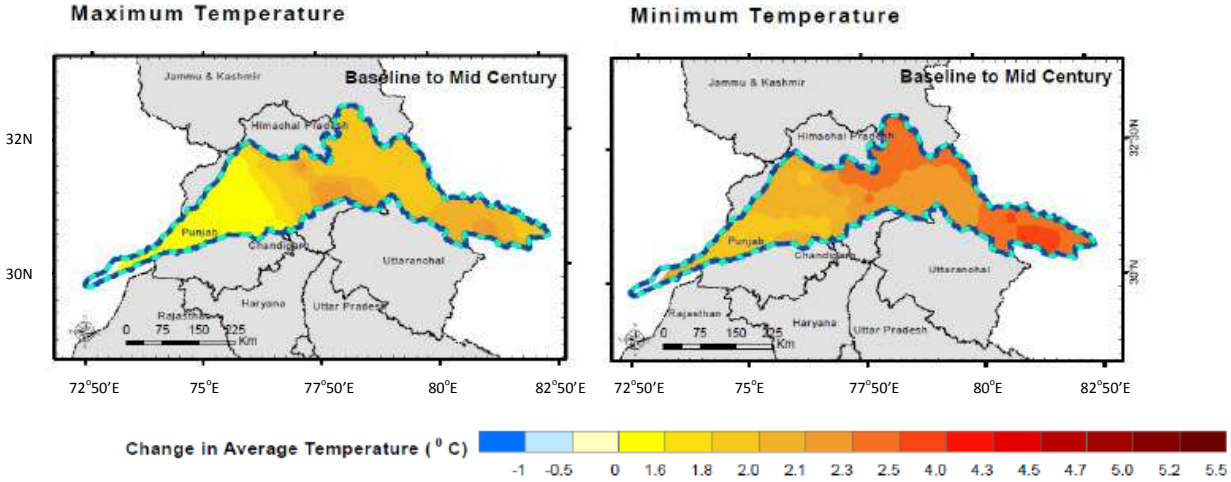


Figure 3.12: Projected changes in temperature in 2021-2050s in the Sutlej basin.

Source: ADB, 2011

Projected Changes in Precipitation

The entire basin is projected to receive more precipitation with respect to the base line, with maximum increase in its western parts, where it may receive 50% more precipitation by the end of the century compared to the current climatological baseline (**Figure 3.13a**)**.** The highest increase in precipitation is projected in the monsoon season and the maximum increase in precipitation is projected in the foothills of the Himalayas, where currently the precipitation is also the highest. Very significant increases in precipitation of the order of 25% or more are projected in the mid-century scenario in the foothills (**Figure 3.13b**). There is a bias in projections in the higher altitudes in the eastern region, and therefore projections are more uncertain.

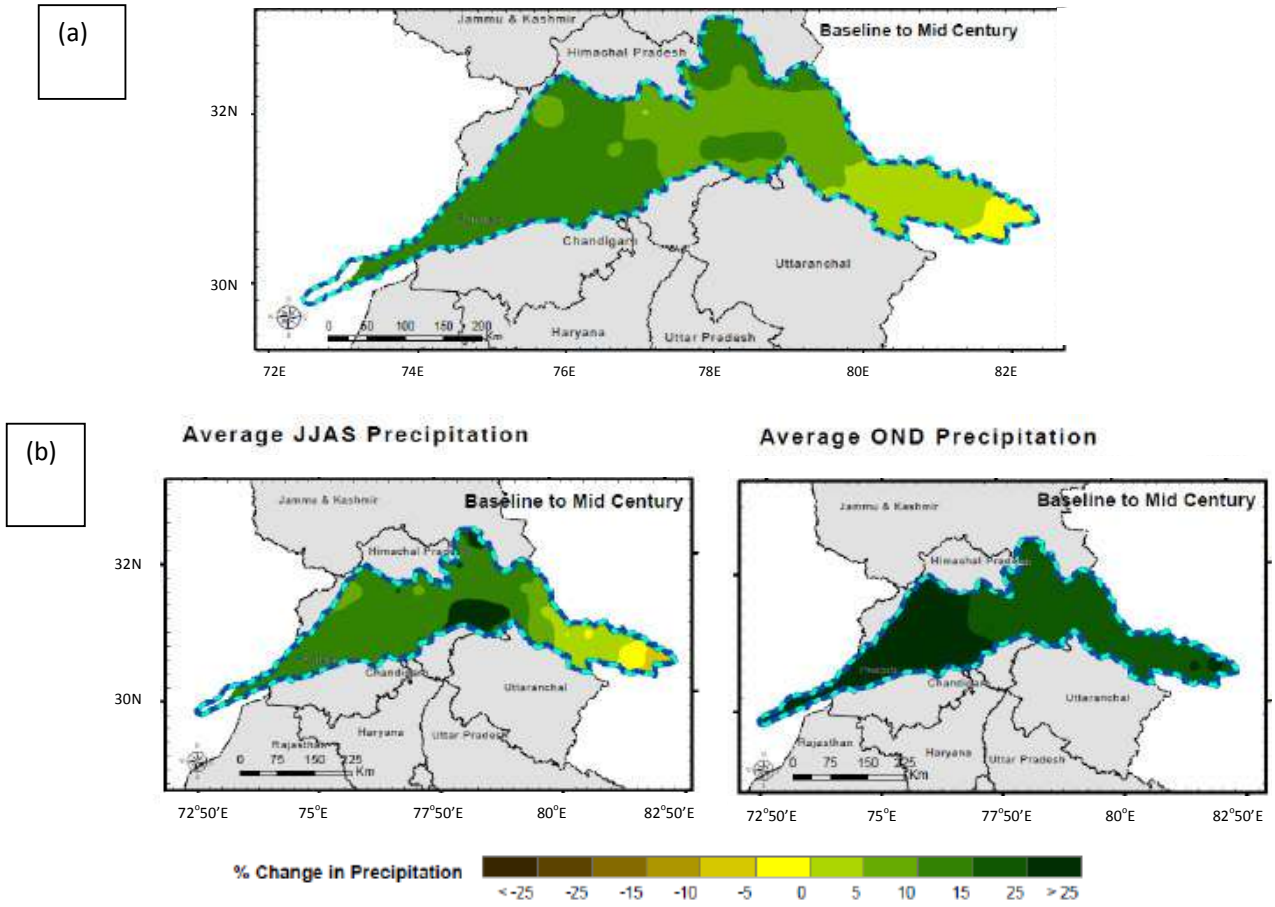


Figure 3.13: Projected changes in precipitation in the Sutlej river basin (a) projected changes in annual average changes, (b) projections for Monsoon and winter seasons. *Source: ADB, 2011*

Projected Changes in Extreme Precipitation Events

In the mid-century scenario the number of rainfall days between 100-150mm/day could increase by 1.2 to 1.8 times in the Shivalik region of Punjab with very little change in the lower half of the basin. Similarly, the rainfall events with precipitation >150mm are projected to increase by 1.2 to 1.5 times in the same region, with minimal increase of such events in the lower end of the basin (See **Figure 3.14 a and b**). Very heavy rainfall events can lead to increased erosion and flooding. It is important to note that heavy precipitation events are often under represented by climate models (both GCMs and RCMs).

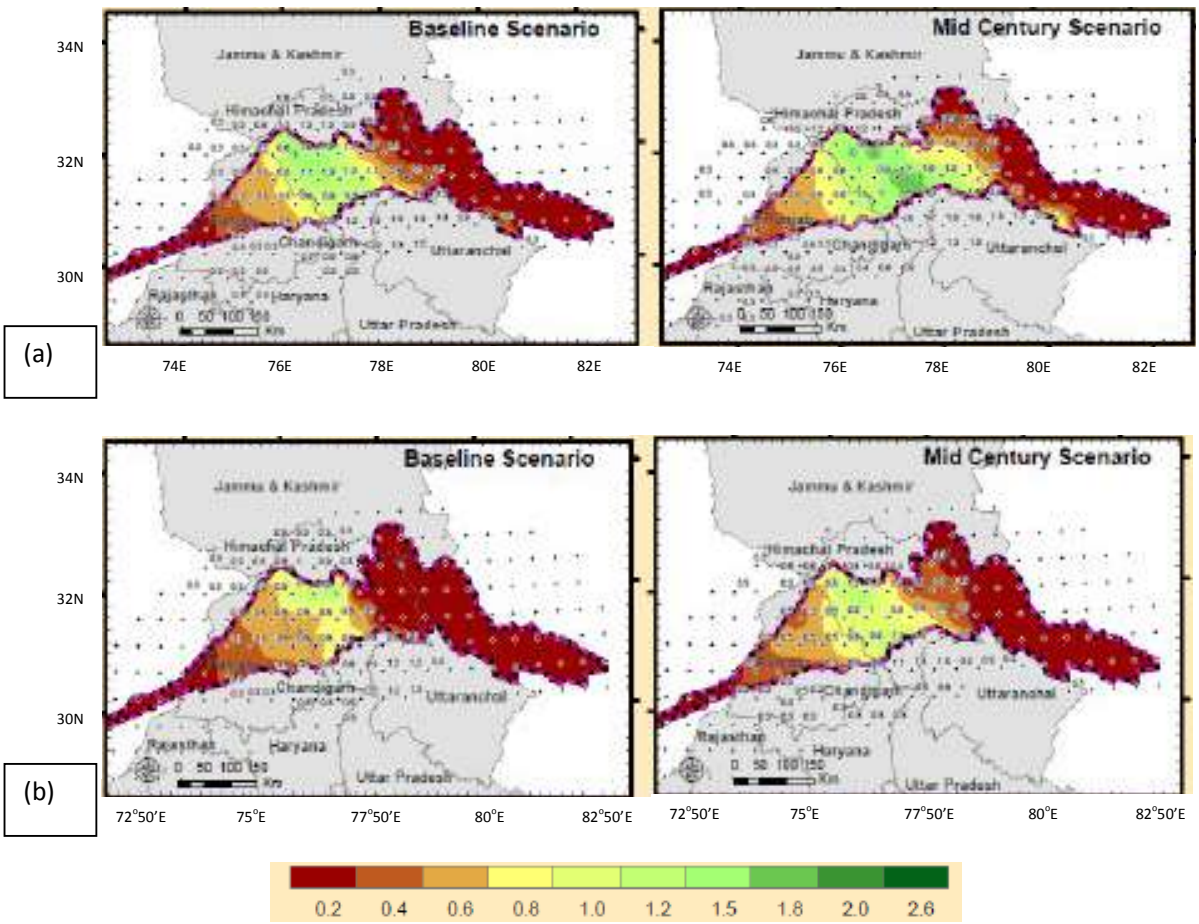


Figure 3.14: Projected changes in number of days of Rainfall between (a) 100mm to 150mm And (b)>150 mm *Source: ADB, 2011.*

Estimates of Changes in Evapo-Transpiration

Potential evapo-transpiration has been estimated from PRECIS simulated weather data for three locations in the Sirhind irrigation command in the lower Sutlej basin. These locations were chosen to be representative of the southwestern part of the command, the middle and the area close to the Ropar head works. The computed annual potential evapo-transpiration figures given in **Table 3.2** indicate that very little change in evapo-transpiration will occur in the mid-century, but by the end century they are likely to increase significantly as temperatures rise much higher. This indicates that demand for water for crops might not increase significantly by the mid-century, but we need to prepare the higher rates of water demand in the end of the century scenario.

Table 3.2: Changes in Annual Potential Evapotranspiration in the Sirhind command

Location	Baseline –ET (mm)	Midcentury- ET (mm)	Percentage change
Southwest	1890	1900	0.53
Middle	1680	1660	-1.19
Ropar Headworks	1260	1290	2.38

Source: ADB, 2011

Droughts

An analysis of drought durations with a 10 mm precipitation threshold in the Kharif (June-July-August-September) and Rabi (October-November-December-January-February) has been made and the mean annual drought durations are shown in **Figure 3.15 a and b**. In the Kharif season, mean

annual drought durations may vary from 23 days in the north east of the state to 46 days in the southwest, where potential evapotranspiration is also highest. During the Rabi season clear periods of over 3 months with virtually no precipitation are expected to be common throughout the lower basin.

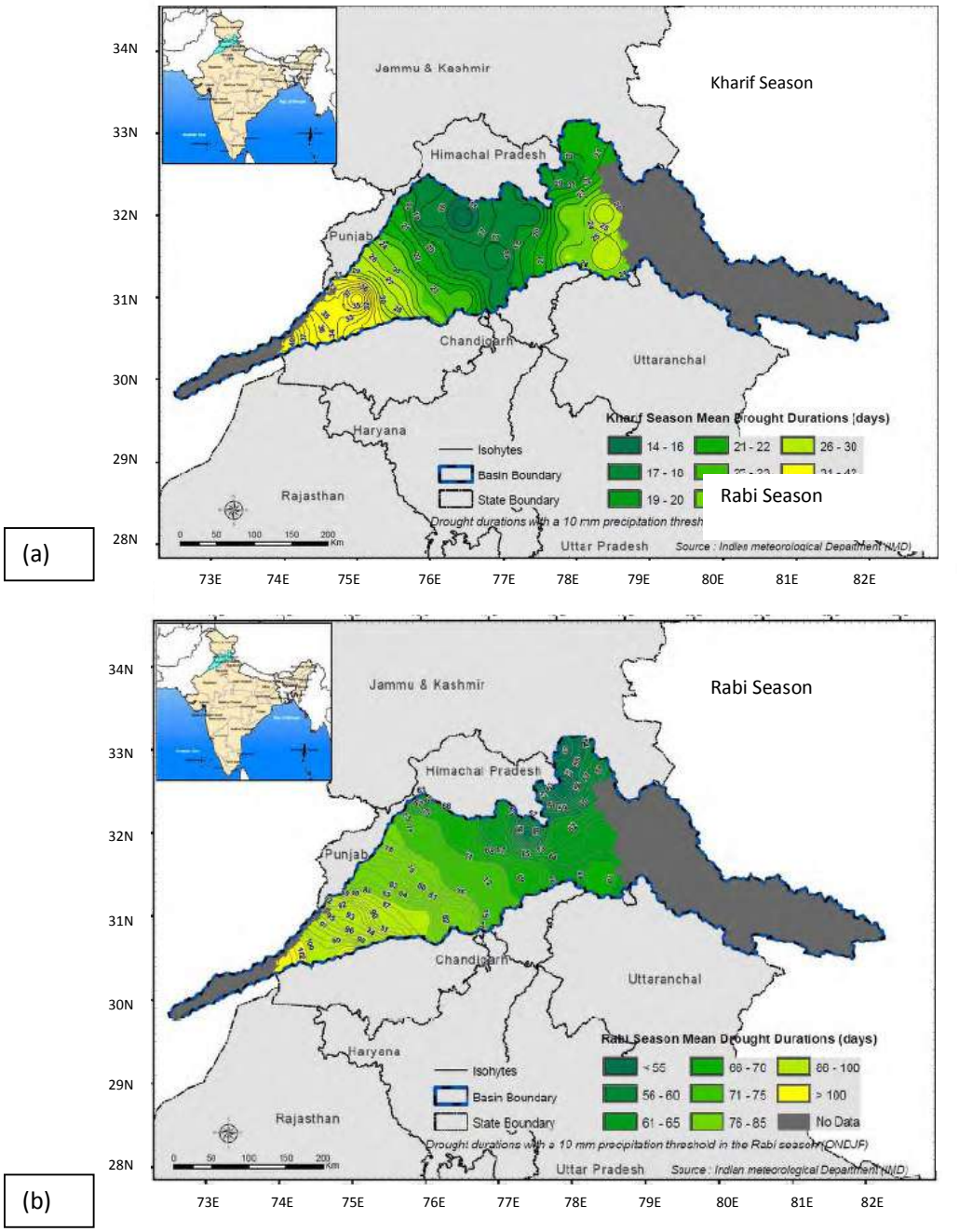


Figure 3.13: Mean drought duration on a 10 mm precipitation threshold for (a) Kharif Season and (b) Rabi season projected for 2021-2050s. *Source: ADB, 2011.*

3.6 CONCLUSION

It is clear from the long term observations (1901-2010) that there is a distinct rise in annual mean temperature all across Punjab. However, in some areas, the minimum temperature is rising at a higher rate than the maximum temperature. There is no significant annual trend in monsoon

precipitation, almost equal number of deficit and excess years have been recorded. Inter annual variability in rain fall is a distinctive trend with wide spatially differences.

Projections indicate that the mean annual precipitation is likely to increase by 13 to 22 per cent in the mid century. Though the precipitation is highly variable spatially, but the monsoon precipitation shows a definite increase by 11 to 21 percent across the entire state. The seasonal projections of precipitation and temperature are tabulated in Table 3.3.

Table 3.3: Summary of projected changes in temperature and precipitation in Punjab in mid-century (2021-2050) with respect to Base line (BL: 1961-1990).

Mean Precipitation	Change in 2021-2050 wrt BL	Mean Max. temp	Change in 2021-2050 wrt BL	Mean Min Temp.	Change in 2021-2050 wrt BL
Annual	13.3-21.5%	Annual	1.0-1.8^{o}C	Annual	1.9-2.1^{o}C
Pre-monsoon	-4.7 to 29.1%	Pre-monsoon	1.8 – 2.2^{o}C	Pre-monsoon	1.8-2.2oC
Monsoon	11.5-20.8%	Monsoon	1.1-1.8^{o}C	Monsoon	1.1-1.8oC
Post monsoon	30.0-63.9%	Post monsoon	-0.3-1.6^{o}C	Post monsoon	-0.3-1.6oC
Winter	-21.8 to 0.0%	Winter	0.6-2.3^{o}C	Winter	0.6-2.3oC

At lower Satluj river basin level, which covers about 60% of area in Punjab, and is the bowl of its grain production, projections indicate that the mean maximum temperature is likely to increase by 1.6^{o}C, with maximum increases happening in October, November and December period. The mean minimum temperature, however, is likely to rise by a much greater degree upto 4.5^{o}C, with maximum increase in the January and February period (see **Table 3.4**).

Table 3.4: Projected Daily Minimum and Maximum temperatures (^{o}C) in 2021-2050s A1B scenario with respect to base line (1961-1990)

	JF	MAM	JJAS	OND	Annual
Change in mean daily maximum temperature	1.7	2.1	1.6	1.3	1.6
Change in mean minimum temperature	6.7	6.4	1.9	2.8	4.5

Further, mid century projections for the same region indicates that number of heavy rainfall days could increase by 1.2 to 1.8 times in the Shivalik region of Punjab with very little change in the lower half of the basin. Potential evapo-transpiration projections in the southwestern part of the command, the middle and the area close to the Ropar head works indicate that very little change in evapo-transpiration in the mid-century, but significant changes in end century as temperatures rise much higher. The drought analysis indicates that in the Rabi season clear periods of over 3 months with virtually no precipitation are expected to be common throughout the lower basin. In the Kharif season, the situation is likely to be better but mean annual drought durations may vary from 23 days in the north east of the state to 46 days in the southwest, where potential evapotranspiration is also highest.

These projections only indicate the likely scenarios of climate in the future and are not absolute. This is because the models and the development story lines driving them have inherent uncertainties associated with them. It is envisaged that multi model outputs run on GHG emission scenarios emerging from multiple development story lines, will reduce uncertainties and enable effective decision making at local level.

References

1. ADB, 2011. Appendix 2: Final Report - Lower Sutlej Sub basin. TA 7417- IND: Support for the National Water Mission - National Action Plan on Climate Change. Prepared for Govt. of India and State Govt. of Punjab by Asian Development Bank, pp157..

2. IMD, 2011. Annual Climate Summary - 2010, National Climate Centre, IMD, Pune, Ministry of Earth Sciences, GoI.
3. IMD, Chandigarh Centre, 2012. Background on Monsoon in Punjab and Haryana.
4. http://www.chdmausam.org/docs/Background%20MONSOON.pdf. Accessed on Dec 5, 2012.
5. MoA, 2011. India's agricultural statistics at a glance, 2011. Publication by Directorate of Economics and Statistics, Department of Agriculture and Cooperation, Ministry of Agriculture. http://eands.dacnet.nic.in/At_A_Glance-2011/4.5 (b).xls. Accessed on Dec 5, 2012.
6. Pattanaik, D. R. and Rajeevan, M., 2010. Variability of extreme rainfall events over India during Southwest monsoon season. Meteorological Applications, 17 (1). pp. 88-104. ISSN 1350-4827.
7. PHD Chamber, 2011. Punjab State Profile, November 2011. Published by PHD Research Bureau, Punjab Chamber of Commerce and Industries.
8. Kaur, P., H. Singh and S. S. Hundal, 2006. Annual and seasonal climate variability at Ludhiana, Punjab, Journal of Agricultural Sciences, Vol. 6, no.1, pp. 39-45.
9. PRECIS, 2012. The PRECIS Regional Climate Modeling System - An Introduction to the PRECIS system. http://www.metoffice.gov.uk/precis/intro. Accessed on Dec 5, 2012.

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4. Water Mission

HIGHLIGHTS

- Status of Water Resource in Punjab
- Institutions Managing Water in Punjab
- Challenges of the Water Sector in Punjab
- Key Water Policies and Acts of the State
- Ongoing Programs and Projects for Managing Water Resources
- Likely implications of climate change on Water Resources
- Strategies to address CC within the Framework of National Mission on Water

4.1. STATUS OF WATER RESOURCES IN PUNJAB

Rainfall

Generally, the rainy season in Punjab begins in the first week of July. The average rainfall is around 480 mm in plains and 960 mm in northern sub-mountainous regions characterized by the lower Shivaliks depending on its elevation. The rainfall decreases from north and north east to south. The monsoon is brought by the monsoonal winds blowing over the Bay of Bengal. About 70% of the annual rainfall is received during monsoon months. District wise average rainfall distribution is presented in **Table 4.1.** It is seen that there is a spatial variability in rain fall across the districts and the average rainfall in the state is showing a decreasing trend, reducing the availability of surface water.

Surface Water

The State is rich in water resources and is traversed by four major rivers, i.e., Satluj, Beas, Ravi and Ghaggar. The wetlands, lakes and ponds scattered all over the State constitute an important part of the States Surface Water resources.

River Satluj: River Satluj, which is virtually the lifeline of Punjab, is a tributary of Indus River. Many important towns like Nangal, Ropar, Ludhiana and Ferozepur are situated along its banks. The river originates near Mansarovarlake in Tibet and is deflected at several places in the Himalayan ranges. It enters Punjab near village Bhakhra (where famous Bhakhra dam is constructed and GobindSagar Lake has been formed), moves on to the plains at Ropar and passes through the Ludhiana district. It joins Beas at Harike before crossing over to Pakistan.

The water quality of the river deteriorates greatly after the confluence of BudhaNala and East Bein. BudhaNala originates near Chamkaur Sahib, in Ropar district. It runs under the high bank along the old course of the Satluj on its south for a fairly large section of its course and ultimately

Table 4.1: District-wise average rainfall in Punjab (in millimeter)

District	1970	1980	1990	2000	2007	2008	2009
Gurdaspur	926.3	1155	1214.9	830.1	823.8	808.6	589
Amritsar	594.6	869.8	650.8	207.9	304.4	265.4	239.5
Tarn Taran	##	##	##	##	394.4	93.3	93.3
Kapurthala	554.9	683	780.5	542	365.5	644	644
Jalandhar	171.4	873.9	1195.7	364.2	376.6	673.8	543.9
S.B.S. Nagar	#	#	#	699.4	622.6	517.8	70.8
Hoshiarpur	999.3	906.1	1075.6	658	432	885.6	609.1
Rupnagar	983.4	759	1092.4	793.4	897.8	957.3	724.8
S.A.S. Nagar	##	##	##	##	452.8	459	459
Ludhiana	756.7	38	523.9	437.2	390.9	775.9	259.9
Ferozepur	232.3	956.2	421.6	130.3	319.1	224.1	170.9
Faridkot	*	511.4	567.8	256.5	537.4	520.6	500.5
Muktsar	#	#	#	358	297.6	379.6	277.1
Moga	#	#	#	175	171.2	428.8	258.5
Bathinda	499.2	355.9	342.1	136.1	344.1	336.7	236.9
Mansa	**	**	**	77.1	139.3	139.3	120.7
Sangrur	521.9	521.4	527.2	202	283.3	355.5	450
Barnala	##	##	##	##	572.3	417	237.9
Patiala	555.6	835.7	662.7	641.2	571.8	950.9	460.2
Fatehgarh Sahib	**	**	**	155	356.7	751.5	751.5
Total Average	**672.3**	**739.1**	**754.6**	**391.9**	**438**	**529.2**	**384.9**

* Data included in Ferozepur and Bathinda districts.

** Districts Mansa and Fatehgarh Sahib were created in 1992; hence data of these districts are included in Bathinda and Patiala districts respectively.

Districts Muktsar, Moga and SBS Nagar (Nawanshahr) were created in 1996; hence data of Muktsar&Moga is included in Faridkot and that of SBS Nagar in district Jalandhar.

District TaranTaran, SAS Nagar and Barnala were created in 2006; hence data of these districts is included in Amritsar, Rupnagar and Patiala, and Sangrur respectively.

Source: PbSAP, 2010; IMD (www.imd.gov.in)

joins the river at Gorsian Kadar Baksh, in the northwestern corner of the Ludhiana. It is a natural stream carrying the treated/untreated industrial waste waters and the domestic sewage of Ludhiana city. East Bein carries the treated/untreated industrial waste waters and the domestic sewage of Jallandhar, Phagwara and other townships/villages along its course.

Snow plays a significant role in river discharge and snowmelt accounts for 50-80% of the annual stream flow in many areas of the World including Himalayan Mountains (Ferris and Congalton, 1989). A major source of runoff and groundwater recharge in middle and higher latitudes is contributed by snowmelt from seasonal snow covered areas of the Earth's mountainous regions (Jain *et al.,* 2010). It has been observed that 80% of the Indian Sutlej river catchment in Himachal is snow fed at some stage during the year. The average number of glaciers that feed into the Sutlej River is estimated to be 935 covering an

area of 1234 sq kms with an estimated ice volume of 77 BCM[1]. These glaciers play an important role in controlling the discharge from the rivers. Jain *et al.,* 2010 has observed in their studies for the year 2000-2001, 2001-2002, 2002-2003 and 2004-2005 that seasonal distribution of stream flow is highly affected as increased air temperature result in shifting of snowmelt to earlier in the snowmelt season leading to more significant decrease of snowmelt runoff in June & July (**Fig. 4.1**). It may be mentioned that the total catchment area of Satluj River up to the Bhakra dam is about 56,500 km^2, of which about 22,305 km^2 lies in India, including the entire Spiti basin. The elevation of the catchment varies from about 500 to 7000 m, although only a very small area exists above 6000 m. The mean elevation of the basin is about 3600 m. Snowmelt contribution is received from the area between elevations 1800-4800 m of Area and elevation-wise glaciers, snow and rain covered zones of Sutlej Basin is depicted in Figure **4.2**. However, more studies are required in the Sutlej basin to assess the impact on total water availability from snowfall/snowmelt due to rise in temperature.

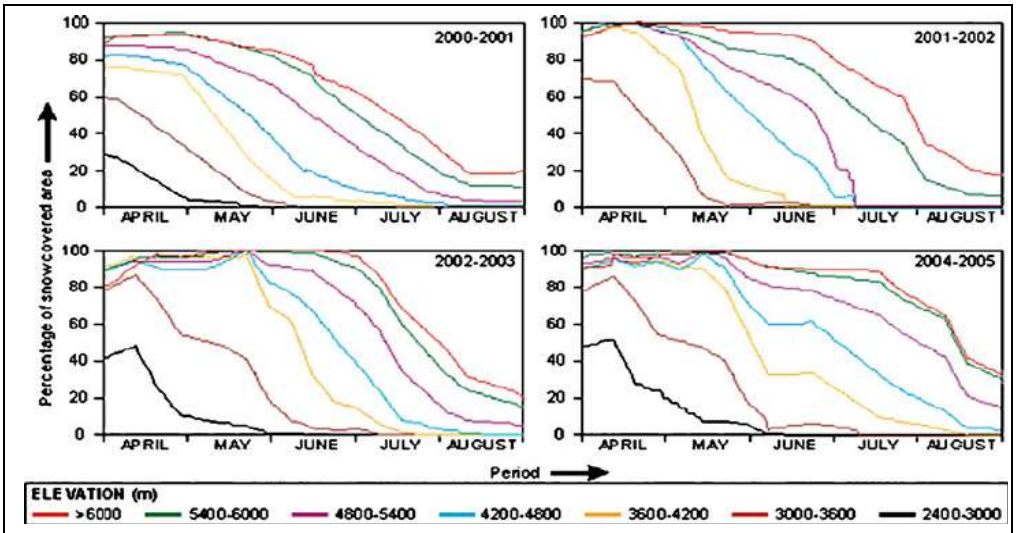


Fig 4.1: Snow cover depletion curves for different years (Source: Jain *et al*., 2009)

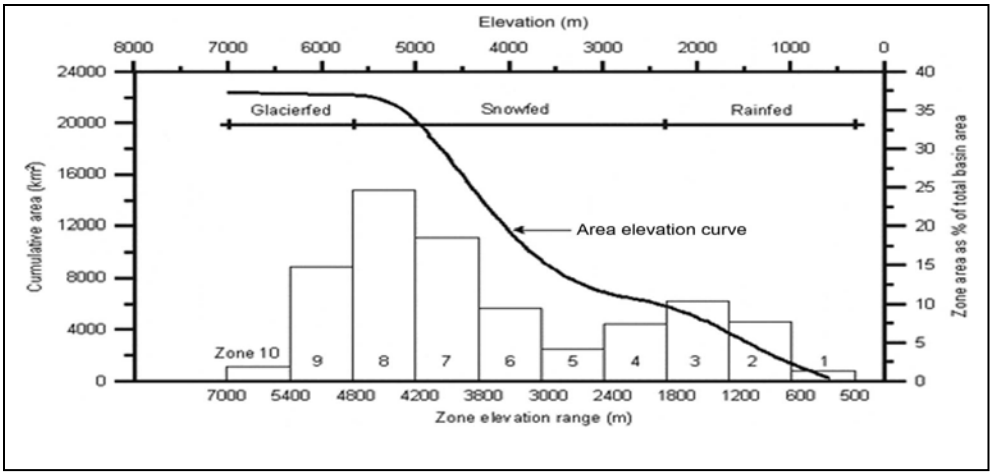


Figure 4.2: Area difference elevation zones as a percentage of the total basin area and the area elevation curve for the Sutlej basin (Source: Jain *et el.,* 2010)

[1]Source: averaged from studies carried out by the Geological Survey of India and by Palampur University, Himachal Pradesh

Bhutiyani et al., 2008, report a decrease in discharge from Sutlej River between 1991 and 2004, with increase in frequency of high magnitude floods. These have been correlated with sharp increase in annual air temperature trends at the rate of 1.7°C/100 years and recession of glaciers, with smaller glaciers receding faster than larger ones. Recent studies carried out by Sharma et al (personal Communication, 2014), based on MODIS[2] sensor data for the period 2001-2012, indicate a decrease in Snow Cover Area of the Sutlej river basin which covers an area of 36283 km2 and the annual decrease is noted as 1.36±0.6% at 1500-2000 m altitude to a maximum of 2.17±1.61% at 4000-5000m altitude within the basin, with a significant annual trend of decrease of 4.5±0.7% at 2000 to 2500 m altitude within this period.

Beas: River Beas is comparatively much shorter in length than Sutlej. The river enters Punjab at Talwara, where Pong dam has been constructed over the river and major portion of the water is diverted for irrigation. It joins Satluj near Harike running south west for about 179 km. The important towns situated along its banks are Talwara, Mukerian and Beas. Changing snowfall trends in response to climate change have been observed for Beas Basin as depicted in **Fig 4.3**.

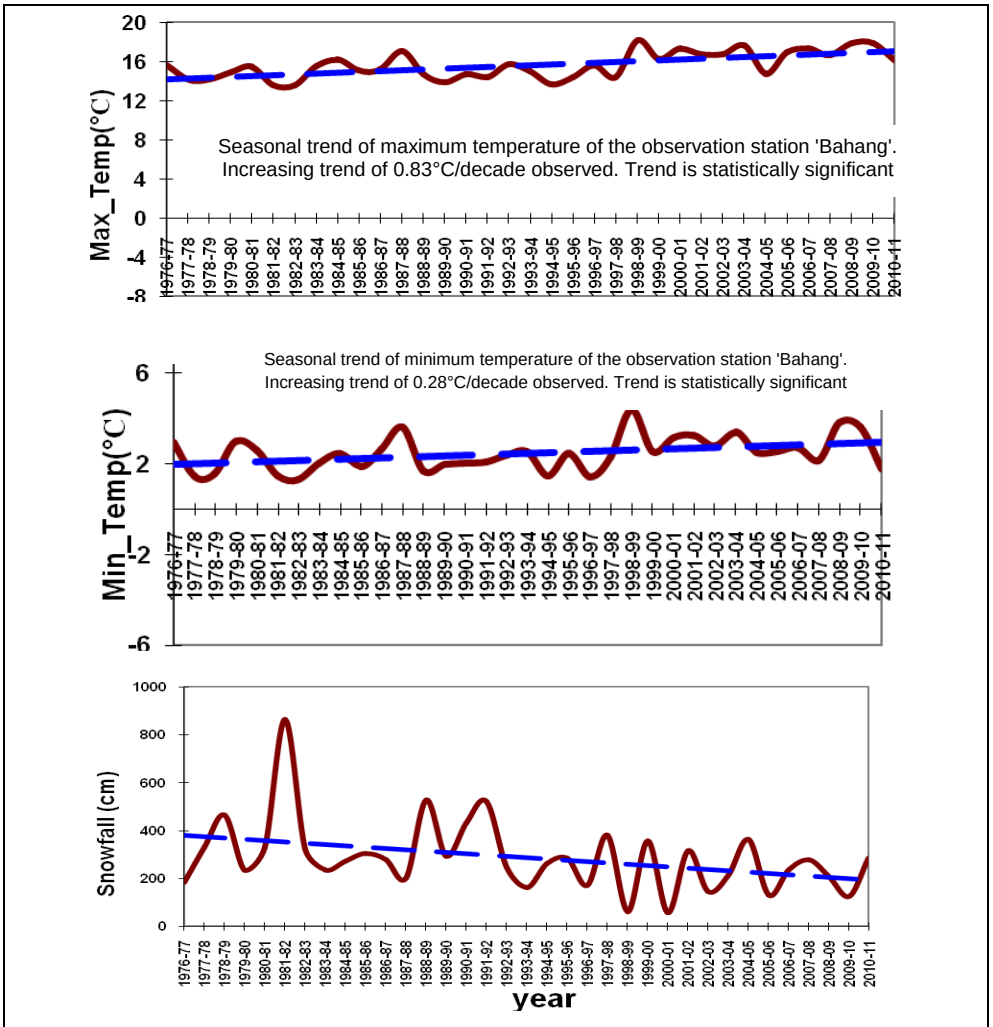


Fig. 4.3 Seasonal trends of minimum and maximum temperatures and snowfall of the observation station 'Bahang'. Decreasing trend of 64.4cm/decade observed. Trend is statistically significant (Source: Gusain, *et al.* 2012)

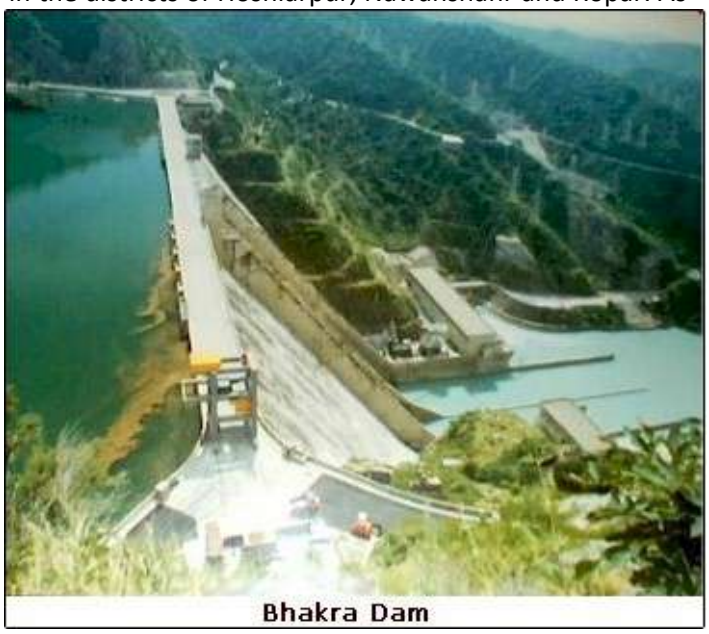
[2]Moderate Resolution Imaging Spectroradiometer (MODIS)is a key instrument aboard the Terra (EOS AM) and Aqua (EOS PM) satellites which are viewing the entire Earth's surface every 1 to 2 days,

Ravi: River Ravi flows along the international boundary of India and Pakistan and only a small portion of the river flows through the State. It enters Punjab at Shahpur near Pathankot and is barraged at Madhopur forming a lake. Major portion of its water is diverted for irrigation. The river leaves Punjab at village LodhiGujjar and enters Pakistan.

The Beas and Ravi basins in the North Western Himalayas, are comparatively smaller covering an area of 10623 sq km and 7117 sq km with glacier inventory of 277 and 94 respectively[1]. The discharge from the snow/glacier melt is observed to be decreasing (Sharma et al., 2013) between 2001-2012 and are insignificant as compared to the contribution of monsoon rains feeding these rivers in its lower catchment areas.

Ghaggar: River Ghaggar originates in Shivalik ranges in Himachal Pradesh and enters Punjab at village Kakrali in DeraBassi block. It traverses through Patiala, Sangrur and Bathinda districts covering a distance of 180 km. It leaves Punjab near village Munak and enters Haryana. The river remains dry for most part of the year. Chhatbir Zoological Park is located by the river and a part of the river water is diverted for feeding water to the zoo animals.

Choes: Rivers/rivulets known as 'Choes' are found in Shivalik area. These choes form an important part of drainage and are responsible for soil erosion in the districts of Hoshiarpur, Nawanshahr and Ropar. As many as 93 'choes' are reported to flow in Hoshiarpur district alone. An estimate indicates that in a business as usual scenario, these choes erode soil from the hill slopes by about 35 tons/ha/annum (Tiwana*et al.*, 2007). This has been brought down to 18 tons/ha/annum due to soil conservation measures and afforestation measures.


Bhakra Dam

Dams: The state has the twin dams of Bhakhra and Nangalon River Satluj and RanjitSagar on river Ravi. The Bhakra Dam has a reservoir area of 168.35 km^2 with a gross storage capacity of 7551 million cum with a live storage capacity of 6007 million cum[3]. The Nangal Dam is situated about 13 km downstream of Bhakra Dam. Nangal Dam diverts the water of river Satluj into NangalHydel Channel &Anandpur Sahib Hydel Channel for power generation and irrigation purposes. It is estimated that about 60% of the inflow in Bhakra is derived from snow and glacier melts (*Singh and Jain, 2002)*. The RanjitSagar Dam has a catchment area of 6086 km^2 and a storage area of 87.0 km^2; with a gross storage capacity of 3280 million cum. The barrages are at Madhopur, Hussainiwala, ShapurKandi, Shah Nehar etc., in addition to Harike and Ropar.

Canals: Punjab has a developed and interlinked 14500 km long Canal System. This system is more than a century old. The upper Bari Doab Canal from river Ravi at Madhopur, Sirhind Canal from river Satluj at Ropar, Eastern Canal & Bikaner Canal from river Satluj at Hussainiwalaheadworks date back to pre-independence era. The seven canal systems constituting Sirhind Canal System, Sirhind Feeder System, Eastern Canal System, U.B.D.C. System, Bhakra Canal System, Bist Doab System and Shah Nehar System together have a culturable command area (CCA) of 30.88 lakh ha. The list of main canals and their capacities is given in **Table 4.2.**

[3] Source: http://bbmb.gov.in/english/menu2.asp

Table 4.2: Main Canals in Punjab

Sr No	Name of Canal	Capacity (Cusecs)	Sr No	Name of Canal	Capacity (Cusecs)
1	Sirhind Canal	12622	**9**	Rajasthan Feeder	18500
2	NangalHydel Channels	14500	**10**	Abohar Branch Lower	1692.50
3	Combind Branch	7635	**11**	Bikaner Canal	*2720/3027*
4	Sidhwan Branch	1751	**12**	Eastern Canal	3929
5	Abohar Branch	3029	**13**	Bist Doab Canal	1408
6	Bathinda Branch	2890	**14**	Upper Bari Doab Canal	8200
7	Ferozepur feeder	11192	**15**	MukerianHydel Canal	11500
8	Sirhind Feeder	5264	**16**	Bhakra Mainline Canal	12455

Source: Department of Irrigation, Govt. of Punjab

The drainage system: The drainage system is complementary to the canal irrigation system in Punjab. The system is 8000km long. Important drains between Ravi and Beas are ShakkiNallah, HudiaraNallah, KasurNallah and Patti Nallah. Also the drains between Beas and Satluj are West/Kali Bein and East/SafedBeinare part of the drainage system. Other major drains falling in River Satluj are Jalalabad drainage system, Chand Bhan drain. Ditch drain and BudhaNallah. The drainage system also includes the ShirhindChoe, LassaraNallah, Patiala Nadi and PacchidaraNallah drains out falling in river Ghaggar. These drains help in quickly dealing with heavy runoff and in preventing water logging. The choes in the Shivaliks also constitute a part of the drainage system in Punjab. A drainage map of Punjab is provided in **Figure 4.4.**

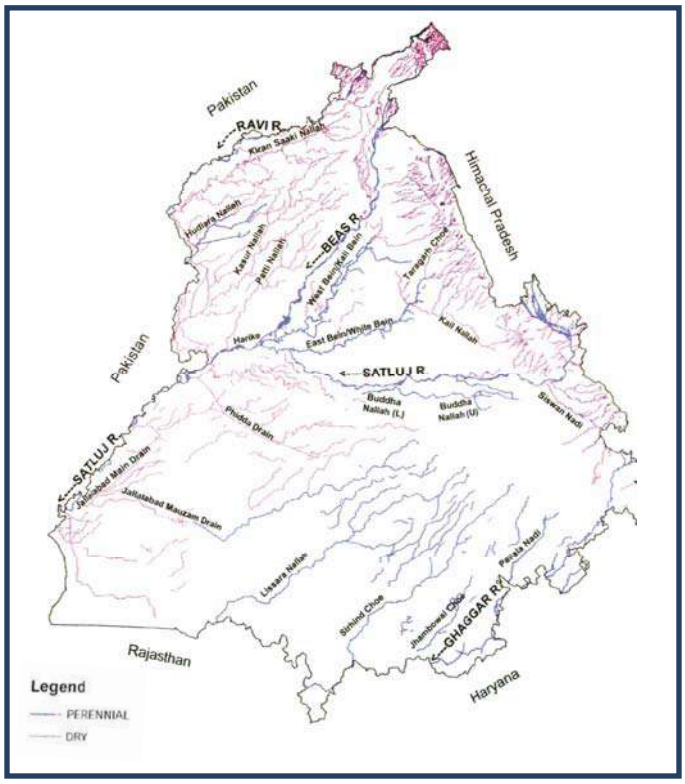


Figure 4.4: Drainage map of Punjab.
Source: Punjab Remote Sensing Centre, Ludhiana

Ponds: Punjab is dotted with a large number of large and small lakes, ponds and pools which are an important part of the State's surface water resource. A large number of pools of water are found in the intervening tracts of the Satluj and the Beas. Some of these have a linear shape and have a length of about 2-3 kilometers in each case. These water bodies are the remnants of the abandoned channels of the major streams. Also, a number of ox-bow lakes are found in the abandoned courses of the Satluj. The

ponds, which are sporadically distributed over the whole of the upland plain, are local depressions filled with rainwater; they are used for bathing the cattle, and for providing drinking water to them. The State has 4952 village ponds, which includes 1821 ponds having an area of more than 2.5 ha each and 3131 ponds with an area less than 2.25 ha (Tiwana*et al.*, 2007).

Wetlands: The State has some important natural wetlands. With the construction of dams & barrages, several man-made wetlands have also emerged on the state's landscape. The State has 12 natural wetlands covering a total area of 8.39 square km and 9 man-made wetlands covering an area of 147.39 square km, which have been detailed in Table 4.3. Harike, Kanjli and Ropar wetlands in Punjab have biodiversity of international significance and are designated as Ramsar Sites.

Table 4.3: List of Wetlands in Punjab

SN	Name of Wetland	Nearest town	District	Area (km^2)	Status
A. Natural Wetlands					
1	JastarwalJheel	Jastarwal / Ajnala	Amritsar	0.55	Permanent
2	AliwalKotli	Aliwal / Ajnala	Amritsar	0.10	Permanent
3	Bareta	Bareta	Mansa	0.20	Seasonal
4	KahnuwanChhamb	Kahnuwan / Man Chopa / Chhawarian Banghar	Gurdaspur	1.28	Permanent
5	Keshopur – MianiJheel	KeshopurMianiJhamela	Gurdaspur	4.08	Permanent
6	MandBharthala	Bharthala	Nawanshahr	0.61	Permanent
7	Narayangarh – Terkiana	Terkiana/ Dasuya	Hoshiarpur	0.82	Permanent
8	SitalSagar	Mansar	Hoshiarpur	*	Permanent
9	Rababsar	Bharowana	Kapurthala	0.41	Temporary
10	Lobana	Patiala	Patiala	0.11	Temporary
11	LahailKalan	Lehail	Sangrur	0.20	Temporary
12	GobindgarhKhokhar	GobindgarhKhokhar	Sangrur	0.08	Temporary
B. Manmade Wetlands					
1	Harike Lake	Harike	Tarn Taran, Kapurthala Ferozepur	41.0	Ramsar Site
2	Kanjli Lake	Kanjli	Kapurthala	0.44	Ramsar Site
3	Ropar Lake	Ropar	Ropar	13.65	Ramsar Site
4	HussainiwalaReservoir	Ferozepur	Ferozepur	6.88	Nominated for recognition as National Wetland
5	RanjitSagar	ShahpurKandi	Gurdaspur	32.64	Construction completed in 2000
6	Dholbaha Dam	Dholbaba	Hoshiarpur	13.2	Earth filled dam
7	Maili Dam	Maili	Hoshiarpur	0.72	-
8	Mangrowal Dam	Mangrowal	Hoshiarpur	0.70	-
9	Nangal Lake	Nangal	Ropar	4.0	National Wetland

Source: Tiwana et al., 2005

Ground water

The State is mainly underlain by quaternary alluvium of considerable thickness, which abuts against the rocks of Shiwalik system towards North-East. The alluvial deposits in general act as a single ground water body except locally as buried channels. Sufficient thickness of saturated permeable granular horizons occurs in the flood plains of rivers which are capable of sustaining heavy duty tube wells. However, over-exploitation of ground water in the state has resulted in depletion of its ground water resources. (Source: Central Ground Water Board, 2010).One of the reasons of increased stress on ground water is due to the decrease in surface water availability leading to lower recharge.

Ground water potential: Groundwater resource estimation of Punjab state has been carried out as per GEC (Groundwater Estimation Committee) methodology published in 1997. The last assessment of ground water was carried out on 31.3.2009. According to this assessment, net groundwater resources of Punjab State are 20.35 BCM, whereas net draft was 34.66 BCM, leading to groundwater deficit of 14.31 BCM. The state of groundwater development for the State was 170% and the State as a whole falls under "over exploited" Category. The status of the State's Ground Water Resources is provided in **Table 4.4.**

Ground water depth: The depth of groundwater in most parts of the state ranges between 5 to 20 meters below ground level (mbgl) except in the southwestern parts where it is less than 5 mbgl. Depth of water level is 20 meters below ground level around major cities like Jalandhar, Ludhiana, Amritsar, Patiala, Fatehgarh Sahib, Nawanshahr and Sangrur. Observations by local population in Ajitgarh indicate that in the last 24-25 years water level has gone down even as much as 30 m. Water levels deeper than 40 m occur in the plateau region of Garshankar Block of Hoshiarpur district. Out of 50,362 Sq.km area of the State, 42,908 Sq.Kmarea (85.2%) shows a decline in water levels. On an average, the water table is declining at the rate of 0.3 m/yr. The decadal fluctuation in water level show that fall in water levels is less than 2 meters to more than 4 meters. Ground Water is currently a free resource and as such the motivation for its judicious and conservative use does not exist. As a result, the agricultural, residential, commercial and industrial sectors utilize this resource extensively.

The Central Ground Water Authority, in 2011 vide 'public notice 2/2011' has notified 12 blocks of Punjab State as over exploited areas where ground water withdrawal is more than the average annual replenishment and have declining levels. In these areas restrictions have been imposed on the construction and installation of new structures for ground water extraction without prior approval of the Deputy Commissioner. Only bore wells with hand pumps and open wells without pumps extracting water for domestic use and drinking purposes have been excluded.

Tube Wells

The depletion of ground water may be attributed to the increase in the number of tube wells in Punjab. The area irrigated by tube wells and wells has increased by 52.1% in 29 years period, between 1980-81 and 2008-09, while number of tube wells has increased about 112.7% during the same period. The net area irrigated by tube wells and number of tube wells in Punjab is given in **Table 4.5 below**.

Table 4.4: Status of Ground Water Resources of Punjab

Dynamic Groundwater Resources	
Net Annual GW Availability	20.35 BCM
Annual Groundwater Draft	34.66 BCM
Groundwater Deficit	14.31 BCM
Stage of Groundwater development	170 %

Groundwater Development & Management	
Over Exploited	64 blocks in 1964; 110 Blocks out of 138 blocks in 2009
Critical	3 Blocks in 2009
Semi- critical	2 Blocks
Additional Groundwater problems	
Water logged area	200,000 ha
Salinity (EC > 3000 µS/cm at 25 ° C)	Ferozepur, Faridkot, Bathinda, Mansa, Muktsar, Sangrur(Area ~1 million ha)
Fluoride (>1.5 mg/l)	Amritsar, Bathinda, Faridkot, Fatehgarh Sahib, Ferozepur, Gurdaspur, Mansa, Moga, Muktsar, Patiala, Sangrur
Chloride (> 1000 mg/l)	Ferozepur, Muktsar
Iron (>1.0 mg/l)	Bathinda, Faridkot, Fatehgarh Sahib, Firozepur, Gurdaspur, Hoshiarpur, Mansa, Rupnagar, Sangrur
Nitrate (>45 mg/l)	Bathinda, Faridkot, Fatehgarh Sahib, Ferozepur, Gurdaspur, Hoshiarpur, Jalandhar, Kapurthala, Ludhiana, Mansa, Moga, Muktsar, NawanShahr, Patiala, Rupnagar, Sangrur

Source: Personal communications with Ground water Board, Chandigarh office

Table 4.5: Net area irrigated by tube wells and number of tube wells in Punjab

Year	Irrigated Area (in 000 Ha)	% Increase	No of Tube Wells (in '000)	% Increase
1980-1981	1939	-	600	-
1990-1991	2233	15.2	800	33.3
2000-2001	3074	58.5	1073	78.8
2006-2007	2878	48.4	1232	105.3
2007-2008	2922	50.7	1246	107.7
2008-2009	2950	52.1	1276	112.7
2009-2010	Not available	-	1315	119.2

Source: PbSAP, 2010

4.2 INSTITUTIONS MANAGING WATER IN PUNJAB

The three key elements of water management include (i) water source creation/augmentation and distribution, (ii) Regulation – which implies implementation of laws and monitoring and (iii) Promotion of new technologies for water conservation and improving water quality. These functions are carried out by various departments of the Punjab government and are shown in **Figure 4.5.**

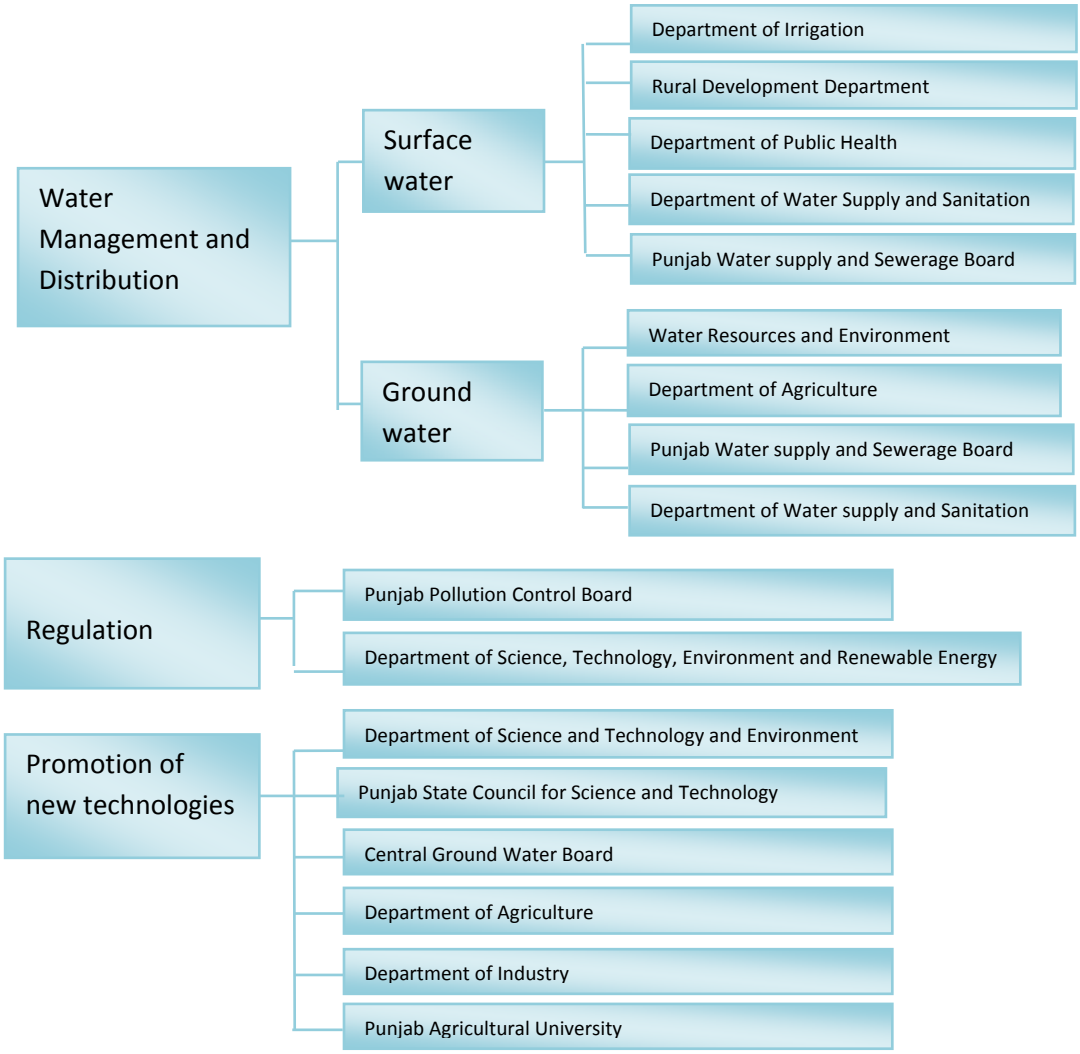


Figure 4.5: Institutions managing water in Punjab

4.3 CHALLENGES OF THE WATER SECTOR IN PUNJAB

Water demand

The high yielding varieties (HYV) of rice and wheat are the main consumers of water in agriculture sector in Punjab. The area covered under HYVs of wheat increased from 69% to 100% of the total area under wheat in Punjab between 1970-71 and 2001. Since then, the total area under HYV wheat has increased from 3408 thousand ha to 3522 thousand ha in 2009-10. Similarly, area under HYVs of rice comprised of 33% of the total area under rice in 1970-71, the share increased to 95% in 2001 and became 100% in 2005. The area under rice cultivation was 2612 thousand ha in 2000-01 and it increased to 2802 thousand ha in 2009-10 (SAP, 2010), clearly indicating an increasing trend in demand for water for irrigation over the years.

Ground Water Exploitation

With increase in industrial units, consumption of water is increasing proportionately. Between 1966 and 2009, medium and large industries have increased from 122 to 306 in Punjab and small scale industries have increased from 24 to 162559 during the same period (Tiwana*et al.*, 2005; and Deptt. of Industry, 2009). This is further reflected in the increasing collection of cess by Punjab PCB over the years, for example, the receipt of cess has increased from Rs. 52.8 million in 2001-02 (Tiwana*et al.*, 2005) to Rs. 130.95 million in 2009-10 (Press Information Bureau, August 29, 2011). Similarly demand for drinking water in the state is continuously increasing as the population has increased from 1.35 crore in 1971 to 2.77 crore in 2011.

The rapid spread of HYVs, has been facilitated by availability of ground water in Punjab. Further, the free power enabled the Punjab farmers to extract water from the ground and transplant rice before mid-June when the monsoon is still far away, temperatures are very high with maximum evapo-transpiration rate (ETR). Such water intensive cropping facilitated by free or subsidized water enabled farmer to over exploit groundwater. The number of tube wells in Punjab has increased from 0.19 million in 1970-71 to around 2.3million in 2010 leading to fall in water table from 18 cm in 1982 to 1987, to 42cm during 1997 to 2002 (Hira*et al.,* 2004), and to 75cm during 2002 to 2006 (Singh, 2006). In order to save the groundwater resources the Government of Punjab has enacted "The Punjab Preservation of Sub Soil Water Act, 2009". It prohibits farmers from sowing paddy nursery before May 10 and transplantation of paddy before June 10.

Canal Efficiency

The canal network is more than a century old and has become inefficient due to heavy silting, seepage of water, erosion of banks and embankments. The canals are now working at 30% below their designed capacity[4]. As a result, area irrigated by canals has declined from 1.286 million ha in 1970-71 to 1.189 million ha in 2006-07 due to reduced carrying capacity and efficiency of the system and decreased availability of surface water. Thus, presently surface water resources serve only about 30% of the irrigated area in the State.

Water Pollution

Use of nitrogenous fertilizers and pesticides in agriculture is enhancing the nitrate concentration and accumulation of pesticide residues in water (Tiwana*et al.*, 2005). NPK consumption in Punjab has increased from 1220 tons in 1990-91 to 1866 tons in 2009-10. An increase of 53% in consumption in the twenty year period has occurred (Directorate of Agriculture, Punjab, as cited in SAP of Punjab, 2007, 2008, 2009, 2010). The pesticide consumption during 2005-06 to 2009-10, fluctuated between 5600 tons to 6080 tons (Directorate of Plant protection, Quarantine and Storage[5]. Consumption of synthetic fertilizers and pesticides in Punjab is the highest amongst all states and Union Territories in India.

Further, rapid increase in population, urbanization and industrialization has polluted fresh water resources both in physicochemical and biological terms. The industrial pollution is in the form of organic/inorganic pollutants. Domestic, industrial and agricultural wastes accumulate in the aquatic ecosystem and enter the primary, secondary and tertiary webs of the food chain. As heavy metals move along the food chain these get magnified (Tiwana*et al.*, 2005).

Flooding

A major part of geographical area of the state is prone to floods although substantial part has been protected as the massive retention of multipurpose storage reservoirs constructed on River Satluj at Bhakra, River Beas at Pong and RanjitSagar Dam on river Ravi absorb the flood flows. The reservoir at Bhakra has only filled up a few times since construction. In 2010 it filled to its design level but flood was avoided by careful management of releases. However, flood risk persists due to high releases from reservoirs and saturation of embankments. Floods are still experienced in river Ghaggar. Considerable damage also occurs by a number of choes (Hill torrents) flooding Hoshiarpur, Jalandhar, Kapurthala and

[4]Punjab state plan 2011-2012

[5] Source: http://ppqs.gov.in/IpmPesticides Cont.htm#variousPest accessed on 29th May, 2012

Roopnagar districts during monsoon. The main problem during the flood period is drainage congestion and water logging. The water logging problem is predominant in Muktsar, Fazilka, Ferozepur and Faridkot districts. Intense rainfall, inadequate drainage system and lack of proper maintenance of flood control and other works such as the embankments, drainage system, cross drainage works, etc. often accentuate the flood situation in these areas (Source: Punjab State Disaster Management Plan, 2011). Between 1980 and 2010, area affected by flash floods has increased and as a consequence the number of villages affected have increased from 1191 in 1980 to 1884 in 2010 (*Source: Economic Advisor of Punjab, as cited in Punjab State Disaster Management Plan, 2011*).

Water Logging

Water logging in the state mainly occurs in the south-western part of the state. The water logging is due to (i) non extraction of ground water as the quality is - brackish/saline (ii) saucer shaped topography of the area impedes natural as well as artificial drainage; and (iii) seepage and return flow from twin irrigation canals of Rajasthan and Sirhind Feeder Canals which were built in addition to Abohar Branch and Bikaner Canal. In the 1950s, the sub-soil water level in this area was about 33 meters below ground level. After the construction of twin canals, the sub-soil water level started rising at the rate of 0.2 meter to 1.0 meter annually. The area has witnessed a rise in water level upto 22 meter in the last 25 years. The net impact of water logging in this area is that about 86400 hectare area out of 2.16 lac hectare area of Muktsar has become critically water logged, making the land unfit for any worthwhile purpose. In low lying areas, the land stands submerged and is totally unfit for cultivation, as a result not only agriculture production of this area has declined over the last few years, but also the soil quality has deteriorated quite substantially.

Potable Drinking Water Accessibility

The Rural water supply programme in the state is successful but the number of habitats that slip back is also quiet frequent. The challenge is to cover those habitats on a continuous basis and cover the partially covered and not covered categories as well. As of February 2012, 14013 habitations have been covered (Deptt. of Water Supply and Sanitation, 2012) and the rest out of total 14,605 habitations will be covered by December, 2013. In the urban areas, many cities are still not fully covered by piped water supply, and the Punjab Government aims to cover 100% of the urban habitations under piped water supply soon.

Ground Water Contamination

In the Malwa region of Punjab (Bathinda, Faridkot, Fatehgarh Sahib, Ferozepur, Ludhiana, Mansa, Moga, Muktsar, Nawanshahr, Patiala, Rupnagar&Sangrur) the ground water is contaminated with fluorides and salt. Recent cancer incidences in the region have been linked to Uranium traces found in the water. Kumar *et al.*, 2011 of BARC have found traces of Uranium measured by laser fluorimeter in 235 subsurface water samples collected from four districts of Punjab state in India. The concentration of Uranium in water samples ranged between <2-644 µg/L with a mean value of 73.1 µg/L. The radiological risk was observed to be in the range of 5.55 × 10-6-1.78 × 10-3 with a mean value of 2.03 × 10-4, which is around 22% more than the maximum acceptable level (l.67 × 10-4) as per guidelines of India's Atomic Energy Regulatory Board. The mean of chemical toxicity risk, expressed as life time average daily dose (LADD) was worked out to be 5.56 µg/kg/day with a range of 0.15-48 µg/kg/day by considering a bodyweight of 51.5 ± 8.5 kg, water ingestion rate of 4.05 L/d, and life expectancy of 63.7 yrs for an adult Indian reference man and compared with the reference dose (4.53 µg/kg/day). The average exposure level of Uranium was comparatively high and the chemical toxicity was expected to be more. The mean of hazard quotient (LADD/ RfD) for all four districts was found to be greater than 1, indicating that groundwater may not be suitable for consumption from a chemical toxicity point of view.

In the Malwa region water is supplied through canal based water supply schemes and additionally reverse osmosis systems have been installed at the tail of the canal network. As of March 2012, 450 RO systems have been commissioned and 189 are in progress. In areas where water supply is through tube wells and Total Dissolved Solids are beyond 800 ppm, 693 reverse osmosis systems have been commissioned and 309 are in progress. 55 RO systems have been commissioned and 112 are in progress

in areas where Uranium has been found to be above the permissible limits in the drinking water Tube wells.

4.4 WATER POLICY AND KEY ACTS

Punjab State Water Policy

State Water Policy was first adopted in May 1997 on the lines of National Water Policy-1987 (NWP-1987). NWP-1987 was updated in 2002 as a number of issues and challenges had emerged during last two decades in the development and management of the water resources.

Since Punjab has been facing serious challenges in management and utilization of its water resources, it reviewed and updated its existing water policy and came up with the Draft State Water Policy, 2008. It envisions that available water resources should be utilized efficiently and judiciously to meet drinking water needs and irrigation requirements in a manner that also promotes its conservation and community participation. It seeks to make water everybody's business and to catch rainwater where it falls or where it can be used optimally. Besides, the harnessing of water for commercial, industrial and hydro-power generation, its usage must take place in a sustainable manner ensuring desired quality of water. The policy also seeks to ensure that water, which is an essential requirement for sustaining all forms of life, is given due importance as a part of a larger ecological system.

Regulations For Conserving and Augmenting Ground Water

Punjab State Tube Well Act, 21 of 1954 enabled the government to provide for the construction, improvement and maintenance of State Tube well Irrigation works in Punjab. The Punjab Ground Water (Control and Regulation) Act, 1998 was enacted to regulate indiscriminate extraction of ground water. Further, in March 2009 the Punjab Legislative Assembly passed the Punjab Preservation of Sub-Soil Water Act, 2009, to restrict paddy transplantation not before 10th June

Building Bye-laws have been amended (PUDA Building Rules, 1996) to make rain water harvesting system mandatory in all buildings of 500 sq. yards and above. Municipal Corporations of Ludhiana and Jalandhar have also framed Bye-laws to make RWH mandatory in new buildings.

In urban areas for all the residential projects, commercial projects and other mega projects, PPCB has made it mandatory to implement the rain water harvesting. While granting NOCs and other statutory clearances to the project proponents, the Punjab Pollution Control Board as well as the Ministry of Environment and Forests, New Delhi, stipulates special conditions to this effect.

Regulations for Surface Water

For surface water management and protection, some of the important acts enacted are:

- The Northern Indian Canal and Drainage Act, 1873. According to this, water of any river or stream flowing in a natural channel, or of any lake or other natural collection of still water, can be applied or used by the State Government for the purpose of any existing or projected canal or drainage work, through a notification in the Official Gazette;
- The Punjab Minor Canal Act, 1905, augments the power of the Northern Indian Canal Drainage Act, 1873 by including all private water canals under the jurisdiction of the government;
- The Easement Act, of 1882 provides the right to the Government to regulate the collection, retention and distribution of the water of rivers and streams flowing in natural channels, and of natural lakes and ponds, or of the water flowing, collected, retained or distributed in or by any channel or other work constructed at the public expense for irrigation;
- The Punjab Land Preservation (Choes) Act, 1900 allows the government to implement measures to regulate the beds of choes;
- The Punjab Betterment Charges and Acreage Rates Act, 2 of 1953 allow the government to assess land valuation.

Pollution Control

The Punjab Pollution Control Board established in 1975 enforces the national Environmental laws and Acts such as the Water (Prevention and Control of Pollution) Act, 1974, Amended 1988; Water (Prevention & Control of Pollution) Cess Act, 1977; the Environment Protection Act, 1986 and the associated rules; Water (Prevention & Control of Pollution) Cess Rules 1978; (for details see http://www.ppcb.gov.in/environmental_acts_rules.php).

4.5 ONGOING PROGRAMMESAND PROJECTS FOR MANAGING WATER RESOURCES

Several centrally sponsored schemes, state schemes and loans from financial institutions such as NABARD, World Bank and the ADB, help to finance the various activities towards management of water resources in the state. These are summarized in **Table 4.6.** The Table also details the achievements of the state as of March 2012.

Table 4.6: Summary of programmes and projects and achievement of the State initiatives towards management of its water resources

Area of Action	Programmes/Projects	Achievement
Irrigation	- Accelerated Irrigation Benefit Programme (75%) - Participatory Irrigation Management Programme - Command Area Development and Water Management Programme - NABARD assistance for lining of Abohar and Bhakra main line canal - Project to rehabilitate ponds in all villages of the state - Project for modernization, remodeling, renovation and extension of canals, deep tube wells, lining of water courses, cleaning of head works, repairing of gates etc - Construction of ShahpurKandi Dam NEW Dasmesh Canal irrigation project - Remodeling and construction of distributaries/minors in the State - anti-water logging project in Muktsar, Ferozepur and Faridkot districts. - developing a Public Works Information Management system (PWIMS)	- Net area irrigated as of 2007-08 was 4112 thousand ha i.e 98.21% of the net sown area - Assured irrigation to the farmers through 2 projects namely Sirhind feeder Phase-II and Bathinda canal Phase-II
Drinking water and Sewerage	Rural Programmes - Accelerated Rural water supply programme - Rajiv Gandhi National Drinking Water Mission - SwajalDhara - National Rural Drinking Water Programme - Punjab Rural Water Supply and Sanitation Project - NABARD assistance for drinking water supply to NC Rural habitats - Rejuvenation of Drinking Water Supply Schemes including the Operation and Maintenance (O&M) of the completed rural water supply schemes is being handed over to Panchayats	- As of Feb 2012, 14013 rural habitations have access to drinking water out of the total 14605 rural habitations- achieving 99.3% coverage. - For water quality monitoring every month, 4450 water samples monitored for chlorination / silver ionization; 3000 water samples collected for physical & chemical analysis; Around 2140 water samples collected to check indicative bacteriological contamination. - Installation of reverse Osmosis systems in the Malwa region - These are being done under Punjab Nirman programme

	- NABARD assisted programme for Individual House Hold Latrines in rural areas	- Cleaning up brackish/fluoride affected and water logged villages in the state are being targeted. Target is to cover 564 NC (Not covered), 539 PC (Partially Covered), 703 OH (Other Habitats). - The Department of Soil and Water Conservation is laying pipes in 100 cities and towns from STPs setup by the Punjab Water Supply & Sewerage Board to reuse the waste water for irrigation.
	Urban Projects - Abatement of Pollution of rivers Satluj and Beas - Water supply and sewerage schemes for religious towns - Rehabilitation of existing sewerage system in walled city area of Amritsar - Water supply under UIDSSMT (Urban Infrastructure Development Scheme for small and Medium Towns) - Sewage Treatment Plant for Ludhiana, Jalandhar, Bathinda, Phagwara under JNNURM - Water supply/ sewerage/storm water drainage under JNNURM for Gidderbaha, Patti, Amritsar, Tarn Taran, Talwandi Sabo , - Intercepting sewer to tap sullage–Kala Sanghian drain, Jalandhar - Integrated Development of Urban Infrastructure in cities in Punjab funded by Japan International Cooperation (JICA), sewerage projects in Bathinda, Jalandhar, Amritsar , and at Tarn Taran - World Bank project for Water Supply and Sewerage in urban areas (in the anvil)	- As of Feb 2012, 88% urban population in 139 towns has access to drinking water supply. - 88 towns have sewerage covering 63% of the urban population - Reuse of treated waste water after treatment of 45 MLD domestic waste water of Ludhiana at Bhatian.
Pollution control	- National River Conservation programme - Surface Water monitoring under the MINAR scheme - Waste water pollution control programme. - PPCB advices, guides, encourage, persuade & help the industry in putting up effluent treatment plants (ETPs) to control and reduce pollution. - Water quality programme	- Monitors water quality at 37 monitoring locations on all the four rivers of the State viz. Satluj, Beas, Ravi &Ghaggar and also at Harike lake Discharge monitoring in towns of Jalandhar, Phagwara, Tanda, Dasuya, Mukerian, Bholath, Hoshiarpur, Moga, Phillaur and Banga along the Ghaggar and Satluj - PWSB is laying lateral sewers, main sewers and setting up STPs at 45 towns along these rivers - Monitors groundwater quality in industrial towns of Ludhiana, Jalandhar, Amritsar, Nangal etc. - Sludge sampling of waste water discharge from tannery, beverage, chemicals, electro plating and other industries

		- 5 CETPs set up in leather (2), dying (2 under proposal), Electroplating (1 in Ludhiana and 1 in MalerKotla), 8 more in electroplating industry, Bag tanning at Phillaur (1). - RO Plants installed in industries for reuse of waste water
Wetland management	- Conservation measures at Harike, Kanjli and Ropar Wetlands	- With the efforts of the PSCST, Harike, Kanjli and Ropar wetlands have been included in the Ramsar List of Wetlands of International Importance. These wetlands were earlier designated as wetlands of national importance by MoEF, GOI.
Controlling floods and Water logging	- Flood Management Programme - Flash flood control programme - NABARD scheme for construction of subsurface drainage	- Flood protection works along river Satluj, Beas, Ravi and its tributary Ujh - Flash flood control along Ghaggar, embankments, river training, construction of drains; canalization in Amritsar and Gurdaspur; construction of FPWs along river Satluj and along choes in Nawanshahr and other areas - Work in progress on the canalization of Sakki/KiranNallah in border districts of Amritsar and Gurdaspur - Re-modeling of cross drainage works has been initiated

4.6 LIKELY IMPLICATIONS OF CLIMATE CHANGE ON WATER RESOURCES IN PUNJAB

Evaluating the potential impacts of climate change on water resources (precipitation) requires the application of hydrological simulation modeling techniques, driven by scenarios of changes in temperature, precipitation and potential evapo-transpiration derived from global and regional climate modeling Studies. Precipitation is one of the least well represented processes in climate models at present, and the uncertainty in projections of climate change impacts on water resources is therefore high.

A study has been carried out by ADB (ADB, 2011), to assess the likely changes in water balance projections for the Satluj basin encompassing almost major parts of Punjab (see **Figure 4.6**). The study uses Soil and Water Assessment Tool (SWAT) with inputs from PRECIS Regional Climate Model run on IPCC A1B SRES. One realisation of the HADCM3 QUMP (Quantifying Uncertainty in Model Predictions, Q14) provided the boundary conditions for the PRECIS run.

Upper Satluj Basin

No definitive assessment of the projected changes in surface water resources in the upper catchment has been possible due to the complexity of the water systems Whichever scenario unfolds, the need to conserve groundwater is critical now and in the future.

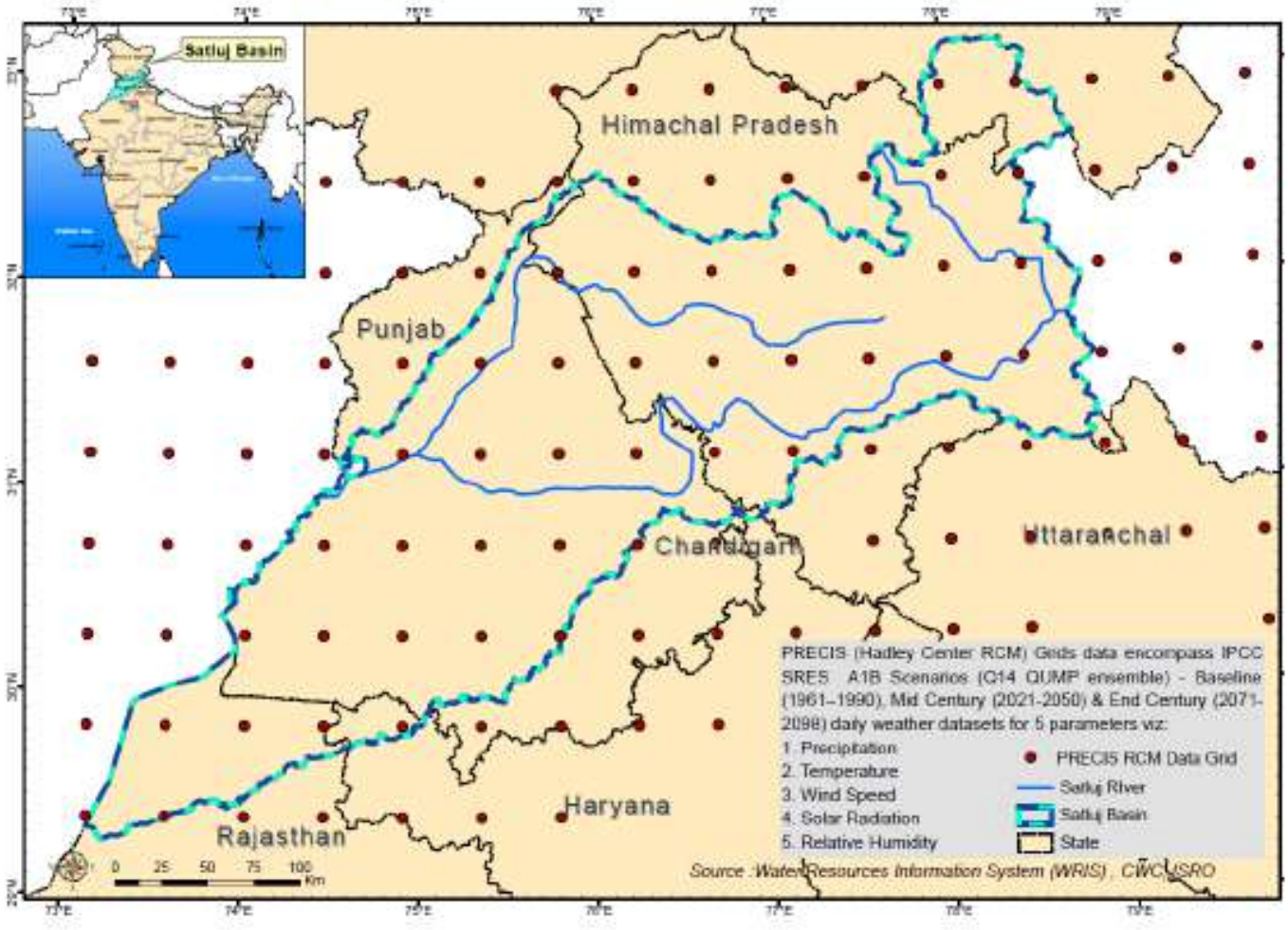


Figure 4.6: The boundary of the Satluj basin (dashed line) and the PRECIS Grid Points at $1^{o}x1^{o}$ resolution (*Source: ADB, 2011)*

Lower Satluj Basin

The projections for the lower catchment area of the Satluj basin, however, is more definitive and a summary of the average water balance, (a) annually, (b) for monsoon period (June July August September-JJAS-or Kharif Season), and (c) for lean period (Oct, Nov, Dec-OND- or Rabi season) for the mid century period is provided in **Table 4.7**.

Table 4.7: Changes in water balance in mid-century (2021-2050) in the lower Sutlej basin with respect to base line (1961-1990)

Scenario/Season	Precipi-tation	Evapo-transpiration	Surface Runoff	Base[1] flow	Total water yield[2]	Ground water Recharge[3]
Av. Annual (A1B Baseline)	402	290	71	0	73	52
Av. Annual (A1B- mid century)	512	327	125	1	127	73
Net Change in mm	110	37	54	0	54	21
% Change[4]	27	34	49	0	49	19
Av. JJAS (A1B base line)	316	127	65	0	65	42
Av. JJAS (A1B mid century)	411	135	114	0	115	56
Net Change (mm)	95	8	49	0	49	14
% Change[4]	30	8	52	0	52	15
Av. OND (A1B base line)	37	36	4	0	52	15
Av. OND (A1B mid century)	53	39	8	0	9	10
Net Change (mm)	15	4	4	0	5	5
% change[4]	41	23	29	1	31	33

Note: All units are in mm

[1]Base flow: Is the contribution of the stream flow in non-rainy period

[2]Water Yield: surface runoff+baseflow+lateral ground water flow

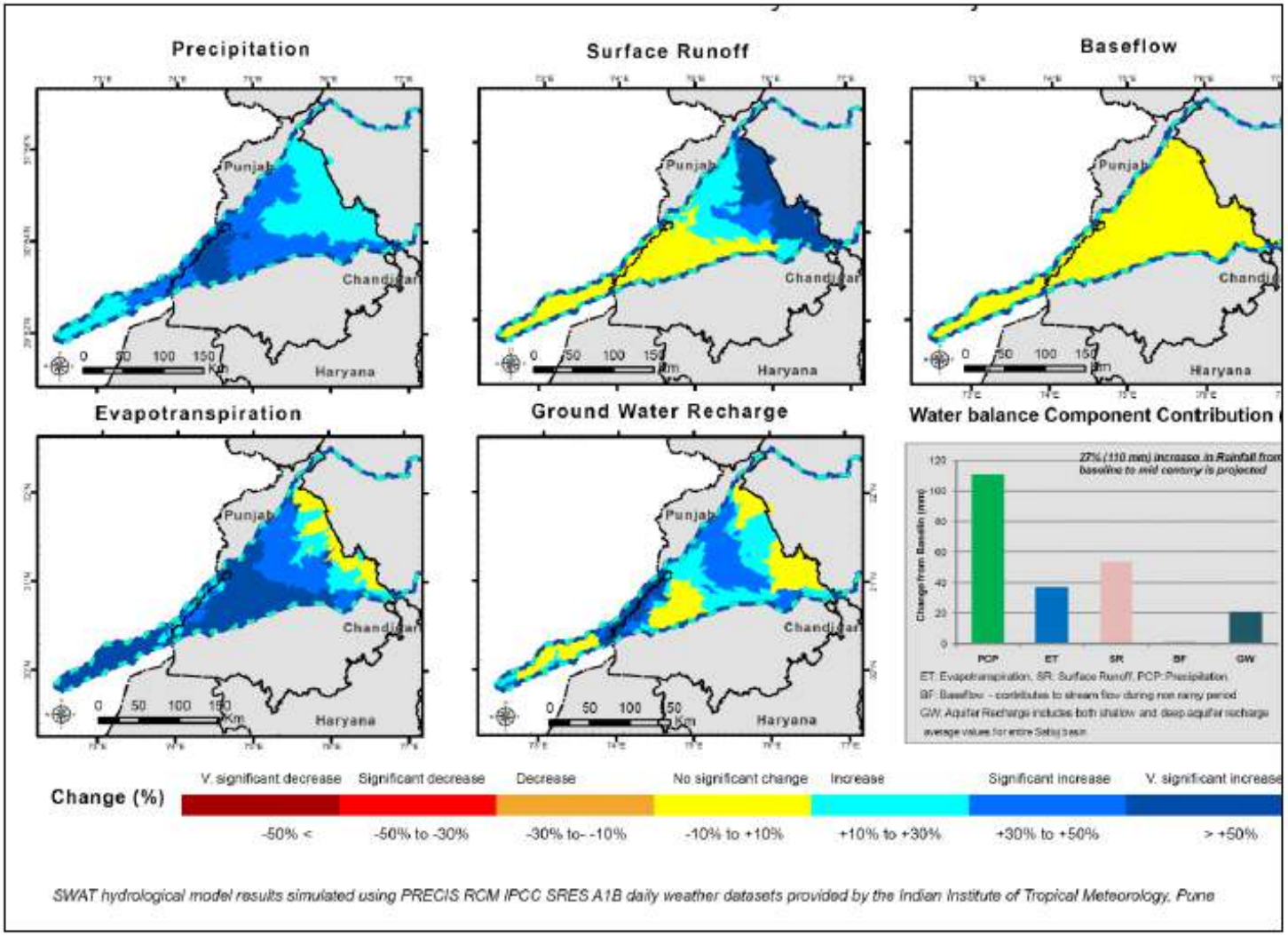
[3]Ground water recharge: Shallow and deep aquifer recharge

[4]Distribution of water balance components as a percentage of change in precipitation

Source: ADB Report, 2011

The projections of average annual changes in precipitation in the mid century (**Figure 4.7 a**)under A1B scenario indicates that there is likely to be an increase in annual average precipitation all across the Satluj basin by about 27% with respect to base line scenario, however, with a high spatial variation. The lower end of the basin is likely to experience an increase in precipitation by more than 50% and the middle of the basin is likely to receive 30% more precipitation with respect to base line. The Shivalik region is likely to receive precipitation in the range of -19% to +10% with respect to the base line precipitation. As a result the average precipitation across the basin is likely to increase by about 27% with respect to base line. Further, the annual average surface runoff is likely to increase in the MC (mid century) by 54 mm or 49% with respect to base line. Annual average evapo-transpiration rate is also projected to increase by about 34%.

The projections of precipitation for South West Monsoon Period - JJAS (**Figure 4.7 b**) indicates that it is likely to increase by about 30% or more by mid-century. The model results indicate that around 52% of this increase in precipitation will get converted to runoff with negligible change in base flow. An increase by about 15% in ground water recharge and 8% in evapo-transpiration is projected. The projections show that there is negligible change in simulated base flow, and hence most of the increased precipitation has to form surface runoff and groundwater recharge. The indication is that in parts of the basin surface runoff would double under the A1B scenario with respect to base line scenario. This should be treated as a very optimistic projection from a water resources perspective, but would offer opportunities for increased water harvesting and groundwater recharge. A concern should be the potential impact on drainage and on flood risk. Clearly this should be investigated further, and drainage design criteria reviewed.



4.7(a) Change in Annual Surface runoff, ground water flow and evapotranspiration in Mid Century with respect to Base Line scenario (*Source: ADB, 2011)*

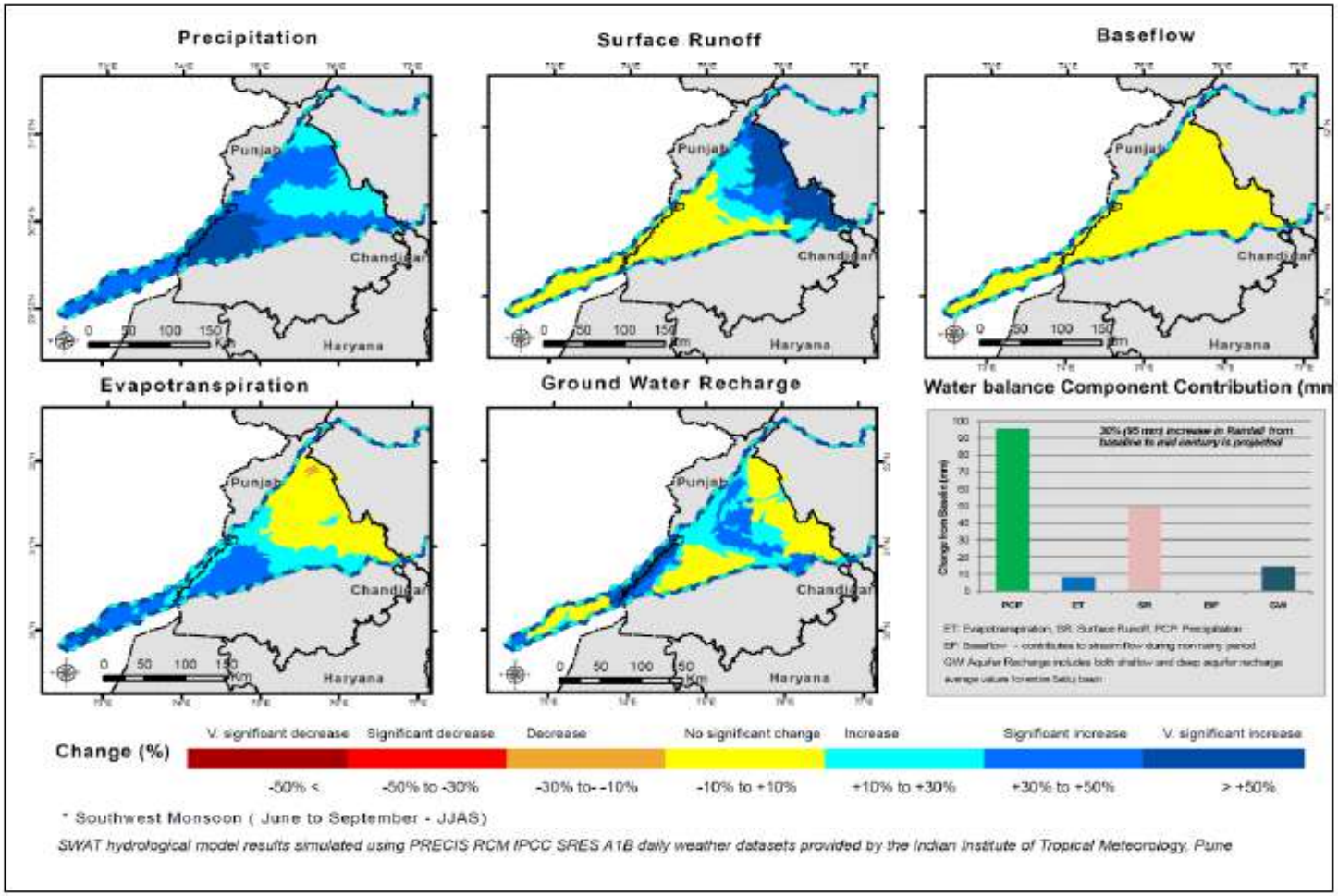


Figure 4.7 (b) Change in JJAS Surface runoff, ground water flow and Evapotranspiration in Mid Century wrt Base LineScenario (*Source: ADB, 2011)*

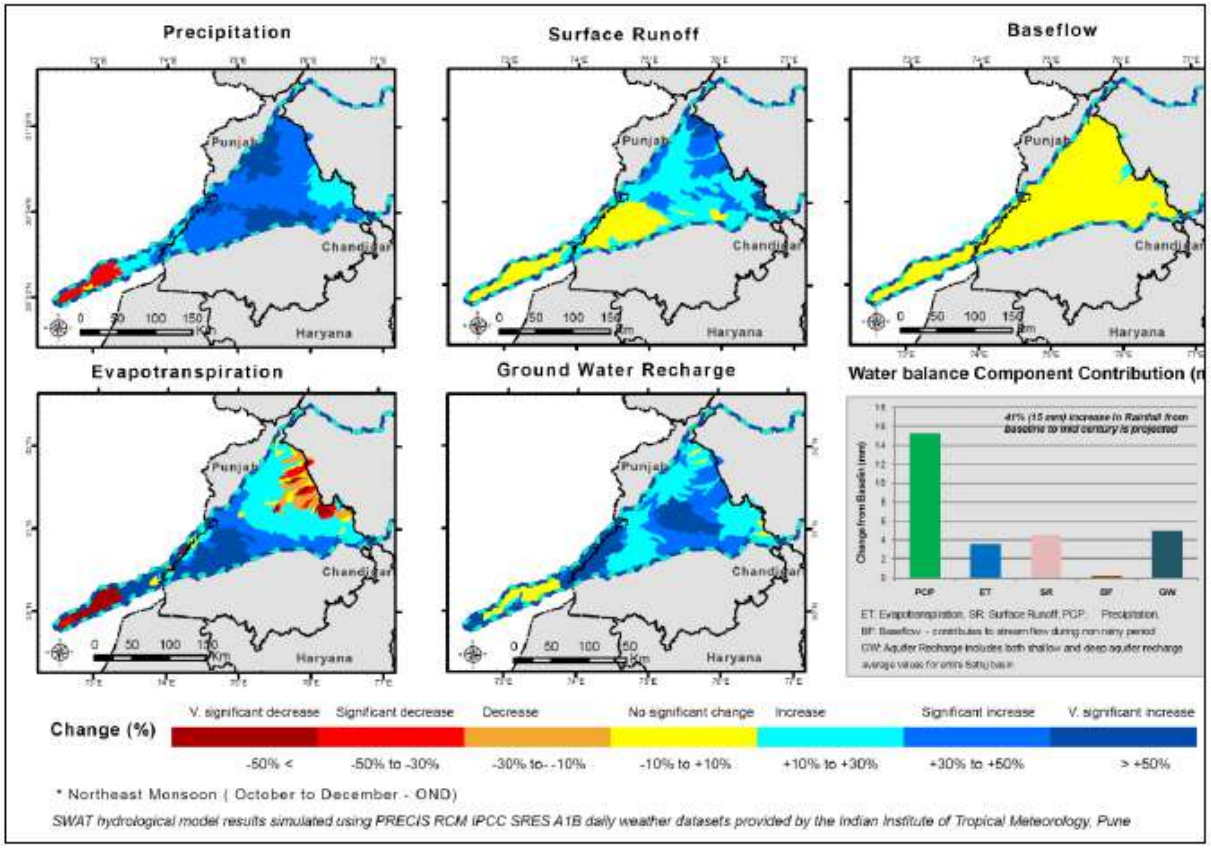


Figure 4.7 (c): Change in OND Surface runoff, ground water flow and Evapo-transpiration in Mid Century wrt Base Line Scenario. *Source: ADB, 2011*

Similarly, projections for South East Monsoon (Rabi) – OND (**Figure 4.7c**) indicates that the precipitation is likely to increase by 41% (15mm) resulting in an increase in runoff of 29% and a increase in ground water recharge by 33%. Evapo-transpiration is projected to increase by 23%. This is significant compared to JJAS scenario and the reason for this may be attributed largely to increases in temperature. Marginal changes in the base flow are seen. The contribution of the OND season to the annual water balance is small.

It is clear from the above discussion and recalling of the climate projections made in chapter 3 of this document, that in the mid-century (2021-2050), the state of Punjab is likely to experience the following:

- Temperature is projected to increase all across the basin by about 1.7^{o}C to 2.0^{o}C. The increase in minimum temperatures is likely to increase more than the maximum temperatures.
- Changes in evapo-transpiration projections are minimal in the mid century within the basin, and likely to range between 1290 to 1900 mm as against the base line range of 1260 to 1890 mm. The lower end of the range of evapo-transpiration corresponds to upper end of the catchment area and upper range corresponds to southwest part of the basin.
- An overall increase in rainfall of about 32% is expected with respect to the present average annual rainfall that ranges between 960 mm in sub-mountain region and 460 mm in the plains. The western parts of the basin may receive up to 50% more precipitation by the end of the century compared to the current climatologically baseline. This also means that the water logging conditions in the south western region of the state may intensify.
- Increase in heavy precipitation events of the order of 100mm/day and 150mm/day level are also projected for the entire basin. Smaller increases are projected to occur in the central region of the basin, and some regions could see the number of such days double from about 3 per yr to 6 per yr. Mountainous regions are less affected. With increase in heavy precipitation events likelihood of flash floods increases.
- An increase in annual average surface runoff is projected with the largest increase in the southwest monsoon period (JJAS).
- The increase in annual average run off is likely to be 1.6 times more than annual precipitation. This can be attributed to more precipitation falling on saturated soils.
- Increases in evapo-transpiration are more significant during northeast monsoon period (OND) or during the Rabi season which may be attributed largely to increases in temperature.
- Increase in glacier melt and precipitation in the form of snow is expected uptomid century thereby increasing the availability of river water. However, after 2050s glacier melt as well as snow precipitation is likely to reduce, thereby affecting river flow/ inflow into Bhakra.

The state of Punjab, therefore, needs to address its water management issues keeping in view the above mentioned projections.

4.7 NATIONAL WATER MISSION

The Water mission under the National Action plan on climate change focuses on augmentation and efficient management of the water resources, and within the purview of the same the Punjab Government aims to address the climate change issues.

The main objective of the National Water Mission is “conservation of water, minimizing wastage and ensuring its more equitable distribution both across and within States through integrated water resources development and management”.

The five identified goals of the Mission are:

- Creation of a comprehensive water data base in public domain and assessment of impact of climate change on water resource;
- Promote action for water conservation, augmentation and preservation;
- To have a focused approach to redeem the water levels in over-exploited areas
- To increase water use efficiency by 20%, and
- To promote basin level integrated water resource management.

4.8 PUNJAB WATER MISSION AND STRATEGIES

State Objective

Under the aegis of the National Water Mission the state aims to undertake an integrated approach for conservation and management of its water/water resources, improve water use efficiency, control water pollution, minimize wastage and ensure equitable distribution of water across the state by addressing the impacts of climate change on water resources.

The following strategies will be undertaken by the state to achieve the objectives of the water mission and adapt to climate change.

Strategy 1

Draft a State Water Policy to undertake an integrated water resource management at a basin level within the state to conserve water, minimize wastage and ensure equitable distribution.

The Policy will consider precipitation as the basic water source. It will promote surface and ground water augmentation in the state using all possible techniques keeping in view the fact that the state is likely to have more erratic but heavier precipitation events. The policy will ensure regular monitoring of ground water. It will encourage water use efficiency, and crop diversification to discourage rice and wheat crop intensification. It will have provisions for arresting excess irrigation, and encourage waste water reutilization.

The policy will propagate differential/ telescopic water tariffs for domestic use. It is proposed that base line use for urban and rural homes will be fixed and any use beyond that will be charged to recover the production and transmission of water. Currently the per capita use in urban areas is fixed at 135 litres/capita/day and in rural areas it is 70 litres/capita/day. 100% coverage of homes by water meters to be ensured.

The state will prepare a ground water bill including guidelines for RWH (Rain Water Harvesting) and Artificial Recharge. It will endeavor to enact legislation to restrict withdrawal of ground water wherever/whenever needed. It will also endeavor to enact enabling legislation to regulate ground water during droughts.

The mandate within the Water policy will also be to come up with new policies on various aspects of water management as and when required and review existing related policies and bring in addendums to ensure their relevance as per the circumstances and requirement of the state. It will endeavor legislation and regulation.

To support policy formulation, policy analysis will be undertaken for sustainable water management, enabling water augmentation, conservation, and distribution.

Strategy 2:	**12th Plan**	**13th Plan**	**Total Cost**
Cost Implications	Rs 0.50 Cr	Rs. 0.25 Cr	Rs. 0.75 Cr

Strategy 2

Undertake a focused approach to augment ground water especially in problematic/over exploited areas taking advantage of continued projection of excess rainfall with respect to base line scenario.

The actions would include continuation of implementation of Punjab Preservation of Sub-Soil Water Act, 2009 to regulate rice plantation activities, conjunctive use of water that uses both groundwater and surface water in a coordinated fashion with aquifer acting as a water source during dry periods, and a storage reservoir during wet periods, Artificial recharge of ground water including use of storm water, Rain water harvesting in village clusters and urban households and commercial establishments in critical and semi critical areas, and Implementation of metering and charging of ground water extraction and implementation of CGWA notice with respect to 'Notified Blocks' of Punjab

Strategy 2:	**12th Plan**	**13th Plan**	**Total Cost**
Cost Implications	Rs 875.00 Cr	Rs. 1939.00 Cr	Rs. 2814.00 Cr

Strategy 3

Enhance water use efficiency by 20% with respect to the present.

The actions would include enhancement of share of waste water reuse in the total water used in different sectors. Besides, avoidance of leakage through water distribution pipes, metering of unauthorized connections, promotion of water use efficiency in agriculture and industrial sectors, implementing differential pricing of water use for agriculture, industrial and domestic sectors and by reducing water allowances for agriculture in water logged areas there by saving water would be promoted.

Strategy 3:	**12th Plan**	**13th Plan**	**Total Cost**
Cost Implications	Rs. 2373.81 Cr	Rs. 3911.00 Cr	Rs. 6284.81 Cr

Strategy 4

Augment surface water resources to accommodate excess rainfall and runoff projected for mid century.

Actions would include speedier implementation of major and minor surface irrigation projects and schemes proposed so far in sensitive areas, rehabilitation of ponds and lakes in rural and urban areas including revival of traditional water storage bodies, rehabilitation and conservation of wetlands in the state, generating awareness programmes on conservation of wetlands for all stakeholders, and enhancement of canal efficiency.

Strategy 4:	**12th Plan**	**13th Plan**	**Total Cost**
Cost Implications	Rs. 1926.10 Cr	Rs. 3571.00 Cr	Rs 5497.10 Cr

Strategy 5

Manage floods in a future erratic and excess extreme rain fall scenario.

The actions would include remodeling of drainage crossings of canals such as Satluj Yamuna link, Bhakra main line, Bhakra main branch that are obstructing the free flow of Ghaggar river to avoid flash floods; flood protection works along river Ravi in flood prone areas (NarotJaimal Singh block in Gurdaspur on the right and other areas on left bank of Ravi in Gurdaspur and Amritsar); and flood protection along the right side and Ropar, Ludhiana, Moga and Ferozepur on the left side of River Satluj.

Strategy 5:	**12th Plan**	**13th Plan**	**Total Cost**
Cost Implications	Rs. 63.00 Cr	Rs. 87.00 Cr	Rs. 150.00 Cr

Strategy 6

Contain the likely enhanced water logging situation in the south west districts of Punjab due to the projected rain fall exceeding 50% of the base line scenario in this region.

The actions would include an assessment of amount of water that is likely to be logged in the south western parts of the state; promotion of conjunctive use of canal water, other surface water and ground water, promotion of bio-drainage through planting of high water intensive plantations, construction of subsurface drainage network; identification of multiple well points in water logged areas for channelizing flood waters for ground recharge, avoidance of seepage in Shirhind and Rajasthan Canals by strengthening their lining.

Strategy 6:	**12th Plan**	**13th Plan**	**Total Cost**
Cost Implications	Rs. 1871.00 Cr	Rs 330.00 Cr	Rs. 2201.00 Cr

Strategy 7

Abate continued water pollution of underground and surface water sources which is likely to increase due to increase in industries and population.

Actions would include (i) control of water pollution due to industrial effluents at source and residual pollution before/at discharge point into the rivers; (ii) abatement of fertilizer and pesticide pollution by promoting use of herbal pesticides and organic fertilizers, and (iii) abate water pollution due to domestic waste water discharge at nodal points within the cities and at discharge points into the rivers, and (iv) Study the impact of Climate change on depletion in water tables and its quality. The actions suggested includeMonitoring water tables and ground water quality in each block using Pz tubes (Piezo-electric tubes), Identifying changes in water quality and water table due to climate variability and change and POL and others to study in situ effects in the farmers' fields.

Strategy 7:	12th Plan	13th Plan	Total Cost
Cost Implications	Rs 3525.13 Cr	Rs. 4005.00 Cr	Rs. 7530.13Cr

Strategy 8

Establish adequate institutional support for efficient water resource augmentation, conservation, distribution and governance through development of basin level Integrated Water Management plans.

Actions would include establishment of a State Water Resource Committee; A Basin Level Water Regulatory Authority; establishment of Integrated Water Resource Management (IWRM) units at state and district levels to develop sub basin level plans for water resource management which can be integrated to form basin level management plans;

Strategy 8:	12th Plan	13th Plan	Total Cost
Cost Implications	Rs 45.50 Cr	Rs 13.50 Cr	Rs 59.00 Cr

Strategy 9

Suggested Research and monitoring activities for effective decision making.

The research activities suggested include assessment of water availability in various climate scenarios; development of digital elevation models for flood prone areas for forecasting floods with inputs from climate change scenarios; estimation of river flows in mountainous areas; isotopic tracer based monitoring of river water discharge at all major river monitoring stations; assessment of likely excess water inflow into the dams due to climate change and design of possible strategies for containing the same; assessment of conjunctive water use efficiencies and potential for a sustainable surface and ground water utilization; assessment of technical feasibilities, economic and environmental implications of various catchment and artificial recharge options including those of wetlands; development of appropriate implementable technologies for saline and other pollutant management in ground water; assessment of water availability and demand by sector for a better water resource management across sectors in a base line and climate change scenario in depth studies of characteristics of snow and glacier melt feeding the rivers flowing through the state of Punjab.

Strategy 9:	12th Plan	13th Plan	Total Cost
Cost Implications	Rs. 133.50 Cr	Rs. 60.00 Cr	Rs. 193.50 Cr

The total cost for implementation of 9 strategies under the aegis of the water mission in Punjab is estimated to be:

Plan period	Cost
12th Plan	Rs. 10865.74 Cr
13th Plan	Rs. 13978.35 Cr
Total Cost	Rs.24844.09 Cr

The details of the actions, and time lines, responsible agencies for each action are provided in Annexure 3 of this report.

REFERENCES

1. ADB, 2011. Appendix 2: Final Report - Lower Satluj Sub basin. TA 7417- IND: Support for the National Water Mission - National Action Plan on Climate Change. Prepared for Govt. of India and State Govt. of Punjab by Asian Development Bank, pp157.
2. Bhutiyani M. R., Vishwas S. Kale, and N. J. Pawar, 2008. Changing stream flow patterns in the rivers of northwestern Himalaya: Implications of global warming in the 20th century; Current Science, Volume 95, no 5, pg 618-626.
3. Dhillon, S.S. and H. Kaur 1996. Analytical studies on the aquatic ecosystems of Punjab. Final Technical report, Punjab State Council for Science and Technology, Chandigarh.
4. DoI, 2008. Draft Punjab state water policy, 2008. Department of Irrigation. Government of Punjab. http://www.cseindia.org/userfiles/Punjab_state_water_policy_-_Draft_2008.pdf. Accessed on Dec 6, 2012.
5. Ferris, J.S. and Congalton, R.G., 1989. Satellite and geographic information system estimates of olorado River basin snowpack. Photogrammetric Engineering and Remote Sensing,55, pp. 1629–1635.
6. Gosain, H.S., Mishra, V.D. and Bhutiyani, M.R., 2012. Winter Temperature and Snowfall Trends in the Cryospheric Region of North-West Himalaya. International Symposium on Cryosphere and Climate Change, Snow and Avalanche Study Establishment, Research and Development Centre, Chandigarh 2-4 April 2012, Manali, India
7. Hira, G.S., Jalota, S.K., Arora, V.K., 2004. Efficient management of water resources for sustainable cropping in Punjab. Technical Bulletin, Department of Soils, Punjab Agricultural University, Ludhiana, India, pp, 20.
8. Jain, S.K., Goswami, A. and Saraf, A.K., 2010. Snowmelt runoff modelling in a Himalayan basin with the aid of satellite data. Intl. J. Remote Sensing. 31(24): 6603-6618.
9. Jain, S.K., Goswami, A. and Saraf, A.K., 2009. Assessment of snowmelt runoff using remote sensing and effect of climate change on runoff. Water Resource Manage. 24: 1763-1777.
10. Jerath, N. 1992. The Environmental problems of Harike Wetland: Some strategies for conservation. In: Wetlands of India (Ed: Chatrath, K.J.S). Ashish Publishing House, New Delhi; pp.103-124
11. Kumar Ajay, N. Usha, P. D. Sawant, R. M. Tripathi, R. Sanu Raj, Manish Mishra, Sabyasachi Rout, P Supreeta; Jaspal Singh, Sanjeev Kumar, and H S Kushwaha, 2011. Risk Assessment for Natural Uranium in Subsurface Water of Punjab State, India. Human and Ecological Risk Assessment, Volume 17, Number 2, March 2011, pp. 381-393(13).
12. Ladhar, S.S., M. Chauhan, S. M Handa, and N. Jerath, 1994.Ramsar Sites of India: Harike Lake, Punjab. World Wide Fund for Nature, India. New Delhi; pp.57.
13. PbSAP, 2010. Statistical Abstract of Punjab, 2010. Published by the Department of Economic and Statistics, Government of Punjab
14. PbSAP, 2011. Statistical Abstract of Punjab, 2011. Published by the Department of Economic and Statistics, Government of Punjab.
15. Personal Communication, 2014. Sharma, Vaibhav; Varunendra Mishra, and P K Joshi. Topographic controls on spatio-temporal snow cover distribution in Northwest Himalaya. Communicated to International Journal of Remote Sensing in Oct 2013.
16. Tiwana N. S., N. Jerath, S. K. Saxena, P. Nangia and H. K. Parwana, 2005. State of Environment: Punjab 2005, Punjab State Council for Science & Technology, Government of India; pp: 315.
17. Tiwana, N.S; N. Jerath S. S.Ladhar, G. Singh, R. Paul, D. K. Duaand H. K. Parwana, 2007. State of Environment, Punjab-2007, Punjab State Council for Science & Technology, pp 243

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5. Sustainable Agriculture Mission

Highlights

- Agro-climatic zones in Punjab and their vulnerabilities
- Agriculture Production trends in Punjab
- Current Challenges of the Agriculture Sector in Punjab
- Institutions Managing Agriculture in Punjab
- Key Agriculture Policies and Acts of the State
- Likely implications of climate change on Agriculture in Punjab
- Strategies and actions to address Climate Change concerns

Punjab has pioneered the green revolution in India. Since mid-sixties, the green revolution transformed the state's agriculture and economy and contributed significantly in making the country self-reliant in food. Food grain production in the state increased from 3.16 million tons in 1960-61 to 25.66 million tons in 2004-2005 (Source: Statistical Abstract of Punjab, 2005), thus contributing more than 50% of grain into the central grain pool leading India from a famine affected and grain importing country to a self reliant, self sufficient and export surplus nation.

5.1 AGRO-CLIMATIC ZONES IN PUNJAB AND THEIR VULNERABILITIES

Punjab is divided into five agroclimatic zones on the basis of homogeneity, rainfall pattern, distribution, soil texture, cropping patterns etc. (see **Figure 5.1**).

Zone I- Submountanous undulating zone: It extends along the eastern borders of the state and occupies an area of 4800 sq km (The northern and southern parts of the zone have medium to heavy soil while the central part has light to medium soils. Average annual rainfall is 900mm and average temperatures are 40-41^{O}C (maximum) and 6-7^{O}C (minimum). The zone is dissected by innumerable seasonal streams called 'choes' and there is serious problem of soil erosion. Maize, rice, sugarcane and wheat are the main crops.

Zone II -Undulating Plain Zone: It runs parallel to the sub mountainous zone and is about 15 to 30 km in width. It covers an area of about 4600 sq km. Soil type is medium to heavy in north-south and light to medium in central region. Annual rainfall is 800-900mm. Soil erosion is less severe and alkali soils are present in some blocks. Rice, maize, sugarcane and wheat are the main crops of this region.

Zone III- Central Plain Zone: It covers an area of about 18,000 sq km in the state. The northern part of the zone has medium to heavy soil while the southern part has light to medium soils. The zone is homogenous except few small pockets of sand bars in some blocks. Mild to severe alkali problems and water logging problems are there in some districts. The average annual rainfall is 500-800mm and temperature is 41-42^{O}C (Max) and 4-7^{O}C (Min). Rice, wheat, maize, rapeseed and mustard, mungbean, potato and tomato are the main crops of this region.

Zone IV- Western Plain Zone: It lies between the central flat plain on the east and the western zone in the extreme west. It covers an area of 9,500 sq km and has medium to heavy soil. Annual rainfall is about 400-500mm on an average. Eastern part of the zone has mild to serious alkali problems

while the southern part has water logging problems. Rice, wheat, sugarcane and cotton are main crops of this region.

Zone V - Western Zone: It lies in the extreme south west of the state and covers about 10,000 sq km (19.5%) area. Towards the north, the soils are medium to heavy and towards south these are light to medium. Rainfall is less than 400mm annually. Soil moisture in kharif season is deficient for most of the crops. There is problem of shifting sand dunes and wind erosion in some parts. Some northern parts have serious alkali and water logging problems. In this region cotton, rice, wheat and sugarcane are the main crops.

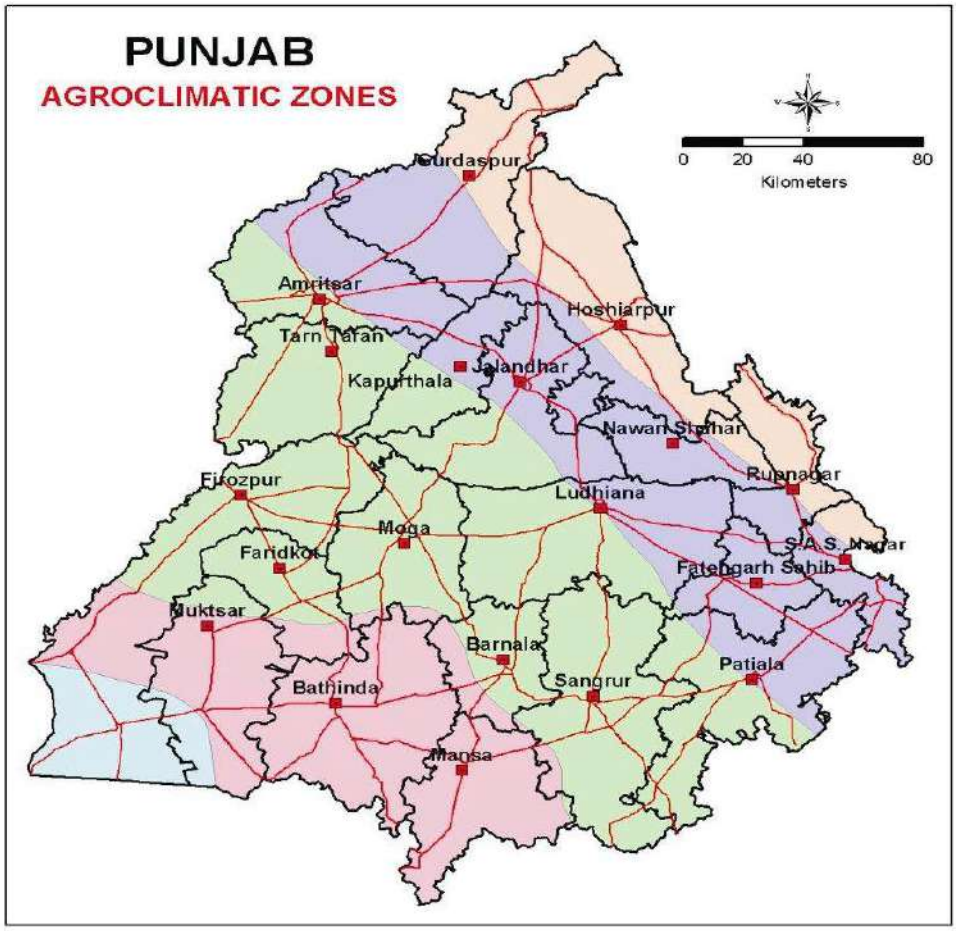


Figure 5.1: Agroclimatic zones of Punjab

Source: Punjab Revenue, 2012

Table 5.1: Agroclimatic features of the five agroclimatic zones of Punjab

Sub Region	Rainfall (in mm)	Climate	Soil	Most suitable Crops
AGROCLIMATIC FEATURES OF ZONES I AND II				
High altitude temperate	165	Humid to cold arid	Hill soils, mountain, meadow skeletal, tarai	Wheat, maize, rice, Jowar.
Hill temperate	2000	Humid	Brown Hill	Rice, maize, wheat, rapeseed
Valley temperate	400	Sub-humid	Sub-mountain, mountain skeletal, meadow	Wheat, maize, rice, sugarcane.
Sub-tropical	1030	Semi-arid to humid	Alluvial (Recent), brown hills.	Wheat, barley, potato.
Average rain fall	900			
AGRO CLIMATIC FEATURES OF THE ZONE III, IV AND V				
Plains – Zone III	561	Semi-arid to Dry sub-humid	Alluvial (Recent)	Wheat, rice, maize, sugarcane
Scarce Rainfall arid region - Zone IV and V	360	Arid and Extreme arid	Calcareous, Sierozemic, Alluvial (Recent), desert	Wheat, cotton, gram, Bajra, rice

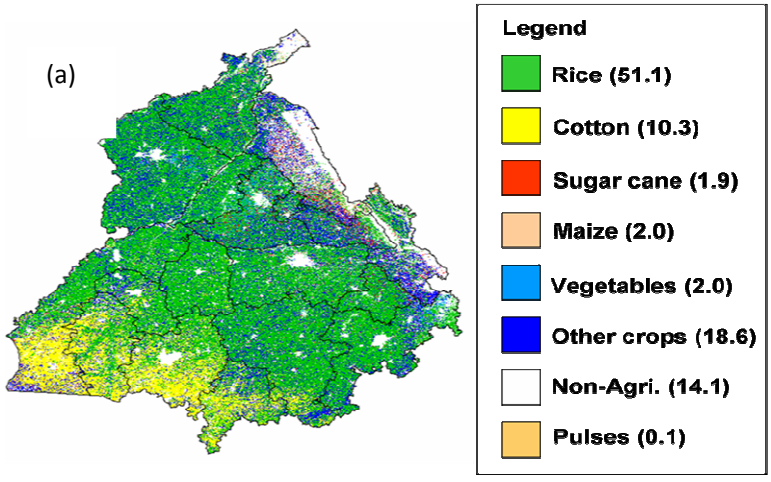
Source: DACNET, 2012

5.2 AGRICULTURE PRODUCTION TRENDS

Current Cropping pattern

Low resolution satellite pictures indicate that currently, in the agro-climatic zones of undulating plain, the central plains and eastern parts of the western zones in Punjab rice is grown extensively in the Kharif season. Only in the south western parts of the western agro-climatic zone is cotton grown during the same period. Other crops are also grown all across Punjab but in very small pockets, the diversity being more in the undulating sub mountainous agro-climatic zone of the state. In the Rabi season, the entire state grows wheat extensively. Potato is a dominant horticulture crash crop that seems to be growing in this season in the upper central region of the central plains. Other crops are also interspersed in small pockets all across the state, again with more crop diversity in the sub-mountainous undulating agro-climatic zone (**Figure 5.2**).

(a)



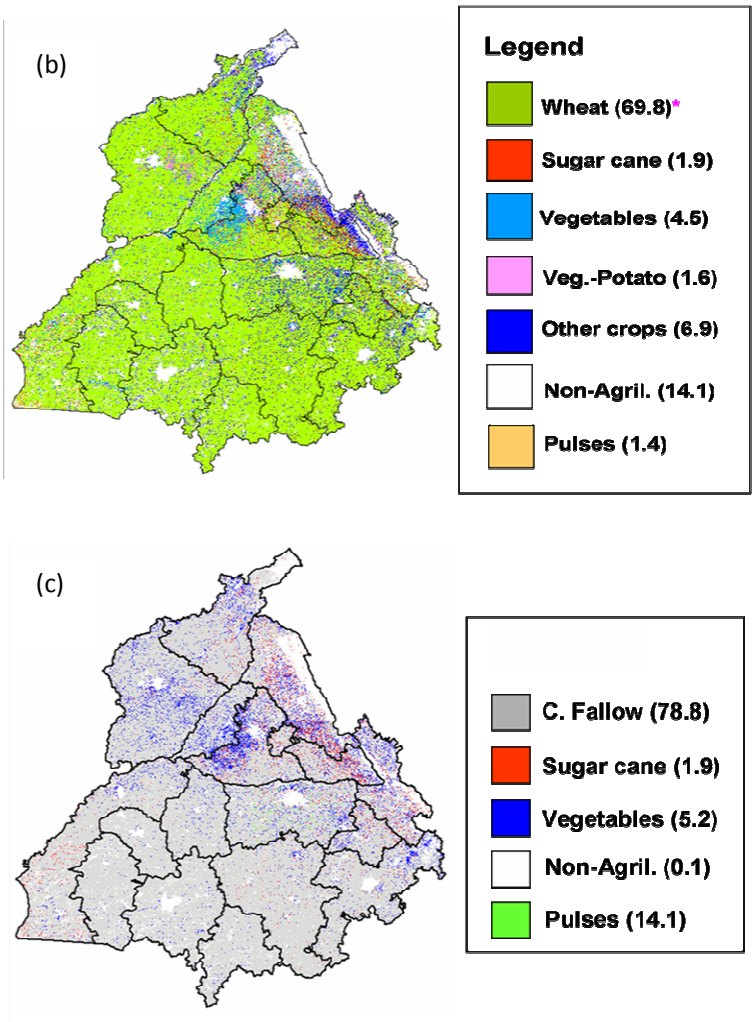


Figure 5.2: Cropping pattern of Punjab (a) Kharif, (b) Rabi, and (c) Summer. Figures in brackets represent percentage of area under each crop with respect to net sown area

Source: Panigrahy et al., 2009.

Annual Crop Production Trends

Since the Green Revolution in 1960s, Punjab has been contributing substantially to the central pool of food grain. Even in 1980-81, it contributed 2.52 million tons of rice and 4.3 million tons of wheat, and this contribution has increased to 9.3 million tons of rice and 10.7 million tons of wheat in 2009-10 (*SAP, 2010*).

This achievement has been possible due to continuous increase in agricultural production (see **Figure 5.3 a and b),** mainly due to rich farming inputs in terms of land, water through assured irrigation, fertiliser, and others. The total area under assured irrigation has increased from 2888

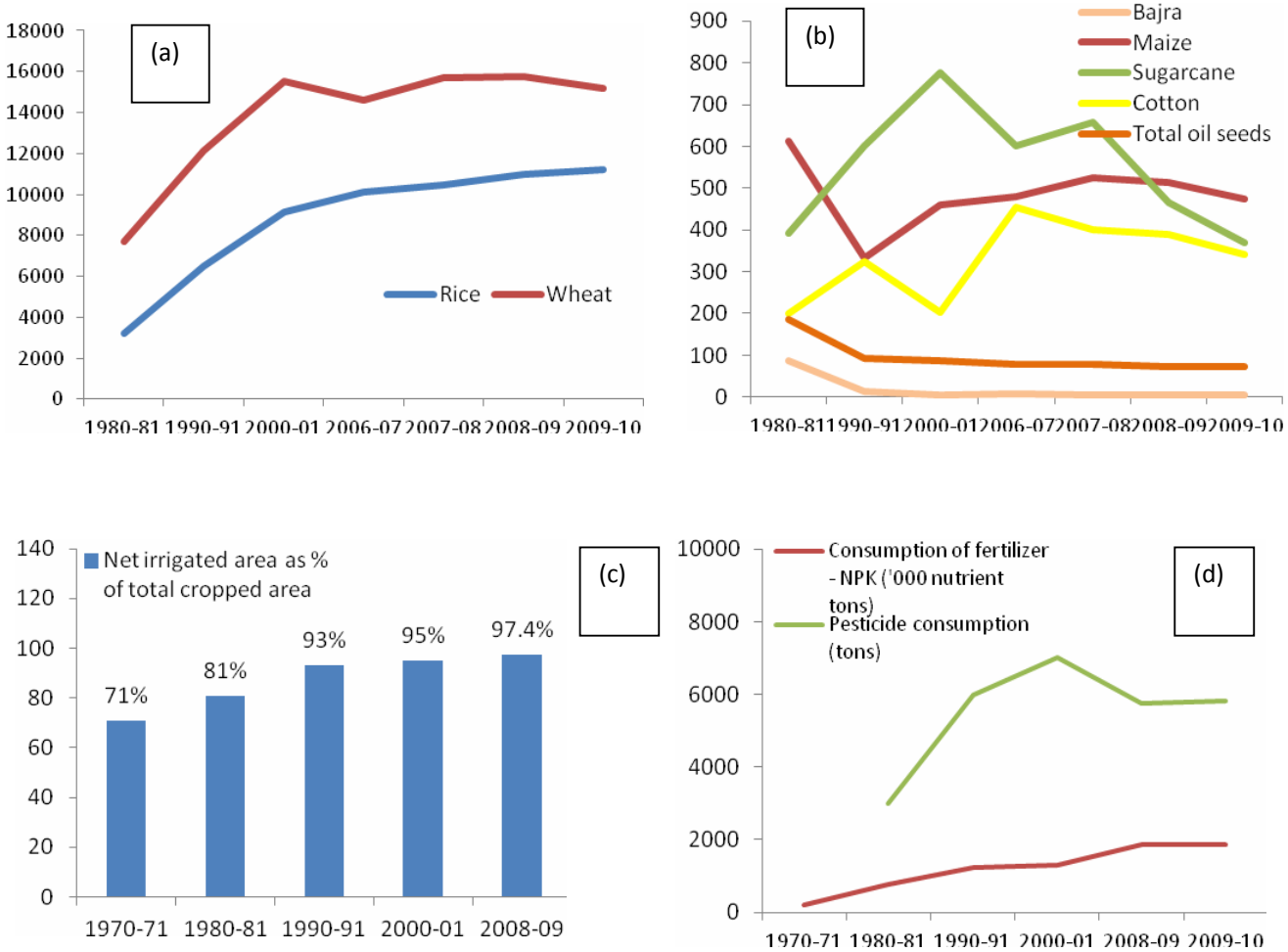


Figure 5.3: (a) Trends of production of rice and wheat in '000 tons, (b) Trends of production other key crops in '000 tons, (c) Increase in irrigated area as percentage of cropped area across the years, and (d) Fertilizer and pesticide consumption trends. *Source: SAP, 2009, 2010*

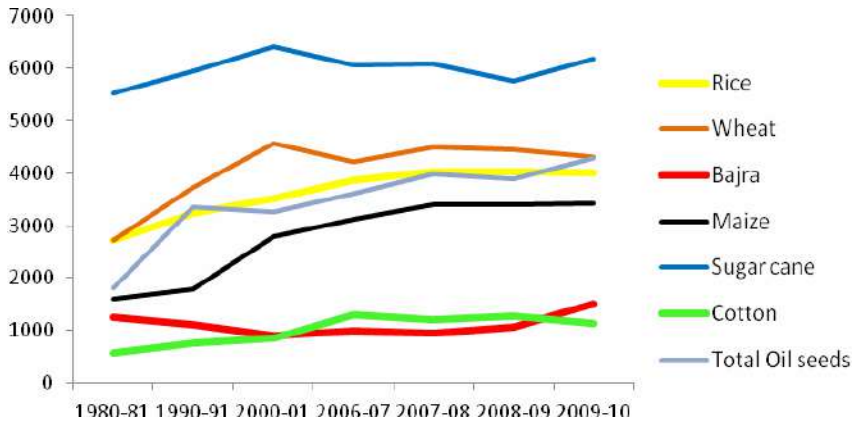


Figure 5.4: A comparison of trends of yields in kg/ha of key crops in Punjab

Source: SAP, 2010

thousand ha in 1970-71 to 4070 thousand ha in 2010-11. The fertiliser consumption (NPK) also has increased nine times from 213 thousand nutrient tons to 1911 thousand tons during the same period (See **Figure 5.3 c and d**). This is mainly to meet the high production targets. However, the consumption levels have plateaued since 2008 onwards. In spite of the growing farm inputs, the yields of wheat has plateaued of late and is hovering around 4500 kg/ha (4307 kg/ha in 2009-10 and 4693 kg/ha in 2010-11). Similar is the case of yields of rice, sugar cane, maize, and cotton. However, bajra and total oil seeds show an increasing trend in yields over the years, inspite of decreasing area under these crops (**see Figure 5.4**). (*SAP, 2009, 2010, 2011*).

In order to remain profitable in spite of plateauing yields, the cropping pattern has changed dramatically. The total area under rice and wheat combined is continuously increasing and 100% of this area is under high yielding rice and wheat varieties. Since 2000-01, the combined area under rice and wheat has crossed 75% of the total cropped area, and consequently area under other traditional crops like maize, and cotton have considerably declined**.**

District wise distribution of crops

An examination of district-wise data for 2008-09 reveals an interesting pattern (*Source: Statistical Abstract, 2010*). All districts grow, rice, wheat and potato. The variabilities in the yields across the districts are minimal. For instance, rice yields range from a low of 3135 kg/ha in Gurdaspur to a high of nearly 3770 kg/ha in Barnala. Similarly, wheat yield varies from around 3849 kg/ha in Hoshiarpur to a high of 4932 kg/ha in Fatehgarh Sahib. The potato yields vary from 21232 kg/ha in Muktsar Sahib to a maximum of 25716 kg/ha in Fatehgarh Sahib. Bajra seems to be growing only in Mansa, Sangrur and Fatehgarh Sahib; and Jowar only in the district of Ferozepur. Sugarcane, maize, cotton, pulses and oil seeds though are not grown in all districts, but the variability in yields across these districts is not very high.

Horticulture Production Trends

Between 1990-91 and 2010-11, the area under fruit cultivation in Punjab has gone up from 68806 ha to 69813 ha (SAP *2011*; *HM 2011)*. Correspondingly, the fruit production has gone up from 629279 tons to 1373173 tons within the same period. Though area covered under fruit production in Punjab is only 1.1% of the national area under fruit crops, it ranked 4th in terms of yield of fruits at 19.7 tons/ha in 2010-11. This is also above the average yield at India level which is 11.3 tons/ha. The high level of yield is a marker towards a possibility of higher level of production, if more area and appropriate farm inputs are provided with continuous innovation in technology. Kinnow, a variation

of Orange is the major fruit produce of the state which is now occupying 41207 ha i.e 60% of the total area under fruit production in Punjab. Besides, guava, mango, ber, and pear are other important fruits of Punjab (**Figure 5.5)**

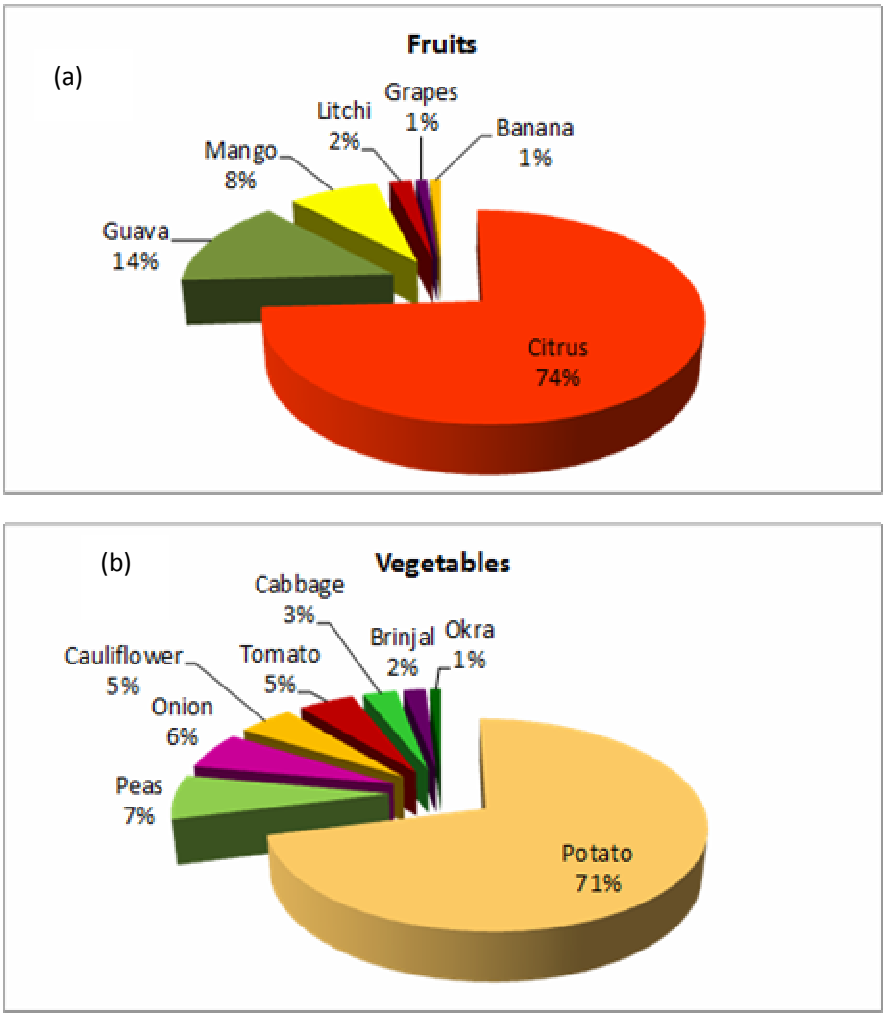


Figure 5.5: Share of production of different types of horticulture crops (a) Fruits and (b) Vegetables grown in Punjab in 2010-11

Source: NHB, 2011

The area under vegetable production has gone up from 83000 ha to 188436 ha between 1990-91 to 2010-11. The production has gone up from 1439000 tons to 3645030 tons, with productivity increasing from 17.3 tons/ha to 20.6 tons/ha. As a result Punjab ranked 5th in terms of productivity per ha in 2010-11. This is again above the average Indian yield of 16.7 tons/ha. Again, high yields per ha achieved in Punjab also point towards a high potential of production of vegetables in the state (NHB, 2011). Presently potato occupies 44% area of the total vegetable cropping area in the state. The area under potato during the period 1990-91 to 2010-11 has gone up from 46000 ha to 83573 ha and production has gone up from 913542 tons to 2088359 tons (See Figure 5.5 (a) and (b)).

Milk Production Trends

The State's milk production has increased from 8554 thousand tons to 9423 thousand tons in 2010-11 (*NDDB, 2012).* The per capita milk availability is the highest in Punjab. It has increased from 917 gm/day in 2004-05 to 944 gm/day in 2009-10 as against the national average of 273 gm/day in 2009-

10 (*same source as above)*. During 2009-10, Punjab produced 3022 thousand tons of milk from cows, 6323 thousand tons of milk from buffalos and about 44 thousand tons of milk from goats. The cows' milk is obtained from cross bred and indigenous varieties both, with milk from cross bred being 10 times more than from indigenous cows (in 2009-10, 2749 thousand tons of milk was obtained from cross bred cows and 273 thousand tons from indigenous varieties). The buffalo milk is produced by Murrah, Nili Ravi and graded varieties.

As of 31st March 2010, Punjab had a total milk generating capacity of 3320 thousand litres per day or 121.2 million litres annually. It has currently 6000 commercial dairy farms, with 1000 being added every year. Keeping in view that the cross bred cattle and buffalo's both have reduced by about 4% between 2003 and 2007 livestock census, Punjab has posted a rise in milk production through the years and in 2009-10 ranked 4th amongst all states. This has been possible as the state has one of the most high yielding varieties of cows and buffalo's (**Figure 5.6** – A comparison with other high yielding states) and a good veterinary support system. It has 1362 veterinary hospitals/polyclinics and 1486 veterinary dispensaries, indicating that for every 2500 livestock in the state, one hospital/dispensary is available. Further, the state has one Grade A semen station and two Grade B semen stations (*Sources: Annual Report, DAHD, 2010, 2011, 2012; DADF, 2010).*

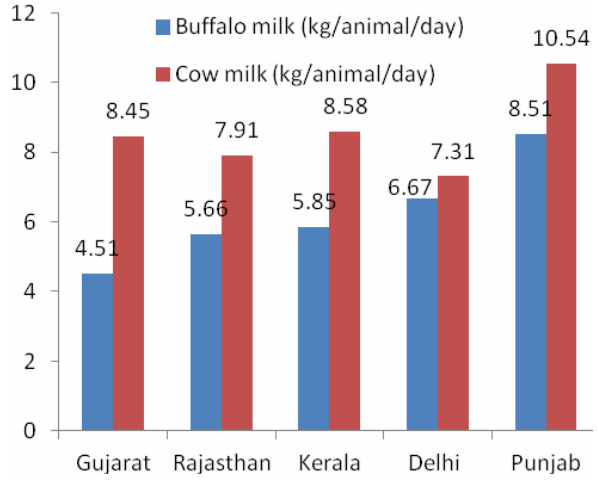


Figure 5.6: A comparison of milk yields (kg/animal/day) across 5 high milk yielding states in India

Source: DAHD, 2010

Egg Production Trends

Egg production in Punjab fluctuated from a maximum of 3791.4 million to a minimum of 3282.8 million during 2004-05 and 2009-10. In fact, the year 2009-10 has registered the minimum production. The per capita egg availability has decreased from 144 eggs/capita/yr to 121 eggs/capita/yr in 2009-10. The reduction in total production of eggs and per capita availability cannot be fully attributed to slight decrease in poultry population from 10779 thousand in 2003 to 10685 thousand in 2007 (*DAHDF, 2010, 2011, 2012).* In spite of this Punjab has the highest yield of 193 eggs/layer.

Fish Production Trends

Punjab for six years in succession has maintained the number one position in the country with regard to fish production per unit area at 6.5 tons/ha/annum (*Source: RTI Proactive disclosure, Department of Fisheries, Gov of Punjab*), though the total annual production of fish in Punjab is still at 97,000 tons per year which is not in the top 10 states list. At present, fish farming in Punjab is being practiced in natural water, including rivers like Sutlej, Beas, Ravi, reservoirs and in artificial

ponds. Also, fish farming is being adopted as allied activity for diversification of agriculture. Fish farming is done on agricultural land, low lying areas and in village ponds. Comparatively poor soils such as water logged, Kallar & alkaline soils which are unfit for agriculture can be used for fish farming. Besides, a good source of income, it also generates self-employment opportunities.

5.3 CURRENT CHALLENGES OF THE AGRICULTURE SECTOR

The Government of Punjab is making all out efforts to sustain the high productivity of its agriculture crops, and some of the initiative are listed in **Box 5.1**. The state's agriculture has reached a plateau under the available technologies and natural resource base. Some of the issues that have lead to plateauing of productivity and falling farm includes Rising multi-nutrient deficiencies in soils due to over-mining of inherent nutrient reserves and increasing fertilizer use as over intensification of rice and wheat cropping system has taken place in the state. Over intensification of wheat and rice also has lead to loss in biodiversity of indigenous crops in Punjab. Further, though now regulated, soil and air pollution due to burning of crop residue is an added woe. New insect pests, pathogens, and weeds are emerging due to changes in cropping pattern and climate and adoption of new varieties that otherwise are highly productive making crop management an uphill task. The Government realizes that productivity is also being inhibited by low broadcasting rate of appropriate agriculture technologies for conservation of natural resources, Low spread of agro-processing technologies for value-addition.

Box 5.1: Initiatives Of The Punjab Government To Enhance Agriculture Productivity

The Punjab Government is

- Widely disseminating latest crop production technologies
- Making arrangements for timely and adequate supply of quality inputs
- Strengthening seed production and supply programmes and improving seed replacement ratio
- Promoting resource conservation technologies, green manuring etc. to improve soil fertility
- Strengthening seed production and supply programmes and improve seed replacement ratio
- Promote INM and IPM for judicious use of fertilizers and pesticides.
- Improvement in area and productivity of horticultural crops.
- Creation of infrastructure for agricultural marketing and post harvest management
- Conservation of irrigation water through better on-farm water use efficiency and conjunctive use.
- Diversifying extensively into horticulture crops to augment income of farmers
- Promoting Micro Irrigation to improve water use efficiency

Source: http://agripb.gov.in/

Intensification of Rice cultivation

High yielding varieties of rice and wheat are water-intensive, therefore causing large-scale depletion of ground water in many areas. Both these crops are heavy consumers of macro- and micro-nutrients, thus degrading the soil. The wheat-rice rotation adversely affects physical characteristics of the soil as, due to puddling for paddy, an impervious layer is formed in the soil, which does not allow root-penetration to deeper layers, thus restricting nutrient use. The wheat-rice rotation consumes heavy doses of fertilizers, pesticides and weedicides, to meet the production targets, however they create environmental pollution, fauna and flora imbalances, and builds up of residual toxicity in soil, water and air. The spread of monoculture of wheat and paddy has rendered these crops vulnerable to pest attacks, thus making them more susceptible to pests and diseases.

Seventy percent population of the state is engaged in agriculture and allied activities and with increase in population per capita availability of land is decreasing. Over 63% of the farmers have land holdings less than 4 ha. To maximize profits from small holdings, the farmers are banking on the policies of subsidy on pump sets, free electricity, water, and subsidy on fertiliser and have thus been encouraged to go in for intensive rice-wheat cropping system. This practice has started a spiraling

effect by way of which the productivity levels have plateaued, with decline in soil nutrient status and depletion in ground water.

The impacts can clearly be gauged from the changes seen in cropping pattern and extent of crop intensification (harvesting the crops at least 2-3 times in a year) as shown in **Table 5.2.** The cropping pattern indicates increase in area under rice cultivation over the years. Other crops are being consistently ignored and their yields are hence decreasing. While productivity of crops increased during the first two decades of Green Revolution, on account of increasing nutrient-use efficiency, it began to decline thereafter on account of imbalances in the use of N, P and K, along with the deficiencies of micro-nutrients (*PSDR, 2004).*

Table 5.2: Shift in cropping pattern in Punjab (Area in '000 ha)

Crop	1970-71	1980-81	1990-91	2000-01	2007-08	2008-09	2009-10	2010-11	Percentage Change (1970-71 to 2010-11) *
Rice	390	1183	2015	2611	2609	2734	2802	2831	625.9%
	6.9%	17.5%	26.9%	32.9%	33.2%	35.4%	35.6%	35.9%	420.3%
Wheat	2299	2812	3273	3408	3488	3526	3322	3510	52.7%
	40.5%	41.6%	43.6%	42.9%	44.3%	44.5%	44.7%	44.5%	9.9%
Cotton	397	649	701	474	604	528	511	483	21.7%
	7.0%	9.6%	9.3%	6.0%	7.7%	6.5%	6.5%	6.1%	-12.9%
Sugarcane	128	71	101	121	108	81	60	70	45.3%
	2.3%	1.0%	1.3%	1.5%	1.4%	0.8%	0.8%	0.9%	-60.9%
Maize	555	382	188	165	154	152	139	133	-76.0%
	9.8%	5.6%	2.5%	2.1%	2.0%	1.8%	1.8%	1.7%	-82.7%
Bajra	207	69	11	5	4	5	3	3	-98.6%^
	3.6%	1.0%	0.2%	0.1%	0.1%	0.04%	0.04%	0.04%	-98.9%^
Total oil seeds	295	248	113	86	59	62	62	54	-81.7%
	5.1%	3.7%	1.4%	1.1%	0.7%	0.8%	0.8%	0.7	-86.3%
Cropping Intensity	140	161	178	187	188.5	189.7	189.4	189.6	35.4%
Total Cropped area	5678	6763	7501	7941	78769	7912	7875	7882	38.8%

*The percentage figure is the percentage of area under each crop with respect to total cropped area in that year

Source: DoA, 2013

Nutrient Status of Soils

In Punjab, 2000 ha area is declared wasteland (*SAP, 2010*). About 70% of the geographical area has soil micro-nutrients imbalance. In 20% of the area there is increasing soil alkalinity and salinity and water logging and heavy soil erosion occurs in 10% of the Northern belt of the state (*Sondhi, 2012).*

The soils in Punjab are alkaline in nature. They have low to medium nitrogen content, medium phosphorus content and medium to high potash content. The soil is saline in the southern districts of the state. **Table 5.3** below shows the extent of deficiency of nutrients across Punjab.

Table 5.3: Soil Health Status in Punjab

Nutrient	%age deficient soils
Nitrogen	43.2%
Phosphorus	27.0%
Pottassium	7.9%
Zinc	16%
Magenesium	-
Managanese	25%
Boron	NIL

Source: Sodhi, 2012

Soil and Water Pollution

The state has highest per hectare usage of fertilizers (NPK Total), at 237.05 kg/ha in 2009-10, as against the all India average of 135.27 kg/ha in the same year (Agricoop, 2012). High usage of nitrogenous fertilizers with relative under-utilization of other fertilizers and micronutrients has lead to imbalance in micro nutrient in soils of the Punjab. Similarly, pesticide consumption in Punjab is 923 g/ha (Tiwana *et al.,* 2007) as compared to the average consumption of 381 g/ha at India level (Agriccop, 2012). Residues of chemical pesticides like organochlorines, organophosphates, synthetic pyrethroids and carbamates have been found in Punjab in human milk, water, vegetables and other food products at levels, which are dangerous for human and cattle health (Tiwana *et al.,* 2007).

Loss in Biodiversity Of Indigenous Crops

Due to increasing adoption of a narrow range of HYVs over larger cropped area the broad range of traditional varieties which were naturally suited to the climatic and edaphic conditions of the state have been lost. The area under input intensive HYVs of wheat has increased from 69% in 1970-71 to 100% in 2000-01. Similarly, area under HYVs of rice comprised 33% of total area under rice in 1970-71. It increased to 100% in 2005. Prior to the green revolution, 41 varieties of wheat, 37 varieties of rice, four varieties of maize, three varieties of bajra, 16 varieties of sugarcane, 19 varieties of pulses, 9 varieties of oil seeds and 10 varieties of cotton were reported to be in use in Punjab. Data indicates that out of 47 post green revolution varieties of wheat released by PAU, only 5 are widely used. Similarly, out of 19 varieties of rice released, only eight are currently in use. Desi maize is, however, still favored by farmers (Tiwana *et al.,* 2007).

Air pollution due to Field Burning of Crop Residue

Use of harvester-combines for wheat and paddy has been on an increase. Their use leaves uncut straw and stubbles in the fields, which are often burnt, causing air pollution. It is estimated that annually, around 20 million tons of paddy straw and 18 million tons of wheat straw is generated in Punjab (PSCST, 2008). The wheat straw to an extent is used for cattle feed. Paddy straw is not preferred as cattle feed and about 80% of this or about 16.0 million tons is burnt on site on farm fields to clear land for timely sowing of wheat crop, which could otherwise have been used as feed for cattle or ploughed back into the soil to improve some of its characteristics (PSDR, 2004).

In addition to loss of entire amount of C due to burning, 80% of N, 25% of P, 50% of S and 20% of K present in straw is also lost due to burning. If the crop residues are incorporated or retained, the soil gets enriched, particularly with organic C and N. Heat from burning residues elevates soil temperature causing death of bacterial and fungal populations. However, the death is temporary as the microbes regenerate after a few days. Repeated burning in the field, however, permanently diminishes the microbial population. Burning immediately increases the exchangeable $NH4^{+}$-N and bicarbonate extractable P content, but there is no build up of nutrients in the profile. Long-term burning reduces total N and C and potential of mineralized N in the 0-15 cm soil layer (Pathak, 2012).

Estimates by Badrinath *et al.,* 2006, have indicated that wheat straw burning in the state in 2005 lead to an emission of 113 Gg (Giga Gram) of CO, 8.6 Gg of NOx, 1.33 Gg of CH_4, 13 Gg of PM10, and 12 Gg of PM2.5. The same year, burning of rice crop residue (rice straw) lead to an emission of 261 Gg of CO, 19.8 Gg of NOx, 3 Gg of CH_4, 30 Gg of PM10 and 28.3 Gg of PM2.5. At a local level, studies conducted by PPCB, in Nov. 2006 in villages Dhanouri, Simbo and Ajno-da-kalan in Patiala indicated CO concentrations in excess of 114.5 μ/m^3 at 30 m distance from burning site and 20.6 micro-g/m^3 of CO was recorded in residences which were 150 m away. Permissible limit of CO in ambient air being 4 μ/m^3. Further, significant amounts of PM 2.5 (146-221 micro-gram/m^3), PM10 (~300 $\mu g/m^3$ against permissible limits of 60 μg /m^3) were also recorded, NO_X and NH_3 at even 200-400 m away from the burning site were traced.

Falling Farm Incomes

The rural debts in Punjab are estimated to be Rs. 35000 crore for the loans taken for tractors, tube wells, farm chemicals, seeds, as well as for other social needs (*Punjab Annual Plan, 2011-2012*). The NSSO survey on indebtness (*NSSO, 2003*) , reveals that the indebtedness of Punjab farmers on an average was Rs. 41,576/- against the national average of Rs. 12,585/-. The high indebtness is due to reducing farm yields in the Doaba region of Punjab (**Box 5.2**). The declining productivity of soil and depleting water table are enhancing the requirement of farm inputs resulting in higher cost of production. The Market Support Prices (MSP), are however not increasing in commensuration with escalating input costs. This is pushing marginal and small farmers into the debt situation. 65.4% of farmer households are under debt in the state. One of the solutions suggested by the National Commission on Farmers headed by the noted farm economist, Dr. MS Swaminathan, is to make MSP equal to the cost of production plus 50% as profit. The commission further suggests farm labour to be treated as semi-skilled and the value of land to be taken into account while working out the cost of production.

Box 5.2: Impact of current climate variability on wheat yields

Analysis of block level wheat yield data that ranges from 1000 to 6500kg/ha (low to high), and soil & water parameters of last 20 years in seven productivity zones indicate that climatic fluctuations such as continuous or abrupt change in minimum temperature along with increased variability in rainfall during winter is one of the causes of stagnation/or decline of wheat yields in Doaba region of Punjab (Wheat bowl of India). Productivity of wheat is declining mainly in high-productivity zones (parts of Ludhiana, Patiala, Amritsar, Jalandhar and Kapurthala, Fatehgarh Sahib and Sangrur districts). However, Kandi regions (terai & foot hills of lower Himalayan range) are having increasing trend in wheat productivity due to favorable change in temperature, technological interventions, and development of irrigation facilities. Overall, the yield gap among different regions of Punjab is bridging due to increase in productivity in low and medium productivity zones.

Source: Chandna *et al.* 2009

Increasing Requirement of Crop Storage Capacity

The increased food production and slow movement of food grains have compounded the problem of food storage in the State. As per estimates, Punjab has no place to stock more than half its produce. Half of its fresh crop cannot be pushed into already overflowing warehouses. The state needs at least 78 lakh Metric Tonnes of long term storage capacity out of which 25 lakh Metric Tonnes should be in the form of silos which can store food grains up to three years (*Punjab Annual Plan, 2011-12*). In a public private partnership initiative in 2010, PUNGRAIN in association with a leading exporter of basmati rice with a strong distribution network is building modern, temperature-controlled steel grain silos with a capacity of 50,000 metric tons. If successful, the pilot will be expanded to add capacity of 2.5 million metric tons in Punjab alone.

Disease Outbreak in Livestock

In the year 2001 the Northern Regional Disease Diagnostic Lab (RDDL) was established in Punjab at Jalandhar. The RDDL is a referral laboratory for disease diagnostics, surveillance and monitoring catering to the needs of the North Indian States. The disease outbreaks as per the 2010-11 records of this centre and also published in the Annual Report of Deptt. of Animal Husbandry and Dairying, 2011, is detailed in **Table 5.4.**

Table 5.4: Disease outbreak in Livestock in Punjab in 2010-11.

Disease	Species	Number of outbreaks	Animal at Risk	Animal Affected	Deaths
Hemorrhagic Septicimia	Cattle/ Buffalo	3	136	20	6
Foot and Mouth Disease	Cattle/ Buffalo	4	577	57	6
Black Quarters	Buffalo Calves	1	3	2	2
Sheep Pox	Sheep	1	240	35	14
Coccidiosis (poultry)	Poultry	1	1000	35	6
Other diseases like Ana-plasmosis, Aflatoxicosis, Trypanosomiasis, Theliriosis, Chlorpyriphos and Methyl Toxicity etc.	Cattle/ Buffalo	20	324	114	33
TOTAL		**30**	**2280**	**263**	**67**

Loss in Biodiversity of Fish

Ecological degradation has affected productivity and disturbed the indigenous fish fauna diversity in Punjab. A substantial decline in fish population has occurred in all the major wetlands of Punjab. Nearly 26 species have been placed under different categories of threatened species in Punjab which include the valuable indigenous major carps like catla, rohu, mrigal and mahaseer. Buddha Nallah, a tributary of river Sutlej in district Ludhiana once known to have 56 fish species, does not have even a single fish species today (*GADVASU, 2007).*

Role of women in Agriculture and their Concerns

Women from rural areas in Punjab are engaged in farm operations as cultivators, assistants to male cultivators and agricultural labourers. Women are actively involved in pre-sowing, post-sowing, harvesting and post-harvesting operations as well as allied activities. Women belonging to low socioeconomic strata are engaged as agricultural labour. They are also involved in planning, decision-making and supervisory activities. According to the *Census 2001*), female work participation is recorded at 8.7% in Punjab. Their role in agriculture is continuously rising; however, it is imperative that for them to be involved more they would require infrastructural support to look after their families such as providing crèche for children.

5.4 INSTITUTIONS MANAGING AGRICULTURE IN PUNJAB

The institutional arrangement for managing agriculture in Punjab is shown in **Figure 5.7.** The main institutions managing agriculture are the

- Department of Agriculture
- Department of Horticulture
- Department of Soil and Water Conservation
- Department of Animal Husbandry, Dairying and Fisheries.

Various corporations, Development Boards and societies operating under above four departments help the government in marketing and developing its resources. Agriculture being the most important livelihood option in the state, for its development, the state is strategically supported by two research institutions, namely, the Punjab Agriculture University (PAU), Guru Angad Dev Veterinary and Animal Sciences University (GADVASU).

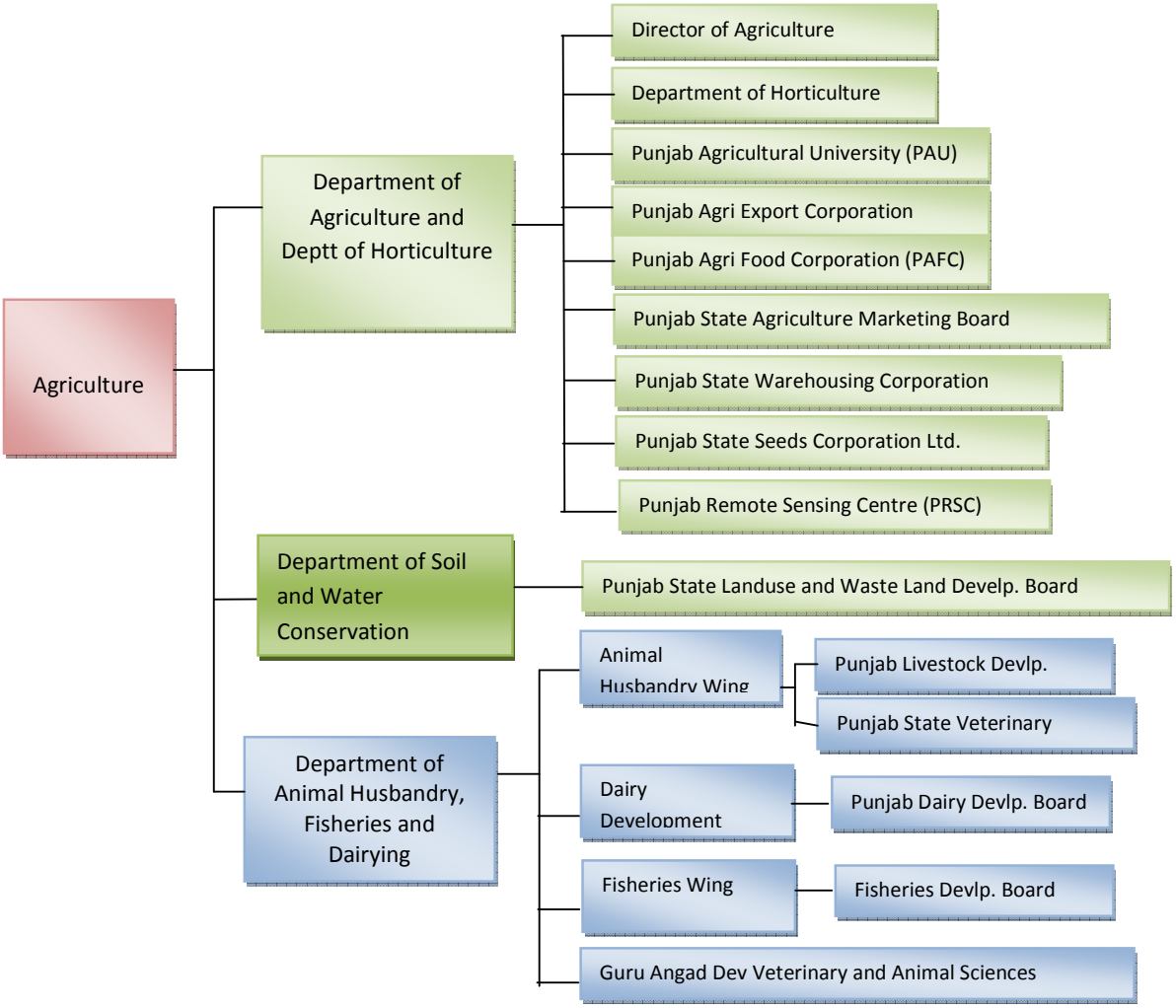


Figure 5.7: Institutional Arrangement for managing Agriculture in Punjab

The mission of the Agriculture Department is to sustainably increase the productivity and production of crops to ensure food security of the state and the nation and to uplift the social and economic status of people in rural areas in the state. The department does that through dissemination of latest crop production technology to bridge knowledge gap between farmers and experts; puts in efforts to sustainably increase crop production and productivity thereby ensuring food security and enhanced income level of farmers; Promotes conservation of agriculture; Promotes Integrated Nutrient Management (INM) and Integrated Pest Management (IPM), diversification to horticulture and other high value crops; and promotes practices for efficient management of water resources for irrigation. For food production and horticulture development, the Department has two wings, namely the Directorate of Agriculture and Department of Horticulture. These two are supported by various institutions that provide technical and marketing support such as the PAFC, PAEC, PSAMB, PSLWLDB, PSWC, and PSSCL.

The state has also set up Punjab State Farmers Commission, four Agriculture Councils and State Medicinal Plants Board that augment the activities of the Agriculture Directorate and Horticulture Department. Punjab Biodiversity Board has also been notified in the state to conserve agricultural biodiversity and ensure sustainable use of its components. The Punjab Agricultural University (PAU), Ludhiana is helping the state in research and development on crops, and developing package of practices of latest technologies in agriculture. The Krishi Vigyan Kendras (KVKs) in each district are

further helping in widely disseminating the latest technologies through extension education, awareness and training.

The Animal Husbandry and Dairy Development wing of the Department of Animal Husbandry, Dairying and Fisheries aims to provide efficient and effective health cover to the livestock of the state; Improve the genetic potential of the livestock through scientific breeding; Provide improved feeding and management practices; and Provide effective extension services in the field of Animal Husbandry. The technical and marketing support of the animal husbandry and dairy development is provided by its institution such as the PLDB, PSVC, PDDB and GADVASU (Refer to **Figure 5.7**).

The Fishery Department is providing technical and financial support through subsidies for diversification in agriculture to farmers, other than supporting fisheries in rivers and major reservoirs in the state. It has 17 Fisheries Development Agencies working across the state.

5.5 KEY AGRICULTURE ACTS, POLICIES AND PROGRAMMES

Important Acts and Regulations and Task Forces

The Punjab Preservation of Subsoil Water Act, 2009 has been brought into force for prevention of over exploitation of ground water. This prohibits farmers from sowing nursery of paddy and transplanting paddy before the notified date of 10th Day of May and June respectively or such other date as may be notified by the State Government by notification in the Official Gazette for any local area, but is not applicable to water logged area where the depth of the water table is less than one metre below the ground level.

The Punjab Agriculture Produce Markets Act, 1961 is an act to consolidate and amend the law relating to the better regulation of the purchase, sale and storage and processing of agricultural produce and the establishment of markets for agricultural produce in the State of Punjab. It has been amended several times to fit in the emerging agriculture scenario in the state. The latest amendment was made by the Punjab State Agricultural marketing Board and marketing Committees (Reconstitution and re-organisation), Order, 1969 (of G.O.I).

Punjab Land Improvement Act, 1963 encompasses land and soil improvement activities in notified areas such as prevention of erosion of soi,l preservation and improvement of soil; reclamation of waste land; improvement in the methods of cultivation including dry farming practices and extension of cultivation; construction of earth and masonry works in fields, gullies and ravines; training of streams; planting and preservation of trees, shrubs and grass on uncultivable land or providing shelter-belts against wind or sand movement; regulation of prohibition of firing of vegetation; improvement of water-supply; farm drainage and other works incidental to, or connected with any of the aforesaid purposes; and any other matter which may be prescribed.

The Punjab Livestock Improvement Act, 1953 was initiated for protecting and improving the stock of cattle species in the state by making it compulsory to mark all bulls, certifies bulls to be used for breeding purpose, and castrate the ones without owners. The Punjab Livestock and Birds Disease Act, 1948 and Punjab Animal Contagious Disease Rules, 1953 have been invoked whenever there has been a widespread disease amongst livestock and birds in the state. The Department has special rules on Compound Cattle Feed, Concentrates and Mineral Mixtures, Milk and milk products, on Haryana Murrah Buffalo and other Milch animal Breeds for preservation and development of Dairy sector.

The prevention and Control of infectious and contagious disease in Animals Act, 2009: This act provides for the control and eradication of the infectious and contagious diseases affecting animals for prevention of outbreaks or spreading of such diseases from one state to another and to meet the international obligations of India for facilitating import and export of animals and animal products and for matters connected therewith or incidental there to.

Considering that large scale field burning of agriculture residue is causing adverse effects on soil health and causing air pollution as well, and indirectly impacting human health, the Punjab Government had constituted a Task force under the Punjab State Council on Science and Technology (vide order dates 11.08.2006 and 17.01.2007 to look into the issue and suggest remedial action. The report of the task force was submitted to the Punjab and Haryana High Court w.r.t CWP no. 10138 of 2008. **See Box** 5.3 for the approach to mitigate the problems due to on field burning of crop residue.

Box 5.3: Suggestions of the Task Force on Mitigation of Adverse Impacts of on Field Burning of Crop Residue in Punjab*

- Crop diversification (from rice and wheat to others).
- Retention of biomass on field as mulch to improve soil health by promoting Happy Seeder, Zero tillage, etc.
- Organize demo of these technologies through PAU and Cooperative societies.
- Use of paddy straw for generating energy.
- Use of straw for Animal feed, animal hay bedding, and any other use.
- Regular Monitoring of air quality in rural areas.

**Task force under the Punjab State Council on Science and Technology (vide order dated 11.08.2006 and 17.01.2007) to look into the issue and suggest remedial action.*

Agriculture Policy of the State

Concerned with the slow growth of Agriculture and allied sectors, the National Development Council (NDC) of the Planning Commission in its meeting on 29th may 2007, has drawn up plans to achieve 4% national annual growth rate in Agriculture through the Rashtriya Krishi Vikas Yojana (RKVY). It aims to develop agriculture potential as per the natural resource availability, and climate characteristics of the various agro-climatic regions within the country including augmentation and sustainability of production of livestock, poultry and fishery.

For improving productivity, the Punjab Government aims to upgrade production technology and its effective dissemination, expand agriculture produce for market by diversification towards Horticulture and Live-stock sector; and enhance investments to expand marketing infrastructure and for Natural Resources Management. Under the RKVY programme the Punjab Government has drawn up a State Action Plan at district level keeping in view the typical characteristics of its 5 agro-climatic zones (**refer to section 5.1**). District Agriculture Plans have been prepared for the period 2007-08 to 2011-12 and for 2009-10 to 2013-14 encompass the following strategies:

- Improvement in rate of seed replacement.
- Judicious and balanced use of fertilizers based on soil test.
- Integrated nutrient and pest management.
- Improvement in productivity and promotion of livestock sector.
- Conservation, development and sustainable management of water resources.
- Popularization of efficient on-farm water management systems.
- Strengthening of Strategic Agricultural and Live-stock Research.
- Efficient dissemination of latest technology to the farmers.
- Mitigate problems due to burning of agriculture residue.

Programmes for managing agriculture

Several centrally sponsored schemes, state schemes and loans from financial institutions such as NABARD, help to finance the various activities towards management of agriculture in the state. Between 2007 and 2012, the central programme - RKVY (Rashtrya Krishi Vikas Yojana) has granted the state an amount of Rs.673.47 Cr. The summary of some of the important projects and programmes operational in Punjab as of 2012 in the agriculture sector are indicated in **Table 5.5**.

Table 5.5: Summary of programmes, projects and achievements of the state towards management of Agriculture in Punjab

Area of Action	Programmes/ Institutions	Achievement
Agriculture	RKVY, Deptt. of Agriculture Deptt. of Soil and Water Conservation	○ Setting-up of Agro-Service Centers-92 sanctioned, 8 in operation; ○ Facilitating Agriculture mechanization- Agriculture machinery service centers (each service centre containing – Tractor, Laser Leveler, Happy Seeder, Rotavator, Raised Bed Planter, and Other Equipments as per local need; Mechanization of maize cultivation, Propagation of mechanized paddy cultivation, and Strengthening facilities for testing and certifying agri-equipment and machinery; ○ Extension- Setting-up of Farmers Training Centers, and establishment of new integrated farmers training centers in district Gurdaspur ○ Conservation of irrigation water for sustainable production, Reclamation of degraded soil in Punjab- 40 projects identified; ○ Increasing area under irrigation- 95 ha benefitted. ○ Producing quality Seeds- Wheat seed replacement - 200,000 quintals of improved varieties of seeds @ Rs 500/quintal, strengthening infrastructure for distribution of quality seeds, distribution of seed treatment drums, creation of new seed farms at Rania, Amritsar, creation of seed treatment facilities at village level; ○ Promotion of basmati rice to conserve ground water; Integrated Pest Management- setting up pesticide residue laboratory; up gradation of pesticide testing labs; and control of yellow rust in wheat; ○ Efficient fertiliser distribution promotion of balanced use of nutrients based on soil testing, distribution of micro nutrients; ○ Promotion of organic Farming- Demonstration of green manuring for improving soil health; ○ Promotion of resource conservation technologies- promotion of zero tillage, laser leveling of land, adoption of ridge planting method, sprinkler irrigation for vegetables; ○ Conservation of water in Agriculture- Promotion of timely transplantation of paddy after June 10 to conserve ground water;
Promotion of Horticulture	RKVY Deptt. of Horticulture	○ Under RKVY, 16 projects identified, focused on citrus plantation development; ○ Promoting low cost net houses; ○ Strengthening of existing nurseries and setting up hi-tech nurseries;

		○ New plantations- Financial assistance to Horticulture in non National Horticulture Mission Districts including Moga, Mansa, Barnala and Ropar Districts – target to bring in 914 ha area under new plantation for fruits plants, Spices/ Aromatic plants, 50 ha under rejuvenation of old orchard, 5 community water tanks, 20 units of vermicompost; ○ Disease free horticulture- promote disease free horticulture by providing 50% subsidies on agro chemicals, establish citrus nursery certification against plant pathogen; ○ Urban Vegetable clusters- Develop vegetable clusters in Ludhiana.
	NHM Deptt. of Horticulture Deptt. of Soil and Water Conservation	○ Area covered under horticulture upto 2012 – 34252.36 ha ○ Area rejuvenated- 10269.67 ○ Organic farming- coverage – 6300 ha ○ Integrated Pest Management – 2000 ha ○ Integrated Pest Management Infrastructure – 22 units ○ Protected cultivation- 30.75 ha ○ Nurseries established – 2 in no. ○ Water resource augmentation- 343 ha ○ Post Harvest Management Units – 222 ○ Markets developed – 46 in no.
Animal Husbandry	RKVY NABARD Animal Husbandry wing of Deptt. of Animal Husbandry, Dairy and Fisheries	○ Supporting small and marginal farmers- by providing Improved Protein supplements through Distribution of 8360 milch cows; for income through selling of pigs and goats- Establishment of new piggery units and stall fed goat rearing units; ○ Improved diseases free productivity cattle through superior germplasm - Import of HF frozen semen; ○ Maintaining superior semen bank - Bull Mother Farm at Mattewara; ○ Facilitating Animal Insurance– chips fitted in 7500 animals of 980 beneficiaries as unique identification; ○ Feed Control- Setting up of Residue Analysis laboratory in the State; Establishment of Fodder Seed Processing Units; developing area specific mineral mixtures; providing barseem seeds to farmers. ○ Processing of Turkey meat into value added meat products and popularization thereof ; ○ Strengthening of disease and pest control- FMD control programme in the state; Awareness Programme on Mastitis control; ○ Strengthening Veterinary care centres including hospitals and supply chain of medicines, and
Dairy development	RKVY Dairy wing of Dept. of Animal Husbandry, Dairy and Fisheries	○ Improvement in Animal Housing; ○ Establishment of modern dairy training and extension centres; ○ Setting up of bypass protein plant by MILKFED; ○ Facilitating Clean milk production and setting up of testing labs; ○ Strengthening infrastructure for quality and clean Milk production; ○ Mechanisation of dairy farming operations;

		○ Subsidy on milk machines; ○ Establishment of biogas plants at dairies for power;
Fisheries	RKVY Fisheries Wing of Deptt of Animal Husbandry, Dairy and Fisheries	○ Establishment of model fish ponds, hatcheries; ○ Setting up of Fish diagnostic centres; ○ Extension training programmes and centres; ○ Establishment of mobile labs for fisheries;
Agriculture Marketing	RKVY Department of Horticulture Department of Agriculture Punjab Mandi Board State	○ Strengthening of Marketing Infrastructure in existing mandies; ○ providing plastic crates for better marketability of fruits and vegetables; ○ Promotion of potato cultivation through market intervention; ○ Strengthening and up gradation of perishable cargo centre at Amritsar International Airport;
Information Technology	RKVY Agriculture Deptt.	Satellite Remote Sensing and GIS based Agri-informatics for improved productivity and policy implication;
Research and Development	RKVY PAU GADVASU	20 Projects given under RKVY (10 to PAU and 10 to GADVASU)
Natural resource Management	RKVY NABARD-RIDF Deptt. of Soil and Water Conservation Deptt. of Agriculture	○ Conservation of irrigation water- 34938 ha; ○ Rain Water Harvesting structures- 50 check dams, micro water bodies/community tanks for ground water recharge. ○ Reclamation of degraded soils- A degraded area of 800 ha is expected to be reclaimed and put to productive use; increase in yield and production by 50%; and increase in land value by more than 60%; ○ Conjunctive use of surface and underground water- Increase in yield/ production, conservation of irrigation water, increase in land value, Saving of land/labor and Assured/ Life-saving irrigation to 8340 hectares and Control of salt-accumulation & erosion control in 2000 hectares; ○ Checking declining trends of ground water- through rain water harvesting, catchment area rehabilitation, and control damages due to flash floods to agriculture land; ○ Developing rain fed farming outside watershed areas; ○ Deep tube wells in Kandi area; ○ Promoting drip and sprinkler irrigation
Management of on field Burning of crop residue	Deptt. of Agriculture	○ Awareness campaigns on adverse impacts of burning of residue on soil and technology on soil health improvement by reincorporation of soil residue - by 2008-09, 5117 farmer training camps trained 3.01 lakh farmers; ○ Front line Demonstration on zero tillage , Happy seeder, Rotavators to help mulching of biomass in the soil- by 2008-09, 2050 FLDs conducted; these technologies adopted over 5.92 lakh ha in 2007-08 and 7.21 lakh ha in 2008-09; ○ Distribution of equipments at subsidised rates such as

		20659 Rotavators, 2 Happy seeders, 1383 zero tillage drills, 448 Straw reapers in 2007-08 have helped the farmers who bought these machines in avoiding burning of crop residue on their fields; ○ Crop diversification to Basmati rice from 1.5 lakh ha to 3.5 lakh ha also has avoided this problem as the straw is used as feed for cattle as well as energy generation, other than saving ground water
	PEDA	○ Plan for utilizing 1 million tons of paddy straw for 1000 MW energy generation. Commissioned by PEDA: 28.5 MW at 3 sites; Ongoing projects on BOO basis – 282 MW at 27 sites (Phase I- 56 MW, Phase II-10 MW, Phase III-226 MW)
	Deptt. of Animal Husbandry, Dairy and Fisheries	○ Conducting training programmes to promote use of urea in paddy/wheat straw feeds. Utilization of rice straw as feed is not common in Punjab; ○ Dissemination of information on rice straw as animal bedding ;
	PAU	Technologies developed ○ Happy seeder machine for planting in standing paddy stubble to avoid burning of the stubble also leads to 60 to 75% less of weed growth, improved soil health; ○ Tractor operated paddy chopper- to incorporate paddy stub into the soil can cover 6-8 acres a day; ○ Straw collector and baler- collects loose straw on the field thus again avoiding burning and help in card broad making, briquettes, power generation or composting; ○ Composting techniques using paddy straw with NPK content equivalent to compost obtained from vermin composting being prepared within 35-40 days
	Punjab State Farmers Commission	Is encouraging reduction of area under rice paddy-Diversification through ○ Promotion of commercial dairy farming and use area under fodder production; ○ Promotion of vegetable production under net housing technology; ○ Promotion of Hybrid maize in Kharif season; ○ Introducing new high value crops such as Banana
	Dept. of Rural Development and Panchayat	Facilitating PEDA by providing Panchayat Land for setting up biomass powered energy generation units at 33 yrs lease in 5 villages.

Key ongoing PAU Programmes

The Punjab Agricultural University has undertaken a number of research activities to develop the Agriculture productivity in the state in a sustainable manner. Some of the key initiatives are:

- Crop Improvement programme: The Punjab Agricultural University has developed/ recommended 707 varieties/ hybrids of different crops including 359 varieties of field crops. Out of these, more than 117 varieties/hybrids have been released at the national level.
- Horticulture Improvement: The PAU has released 158 varieties of vegetable crops, 132 of fruit crops and 30 of floricultural crops.
- Natural Resource Management: To check the erosion of natural resource base, the PAU has developed several resource conservation technologies such as laser land leveler, tensiometer, zero tillage, bed planting, mulching, green manuring, direct seeding of rice, leaf colour chart, net-house cultivation, micro-irrigation and fertigation. The relevant farm machinery such as zero till

drill, strip till drill and Happy seeder have been designed and recommended for bringing in precision and timeliness in farm operations and for saving irrigation water.

- Plant Health Management: The University has developed and recommended economical and efficient technologies for the management of insect pests, diseases and weeds in different crops. Supervised pest control modules, based on economic threshold values, have been developed and recommended against a large number of insect pests of cotton, rice, rapeseed-mustard, gram, okra, cauliflower, radish, tomato and berseem. The implementation of IPM technology, developed by the PAU, has led to a decreased dependence on pesticides and has resulted in an economical pest management in cotton, rice and maize in the State.
- The other areas where the PAU has worked extensively include Agro-Forestry, Development, Agro-Processing technologies for value addition and Farm Machinery development.
- It has also worked towards developing Subsidiary Agriculture through beekeeping since 1962 and Mushroom Cultivation.

Examples of Farm Mechanization in Punjab.
(a) Laser Assisted Land Leveling,
(b) Machine for Raised bed Planting,
(c) Happy Seeder
Source: Deptt. of Agriculture, Govt. of Punjab.

Figure 5.8: Examples of water harvesting in Punjab
(a) Earthen water harvesting Dam, village Sahomjara, Ropar; (b) Masonary Check Dam, Village Mansali, Ropar. *Source: Deptt. of Soil and Water Conservation, Government of Punjab*

5.6 CLIMATE CHANGE DRIVERS AND AGRICULTURE

Rising Temperatures: In general, with rise in temperature up to 2-3°C, increase in crop yields can be expected in temperate latitudes, however above 3°C warming, negative impacts of temperature could occur in most areas. In tropical latitudes, even a slight increase in temperature would reduce grain yields as the crops are already near to their threshold temperatures (*Parry et al., 2004, IPCC 2007; Stern, 2006, NATCOM 2004; NATCOM, 2012; INCCA, 2010*).

Rising concentrations of $CO_2$and C3 and C4 crops: High ambient CO_2 levels reduce the stomata openings of some crops thereby reducing transpiration per unit leaf area while enhancing photosynthesis leading to improved water-use efficiency (the ratio of crop biomass to amount of water used in evapo-transpiration). As a result of these interactions, elevated CO_2 alone tends to increase growth and yield of most agricultural plants as indicated in various experiments as well. CO_2 concentration is known to have more positive effect on C3 crops (e.g. rice, wheat and soybean) than C4 crops (e.g. maize, sugarcane and sorghum). In fact a study carried out by Long *et al.,* 2007, indicates, about 8-15% increase in crop yields for C3 plants and no significant change for C4 plant (Kimberley *et al.,* 2002; Long *et al.,* 2007, NATCOM, 2004; NATCOM 2012)

Weeds, insects, pests and diseases that also drive agriculture productivity: Temperature rise and elevated CO_2 concentration could increase plant damage from pests in future decades, although only a few quantitative analyses exist to date. Weeds show a larger growth, to elevated CO_2 due to their greater genetic diversity. Temperature rise will boost insect growth and development by increasing geographical distribution and increasing overwintering. Pathogens are recognized as a significant limitation on agronomic productivity. Due to increase in temperature, increase in northward migration of pests, migration upwards along the elevation gradient, insect development rates and ovipositor potential for insect outbreaks and invasive species introduction have been observed to have changed. Simultaneously decrease in effectiveness of insect bio-control by fungi, decrease in reliability of economic threshold levels, decrease in insect diversity in ecosystem and decrease in parasitism have been observed world wide (*Das et al.*, 2011).

Impacts on soils: Soil health refers to soil's capacity to perform agronomic functions including sustainable production of crops and animals while maintaining and improving the environment. Key indicators of soil health are soil texture, tilth, color, biodiversity, water intake rate, droughtiness, internal drainage and resilience against perturbation. The projected climate change may adversely impact soil health by reducing soil organic matter content, decreasing soil structure and increasing vulnerability to erosion and other degradation processes. Soil C sequestration by improving soil health is a cost-effective and a natural process of off-setting anthropogenic emissions while also advancing food security and improving the environment (Ratan lal, 2011).

5.7 REVIEW PUNJAB SPECIFIC IMPACT STUDIES ON AGRICULTURE CROPS

Rice

Impact of rising temperature on rice: A study carried out to evaluate likely impact of climate change on rice productivity in Punjab, using CERES (Crop Environment Resource Synthesis) - Rice model available as a part of the DSSAT (Decision Support System for Agrotechnology Transfer) package, indicates that with increase in temperature by + 0.5°C to +2°C, grain yield of rice is likely to decrease by -0.16% to -9.6% with respect to the normal conditions (**Table 5.6**). The normal conditions have been generated based on observed data for a 30 yr period up to 2006 (*Siddhu and Hundal, 2011*).

Table 5.6: Percentage change in yield and yield attributes of rice with respect to normal yield due to increase in temperature

Phenology/ Growth/ Yield	- 2.0°C (%)	-1.0°C (%)	-0.5°C (%)	Normal (kg/ha)	+0.5°C (%)	+1.0°C (%)	+2.0°C (%)
Anthesis date	+2	0	0	223	0	0	+1
Maturity date	+6	+2	0	263	+1	+1	+1
Grain Yield	+55.24	+8.07	+6.56	6692	-0.16	-2.82	-9.59
Biomass Yield	+9.92	+4.35	+2.93	11717	-0.94	-2.35	-5.02

Source: Siddhu and Hundal, 2011

Impact of rising CO_2 concentrations on rice: The temperature is not rising in isolation, but is driven mainly by the rise in GHGs from anthropogenic sources, with CO_2 playing a major role as its concentration is highest amongst all GHGs in the atmosphere. As of January 2013, , the global CO_2 concentration was 391.57 ppm, compared to 1960 when it was around 320 ppm, the safe levels being less than 350ppm, which was crossed in 1988 (*NOAA, 2013*). The UNFCCC aims to stabilize the concentration of CO_2 at 450 ppm which corresponds to a 2^0C rise in temperature wrt to preindustrial times.

The direct effects of increased concentrations of CO_2 is generally beneficial to vegetation at elevated levels leading to higher assimilation rates, but combined effect of CO_2 and temperature is to a large extent negative. Siddhu and Hundal have also studied the combined effect of rise in CO_2 concentrations from 300ppm to 600 ppm with change in temperature upto 2^0C wrt normal. As seen from **Figure 5.8,** grain yields continuously decrease with rise in temperature. Higher the concentration of CO_2, higher is the temperature at which the grain yield becomes –ve with respect to normal. For example at a concentration of 400 ppm of CO_2 in the atmosphere, the grain yield may gain by a maximum of 1.5% wrt to normal yields but will start declining with increase in temperature and at around 0.25^0C rise, the yields will start declining with respect to normal. At 500 ppm, the grain yields may gain by a maximum of 6.2% with respect to normal, but become negative with rise in temperatures just above 0.75^0C. Similarly, at 600 ppm, the rice grain yields are likely to gain by a maximum of 8.9%, but will become less than normal at rise in temperatures just above 1^0C.

Impact of decreasing solar radiation on rice: Siddhu and Hundal (*2011*) have observed a decrease in solar radiation in general over Punjab, for example, in Ludhiana the solar radiation has decreased at a rate of 0.02, 0.01 and 0.03 MJ/m^2/year. The simulation by CERES rice for decrease in solar radiation by 5.0%, points towards a decrease in maximum Leaf Area Index (LAI), biomass yield and grain yield of rice in Punjab by 2.79%, 4.44 and 6.0% respectively wrt normal.

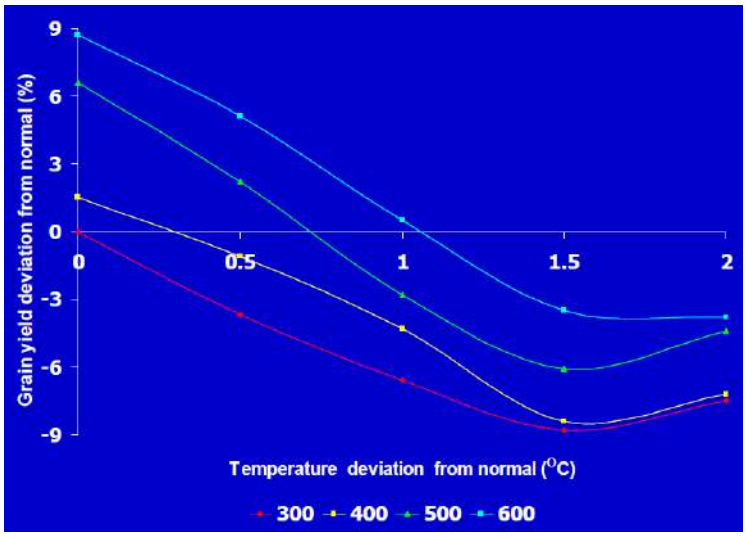


Figure 5.9: Effect of CO_2 and temperature increase on rice grain yields wrt normal

Source: Siddhu and Hundal, 2011.

Wheat

CERES-Wheat model was used from the DSSAT package by Siddhu and Hundal (*2011*), to evaluate the impacts of temperature and radiation with increasing CO_2 levels to assess the likely wheat yields in the future. The enhanced levels of CO_2 are seen to counteract the adverse effects of temperature increase on growth and yield of wheat.

Impact of rise in temperature: With an increase in temperature by 1.0 to 2.0^{0}C, the anthesis date gets advanced from 6 to 12 days and the grain yield decreases from 14% to 23% from normal. **See Table 5.7.** (*Siddhu and Hundal, 2011*).

Table 5.7: Likely impacts of changes in temperature wrt normal on growth and yield parameters of wheat

Phenology/ growth/ Yield	Normal	+0.5 °C	+1 °C	+2 °C	+3 °C
Anthesis date	41	-3	-6	-12	-16
Maturity date	81	-3	-6	-12	-17
Maximum LAI*	4932	-2.75	-9.87	-18.02	-27.03
Grain Yield	13304	-4.60	-13.76	-22.87	-32.35

**LAI: Leaf Area Index* *Source: Siddhu and Hundal, 2011*

Impact of interaction of minimum and maximum temperature: The minimum temperature is reported to be increasing in all districts of Punjab, but the maximum temperature trends is variable across districts as evidenced in Chapter 3 of this document. For example in Ludhiana, the maximum temperature is decreasing, where as in Amritsar, it is increasing. The increasing minimum temperatures have a deleterious effect on anthesis, LAI, biomass yields and grain yields of wheat. However, in areas where the maximum temperatures are decreasing may see moderate decrease in wheat grain yields. Study carried out by Siddhu and Hundal, shows that increasing maximum temperature by 1-2^{0}C and decreasing maximum temperatures, by -0.25^{0}C wrt normal may advance the anthesis date by 2 to 6 days and the grain yield may only decrease by -2.9% to -12.0% (**Table 5.8**)

Table 5.8: Impacts of rising minimum temperatures and decreasing maximum temperature on wheat growth and yield parameters in Punjab

Phenology/ growth / yields	Minimum Temperature								
	+1^{0}C			+2^{0}C			+3^{0}C		
	Maximum Temperature			Maximum Temperature			Maximum Temperature		
	-0.25 °C	-0.5 °C	-1.0 °C	-0.25 °C	-0.5 °C	-1.0 °C	-0.25 °C	-0.5 °C	-1.0 °C
Anthesis	-2	-2	0	-6	-4	-3	-8	-8	-6
Maturity date	-1	-1	+1	-3	-4	-3	-8	-7	-6
Maximum LAI	-2.97	-2.97	-3.51	-16.21	-15.40	-12.16	-40.81	-20.27	-17.84
Grain yield	+2.67	+2.67	+5.61	-3.22	-2.27	+0.06	-6.33	-3.38	-3.22
Biomass Yield	+2.02	-2.02	+0.28	-12.19	-10.68	-9.18	-16.02	15.59	-12.38

Source; Siddhu and Hundal, 2011

Impact of solar radiation on wheat yields: To understand the impact of changes in solar radiation on wheat yields, Siddhu and Hundal (2011), simulated the rice grain yields per unit of biomass for a ±1-5% change in radiation with respect to normal. A decrease of solar radiation by 1% wrt normal decreased the grain yield by about 1.8%, and a decrease of solar radiation by about 5% wrt normal, indicated a decrease in grain in yield by above 6% (See **Figure 5.10**).

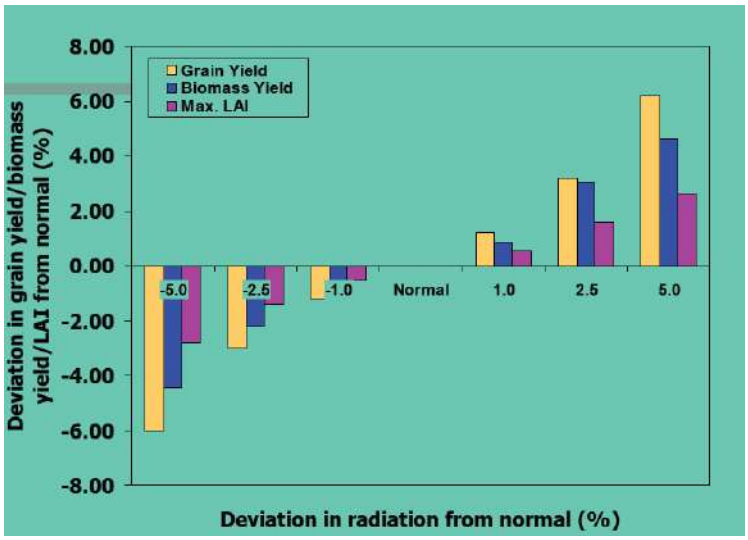


Figure 5.10: Changes in rice grain yield, biomass yield and Maximum Leaf Area Index of wheat with respect to changes in solar radiation with respect to normal.
Source: Siddhu and Hundal, 2011

Impact of increasing CO_2 concentration on wheat yields: If the temperature rises by 2^0C then at 400 ppm and 500 ppm concentration of CO_2 in the atmosphere the grain yield is likely to decease by -10.4% and -1.4% wrt normal respectively. If the concentrations increases to 600 ppm, all the growth and yield attributes show a +ve increase for the given rise in temperature (**Table 5.9**) indicating higher concentration of CO_2 compensates for the decreasing yields with rising temperatures.

Table 5.9: Impacts of rising concentration of CO_2 and temperature on Wheat yield and growth parameters

Growth and yield attributes	+1°C				+2°C			
	CO_2 concentration in ppm				CO_2 concentration in ppm			
	330	400	500	600	330	400	500	600
Maximum LAI	-18.3	-11.2	-2.3	+7.8	-29.1	-17.6	-4.5	+2.8
Grain Yield	-9.9	-5.6	+2.1	+10.4	-18.0	- 10.4	-1.4	+5.6
Biomass Yield	-13.7	10.7	-1,4	+8.6	-22.9	-12.5	-3.3	+3.9

Cotton

Production of cotton has increased from 176 lakh bales in 1996-97 to an all time record of 280 lakh bales during 2006-07, and since then it has reduced. This record production became possible only due to the good weather and introduction of *Bt.* cotton hybrids. The unpredictability of cotton yield is a matter of concern to the cotton industry. Many factors, such as length of the growing season, climate (including solar radiation, temperature, light, wind, rainfall and dew), cultivar, availability of nutrients and soil moisture, pests, and cultural practices affect cotton growth. Of these, temperature is considered to be one of the main environmental factors contributing to variable yields in cotton. Jalota *et al.*, 2009, ran the Crop Syst model using the data of crop, soil and weather for an experiment conducted on *Bt.* cotton hybrid RCH 134 during 2005 at Bathinda and simulations were made for 15 years period from 1991-2005. From the simulated results, relationship is between temperature and duration of total crop growth period as well as of phenol phases (sowing to flowering, flowering to boll formation and boll formation and maturity) and subsequently between duration of phenol-phases and cotton seed yields were developed. The results indicated that with increase in temperature from 28 to 32 ^{o}C cotton seed yield decreased from 4700 to 2300 kg/ ha following a linear relation with high coefficient of determination (0.97) and the reduction was more during sowing to flowering stage than others. Regarding water relationships, real crop water productivity was more (10.2 kg/mm) than apparent (8.8 kg/mm) (Jalota *et al.,* 2009).

Maize

Jalota *et al.*, 2009 using Crop Syst model, concluded that doubling of CO_2 (at 700 ppm) with respect to current concentration at 350 ppm, is preferring Maize a C4 plant with respect to C3 plants such as rice and wheat. The maize yields increased by 6.5%. Tripathy *et al*, 2009, using the same model found that with doubling of CO_2 at 700 ppm, the yields of all crops increase with increasing temperature upto about 2^{o}C, but beyond this the yields reduce, except in the case of C4 plants which can use more efficiently the enhanced concentration of CO_2. Maize which is a C4 plant when exposed to doubled CO_2 concentrations, gains in yield upto a rise of 3^{o}C with respect to base line (Tripathy *et al*., 2009*).*

Therefore, it is expected that with doubling of CO_2 concentration with respect to normal, and temperature rise upto 3^{0}C, Maize production in Punjab will benefit. Maize, however, is also very sensitive to water availability. Irrigated conditions lead to more crop yield, but excess rainfall, leading to more run off may adversely affect the yields with increase in temperature.

The Punjab Agriculture University has been undertaking basic, applied and adaptive research on agriculture to ensure food and livelihood security since 1962. Its researchers have carried out studies to ascertain the likely impacts of climate variability and climate change as well. **Table 5.10** below summarizes the findings vis a vis the vulnerabilities and opportunities of certain staple crops to climate change that are grown in Punjab.

Table 5.10: Summary of vulnerabilities and opportunities of different crops to climate change

Crop	Opportunity/Vulnerabilities to climate change
Wheat	High temperature during grain filling causes forced maturity that leads to reduced yield
Rice	Basmati rice uses less water and farm inputs as compared to Non basmati rice High temperature increases the incidence of blast in basmati rice
Maize	Maize cultivation can help in diversification by reducing area under rice High temperatures reduces seed setting Maize is sensitive to both flooding and drought
Moong/Mash	Additional crop during summer can help in increasing the farm income High temperature during crop growth period and rains at the time of maturity is detrimental Incorporation of pulses in crop rotation improves soil health
Arhar	High temperature during seedling emergence causes mortality
Soybean	Diversification option – high productivity among pulse crops
Sugarcane	Winter hardiness for better ratoonability High temperature during seedling emergence in case of summer planting after wheat
Berseem	Low temperature causes frost injury and slow down the growth during January Terminal heat tolerance in berseem hindering seed production
Pearl millet and Sorghum	Pearl millet and sorghum can grow well under drought conditions Being high biomass crops can be used for silage production for lean period Represent good diversification options as fodder crops
Cotton	High temperature at seedling stage causes seedling mortality leading to reduction in plant stand, thus lowering yield and productivity. Low water requiring crop as compared to rice Rice cultivation in South –Western districts causes salt accumulation near soil
Oilseeds	High temperature at seedling and terminal stages Oilseeds are grown under conserved moisture conditions Assured farm income

Source: Synthesized by PAU

5.8 IMPACT ON HORTICULTURE CROPS

Rising Temperature

All horticultural crops are sensitive to temperature and most have specific temperature requirements for optimum yield and quality. Studies have shown that the production and quality of fresh fruit and vegetable crops can be directly and indirectly affected by high temperatures and exposure to elevated levels of carbon dioxide and ozone. Temperature increase affects photosynthesis directly, causing alterations in sugars, organic acids, and flavinoids contents, firmness and antioxidant activity (*Moretti, et al., 2010*). Specific example of impact of climate change on horticulture, namely potato is highlighted in **Box 5.4.**

Box 5.4: Impact of rising temperatures on Potato in Punjab

Potato grows between 2°C and 30°C. It requires cool night temperature to induce tuberization. Although photosynthesis in potato is suppressed by high temperature, it is not as sensitive to temperature as tuberization and partitioning of photosynthesis to tuber. The radiation use efficiency (RUE) is suppressed under high temperatures. High temperature reduces tuber number and size.

Potato tuber yield was simulated for Jalandhar in Punjab using INFOCROP-Potato, without adaptations i.e. with recommended date of planting and optimal management practices for the current and future climates of varying temperature and CO_2 concentrations. The future climate scenario projects that the potato yields are likely to increase by 7.31% in 2020 (at 1°C and 400 ppm), and by +3.6% in the 2050s (at 3 °C and 550 ppm) with respect to current climate.

Amongst the major potato growing states in India, only Punjab and Haryana are likely to have increased in potato yields with the changing climate scenario, the rest are likely to lose yields.

Source: Singh and Lal, *2011*

Some of the general impacts of rising temperature on Horticulture crops are (*Singh, 2012):*

- A rise in a temperature above 1ºC may shift a major area of potential suitable zones of horticultural crops to higher latitudes.
- Production timing is likely to change. Because of rise in temperature, crops will develop more rapidly and mature earlier. For example, citrus, grape, melons and mangoes will mature earlier by about 15 days.
- Photosensitive crops such as onions are likely to mature faster leading to small bulb size. Strawberries will have more runners at the expense of fruits.
- Higher temperature induced ripening will make the produce, especially fruits to have less storage period in trees/ plants. They will overripe.
- Pollination will be affected adversely because of higher temperature. Floral abortions will occur.
- Higher temperature will reduce tuber initiation process in potato, reduced quality in tomatoes because of tip burn and blossom end rot and lead to poor pollination in many crops. In case of crucifers, higher temperatures may lead to bolting.
- Specific chilling requirements of pome and stone fruits will be affected hence dormancy breaking will be earlier.

Impact on interactions of pollinators and onset of flowering

Fruits are mostly dependent on insect lead pollination and it has been observed that onset of flowering in plants and first appearance dates of pollinators in several cases appear to advance linearly in response to temperature increases. Phenological responses to climate warming may therefore occur at parallel magnitudes in plants and pollinators, although considerable variation in

responses across species should be expected. Despite the overall similarities in responses, a few studies have shown that climate warming may generate temporal mismatches among the mutualistic partners. Mismatches in pollination interactions are still rarely explored and their demographic consequences are largely unknown (*Stein Joar et al., 2009).*

Impact of CO_2

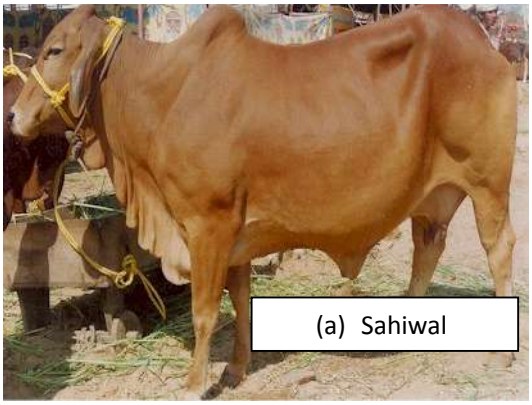
Enhanced CO_2 concentration in the atmosphere is likely to have variable effects on different types of horticulture produce. For example, experiments conducted by growing citrus fruit (orange) under a CO_2 enriched environment (over and above the ambient) shows a large and sustained increase in the number of fruit produced by orange trees, a small increase in the size of the fruit and a modest increase in the vitamin C concentration of the juice of the fruit. A study carried out by *Idso et al., 2002*, indicates that a 75% increase in atmospheric CO_2 concentration(a long term exposure whereby the concentration of CO_2 increases from 400 ppm to 700 ppm) has increased the number of fruit produced by the trees by 74±9%, the fresh weight of the fruit by 4 ± 2% and the vitamin C concentration of the juice of the fruit by 5±1%. However, negative effects of carbon dioxide accumulation in the atmosphere can be expected on the post harvest quality potato - causing tuber malformation, occurrence of common scab and changes in reducing sugars contents on potatoes (*Moretti et al., 2010)*.

5.9 IMPACT ON LIVESTOCK

The Temperature Humidity Index is a good indicator of degree of heat stress. A composite Temperature Humidity Index (THI) has been estimated by NDRI based on temperature-humidity values all across India *(NATCOM, 2012*). Animals are comfortable at THI between 65 and 72, are under mild stress when THI is between 72 to 78 and are under severe stress when THI is above 80. In the Punjab region the annual average THI is between 70-73, Indicating that livestock are already in a mild to severe stress conditions between the period March to September when maximum temperature increases beyond 25^0C, with heat stress levels being highest in the month of May. The higher THI in general has a negative implication on milk production, production process and diseases prevalence amongst livestock.

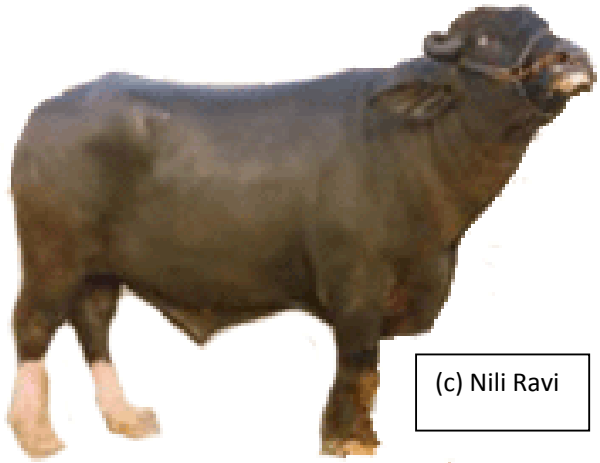
In Punjab the native cattle and buffalo species are Murrah buffalo, Sahiwal cows and Nili Ravi buffalo's, amongst small ruminants, Beetal goat is native and amongst poultry brown poultry is native (see photos below). These are comparatively hardy animals as compared to the cross bred varieties.

A study on Sahiwal and Holstein Friesian crossbred (Karan-Fries) heifers under natural environment and at extreme temperature exposures in a climatic chamber (40ºC and 50% RH and 45°C and 50% RH for 4 hr) indicates that the HSP72 protein level increased due to thermal exposures. The Karan-Fries exhibited higher increase of HSP72 (106%) than Sahiwal (22.4%) (*ICAR/DARE report, 2011*). **See Figure 5.11.**



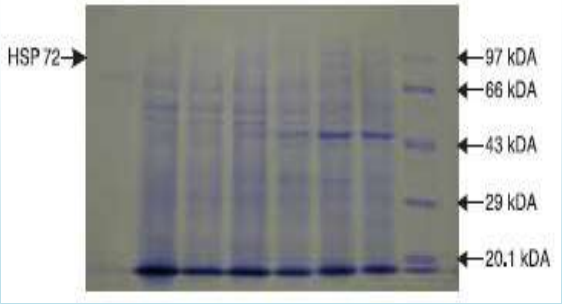
(a) Sahiwal

(b) beetal



(c) Nili Ravi

(d) Murrah Buffalo



SDS-PAGE of HSP72 (purified, sigma) and total protein in lymphocyte cell lysates of Sahiwal and Karan-Fries exposed at 45℃ and 50% RH. Lane 1- HSP72 (purified), lane 2 and 5- Before exposure, lane 3 and 6– after 2 hr of exposure, lane 4 and 7 after 4 hr of exposure; Lanes 2,3, and 4 are for Sahiwal and 5,6, and 7 are for Karan-Fries. M- Molecular weight marker

Figure 5.11: Protein function response of Sahiwal and Holstien under normal and heat stress conditions.

5.10 IMPACT ON POULTRY

Studies by ICAR project directorate on poultry indicates that as the ambient temperature reaches ≥34°C the mortality due to heat stress becomes significantly high in heavy meat type chickens (8.4%) as compared to light layer type (0.84%) and native type (0.32%) chickens. Feed consumption decreased from 108.3 g/bird/day at 31.6°C to 68.9 g/bird/day at 37.9°C. Egg production also decreased both in broiler (by 7.5%) and layer (by 6.4%) breeders as compared to their standard egg production. The body temperature increased from 41 to 45°C as the shed temperature rose from 28° to 42°C and the critical body temperature at which the birds succumbed to death was 45°C, which was observed at the shed temperature of 42°C. Naked neck birds performed significantly better than the normal birds with respect to thermo tolerance, growth, feed efficiency and immunity at high temperatures (*Source: ICAR-DARE, 2010-11*)

Further, it has been observed that the fertility and hatchability of the hens reduce with increase in temperature (under observation were the varieties *Grampriya, Vanaraja* and *Broiler)*. Maximum reduction takes place in *broiler variety.* Also it has been observed that the immune response to Newcastle disease vaccine and Sheep Red Blood cell (SRBC) antigen was significantly less at higher temperature wrt to ambient in summers than at higher temperatures wrt to ambient in winters (**See Table 5.11**). Also live semen content reduces at higher temperatures and quantity of dead spermatozoa increases (**Table 5.12**) (*ICAR 2010-11).*

Table 5.11: The immune response of layer, broiler and rural birds to ND vaccine and SRBC antigen during three cyclical temperatures

Strain	Antibody titers (Log 2 HI/HA)					
	15.3-27.2°C		25.3-39.2°C		21.0-29.5°C	
	ND	SRBC	ND	SRBC	ND	SRBC
Layer	5.6	6.3	5.7	5.3	6.9	6.8
Broiler	5.3	5.7	4.1	4.9	6.3	7.2
Rural	5.4	6.1	4.3	5.2	6.6	7.1

Source: Annual Report, 2010-11, Project Directorate on Poultry, ICAR, MoA, GoI

Table 5.12: Effect of temperature variability on semen quality parameters

Semen quality parameters	Winter	Summer
Volume (ml)	0.25 ± 0.02	0.32 ± 0.03
Appearance	3.504 ± 0.13^{b}	4.04 ± 0.17^{a}
Individual progressive motality	63.39 ± 2.01	59.29 ± 1.87
Spermatozoa concentration (million/µl)	4.52 ± 0.34^{b}	6.30 ± 0.32^{a}
Fertilising ability (nM of MTT) Formazan/min/million sperms)	19.95 ± 1.06	20.43 ± 1.13
Live Spermatozoa (%)	91.38 ± 0.80^{a}	78.74 ± 3.72^{b}
Dead spermatozoa (%)	8.62 ± 0.80^{b}	21.26 ± 3.72^{a}
Abnormal Spermatozoa (%)	1.45 ± 0.24	2.71 ± 0.76

Source: ICAR, 2011

5.11 IMPACT ON FISHERIES

Some of the impacts of increase in temperature on inland fisheries can be as follows:

- Likely decrease in fish spawning and hence decrease in fish seed availability as has been observed in some of the studies.

- Mass mortalities may be reported due to increase in temperature as has been implicated in mass mortalities of many aquatic species, including plants, fish, corals, and mammals.
- Increased temperature may cause thermal stress in aquatic animals, leading to reduced growth, sub- optimal behaviors and reduced immune competence resulting in changes in the distribution and abundance of their hosts.
- There can be a positive impact of climate change. In recent years in India with increase in temperature the inland aquaculture centered on the Indian major carps, *Catla catla, Labeo rohita* and *Cirrhinus mrigala* who's spawning occurs during the monsoon (June-July) and extends till September, has seen maturing and spawning as early as March, making it possible to breed them twice a year. Thus, there is an extended breeding activity as compared to a couple of decades ago.

(*Sources: Battin et al., 2007; Harvell et al. 1999; Marcogliese et al., 2008 Harvell et al., 2002; Dey et al., 2007; Walther et al., 2009).*

5.12 OVERVIEW OF THE NATIONAL AGRICULTURE MISSION

Punjab intends to address the concerns of climate change within the purview of the National Mission on Sustainable Agriculture which is one of the 8 missions of the National Action Plan on Climate Change of India. A brief description of the National Missions is provided below. Next, this section gives the mission objective in the state context within which strategies to address the concerns of climate change have been defined.

The National Mission for Sustainable Agriculture seeks to :

- Transform agriculture in India into an ecologically sustainable climate resilient production system while at the same time, exploiting its fullest potential and thereby ensuring food security, equitable access to food resources, enhancing livelihood opportunities and contributing to economic stability at the national level;
- Develop strategic plans at the Agro-Climatic Zone level so as to contextualize at regional scales, Research and Development, Technology and Practices, infrastructure and Capacity Building;
- Enhance agricultural productivity through customized interventions such as use of bio-technology to develop improved varieties of crops and livestock, promoting efficient irrigation systems, demonstration of appropriate technology, capacity building and skill development;
- Facilitate access to information and institutional support by expanding Automatic Weather Stations (AWS) networks to the Panchayat level and linking them to existing insurance mechanisms including Weather Based Crop Insurance Scheme (WBCIS) and National Agriculture Insurance Scheme (NAIS), scaling the returns at that level.
- Promote "laboratory to land" research by creating Model Villages and Model Farm Units in rain fed and dry land areas;
- Strategize long term interventions for emission reduction from energy and non-energy uses by way of introduction of suitable crop varieties and farm practices, livestock and manure management;
- Realize the enormous potential of growth in dry-land agriculture through development of drought and pest resistant crop varieties, adopting resource conserving technologies, providing institutional support to farmers and capacity building of stakeholders;

The Mission would further devise appropriate strategies by identifying key dimensions of sustainable agriculture and formulating a Programme of Action (PoA) for adaptation and mitigation measures covering research and development, technology and best practices, infrastructure and capacity building. This will be supported by synergizing traditional knowledge, agricultural heritage and modern technology and research;

The Mission would seek "convergence and coordination" among the key ministries and departments at all levels of governance. Since climate change adaptation in the agriculture is a cross-sectoral

issue, requiring cooperation of several government departments and integration of their programs and actions, this would also establish linkages with the other National Missions.

5.13 PUNJAB STATE AGRICULTURE MISSION

Given the current scenario of Agriculture in Punjab and future concerns due to climate change, Punjab aims to usher in the 2nd green revolution through sustainable management of agriculture and use of appropriate latest state of the art science and technology to enhance production, thereby ensuring food security of the state and the nation and providing livelihood security to the farmers of the state.

Strategies to achieve this objective are indicated in the following section and details of actions, timelines, budgets, and responsible agencies that will carry out the actions are given in Annexure 3.

Strategies for Agriculture and Horticulture

Strategy 1

Promote crop diversification in the state as per the suitability of production in its different agroclimatic zones and take advantage of efficiency of C3 vs C4 crops in the enhanced CO_2 environment.

The actions suggested include:

i. Undertake a study for assessment of impacts of climate change on different crops in 6 agro-climatic zones of Punjab to enable identification of suitable crops and design crop diversification packages in a changing climate scenario

ii. Start crop diversification process. Increase area under crops such as maize, guar, pearl millet, oil seeds, pulses, cotton, sugarcane, forages etc. These crops, sidelined due to mono cropping of rice, have to be selected keeping in view their productivity potential in each agro-climatic zone and their CO_2 utilisation efficiency without compromising Punjab's target of contribution of grain to the central pool.

iii. Increase area under horticulture plants such as potato and fruits, as their yields in Punjab is likely to increase with climate

iv. Support the increase in horticulture diversification through research

- Raise nursery plantations in screen houses to protect from adverse soil and climate conditions
- Identify and introduce low chill varieties of temperate fruits grown under sub-tropical area
- Refine existing production and post harvest technologies used for commercial level of production of fruit in Punjab.
- Undertake research under protected conditions using conventional and biotechnological approaches to understand the impacts of Climate change on appearance, change of host plan, build up of insect and mite population, and Disease buildup in fruits such as guava, mango, grapes, papaya, banana etc. and devise remedies for the same.
- Promote plantation of horticulture crops resistant to water logging in addition to *Eucalyptus*. This action would include identification of suitable horticulture plants resistant to water logging, Conduct Pilots for broadcasting the identified water resistant plants and undertake extension activities to reach out to farmers. Some of the other trees/crops that can be planted and harvested include Willow, Arjun, Jamun, deep water rice amongst others

v. Provide minimum support prices for the non rice and wheat crops as per the recommendation of the Farmers Commission without taking into account price of subsidised power. Formula: MSP= Cost of Input+ 50% Profit

Strategy 1:	12th Plan	13th Plan	Total Cost
Cost Implications	Rs. 5035.51 Cr	Rs. 5038.01 Cr	Rs. 10073.52 Cr

Strategy 2

Sustainably manage agriculture crop residue to avoid the ill effects of on farm burning of crop residue in Punjab and also benefit from management of the same. This essentially uses some of the similar actions as indicated in crop diversification, but nonetheless are repeated here indicating their relevance.

This would entail promotion of

i. Awareness amongst farmers to urge them to go for diversification of cropping to generate less rice and wheat straw.

ii. Straw mulching through reincorporation in soil for improvement in soil health in areas where soil is degraded due to residue burning.

iii. Frontline demonstration and distribution at subsidized cost of rotavators, happy seeders, zero tillage machines to support soil conservation in areas where soil has been degraded due to residue burning.

iv. Setting up of agriculture machinery service centres

v. Organisation of awareness programmes on ill effects of residue burning.

vi. Promotion of biomass power plants to use the excess residue and also to enhance share of renewables in Punjab.

vii. Utilisation of rice straw in cattle feed for protein augmentation in feed and for hay bedding.

Strategy 2:	12th Plan	13th Plan	Total Cost
Cost Implications	Rs.146.70 Cr	Rs.146.70 Cr	Rs. 293.40 Cr

Strategy 3

Promote resource conservation of soil, water and energy. The actions suggested include

i. Promotion of integrated nutrient management in soils through

- Enhanced C sequestration in soils.
- Stabilization of sequestered C in soils.
- Regular and compulsory soil testing, water testing, measurement of soil temperature and reported in soil health cards given to each land holder. This in turn will be used to design integrated nutrient management for each land holding.
- Promotion of green manuring.
- Use of laser levelers, ridge planting, straw and bio mulching and micro irrigation.
- Micro nutrient demonstration for farmers.
- Amelioration of alkaline and acidic soils.

ii. Install automatic weather stations all across Punjab at 25kmx25km grid to develop agro climate wise cropping plan and adequate deployment of farm inputs.

iii. Continuation of policy for preservation of sub soil water.

iv. Direct seeding in moist soils.

v. Alternate wetting and drying.

vi. Develop schedule of irrigation based on crop simulation modeling that take into account the on farm tensiometer readings and weather data.

vii. Promotion of basmati rice which is less water intensive wrt to other rice.

viii. Identification and promotion of rice cultivars that can be grown in water logged areas under continuously deep water conditions.

Strategy 3:	**12th Plan**	**13th Plan**	**Total Cost**
Cost Implications	Rs. 2169.67 Cr	RS. 2484.00 Cr	Rs. 4654.39 Cr

Strategy 4

Formulate Agriculture Market Intelligence Cell within the Deptt. of Agriculture in order to adjust the production systems each year which have to be aligned according to the variable climate as well as to the demands of the markets after meeting the basic demand of food security of the state. This would entail defining the terms of reference of the cell and taking necessary actions to formulate the marketing intelligence cell.

This strategy is also towards ensuring livelihood security in the changing climate scenario. This cell will review the markets; will provide information to the farmers on available markets domestically as well as internationally. The cell will also monitor national and international prices of agriculture grains, horticulture crops, animal products and other value added products and advise the farmers.

Strategy 4:	**12th Plan**	**13th Plan**	**Total Cost**
Cost Implications	Rs. 5.00 Cr	Rs. 5.00 Cr	Rs. 10.00 Cr

Strategy 5

Develop cultivars and enhance germ plasm base that are (a) thermal resistant, (b) can withstand water stress, (c) Can grow in water logged areas, (d) withstand emerging pests and diseases and (e) withstand enhanced levels of CO_2. The focus crops can be:

Crop	**Opportunity/Challenges for sustainable agriculture**	**Action plan/ strategy**
Cereals		
Wheat	• High temperature during grain filling causes forced maturity that leads to reduced yield, shriveled grains and reduced quality	• Development of early maturing and heat tolerant varieties
Basmati Rice	• Non basmati rice is more exhaustive in terms of water use and other inputs. • High temperature increase the incidence of blast in basmati rice	• Popularization of basmati cultivation to increase area upto 10 lac hectares • Development of varieties with basmati quality in productive backgrounds • Development of basmati rice

Crop	Opportunity/Challenges for sustainable agriculture	Action plan/ strategy
		varieties resistant to insect pests by introgression of resistance from cultivated and wild rice varieties
Maize	• Maize cultivation can help in diversification by reducing area under rice • High temperature reduces seed setting • Maize is sensitive to both flooding and drought	• Climate resilient high yielding maize hybrids • Enhanced production of hybrid seed
Pulses		
Arhar	• High temperature during seedling emergence causes mortality	• Development of varieties tolerant to heat stress at seedling stage
Soybean	• Diversification option – high productivity among pulse crops	• Resistance to yellow mosaic virus needs to be incorporated • Development of determinate types to serve as short duration additional crop
Sugarcane	• Winter hardiness for better ratoonability • High temperature during seedling emergence in case of summer planting after wheat	• Development of sugarcane varieties with better frost tolerance under low temperature conditions • Development of varieties with high germination percentage under high temperature.
Forages		
Berseem	• Low temperature causes frost injury and slow down the growth during January • Terminal heat tolerance in berseem hindering seed production	• Development of multi-cut berseem varieties with better frost tolerance/winter hardiness • Development of varieties with inbuilt tolerance to terminal heat stress for high seed yielding ability
Pearl millet and Sorghum	• Pearl millet and sorghum can grow well under drought conditions • Being high biomass crops can be used for silage production for lean period • Represent good diversification options as fodder crops	• Development of pearl millet and sorghum multi-cut hybrids with tolerance to high temperature and drought. • Identification and development of varieties suitable for good quality silage.
Cotton	• High temperature at seedling stage causes seedling mortality leading to reduction in plant stand, thus lowering yield and productivity. • Low water requiring crop as compared to rice • Rice cultivation in South –Western districts causes salt accumulation near soil	• Development of heat tolerant cotton cultivars. • Identifications and exogenous application of chemicals providing heat tolerance at seedling stage • Revival of cotton cultivation in South –Western districts

Crop	Opportunity/Challenges for sustainable agriculture	Action plan/ strategy
Oilseeds	• High temperature at seedling and terminal stages • Oilseeds are grown under conserved moisture conditions • Assured farm income	• Development of high temperature tolerant varieties • Drought tolerant varieties • Development of cost effective production and protection technology • Development of dual purpose canola (Fodder and seeds)

Strategy 5:	12th Plan	13th Plan	Total Cost
Cost Implications	Rs. 664.65 Cr	Rs. 545.00 Cr	Rs. 1209.65 Cr

Strategy 6

Manage new and emerging pests, diseases and weeds in crops.

The actions suggested include:

i. Map the existing pest and disease profiles of important crops in Punjab and link it to climate important parameters
ii. Develop models for forecasting emerging as well as existing crop pests and diseases
iii. Develop improved integrated pest and disease management system for important agricultural crops in Punjab. It will involve (a) Monitoring of quantitative as plan, (b) Advance warning system incorporating climate factors, Preventive measures, Remedial measures, in case of attack
iv. Undertake studies on important pollinators and natural enemies of crop pests and phytopathogens in agricultureal crops to link their population dynamics/epidemiology with climate factors
v. Develop integrated weed management approaches for conservation agriculture
vi. Undertake management of herbicide resistance in *Phalaris minor* in wheat
vii. Monitor herbicide residue in crop residue and ground water
viii. Monitor changing weed behavior and their competitive ability due to climate change

Strategy 6:	12th Plan	13th Plan	Total Cost
Cost Implications-	Rs.22.45 Cr	Rs. 8.00 Cr	Rs. 30.45 Cr

Strategy 7

Diversify into value addition activities to avoid waste of agriculture produce and increase storage capacity for grains to ensure farmer incomes in a changing climate scenario. The actions for this activity would include:

i. Enhancement of storage capacity to accommodate excess grain produced each year.
ii. Improvement in the PDS system.
iii. Undertaking value addition activities to convert excess grain to other processed food such as biscuits, paper, chips etc. through tie ups with established processing industries to sell these value added products in a pan India market.

Strategy 7:	12th Plan	13th Plan	Total Cost
Cost Implications	Rs.225.00 Cr	Rs. 225.00Cr	Rs. 450.00 Cr

Strategy 8

Promote cooperative farming amongst marginal, small and medium farm land owners to reduce input costs, and maximize productivity and farm incomes and hence ensure livelihood security and income for farmers. The actions would include:

i. Generation of awareness amongst farmers on benefits of cooperative farming such as input cost reduction benefits and increase in yields due to application of adequate farm inputs availed from pooled resources, easy and inexpensive accessibility to relatively expensive farm mechanization tools such as crushers, balers, land levelers and happy seeders, etc.
ii. Formation of cooperatives with handholding through NGOs and the Government.
iii. Review and/or introduction of policies suitable for successful operation of farm cooperatives.

Strategy 8:	12th Plan	13th Plan	Total Cost
Cost Implications	**Rs.5.5 Cr**	**-**	**Rs. 5.5 Cr**

Strategy 9

Manage Climate Risk through insurance and by assessing the socio economic impacts of Climate change on Agriculture.

Other than crop diversification to manage risks associated with climate, such as crop failure in the face of a calamity and inter year fluctuations, support through insurance to over come the losses is also another risk diversification mechanism. The action suggested includes development of weather indexed crop insurance for different crops in Punjab. Also includes an assessment of the socio economic impacts of climate change on agriculture and communities.

Strategy 9:	12th Plan	13th Plan	Total Cost
Cost Implications	Rs. 201.50Cr	Rs. 1750.00Cr	Rs. 1951.50Cr

The total cost for implementation of 9 strategies for addressing concerns of climate change regarding agriculture and horticulture in Punjab is estimated to be:

Plan period	Cost
12th Plan	Rs. 8475.25 Cr
13th Plan	Rs. 10202.43 Cr
Total Cost	Rs. 18678.41 Cr

Strategies for Managing Livestock and Dairy

Strategy 1

Manage heat stress and ensure sustainable productivity of livestock in a climate change scenario. The actions suggested are:

i. Special thrust on preservation, development and popularization of superior indigenous germ plasm – large and small ruminant and poultry. This would help to harness the gene pool of indigenous varieties of livestock (Sahiwal cow, Nil Ravi Buffalo and Beetal goat, and Punjab Brown poultry) that can withstand heat.
ii. Develop climate resilient crossbred of high milk yielding cows/buffalos with indigenous livestock and that of poultry as well.
iii. Ensure adequate sheds for livestock to avoid exposure to extreme heat.

Strategy 1:	12th Plan	13th Plan	Total Cost
Cost Implications-	Rs 45.55 Cr	Rs 46.40 Cr	Rs 91.95 Cr

Strategy 2

Recover energy from livestock waste

The actions include:

i. Promotion of Biogas plants in commercial dairies in Punjab using Dairy farm waste including dung and urine for electricity generation which will be utilized for dairy operations and excess supplied to the grids. Co-benefits, avoid CH4 emission.
ii. Make mandatory Installation of Biogas plants for farmers holding land more than 4 ha or having more than 5 mulching animals.

Strategy 2:	**12th Plan**	**13th Plan**	**Total Cost**
Cost Implications	Rs 233.00 Cr	Rs 281.00 Cr	Rs 514.00 Cr

Strategy 3:

Manage livestock health in the emerging pest and disease scenario

The actions suggested are:

i. Mapping of existing pest and disease profile of various livestock in Punjab and linking it to climate parameters triggering them.
ii. Developing advance warning systems about emerging pests and disease attack through modeling.
iii. Developing integrated Pest and Disease management packages for each commercially important livestock in Punjab. The package will contain
    - Monitoring of pests and disease
    - Advance warning system that indicates online weather
    - Preventive measures
    - Remedy in case of an attack
    - Ensuring enough veterinary dispensaries and units to treat the livestock population in Punjab adequately

Strategy 3:	**12th Plan**	**13th Plan**	**Total Cost**
Cost Implications	Rs 20.00 Cr	Rs 10.00 Cr	Rs 30.00 Cr

Strategy 4:

Ensure adequate green fodder availability for livestock

The actions would include

i. Estimation of additional requirement of green fodder in the future
ii. Ensuring adequate green- feed for livestock. Currently there is an availability of 28 kg green fodder/animal/day. The deficit to be met by increasing the productivity of green fodder.
iii. Developing new varieties of fodder seeds.
iv. Promotion of mechanization in fodder cultivation to lower the cost of fodder production.

Strategy 4:	**12th Plan**	**13th Plan**	**Total Cost**
Cost Implications	Rs 130.50 Cr	Rs 125.00 Cr	Rs 255.50 Cr

Strategy 5

Ensure cover for Climate Risk to livestock.

The actions under this strategy would include:

i. Encouraging small and marginal farmers and nomads to have a mix of small ruminants to ensure protection from climate risk (having a mix of poultry, sheep/goat, pigs and rabbits).
ii. Development of early warning systems for disease and pest outbreak forecast, and information on dispensaries available that can provide cure in each area/region of the state. Information to be provided through modern tools of IT.
iii. Develop climate index based livestock insurance and market the same.

Strategy 5:	12th Plan	13th Plan	Total Cost
Cost Implications-	Rs 18.00 Cr	Rs 15.00 Cr	Rs 33.00 Cr

The total cost for implementation of 5 strategies to be carried out to address climate change concerns for the dairy and livestock sector is estimated to be:

Plan period	Cost
12th Plan	Rs.447.05 Cr
13th Plan	Rs. 477.40 Cr
Total Cost	Rs.924.45 Cr

Strategies for Fisheries

The main strategy for fisheries in the state is to ensure sustainable production of Fish to withstand the impacts of climate change and ensure livelihood security of people dependent on this sector

The actions suggested to achieve the strategy are:

i. Renovation/rehabilitation of village ponds and development of new ponds/tanks in saline affected waterlogged land in the south-western districts of Punjab.
ii. Develop Saline affected waterlogged area in the south-west districts of Punjab to make fisheries to grow there and become a major livelihood activity for the farmers.
iii. Assess impacts of climate change on fisheries in Punjab.
iv. Determine the hydrological and physico-chemical characteristics of water bodies and correlate them with fish productivity.
v. Supply of quality fish seed for table fish production.
vi. Develop information and knowledge with respect to water conservation measures and increasing water use efficiency and disseminate the same amongst farmers.

The total cost of implementing the actions for the Fishery sector is as follows:

Plan Period	Cost
12th plan	Rs 56.04 Cr
13th Plan	Rs 50.10 Cr
Total Cost	Rs 106.14 Cr

The details of the strategies are provided in Annexure 3, in terms of actions, timelines, budgets and institutions that will be responsible for each activity.

The total cost of the agriculture mission (agriculture + horticulture + livestock + fisheries) in the various plans is as follows:

Plan Period	Cost
12th Plan	Rs. 8979.07 Cr
13th Plan	Rs 10729.93 Cr
Total	Rs 19709.00 Cr

REFERENCES

1. Agricoop, 2012. State of Indian Agriculture 2011-12., Department of Agriculture and Cooperation. Ministry of Agriculture, Government of India.

2. Badrinath, KVS, T R Kiran Chand, and V Krishna Prasad; 2006. Agriculture crop residue burning in the Indo-Gangetic Plains – A study using IRS-P6 AWiFS satellite dat, Current Science, Vol 91(8), pp 1085-1089.

3. Battin, J., M W Wiley, M H Ruckelshaus, R N Palmer, E Korb, K K Bartz, & H Imaki, 2007. Projected impacts of climate change on salmon habitat restoration, Proc. Natl. Acad. Sci, USA, 104, 6720-6725.

4. Chandna P., B. S. Sidhu, M. Punia, J. K. Ladh, and Raj Gupta; 2009. Impact of climate variability on high productivity wheat region of Punjab, ISPRS Workshop Proceedings: Impact of Climate Change on Agriculture. ISPRS Archives XXXVIII-8/W3 Workshop Proceedings: Impact of Climate Change on Agriculture.

5. DACNET, 2012. Agroc climatic Region- Trans-Gangetic Regions. State Punjab, India. Accessed from http://dacnet.nic.in/farmer/new/dac/AgroClimaticZones.asp?SCod=16 on Dec 2012.
6. DAHDF 2010. Annual Report 2009-10. Department of Animal Husbandry, Dairy and Fisheries, Ministry of Agriculture, Government of India.

7. DAHDF2011. Annual Report 2010-11, Department of Animal Husbandry, Dairy and Fisheries, Ministry of Agriculture, Government of India.

8. DAHDF, 2012. Annual Report 2011-12, Department of Animal Husbandry, Dairy and Fisheries, Ministry of Agriculture, Government of India.

9. Das, D.K., J. Singh and S. Vennila, 2011. Emerging Crop Pest Scenario under the Impact of Climate Change – A Brief Review, Journal of Agricultural Phys.Vol. 11, pp. 13-20.

10. DoA, 2013. Input received from Deptt of Agriculture on shift in cropping pattern between 1970-71 to 2010-11. Deptt of Agriculture, Govt. of Punjab.

11. NDDB, 2012. Estimates of Milk production by states. Accessed from:
12. http://www.nddb.org/English/Statistics/Pages/Milk-Production-States.aspx. in July 2012 and also on Feb 2013.

13. DARE/ICAR 2011. Dare/ICAR Annual report, 2010-11. Deptt of Agriculture Research and Education, Indian Council of Agricultural Research, Ministry of Agriculture, Givernment of India. Accessed from http://www.icar.org.in/en/node/2763 in August 2012.

14. Dey, S., P K Srivastava, S Maji, M K Das, M K, Mukhopadhyay, P K, & Saha, 2007. Impact of climate change on the breeding of Indian major carps, West Bengal. J. Inland Fish. Soc. India, 39, 1, pp 26-34.

15. GADVASU, 2007. Action Plan for Fisheries, Published by Guru Anagad Dev Veterinary and Animal Sciences University, 2007.

16. Harvell, C. D., K. Kim, J. M. Burkholder, R. R. Colwell, P. R. Epstein, D. J. Grimes, E. E. Hofmann, E. K. Lipp, A. D. Osterhaus. and R. M. Overstreet,. 1999. Emerging marine diseases- climate links and anthropogenic factors, Science, 285, pp 1505-1510.

17. Harvell, C. D., C. E.Mitchell, J. R. Ward, S. Altizer, A. P. Dobson, R. S. Ostfeld, R. S and M. D. Samuel, 2002. Climate warming and disease risks for terrestrial and marine biota, Science, 296, 5576, 2158-2162.

18. ICAR, 2011. Annual Report, 2010-11, Project Directorate on Poultry, ICAR, MoA, GoI.

19. Idso, S.B., B. A. Kimball, P. E. Shaw, W. Widmer, J. T. Vanderslice, D. J. Higgs, A. Montanari, and W. D. Clark, 2002. The effect of elevated atmospheric CO2 on the vitamin C concentration of (sour) orange juice. Agriculture, Ecosystems and Environment 90: 1-7.

20. IHDB, 2011. Indian Horticulture Data base, 2011, Published by Horticulture Mission, Ministry of Agriculture, Government of India.

21. INCCA, 2010. Climate Change and India: A 4X4 Assessment. A sectoral and regional Analysis for 2030s. INCCA Report #2. Published by the Ministry of Environment and Forests, Government of India.

22. IPCC, 2007. Impacts of Climate change, Working Group II report of the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Published by IPCC.

23. Jalota, S K., Anil Sood, G S Butter, Savitoz Siddhu, and P K Sharma; 2009. Printed in the Proceedings of the ISPRS workshop on Impacts of Climate Change on Indian Agriculture, Ahmedabad.

24. Kimball, B.A., K., Kobayashi, M., Bindi, 2002. Responses of agricultural crops to free-air CO2 enrichment. Advances in Agronomy 77, 293–368.

25. Long S P, E A Ainsworth, A D B., Leakey, D.R. Ort, J. Nosberger and D.Schimel. 2007. Crop models, CO2, and climate change – response. Science, 315, 460-460.

26. Lotze-Campen, H. and H J Schellnhuber, 2009. Climate impacts and adaptation options in agriculture: what we know and what we don't know. - Journal für Verbraucherschutz und Lebensmittelsicherheit - Journal for Consumer Protection andFood Safety, 4, 2, 145-150.

27. Marcogliese, D J. , 2008. The impact of climate change on the parasites and infectious diseases of aquatic animals, Rev. sci. tech. off. int. Epiz., 27, 2, 467-484.

28. Moretti, C.L.; L M Mattos, A G Calbo, S A Sargent, 2010. Climate changes and potential impacts on postharvest quality of fruit and vegetable crops: A review; Food Research International, Volume 43, Issue 7, August 2010, Pages 1824-1832.

29. Moretti, C.L.; L M Mattos, A G Calbo, SA Sargent, 2010. Climate changes and potential impacts on postharvest quality of fruit and vegetable crops: A review; Food Research International, Volume 43, Issue 7, August 2010, Pages 1824-1832).

30. NATCOM 1 and 2, 2004 and 2012. India's National Communication to UNFCC, MoEF, GoI.

31. NOAA, 2013. Recent global monthly mean CO2 concentrations. Global monitoring division, Earth system research laboratory, National Oceanic and Atmospheric Administration, U. S. Deptt of Commerce. Accessed from

32. http://www.esrl.noaa.gov/gmd/ccgg/trends/global.html, on March 2013.

33. NSSO, 2003. NSS Report no. 498: Indebtedness of Farmer Households, 2003. National Sample Survey Organisation, GOI.

34. Panigrahy, Sushma, P K Sharma, Anil Sood, S S Ray, B U Chaudhary, K R Manjunath, 2009. Cropping System Analysis in Punjab using Remote Sensing and GIS. Punjab Remote Sensing Centre Publication.

35. Parry M L, Rosenzweig, A. Iglesias, M. Livermore, G. Fischer 2004, Effects of climate change on global food production under SRESemissions and socio-economic scenarios, Global Environmental Change 14 (2004) 53–67.

36. Pathak, H., 2012. Final Base Paper on Crop Residue Management, presented in Brainstorming Session on Crop Residue Management in the Context of Conservation of Agriculture, April 16, 2012, Under the aegis of National Initiative on Climate Resilient Agriculture; http://www.nicra.iari.res.in/FinalCRM.doc).

37. PSCST, 2006 and 2007.Task force under the Punjab State Council on Science and Technology (vide order dates 11.08.2006 and 17.01.2007 to look into the issue and suggest remedial action. The report of the task force was submitted to the Punjab and Haryana High Court w.r.t CWP no. 10138 of 2008.

38. PSCST, 2008. Action Plan to Mitigate the problem due to burning of Agriculture wastes in Open Fields; Punjab State Council for Science and Technology, Government of Punjab.

39. PSDR 2004. Punjab State Development Report, 2004. Published by UNDP.

40. Punjab Annual Plan, 2011-2012. Punjab State Planning Board, Government of Punjab. http://pbplanning.gov.in/annual%20plan%202011-12.htm

41. Punjab revenue, 2012. Accessed in Dec 2012 from
42. http://punjabrevenue.nic.in/for%20website/agro-climatic%20zone.htm

43. Lal Rattan, 2011. Soil health and climate change- An overview. In the Book "Soil health and Climate change", edited by Bhupinder Pal Singh, Annette L Cowie, and K Yin Chan, Published by Springer Link. ISBN: 978-3-642-20255-1 (Print) 978-3-642-20256-8 (Online).

44. Tripathy Rojalin, S S Ray and A K Singh 2009. Analysing the impacts of climate rising temperature and CO2 on growth and yield of Major cereal crops using simulation Model; in ISPRS Workshop Proceedings: Impacts of Climate Change on Agriculture; held in Bhopal, 2009).

45. SAP, 2009, 2010, 2011. Statistical Abstract Punjab. Published by the Department of Economic and Statistics, Government of Punjab.

46. Siddhu Prabhjyot Kaur and S S Hundal, 2011. Assessment of Impacts of climate change on rice and wheat in Punjab, Report published by Punjab Agriculture University. Submitted to NATCOM II, Ministry of Environment and Forests, Government of India.

47. Singh, H P.2012. Ongoing Research in Abiotic stress due to climate change in horticulture, Accessed from www.niam.res.in/pdfs/DDG_Hort_lecture.pdf on Dec 9, 2012.

48. Singh J P and S S Lal, 2009. Climate and Potato production in India. ISPRS Archives XXXVIII-8/W3 Workshop Proceedings: Impact of Climate Change on Agriculture held in Space Application Centre, Ahmedabad, Dec 2009.46.

49. Sodhi, A K 2012. Golden Soils and Heavenly Water: -An Overview of the Past, Present & Future of Soil & Water Conservation in Punjab, by A K Sondhi, Chief conservator of Soils, Punjab;

50. downloaded from: dswcpunjab.gov.in/contents/pdf_forms/ak%20sondhi_paper.doc. Accessed in July 2012.

51. Stein Joar Hegland, Anders Nielsen, Amparo La´ zaro, Anne-Line Bjerknes and Ørjan Totland; 2009. How does climate warming affect plant-pollinator interactions?- A Review, Ecology Letters, (2009) 12: 184–195).

52. Stern, Nicholas, 2006. Stern Review on the Economics of Climate Change, London: Her Majesty's Treasury and the Cabinet Office. United Kingdom.

53. Tiwana, N.S; N. Jerath, S. S.Ladhar, G. Singh, R. Paul, D. K. Dua and H. K. Parwana, 2007. State of Environment, Punjab-2007, Punjab State Council for Science & Technology, pp 243.

54. Upadhayay 2011, Climate change and heat stress. Report submitted to NATCOM II, 2012, MoEF, GoI.

55. Walther, G. R., A. Roques, P E Hulme, M T Sykes, P Pysek, I Kühn, , M Zobel, S Bacher, Z Botta-Dukát, H Bugmann, B Czúcz, J Dauber, T Hickler, V Jarosík, M Kenis, S Klotz, D Minchin, M Moora, W Nentwig, J Ott, V E Panov, B Reineking, C Robinet, V Semenchenko, W Solarz, W Thuiller, M Vilà, K Vohland, K., and J Settele, 2009. Alien species in a warmer world- risks and opportunities, Trends Ecolo Evol. 2009 Dec, 24 (12, 686-93).

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6. Green Punjab Mission

HIGHLIGHTS

- Status of Forests, Wildlife and Ecotourism in Punjab
- Current challenges of the Forest Sector in Punjab
- Institutions Managing Forests and Wildlife in Punjab
- Key Forest Policies and Acts of the State
- Ongoing programmes and projects for managing forests
- Impact of climate change on forests in Punjab
- Strategies to address CC within the Framework of Green India Mission

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6.1 STATUS OF FORESTS, WILDLIFE AND ECO-TOURISM IN PUNJAB

Forest Types

The forests of Punjab state present a kaleidoscopic spectrum of diverse vegetation types varying from the pine forests to thorn forests of deserts as per variations of altitude and climate. According to Champion and Seth classification the forests of Punjab are categorized as under:-

Northern Dry Deciduous Mixed Forests: In this type of forests vegetation is predominantly of xerophytes. The preponderance of species like *Acacia catechu, Acacia nilotica, Acacia leucophloea and Anogeissus latifolia* with the scrub of *Carissa opaca, Grevia optiva, Adatoda vasica*, etc. is common in this type of forests. Khair-Sissoo forests are found along the banks of streams.

Dry Deciduous Scrub Forests: These forests are mostly found in Kandi tract. Predominant species are like *Acacia catechu*, *Dalbergia sissoo, Bombax ceiba, Emblica officinalis, Lannea grandis, Toona ciliata, Cassia fistula*, etc.

Khair, Sissoo forests in foot hills, Bela and Mand areas: These forests are mostly man made by planting in the foot hills of Bela and Mand areas. Mostly Khair, Sissoo and *Eucalyptus* hybrid have been planted in these areas. Groves of mango are found in these forests.

Shivalik Chir Pine Forests: *Pinus roxburghii* is the main species found in these forests at an elevation of 850m and above. Associated species are *Terminalia alata, Terminalia bellerica, Terminalia chebula, Anogeisus latifolia, Emblica officinalis, Cassia fistula*, etc.

Dry Deciduous Bamboo Forests: These forests are found in Dasua Forest Division only. The main species found in these forests is *Dendrocalamus strictus*. The other associates are *Lannea grandis, Diospyros montana, Butea monosperma, Holoptelia integrifolia and Cassia fistula*.

Forest Cover and Spread

The recently published India State of the Forest Report, FSI 2011, gives an encouraging scenario of forest cover in Punjab, indicating an increase by 100 km^2 between 2007 and 2009, bringing the total forest cover to 1764 sq km or 3.5% of the total geographical area. Notionally computed tree cover outside the legal forest area is 1699 sq km, which is 3.37% of total geographical area. Therefore the total tree cover (forest and outside forest) in Punjab is 3463 sq km or 6.87% of the total geographical area. The year wise forest cover area in Punjab is shown in **Figure 6.1.**

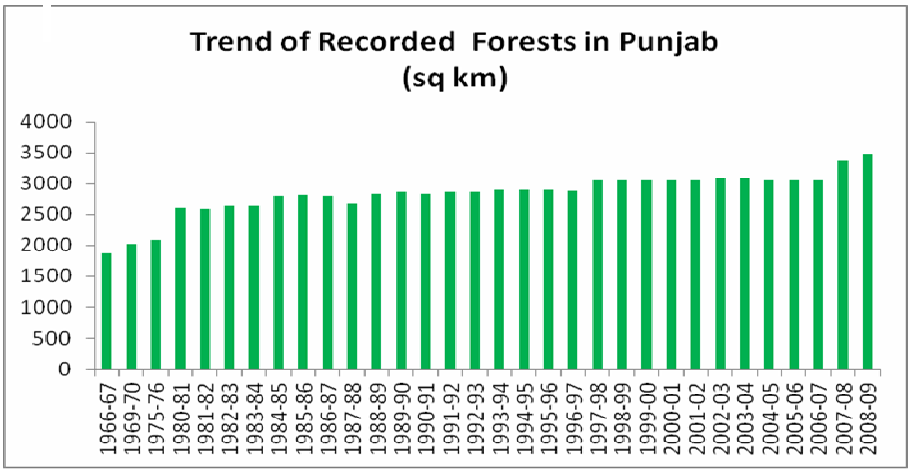

Figure 6.1: Year wise recorded forests in Punjab. This includes state forests and trees outside forests and private forests. (*Source: Year wise recorded forests 1966-67 to 2006-07. Downloaded from http://www.pbforests.gov.in/forestrystati.html and later data sourced from India Status of Forest Report 2011)*

The forest cover in Punjab is spread across the (a) Bist circle covering 17 ranges, (b) Shivalik Circle covering 18 ranges (c) South circle covering 14 ranges and (d) Ferozepur circle covering 17 ranges. In total there are 83 ranges managed by the Forest and Wildlife Department. Wildlife preservation ranges extend upto 9 circles, including Shivalik circle and parks and protected areas in Patiala and Ferozepur.

Forest Produce

In 2001-02, Punjab produced, 1,54,034 cu m of timber wood from government forests (*source: pbforestdevcorp.gov.in/active.html#a),* which was valued at Rs1896.37 lakh. The produce has since then reduced to 69,756 cum, with a valuation of Rs 2215.88 lakh. However the wood production from private areas is much more than that from the Government Forests.

Punjab also produces non wood timber forest products such as bamboo, bhabbar grass, fodder for grazing, fruits, resin, etc. During the year 2005-06 the government and private sector together produced non timber forest produce worth Rs. 344.29 lakhs.

There is wide gap between the demand and supply of wood in the state. The State imports large quantities of wood from different sources to meet the demand. The State imported timber worth Rs. 145.84 crores during 2005-06. This is going to increase over the years.

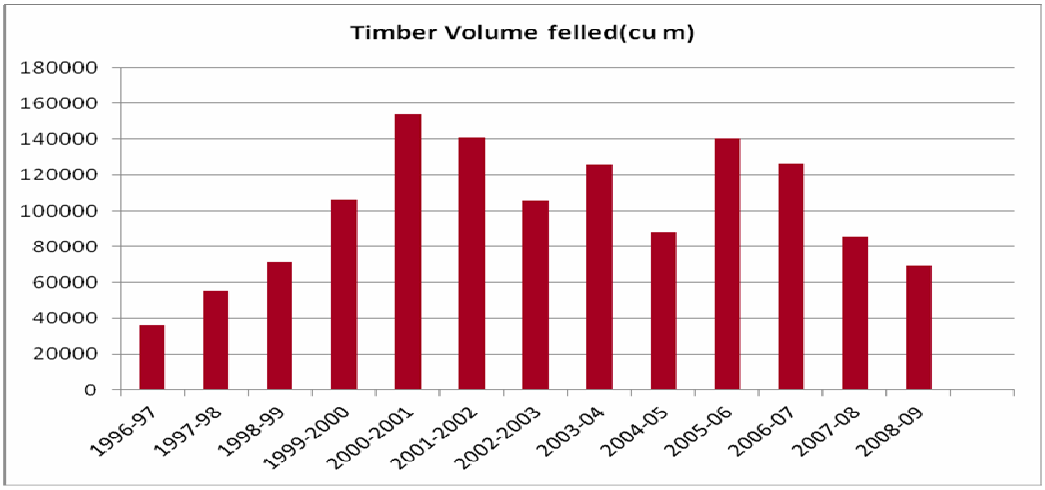

Figure 6.2 The trend of timber wood harvested in Punjab from government Forests

Wildlife

Punjab has 12 wildlife sanctuaries, 2 zoological parks, 3 deer parks and 2 community reserves. The list of these is presented in Table 6.1. The community reserves in Punjab were the first to be notified in India. The main wild animals found in the state are sambhar, nilgai, black buck, wild boar, barking deer, etc. Few sightings of leopard have been reported recently in the Shivalik hill areas adjoining Himachal Pradesh.

Table 6.1: List of Wildlife Sanctuaries, Zoological parks and Community Reserves

Type of reserve	Name of the reserve	Area covered (ha)
Wild life Sanctuaries	Bir MotiBagh Wildlife Sanctuary, Patiala	654
	Bir Bhunerheri Wildlife Sanctuary, Patiala	661.66
	Bir Dosanjh Wildlife Sanctuary, Patiala	517.59
	Bir Bhadson Wildlife Sanctuary, Patiala	1022.63
	Bir Mehas Wildlife Sanctuary, Patiala	123.43
	Bir Gurdialpura Wildlife Sanctuary	620.53
	Bir Aishwan Wildlife Sanctuary, Sangrur	264.40
	Harike Wildlife Sanctuary, Ferozepur, Tarn Taran, Kapurthala	8600.00
	Takhni-Rehmapur Wildlife Sanctuary, Hoshiarpur	382.00
	Abohar Wildlife Sanctuary, Firozepur	18650.00
	Jhajjar Bacholi Wildlife Sanctuary, Rupnagar	116.00
	Kathlaur-Kaushlian Wildlife Sanctuary, Gurdaspur	758.40
Zoological Parks	Mohindra Chaudhary Zoological Park, Mohali	202.00
	Tiger Safari, Ludhiana	35.00
	Deer Park, Nilon, Ludhiana	4.00
	Deer Park, Bir Moti Bagh, Patiala	8.00
	Deer Park, Bir Talab, Bathinda	20.00
Community reserves	Lalwan Community Reserve, Hoshiarpur	1266.80
	Keshopur Chamb Community Reserve, Gurdaspur	340.00

Ecotourism

Some of the ecotourism sites identified by Department of Forest and Wildlife Preservation, Punjab are: Keshopur Wetland, Shalla Pattan Wetland, Kathaur Kaushalaya Forests in district Gurdaspur, Nangal Wetland and adjoining forests, Ropar Wetlands and land along the banks of Sutlej River, Kukanet-Dehrian Mengarwal-Kort-Patial, Mirzapur Dam in Ropar district, Perchh, Seonk/Jayantimajri in Mohali district, Harike Wetland in Ferozpur, Tarn Taran and Kapurthala Abohar Wildlife Sanctuary, Ferozepur, Chhatbir Zoo, district Mohali, etc. The Department intends to develop eco sites, create environment parks, set up interpretation centres, facilitation centres, chalk out trekking routes, expand the lake at Chhatbir Zoo, introduce toy train, procure equipment like boats, vehicles etc., and set up information booths at strategic locations like airports, bus stations and brand building for promotion of campaigns.

The Punjab Heritage & Tourism Development Board is promoting farm tourism, home stays and hotels with rain water harvesting, solar energy devices, recycling treated water and promoting use of biogas generation. It has initiated steps to promote ecotourism at wetland areas like Kanjli and Keshopur Miani. It is developing these areas as ecotourism sites with installation of eco-friendly

infrastructure. It is also promoting use of tents to avoid building of permanent structures inside forests for tourist accommodation.

6.2 CURRENT CHALLENGES OF THE FOREST SECTOR IN PUNJAB

Covering Additional Area under Forests and Tree Cover

The draft Forest Policy of Punjab brought out in 2008 states that it would aim to extend the tree and forest cover in Punjab to 15% of its geographical area by 2015. If the increase continues at a business as usual rate of 100 sq km every 2yrs, then the desired tree and forest cover will be achieved only by 2070, If the target is lowered to 10% of the total geographical area, then under the same scenario, the target can be achieved by 2045 (**Figure 6.3**). However, the recently formulated Green Mission for Punjab, reiterates the same objective of bringing in tree and forest cover area in the state to about 15% of the geographical area within the period 2012-2020 overlapping the 12th and the 13th plan of the government.

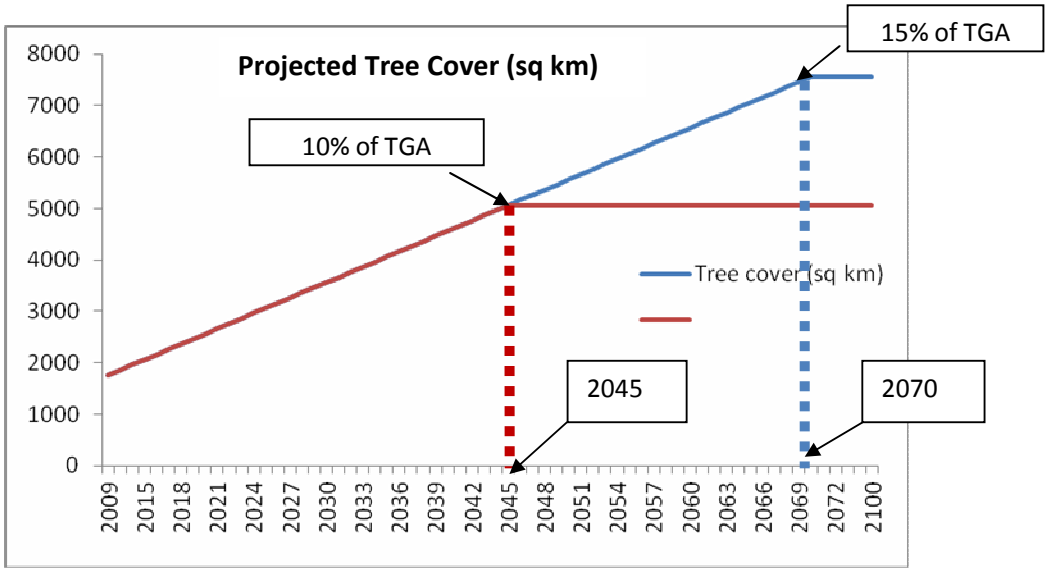

Figure 6.3: Projected Tree Cover for Punjab.

In figure 6.3, the red line indicates the possible tree cover of 5564 sq km that can be achieved by 2045 if growth rate is 100 sq km every two years. With the same growth rate the desired tree cover as per the Draft Forest policy i.e. 15% of total geographical area can be achieved only by 2070s. Here TGA is total Geographical area of Punjab.

Increasing Open Forest Cover

Between 2009 and 2011 assessment of FSI, though the total Medium dense forest cover has increased from 733 sq km to 736 sq km, the open forest cover has increased by 97 sq km from 931 sq km to 1028 sq km (**Figure 6.3**). The open forest area has 10-40% forest cover density. Of this approximately 75% i.e. 765 sq km falls under Hoshiarpur, Rupnagar, Nawanshehr and Pathankot districts of Punjab.

Similarly scrub land has increased from 20 sq km to 37 sq km. As a result, the share of medium dense forests decreased from 44% to 41% and area of Open Forests increased from 55% to 57%. These are worrying trends for the state, given the fact that the increasing demand of timber has to be met through a sustainable forest management system.

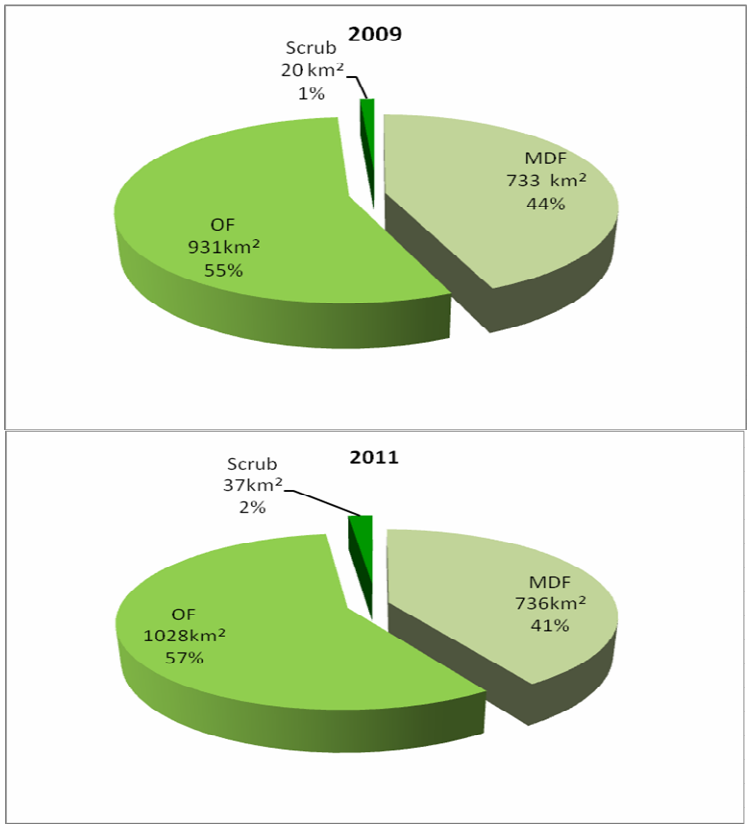

Figure 6.4: Share of different types of forest covers in 2009 and 2011. MDF: Medium Dense Forests and OF: Open Forests *Source: Punjab, India State of Forest Report, 2011, FSI*

Degraded Forest Area

The recorded forest area in the state including government/ private forests under management of Forest Department covers 2497 sq km. As per the ISFR 2011, the actual forest cover is only 1764 sq km. Thus the gap between the recorded forest and actual forest is 733 sq km. However, field assessments carried out by the Department of Forest and Wild Preservation of Punjab indicates that actual degraded blank forest area is about 500 sq km or 1% of the states geographical area.

Meeting Demand for Forest Produce

As per a PAU study the per capita wood demand in the state is 0.274 cum per annum therefore the total state demand is estimated to be 7.59 million cum (population being 27.70 million as per the 2011 Census). According to the ISFR 2011, the growing stock in recorded forests in Punjab is 15.71 million cum. The per annum yield from recorded forests at the average rotation age of 30 years works out to be 1.05 million cum. The growing stock of trees outside forests is 19.31 million cum (ISFR, 2011) in Punjab. The per annum yield from trees outside forests at an average rotation of 15 yrs, assuming 50% of trees are long rotation and the rest short rotation, works out to be 2.57 million cum. Thus the total wood availability in the state is estimated to be 3.62 million cum.

According to norms of the Central Empowered Committee of the Hon'ble Supreme Court, approximately 3 milllion cum wood is already adjusted against the licenses granted to approximately 6500 wood based units in the state (Table 6.2 for the type of wood based units operational in Punjab), therefore, hardly any wood is left for use if expansion of these units is undertaken. Currently, most of the units are running below their capacity and importing wood from other states. Thus, growth of the wood industry is hampered by non availability of wood.

Table 6.2: Wood based industries

Type of Unit	No. of Units
Saw mills	5994
Veneer mills	160
Plywood units	310
MDF/Particle Units	2
Others	23
Total	

Diminishing population of Kikar and Sheesham

Kikar (*Acacia nilotica*) and Tahli (*Dalbergia sissoo*) trees are a common sight in Punjab, but fully grown trees of these varieties are fast diminishing. The trees died extensively during the period 1996 to 2006 but are now reviving, however, the revival now is not comparable to the die back that has taken place. High rate of mortality have been observed in Sheesham and Kikar trees because of various biotic and edapho-climatic factors.

The Regional Center of NAEB, MoEF, the University of Horticulture and Forestry, Solan, Himachal Pradesh in collaboration with Punjab Forest Department have conducted a study and have concluded that the pre disposed factors such as fungal and insect pests infestations are causes of die back. The study also mentioned biotic, climatic, environmental factors like appreciable variation in temperature, rainfall, relative humidity, increase in frost and number of foggy days and reduction in sunshine hours. All these factors create the congenial conditions for the growth of fungus and pest. Other factors such as (i) changing climatic conditions, (ii) altering soil conditions, (iii) water-logging etc have been attributed to rapid die back of of Sheesham or Tahli trees. Again, this needs to be investigated and remedial measures taken.

Forest Fires and encroachment

During summer months, the forest fires are a regular feature in the forests. The forests having thick growth of kana, kahi and dhab grasses have the danger of forest fires in the hot season. Forest fires also occur after the harvesting season when the farmers in the adjoining areas burn their agricultural residue in fields and the fires extend to the forest areas. Fire-lines are maintained and fire watch-towers have been constructed in some of the forests, however a constant vigil by field staff is necessary to check these fires. Besides educating the farmers, awareness among the general public, maintenance of fire lines in the birs and strict legal action are the remedies to counter this problem.

More than 20,000 acres of forest land has been encroached upon in various parts of the state. The problem is serious as about 916 cases have been registered against violators under the Punjab Land Preservation Act, 1900 by the Forest Department within 2010 itself. The department had recently got 190 acres of encroached forest land freed in Machhiwara area. The encroached lands are in the periphery of cities where illegal urbanization extends and are also in rural areas in the periphery of forests which are illegally used for agriculture purposes.

Soil erosion in the Shiwalik tracts

Along the Shiwalik hills the Kandi tract includes narrow band of undulating under developed farm land areas and covers a total area of approximately 4.88 lac ha , which is 9.5% of the geographical area of the state. Of this around 1.10 lac ha is preserved under the PLPA (Punjab Land Preservation Act). About 0.56 lakh ha is delisted from the list of forest area by GoI. Only 0.31 lakh ha is the forest area. Approximately, the remaining 2.91 lakh ha is not regulated under PLPA.

The terrain is inaccessible and due to fragile nature of the soil it is highly erodible. Most of the soil is poor in nutrients and has limited irrigation facilities, the terrain is inaccessible, unproductive, highly

erodible and only rain-fed or marginal agriculture is being practiced. Land is highly infested by weeds such as *Lantana* (locally called Panjphulli, Chandel buti). Crop yield is low and below subsistence level. Only 20% of this area is under assured irrigation against the 97% assured irrigation for cultivated areas in the remaining part of the state. Further, crops get damaged often by wild life and stray cattle.

Economic backwardness, lack of area oriented schemes leading to inadequate infrastructure including low availability of water for irrigation and drinking, and lack of employment opportunities are some of the concerns of this area.

6.3 INSTITUTIONS MANAGING FORESTS AND WILDLIFE IN PUNJAB

Forests and Wildlife Preservation Department in Punjab is making efforts to increase the forest/tree cover in accordance with the National Forest Policy. Simultaneously, measures are being taken to protect & conserve the existing tree species and fauna to arrest and reverse ecological degradation besides plantation of quality tree species and conservation of forests and wildlife. The Department undertakes scientific management of forest areas that helps to increase forest productivity, check soil erosion in hilly areas and improve ground water recharge.

The Punjab State Forest Development Corporation operates under the State Forests and Wildlife Preservation Department. The objectives of the Corporation include (a) obtaining standing trees from the State Forest Department on payment of royalty, harvest them with efficient tools and make timber wood available to consumers with the object of eliminating unscrupulous middleman, (b) raise plantation for industrial use by obtaining some forest areas from the State and thus ensure a minimum requirement of industry(c) assist in the establishment of a large number of forest based industries (d) assist the private land owners by supplying plants for increasing forest produce for industrial use and (e) help for proper marketing of the produce so raised by the private owners through liaison with the consuming industries.

The Punjab Heritage and Tourism Development Board operating under the aegis of the **Punjab Tourism Department** is also foraying into providing support to Ecotourism in Punjab. Some of its related activities have been described in Section 6.1.

Punjab Bamboo and Fiber Development Board (PBFDB) has been constituted to execute the works in the State sanctioned under National Bamboo Mission which envisages integration of different Ministries/Departments and involvement of local people/initiatives for the holistic development of bamboo sector in terms of growth of bamboo through increase in area coverage, enhanced yields and scientific management, marketing of bamboo and bamboo based handicrafts, generation of employment opportunities, etc. PBFDB is a registered entity. The National Bamboo Mission is a Centrally Sponsored Scheme with 100% contribution from Central Government. It is being implemented by the Horticulture Division under Department of Agriculture and Co-operation in the Ministry of Agriculture.

6.4 KEY FOREST POLICIES AND ACTS OF THE STATE

The Punjab Forests and Wildlife are preserved, protected and conserved under the **aegis of many policies, acts and rules. Some of them are The Punjab Land** *Preservation (Chos) Act, 1900, The Indian Forest Act, 1927, The Indian Wildlife (Protection) Act, 1972, Forest Conservation Act, 1980, The National Forest Policy, 1988, Participatory Forest Management Circular, 1990, Punjab Apportionment of Tree Rules, 2000, Joint Forest Management notification and guidelines, 2003, Gov. of Punjab, The Indian Forest (Punjab Amendment) Act, 2004, The Forest Rights Act, 2006 , The Draft Punjab Forest Policy, 2008, Punjab Ecotourism Policy, 2009, The Punjab Tented Accommodation Guidelines, 2010, Punjab Regulation of Saw Mills and Veneer Plywood Rules, 2006.*
Some of the Key policies relevant to the state are enumerated below:

Joint Forest Management

has been extended to the entire state as per the Punjab specific JFM notification 2003. In Kandi area, it was operational since 1993. JFM provisions in Punjab are applicable on Reserve Forests and Protected Forests and specifically on Un-classed Forests in its Kandi area involving local people

through Forest Protection Committee (FPCs), Non-Government Organizations (NGOs)/ Voluntary Agencies (VAs)/Institutions/Religious Bodies, etc and farmers. Under this scheme, villagers are assigned a specific role in the protection of government forests adjoining their village and community/private forests of the village itself. In return the local people are allowed to collect dry/fallen twigs and leaves, wild fruits, medicinal herbs, etc. from the government forests free of cost. They are also entitled to get fodder grasses (but not bhabber grass) from the government forests free of cost where such grasses are not auctioned and the villagers have been conventionally obtaining grass from the forests. The local people are allowed to obtain fodder grass at comparatively cheaper rates through limited auctions i.e. auctions which shall be confined to the residents of the assigned village.

Agroforestry

It involves growing trees and crops in combination, while social forestry deals with growing trees in the socially inhabited areas, such as towns, villages, roads, parks, railway tracks etc. Punjab Agriculture University (PAU), after years of research, has identified tree species of Poplar, E*ucalyptus*, *Leucaena*, *Acacia*, *Melia*, etc., for agroforestry and developed matching technology for their block and boundary plantation. For boundary plantation, planting of *Eucalyptus* in the north-south direction and specific management of crop nutrients and water management have been standardised. Guniea grass, oats and sorghum have been identified as suitable crops for block plantation. Keeping in view the demand for several plywood units in the state, considerable emphasis has been laid on Poplar plantation. Cultivation of fodder crops, as inter-crop in the early stages of Poplar plantation has been found to be profitable and better than wheat-paddy rotation. The state Forest Department has identified 50,000 ha institutional and 2.5 lac ha farm lands which can be brought under tree cover by adopting suitable afforestation technologies.

Draft Punjab Forest Policy, 2008

This policy aims to increase the area under forests and tree cover from present 6.87% to 15% of the State's geographical area, and protect, conserve, improve the State's forests and other natural resources for improving the quality of soil, air and water. This is aimed to be achieved through:

- Sustainable forestry practices based on sound principles of sustainable forest management through use of modern technologies and scientific knowledge.
- Protection, conservation and enhancement of the wildlife and remnant biodiversity resources of the State by developing a suitable Protected Area Network.
- Promoting non-timber uses of forests such as eco-tourism, Non-Timber Forest Produce, medicinal plants and biodiversity.
- Practicing socially-inclusive forestry and solicit cooperation and participation of the rural and forest dependent communities and other stakeholders in greening the State.
- Providing technical assistance, financial incentives and extension services to the people for promoting social forestry, agroforestry and tree farming for land use diversification.
- Implementing Government policies and programmes by adopting innovative approaches for optimising social, economic and environmental benefits from the forestry sector to the state and its people.

Punjab Ecotourism Policy, 2009

This aims to improve the natural resource base of the state and promote ecotourism through (a) Identification and promotion of ecotourism potential sites; (b) Development of permissible and ecologically sound ecotourism infrastructure; (c) Diversification of the range of tourism activities available at destinations; (d) Development and enforcement of standards and norms for ecotourism activities; (e) Securing involvement of the local communities living in and dependent on peripheral and other areas for their livelihood; (f) Awareness building amongst general public; local communities and government staff; (g) Enunciate mechanism for securing partnership of private sector enterprise committed to the goals of ecotourism for development of infrastructure and services; and by (h) Sensitization of community and for augmentation of local livelihood through the ecotourism route.

6.5 ONGOING PROGRAMMES AND PROJECTS FOR MANAGING FORESTS

The Department of Forests through its various schemes and programmes maintains old plantation, puts in efforts to enhance the green cover, undertakes soil and water conservation works in forest areas, does fire protection and detection, maintains nurseries of saplings/plants, undertakeswild life protection and conservation etc. amongst others. Table below lists the ongoing programmes and activities of the Department.

Table 6.3: Ongoing activities of the state towards preservation, conservation and development of Forest and Wildlife in the state of Punjab

Programmes/Schemes/ projects	Purpose	Responsible Department/ Institution	Achievement
Externally aided afforestation project (JBIC project and now renamed as JICA)	Maintenance of old plantation Enhancement of green cover Soil and water conservation in Shivalik Hills Forestry research : hi-tech nurseries for production of quality planting stock to increase the productivity, species provenance trials, post harvest treatment of wood, soil amelioration measures and edaphic factors effecting tree growth. And support for mass production of quality seedlings. Supply of plants/saplings for planting in institutional land – army, paramilitary, schools, forest parks etc	DoFWLP	Maintenance of 29221 ha plantation carried out during 2007-09.
Development of Forests- 12th Financial Commission	Demarcation, Enumeration of trees, preparation of management / working plans of Divisions, and silviculture operation in forest areas.	DoFWLP	All activities being carried out.
Integrated Forest Protection scheme (75:25)	Fire protection and other protection works	DoFWLP	Fire protection and other activities being carried out on a regular basis
Forestry Development under JFM	Better protection of Forests through Community participation	DoFWLP	Village Forest Protection and Management Committees formed (VFMC) 1224 Area managed under JFM 178,333 ha Benefits accrued to the committees per annum Rs 90 lakhs Employment generated in JFM worth RS 800 lakhs

Programmes/Schemes/ projects	Purpose	Responsible Department/ Institution	Achievement
Bamboo Mission	Develop the bamboo sector through increase in area coverage, enhanced yields and scientific management, marketing of bamboo and bamboo based handicrafts, generation of employment opportunities	DoFWLP	Created 14 ha of centralized nurseries, undertaken plantation in 133 ha of forest areas, improved existing stock in 87 ha. Provided training to farmers. Control of pests and diseases, capacity building and information dissemination; and M&E
Awareness generation- Nanhi Chhan and Religion supported tree plantation campaigns	Encourage planting of trees	DoFWLP NGOs	State Govt. is mobilizing public to plant trees on large scale under the scheme 'Nanhi Chhan'. Religious leaders have initiated mass plantation programes in the state involving the public students, and NGOs.
National Green Corps Programme and National Environment Awareness Campaign	Environment conservation Plantation of native species of trees, shrubs, herbs and medicinal plants	PSCST	Schools and other institutions including NGOs are actively taking up plantation activities in the state.
Plantation along roads in Malwa region	Extending tree cover in the state	DoFWLP	An outlay of Rs.9.39 crore was provided in 12th Five Year Plan and an outlay of Rs.4.10 crore is provided in the Annual Plan 2012-13
Intensification of Forest Management (Previously named as Integrated Forest Protection) (75:25)	To curtail the damage to forests due to fire, by creation of maintenance of fire lines, construction of watch towers and construction of water storage & deployment of fire watchers and to create awareness amongst people	DoFWLP	Rs 13.69 Cr provided for in 12th Plan
Accelerated Programme of Restoration and Regeneration of Forest Cover	This project will be implemented in all the 15 territorial forest divisions through involvement of 650 Joint Forest Management (JFM) committees. It is proposed to undertake the following activities:-	DoFWLP	The state received an amount of Rs. 59.00 lac as one time Additional Central Assistance from Government of India

Programmes/Schemes/ projects	Purpose	Responsible Department/ Institution	Achievement
	Ecological restoration and re-generation of degraded forests. Conservation of the existing forests for enhancing ecological values. Providing forest – based sustainable livelihood to dependent communities especially through NTFP resources		during 2009-10, and the same has been utilized.
Purchase of Land for Compensatory Afforestation on account of Nonavailability of degraded land in the State.	To increase the forest cover outside the forest area in the state	DoFWLP	An outlay of Rs.20.00 crore has been provided in 12th Five Year Plan and an outlay of Rs.1.00 crore is provided in the Annual Plan 2012-13.
Action to Control Environment Pollution in Critically Polluted areas in the State	To improve the environment and control pollution levels in Ludhiana, Jalandhar, Mandi Gobindgarh and Batala through ▪ Increasing forest/green cover, ▪ organizing trainings/ seminars/ awareness camps, ▪ Providing green belt around the industrial area and the pollution sources ▪ Establishment herbal gardens ▪ Enrichment planting in protected forest areas, ▪ Providing more plants/saplings free of cost in these cities.	DoFWLP	Rs.50.00 crore has been provided in 12th Five Year Plan and Rs 4.00 Cr for 2012-13

6.6 PROJECTED IMPACT OF CLIMATE CHANGE

A digital forest map of India (FSI, 2001, Chaturvedi *et al.,* 2011) was used to determine the spatial location of all forested areas. This map is based on a high-resolution mapping (2.5' x 2.5' corresponds to an average of 20 km^2 area), wherein the entire area of India is divided into over 171,028 grids (http://www.fsi.org.in/fsi_projects/national_forest_type_mapping.pdf). Out of these, 35,899 grids were marked as forested grids (along with the forest density and the forest type). The Punjab state has 41 forest grids.

The impacts of climate change on forests in India including Punjab have been assessed based on the changes in area under different forest types, shifts in boundary of forest types and Net Primary Productivity (NPP) (Gopalakrishnan *et al.,* 2011). The assessment is based on: (i) spatial distribution of current climatic variables, (ii) future climate projected by the high-resolution regional climate models PRECIS for two different periods (2021-2for the A1B climate change scenario, and (iii) vegetation types, NPP and carbon stocks as simulated by the dynamic model IBIS v.2 (Integrated Biosphere Simulator).

Box 6.1: IBIS

The dynamic vegetation model IBIS is designed around a hierarchical, modular structure (Kucharik, *et al.,* 2000). The model is broken into four modules namely 1) the land surface module, 2) Vegetation phenology module, 3) Carbon balance module and 4) Vegetation dynamics module. These modules, though operating at different time steps, are integrated into a single physically consistent model. The state description of the model allows trees and grasses to experience different light and water regimes and competition for sunlight and soil moisture determines the geographic distribution of plant functional types and the relative dominance of trees and grasses, evergreen and deciduous phenologies, broadleaf and conifer leaf forms, and C3 and C4 photosynthetic pathways.

The projected change in vegetation information in MC scenario was combined with the spatial location of FSI grids, and it was evaluated that hardly 2 grids out of 41 (i.e. 4.9% of the total forest grids in Punjab) are likely to change their vegetation type (**Figure 6.5**). Further, the NPP in the state is projected to increase by 0.6 to 1.2 kgC/m^2/year in the MC scenario wrt the BL scenario. In the figure, Green indicates no change in vegetation with respect to base line (1961-1990) and red indicates change.

Additionally with increase in extreme precipitation, soil erosion in Shivalik hills is likely to increase further. This will lead to more loss in soil nutrients and resulting into reduced subsistence agriculture, which is happening now. Therefore this area may not remain fit for sustainable agriculture, agroforestry and forestry based livelihoods

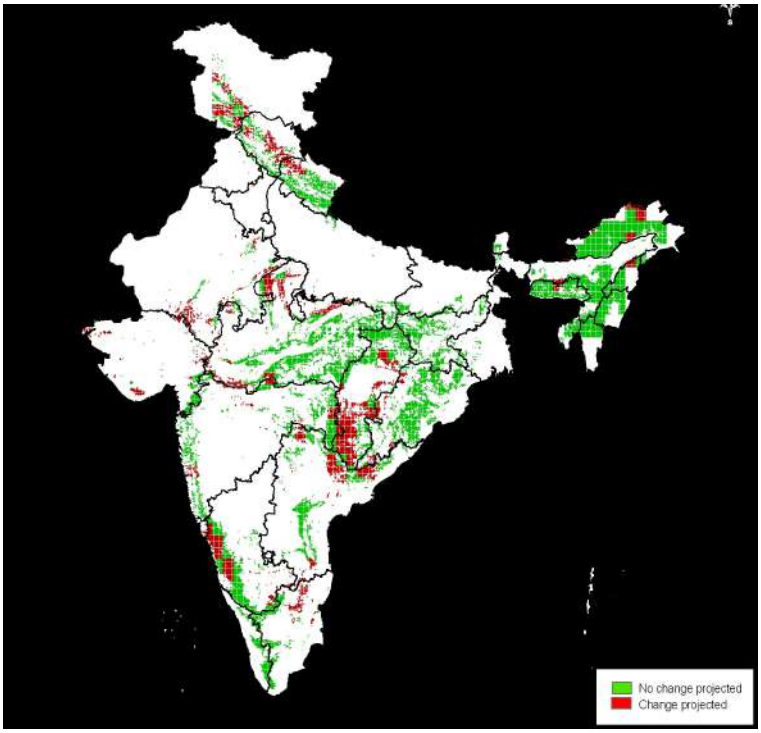

Figure 6.5: Projected Changes in forest vegetation in India for the period 2021-2050.
Source: Gopalakrishnan et al., 2011

6.7 THE GREEN INDIA MISSION

The Green India Mission (GIM) aims to respond to climate change by a combination of adaptation and mitigation measures, which would help enhancing carbon sinks in sustainably managed forests and other ecosystems, adaptation of vulnerable species/ecosystems to the changing climate; and adaptation of forest-dependent communities. Activities under the National Green India Mission are to be implemented on landscape approach.

The Mission objective is therefore to:

- Increase forest/tree cover on 5 m ha of forest/non-forest lands and improve quality of forest cover on another 5 m ha (a total of 10 m ha).This is proposed to be achieved through (a) Qualitative improvement of forest cover/ ecosystems in 1.5 m ha dense forests, 3.0 m ha of degraded forests, 0.4 m ha of grasslands, and in 0.1 m ha of wet lands and (b) by creating new forest cover through eco-restoration/afforestation under which it is proposed to bring in 1.8 m ha of scrub, mangroves, ravines, cold desert, shifting cultivation areas; and through eco-restoration/afforestation in abandoned mining areas. About 0.2 m ha of urban peri-urban areas will be afforested and about 3.0 m ha will be brought under agro/social forestry without compromising on the yields already received from cultivable lands.
- Improve ecosystem services including biodiversity, hydrological services and carbon sequestration as a result of treatment of 10 million ha.
- Increase forest-based livelihood income for 3 million forest dependent households and
- Enhance annual CO_2 sequestration of 50-60 million tons by the year 2020.

Approaches laid out by the MoEF which is the nodal ministry for implementing GIM, for achieving the objectives of the Green India Mission are as follows:

- Decentralized Forest Governance with Gram Sabha and its Committees being central to the decision making process. The revamped JFMC will be the committee of the Gram Sabha, with Cadre of Community Youth inculcated into the system with new skill sets.
- Revamping Forest Development Agency (FDA) to facilitate implementation by Gram Sabha, strengthened capacity of forest department to assume new roles.
- Engaging new stakeholders such as the NGOs and Schools/Colleges, involving NSS/NCC cadres, and the Private sector especially in agro forestry, institutional lands and abandoned mines.
- Convergence with existing programs and other Missions.
- Research: Need assessment; adaptation options, carbon capture potential by forest types, etc.
- REDD Plus Cell Strategy; technical advice on REDD+ matters to Ministry and States.
- A People's Programme: Outreach/Communication; Space for meaningful engagement.

6.8 GREEN PUNJAB MISSION

The Punjab government intends to undertake climate change adaptation and mitigation works in the state in the forestry sector under the aegis of the Green India Mission of the National Action Plan on Climate Change.

The 1st objective of the mission is to increase the Green cover. As per the 2008 Draft Forest Policy of the state, it is envisaging to bring 15% of total Geographical area under forests cover. This is again reiterated in the Green Punjab Mission recently launched in the state in 2012 and is to be achieved by 2012-2020 covering the 12th and the 13th plan.

Area under forests and tree cover in Punjab can be increased by extending forest cover to about 226,400 ha and tree cover to about 523,600 ha, thereby bringing in 750,000 ha under total tree and forest cover which is equivalent to 15% of the total geographical area.

Increase in area under forest and tree cover will have additional co-benefits of enhanced C sequestration, availability of more forest produce including timber and other NTFPs, and generation of additional forest based livelihoods.

The strategies therefore to achieve the objectives of the Green Punjab Mission are:

Strategy 1

Add at least 8.13% more area under forest and tree cover to the existing area bringing the total area under forest and tree cover to 15% of the total geographical area of Punjab by 2020 (current forest cover including tree outside forests is 6.87% of the total geographical area of Punjab as per the India Forest Report 2011). This will also lead to additional CO_2 sequestration over and above the current base line.

The proposed actions include:

- Extend Forest and tree cover

- In Areas with saline/ alkaline soils - In some areas in Patiala, Muktsar, Kapurthala, and Amritsar there are blank patches in forests where the soils has become saline/alkaline due to impeded drainage and high water table. The pH of some soils in these areas is high as Kankar pans are also occasionally present in these saline patches at varying depths. The areas can be reclaimed by bringing them under green cover using appropriate technology. Such reclaimed areas are expected to enhance timber and fuel wood productivity which can be supplied to the adjoining village communities. The Kikar tree that tolerates a wide range of soil types and when used in land reclamation, can be planted onto degraded saline/alkaline soils with a soluble salt content below 3 per cent.

- In water logged areas- Over exploitation of ground water and the introduction of canal irrigation, especially in the arid zones have led to problems of salinity and water logging. There has been a rise in the water table by 1 to 2 meters in Muktsar, Ferozepur, Bathinda and parts of Mansa districts resulting in water logging and salinity. Besides, sweet ground water table has also risen by 0-2 m in some blocks of districts Ludhiana, Patiala, Mohali, Ropar, Gurdaspur and Amritsar. These areas could be reclaimed through bio-drainage techniques, which is vertical drainage of sub-soil water through evapotranspiration. This is more effective and viable, economical and eco-friendly method in comparison to conventional surface and sub-surface drainage techniques. The later require periodic maintenance and has the problem of effluent management. The trees because of their deep root system have the characteristic of harnessing the ground water. The most important species for reclamation of water logged areas is the *Eucalyptus* which is being grown since 1960s and has got acclimatized. Yield of plantation of *Eucalyptus* in water logged and non water logged areas is comparable. The treatment in water logged areas includes making parallel ridges of soil along the canals which are 1 m wide at the base and attain 40-50 cm height with a base of 50 cm at the top whereby seedlings are planted in the centre of the ridge. Another method is to raise soil mounds 1 sq m at the base and 0.25 sq m at the top, height depending on the depth of the water expected. Clone 413 of *Eucalyptus* has been identified for planting in the water logged areas. Other than *Eucalyptus*, Jamun, jamboa, Arjun, and Willows are well known water resistant species. Willows though planted along the canals, are not very popular. Arjun trees are extensively planted and were introduced under the JICA project. Kikar (*Acacaia nilotica)* though growing in arid areas survives water logging to a considerable extent. The Kikar tree adapts itself to annual rainfall of 300 and 2,200 mm and tolerates extremes of temperatures. Jamun is suitable for growing along village ponds and on mounds in water logged areas. Next to *Eucalyptus* it is the most economically viable species.

  Undertake extensive Agro-forestry (farm forestry) - Bring additional area under agro forestry with trees such as *Eucalyptus*, Seesham, Poplar, Drake, etc. Additionally farm forestry will aid conservation of water, reduction in pesticide and fertilizer use and provide other ecological services besides increasing the green cover of the state.With about 83% of the area under cultivation in Punjab, farm forestry or agro forestry holds the maximum potential for increasing tree cover in the state. Farm forestry is envisaged to improve rural livelihoods,

reduce poverty, render the ecosystem services and combat water logging especially in west Punjab. This will also create the basis for raw material for the wood industry in the state and fuel wood requirement of the people. Further, farm forestry or agro forestry in private lands reduces pressure on government area and can be managed for long term ecological benefits. It is proposed that 8% of the geographical area of the state i.e. 4.00 lakh ha will be brought under farm forestry on a sustainable basis through block and line plantation in agriculture lands in 8 years. This means annually 50,000 ha have to be brought under farm forestry.The requirement of the plants will be approximately 375 lakh/year, presuming that area will be under poplar, dhrek and other fast growing species @ 500 plants/ha and 50% of the area will be under *Eucalyptus* @ 1000 plants/ha. Assuming that 75 lakh plants are to be supplied to the farmers by private nurseries in the state, approx. 300 lakh plants will have to be raised by the forest department each year for the next 8 years. Out of the 375 lakh plants to be raised at least 80 lakh shall be of high yielding clonal varieties. It is estimated that the mean annual increment (MAI) of 25 cum /ha/annum over a rotation period of 8 yrs is to be achieved in this 4.0 lakh ha area leading to a generation of 10 million cum/annum of wood. This quantity is envisaged to be sufficient to meet the per capita requirement and sustain existing wood based units and cater to the extra demand due to their expansion plans in the future. At a conservative rate of Rs 700 per quintal, the income to farmers works out to be Rs 1.75 lakh/ha/annum i.e Rs 70,000 per acre/year. Assuming 20% of the above is input costs, the net income works out to be Rs 56,000/acre/annum. The prevalent rent charges for agricultural land in the state are about Rs 30,000 to Rs 35000/acre/annum. Hence farm forestry plantation will provide significantly better returns than the one received from current agricultural crops. Directly *Eucalyptus* and Poplar are known to C sequester 0.45-0.47 times their oven dry weight. Indirectly as farm forestry allows foresters to go for long rotation species in conventional forest areas, therefore it can be a sink for sequestering C for a long period.

- *Plant Trees in institutional areas, urban and peri-urban areas* **-** along railway lines, roads, drains and canals, parks, govt. and private office lands, schools, colleges, police posts, police lines, cremation grounds, panchayat lands, etc.. Plantations of suitable species such as *Acacia nilotica, Dalbergia sissoo, Melia azedarach, Ailanthus excelsa, Toona ciliata, Azadirachta indica*, etc. can be done.Two models of plantation are proposed: 1.)Institutional land plantation by the Forest Department, wherever the areas are equal to or more than 10 acres in extent and 2.) Institutional land plantation by concerned institution/agency in their own land for area less than 10 acres

The responsibility for maintenance of plants will be of the Forest Department wherever the plantation will be done by the department and of the concerned institution/agency in case plantation is done by them.

In both the above models technical inputs on site preparation, species selection and plantation will be provided by the Forest Department. About 172 lakh saplings will be planted and maintained for a period of 3 years at a cost of Rs 28.30 Cr under this model.

- Restore and rehabilitate *Dalbergia sissoo* and *Acacia nilotica*: As the population of *Dilbergia sissoo* or Sheesham which is the state tree of Pujab has been on decline, it is essential to rehabilitate the same. Recently DS 14 clone of of this tree was released by the ICFRE (Indian Coucil for Forest Research and Education) from multiple trials established in the state. Germplasm of more than 125 accessions of Shisham in Hoshiarpur is available. Clonal seed orchards of Shisam and Kikar have been established in Patiala and Hoshiarpur. Other companion species of Shisham and Kikar are *Acacia catechu, Acacia modesta, Alibizia lebbek A. procera, Holoptelia integrifolia, and Emblica officinalis*. As per the policy of the Forest Department, these species are already being planted in suitable areas. However, these species are not favoured by farmers in the agroforestry systems as they do not grow fast enough and do not have much market utility including fuel wood.
- *Farm forest fire management strategies and prevention of encroachment into forests* by involving technology and involving people's participation by creating watch committees and creating trained forest fire management committees.
- Estimate current C from all pools of C in the state and measure changes in the same every year to assess the amount of C sequestered due to all the above mentioned activities.

The total cost estimated for undertaking the above mentioned activities is as follows:

Strategy 1	12th plan	13th plan	12th +13th Plan
Cost estimates	Rs 1225.20 Cr	Rs 1304.80 Cr	Rs 2530.00 Cr

Strategy 2

Enhance forest density in the Shivaliks. The aim is to improve plantation in degraded forests by end of 2020.

The blank or degraded forests on Government/PLPA (governed by Punjab Land Preservation Act) areas in the Kandi tract are already part of ongoing programmes. Parts of non PLPA areas that are not under forests are now to be identified and targeted for tree plantation under this strategy. It is proposed that about 50,000 ha of the non forest PLPA area which is 1% of states geographical area will be targeted..

Stabilise Shiwalik tracts to prevent soil degradation, avoid unsustainable agriculture and empower communities enabling them to undertake diversified income generation activities

It is planned to be achieved by undertaking the following actions:

- *Reduce fragmentation of forests*. This can be done by providing corridors for species migration; both fauna and flora (refer to Chapter 7 for details of action).
- *Undertake Enrichment plantation in non PLPA land*: The enrichment-planting model has been found suitable for treatment of degraded forest areas of Shivalik hills. Under this model gap planting is carried out to fill up the blanks to improve the density of forests. Mostly indigenous species are planted. Species to be planted include *Acacia catechu, Acacia nioltica, Albizzia procera, Bauhinia purpurea, Terminalia bellerica, Holoptelia integrifolia, Dalbergia sissoo, Emblica officinalis, Mangifera indica,* etc. Planting of Bamboo in better soil moisture regime areas, particularly along the depressions, choes, rivulets and khuds is feasible. Eradication of weeds like *Lantana* and *Parthenium* and replacing them with more useful fodder and economical grasses and medicinal plants would help in improving the condition of the natural forests and availability of utilisable biomass for local people.
- *Encourage Aided Natural regeneration in degraded and open forest areas.* Wherever sufficient root stock is present and growth of naturally grown seedlings is being hampered by biotic/abiotic factors, suitable silvicultural interventions to promote natural regeneration can be undertaken. The steps include singling of coppice shoots, clearing of climbers, invasive weeds, tending natural seedlings and sowing of seeds and planting in blank patches. Simultaneously, 250 plants per ha. of the native species of the area will be planted.
- *Establish Sacred Groves, Panchwatis (Green Clusters) and such other community utility sites* (parks, green belts, etc.) through the Nanhi Chhan programme and Religious tree plantation campaigns, etc
- *Undertake soil conservation measures in degraded forest areas in Shivalik hills*: In Punjab about 9.5% of the total geographical area of 5.04 m. ha is hilly and undulating which is about 52 percent of the total forest area in the state. It comprises of Shivalik foot hills and Piedmont plain in the north and north-eastern fringe. This region is popularly known as Kandi belt. About 83 percent of forest area in the Kandi tract belongs to the local communities and private individuals. The Forest Department exercises control over these forest areas under the Punjab Land Preservation Act, 1900.

The Kandi Forest belt of Punjab are subject to soil and water erosion due to undulating topography, steep slopes, poor vegetative cover (scrub forest) and coarse to medium texture of the sedimentary material. Water erosion of top soil is a major threat to natural vegetation in the area. The problem can be attributed to seasonal choes which wash away the fragile fertile top soil. Vegetative and engineering measures should be adopted for soil conservation by following watershed development approach. The watersheds have to be treated by bunds, terraces, structures, check dams, and other

measures of soil conservation along with improved agriculture, horticulture, forestry and animal husbandry. Priority should be given to vegetative measures over engineering measures.

Vegetative Measures: Plantation of soil binding species such as *Vitex negundo* (Nirgundi), *Dodonaea viscosa* (Vilayati mehndi), *Carissa opaca, Carrisa spinarum* (Karonda), *Agave americana* (Rambans), *Cynodon dactylon* (Doob), *Saccharum munja* (Munj), *Ipomaea cornea* (besharam), *Peuraria thunbergiana* (Kudzu vine) *Arundo donax, and Bamboo* can be done on staggered bench terraces/check dams/ gully plugging. Other tree species, which have multiple uses like fuel and fodder, such as *Acacia nilotica*, *Azadirachta indica, Ailanthus excelsa, Zizyphus mauritiana, Robinia pseudoacacia, Grevia optiva*, etc., should also be taken up for plantation.

- For planting saplings and seedlings, except in flat area, pitting may be avoided; and staggered contour trenches should be made properly. If trenches are not considered desirable in steep slopes because of geomorphologic conditions, zero tillage may be adopted. Afforestation programme must be taken up with the participation of the local communities so that biotic interference through grazing is eliminated/ reduced.
- Engineering Measures: Engineering measures include construction of check bunds, check dams, gully plugs and Water harvesting structures. The watershed based micro-planning should be done with the active participation of the villagers. This should be carried on at all stages of implementation till the completion of works.
- *Undertake Nitrogen fixation in soils:* It is well known that certain trees enhance the nitrogen content of the soil, thus aiding tree growth. In Punjab, nitrogen fixing trees in agro forestry system include *Dalbergia sissoo, Albezia lebbeck, Albizia procera, Acacia nilotica and Acacia catechu. Acacia catechu is found in the private khair-sissoo scrub forests of* Shiwalik hills. Farmers are allowed to fell Khair trees after a cycle of 5 years. *Dalbergia sissoo* is also favoured and retained by the farmers in the plains as well as in hilly areas. But the practice of shelter belts along the boundaries has been abandoned by the farmers after the Green Revolution when Subabul was introduced as a fodder cum fuel wood tree in Shivalik hills. This has spread like weed in most areas. *Albizia* is not favoured in the plains but find favour in the Kandi area. *Prosopis spicigera* is found scattered and protected by the Bishnois in the Fazilka and Abohar area of the state. These species are raised in the departmental nurseries for distribution amongst farmers. Some of the other Nitrogen fixing trees (NFTs) such as *Flemingia macrophylla, Leucaena leucocephala and Tephrosia candida* can also be considered for intercropping with maize and other crops grown in the hilly terrain.
- *Revitalise and upscale community based initiatives and ensure payment for ecosystem services:* Joint Forest Management (JFM) and Van Panchayat Committees for forest management are important tools in this regard. The principles of Joint Forest Management (JFM) are paramount for involving rural communities for implementation of all the activities of Action Plan for Climate Change. The focus of participatory approach is to institutionalize JFM. Some of the steps necessary to initiate the JFM process as successfully tried in the country are through initiating of Entry Point Activities, which are listed below:
    - *Create infrastructure in villages such as water harvesting structures, green walk ways, etc. as articulated in micro plans*. Ascertain local needs during Participatory Rural Appraisal (PRA) and Micro-planning exercises - construction of small dams, water harvesting structures, tube wells or other drinking water facilities, community utility assets like buildings, village roads, footpaths, community sheds, etc.
    - Promote micro credit and undertake Skill up-gradation and capacity building activities through training in selected professions like Bee Keeping, Muda Making, Midwife, Stitching/Sewing, carpentry, etc. for income generation.
    - *Control damage to crops by extensive habitat improvement away from the crops and fencing wherever necessary.* Extensive silvi-pasture treatment, water holes at suitable places can be provided keeping in view the steps needed for protection of wildlife.

- *Avoid unstable agriculture: by providing viable alternatives through tree planting, cultivation of bamboos, grasses, medicinal plants and aromatic plants. Prepare and implement sustainable model schemes keeping in view the land capability classification.*
- *Take need based steps for community empowerment and capacity building for income generation activities.* This can be done by encouraging gainful use of raw material available in the area by value addition and by establishing micro processing units and industries of the raw material (e.g. fruits like amla, harar, bahera, bel, aromatic and medicinal plants). For this, the various developmental schemes can be explored that can provide support to such activities as well as provide employment to the poor and marginal stakeholders.

The total cost estimated for undertaking the above mentioned activities is as follows:

Strategy 2	**12th plan**	**13th plan**	**12th +13th Plan**
Cost estimates	Rs 1563.60 Cr	Rs 1772.40 Cr	Rs 3336.00 Cr

Strategy 3

Undertake capacity building activities for sustainable forest management based on scientific principles of forest management and integrate the same in working plans and management plans.

In order to achieve the above, capacity building activities need to be undertaken such as

- *Strengthen Extension wing of the Forest Department* for improving the support system by making technological and material inputs available at the door steps of the farmers.
- *Undertake training and dissemination activities for policy makers and other key stakeholders to undertake actions on various CC strategies*

- Prepare, develop and disseminate publicity material like publications on Action Plan activities, technologies adopted, facilities and opportunities offered, participatory process and sharing mechanism devised, government resolutions as well as training material, posters, stickers, handouts, pamphlets and other relevant information necessary to promote Action Plan activities.
- Design training programmes for education of all the stake holders and particularly those dependent upon the forests resources.
- Provide extension support services to the all stake holders including schools/colleges and other educational institutions to make students aware of the role and value of forests for human welfare and environmental amelioration.
- Initiating dialogue and continuing negotiation by organizing group meetings of the villagers, Village Forest Protection and Management Committee (VFPMCs) members.
- Motivate VFPMCs (Village Forest Protection and Management Committee's) members to involve them in implementation of the Action Plan activities.
- Organize exhibitions, puppet shows, drama and other forms of folk art and film shows on the themes relevant to the conservation of biodiversity (forests and wildlife) and development activities such as afforestation, pastures development and agro forestry/farm forestry.
- Organize training programmes, seminars, conferences, experience sharing workshops and exchange visits for all categories of Forestry Personnel, Extension workers, VFPMC/Eco-development Committee functionaries and Local Self Government representatives - Panchs and Sarpanchs of the Village panchayats. Use mass media for information dissemination through the network of Television, Radio, Press, etc. for wider publicity to sensitize politicians, public servants, media men and general masses

for better appreciation of the role and value of forests and make them aware of the intended benefits.

The total cost estimated for undertaking the above mentioned activities is as follows:

Strategy 3	12th plan	13th plan	12th +13th Plan
Cost estimates	Rs 20.00 Cr	Rs 24.00 Cr	Rs 44.00 Cr

Strategy 4

Strengthen biodiversity conservation measures

- Undertake production of planting material of different tree species
- Identify and develop drought tolerant clones of fast growing tree species for matching tree species clones for different sites
- Enhance productivity from agro-forestry plantation through development of production technologies for various tree species to increase income of the farmers.

The total cost estimated for undertaking the above mentioned activities is as follows:

Strategy 4	12th plan	13th plan	12th +13th Plan
Cost estimates	Rs. 1.70 Cr	Rs 0.40 Cr	Rs 2.10 Cr

Total cost of the Green Punjab Mission is as follows:

12th Plan	**Rs 2810.50 Cr**
13th Plan	Rs 3101.60 Cr
Total 12th + 13th Plan	Rs 5912.10 Cr

The cost norms are presented in Table 6.4 below and the details of the strategies and actions in terms of costs, timelines and agencies responsible for the actions are given in Annexure 3.

Table 6.4: Cost of various models for increasing forest cover and forest density in the state of Punjab

Plantation Model	No. of Plants/ ha	Total (in Rs) 12th plan	Total (in Rs) 13th plan
Rehabilitation of Degraded Forest area	1000	80,000	**88,000**
Reclamation of Saline/Alkaline Areas	1000	100000	**110,000**
Reclamation of Waterlogged areas*	1000	90,000	**100,000**
Enrichment Planting in Shivaliks	500	70000	**77,000**
In hilly areas (Shiwaliks), planting for avoiding soil erosion and aiding nitrogen fixation +Soil and water conservation structures	750	900,000	**1,000,000**

Plantation Model	No. of Plants/ ha	Total (in Rs) 12th plan	Total (in Rs) 13th plan
with maintenance for 4 years			
Assisted Natural Regeneration	400	40000	**44,000**
Integrated Watershed Development	500	70000	**77,000**
Institutional Plantation	Per plant	20	**25**
Farm Forestry	Per Plant	15	**20**
Maintaining saplings	1422 Lakh saplings for 3 yrs	Rs 126 Cr (Total)	-

***** *Other than Eucalyptus, Jamun (Syzygium cuminii), Jamboa, Arjun (Terminalia arjuna), Willow (Salix tetrasperma), Karanj (Pongamia pinnata), Morus alba (Shahtut) are suggested for plantation in water logged areas. Kikar (Acacia nilotica) though a species of arid and semi-arid areas survives water logging to a considerable extent.*

REFERENCES

1. Chaturvedi R. K., R. Gopalakrishnan, M. Jayaraman, G. Bala, N. V. Joshi, R. Sukumar & N. H. Ravindranath. 2011. Impact of climate change on Indian forests: A dynamic vegetation modeling approach. Mitigation and Adaptation Strategies for Glob Change, Volume 16, Issue 2, pp 119-142. DOI 10.1007/s11027-010-9257-7.
2. ISFR. 2011, 2005. India State of the Forest Report 2011 and others. Published by the Forest Survey of India, Government of India.
3. Gopalakrishnan, R. M Jayarama1, G. Bala and N. H. Ravindranath, 2011. Climate change and Indian forests, Current Science, 101(3), pp 348-355.
4. FRI, 2006. Studies on the Interrelationship between production level and marketing of industrial forestry species in Punjab; Resource Survey & Management Division FRI, Dehradun.

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7. Sustaining Himalayan Ecosystem and Biodiversity

Highlights

- The Himalayan ecosystem in Punjab– Shivaliks
- Current challenges
- Institutions Managing the Ecosystem
- Key Policies and Acts governing the ecosystem
- Key programmes and actions on ground
- Likely implications of climate change on shivalik ecosystem
- Adaptation strategies to sustain the Himalayan ecosystem

7.1. THE HIMALAYAN ECOSYSTEM IN PUNJAB- SHIVALIKS

The ecosystem of the Shivalik range in the North West India extend across the states of Jammu and Kashmir, Himachal Pradesh, Punjab, Haryana, Uttarakhand and Uttar Pradesh in India. It represents a highly dissected topography created by ephemeral streams which carry huge amount of silt and detritus leading to siltation and deposition of sand on agricultural fields making it one of the most degraded rainfed agro ecosystems in the country.

The Shivalik hill area of Punjab is spread over geographical area of 9448.97 km^2 and lies in the north-eastern part of the state (**Figure 7.1**) extending from north-west to south-east along the Himachal Pradesh border. It is spread across the eastern parts of the districts of Pathankot, Hoshiarpur, Nawanshahr and Rupnagar.

Erratic distribution of rainfall, small land holdings, limited irrigation facilities, heavy biotic pressure on natural forests, inadequate vegetative cover, heavy soil erosion, landslides, declining soil fertility and frequent crop failures resulting in scarcity of food, fodder and fuel are the characteristic features of this region (*Grewal, 1996*).

The Forest Ecosystem

As per the latest state of the Forest Report of Punjab brought out by the Forest Survey of India (ISFR, *2011*), the forest cover in the Shivalik region covering the four districts of Gurdaspur, Hoshiarpur, Nawanshahar, and Rupnagar is 1373 km^2 which is 77% of the total forest area of the state.

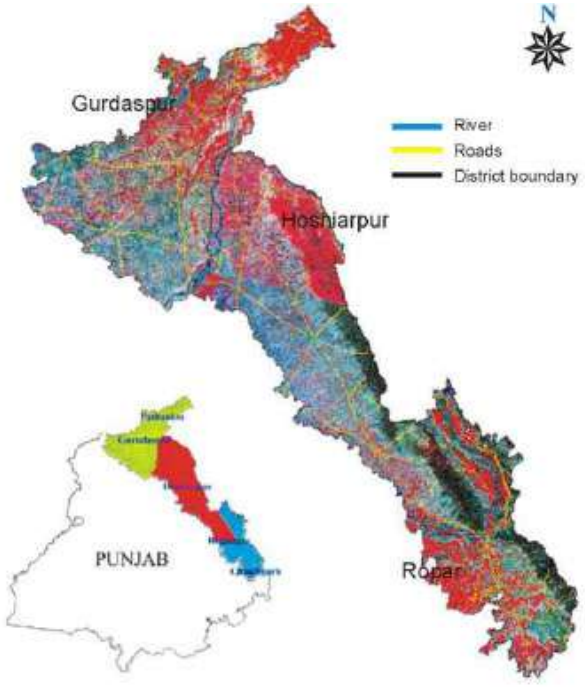


Figure 7.1: Standard FCC map of Punjab Shivaliks
Source: Roy et al., 2001

The non-forest area such as under agricultural, grasslands, water bodies, canals, settlements, riverbeds and barren land together contribute 7849.55 km^2 constituting 83.07% of the total geographical area (Jerath *et al., 2006.)*. Four major forest types are found here which are:

Dry Deciduous forests - Covers about 775 km^2area, accounting for almost ½ of the forest area in Punjab Shivaliks. These forests are dominated by *Acacia catechu, Anogeissus latifolia* with association of *Lannea coromandalica, Aegle marmelos, Ehratia laevis, Mallotus philippensis, Nyctanthes arbor tristis, Dendrocalamus strictus* etc.

Dry Deciduous Scrub (including *Euphorbia*) forests- This is the second dominant forest type mainly consisting of *Lantana* scrub distributed throughout the region. Dominant vegetation species consist of *Acacia catechu, Acacia modesta, Carrisa opaca, Dodonaea viscosa, Nyctanthes arbortristis, Woodfordia fruticosa, Zizyphus mauritiana, Zizyphus nummularia and Euphorbia royleana*. In many areas there are Khair, Sissoo forests in foothills. In these forests the undergrowth consists of shrubs in the *choe* valley and in sheltered slopes. On hilltops and at higher altitudes, bagar or bhabbar grass grows widely. Sheesham is widespread and dense along the *choe* beds.

Moist Deciduous (including Khair and *Dalbergia sissoo* with Dry Bamboo Brakes) forests- *Dalbergia sissoo* dominates this forest type in the Shivaliks. The canopy is open and is associated with *Accacia catechu*. The older wood have definite under storey, which includes the young saplings of *Tamarix dioica, Acacia farnesiana, Cannabis sativa* and grasses like *Saccharum spontaneum, Erianthus munja etc.*

Chir Pine forests – Such forests are found in Pathankot district and some areas of Gurdaspur and Hoshiarpur districts with altitudes ranging from 500 to 800 m. These areas have moist and favourable climate. The areas are less accessible and hence the forests are less disturbed. The major forest produce from these forests is Resin and Turpentine. The Chir Pine forests are dominated by *Pinus roxburghii, Mallotus philippensis and Acacia catechu,* etc.

The Dry Deciduous forest areas show maximum biodiversity (high Importance Value Index and high Shannon-Wiener Index) with total no. of species recorded being 363. Whereas Chir pine forests show minimum diversity with only 58 species being found.

Forest Ecosystem Produce

The percent utilizable ecosystem produce within each forest type in Shivalik hills is estimated and shown in **Table 7.1**.

Table 7.1: Percentage utilizable ecosystem produce of the Shivalik hills

Produce	Dry Deciduous Forests	Moist Deciduous Forests	Dry Deciduous Scrub	Pine Forests	Total
Food	11.15	12.7	10.05	0	33.9
Fuel	0.79	2.36	2.21	0	5.36
Fodder	9.09	6.94	9.06	8.56	33.65
Fibre	9,8	7.91	9.31	0	17.22
Timber	10.2	2.6	9.55	0	22.35
Medicinal Plants	31.66	32.1	31.61	20.78	116.15
Oil	5.02	0.65	6.37	0	12.04
Gums/Resin	3.5	0.86	3.18	0	7.54
Tannin	5.18	1.3	6.61	0	13.09
Others	9.83	8.45	8.09	2.35	28.72

Source: Jerath et al., 2006

Biodiversity rich areas in Shivaliks

Some of the biodiversity rich areas identified in the Shivaliks include Guru Gobind Singh Nature Reserve, Anandpur Sahib, Rupnagar, Chohal Forest, Hoshiarpur, Talwara Forest, Hoshiarpur Dhar and Dunera Forest , Gurdaspur, Sadavarat Forests and Ropar ,Nangal Wetland, Rupnagar, Kahanpur Khuhi Forest, Rupnagar, Takhni-Rehampur Wildlife Sanctuary, Hoshiarpur, Manguwal Forest, Hoshiarpur Siswan-Dulwan area in Rupnagar , Narangpur Forests, in Rupnagar, Nara Forest in Hoshiarpur, Dholbaha , Dada Forest area, Hoshiarpur, Bindraban and Nandi Bir areas in Dasuya, Siali Dhar in Gurdaspur, Nagdhar in Gurdaspur and Ranjit Sagar in Pathankot.

Information on other biodiversity rich areas, especially wetlands falling outside Shivaliks are provided in Chapter 4 under Water Mission.

Floral Biodiversity

The Shivaliks have a rich floral diversity. 562 species of Angiosperms, 560 species of Fungi, 104 species of Algae, 21 species of Lichens, 27 species of Bryophytes, 30 species of Pteridophytes and 1 species of Gymnosperm have been recorded. Within the Angiosperms, 11 sub species have been classified with dominant families like *Poaceae, Papilonacae* and *Asteraceae*. The percentage distribution of floral species by type is shown in **Figure 7.2.**

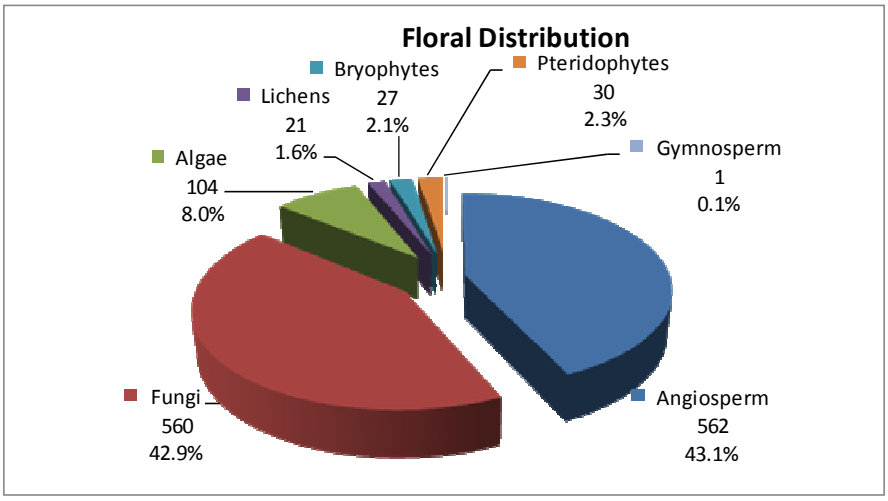


Figure 7.2: Recorded floral distribution in terms of absolute numbers and percentage of total floral species in Shivalik hills of Punjab.

Source; Jerath *et al.,* 2003

Faunal Biodiversity

Invertebrates - About 907 types of invertebrates have been recorded. Of these 819 are Arthropods, 34 are Nemathelminthes, 31 are molluscs and 23 are annelids. Within Arthropods, 686 are different insect types, 104 are *Arachnida*, 12 belong to *Crustacea* family and 5 belong to *Chilopoda* family. Within the Insect family, which is the dominant Arthropod, 199 different types of Hymenoptera have been identified which is also the dominant sub arthropod, followed by moths with 135 sub species, Homoptera with 77 sub species and butterfly with 74 sub species (**Figure 7.3a).**

Vertebrates- Amongst the vertebrates, 396 types of Aves i.e. birds 55 types of Pisces i.e. fish, 20 types of reptiles, 19 types of mammals and 9 types of amphibians have been identified from the Shivalik ecosystem. (**Figure 7.3 b).**

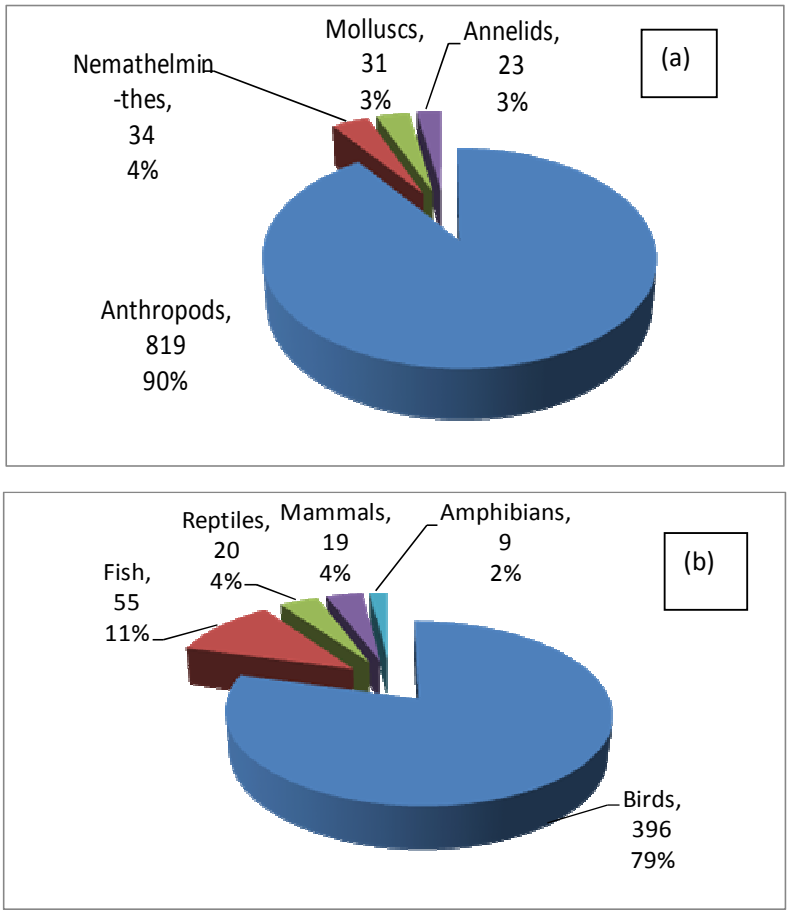


Figure 7.3: Reported number of (a) Invertebrates and (b) Vertebrates in the Shivalik Ecosystem and their distribution.

Source: Jerath *et al.,* 2003

The Cropland Ecosystem

Due to denudation in the upper hills, water runoff and soil erosion is high and fertility is low. The cropping pattern is dominated by wheat in Rabi and rice –maize crop rotation in the Kharif season. The other crops grown are other cereals, pulses, potato and some oil seeds such as rapeseed. Though production of all crops has grown due to increase in farm inputs, however, area under production of Bajra, maize and wheat has decreased considerably between 1990-91 to 2009-10 (see **Figure 7.4).** An analysis of key cereals grown in the area indicates that the area under maize and wheat has decreased by about 2% and 4% respectively between 1990-91 and 2009-10 and there is no cultivation of Bajra as of 2009-10.

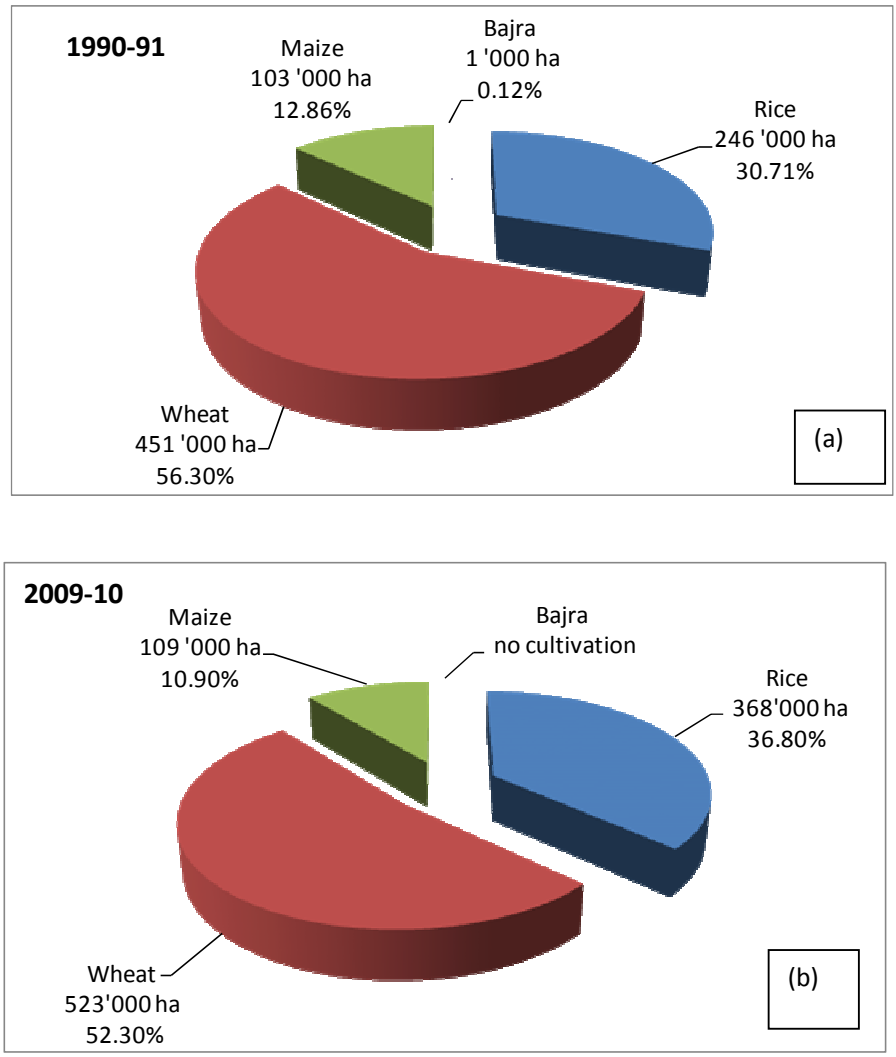


Figure 7.4: Trends of crop diversification in the districts of Hoshiarpur, Gurdaspur, Nawanshahr and Rupnagar covering Shivalik ecosystem between 1990-91 and 2009
Source: Pb Planning, 2010

Wetland Ecosystem

The wetlands absorb floods and thus help to decrease the severity of flooding besides improving water quality. These act as reservoirs and help in maintaining water discharge into rivers by releasing wet season flows slowly during drought periods. They also recharge ground water aquifers and help in maintaining ground water balance. Also these are reservoirs of alternate source of food, water and biodiversity. Some of the man-made wetlands in the Shivalik ecosystem are listed in **Table 7.2**. These wetlands provide habitats to different species of mammals, reptiles, amphibians, fish, and others.

Table 7.2: List of wetlands in districts where the Shivalik area extends in Punjab.

Name of Wetland	District	Area (Ha)	Category/ Status
Ranjit Sagar	Gurdaspur	8000 in Punjab.	Man-made National Wetland
Dholbaha Dam	Hoshiarpur	132	Man-made. The dam provides water facilities, protects from floods but is threatened due to siltation.
Maili Dam	Hoshiarpur	72	Man-made. Heavy siltation taking place
Mangrowal Dam	Hoshiarpur	70	Man-made. Heavy siltation taking place
Nangal Lake	Ropar	400	Man-made. National wetland
Ropar Wetland	Ropar	1365	Man-made. Ramasar site

7.2 CURRENT CHALLENGES

Forest Ecosystem

Decrease in Forest cover: An analysis of district wise forest cover between 2005 and 2011 assessment of FSI indicate an overall decrease in medium dense forest cover and considerable increase in open forest cover in the Shivalik hill area of Punjab. This indicates degradation of forest cover as a whole in the region. In Gurdaspur, Nawanshahar and Rupnagar the medium dense forests have decreased by 4, 5 and 13 km^2between the 2005 and 2011 assessments, whereas the medium dense forest cover in Hoshiarpur has increased by 21 km^2. The Open forest area is seen to be increasing in Hoshiarpur, Nawanshahr and Rupnagar by 33, 19 and 32 km^2 respectively. The open forest cover is only decreasing in Gurdaspur (**Figure 7.5**).

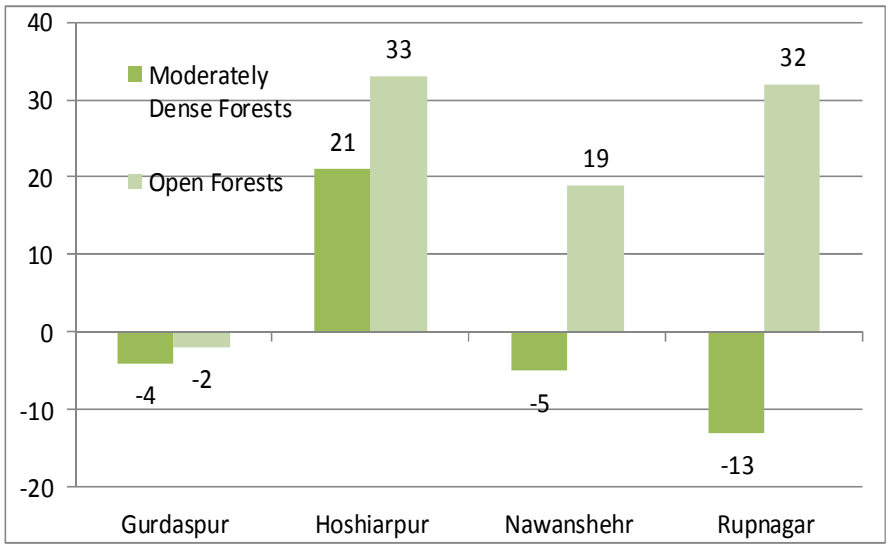


Figure 7.5: Change in Forest Cover in km^2 in the Shivalik Forest Ecosystem between 2005 and 2011 as per assessment of FSI. *Source: ISFR 2011& 2005*

Degradation of Forests: Studies carried out by Roy *et al*., 2001 indicate that dry deciduous scrub forests show high degree of fragmentation (around 40%), followed by dry deciduous forests (5.63%). Moist deciduous forests show least degree of degradation. Deciduous scrub show high degree of disturbance (~51% and 18% respectively). Comparatively, moist deciduous forests are less disturbed and the least disturbed are the pine forests. This is further corroborated by a satellite based study in 2008 (*Source: Wimalathilake, 2008).*

Threatened Flora and Fauna: Many species of flora and fauna recorded from the region have been found to be listed under different threat categories. These include categories specified by International Union for Conservation of Nature- IUCN [Extinct in the Wild, Critically Endangered, Endangered, Vulnerable, or Near Threatened]; categories specified by theIndian Wild Life (Protection) Act, 1972 (Schedule I-VI); and the ones listed in the Appendix I, II, and III of Convention on International Trade of Endangered Species (CITES) of Wild Life Fauna and Flora. The plant species occurring very rarely in the Punjab Shivaliks include 3 species of Algae, 2 species of Fungi, 5 species of Pteridophytes, and 44 species of Angiosperm (Tiwana *et al, 2005*). Amongst fauna, the globally threatened species are 2 types of reptiles, namely, brown river turtle and Indian rock python; 4 species of birds – Oriental Darter, Ferruginous Pochard, Pallied Harrier and Painted Stork; and 2 species of mammals - Common Otterand Indian Pangolin (*Source: ZSI, Dehradun*).

Pressure of Development: Developmental activities in the Punjab Shivaliks are posing threats to biodiversity of the forests due to habitat loss, degradation and associated effects. The eco-fragile Shivalik Hills are being leveled for building roads and for creating urban settlements. For example, the hillocks in the Shivalik forests which lie in and around the Chandigarh's periphery have been leveled to carve out roads. The hillocks targeted are spread over the common village land in the Majri block comprising five villages - Bhagindi, Gurdha, Kasauli, JyantiMajri and Karaundewala (*Source: The Tribune News Service, 14th May 2010*). Similarly, establishment of engineering industries, pharmaceutical firms and paper mills in Ropar and Hoshiarpur districts and stone crushers in Pathankot district are a serious threat to the Shivalik forest cover and biodiversity.

Invasion of exotic species: The plantation of exotic species like Poplar and *Eucalyptus* has also resulted in the neglect of native species. Similarly, the invasion of *Lantana* and *Parthenium* has resulted in the decline of flora. Infestation of *Lantana* has reached alarming proportions. Due to its allelopathic effect, the *Lantana* is not allowing other economically important plants to grow, thus affecting the income of communities depending on the forest produce. It can also catch fire quickly, thus posing a threat to forests. Further, poor coverage under PAs (Protected Areas) and consequent inadequate protection has led to degradation of biodiversity especially in Punjab, Haryana and Chandigarh areas.

Forest fires: Most of the fires in this area are man-made and are caused by throwing of bidi's/ cigarette on to dry grass patches by herders when they take cattle for grazing into the forests. .

Grazing Pressure: Due to undulating topography, cultivation on steep slopes, traditional agricultural practices and rain-fed conditions, the local population keeps large herds of cattle but the availability of fodder is about one third of its requirement thus leading to grazing pressure on the forests.

Wetlands

Encroachment: Local people living in and around the wetlands have converted some low lying areas to bring the same under plough for growing traditional crops for getting more income.

Invasion of exotic weeds: Water Hyacinth, an exotic weed has degraded water bodies/ wetlands. The vast green carpet of Water hyacinth prevents light to enter the water bodies, thereby affecting fish culture.

Water Pollution: Agricultural run-off from agricultural land containing pesticides and insecticides are a major polluter of water in these wetlands. Also industrial pollution in wetlands such as Ropar is an issue.

Soil Erosion and Land reclamation: Soil erosion is influenced by reclaiming of land for agricultural purpose.

Silting and sedimentation in wetlands in the Shivalik region have considerably reduced the water holding capacity of the wetlands. The silt is received from adjoining hills and ravines.

Cropland Ecosystem

Loss of Crop Biodiversity: Agriculture within the Shivaliks continues to be primarily of subsistence nature due to limited irrigation facilities. It is characterized by large number of varieties of major and minor crops. Many of these traditional varieties are ecologically adapted and their germplasm needs to be preserved for posterity. However, the introduction of HYVs of rice and wheat is replacing native varieties and pushing them to extinction including the crops of maize, gram, pulses, groundnut, oil seeds, bajra & jowar, etc., indicating a decrease in species diversity (Figure 7.3). Further, varietal diversity within species has also decreased due to greater emphasis on high yielding varieties.

Loss in biodiversity of fruits: *A large number of desi* varieties of Mangoes from district Hoshiarpur, Nawanshahr and Gurdaspur are lost due to introduction of new varieties.

Introduction of invasive species: Invasive alien species have been identified as one of the threats to crop biodiversity. The unchecked growth of *Parthenium hysterophorus* which was introduced accidentally in the state along with wheat variety PL480 at the time of advent of green revolution and spread of *Lantana camara* in parts of Shivaliks and *Eichhornia crassipes* throughout the state are striking examples of replacement of natural species by these exotics.

7.3 INSTITUTIONS INVOLVED IN MANAGEMENT OF THE SHIVALIK ECOSYSTEM

Forests	**Department of Forests and Wildlife Preservation -**The forests and its biodiversity and activities related to NTFPs are being managed by this dept.
	Punjab State Forest Development Corporation is responsible for timber extraction and management.
Biodiversity	**Punjab State Biodiversity Board:** The State Biodiversity Board has been constituted under the Biological Diversity Act, 2002. The Chief Minister is the Chairman of the Board and Executive Director, PSCST is the member Secretary.
	Wildlife Advisory Board – is responsible for conservation of faunal biodiversity.
	Punjab Agro Food Grain Corporation, Punjab Agriculture University, National Mission on Horticulture etc. are encouraging crop diversification in the area and helping farmers to move away from growing of High Yielding Varieties (HYVs).
Wetlands	**Punjab State Council for Science and Technology -** coordination with various executing department such as Forests & Wildlife Preservation, Agriculture, Fisheries, Soil and Water conservation, Education, Irrigation and Power Research Institute, Pollution Control Board, etc. for taking conservation measures at Ropar and Nangal wetlands. A Steering Committee for Wetland Conservation to review and evaluate wetland activities has been constituted to overlook this activity.
	Chief Wildlife Warden – Wetlands within the protected areas of wildlife sanctuaries are to be taken care of by the Forests and Wildlife Preservation Department.
Soil and water Conservation	**Department of Soil and Water Conservation** is undertaking Integrated Watershed Management and soil conservation activities in the Shivalik hill area of Punjab.

7.4 KEY POLICIES AND ACTS GOVERNING THE ECOSYSTEM

Polices, Acts, and Rules

Most of the policies and acts related to the Forest and Wildlife Preservation Department have been discussed in the previous chapter. The key policies relevant to Shivalik ecosystem preservation are as follows:

Forest management plans for managing private forests as "closed areas" were formulated by the govt. for districts across which the Shivaliks extend in Punjab (Hoshiarpur and Rupnagar for the period 2006-07 to 20016-17; and for Gurdaspur 2003-04 to 2012-13). The ownership of these areas is either with private individuals, Revenue Department or Panchayats. However, they are managed by the Punjab Forests Department and are closed under section 4 & 5 of Punjab Land Preservation Act, 1900 as per the provisions of the Act. The Management Plans of these areas are approved by the Govt. of India. To give effect to the provisions of section 4 & 5 of the said Act, Punjab Govt. has issued notifications for specific periods in conformity with the broad outline of the Act. The purpose of declaration of these areas as Closed Areas is to conserve the land resources of the ecosystem, protect these areas from soil erosion, to conserve the forest wealth and prevent degradation, to encourage the people to plant more trees and reduce biotic pressure on forests through extension education.

Biological Diversity Act, 2002: Biological Diversity Act recognizes the sovereign right of our country on its biological resources. It envisages the constitution of National Biodiversity Authority (NBA) at the national level, State Biodiversity Boards (SBBs) at the state level & Biodiversity Management Committees (BMCs) at the local level to protect biodiversity, especially with respect to economically and ecologically important flora and fauna and to regulate access to these resources.

The Biological Diversity Rules, 2004: The key elements of these Rules are that these lay down (a)The procedures for accessing biological resources and associated traditional knowledge, (b) Restriction on activities related to access to biological resources, (c) Procedure for seeking approval for transferring results of research, (d) Procedure for seeking prior approval before applying for intellectual property protection, (e) Criteria for equitable benefit sharing that will include sharing of royalty, technology transfer; product development; education and awareness raising activities; institutional capacity building.

Wetland Conservation and Management Rules, 2010: These rules aim at conservation of wetlands. These restrict activities such as reclamation, setting up of industries, storage or disposal of hazardous substance, solid waste dumping, discharge of untreated water, construction of permanent nature and any other activities likely to affect adversely the wetlands that are designated as Ramsar sites, wetlands that are ecologically sensitive, wetlands lying in and around UNESCO heritage sites, wetlands with area greater than 500 ha and lying below 2500 m above mean sea level, and any other wetland identified by competent authority. Rules also list activities which cannot be carried out in identified wetlands unless prior permission is taken such as withdrawal of water, impounding water, dredging, constructing jetty's, etc.

Key Programmes and Actions on ground

Establishment of Protected Area (PA) Networks, Wildlife Sanctuaries and Community Reserves. The list of Wildlife sanctuaries and Natural Reserves that have been established in the region is given in **Table 7.3**.

Table 7.3: List of Protected areas in Shivalik region of Punjab

Name of Protected area	Area of spread (sq km)	District	Year of establishment
Jhajjar Bacholi WLS	1.16	Roopnagar	1998
Takhni Rehampur WLS	3.82	Hoshiarpur	1992
Kathlaur Kushlian WLS	7.67	Gurdaspur	2007
Lalwan Community Reserve	12.67	Hoshiarpur	2007

Source: NWLDB, 2011.

Establishment of Biodiversity Management Committees (BMCs) and Technical Supporting Groups (TSGs): In accordance with provisions contained in Biological Diversity Act, 2002, as of February 2012, BMCs and TSGs, have been notified at district level in all the districts. A few BMCs have been set up at village level also in district Hoshiarpur and Gurdaspur but are largely non-functional. The primary function of the BMC is to promote conservation, sustainable use and documentation of biological diversity including preservation of habitats, conservation of land races, folk varieties and cultivars, domesticated stocks and breeds of animals and chronicling of traditional knowledge.

Preparing People Biodiversity Register: It is proposed that the Panchayat Secretary/Executive Officer will prepare and maintain People Biodiversity Registers in consultation with the community. These Registers shall contain comprehensive information on availability of local resources, their economic uses and linked traditional knowledge. These are being piloted for Hoshiarpur and Ropar districts.

Declaration of biodiversity heritage sites: Punjab Biodiversity Board has identified "Inami Baag" (a mango orchard), at Village Bassi Umar Khan, Block Bhunga, District Hoshiarpur as a biological rich site with large diversity of native mango varieties. However, many varieties are endangered due to various pressures including fragmentation in the mango orchard caused by passing of 'Kandi canal', an irrigation channel, through the middle of the site. Thus, the site is under threat. These native mango varieties/land races need to be conserved for the benefit of posterity. In view of its importance due to rich biological diversity, the Board has initiated actions to conserve it for *in-situ* preservation as Biodiversity Heritage Site (u/s 37 of Biological Diversity Act, 2002). Besides conservation, the activities will help mainly for carrying out selection of desirable traits for evolving new varieties of mangoes. A proposal has been prepared and submitted to Govt. of Punjab in this regard.

Crop diversification activities: The Punjab Agro Food Grains Corporation Limited (PAFC), is supporting Diversification of Agriculture through Contract Farming. It has grown over the years from 9029.36 hectares in the year 2002 to 102385.63 hectares during 2006-07. The objective is to shift area under wheat and paddy crops to the crops requiring lesser irrigation to conserve water and to improve soil health for better productivity. The crops being promoted are Hybrid rapeseed mustard (Hyola) and Malting Barley, winter and spring maize in the Rabi and Basmati, Maize, Guar, Moong and castor in the Kharif season.

Soil and Water Conservation: Department of Soil & Water Conservation is implementing GOI sponsored National Watershed Development Project for Rainfed Areas (NWDPRA) in Kandi (Shivalik hills) area and Treatment of catchment area of Flood Prone River (FPR) Ghaggar and State Plan scheme for watershed development in non-project areas in Kandi. Under the programme it has treated approx. 69071 ha area since 8th Plan. Components of the scheme include plantation activities, Soil & Water Erosion Control and Livelihood support through sustainable agriculture & allied activities on watershed basis in middle & lower reaches of Kandi area. Further, it proposes to extend the activity to 24276 ha area (*Source: Deptt. of Soil and Water Conservation as submitted for SAPCC*).

Wetland Conservation: With the efforts of the PSCST, MEF has designated Ropar Wetland (Ramsar site) Nangal Wetland, and Ranjit Sagar Dam Wetland located in the Shivaliks/its foothills as wetlands of national importance. Conservation measures at Ropar and Nangal are being taken by involving various state agencies under the coordination of PSCST with financial support from MEF, GOI. Steps are being taken for plantation of native species, soil conservation, water quality assessment, promoting organic farming to reduce agro-chemical runoff, etc. The PSCST is also carrying out awareness campaigns amongst school children and the community around the wetlands.

7.5 CLIMATE CHANGE CONCERNS

Long term observations are required to ascertain the impact of climate change on ecosystems and globally they are only available in the northern hemisphere. Based on these observations, IPCC in its 4th review published in 2007 has concluded, that ecosystems in the alpine region and habitats of the biodiversity lying within, being sensitive to climate are showing signs of degradation. With climate change and enhanced levels of CO_2 in the atmosphere, the changes in the ecosystems are likely to have a deleterious effect on the human well-being which depends on the ecosystem produce. Impact on the alpine regions may also to have some adverse implications for the regions in lower altitudes.

Box 7.1: IPCC projections on impacts of climate change on biodiversity and ecosystems and consequences for human wellbeing

There is a high confidence probability that the resilience of many ecosystems will be undermined by increasing temperatures, variable precipitation patterns and rising CO_2 levels, reducing biodiversity, damaging ecosystems, and compromising the services that they provide. Over the past three decades, the lines marking regions in which average temperatures prevail (isotherms) have been moving pole-ward at a rate of about 56 km per decade. Changes in flowering seasons, migratory patterns, and the distribution of flora and fauna have been detected. Alpine plants are most at risk and are being pushed towards higher altitudes and literally off the planet.

If the pace of climate change is too rapid, or when natural barriers block migration routes, extinction looms. According to the IPCC, 20-30% of plant and animal species are likely to be at increased risk of extinction if global average temperature increases exceed 1.5-2.5°C (medium confidence).

If temperature increases in excess of 2°C, rates of extinction will start to increase. Environmental degradation will gather pace, with wetland and forest systems suffering rapid losses. The loss of ecosystems and biodiversity is intrinsically bad for human development and the poor, who depend most heavily on ecosystem services, will bear the brunt of the cost.

Source: IPCC, 2007.

Currently long term observations of ecosystems in the Shivaliks are not available to conclusively decipher the impacts of climate change. This situation is true for all countries in the south-south region as noted by the IPCC (IPCC, 2007).

With physical changes in the glaciers, wetlands, forest ecosystem and changes in domesticated crop and livestock diversity there is a potential for changes in the ecosystem produce and hence long-term food security and livelihood of the population downstream. Rising human population and development of large infrastructure projects are increasing pressure on forest resources. The species biodiversity of the various ecosystems is likely to respond variably as the climate changes and CO_2 concentration increases in the atmosphere. A summary of the likely impacts is shown **in Table 7.4**.

Table 7.4: Likely impacts of Shivalik ecosystems with changes in climate

	Likely impacts
Wetlands	These are physiographically limited systems, therefore biodiversity within will be unable to migrate except migratory birds, hence wetlands are highly vulnerable to changes in hydrology, nutrient availability, and species abundance, distribution and composition which are likely to occur as temperature increases. This in turn may affect the transient visit of migratory fauna from far away regions. Further, increase in water temperatures may decrease its ability to treat polluted water. In Punjab, excess initial flooding in the wetlands may be due to melting of glaciers which is likely to result in siltation and hence affect the water holding capacity of the wetlands. Subsequently, increasing frequency of droughts is likely to lead to high infestation of water hyacinth and eutrophication.
Forests	Ecological shift, habitat alteration of the floral and faunal species within, phenological changes, reduced net primary productivity and increased potential for widespread wildfires and the subsequent potential for transformations in disturbed ecosystems, such as expedited colonisation by invasive species and resultant new species assemblages are expected. All these may lead to reduced forest produce and hence less income of communities dependent on forests.
Crop biodiversity	Reduced agro-biodiversity over and above current levels is expected. Further continued practice of monoculture, inorganic Chemical utilisation, use of modern crop varieties is leading and will further lead to degeneration of crop wild relatives.

Source: Punjab ENVIS news letter. vol 7

7.6 NATIONAL MISSION ON SUSTAINING HIMALAYAN ECOSYSTEM

The mission recognizes that ecosystem goods and services from the Himalayas support a vast population and provides food and water security. It acknowledges sustainable management of the ecosystems is of utmost importance in a climate change scenario to ensure in the long term the food, water and livelihood security of the population residing therein. Therefore it lays emphasis on tracking changes in, and protection, preservation and conservation of the Himalayan Glaciers, and the floral and faunal biodiversity of the forests, wetlands and the cropland ecosystems. As a co benefit, it envisages to also increase the C sequestration potential of the forests in the region.The mission aims to achieve the same through:

- Development of a network of knowledge institutions engaged in research on Himalayan Ecosystem.
- Develop a coherent data base on the geological, hydrological and biological and socio cultural dimensions including traditional knowledge systems on preservation and conservation of the ecosystem.
- Assessment of natural and anthropogenic induced signals of global environmental changes in mountain ecosystems and predict future trends on potential impacts of climate change on the Himalayan ecosystem with a sound S&T backup.
- Assessment of the socio-economic and ecological consequences of global environmental change and design appropriate strategies for growth in the economy of the mountain regions and the lowland systems dependent on mountain resources in the region.
- Documentation of traditional knowledge systems for community participation in adaptation, mitigation and coping mechanisms inclusive of farming and traditional health care systems.
- Evaluation of policy alternatives for regional development plans towards sustainable tourism development, water and other natural resource management for mountain ecosystems in the region.

- Creation of awareness amongst stakeholders in the region for including them in the design and implementation of the programme.
- Cooperation amongst states lying within this region and Regional Cooperation with neighbouring countries, to generate a strong data base through monitoring and analysis, to eventually create a knowledge base for policy interventions.

7.7 PUNJAB MISSION ON SUSTAINING HIMALAYAN ECOSYSTEM

Considering that the Himalayas are not homogenous and micro-level issues need to be addressed across its length and breadth, the primary objectives of Punjab to protect its Shivalik hills which are a part of the Himalayan system will be to:--

- Understand the behavior of glaciers to prepare the state to take measures towards its water management in a climate change context.
- Protect, preserve and conserve the biodiversity of the Shivaliks, thereby avoiding soil erosion, species extinction, habitat fragmentation and enhance water conservation, forest produce and C sequestration capacity of the Shivalik forests. This can be a regional approach including states to which the Shivalik region is common and also exclusive strategies need to be set by the Punjab State to protect its own interests.
- Avoid degradation of the natural and man-made wetlands and preserve, protect and conserve the biodiversity of the wetlands.
- Protect the diversity of the crops in the Shivaliks to ensure food security.
- Promote ecotourism to enhance livelihood security of population sustaining on produce of the Himalayan ecosystem.

Strategy 1

Understand the response of Himalayan glaciers to climate change, The action under this strategy will essentially include Development of an interstate –inter institutional programme along with the states of Jammu & Kashmir and Himachal Pradesh to study Himalayan glaciers feeding the rivers flowing through Punjab and particularly to assess the trends of glacier melt.

Strategy 1	**12th plan**	**13th plan**	**12th +13th plan**
Cost of implementing strategy 1	Rs 2.00 Cr	Rs 5.00 Cr	Rs 7.00 Cr

Strategy 2

Protect, Preserve and Conserve Shivalik biodiversity of forests. *Launch a strong initiative to conserve Shivalik biodiversity to facilitate protection of species through*

- Micro level assessment
- Analysis of Remote sensing Data
- Perspective planning
- Addressing Livelihood issues

The protected area in Shivaliks currently extends over an area of 2524.17 sq. km only. Out of this, the larger share is in Uttarakhand including the Rajaji - Corbett National Park. It is proposed to conserve wild flora and fauna of the area which offers a wealth of medicinal and economically important resources (many of which are endemic, rare or threatened). Therefore the actions need to include

- Conserve wild flora and fauna many of which are endemic and rare.
- Improve habitat through special programmes on soil and water conservation.
- Promote species conservation especially of flagship species.
- Promote wise and sustainable resource utilization.
- Assess impacts of developmental projects.
- Conserve traditional crop varieties/land races, traditional ecologically adapted agricultural practices, associated knowledge and livestock breeds.

Conserve existing forest resources and plantations through natural and artificial regeneration in degraded areas and also conserve soil and moisture in these areas. Initially the actions will be extended to forest areas in 2,154 villages located around Shivalik hills in Punjab. Another 3533 villages to be brought under this plan later.The activities will include similar activities as identified in Chapter 6 but limited to Shivalik hills. The cost of actions is included in Chapter 6. The actions to be undertaken being:

- Enrichment-plantation in gap areas in degraded forests areas of Shivalik hills with indigenous species like *Acacia catechu, Acacia nioltica, Albizzia procera. Bauhinia purpurea, Terminalia bellerica, Holoptelia integrifolia, Dalbergia sissoo, Emblica officinalis, Mangifera indica,* etc. Planting of Bamboo in better soil moisture regime areas, particularly along the depressions, choes, rivulets and khuds.
- Aided natural regeneration in areas wherever sufficient root stock is present and growth of naturally grown seedlings is being hampered. The steps include singling of coppice shoots, clearing of climbers, control invasive weeds, tending natural seedlings and sowing of seeds and planting in blank patches.
- Eradication of weeds like *Lantana* and *Parthenium* and replacing them with more useful fodder and economical grasses and medicinal plants for improving the condition of the natural forests and availability of utilisable biomass for local people.

Analyse satellite maps at regular intervals to keep a check on the progress of the mission.
Prepare and maintain biodiversity registers by the communities. This will enable stock taking of biodiversity and enable tracking of the changes in biodiversity. This has to be extended to all villages lying in this area.

strategy 2	**12th plan**	**13th plan**	**12th +13th plan**
Cost of implementing	Rs 68.00 Cr	Rs 102.00 Cr	Rs 170.00 Cr

Strategy 3

Protect, Preserve and Conserve Wetlands in Punjab. *Rehabilitate natural wetlands to enhance their capacity to withstand the impacts of climate change by involving the community.* It is proposed to set up an Interpretation Centre near wetlands and take conservation and pollution control activities during 12th and 13th plans.

Continue conservation of manmade wetlands that include Ramasar sites and also nationally important wetlands by involving the communities to enhance the capacity of the man-made wetlands to withstand the impacts of climate change. Conservation activities to be taken at Dholbaha Dam, Maili Dam, Mangrowal Dam, etc., wetlands will include

- afforestation of native tree species for habitat improvement,
- soil conservation to prevent siltation,
- conservation of wildlife and fisheries,
- weed control,
- water quality monitoring and
- public awareness

Strategy 3	**12th plan**	**13th plan**	**12th +13th plan**
Cost estimates	Rs 18.00 Cr	Rs 21.00 Cr	Rs 39.00 Cr

Strategy 4

Promote cropping of indigenous varieties. Cover at least 15% of the agriculture area in Shivaliks under a crop diversification scheme by 2022, where indigenous crops are the focus. Actions would include:

- Promotion of crop diversification in Kandi area by promoting indigenous crops having significant commercial value to avoid mono cropping, degradation of soil nutrient, and to protect food security. Undertake research to upscale productivity of indigenous crops through biotechnology.
- Support water conservation activities in these areas. Conservation to be done through construction of rain water harvesting structures (WHS) and micro irrigation for horticulture.

Strategy 4	12th plan	13th plan
Cost estimates	Rs 81.50 Cr	Rs 40.00 Cr

Total Cost for funding the Mission for sustaining Himalayan ecosystem and biodiversity

12th Plan	Rs 169.50 Cr
13th Plan	Rs 168.00 Cr
Total (12th +13th Plan)	Rs. 337.50 Cr

The details of the strategies are given in Annexure 3

REFERENCES

1. Brraich, O.S. and Ladhar, S.S. 2005. Fish Biodiversity in wetlands of Punjab (A Field Guide). Punjab State Council for Science & Technology, Chandigarh.
2. Dhaliwal, G.S., B.S. Hansra and S.S. Ladhar. 1993. Wetlands: Their Conservation and Management, PAU publication.
3. Wimalathilake E. M. S. A, 2008. Biodiversity Characterisation at landscape level in part of Hoshiarpur district in Punjab state using satellite remote sensing and GIS, Centre for Space Science and Technology Education in Asia and Pacific (CSSTEAP), IIRS.
4. Grewal, S.S. 1996, "Socio-Economic Development through Integrated Watershed Project, Railmajra, Punjab", CSWCRTI, Chandigarh.
5. IPCC, 2007. The Physical Science Basis. Contribution of the working Group I. Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller (eds.). Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA. pp 996.
6. Jerath, N., Puja, Chadha J. 2006. Executive Summary. Study of Biodiversity of Shivalik Ecosystem of Punjab, India. Published by Punjab State Council for Science and Technology, India.
7. Ladhar, S.S. 2005. Ropar Wetland. Punjab State Council for Science & Technology, Chandigarh.
8. NWLDB, 2011. National Wild life database cell, List compiled as on 24.1.2011.Wildlife Institute of India. Accessed from http://oldwww.wii.gov.in/nwdc/pa_list.pdf on 27th July, 2012
9. PSBB. 2011. Annual report Biodiversity Board. 2010-11. Published by Punjab State Biodiversity Board, Govt. of Punjab.
10. Roy, P.S., S. Chandrashekhar, N. Jerath and C. Prakash. 2001. Biodiversity Characterization at landscape level using satellite remote sensing and GIS: Shivalik Hills Punjab. Forestry and Ecology Div. Indian Instt. of Remote Sensing Dehradun. India.
11. Tiwana NS , N. Jerath, S. K. Saxena, P. Nangia & H K Parwana. 2005. State of Environment: Punjab -2005, Punjab State Council for Science & Technology, pp: 315.
12. Tiwana, N.S., N. Jerath, S. S. Ladhar, G. Singh, R. Paul, D. K. Dua. and H. K. Parwana, 2007. State of Environment: Punjab-2007, Punjab State Council for Science & Technology, pp 243.

8. Sustainable Habitats

HIGHLIGHTS

- Urban and Rural Population Trends
- Urban and Rural Housing
- Water availability
- Sanitation and sewerage
- Human health
- Waste Management
- Urban Transport
- Water and Air Quality
- Concerns Due To Climate Change
- Strategies to address Climate change

Habitats are essentially a function of the people living in them and the facilities built to sustain the same through planning. In effect, a sustainable habitat will be the one that provides adequate housing for its people in a clean and green environment, provides accessibility to energy, potable water and sanitation, adequate drainage undertakes efficient management of waste, has a robust health delivery system, and has good roads and a sustainable integrated transport system. With increase in population, Climate change drivers may jeopardize the functioning of the habitats if steps are not taken to address the concerns that are being identified now such as extreme precipitation and higher ambient temperatures. Also habitats are increasingly becoming sources of high GHG emissions as consumption of energy is rising.

The habitats are more organized in urban areas and since have more livelihood opportunities; the population in all states in India, including Punjab are surging towards cities. This creating pressures on water availability, sanitation, housing, management, electricity, and transport amongst others. The following section reviews the status of habitats in Punjab, both rural and urban, with respect to the parameters mentioned above.

8.1 URBAN AND RURAL POPULATION TRENDS

The proportion of urban population with respect to total population in Punjab has increased from just 22% in 1951 to 38% in 2011 with a compounded annual growth rate (CAGR) of 2.8% (**Table 8.1)**. Consequently, the number of towns in Punjab has also increased from 110 in 1951 to 157 towns. Out of these, 14 are class I towns, 18 are class II towns while number of class III, IV, V and VI census towns are 36, 54, 28 and 7 respectively. [Source: Director of Census Operations, Punjab, 2001].

Increase in the urban population of Punjab over the years, is the outcome of rapid industrialization, migration from rural to urban areas and migration from other states in search of employment, and better health and educational facilities in the towns and cities. The rapid increase in urban population has also created many slums in peri- urban areas, with no *pucca* housing and minimum amenities for the population residing in these areas. Though recent statistics is not available, but an indication of percentage of slum population is obtained from Census 2001, according to which nearly 14% of the urban population in the State were living in slums in 2001. To accommodate the increasing population in urban centres and provide the urban population with state of the art infrastructure, housing and other amenities, the Punjab govt. has taken initiatives through various programmes such as the Integrated Housing and Slum Development Programme (IHSDP) under the JNNURM programme of GoI, construction of housing for EWS (economically weaker section) of society in urban areas, houses for houseless SCs in rural and urban areas, etc.

Table 8.1 Trends of urbanization in Punjab.

Year	Total Population	Urban population	Urban population (%)	Decadal growth of urban population (%) /absolute	Total no of UAs/ Towns	Rural Population	Rural Population (%)
1951	91,60,500	19,89,267	21.72	20.02/3,31,853	110	71,71,233	78.3
1961	11,135,069	25,67,306	23.06	29.06/5,78,039	106	85,67,763	76.9
1971	13,551,060	32,16,179	23.73	25.27/6,48,873	106	1,03,34,881	76.3
1981	16,788,915	46,47,757	27.68	44.51/14,31,578	134	1,21,41,158	72.3
1991	20,281,969	59,93,225	29.55	28.95/23,45,468	120	1,42,88,744	70.5
2001	24,289,296	82,45,566	33.95	37.58/22,52,341	157	1,60,43,730	66.1
2011	27,704,236	10,387,436	37.49	37.49/21,41,870	-	1,73,16,800	62.5
2021 #	33,315,833	13,681,832	41.06	41.06/42,63,168	-	1,96,34,001	58.9

Our estimates are based on CAGR (Compounded Annual Growth Rate) between 1951 and 2011.

Source: Census, 2001, 2011 and others.

The Rural population in Punjab (Table 8.1), as per the 2011 census is 62.5% of its total population. It has though increased from about 71.7 lakhs in 1951 to 1.96 Crores in 2011, but the compounded annual growth rate (CAGR) is half (1.48%) of the urban CAGR at 2.8%.

The Migration to urban areas from rural areas has created a stress on urban amenities. It is imperative that livelihood options need to be expanded in the rural areas for the population to stay back. One of the steps that can be taken is to develop the peri urban areas in and around the cities that are also encroaching the rural areas, in self-sufficient habitats with sufficient livelihood generating options For example, livelihood generating units manufacturing eco friendly products which can be used for constructing eco-friendly buildings and be key livelihood generating sources. One such example of eco-friendly production unit has been developed by PSCST (Box 8.1).

Box 8.1: Development of ecofriendly brick kilns (PSCST)

Bulls Trench Brick kilns operating in the rural areas in the country are coal intensive. Coal in these units is burnt inefficiently. The inefficient burning of coal along with the low air handling capacity of chimnies with low heights result in the presence of high concentration of air pollutants(SPM) in and around the brick kilns. The pollutant emission concentration ranges between 1000-2500 mg/Nm^3 with the peak value going up to 4200 mg/m3. The stipulated norm being only 500 mg/Nm^3.

PSCST has developed a technology whereby pollutant release in the atmosphere is reduced by optimizing combustion of coal and by adopting better feeding, firing and operating practices such as

- Installation of gravity settling chambers for pollution control at the base of the chimney.
- Higher chimney heights (120 ft) provide sufficient draught for optimum combustion of coal and increasing the cross section area at the top of the chimney
- Incorporating modifications in the flue systems

As a result the SPM levels get lowered to 187-369 mg/Nm3. The coal consumption is reduced by about 10% leading to substantial saving of input costs. Further, the output of the kilns increases by 10-15%.

Source: PSCST Bulletin

8.2 URBAN AND RURAL HOUSING

As per the Punjab Habitat and Housing Policy, 2008, the State is facing shortage of houses, inadequate sanitary conditions, and lack of basic amenities, slums in urban agglomerations and slum like situations in many semi-urban and rural areas. Lack of purchasing power, security of tenure of land, unclear titles of house property in rural areas, speculative land market, inflexible housing finance system, inappropriate planning and building regulations, lack of awareness about appropriate building materials and technologies, paucity of

public funds and problems with the institutional framework in providing adequate support to low income segment households, are some of the constraints resulting in inadequate housing and habitat conditions for the poor and EWS/LIG segments in the State. As a result, the gap between supply and demand of adequate and affordable houses has increased considerably in the State.

In urban areas, state agencies like PUDA, Urban Estates and public local agencies have been undertaking development and construction of land/houses/flats and allocating the same to the different sections of economic groups.

Box 8.2: New Urban estates

A number of urban estates are being developed by Department of Housing & Urban Dev. in different cities of Punjab. Recently Aerocity, Ecocity, ITcity, Medicity, etc. have been launched by GMADA and there had been massive response from the public.

Under the development of Urban Estates, GMADA has started the development of Aerocity as a model Township. For the first time any Govt. agency is providing separate connections for fresh water as well as treated waste water for flushing as well as gardening purposes. The houses in the city are also being provided connections for sewerage and rain water disposal to every plot. This model is being replicated in Ecocity as well.

In GMADA region, a number of private residential Mega Projects are also coming up which are being developed by National Level Builders / Developers.

Small colonizers are also developing residential colonies in almost all major cities of Punjab after seeking requisite approvals from the Competent Authority under Punjab Apartment and Property Regulation Act - 1995.

As per Census 2001, the rural areas in Punjab State had a shortage of 90,000 units(Punjab state Housing and Habitat Policy, 2008).The document indicates that the state required about 12 lakhs additional housing units in rural areas during 2007-12. Not enough data is available on rural housing stock for recent years. It is, therefore, imperative to have surveys conducted to ascertain the status of rural housing and requirements, including information on types of houses being lived in by households with different economic status. However, it is clear that given the population increase between 2001 and 2011, there is a huge gap in adequate housing availability in rural areas in Punjab.

Key Housing Policies

Punjab Housing and Habitat Policy-2008: This Policy provides comprehensive guidelines towards creating a surplus of cost effective, green and intelligent housing stock and development of sustainable habitats in the state.

The policy aims to facilitate development of the same by accelerating processes of acquisition of serviced land by ULBs, developing supporting infrastructure and basic services, promoting flow of funds for investment in housing and infrastructure by nongovernmental organization, community based organizations, micro finance institutions and self help groups (NGOs/CBOs/MFIs/SHGs) to undertake housing micro credit activities at larger scale for increased outreach and by encouraging strong partnerships between private, public and cooperative sectors to enhance public private people's partnership in every sphere of housing and habitat; plan urban settlements through appropriate planning and zoning laws and innovative programmes, remove legal and administrative barriers; bring in appropriate rules governing the use of land for housing by private sector builders and corporate and facilitate their involvement in construction; and establish Management Information System to strengthen monitoring of building activity in the State.

Punjab Regional Town Planning and Development Act, 1995 (Amended in 2006): The Punjab Regional Town Planning and Development Act, 1995 (Amendment) 2006 provides the legal framework for preparation of Master Plan. The Act stipulates that a master plan needs to Provide a broad indication of the manner in which the land in the area will be used; Allocation of areas or zones of land for use for different purposes, Indication, definition and provision of the existing and

proposed highways, roads, major streets and other lines of communication; Indication of areas covered under heritage site and the manner in which they will be conserved; Regulations to regulate within each zone - the location, height, number of storeys and size of buildings and other structures, open spaces and the use of buildings and structures. The Act also provides for "Control of Development and Use of Land in Area where master plan is operational.

EWS housing policy: For addressing the needs of the Economically Weaker Sections, the EWS housing policy, was formulated vide Notification No.17/91/08-iHG2/7069 dated 07-11-2008. This policy is for allotment / construction of one / two room tenements for economically weaker sections by private developers in Mega / Super Mega Housing Projects. The developer has to essentially reserve 5% of the Project Area for EWS Houses.

PUDA's new policy initiatives: PUDA's policy initiative to encourage socially inclusive housing development include reducing rate of on half yearly/yearly installments by 3%, Penalty on late payment of installments reduced; Building by laws simplified; Procedure for change of land use simplified; Conversion of trade in commercial sites permitted; and Land alloted for setting up of old age homes, schools and hospitals.

8.3 WATER AVAILABILITY

Urban Water

The Punjab Water Supply & Sewerage Board was set up under the Punjab Act No. 28 of 1976 for the purpose of regulation and development of drinking water supply and sewerage services in the urban areas of the Punjab State. Many water supply and sewerage projects like World Bank aided Water supply & Sewerage Project, Urban Renewal Project for Water Supply and Sewerage services, HUDCO - aided Water Supply and Sewerage Projects, Prevention of Pollution of river Sutlej and West Bein, Accelerated Water Supply Project have been executed by PWSSB. The present status of urban water supply is provided in **Table 8.2**

Rural

The number of villages with water supply facility has increased steadily over the years in Punjab. Department of Water Supply and Sanitation is the key agency, which implements the water supply schemes in rural Punjab. 863 villages that did not have any water source within 1.6 km have been covered till 2010-11. The progress of coverage of habitations in last 10 years is provided in **Table 8.3.**

Table 8.2 Water Supply Scenario: 1976 vis a vis 2012

Description	1976 Status	2012 Status
Urban population	40 Lakh	103.87 Lakh
Water Supply coverage	40% (16 Lakh)	88% (91.41 Lakh)
Tubewells (nos.)	340	1972
Water supply pipe line(in km)	1780	11868
Towns covered with water supply	80	139

Source: Punjab Water Supply & Sewerage Board

Table 8.3 Coverage by villages under Water Supply Schemes

Year	Coverage of the villages during the year		
	NC villages	PC Villages	Total Villages
2002-03	321	389	710
2003-04	246	482	728
2004-05	156	281	437
2005-06	389	845	1234
2006-07	238	601	839
2007-08	212	265	477
2008-09	907	887	1794
2009-10	893	1034	1927
2010-11	863	854	1717

Note: NC-Not covered i.e., without any conventional drinking water source within 1.6 km,
PC – partially Covered *Source: Department of Water Supply and Sanitation, Govt. of Punjab*

8.4 SANITATION AND SEWERAGE

Urban

63% of the population residing in the State has sewerage facility. 8770 km sewer line has been laid and 88 towns across the state have sewerage facility. **Table 8.4** provides the sanitation coverage of the State and **Table 8.5** provides list of major sanitation projects completed in recent years.

Table 8.4 Sanitation Supply Scenario: 1976 vis a vis 2012

Description	1976 Status	2012 Status
Urban population	40 Lakh	103.87 Lakh
Sewerage coverage	25% (10 Lac)	63% (65.44 Lac)
Sewer laid (km)	1075	8770
Towns covered with sewerage	60	88

Source: Punjab Water Supply & Sewerage Board

Table 8.5 List of Major Sanitation & Sewerage Projects Completed in Punjab

SN	Name of Project	Towns Covered	Estimated Cost (Rs. Crore)
1.	World Bank (IDA) Aided Water Supply & Sewerage Project	8	66.70
2.	LIC Aided Water Supply and Sewerage Projects	78	102.00
3.	Urban Renewal Project For Providing W/S, Sewerage, Street Lights, Street paving and Road Construction.	25	125.00
4.	Prevention of Pollution of River West Bein	2	15.00
5.	Extension & Augmentation of W/S Sewerage & Solid Waste Management at Patiala (NCRPB) Phase-1	1	60.00
6.	Water Supply & Sewerage Projects under Municipal Development Funds (Phase-1)	126	93.76
7.	Water Supply and Sewerage Scheme Samana (IDUI)	1	15.43
8.	Sutlej Action Plan for prevention of pollution of river Sutlej	4	286.00
9.	Sewerage Project Jalandhar Phase-I under UIDSSMT	1	54.79
10.	Water Supply and Sewerage Scheme at Gidderbaha	1	32.71
11.	HUDCO Aided W/S Projects for Towns Having Population less than 20000	44	45.00
12.	Augmentation W/S Jalandhar	1	10.00
13.	Water supply Project Ludhiana	1	42.79

Source: Punjab Water Supply & Sewerage Board

Rural areas

The biological contamination of large number of drinking water sources is a serious problem, primarily due to prevalent open defecation and insanitary conditions around the drinking water sources. Government of Punjab has decided to provide individual households toilets in whole of the state in a phased manner. WSS Department has carried out a base line survey of all the households in Punjab to assess the coverage of houses with toilets from December 2009 to February 2010 (see Table 8.6).

Table 8.6 Toilet Facility in Rural Households

	Total Households (in lacs)	Households with toilets (in lacs)	% of total
APL	25.49	16.71	65.55
BPL	5.70	2.52	44.20
Total	**31.19**	**19.23**	**61.65**

In the first phase, a target has been set to cover as many villages as possible by constructing two lakh toilets in the various villages of the state. One lakh toilets are to be constructed by Department of Water Supply & Sanitation and another one lakh toilets are to be constructed by Rural Development Department. In order to give a push for coverage of the households with toilets, a project for construction of leach pit based individual households (one lakh) toilets amounting to Rs. 124.50 Crore is under implementation in the State by the department.

8.5 HUMAN HEALTH

According to the annual report, 2010 of MoHFW, the communicable disease burden of some diseases in India which are also influenced significantly by climate are showing an increasing trend such as that of Malaria, Dengue, Chikangunea, Japanese Encephalitis, Cholera (especially *Vibrio Cholerae O 139)* and Leptopsoriasis.

The most common climate related diseases that are prevalent in Punjab and also noted by the Integrated Disease Surveillance Programe (IDSP), are malaria, acute diarrheal diseases, cases of chikangunea, Japanese encephalitis and heat stress etc.

Reaching out to the entire population at an adequate and equitable level of medical services delivery is the prime objective of the government. Currently, about 75% of its medical infrastructure is in the urban areas. The trends of Urban and Rural birth rates, infant mortality rates and total fertility rates have shown declining trends between 1971 to 2010. The death rates have plateaued in recent years. However, there is a consistent gap in the Rural and Urban parameters, with urban indicators performing better than the rural ones. A comparative picture is presented in **Figure 8.1**.

In general it is perceived that climate change will impact negatively all climate related diseases in a business as usual scenario. The coping capacities of the poor, unless adequately addressed will be the weakest and hence the health of this section is likely to be the most adversely affected. Also with population in urban areas in Punjab set to become 41% of the total population of the state by 2021 (refer to Table 8.1) increase in urban disease burden is a matter of concern, which is likely to get spiral on the upward side with further changes in climate. Though 75% of the health facilities are available in the urban centres, but private sector's predominance in this sector has led to inequities in access to healthcare. The trends of some of the diseases in terms of incidences that are influenced by climate are as follows.

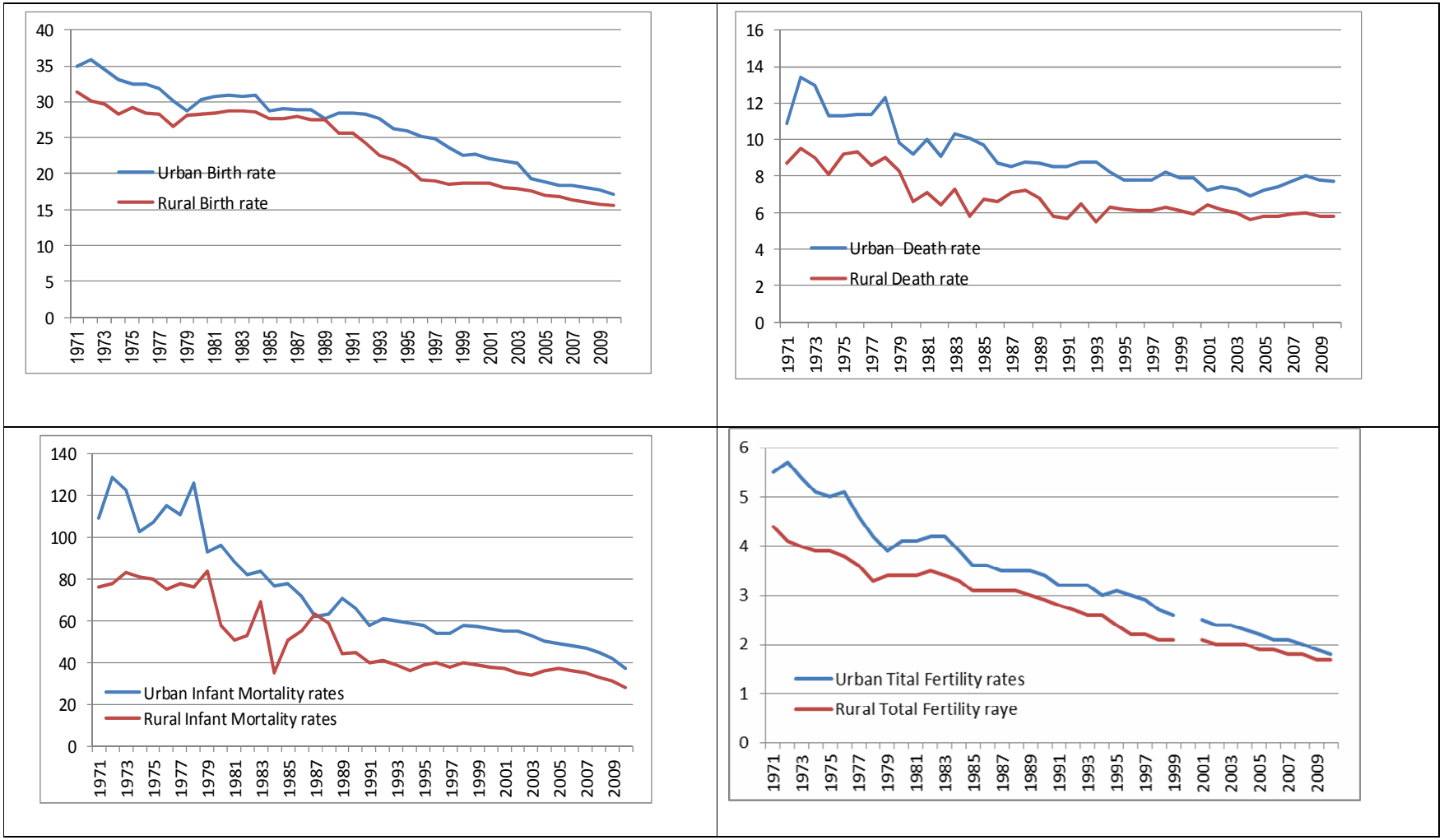


Figure 8.1: Trends of Rural and Urban health indicators in Punjab

Source: Department of Health and Family Welfare. Govt. of Punjab

Malaria

In Punjab as per the Vector Borne Disease Control Programme of the state, in 2006 about 1888 positive cases were reported, which rose to 3476 in 2010 and in 2012 about 1668 cases were reported showing a decline in incidences (see figure 8.2). Along with the rise in incidences the *Plasmodium falciparum* (*Pf*) cases are also increasing indicating resistance to chloroquine. Urban Malaria in the state is being managed through the Urban Malaria Scheme. Anti larval operations are being implemented in 21 towns of Punjab State i.e. Amritsar, Jalandhar, Patiala, Ferozepur, Malerkotla, Bathinda, Kapurthala, Rajpura, Nabha, Jagraon, Hoshiarpur, Gurdaspur, Ludhiana, Sangrur, Barnala, SAS Nargar, Phagwara, Khanna, Faridkot, Malout and Tarn Taran. In these towns , breeding of mosquitoes is checked by carrying out Anti Larval Operations regularly at weekly intervals. Additionally, 11 more towns with population of 40,000 and above are to be included in future (*Source: http://pbhealth.gov.in/pdf/malaria.pdf).*

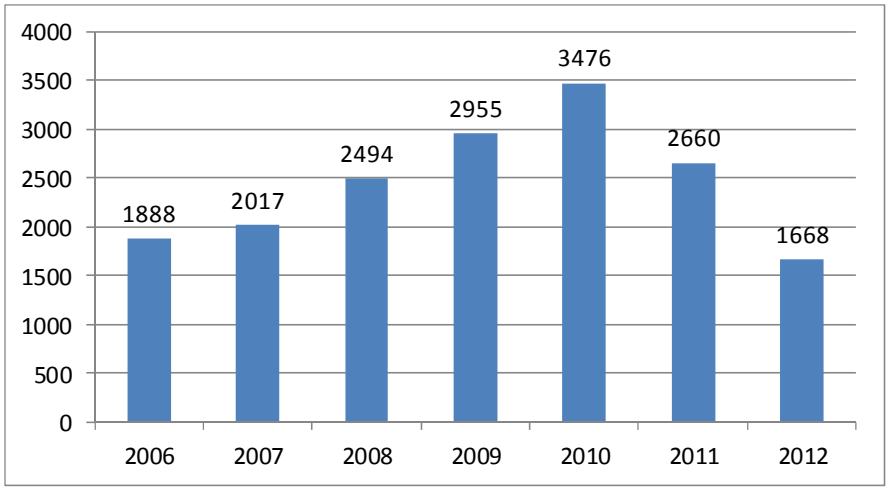


Figure 8.2:Trends of Malaria incidences reported in Punjab during 2006-12

Source:PbDoHFW, 2013

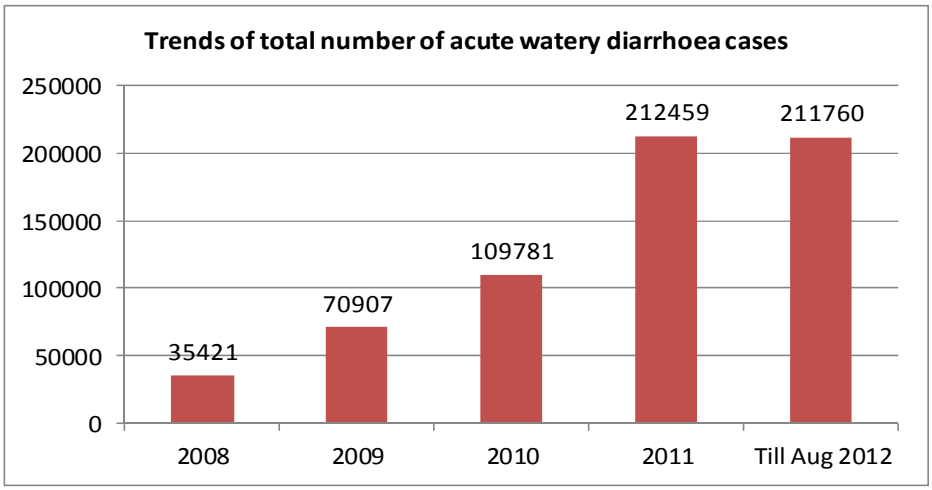
Dengue, Chikangunea, Japanese Encephalitis

In October 2011, as many as 1,159 patients were tested positive for dengue in the state. Of these, 447 persons were tested positive in Ludhiana district, 358 in Bathinda district and 239 in Muktsar district. However, as per official records, only three dengue deaths were reported (*Source: http://pbhealth.gov.in/pdf/malaria.pdf*). Only 1 case of chikangunea, 1 case of Kala Azar and 2 cases of Japanese Encephalistis were detected in 2010 in Punjab. For controlling urban dengue, inter sectoral coordination especially with the Department of Local Bodies has been set up to ensure elimination and control of breeding of the vector of Dengue.

Water borne diseases

Diarrhoea, hepatitis, enteric fever and cholera are some of the water borne diseases that continues to be a cause of concern in Punjab. As an example, figure 8.3, shows the rising trend of acute diarrhoeal diseases in Punjab between 2008 and Aug 2012 and its distribution across districts**.** Gurdaspur, Ludhiana, Jalandhar, Patiala, Amritsar, and Sangrur are some of the districts that consistently report higher number of acute diarrheal incidences with large urban population. Similarly, more enteric fever cases are reported from cities such as Jalandhar, Gurdaspur and Ludhiana (Pb IDSP, 2013).

(a)



(b)

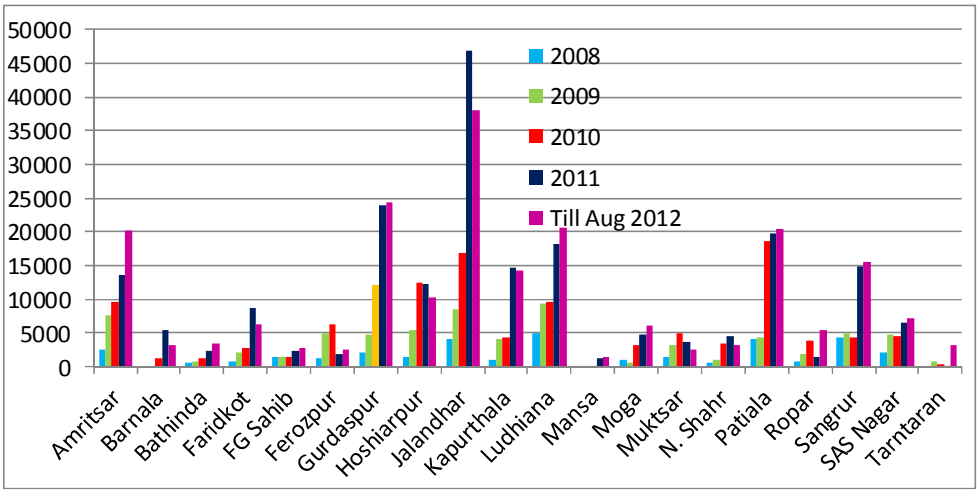


Figure 8.3: (a) Trends of total incidences of Acute Watery Diarrhoeal disease in Punjab. (b) Distribution of Acute Diarrhoeal disease across various districts of Punjab
Source: PbIDSP, 2013

Extreme heat

More and more cases of heat related morbidities and deaths are being reported each year during the summers as extreme heat is becoming more frequent. For example, in June 2012, 40-45 cases of heat-related illnesses including heat cramp cases were reported from only one hospital chain (Tricity hospitals) in Ludhiana and more and more cases are reported each year (*Source: July3,2012, Times of India, Ludhiana,)*. About 25 deaths due to heat stroke were reported from the district in the same month (Source: *June 30th, 2012, Ludhiana Tribune*). Though heat illness is self limiting, it can progress to heat exhaustion and heatstroke - both being severe forms. It is realised that children and elderly are at more risk when the humidity is high. Patients usually complain of fever due to the rise in temperature and exhaustion.

Respiratory diseases

Aero allergens and respiratory diseases: Linkages of aero-allergens including allergens in the atmosphere with respiratory diseases is well established. A recent study carried out by Singh *et al.*, 2011, indicates that allergens (smoke/dust/pollens 38%, humidity 13%, perfume 16%, powder 15%, food article 2%, poullants 10%, temperature 6%) led to respiratory tract problems in a sample population in Punjab. The presence of allergens was found to be more in the urban area (63%), as compared to rural area (37%). The study indicates that the

majority of the patients are male (58%). The most vulnerable age group being 21-30 years (Singh *et al.,* 2011*).*

Total suspended particulates and respiratory diseases: A Cross-sectional household survey has been conducted in "exposed" population of highly polluted Mandi Gobindgarh and in "reference" population in Morinda in Punjab. The study indicated that adult population of Mandi Gobindgarh has significantly more chronic respiratory morbidity (symptoms include cough, wheesing, chronic bronchitis and obstructive defects) as compared to that of Morinda. This has been attributed to the significantly higher concentrations of Total Suspended Particulate(TSP) matter (*Kumar, 2012)*.

Pogrammes Managing Health

The Department of Health and Family Welfare is the nodal department entrusted with the management of disease in the state which it does through its network of hospitals and health centres. The key ongoing programmes that the department is implementing are:

- National Vector Borne Disease Control Programme
- National Leprosy Eradication Programme
- National Cancer Control Programme
- School Health Programme
- Immunization Strengthening Programme
- Janani Suraksha Yojna
- Integrated Disease Surveillance Programme
- Janani-Shishu Suraksha Karyakaram

8.6 WASTE MANAGEMENT

Solid Waste Management

As per Tiwana et al., 2007, about 3035 tons of municipal solid waste is being generated per day in the state, of which 71% is contributed by 5 Municipal Corporations namely Ludhiana, Amritsar, Jalandhar, Patiala and Bathinda. As per estimates, MSW generation in the state increased from 4395.6 tons/day to 5526 tons/day between 2001-2011. 38 municipal authorities have adequate land for disposal of municipal solid waste for more than 20 years. Actions taken by departments for management of solid waste include:

- Constitution of District Level Committees to identify landfill sites for all urban bodies.
- Initiative by Local Bodies for managing solid waste under a Public Private Partnership format for which the state has been divided into 9clusters namely Jalandhar, Ludhiana, Ferozepur, Bathinda, Pathankot, Patiala, Sangur, Amritsar and GMADA (Greater Mohali Area Development Authority). Each cluster comprises a major town and other peripheral towns. The management of solid waste would include door-to-door collection, transportation, Central Integrated Processing Plant, scientific landfill site and transfer stations.
- SWM (Solid Waste Management) project for Ludhiana cluster has been planned under JNNURM (Jawaharlal Nehru National Urban Renewal Mission).
- Preparation of DPR (Detailed Project Report) by Punjab Pollution Control Board for the towns of Mandi Gobindgarh and Kartarpur.

- State Govt. has enacted Punjab Plastics Carry Bags (Manufacture, Usage and Disposal Control Act, 2005).
- Landfill sites for municipal solid waste are being maintained by the respective municipal bodies.

Hazardous waste disposal

As of September 2011, there are 3323 hazardous waste generating units in the State generating approximately 130532 tons of waste per annum (TPA). Of this, 96992 TPA is recyclable, 15108 TPA is incinerable and 18432 TPA is storable. A common Treatment Storage & Disposable Facility (TSDF) has been developed in the state at village Nimbuan, Tehsil Derabassi, Distt. Ajitgarh is on 20.64 acres area by M/s Nimbuan Greenfield Punjab Ltd. through M/s RamkyEnviro Engineers Ltd., Hyderabad. The Facility has an expected life of 15 years.

Animal Waste Disposal

High Rate Bio-methanation Power Project for Recovery of Energy from Dairy Waste has already been installed by PEDA at a Dairy Complex in Haibowal, Ludhiana. The plant has been designed to utilize 235 tons of cattle dung daily for recovering about 18,000 KWhs of electrical energy. The project is also producing almost 47 tons of valuable nutrient rich bio manure per day. Another project for Tajpur Road Dairy Complex is under consideration that is likely to produce 2 MW of power. Similarly, 1MW Biomethanation Cattle Dung based Power Project at Jamsher Dairy Complex, Jalandhar, is being commissioned by PEDA.

Waste water Disposal

Regulating the quality of Industrial & domestic waste water within the prescribed standards is a priority for Punjab Pollution Control Board. The Board has achieved following in this direction:-

- To reduce the point sources of industrial pollution, Punjab Pollution Control Board is encouraging the establishment of common effluent treatment plants (CETPs). For example, a common effluent treatment plant has been installed for Leather Complex, Jalandhar and two CETPs have been installed for electroplating units at Ludhiana and Malerkotla respectively.
- All the large & medium electroplating units in Ludhiana have achieved zero liquid discharge.
- All the small scale electroplating industries of Ludhiana are treating their waste water through CETP's and the treated effluent from these CETP's is being used by other industries.
- Similarly, in case of electroplating units of Jalandhar area, the Board has directed these industries to join the CETP at Ludhiana and most of the units have now become members of the CETP. The treated effluent from these units shall also be used by the industries near CETP.

In case of dyeing units, with the introduction of new technology (machines with less liquor ratio and better absorbing dyes), the quantum of waste water generation has reduced considerably.

- With the introduction of latest technologies like MEE (Multi Effect Evaporation) the condensates generated from waste water are being recycled back in the process and concentrate is mixed with the suspended solids and separated in decanter. This technology is already introduced in the field of Pharmaceutical sector.
- The Punjab Pollution Control Board has directed all the distillery units in the State of Punjab to adopt zero liquid discharge. Four units have already adopted this process.
- Some big units, like NFL, Nangal, PACL Nangal, Gujrat Ambuja Ltd, Ropar etc. have adopted technologies for reusing the treated effluent within the industry itself for processing use as well as for plantation, etc. thereby conserving a lot of water.
- The State Govt. has selected 45 towns located on/near the banks of the three major rivers Sutlej, Beas and Ghaggar for the installation of Sewage Treatments Plants so as to stop the discharge of

untreated effluent into these Rivers. Total project cost for these STPs will be more than Rs. 2500 crores which includes the services like water supply, sewage, roads & irrigation scheme also. This includes 18 towns on river Sutlej, 16 on Beas and 11 on River Ghaggar. Work on some of the STPs (Sewerage Treatment Plants) has already been completed. **Table 8.7** lists the STPs and their capacities provisioned for some of the towns along the river Sutlej, Ghaggar and Beas as on September 2013 (or Table 8.7 indicates the number and capacities of STPs set up in various towns along the river Sutlej and Beas). In order to stop the discharge of treated domestic sewage into rivers. The Deptts. of Soil Conservation and Irrigation have prepared irrigation schemes at a cost of Rs. 333.90 crores to utilize the treated effluent for irrigation in the command area available.

Table 8.7: Number and capacities of STPs commissioned in various towns along the river Sutlej, Ghaggar and Beas in Punjab

Sr. No.	Name of City (River Wise)	STP's already commissioned (No & respective capacity in MLD)
River-Sutlej		
1	Ludhiana	1 No.,152 MLd (Balloke)
		1 No.,105 MLd (Balloke)
		1 No.,111 MLd (Bhattian)
		1 No.,50 MLd (Bhattian)
		1 No.,48 MLd (Jamalpur)
2	Moga	1 No.,27 MLd
3	Jalandhar	2 Nos. (100 + 25)MLd
4	Phagwara	1 No.(20 MLd)
5	Phillaur	1 No. (2.60 MLd)
6	Ropar	1 No. (10 MLd)
7	Nangal	1 No. (8 MLd)
8	Zira	1 No. (8 MLd)
9	Anandpur Sahib	1 No. (8 MLd)
River-Beas		
10	Bhulath	1 No. (4 MLd)
11	Sultanpur Lodhi	1 No. (2.60 MLd)
12	Kapurthala	1 No.(25 MLd)
13	Dasuya	1 No.(4 MLd)
14	Shamchurassi	1 No.(1 MLd)
River-Ghaggar		
15	Sardulgarh	1 No. (4 MLd)

Source: Punjab Water Supply & Sewerage Board, 2014.

8.7 URBAN TRANSPORT

Urban Transport Trends

Number of registered vehicles in Punjab has increased from 2910 thousand in 1980-81 to 5712 thousand in 2010-11, indicating a compounded annual growth rate of around 6.3% **(Figure 8.3a).** The vehicle distribution by type indicates that two wheelers constitute 75% of the total vehicular

population, with cars, jeeps and taxies constituting the next largest category of vehicles (11%), followed by tractors and trailers (9%). The other categories are negligible in comparison (see **Figure 3.8b**).

The cities in Punjab are unable to meet increasing travel demand due to prevailing imbalance in modal split, inadequate transport infrastructure and its suboptimal use, disconnection between land use and transport planning and almost no improvement in the city bus services. It leads to a shift to personalized modes of transport as vehicle loans are available easily from banks as is evidenced from the rise in passenger vehicles which have grown at a CAGR of 10.3% between 1980-81 to 2009-10.

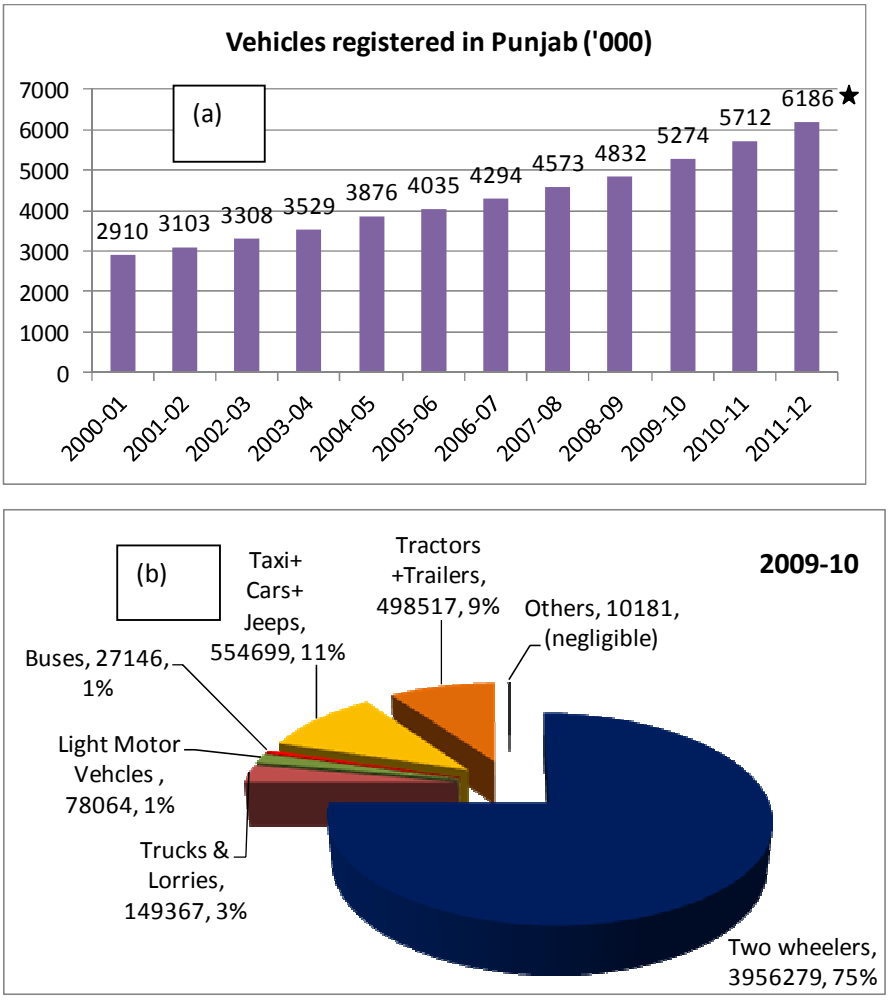


Figure 8.3: (a) Trends of vehicles registered in Punjab between 2001 and 2012(b) Example of vehicle distribution by type in the year 2009-10.
*Note:**The 2011-12 values is projected value based on the growth rate between 2010-11 *Source: ESP, 2011; MoRTH, 2012*

GHG emissions from the transport sector is another area of concern. A paper by Ramachandra and Shewatamala, 2009, estimates that the city of Ludhiana itself emits around 14847.91 Mg/km^2 of CO_2, 7.52 Mg/km^2 of CH_4, and 98.33 Mg/km^2 of NO_X. Whereas, at state level 9.64 to 14.45 million tons of CO_2, 2.8 to 5.6 million tons of CH_4 and 44.6 to 89.2 million tons of NOx are being emitted.

National Urban Transport Policy

To avoid the congestion and provide smooth and affordable transportation, some new initiatives have been undertaken in the state which are all part of the National Transport Policy, 2006. The objectives of the policy are to make Urban Transport an important parameter at the planning stage rather than being a consequential requirement; Reduce travel demand by better integration of land use & transport planning; Allow Equitable Allocation of Road Space; Reduce road congestion; Improve public transport and Road safety; Introduce Integrated Transport Systems; Provide facilities for use of non motorized vehicles; Additionally foster the use of sustainable technologies to reduce dependence on fossil fuel; and Undertake Capacity building at individual & institutional level, and create awareness for smooth transition to cleaner technologies, develop innovative financial mechanisms with greater involvement of private sector.

Key Programmes and Projects

The department of Transport and the urban local bodies together manage the urban transport system.

Metro in different cities

Metro rail project is coming up in Ludhiana. It is likely to be operational by 2018. The estimated cost to construct 12.3 km underground Corridor and 16.9 kms above ground corridor having 27 stations is about Rs 7406.00 Cr. According to the estimated projections it is likely to make 10.09 lakh trips by 2031, starting from 3.15 lakh trips at the start of operations.

Promotion of clean fuel utilsation in transport sector

Deptt. of Soil & Water Conservation has set up an Energy Conservation Cell (ECC) which will take necessary steps for use of clean fuels under the technical assistance from PEDA. The auto fuel quality standards set by the Government of India and followed by all states is given in **Table 8.8.**

Table 8.8: Auto fuel standards of diesel and gasoline

DIESEL SPECIFICATION				
YEAR	**1996**	**2000**	**2005**	**2010**
Cetane No, Min	45	48	48	51
Sulphur % W/w, Max	0.50	0.25 0.25(metro)	0.05	0.035
Distillation T95	-	370	370	360
Polyaromatic	-	-	-	11
GASOLINE SPECIFICATION				
RVP at 38Deg.c,kpa	35-70	-	35-60	60
BENZENE %by Vol.,max	5.0	5.0 3.0(Metro)	3.0(all) 1.0(Metro)	1.0
Lead G/m3, max	0.15 %(low pb) 0.013% (unleaded)	0.013	0.013	0.005
Sulphur % by mass, max	0.10(unleaded) 0.20 (leaded)	0.10	0.05	0.015
Aromatics % v/v., Max	-	-	45	42
Oxygen %by Vol., Max	-	-	2.0	2.7

Source: http://www.cpcb.nic.in/Auto_Fuel_Quality.php

Vehicular pollution control

Department of Transport is issuing instructions to all the Depots from time to time to check the pollution of the buses before sending them on routes. Punjab Roadways has its own Driver's Training School, where training is imparted to the drivers. Similarly, all vehicles that are privately owned are required to get their exhaust emissions checked on a regular basis.

In Punjab, as of Sept. 2012, Bharat Stage III fuel norms are prevalent for passenger cars, heavy diesel vehicles and 2/3 wheelers. Though about 13 cities in India are now following Bharat Stage IV norms, none of the cities in Punjab have yet come under the purview of this norm. **Tables 8.9 a, b and c** give the emission norms of exhaust from passenger cars, heavy diesel vehicles and from 2/3 wheelers.

Table 8.9 a: Emission norms for passenger cars (g/km)

Norms	CO	HC+ NOx
1991Norms	14.3-27.1	2.0(Only HC)
1996 Norms	8.68-12.40	3.00-4.36
1998Norms	4.34-6.20	1.50-2.18
India stage 2000 norms	2.72	0.97
Bharat stage-II	2.2	0.5
Bharat Stage-III	2.3	0.35(combined)
Bharat Stage-IV	1.0	0.18(combined)

Source: http://www.cpcb.nic.in/Vehicular_Exhaust.php

Table 8.9 b: Emission norms for Heavy Diesel vehicles (g/km hr)

Norms	CO	HC	NOx	PM
1991Norms	14	3.5	18	-
1996 Norms	11.2	2.4	14.4	-
India stage 2000 norms	4.5	1.1	8.0	0.36
Bharat stage-II	4.0	1.1	7.0	0.15
Bharat Stage-III	2.1	1.6	5.0	0.10
Bharat Stage-IV	1.5	0.96	3.5	0.02

Source: http://www.cpcb.nic.in/Vehicular_Exhaust.php

Table 8.9 c: Emission Norms for 2/3 wheeler (g/km hr)

Norms	CO	HC+ NOx
1991 Norms	12-30	8-12 (only HC)
1996 Norms	4.5	3.6
India stage 2000 norms	2.0	2.0
Bharat stage-II	1.6	1.5
Bharat Stage-III	1.0	1.0

Source: http://www.cpcb.nic.in/Vehicular_Exhaust.php

Promoting use of battery operated vehicles

Through the Punjab Energy Development Agency (PEDA), the government of Punjab supports dissemination of all types of Battery Operated Vehicles (BOVs), Plug Hybrid Vehicles (PHVs), Hybrid

Electric Vehicles (HEVs) and Electric / Exercise-Bike Generator Inverter (E2BI) for their usages by users for surface transportation. PEDA also provides for Research & Development projects towards development of advanced high energy density batteries, ultra capacitors, control systems and other components for battery operated electric plug, and hybrid electric vehicles for surface transportation. Additionally, support for pilot project on technology demonstration for Battery Operated Vehicles, Plug Hybrid Vehicles, Hybrid Electric Vehicles and Electric/Exercise- Bike Generator Inverter (E2B1) for field performance evaluation leading to commercialization is also provided by the agency. Further, projects and activities related to awareness promotion through education and training, organization of business meetings and seminars/conferences/symposia for promoting use of electric vehicles, plug hybrid vehicles and hybrid electric vehicles etc. are carried out.

As a part of the overall programme for development of alternative means of fuels of surface transportation, MNRE, GOI is supporting the Battery Operated Vehicles Programme and assistance in the form of capital grant / subsidy is provided (**Table 8.10).**

Table 8.10: Physical Targets and Central Financial Assistance for 2011-12 for Alternate Fuels for Surface Transportation

Sr.No	Type of Vehicle		Central financial Assistance Per Vehicle
1	Two Wheeler	High Speed	Rs. 4,000/- or 20 % ex-works cost of vehicles whichever is less
		Low Speed	Rs. 5,000/- or 20 % ex-works cost of vehicles whichever is less
2.	Three Wheeler	7-Seater	Rs. 60,000/- or 20 % ex-work cost of vehicles whichever is less
3.	Passenger Car	4-Seater	Rs. 1,00,000/- or 20 % ex-works cost of vehicles whichever is less
4.	Bus/ Mini Bus	Four Wheelers Buses (Minimum 10-Seater and above)	Rs.4,00,000/- or 20% ex-works cost of the vehicles whichever is less.
5.	R&D and Technology Demonstration		As per R&D Policy guidelines of MNRE.

Source: http://www.peda.gov.in/eng/prom_battery.html

Promoting biofuels

Biofuel Policy of India aims to ensure that a minimum level of biofuels become readily available in the market to meet the demand at any given time. An indicative target of 20% blending of biofuels, both for bio-diesel and bio-ethanol by 2017 is proposed. The blending level of bioethanol has already been made mandatory, effective from October, 2008, and will continue to be mandatory leading upto the indicative target.

The Ministry of New & Renewable Energy, GOI is the nodal Ministry for overall coordination relating to biofuel and preparation of National Policy for the same. For the promotion of biofuel production in the state, Punjab Energy Development Agency (PEDA) has been designated as state nodal agency to coordinate the activities related to Bio fuel production, policies to coordinate with different departments / agencies in the state.

The current share of biofuels in the consumption of transportation fuels is extremely low and is confined mainly to 5% blending of ethanol in gasoline which the government had made mandatory in the states of Andhra Pradesh, Goa, Gujarat, Haryana, Karnataka, Maharashtra, Punjab, Tamil

Nadu, Uttar Pradesh and Uttaranchal and in the union territories of Daman and Diu, Dadra and Nagar Haveli and Chandigarh.

The main feedstock for producing ethanol in the country is molasses, a by-product of sugar manufacturing. The production of ethanol from various distilleries in Punjab is shown in **Table 8.11**.

Table 8.11: Ethanol production in Punjab

Sr. no.	Name & Address of Distillery	District	Total production per day
1	M/s PatranDistilleries (A unit of Piccadily Sugar Allied industry Ltd.,) Jakhal Road, Patran, Distt. Patiala	Patiala	ENA - 40 KLD
2	M/s Patiala Distilleries & Manufactures Ltd., Village Main, Patiala	Patiala	ENA - 50 KLD
3	M/s Chandigarh Distilleries & Bottlers Limited, Banur, Distt. Mohali (Punjab)	Mohali	ENA – 330KLD
4	M/s Pioneer Industries Ltd., Plot no. A-3-A4, Industrial Growth Center, Village Ranipur-145023 The Pathankot, Distt. Gurdaspur	Gurdaspur	1) ENA – 45KLD 2) Industrial Alcohol 3KLD
5	M/s Jagatjit Industries, Hamira, Distt. Kapurthala	Kapurthala	ENA –120KLD
6	M/s Rana Sugars Ltd., (Distillery Division) Village Louka, Tehsil-Patti, Distt. Tarn Taran.	Tarn Taran	1) ENA – 56KLD 2) Industrial Alcohol - 4KLD
7	M/s Khasa Distillery Co., (A unit of Dig Vijay Chemicals Ltd.,) P.O. Khasa, Distt. Amritsar	Amritsar	1) ENA – 40KLD 2) Industrial Alcohol -5KLD
8	M/s A.B. Grain Spirits Pvt. Ltd., (Distillery) Vill. KiriAfgania, P.O. Hardiowal, Distt. Gurdaspur	Gurdaspur	1) ENA – 120KLD 2) Any other IMFL – 4000 Cases/day Country Liquor-5000 Cases/day
9	M/s A.B. Sugars Ltd., Randhawa (Dasuya), Distt. Hoshiarpur	Hoshiarpur	1) ENA – 60KLD
10	M/s Malbros International Pvt. Ltd., Mansoorwal, Tehsil, Zira, Ferozepur	Ferozepur	1) ENA – 45KLD 2) Industrial Alcohol 5KLD

Note- ENA: Extra Neutral Alchohol
KLD: Kilo Litre/Day

Source: Punjab State Pollution Control Board, 2012

8.8 WATER AND AIR QUALITY

Surface water

Discharge of domestic waste water and industrial effluents in the various rivers and nallahs in the state is a matter of concern in the state. The Punjab Pollution Control Board is undertaking survey of major rivers and canal systems to idenfty the sources of pollution, type, quantify the same to design the measures to be taken to check or eliminate the sources of pollution so identified. Department of Irrigation along with Punjab Pollution Control Board is currently monitoring and implementing missions for cleaning the rivers Sutlej, Ravi, Beas and Ghaggar and various canal systems. **Table 8.12** gives the stretches in River Sutlej and Beas that have been identified as polluted along with the level of pollution.

The Water (Prevention and Control of Pollution) Act was enacted in 1974 to provide for the prevention and control of water pollution, and for the maintaining or restoring the wholesomeness of water resources in the country. The Act was amended in 1988.

Table 8.12: Status of water quality in Rivers Sutlej and Beas

No. of Monitoring locations	Year	Temperature (oC)	pH	Conductivity (jmhos/cm)	DO (mg/l)	BOD (mg/l)	COD (mg/l)	Total Coliform (MPN/100ml)	Faecal coliform (MPN/100ml)
Beas: 460 kms long									
19	2002	3-32	7.1-8.7	53-517	5.2-11.5	0.3-5.0	1-13	2-2400	2-1600
19	2003	4-29	7.3-8.9	76-559	7-12	0.1-6.0	1-18	2-2400	2-1600
19	2004	2-29	6.9-8.5	60-396	6.8-11.8	0.2-4.8	-	$2\text{-}5x10^4$	2-3500
19	2005	4-27	7-8.8	54-395	4.8-13	0.2-10	1.8-22	$2\text{-}11x10^3$	2-1100
19	2006	4-27	7.0-8.2	94-395	5.8-11.0	0.2-3.2	2-6.9	$2\text{-}11x10^3$	2-1100
19	2007	2-22	6.2-8.9	86-470	5.9-12.8	0.1-2.9	1.2-38	0-2400	0-2400
19	2008	1.5-22	7.0-8.4	53-432	3.8-12.5	0.1-7.6	1-28	2-1600	2-1600
23	2009	5-26	7.1-8.5	46-338	6.4-11.8	0.1-4.3	1.5-7.6	7-2400	2-1600
23	2010	5-26	6.2-2.88	63-548	5.8-11.2	0.1-2.8	-	7-39000	2-7000
Sutlej: 1078 kms long									
20	2002	9-32	6.8-8.8	131-819	3.8-11.4	0.1-45.0	1-80	8-35000	2-3500
20	2003	5-30	6.9-8.9	164-1226	3.4-11.5	0.1-24	0.8-61	$3\text{-}3x10^4$	1-1300
20	2004	9-29	7.1-8.3	144-694	1.6-10.3	0.1-64	-	$7\text{-}2x10^3$	$2\text{-}9x10^4$
21	2005	10-28	7.1-8.3	150-818	2.8-14.2	0.1-40	2.8-60	$1\text{-}35x10^4$	$1\text{-}11x10^4$
21	2006	7-28	71.8.26	160-958	2.8-10.6	0.1-32	1.6-68	$1\text{-}17x10^4$	$1\text{-}5x10^4$
21	2007	2-26	7-8.6	145-865	3.2-11.9	0-28	1.6-76	$3\text{-}17x10^4$	$0\text{-}9x10^4$
21	2008	4.5-23	7.0-8.5	162-843	1.2-12.4	0.0-48	1.0-172	$12\text{-}11x10^4$	$0\text{-}10x10^3$
22	2009	7.5-26	6.3-8.5	124-932	0.6-11.4	0.1-55	1.4-128	$4\text{-}25x10^4$	$0\text{-}11x10^4$
23	2010	4-27	4.2-8.6	155-982	4.1-11.1	0.1-40	-	$6\text{-}1x10^5$	$2\text{-}5x10^4$

Source: Status of water quality in India, 2010. Central Pollution Control Board

River Sutlej

Many important towns like Nangal, Ropar, Ludhiana and Ferozepur are situated along this river. About 119 industrial units covering thermal power plants, dying units, electroplating units, galvanizing units, wire drawing engineering goods, milk plant, pulp and paper industries, beverage/soft drink plants, breweries, used oil refining units, rubber industries (tiers and tubes), pesticide formulation industries, fertilizer units, sugar mills, bone mills, starch and chemicals, sports and surgical goods etc. are located along the river Sutlej.

Figure 8.4 : Trend of Water quality of river Sutlej between 2002 and 2010

Source: CPCB, 2010

The Punjab Pollution Control Board has been monitoring of certain heavy metals like nickel (Ni), chromium (Cr), cadmium (Cd), copper (Cu), zinc (Zn), lead (Pb), iron (Fe), arsenic (As) and mercury (Hg) and pesiticides (DDT, Endosulfan, Aldrin and BHC) since 2002 at five locations (Sutlej U/S Nangal, Sutlej D/S Rishabh Paper Mills, Sutlej D/S Budha Nallah, Sutlej D/S East Bein and Sutlej D/S Harike Lake) in water and sediments. Table 8.13 gives a comparative scenario for 2006 and 2008 for Sutlej.

Table 8.13: Heavy metal pollutants in Sutlej

*

	Parameters (mg/l)						
	Zinc	**Nickel**	**Tot.chrome**	**Cadmium**	**Lead**	**Iron**	**Copper**
2006	1.71	5.050	0.530	ND	0.15	9.0	0.390
2008	1.81	0.462	0.42	0.444	0.23	23.3	0.30
Permissible *	5.0	-	0.05	0.01	0.05	0.3	0.05

*

* Permissible limits for drinking water as per IS:10500:1991.

Source:http://www.ppcb.gov.in/river_Sutlej.php

River Beas

The important towns situated along the banks of river Beas are Talwara, Mukerian and Beas town. Data indicates that the quality of water of river Beas when it enters Punjab at Talwara is fairly good (class 'A'). The river has sufficiently high dissolved oxygen content (between 7 to 9 mg/l) and a well buffered pH system at this point. The quality of water remains so till it receives effluent and sewage from Mukerian town where it drops down generally to Class C and sometimes to Class D due to high BOD. The water quality improves due to self-purification upstream Beas town. Further downstream, the water quality deteriorates to Class C/D due to discharge of industrial effluents and sewage from

Goindwal town and industrial complex. However, the quality of water improves once again by the time it reaches Harike.

Summer/ winter average data, indicates a general improvement in the water quality of the river over the years, especially from 1999 onwards probably due to diversion of waste water from Mukerian Paper Mills for agriculture. The Board has also initiated monitoring of heavy metals and pesticides once in a year at two locations at Mukerian and at Goindwal along the river. Data indicates high concentration of Iron near Gowindwal. Three industries manufacturing sugar, alcohol and beverages have been identified along river Beas that are potentially polluting and are being monitored.

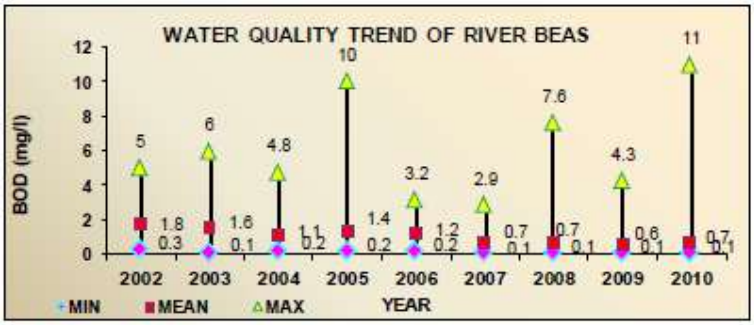


Figure 8.5 : Water quality trends in river Beas between 2002 and 2010

Source: CPCB 2010

River Ravi

There is only one sampling station U/S Madhopur Head Works, Pathankot on this river. The water quality of the river is more or less similar along its entire length. The water quality predominately conforms to A or B class. The physico-chemical analysis of water at Madhopur suggests that the water is clean and almost free from pollution. The concentration of salts, ions and nutrients are well within permissible limits (1993-1997 data as per CPCB). The water is slightly alkaline and well aerated. DO is high and BOD and COD contents are low. The total and faecal coliform are also low.

River Ghaggar

This river is predominantly a monsoonal stream. There are 12 sampling locations on the river. A general increasing trend in the BOD and COD values is observed since 1995 onwards indicating increase in pollution over the years. The feacal coliform values are also very high at times crossing the 5000 MPN/100ml limit specified for 'Class-C' quality water. The measured physico –chemical parameters of the river indicate high pollution near JharmalNadi and downstream Dhankansu Nallah. The Board has initiated heavy metal and pesticide monitoring in the river at three locations i.e. D/S Dhakansunallah, D/S Ratanheri and D/S Khanauri since 2002. High concentration of pesticides has been reported D/S Khanauri, in water.

A Pharmaceutical industry in village Banur, 10 industrial units in Dera Bassi, and plants of Milk foods limited have been identified as possible sources of pollution which directly or indirectly discharge their effluents into the river (*Source: http://www.ppcb.gov.in/ghaggar.php).*

Ground water quality

The quality of ground water is also deteriorating due to industrial and agricultural activities especially in the districts of Jalandhar, Ludhiana, Kapurthala, Patiala, Sangrur, etc. High TDS has been reported for these areas. Further, shallow ground water in some villages of districts Nawanshahr and Hoshiarpur have high Selenium content. Another problem in South West Punjab is that of water logging and salinity. Also see Chapter 4, section 4.3, Ground Water Contamination.

Air Quality

As of 2011-12, about 433 large scale industries, 294 medium scale industries and 11294 small scale units are operational in Punjab. With good road infrastructure, vehicular population is also high as seen in the section on transport. These are major causes of air pollution in the state. The Ambient Air Quality is being monitored by Punjab Pollution Control Board at 7 locations in residential/commercial areas and at 12 locations in industrial areas. Data indicates that PM10/ Respirable Suspended Particulate Matter is a major cause of concern with respect to air quality (**Figure 8.6**).

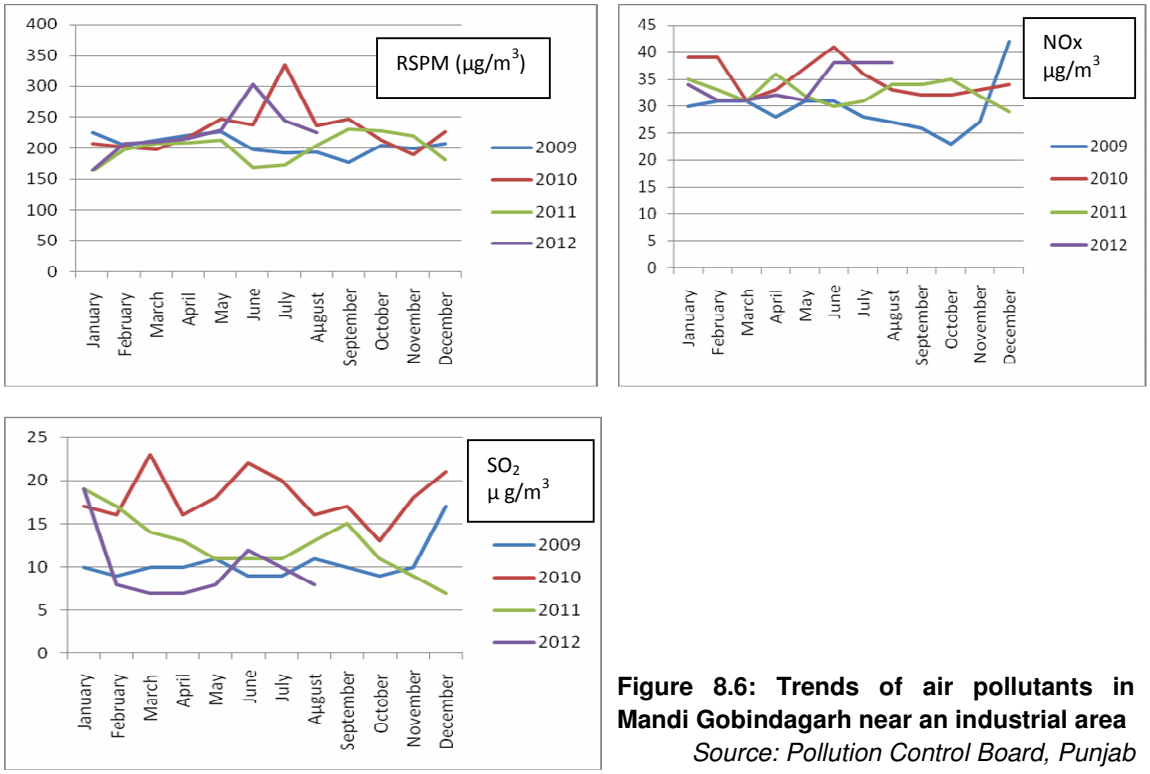


Figure 8.6: Trends of air pollutants in Mandi Gobindagarh near an industrial area
Source: Pollution Control Board, Punjab

8.10 CONCERNS DUE TO CLIMATE CHANGE

Enhanced urban heat island (UHI) effect

The urban heat island effect is another area of concern which is likely to escalate with increase in ambient temperature and as urbanization increases. As urban areas develop, changes occur in their landscape. Buildings, roads, and other infrastructure replacing open land and vegetation, surfaces that were once permeable and moist become impermeable and dry. These changes cause urban regions to become warmer than their rural surroundings, forming an "island" of higher temperatures in the landscape. Heat islands occur on the surface and in the atmosphere.

On a hot, sunny summer day, the sun can heat dry exposed urban surfaces, such as roofs and pavement, to temperatures 27–50°C hotter than the air, while shaded or moist surfaces—often in more rural surroundings—remain close to air temperatures. Surface urban heat islands are typically present during day and night, but tend to be strongest during the day when the sun is shining. Atmospheric urban heat islands are often weak during the late morning and throughout the day and become more pronounced after sunset due to the slow release of heat from urban infrastructure. The annual mean air temperature of a city with 1 million people or more can be 1–3°C warmer than its surroundings. On a clear, calm night, however, the temperature difference can be as much as 12°C. (*Source: Akbari, 2005)*

Such studies have been carried out for some cities such as Chennai and Delhi. The summary of the Delhi study is given in **Box 8.3**. Punjab being in the northern Indian region, the climate of its cities is similar to that of Delhi.

Elevated temperature from urban heat islands, particularly during summer, can affect a community's environment and quality of life. While some heat island impacts seem positive, such as lengthening the plant-growing season, most impacts are negative and include:

Box 8.3: Urban Heat Island Intensities (UHI) in Delhi

- Mohan et al, (2012) in May 2008 studied the UHI (Urban Heat Island Intensity) for the city of Delhi. Here UHI is defined as the difference in maximum temperature in urban built up areas with respect to average temperature observed in parks and forests within Delhi. Measurements of maximum and minimum temperatures were taken at areas with very dense urban canopy, medium dense urban canopy, less dense urban canopy and in industrial areas at 0300hrs (time when minimum temperature occurs), 0900 hrs (when temperature transition takes place -cool to heating), 1500 hrs (maximum temperature), and 2100 hrs (transition from hot to cooler temperature). The study indicates that :
- The UHI in the night i.e at 2100 is highest at 8.3°C in a very dense built up commercial areas in Delhi, In the afternoon at 1500 hrs the UHI of the same area goes maximum upto 7.6°C. At the time of minimum temperature epoch i.e at 0300 hrs, the UHI goes up to 5.6 °C. Considering that these were moderate summer conditions, the UHI obtained are reasonably high at various times of the day.
- During rainy conditions also city showed UHI in the range 2.2 °C to 3.7 °C
- The 3 top ranking UHI locations amongst the entire measurement network in the city are all commercial areas namely CP, Sitaram Bazar and Bhikaji Cama Place. Other pockets with reasonably high UHI are residential or mixed use namely Noida [Station No. 10], Dwarka [Station No. 6], Janakpuri [Station No. 12], Kaushambi [Station No. 16], Adarsh Nagar [Station No. 19] etc.
- Green and forest vegetation has a greater impact on lowering heat island effects as compared to a water body such as a river etc. in vicinity.
- The higher UHI around the time of peak temperatures in the city both in the afternoon hours and night hours increases the energy demand resulting into generation of more anthropogenic heat and thereby increasing the UHI. This would result into strengthening the vicious cycle which reinforces the need for urgent mitigation measures for urban heat centers.

Sources: Mohan et al., 2012

Increase in energy consumption:

Higher temperatures in summer increase energy demand for cooling and add pressure to the electricity grid during peak periods of demand. One study estimates that the heat island effect is responsible for 5–10% of peak electricity demand for cooling buildings in cities (*Akbari, 2005).*

Elevated emissions of air pollutants and greenhouse gases

Increasing energy demand generally results in greater emissions of air pollutants and greenhouse gas emissions from power plants. Higher air temperatures also promote the formation of ground-level ozone.

Compromised human health and comfort: Warmer days and nights, along with higher air pollution levels, can contribute to general discomfort, respiratory difficulties, heat cramps and exhaustion, non-fatal heat stroke and heat-related mortality.

Impaired water quality

Hot pavement and rooftop surfaces transfer their excess heat to stormwater, which then drains into storm sewers and raises water temperatures as it is released into streams, rivers, ponds, and lakes. Rapid temperature changes can be stressful to aquatic ecosystems.

Growth of cities and large-scale migration to urban areas has increased the population in cities (Refer to Table 8.1). The existing population now is disproportionate to the available infrastructural facilities and higher population and rising income levels have increased the vehicular population multi-fold. The Economically Weaker Sections in the cities are increasingly finding it difficult to acquire quality housing and with climate change, these sections may be exposed to extremities of climate making them more vulnerable than the rest of the population, unless fiscal support is provided to them towards retrofitting houses.

Transport system

The concerns of the transport system in the state of Punjab include:

- Decline in share of public transport system over the years and unabated increase in private 4 wheelers, causing road congestions and hence higher utilization of energy and GHG emissions.
- Low penetration of low carbon fuel usage though incentive programs are in place (like tax exemption for battery / compressed natural gas / solar power driven vehicles).
- Congestion on roads also due to trucks carrying freight plying between the industrial towns and outside.
- Poor walkability conditions/pedestrian infrastructure, discouraging people from walking.
- Practically no emphasis on infrastructure for non-motorised transport like cycles & cycle rickshaws.

Box 8.4: Unsustainable transport system - An example of Ludhiana

In Ludhiana the vehicle numbers have increased from 0.13 to 0.82 millions between 1982 and 2005, an increase by 6 times within a span of 23 years. An estimate for the city of Ludhiana indicates that, consumption of petrol by vehicles has increased from 13 thousand tons to 83.2 thousand tons between 1982 and 2005, and the diesel consumption has reduced from 90.8 thousand tons to 27.4 thousand tons in the same period. Indicating a direct increase in private passenger vehicles and almost no public (bus) transport system in recent years. This can be gauged from the fact that the ratio of public private mobility in Ludhiana between 1982 and 2005 decreased from 1.94 to 0.93.

Recently the Ludhiana city under the JNNURM project has planned modal shift to Public transport system.

Source: *Reddy and Balachandran, 2010.*

Extreme rain, Flash floods and Drainage

The cities lying within the flood plains in Punjab (**Figure 8.7**) in the districts of Kapurthala, Ludhiana, Jalandhar, Gurdaspur, and Nawanshahr may become susceptible to flash floods due to extreme rain fall and riverine flooding in a climate change scenario. The impacts are likely to be exacerbated as urbanization in general leads to decreased rates of infiltration and increased surface runoff as shown in **Table 8.14**. If the surface runoff generated exceeds the drainage capacity of the local storm-water drainage system then the area is flooded. Many a times, urban drainage facilities are either not in good shape or altogether missing which also reduces the drainage capacity of the area and causes flooding.

Table 8.14: Effect of Urbanization on Infiltration and Surface Runoff

Types of surfaces	Evapotranspiration	Shallow Infiltration	Deep Infiltration	Surface Runoff
Natural Ground cover	40%	25%	25%	10%
10-20% Impervious Surface	38%	21%	21%	20%
35-50% Impervious surface	35%	20%	15%	30%
75-100% Impervious surface	30%	10%	5%	55%

Source: Arnold and Gibins, 1996.

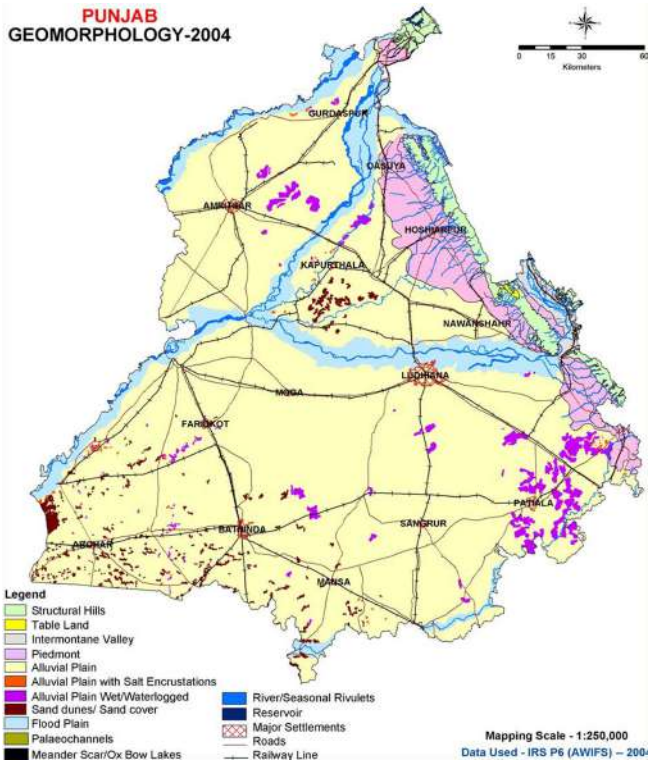


Figure 8.7: Geomorphology of Punjab

Water Supply

As can be seen from Table 8.2, dependence of water supply on ground water is increasing in the state. If this scenario continues, then recharging ground water needs to become the most important activity for the state to meet the increasing demand of water due to rise in population as well as rise in temperature. Considering that climate change scenarios are indicating towards more extreme rain fall events, which may flow off as flashfloods, catching the runoff for drinking water and irrigation also need to be one of the key activities of the state.

Water and Air Pollution

There are hardly any analyses on impacts of water quality on river flows within the Indian region. However, a recent study by Rehana and Majumdar (2011), examines the impact of change in climate variables on the water quality parameters. They establish a direct relationship between increase in air temperature, with increase in water temperature and decrease in water flows based on observed

data from one of the rivers in India. Further, a stream water quality model, QUAL2K[1] is run on six scenarios of future climate that assumes a rise in temperature by 1°C and a decrease in stream flow by 0%, 10% and 20%; and a rise in temperature by 2°C, with stream flow decrease by 0%, 10% and 20%. The results indicate that with increase in temperature and decrease in stream flow, there is a substantial decrease in the DO levels and increase in BOD and river water temperature. The study revealed that a decrease in stream flow of 20% and increase in temperature of 2°C showed a decrease of 1.02 mg/l in DO level. The DO decline is then likely to lead to major degradation in water quality conditions due to increase in oxygen-demanding source dischargers. Further, it was found that there is a significant decrease in DO levels due to the impact of climate change on temperature and flows, even when the discharges were at safe permissible levels set by pollution control agencies.

Considering that it is established that with warmer temperatures, the snow fed rivers of Punjab are likely to have initially faster flows, and then it will decrease, it is expected that the pollution build up will be higher in the rivers in the future when stream flows are low even if the current levels of fractional removal is done. Studies are required to quantify the levels of impacts. (Source*:* Rehana and Majumdar*,* 2011*).*

Carbon pollution from vehicles, power plants and other sources drives climate change, increasing ozone smog, allergens, and sending health-harming particles and toxics into the air.

Human Health

Global climate change will have multiple effects on human health. Diseases such as malaria, dengue, Kala-azar, diarrhea, heat stress related diseases, respiratory diseases may increase due to conducive climate conditions spreading to higher latitudes and disease agents adapting to enhanced temperatures and higher CO2 concentrations. Vulnerable population includes children, the elderly, and the poor—who are likely to be disproportionately affected in a warming scenario (IPCC, 2007b). In the year 2000, climate change related disease burden exceeded 150,000 deaths worldwide. Of this, 88% disease burden fell upon children (Scheffield and Landrigan, 2011). The elderly are also at risk especially for heat stress due to age-related physiological changes that make it harder to regulate temperature, sensitivity to dehydration, and limited mobility. Data from the United States shows that the highest death rates due to excess heat occur in persons aged 65 years or more (Basu and Samet, 2002). As number of elderly is likely to increase in the future with advances in Medicine and better health services, this age group will continue to be vulnerable. Similar will be the situation in India as it develops.

Malaria: Studies undertaken by Bhattacharya *et al,* 2006, Dhiman *et al.*, 2010 *and in NATCOM, 2012* on malaria and climate change reveal that the transmission windows of malaria in Punjab is likely to extend by 2–3 months.

Kala-azar: The link between re-emergence of kala-azar in northern parts of India appears to be due to changing climatic conditions (Singh *and Dhiman,* 2012).

Dengue and Chikangunya: Major issue of concern is urbanization in the context of Vector Borne Diseases (VBDs), particularly dengue and chikungunya. Impact of climate change on dengue also reveals increase in transmission with 2°C rise in temperature in northern India (*Source:* Dash *et al.,* 2007). In a preliminary study using A1B scenario of PRECIS model, transmission windows for dengue (20–32°C temperature and >55% Relative Humidity (RH)) were projected by the year 2030 which show increase in transmission months open for dengue transmission in northern areas and reduction in western part of southern India (NATCOM, *2012)*. However, it seems inconclusive in view of water storage practices, intra-domestic breeding of *Aedes* vector and socioeconomic conditions of inhabitants. Table 8.14 below summarizes the likely impacts of climate change on vector borne diseases.

[1]QUAL2K (or Q2K) is a river and stream water quality model (Brown and Barnwell 1987). It is typically used to assess the environmental impact of multiple pollution discharges along rivers. Pollutants can come from point sources such as industrial wastewater, municipal sewers, and storm water. Pollutants can also come from non-point sources such as agricultural or urban runoff, and commercial activity such as forestry, mining, and construction.

Table 8.14: Likely impacts on vector borne diseases with changes in climate variables

Vector borne disease	Driving climate and socio-economic Parameters	Likely manifestation
Malaria, Dengue, Chikungunya, Japanese Encephalytis, Kala-azar, Filariasis and others	Increase in maximum Temperature, RH remaining >55%	Wider spatial spread in the plains and spread to higher altitudes in the hilly areas in Punjab
		Windows of transmission may open for 6-8 months
		Emergence of new vectors
		Increase in Urban malaria
	Decrease in minimum temperature, RH remaining >55%	Possibility of dengue even in winters
	Increase in Precipitation and RH	Exodus from flooding conditions Increased breeding of mosquitoes if appropriate drainage does not take place
	Changes in Land use leading to changes in micro-climate, Changes in evapotranspiration, Increase in Surface runoff, and soil moisture e*tc.*	More pathogens breed at a shorter period of time leading to a probability of higher incidences of vector borne diseases
	Migration of population	Bringing in new vectors in the region that might acclimatize to the climate conditions.

Source: WHO, 2003

Heat Stress: Hot temperatures in combination with high humidity cause human discomfort and may increase morbidity and mortality. A paper by *Fischer et al.*, 2012, indicates that higher heat stress is experienced in urban areas compared to neighbouring rural areas (Also see section 8.10.1 on Urban heat island effect). It is projected that small changes in mean climate conditions will trigger relatively large changes in the frequency and severity of heat waves. Heat waves are therefore expected to increase in number and intensity in the future. By extrapolation from many prior studies, any future increase in the frequency and severity of heat waves will increase the risks of death and serious illness. The very old, the very young and the sick are particularly vulnerable to thermal stress. Children are less able than adults to modify their local (usually domestic) climate, especially if a heat wave is sudden and severe. In children, heat stroke is the most serious outcome of central or peripheral impairment of body temperature regulation, and may result in death. Some of the extreme heat related disorders are listed in **Table 8.15.** It is necessary to design ecofriendly rural and urban housing which uses material that will absorb least heat. The houses should also meet their energy requirements through renewable energy route generated within their premises or pooled from local area and also have the provision to use roof top solar heating systems, and harvest rain water.

Table.8.15: Extreme heat related health disorder: Direct impacts

Disorder	Cause	Seriousness
Heat rash	Heat buildup in the skin due to clogged pores and sweat ducts. Prolonged skin wetness from sweating.	Relatively minor.
Radiation burns	UV radiation absorbed by the skin.	Minor to relatively serious.
Transient heat fatigue	Loss of fluid reduces circulatory efficiency.	No long-term adverse effects.
Heat Syncope	The body's circulation system allows blood to "pool" in the lower extremities causing insufficient blood and oxygen in the brain	A victim takes a day or two to recover.

Heat Cramps	Loss of important electrolytes in the blood and muscle tissues due to excessive amounts of "salts" being lost in the victim's sweat.	May debilitate the victim for several days.
Heat Exhaustion	Depressed condition of the circulatory system due to a lack of adequate fluid replacement (dehydration).	Victims may require several days or even weeks to recover
Heat Stroke	The body's temperature regulation mechanism fails and sweating stops.	Medical emergency

Source: Fischer et al., 2012

Increase in allergens: Warmer air temperatures can influence the concentration of regional air pollutants and aero-allergens. Allergens such as pollens grow more profusely in a warmer climate leading to respiratory disorders such as asthma, emphysema and chronic bronchitis, and allergy problems. Similarly, moulds developing in humid climate resulting from excess rain are also the causes of respiratory diseases. (*Sources:* D'Amato 2001*;* D'Amato *et al.* 2002; Jacob *et al. 2002).*

*Increase in tropospheric Ozone: Due to v*ehicular pollution, particularly in metropolitan cities, heavy smog and haze is experienced resulting in asthmatic attacks. When combined with smog and other atmospheric pollutants, illness from allergic respiratory diseases, particularly asthma, could increase. Changes in the climate also affect diseases like chronic obstructive pulmonary disease, pneumothorax, and respiratory infections in children. There are also indications of relationship between air pollution and tuberculosis. The quality of air is likely to decrease as surface ozone concentrations begin to rise with increasing temperatures. This will lead to an increasing incidence of asthma and other cardiovascular and respiratory diseases. This issue is being addressed by the Govt. of India by introducing compressed natural gas (CNG) for transport. Also see **Table 8.16**. *(Sources: Seinfeld and Pandis, 2006; Salvi, 2007; Kirk Smith, 2000; Pope et al., 2002).*

Table 8.16: Likely impacts of climate change on pollutants and respiratory diseases

Climate Driver	Change in pollutants	Respiratory diseases implications
Increase in temperature	Increase in tropospheric ozone concentration with increase in temperature	° Reduced lung function ° Increase in chronic respiratory diseases and ° Increase in hospital admissions
	Increase in particulate matter in the atmosphere	° Increased symptoms and reduced lung function in asthmatic children. Higher mortality in adults including lung cancer deaths ° Increase in cardio-pulmonary hospital admissions
	Increase in indoor pollutants including black Carbon	° Increase ARI (Acute Respiratory Illness) in children and in COPD (Chronic Obstructive Pulmonary Disorder) in women.
	Increase in allergens- pollens, molds, dust mites in households, wet air fungal spora	° Outbreak and Exacerbations of asthma and allergic bronchitis.
Increase in precipitation	Increase in damp housing	° Respiratory ill health – coughing and wheezing in children and adults

Source: Seinfeld and Pandis 2006; Salvi, 2007; Kirk Smith, 2000; Pope et al., 2002

8.11 NATIONAL MISSION ON SUSTAINABLE HABITATS

The National Mission on Sustainable Habitat which is a component of the National Action Plan for Climate Change will broadly cover the following aspects:

Extension of the Energy Conservation Building Code, which addresses the design of new and large commercial buildings to optimize their energy

Better Urban Planning and Modal Shift to Public Transport. Making long term transport plans tofacilitate the growth of medium and small cities in such a way that ensures effi cient and convenient public transport.

Recycling of Material and Urban Waste management. A special area of focus will be development of technology for producing power from waste. The National Mission will include a major R&D programme, focusing on bio-chemical conversion, waste water use, sewage utilization and recycling options, plasma conversion of waste of biological origin to liquid fuels that can substitute for petroleum based fuels wherever possible.

Adapting to climate change: Apart from the above, the Mission would also facilitate adaptation to vulnerabilities arising out of climate change like adverse impacts on water resources, increased frequencies of extreme weather like droughts, fl oods, cyclones, storm water surges, rise in sea levels and human health.

8.12 PUNJAB MISSION ON SUSTAINABLE HABITATS

Through this mission Government of Punjab seeks to prepare the state to adapt to the likely increase in floods and higher temperature, adopt improved management of solid waste and recycling to extract energy and undertake better urban transport planning and fuel economy measures leading to efficient and convenient public transport systems.

The overall strategy for the Punjab Mission on Sustainable Habitats needs to:

- Develop policies and strategies that enable the cities to adapt to climate change concerns like increasing temperatures and extreme rain fall.
- Identify and implement GHG mitigation strategies emanating in urban planning especially in buildings, municipal solid waste and transport.

Strategy 1

Avert enhanced heat island affect and promote self-sustainability in cities: Adopt and implement ECBC/GRIHA norms for climate proofing building envelops of both old and new commercial, public and residential buildings in cities. All housing programmes/schemes[2] of the government for the EWSs to make provision for inclusion of building designs with ECBC norms to protect this section from extreme heat and also to introduce energy efficiency without any cost to the house buyer/owner. Undertake capacity building activities for architects, builders, residence owners and other stakeholders including suppliers of material for reducing energy absorption capacities of building envelops. Introduce and encourage retrofitting building envelopes. For example incentives may be provided for use or production of retrofitting material for buildings such as glasses, roof covering material, wall coatings, etc.

If these measures are introduced the building interiors can remain 10-16^{o}C cooler with respect to outside (see ECBC guidelines). PEDA will be the responsible agency for successful implementation.

Currently about 12686 MU of electricity is consumed by commercial and residential sectors in Punjab, which is 27% of the total electricity consumed (Refer to chapter 10). Of this about 50% is consumed towards space cooling. If the ECBC codes are instituted, then about 6342 MU of electricity can be saved all over Punjab.

[2] Integrated Housing and Slum Development programme (IHSDP), Houses to Houseless scheme of the state etc.

Promote higher share of renewables in total energy consumed (e.g. solar, recycle waste, wind) by cities in residential and commercial sector and in rural areas in residential areas. Promote extensively water conservation and water use efficiency measures. Following course of action may be taken:

- Mandatory waste water re-use for flushing and gardening.
- Houses over 500 sq yards not to be given sewerage connection unless mandatory solar water heating systems are installed (also made mandatory by Govt. of Punjab in 2012).
- Awareness generation for conservation of water amongst urban and rural population.
- Follow green building norms- that takes care of efficient lighting, heating, cooling, rain water harvesting.
- Allow harvested rain water to go directly into a central storage in the colony.
- More and more public utilities may be powered by renewables.
- 10 to 20kms of the peri-urban area to accommodate the population providing support services to the urban to avoid GHG emission from transporation.
- Incentivise procurement of green building material from nearby villages.

Strategy 1	12th plan	13th Plan	Total
Cost in each plan	Rs722.00	Rs722.00 Cr	Rs1444.00 Cr

Strategy 2

Address challenges associated with projected excess rainfall scenarios: Adapt to extreme rain fall and avoid flash floods in urban habitats in flood plains of Punjab

Action will include the following:

i. Study to analyse the likelihood of recurrence of extreme events and their intensities.

ii. Measures to reduce surface run off in urban areas by increasing infiltration – maximize the area under rainwater harvesting in identified towns and ground water recharge.

iii. Assess deficit in drainage system including pumping capacities and hydraulic capacities.

iv. Enhance drainage capacities of existing storm water drainage systems in towns in the flood plains.

v. Develop mechanisms to separate sewer and storm water drainage:

- Development of solid waste management systems to avoid clogging of drains.
- Bridge the gap between waste water generated and treated in waste water disposal systems.
- Construct Sewerage drains as per the required length for all cities – based on the gaps identified in the JNNURM vision documents of the cities but factoring in the excess water that is likely to flow through these drains.

Strategy 2	12th plan	13th Plan	Total
Cost in each plan	Rs. 15689.75 Cr	Rs 15,020.00	Rs. 30709.75 Cr

Strategy 3:

Contain pollution in river water in a warming scenario: This will include:

i. Ensure enough water flows at various check points to reduce the enhanced pollutant loadings with warming of river water in the river systems.
   - Assess the pollutant concentrations likely to remain per unit of water flow at higher temperatures.
   - Assess minimum flows that can sustain the pollution loads with increase in temperature and reassign the existing standards for pollution load in river water.

ii. Revise standard levels of pollutants that can be released from the industrial and domestic waste water discharges in order to make rivers less polluted in a climate change scenario.
   - Assess the saturation concentration of pollutants vis a vis water temperature.
   - Develop new standards for waste water discharge and disseminate.
   - Revise water quality monitoring protocol.
   - Assess the requirement and Deploy additional STPs.

iii. Ensure clean air in a warming scenario
   - Assess the saturation concentrations of air pollutants at higher temperatures.
   - Develop revised standards for air pollutant in order for it to be safe for breathing.
   - Strengthen air quality monitoring protocol.
   - Assess the requirement and deploy APCDs.

Strategy 4	12th plan	13th Plan	Total
Cost in each plan	Rs 60.00 Cr	Rs 2000.00 Cr	Rs 2060.00 Cr

Strategy 4:

Ensure human health security vis a vis impacts of climate change: :

i. Punjab Integrated Disease Surveillance Programme (IDSP) to cover all medical health units/facilities including rural health centres, govt and private hospitals and private clinics in all urban centres. All doctors need to report incidences online as soon as patient is diagnosed with identified climate related health issues – namely heat stress, respiratory diseases, water borne diseases, etc. Capacities of IDSP need to be enhanced accordingly in the state, vis a vis no. of epidemiologist required, data entry operators, and any other capacity building needs, etc.

ii. Develop capacities for short, medium and long term climate forecasts and different diseases occurrence probability for all the urban centres, keeping in view the topography and land use to alert citizens and institutions to prepare to take action to avert disease outbreak.

iii. Develop State programme on heat and cold stress management in line with the other national programmes such as the National vector borne disease programme, Revised National TB programme.

Strategy 3	12th plan	13th Plan	Total
Cost in each plan	Rs560.00 Cr	Rs320.00 Cr	Rs 880.00 Cr

Strategy 5

Develop a sustainable integrated transport system in Punjab

i. Policy shift to develop integrated public transport system as per the National Transport Policy 2006in major cities in Punjab. This can be achieved by:

a. Providing Metro in 4 cities (Amritsar, Jalandhar, Ludhiana and Mohali) and integrated feeder bus services to and from the metro stations.

b. Increasing density of public bus transport system to cater to the entire population in these 4 cities by 2017 (1st plan).

c. Creating additional parking spaces based on projected passenger vehicle density.

- Assessing Parking needs, space available and type of parking to be provided keeping in view the future projected vehicle numbers at least up to 2030 (13^{th} plan) for all 4 cities.
- Constructing parking facilities in all 4 Class I and Class II cities in Punjab. Partial cost of construction to be met from car owners through parking charges. The charges need to be fairly high to act as a disincentive.

d. Decongesting roads by building separate tracks for pedestrians and non-motorized transport.

- Assessing requirement of road lengths and breadth based on current and future non-motorized transport numbers.
- Introducing tracks for non-motorized transport along existing roads.

ii. Reduce congestion, improve operational efficiency, reduce noise and air pollution:

a. Introduce intelligent traffic management systems.

b. Install dynamic traffic lights that can operate on the basis of level of congestion on the roads at different times of the day and can, therefore, divert traffic in advance to other roads to ease congestion and can adjust times for stopping traffic at signals according to the traffic flow.

c. Build intelligent systems in 3 cities to be completed by end of 2022. Core areas to be brought under this system by 12th plan and the peripheries by the end of 13th plan.

d. Introduce car free zones and car free days.

iii. Promote Low Carbon Transport system:

a. Introduce a fast moving rail freight corridor between the industrial towns of Punjab (Amritsar, Ludhiana, Jalandhar) to connect to the dedicated rail freight corridor being constructed from Ludhiana to Kolkata in the east and Mumbai in the west.

b. Promote utilization of Battery operated/SPV operated/ alternate fuel run small bus services to travel small distances – like battery operated polo cars. Share to increase by atleast 1% of the total transport system.

c. Reduce emissions from diesel operated heavy duty trucks carrying goods across industrial towns in Punjab.

d. Raise awareness on better driving practices and maintenance of trucks to enhance fuel efficiency.

e. Promote car free days in different zones alternatively in a week in all major cities in Punjab

f. Declare markets and heritage areas as no fossil fuel driven vehicle zones - Identify, demarcate and develop all the markets as only walking areas and where only battery operated vehicles owned by the respective associations- no public/private passenger vehicles to be allowed.

iv. Enhance fuel efficiency and reduce emissions from transport sector.

a. Use bus simulators and infrastructure to raise awareness of better driving practices and maintenance of buses.

b. Enhance fuel efficiency in bus transport and reduce GHG emissions by replacing700 old buses of Punjab Roadways with buses with engines that can run on fuel having the latest emission norms(EURO—IV).

Strategy 5	12th plan	13th Plan	Total
Cost in each plan	Rs. 15355.57 Cr	Rs.15028.47Cr	Rs.30384.04 Cr

Strategy 6

Avail waste to energy in Major cities in Punjab

Use municipal solid waste to generate electricity. It is envisaged to realize 20% of 100 MW energy generation potential from municipal solid waste generated in Punjab by 2022 (end of 13th plan). ULBs will be responsible for implementation of waste to energy projects.

Strategy 6	**12th plan**	**13th Plan**	**Total**
Cost in each plan	Rs 160.00 Cr	Rs 165.00 CR	Rs 325.00 Cr

Total Cost for implementing the entire mission is as follows:

Cost in 12th Plan	Rs. 32547.32 Cr
Cost in 13th Plan	Rs. 33255.47 Cr
Total Cost (12th+13th Plan)	Rs. 65802.79Cr

The details of the strategies are provided in Annexure 3.

REFERENCES

1. Arnold, Chester L. Jr. and C. James Gibbons, 1996. Impervious surface coverage: The emergence of a key environmental indicator. American Planning Association. Journal of the American Planning Association; 62, 2; pg. 243.

2. Basu, R., and J.M. Samet. 2002. Relation between Elevated Ambient Temperature and Mortality:A Review of the Epidemiologic Evidence. Epidemiologic Reviews 24(2): 190–202.

3. Bhattacharya S., C. Sharma, R. C. Dhiman, A. P.Mitra, 2006. Climate change and Malaria in India.CurrentScience. 90 (3): 369-375.

4. Brown L. C. and T. O. Barnwell. 1987. Enhanced stream water qualitymodels, QUAL2E and QUAL2E UNCAS—Documentation and user's Tech. Report. US EPA.

5. Census, 2001, 2011 and various others, Census of India. Government of India.

6. CPCB 2010. Status of Water Quality in India- 2010.Monitoring of Indian National Aquatic Resources- Series MINARS, 2010-2011. Central Pollution Control Board, MoEF, GoI.

7. CPCB, 2011. Status of water quality in India, 2010.Central Pollution Control Board, Ministry of Environment and Forests, Government of India. Series: MINARS/ /2010-11.http://www.indiaenvironmentportal.org.in/files/file/WQSTATUS_REPORT2010.pdf. Accessed on Feb 2013.

8. D'Amato, G., G. Liccardi, M. D'Amato, M. Cazzola, 2002. Outdoor air pollution, climatic changes and allergic bronchial asthma. In: G. D'Amato G and S. Holgate (eds.),. The impact of air pollution on respiratory health. EurRespir Monograph; 21: 30–51.

9. D'Amato, G. 2001. Airborne pauci-micronic allergen-carrying particlesand seasonal respiratory allergy (Editorial). Allergy; 56:1109–11.

10. Dash, S.K. and J. C. R. Hunt, 2007. Variability of climate change in India. CurrSci; 93: 782–788.

11. Dhiman, R.C., S. Pahwa, G. P S. Dhillon, A. P. Dash, 2010. Climate change and threat of vector borne diseases in India: are we prepared? Parasitol Res ; 106: 763–73. doi: 10.1007/s00436-010-1767-4.

12. ESP, 2011. Environment Statistics of Punjab 2011. Published by Economic and Statistical Organisation, Chandigarh, Punjab, pp144.

13. Fischer, E.M., K. W. Oleson, and D. M. Lawrence, 2012. Contrasting urban and rural heat stress responses to climate change. Geophysical Research Letters, vol 39, L03705, 8 PP, 2012, doi: 10.1029/2011GL050576.

14. Fisk, W.J., Q. Lei-Gomez, M, J. Mendell, 2007. Meta-analyses of the associations of respiratory health effects with dampness and mold in homes. Indoor Air; 17: 284–296.

15. PbIDSP, 2013. Punjab Integrated Diseases Surveillance Project. http://pbhealth.gov.in/IDSP%20status%202011.pdf accessed on February 2013.

16. Reddy Sudhakar and P Balachandran,2010. Dynamic mobility- A comparative study of megacities in India, http://www.igidr.ac.in/pdf/publication/WP-2010-023. Accessed on Feb 2013.

17. Jacob, B., B. Ritz, B., U. Gehring, A. Koch, W. Bischof, H. E. Wichmann, and J. Heinrich, 2002. Indoor exposure to molds and allergic sensitization. Environ Health Perspect; 110: 647–653.

18. Manju, M., Y. Kikegawa, S. Bhati, A. Kandya, K.Ogawa, 2009. Assessment of Heat island Intensities over Delhi, The 7th international convention on climate.29th June to 3rd July, Yokohama Japan.

19. Manju, M., A. Kandya, , A. Battiporolrban,2011, Heat Island Effect over National Capital Region of India: A Study using the Temperature Trends; Journal of Environmental Protection, 2, 465-472 doi:10.4236/jep.2011.24054 Published Online June 2011 (http://www.SciRP.org/journal/jep).

20. Manoj, K., 2012. An epidemiological study on effect of air pollutants on respiratory morbidity in adults of a critically polluted city of northern India. Published in Scientific Research and Essays Vol. 7(28), pp. 2448-2456, 26 July, 2012 Available online at http://www.academicjournals.org/SRE DOI: 10.5897/SRE11.999 ISSN 1992-2248 ©2012 Academic Journals).

21. Medina-Ramo´n, M., A. Zanobetti, J. Schwartz, 2006. The effect of ozone and PM10 on hospital admissions for pneumonia and chronic obstructive pulmonary disease: a national multicity study. Am J Epidemiol; 163: 579–588.

22. MoRTH, 2012. Road Transport Year Book (2009-10 & 2010-11). Published by the Transport Research Wing, Ministry of Road Transport and Highways Government of India, pp133.

23. NATCOM 2012.India second national communication to the United Nations Framework Convention on Climate Change. New Delhi: Ministry of Environment and Forests.

24. PbDoHFW, 2013. Data on malaria incidences recorded in Punjab as per the guidelines of the National Vector Borne Disease Control Programme, http://pbhealth.gov.in/pdf/malaria.pdf. Accessed on Feb 2013.

25. Ramachandra, T. V., and Shwetmala, 2009. Emissions from India's transport sector: Statewise synthesis. Atmospheric, Environment, doi:10.1016/j.atmosenv.2009.07.015.

26. Singh, K., Poonam and R, C. Dhiman. 2012. Climate Change and Human Health: Indian Context – Review Article. Journal of Vector Borne Dis. 49, pp. 55–60.

27. Singh, P.K. and R. C. Dhiman, 2012. Climate change and human health: Indian context. J Vector Borne Dis. 49(2):55-60.

28. Kirk, S., 2000. National burden of disease in India from indoor air pollution. PNAS, November 21, vol. 97, no. 24, pp13286–13293.

29. Pope, C.A. 3rd, R. T. Burnett, M. J. Thun, 2002. Lung cancer, cardiopulmonary mortality, and long-term exposure to fine particulate air pollution. JAMA; 287: 1132–1141).

30. Rehana, and P. P. Majumdar, 2011. River water quality response under hypothetical climate change scenario in Tungabhadra river India. Hydrological Processes. Published online by Wiley online library.DOI 10.1002/hyp 8057).

31. Salvi, S. 2007. Health effects of ambient air pollution in children. PaediatrRespir Rev; 8: pp. 275–280.

32. SAP, 2010.Statistical Abstract of Punjab, 2010. Punjab Planning Board, Gov of Punjab.

33. Sheffield, Perry E. and Philip J. Landrigan, 2011. Global Climate Change and Children's Health: Threats and Strategies for Prevention. Environmental Health Perspectives, volume 119, number 3, pp291-298.

34. Seinfeld, J.H., and S. N. Pandis, 2006. Atmospheric chemistry and physics: from air pollution to climate change. Wiley, New York, New York.

35. Singh, B., S. Mallik, N. Kumar, M. Ali, R. K. Mehra, P. Kumar, 2011. Respiratory tracts problems associated with allergies in Punja, India – Asurvey.Indian Journal of Pharmacy Practice, vol 4, issue 4.

36. Uysal, N. and R. M Schapira, 2003. Effects of ozone on lung function and lung diseases. CurrOpinPulm Med; 9: 144–150.

37. WHO, 2003.Climate change and human health - risks and responses. Published by WHO in collaboration with WMO and UNEP. Summary available athttp://www.who.int/globalchange/summary/en/index.html. Accessed on February 2013.

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9. Renewable Energy Development and Solar Mission

HIGHLIGHTS

- Status of Renewable Energy Development in Punjab
- Additional Sources of New Renewable Energy Being Encouraged
- Policies Driving Renewable Energy Development in Punjab and Achievements
- Institutions Involved in the Management Of New and Renewable Energy Development in the State
- Strategies To Propagate Solar Energy in The State

9.1 STATUS OF NEW AND RENEWABLE ENERGY DEVELOPMENT IN PUNJAB AND ACHIEVEMENTS

Energy production using fossil fuels is the major contributor to greenhouse gas emissions in the atmosphere, which is perceived to be the main cause for global warming since the process of industrialization started in late 19th century. Evidences collated by IPCC (IPCC, 2007a) clearly indicate that the warming is having a deleterious effect on ecosystems and its services across the globe. Transitioning to a low-carbon energy economy is a way out for mitigation of the impacts of climate change and energy generation through New and Renewable Sources of Energy (NRSE) provide an opportunity for such transition.

Punjab has been developing its renewable energy resources for some time now and a status of these developments is presented in the following sections.

Solar energy

The state is endowed with vast potential of solar energy estimated at 4-7 KWH/sqm of solar insulation levels. About 10.50 MW of solar power projects have been commissioned by December 2013 . Additionally, a under rooftop programme about 1100 KWp capacity Solar Photovoltaic Power Project has been commissioned in the state at various important Govt., Institutional, and Religious buildings namely Punjab Raj Bhawan, Punjab Civil Secretariat, Golden Temple, Wagah Border, Punjab Agricultural University, Ludhiana and PushpaGujral Science City, Kapurthala. Rooftop projects shall continue to be promoted in all sectors in order to enhance the share of solar power in the state. Other than this, solar street lighting and solar water heating projects are also being supported by Punjab Energy Development Agency (PEDA). Details of Solar related projects are listed in **Table 9.1**.

Table 9.1: Details of the projects commissioned/ sanctioned/ short listed and completed that can be linked to the solar mission:

Location & District	Capacity
Solar Power Projects of MW Capacity so far commissioned through PEDA	
Vill. Khera Kalmout, Distt. Patiala by M/s Soma Enterprises Ltd., Patiala	1MW
Vill. Mehandipur, Distt. Saheed Bhagat Singh Nagar by M/s Sovox Renewables Pvt. Ltd., New Delhi	1 MW
Vill. Boparai Kalan, Distt. Ludhiana by M/s Econergy Inc., USA	1 MW
Vill. Bhuttiwala, Distt. Mukatsar by M/s G.S. Atwal& Co. (Engineers)	1.5 MW

Location & District	Capacity
Pvt. Ltd., Kolkata.	
Vill. Bhagsar, Distt. Mukatsar by M/s Carlill energy Pvt. Ltd., Chandigarh	1.5 MW
Vill. Awan, Distt. Amritsar by M/s. Azure Power	2.00 MW
Vill. Shahdra, Distt. Saheed Bhagat Singh Nagar M/s Enterprises Business Solution Inc., Jalandhar	1.5 MW
Vill. Phollukhari Distt. Bathinda BY PEDA	1.00 MW
TOTAL	**10. 5 MW**
Roof Top Solar Power Project Systems Installed By PEDA Under MNRE, GOI	
SPV Power Plant at Vill. Bajak, Distt. Bathinda	50
SPV Power Plant at Vill. KhatkarKalan, Distt. Sahid Bhagat Singh Nagar	200
PAU, Ludhiana. (2X50)	100
Shivalik Public School,Mohali	50
Pushpa Gujral Science City Kapurthala	100
SPV Power Plant at Mini Secretariat, Chandigarh	50
SPV Power Plant at PEDA Solar Passive Complex, Chandigarh	25
Shivalik Public School, Chandigarh.	50
Judicial Academy Chandigarh	50
Beant College of Engineering and Technology , Gurdaspur	50
Golden Temple, Amritsar	25
DurgianaMandir, Amritsar	10
BSF Complex Wagha Border, Amritsar	15
World Sikh Heritage Centre, Anandpur sahib	25
Governor House Punjab, Chandigarh	45
Punjab Civil Secretariat, Chandigarh	12
Punjab State Assembly, Chandigarh	20
SPV Power Plant at Parliament House, New Delhi	80

Location & District	Capacity
Village Kairon Distt Tarn Taran	25
Village Pahuvind Distt Tarn Taran	10
Village Dhun Distt Tarn Taran	5
Village Bhura KohnaDistt Tarn Taran	10
Village Maniala Jai Singh Distt Tarn Taran	10
Village Babehali Distt. Gurdaspur	10
Village Lehal Distt. Gurdaspur	10
Village Nanowal Khurd Distt. Gurdaspur	10
Village Ghaniye Ke Bet Distt. Gurdaspur	10
Village Kalanaur Distt. Gurdaspur	20
Village Hardowal Kalan Distt. Gurdaspur	10
Village Khwaja Wardag Distt. Gurdaspur	10
Village Lodhi Nangal Distt. Gurdaspur	10
Total	**1107**
Water Heating	
Solar water heating system (LPD)	29.20 lakh LPD commissioned
Street Lighting	
Solar street lighting (Nos.)	5300 commissioned

Source: PEDA, 2013 ., NRSE Policy, 2012

Hydro-electricity

The potential power generation capacity of the state from its extensive canal systems is about 250 MW at Canal falls, out of which 133 MW capacity projects are in operation. The Shirhind Canal system, Bhakra Main line, Bist Doab Canal off taking from Ropar Head works and Upper Bari Doab Canal systems are being harnessed to generate electricity through building small, mini and micro hydel units across these canals. Another 23 MW capacities are under execution including hydel projects undertaken by Punjab State Power Corporation Limited (PSPCL). The State Government is committed to exploit the total potential by the year 2022. In addition to the sites already identified by PEDA in association with Punjab Irrigation Department (PID) and PSPCL, private investors can also apply for self-identified sites in case of small / mini hydel projects, which are not included in the list of projects identified by PEDA.

Wind

In the state of Punjab, as per an earlier Wind Resource Assessment carried out, there is no wind speed at lower heights (25 Mtrs.). However, there is a possibility of higher wind speeds at heights close to 100 meters, which can be harnessed with the improvement in low speed wind power technology. PEDA in a recent initiative to develop the wind energy, has signed MoUs with two major wind power companies for wind resource assessment and on completion of the wind speed assessments, it will set up wind power projects in the state (*Source: http://www.peda.gov.in/eng/Wind%20Power%20Projects.html).*

Biomass

Large Biogas plants **-** High rate Biomethanation Projects (biogas) based on anaerobic digestion technology for Recovery of Energy of about 1MW from Dairy Waste at Haibowal, Ludhiana is operational since 2004. Plans are on to increase the capacity of energy generation from 1MW to 10 MW. Another project of similar capacity ~ 1MW has been approved in Jalandhar. It will also be Cattle Dung based Power Project at Jamsher Dairy Complex, Jalandhar, allotted to M/s. Shakti Enviro Greens Private Limited, Delhi, on Build, Operate & Own (BOO) basis. For this project, all statutory

clearances have been obtained by the company and Implementation Agreement has been signed with PEDA.

Small biogas plants: Numerous biogas plants of about 6cu m size have been installed across the villages in Punjab. The individual families in the villages have been beneficiary as PEDA has provided financial subsidies for setting up the same.

Co-generation: *Co-generation* technologies are used for converting dry biomass (crop residues) for co-generation in sugar, paper, fertilizer chemical, textile and other industries. These industries together are having an estimated co-generation potential of 500 MW. As of December 2013 , about 382 MW of power was commissioned through co-generation and 30 MW was proposed to be added in 2013 -2014. It is proposed to encourage the industry to set up co-gen plants and achieve capacity addition of 500 MW by 2022. These projects shall meet the qualifying criteria of Ministry of New and Renewable Energy (MNRE) under topping cycle as adopted by Central Electricity Regulatory Commission (CERC).

Power generation from Biomass/Agro-residue and waste: Punjab being primarily an agrarian economy, has a high potential for energy generation from agro- residues like paddy straw, paddy husk, cotton stalk, etc. It is estimated that surplus agro residues (including rice straw) and agro industrial/processing waste produced annually can generate 1500 MW of power. PEDA has so far allocated a total of 200 MW capacity Biomass Power Plants in the state and, seven projects of total capacity 62.5 MW have been commissioned. The State Government is committed to support and facilitate harnessing the total potential by the year 2022. One Independent Power Producer (IPP) Biomass project shall be allocated in a Tehsil (Taluka) in the state so as to provide for a sufficient command area for biomass resource as fuel for the project.

Table 9.2: Summary of renewable energy development in Punjab

Energy Sources	Country Potential	State Potential	Power Generation
Biogas plants	12 Million (Nos.)	4,24,700 (nos.)	164 MW installed
Biomass	17000 MW	1500 MW	444 MW(382 Biomass Cogeneration and 62.5 Biomass (IPP))
Solar energy	5x 10^{12} MW	2600 MW	10.5 MW (commissioned till December 2014)
Small hydro	10,000 MW	200 MW	133.65 MW (including PSPCL 97 MW)
Biomass Cogeneration	6000 MW	500 MW	382 MW included in Biomass

Source: PEDA, 2012 a, b, c, d, e, f, and g; Pb NRSE policy, 2012

9.2 ADDITIONAL SOURCES OF NEW AND RENEWABLE ENERGY BEING ENCOURAGED

Energy Plantations, Rice mills integrated small capacity Biomass Plants

Land in areas that are degraded/waste land in Punjab can be used for raising dedicated plantations of fast growing high yielding plant species such as *Bambusa balcooa, Melia dubia,* etc. for generating decentralized energy needs on sustainable basis in rural areas. Small capacity biomass plants in IPP mode up to 5 MW capacities only based on dedicated energy plantations or integrated in rice mills can be setup with the condition that 50% of the biomass used has to be rice straw. These projects can not infringe upon the command area of the allocated *Taluka* based biomass IPP projects. These small capacity projects can be set up in technology neutral mode i.e. Rankin cycle, Gasification cycle or Otto cycle.

Urban Municipal and Industrial Liquid and Solid Waste

At present about 5000 Metric Tonnes of Municipal, Urban and Industrial solid waste is being produced every day in the urban areas of the State. Introducing scientific processing and treatment of this quantity of waste would add to power generation besides being environmentally benign. Punjab intends to launch 5 such projects in the State. PEDA shall act as a facilitator for Waste to Energy projects, where Department of Local Government is directly involved in project allotment. PEDA will allot waste to energy projects to private developers based on cattle dung, vegetable waste, poultry waste, etc. for power generation through biomethanation process on first come first serve basis as self-identified projects.

Fuel cells, Hydrogen energy, geothermal energy, and Bio fuels

All these technologies have great potential of becoming tomorrows RE technologies. All such new NRSE based technologies which can be beneficial to the state are proposed to be adopted and will be eligible for getting all incentives under the NRSE Policy.

9.3 POLICIES DRIVING RENEWABLE ENERGY DEVELOPMENT IN PUNJAB

Policies

In India, legislative, regulatory and governmental initiatives have been initiated to boost the renewable energy sector. These include

- Enactment of the Electricity Act, 2003 enabling disaggregated renewable energy generation and enabling power utilities to purchase a percentage of their power procurement from such sources
- Formation of the Central Electricity Regulatory Commission (CERC),
- Introduction of Renewable Energy Tariff Regulations,
- Initiating Renewable Energy Certificate (REC) mechanism and Setting Regulations on Renewable Purchase Obligation, and
- Providing guidance for solar energy development and energy efficiency through Jawaharlal Nehru National Solar Mission and National Mission for Enhanced Energy Efficiency (NMEEE) of the National Action Plan on Climate Change.

All these have accelerated the growth of renewable energy generation, energy efficiency and conservation in the country.

To bring in a thrust on renewable energy development in the state, the Punjab Government brought in the New and Renewable Sources of Energy (NRSE)Policy in 2006 and in December 2012, the state replaced it with NRSE Policy, 2012, where by the target is :

- To maximize and improve the share of new and renewable sources of energy to 10% of the total installed power capacity in the state by 2022. NRSE sector wise details are mentioned separately.
- To promote renewable energy initiatives for meeting energy / lighting needs in rural areas and supplementing energy needs in urban, industrial and commercial sectors.
- Strategies to implement the objectives would include:
- Creation of conducive conditions for attracting private sector investment in NRSE projects along with broader participation by public community/civil society.
- Encouraging decentralized generation of renewable energy for agriculture, industry, commercial and household sectors particularly in rural areas thereby improving the quality of power and reducing transmission & distribution losses.

- Providing support to specific NRSE projects and schemes for generating energy and conserving energy through energy efficiency.
- Support research and development, demonstration and commercialization of new and emerging technologies in renewable energy sector such as fuel cell, hydrogen and chemical energy, alternate fuels for transportation, etc.

Projects on all renewable sources such as small hydro projects, biomass combustion and gasification, biomass and baggasse Co-generation process, Solar Photovoltaic, Solar Thermal, Urban, Municipal and Industrial Waste, Wind Electric Generators, Biomethanation and New NRSE technologies like fuel cells/Hydrogen/Biofuel technologies of any capacity etc. will be eligible to avail the assistance as per the incentives provided for in this policy.

Incentives provided in the Punjab NRSE Policy, 2012

Leasing of land: Government land may be provided on lease at a notional price decided by the government for the project. The leasing will be done by PEDA from concerned departments of the state owning the land.

Financial fiscal and incentives: The financial incentives include

- Payment of cess only @ one paisa per unit of electricity generated for use of river/ canal water for small hydropower projects.
- The NRSE Power Generation and consumption by generators themselves as a captive unit from NRSE projects shall be fully exempted from levy of Electricity Duty.
- 50% Electricity Duty for power consumed from state licensee during construction and testing of the project shall be waived.
- Octroi on NRSE fuels to be used for energy generation and NRSE devices/equipment/machinery for NRSE Power Projects shall be fully exempted.
- Similarly Octroi on self-consumption of power by captive power plants in the same premises or thru wheeling by open access to same group companies shall also be exempted.
- Manufacturing & sale of NRSE devices/systems, and equipments / machinery required for NRSE Power Projects shall be exempted from Value Added Tax (VAT) and any cess there upon.
- 100% Exemption will be provided from entry tax in respect of all supplies (including capital goods, civil construction material and raw materials) made for setting up and trial operations of the projects.
- 100% exemption from payment of fee and stamp duty for registration/lease deed charges for the land where the project is to be set up.
- Agricultural land shall be allowed to be used for setting up of Renewable Energy Power Projects in the state and no CLU, EDC/or any other charges/fees for the same shall be charged by the Town & Country Planning Deptt. or Revenue Deptt or Local Bodies for change of land use.
- Solar Power projects less than 5 MW capacities shall be exempt from obtaining any NOC/consent under Pollution control laws from the Punjab Pollution Control Board.

All projects developed under this policy will be treated as industry in terms of industrial policy of the state and all the incentives available to new industrial projects will be applicable to Renewable power projects set up under this policy as per industrial policy of the state. Any benefits under any relevant policy such as Mega projects Policy of State Government can be availed by the project covered under this policy, subject to qualifications, if any, and subject to conditions as may be prescribed on case to case basis.

Incentives for supplying electricity to the grid: All can connect to the Grid for supplying power. PSPCL/PSTCL will accept the injection of energy in full even during sustained high frequency hours to ensure full utilization of non-conventional energy resources. Grid interface infrastructure will only be

provided/setup by PSPCL for projects that supply power to the grid on preferential tariff or Average Power Procurement cost on long term basis.

Power Transmission: PSPCL/PSTCL will undertake to transmit/wheel the surplus power through its grid, and make it available to the producer for captive use in the same company units located in the state or third party sale within the State at a uniform wheeling charge of 2% of the energy fed to the grid, irrespective of the distance from the generating station. Such wheeling and/or transmission of power shall be governed by Open Access Regulations /procedures. The captive power production and consumption by beneficiaries i. e. same group companies shall meet the requirements laid down in Electricity Rules, 2005. The NRSE Project developer as per entitlement under the policy will also be allowed interstate open access in accordance with the open access regulations of the appropriate commission.

Tariff for Sale of Power*:* The preferential tariff of sale of power to the PSPCL/PSTCL from NRSE projects to be set up under this NRSE policy 2012 shall be as notified by the PSERC for the year in which the scheduled date of commissioning of the project falls.

Banking: The banking facility for the power generated shall be allowed for a period of one year by the PSPCL/PSTCL. However, power banked during non peak hours will be allowed to be drawn during non-peak hours only.

Renewable Energy Certification in the state

Since there have been constraints in development of renewable energy evenly across the country such as high costs, the concept of Renewable Energy Certificate (REC) mechanism has been introduced in the country that seeks to address the mismatch between availability of RE sources and the requirement of the obligated entities to meet their renewable purchase obligation by purchasing green attributes of renewable energy remotely located in the form of Renewable Energy Certificate (REC).

The National Action Plan on Climate Change (NAPCC) had set the target of 5% renewable energy purchase for FY 2009-10 which is stipulated to increase by 1%for next 10 years. The NAPCC further recommends strong regulatory measures to fulfill these targets. The renewable purchase obligation (RPO) as well as preferential tariff for procurement of such power has been specified by various State Electricity Regulatory Commissions (SERCs).

As per Punjab State Electricity Regulatory Commission (PSERC) Regulations of June 3, 2011 the Renewable Purchase Obligation (RPO) of the Obligated Entities has been fixed for the State of Punjab in percentage terms of total energy consumed at boundary of the state (see **Table 9.3**). It is anticipated that by 2014-15 the energy consumption in the state will raise by 55427 MU from 43974 MY in 2011-12.

Table 9.3: Renewable Purchase Obligation for the state of Punjab as fixed by the PSERC

Year	Total %	Solar%	Non solar%
2011-12	2.4	0.03	2.37
2012-13	2.9	0.07	2.83
2013-14	3.5	0.13	3.37
2014-15	4.0	0.19	3.81

Source: PbNRSE Policy, 2012

In January 2010, the Central Electricity Regulatory Commission (CERC) announced Regulation on Terms and Conditions for recognition and issuance of Renewable Energy Certificate for Renewable Energy Generation. According to this regulation, a generating company involved in electricity generation from renewable sources of energy will be eligible to get Renewable Energy Certificate (REC) for each 1 MWh (1000 unit) of power it generates from renewable energy sources.

The Punjab Electricity Regulatory Commission (PSERC) has appointed Punjab Energy Development Agency (PEDA) for implementing REC mechanism in the state of Punjab and a few projects have been accredited and registered by the REC registry of India (**see Table 9.4**).

Table 9.4: Projects in Punjab registered and accredited by the Renewable Energy Certificate Registry of India

	Energy source	RE Generator	Capacity (Mw)
1	Biomass	Satia industries Ltd.	10
2	Biomass	Nahar Industrial Enterprises Ltd.	10.775
3	Biofuel cogeneration	AB Sugars Ltd.	10
4	Biomas	Ambuja Cement Ltd.	3.5
5.	Biomass	Satia industries Ltd	5

Source: RE Registry, 2013

9.4 INSTITUTIONS INVOLVED IN THE MANAGEMENT OF NEW AND RENEWABLE ENERGY DEVELOPMENT IN THE STATE

Punjab Energy Development Agency (PEDA): PEDA was set up by Govt. of Punjab in 1991 to provide thrust to renewable energy development in the state. PEDA is presently the state nodal agency in Punjab for promotion, development and allocation of Renewable Energy projects, implementation of Clean Development Mechanism (CDM) for claiming carbon credits, implementation of the Energy Conservation Act, 2001 and Accreditation of Renewable Energy Projects for Renewable Energy Certificate (REC) mechanism. It has also been made the nodal agency for implementing the NRSE Policy, 2012 by the Punjab govt.

PEDA is implementing new and renewable energy projects in collaboration with other departments in the state and also through its fully owned subsidiary company GENCO and through public private partnership. The institutional mechanism through which PEDA implements its new and renewable energy projects in the state is shown in **Figure 9.1.**

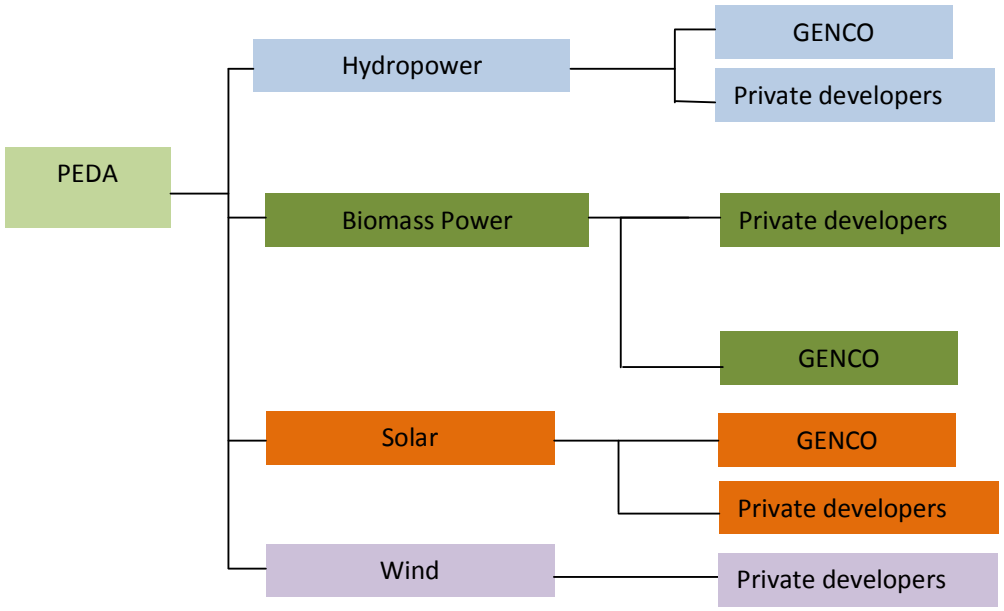


Figure 9.1: PEDA and its activities

Other institutions/Deptts. of Punjab Government involved in supporting the Renewable energy development in the state include:

Punjab State Electricity Regulatory Commission (PSERC): PSERC sets the Renewable Purchase Obligation (RPO) of the Obligated Entities.

Punjab State Power Corporation Limited (PSPCL): PSPCL is responsible for purchasing NRSE power as per the stipulation of PSERC and distribute the same.

Department of Science, Technology, Environment and Non-Conventional Energy (DSTENCE): This department is responsible for formulation/amendment/ relaxation/ addition/ interpretation of provisions of the NRESE policy at the level of State Cabinet.

Department of Industries (DoI): Is extending its industry related incentives to the NRSE projects which will be treated as an industry now.

Others: Department of Irrigation, Deptt. of Forests, Urban Local Bodies, Panchayat bodies, Private party and others will be offering their land on lease for development of renewable energy projects

9.5 NATIONAL SOLAR MISSION

The ultimate objective of this mission is to make solar energy competitive with fossil-based energy options. By increasing the share of solar energy in the total energy mix, it aims to empower people at the grass root level. Another aspect of this Mission is to launch an R&D programme facilitating international co-operation to enable the creation of affordable, more convenient solar energy systems and to promote innovations for sustained long-term storage and use of solar power. The quantitative objectives of the mission being:

- To create an enabling policy framework for the deployment of 20,000 MW of solar power by 2022.
- To ramp up capacity of grid-connected solar power generation to 4000 MW by 2017 through the mandatory use of the renewable purchase obligation by utilities backed with a preferential tariff. This capacity can be more than doubled – reaching 10,000MW installed power by 2017 or more, based on the enhanced and enabled international finance and technology transfer. The ambitious target for 2022 of 20,000 MW or more, will be dependent on the 'learning' of the first two phases, which if successful, could lead to conditions of grid-competitive solar power. The transition could be appropriately up scaled, based on availability of finance and technology.
- To create favorable conditions for solar manufacturing capability, particularly solar thermal for indigenous production and market leadership.
- To promote grid mode program, reaching 800 MW by 2017 and 2000 MW by 2022.
- To achieve 15 million sq. meters solar thermal collector area by 2017 and 20 million by 2022.
- To deploy 20 million solar lighting systems for rural areas by 2022.

9.6 PUNJAB SOLAR MISSION AND STRATEGIES

Increase the share of solar energy mix in the total energy generated to 2000 MW by 2022.

Strategy 1
Increase the share of solar Power in the grid electricity. Target: At least 4 Percent of GOI target of 20000 MW i.e. 800 MW through Private Participation.

Strategy 1	12th plan	13th Plan	Total
Cost in each plan	--	-	--

Strategy 2
Use unproductive land in the state in line with the Charnaka model of Gujarat to generate 300 MW of electricity using SPVthrough Private Participation.

	12th plan	13th Plan	Total
Cost in each plan	-	-	-

Strategy 3
Use the area along the international border for generating electricity using SPV. Target for 9 MW.

	12th plan	13th Plan	Total
Cost in each plan	Rs. 180.00 Cr	Rs.180.00Crore	Rs 360.00 Cr

Strategy 4
Promote roof top solar PV power. Target for 100 MW within 12th plan & 13th Plan

	12th plan	13th Plan	Total
Cost in each plan	Rs.1000.00 Cr	Rs.1000.00 Cr	Rs 2000.00 Cr

Strategy 5
Development of solar cities

	12th plan	13th Plan	Total
Cost in each plan	Rs 10.00 Cr	Rs 10.00 Cr	Rs 20.00 Cr

Strategy 6:
Increase coverage of solar lighting by putting 1000 solar lighting system during 12th and 13th five year plan

	12th plan	13th Plan	Total
Cost in each plan	Rs75 Cr	Rs75 Cr	Rs150 Cr

Strategy 7:
Provide incentive for solar thermal water heating system in Urban/Rural residences.

	12th plan	13th Plan	Total
Cost in each plan	Rs. 200.00 Cr	Rs.300 Cr	Rs.500 Cr

Total Cost: Solar Mission

12th Plan	Rs. 1465.00 Cr
13th Plan	Rs. 1565.00 Cr
Total 12th+13th Plan	Rs. 3030.00 Cr

See Annexure 3 for details of targets and budgets.

REFERENCES

1. PbNRSE, 2006. Punjab New and Renewable Source of Energy Policy, 2006 notified vide No. 10/106/2006-STE (1)/5390 dt. 24th November, 2006. Department of Science and Technology, Environment and Non Conventional Energy Sources. Government of Punjab

2. Pb NRSE, 2012. Punjab New and Renewable Source of Energy Policy 2012, notified vide no.10/174/2012/STE(3)/4725 on 26th Dec 2012. Department of Science and Technology, Environment and Non Conventional Energy Sources. Government of Punjab.

3. PEDA, 2012a.Small/microhydropower development in Punjab, Accessed from http://peda.gov.in/eng/Smal_hydor%20power.html in Dec 2012.

4. PEDA, 2012b.Biomass Power Project Development in Punjab. Accessed from http://peda.gov.in/eng/Bio-mass%20Power.html in Dec 2012.

5. PEDA, 2012c.Solar power project development in Punjab. Accessed from http://peda.gov.in/eng/SPV%20Power%20Projects.html in Dec 2012.

6. PEDA, 2012 d. Wind power projects. Accessed from http://peda.gov.in/eng/Wind%20Power%20Projects.html in Dec 2012.

7. PEDA, 2012 e. Developing Solar passive Complexes in Punjab. Accessed from http://peda.gov.in/eng/Solar%20Passive%20Complex.html in Dec 2012.

8. PEDA, 2012 f. High rate biomethanation power project for recovery of energy from dairy waste. Accessed from http://peda.gov.in/eng/high%20Projects.html in Dec 2012.

9. PEDA 2012 g. Co generation projects. Accessed from http://peda.gov.in/eng/cogeneration.html in Dec 2012.

10. REREgistry, 2013.RE generators- Acceredited and Registered. Accessed from https://www.recregistryindia.nic.in/index.php/general/publics/accredited_regensin Feb 2013.

10. Mission on Enhanced Energy Efficiency

HIGHLIGHTS

- Energy consumption trends and Projections
- Energy saving potential in different sectors
- Policies and programs for promoting Energy Conservation and Energy Efficiency in the state and the achievements so far
- The National Mission on Enhanced Energy efficiency
- Punjab Mission on Enhanced Energy Efficiency – Strategies

10.1 ENERGY CONSUMPTION TRENDS AND PROJECTIONS

Per capita consumption of electricity in the State has increased from 163 kWh in 1968 to 1163 kWh in 2010-11 and accordingly electricity consumption has increased from 700 million units in 1968 to 42631.042 million units in 2010-11. The total installed capacity in 1967- 68 was 614 MW which has increased to 7035 MW including central share of 1973 MW by the end of March, 2011 (SAP, 2011). The monthly trend of demand and availability of power in 2010-2011 is shown in **Figure 10.1**(CEA, 2011)**.** Also during 2011-2012 the available supply against demand was less by 16.9% (CEA, 2012).

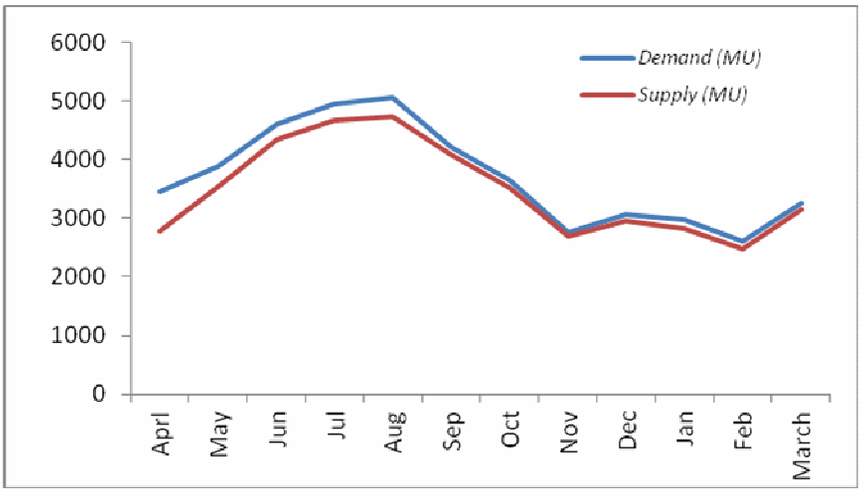


Figure 10.1: Trends of monthly supply and demand of power during 2010-2011 in Punjab.

Source CEA, 2011.

As the demand for power is increasing, so is the installed capacity. However, there are apprehensions that the gap between supply and demand will rise with rise in activities in different sectors in a business as usual scenario. **Figure 10.2** shows the trend of power consumption which has increased from 1219.5 million KWh in 1970-71 to 32231.72 million KWh in 2010-11 (*PbSAP, 2011*).

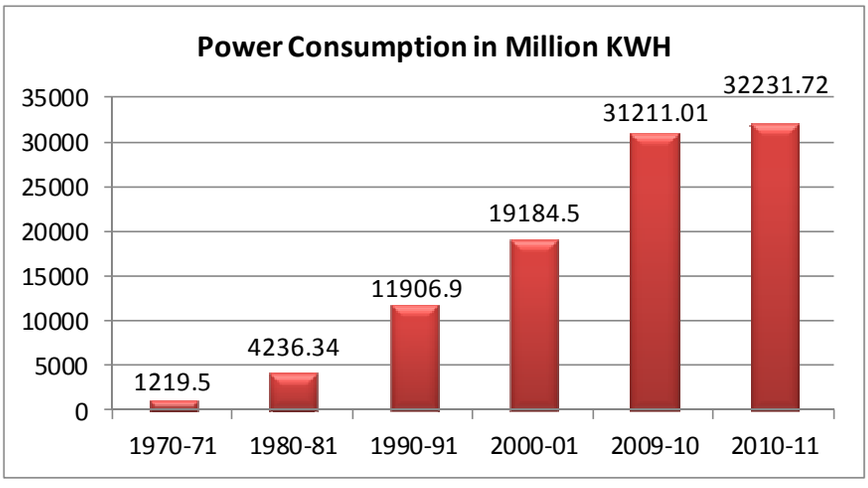
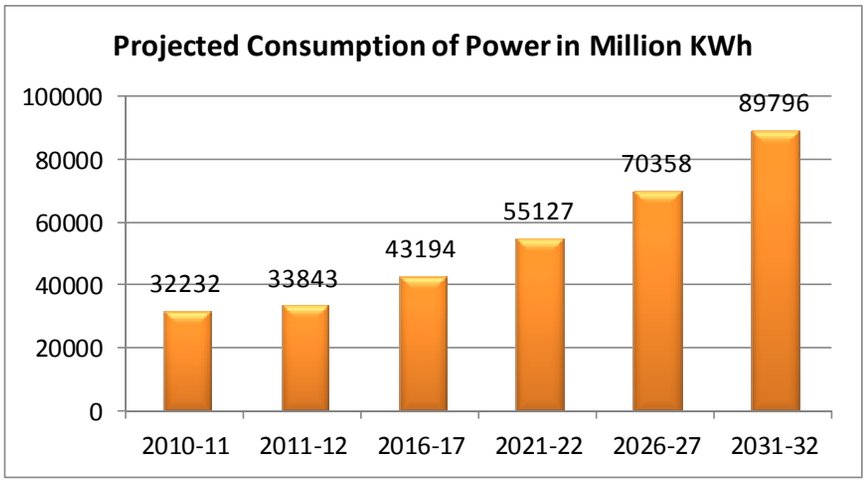


Figure 10.2: Trends of power consumption in the state of Punjab
Source: SAP, 2011.

The compounded annual growth rate (CAGR) of power consumption in Punjab between 1990-91 and 2010-11 is estimated to be 5.1%. If it is assumed to grow at the same rate annually, then power consumption in the state is likley to increase from 32232 Million KWh in 2010-11 to 55127 Million KWh by the end of 13th plan i.e. by 2021-22. Further by the end of 2031-32, it is likely to grow to 89796 million KWh (see **Figure 10.3**).



Figre 10.3: Projections of power consumption in Punjab

Due to initiatives taken by the government, the transmission and distribution (T&D) losses which were 30.82% in 1999-2000 have been brought down to 20.12% in 2010-11 achieving an overall reduction of about 12.86%. The T&D losses are expected to be brought down to 15% by the end of 12th plan (*PbPlan, 2013*). Conservation of Energy, enhancing Energy Efficiency, increasing the share of new and renewable energy sources in the total energy mix and curtailing T&D losses are some of the initiatives that are expected to reduce the gap between generations and demand in the future.

10.2 ENERGY SAVING POTENTIAL IN DIFFERENT SECTORS

As per the sale statistics of electricity in Punjab, the total consumption of electricity by different sectors in 2010-11 was 32231.72 million KWH (PbSAP, 2011). The top 3 consumers of electricity were the Industrial sector , Agriculture sector and domestic sector that consumed 34.22% (or 1030.57 Million KWH), 31.38% (or 10116.89 Million KWH) and 24.56% (or 7915.24 Million KWH) of the total sales of electricity in the state respectively. In these three sectors lies a large scope of reducing electricity consumption through enhancement in energy efficiency. For example, in agriculture sector, scope exists in improvement in efficiency in pump sets and also switching over to renewables to power the pump

sets. In Domestic sector, use of energy efficient domestic gadgets for lighting/heating/washing etc. can go a long way.

The following section enumerates the scope of energy efficiency in various sector of the state which is based on a study carried out by National Productivity Council on behalf of BEE (BEE/NPC, 2009).

Agriculture Sector

The annual electricity sale to agriculture sector in 2010-11 was 10116.89 million KWH (PbSAP, 2011). As the major consumption of energy in agriculture sector is for energizing pump sets, there is a need to focus on assessing energy efficiency potential only from agricultural pump sets. The number of agricultural pump sets was estimated to be around 11,90,000 in 2010. This corresponded to a connected load of 6290.8 MW and annual consumption of 9.6 BU.

Based on several studies carried out on agricultural pump set efficiency, it has been found that the pump efficiency varies from 25-35% due to various factors. By adopting BEE star labeled agricultural pump sets, the efficiency can be enhanced upto 50-52% (BEE/NPC, 2009 study, BEE/TUV 2010). It is estimated that, by replacement of existing pumps with the BEE star labeled pumps, the achievable saving potential is 30-40% and sectoral saving potential works out to be 4.8 BU per year.

Commercial Buildings

The annual electricity sale to commercial sector is estimated to be 2.82 BU in 2010-11. The commercial sector constitutes government & private establishments, hospitals, hotels, restaurants, educational institutions, malls etc. During the period 2007-08 to 2010-11, there was 10% increase in commercial buildings drawing power over 500 KW. These together drew an amount of 453 MU from the grid, accounting for 14% of the total power consumption in the commercial sector in Punjab.

Studies by BEE/NPC(2009) reveal that energy savings potential in commercial buildings is 20-30%. The annual energy savings potential for 1344 commercial buildings is assessed to be 114.87 MU.

Municipalities

Considering that there is an annual increase of 10-12% in sales of electricity to the public works constituting public lighting, public water works and sewage, in 2010-11, this sector consumed 641 MU with respect to 469 MUs consumed in 2007-08. Public lighting in 2010-11 consumed 185 MU, Public water and sewerage works consumed the rest of it.

Based on sample studies, (BEE/NPC, 2009) the energy savings potential for street lighting in municipalities & corporations is assessed to be 25% and works out to 46 MU per annum. While, the energy savings potential for water works & sewage in municipalities & corporations is assessed to be 20% and works out to 111 MU per annum. The aggregate sectoral saving potential among the above works out to 157 MU.

SME Clusters

Five energy intensive clusters have been identified in Punjab, namely Foundry, Hand Tools, Auto Components, Hosiery and Dyeing for energy savings assessment. Table 10.1 gives a summary of that assessment. In this document we assume that the SME sector continues to draw the same level of energy as assessed in the referred study. The clusters are located in Batala, Jalandhar and Ludhiana. Together they consume 2891.3 MU of electricity and the energy saving potential is about 175.75 MU.

Domestic Sector

In Punjab, the annual electricity sale to domestic sector was 9.866 BU in 2010-11 which accounts for 21 % of the total electricity sold in 2010-11. The typical energy consumption pattern in urban domestic sector is shown in Table 10.2.

Table 10.1: Energy consumption and saving potential in energy intensive SME cluster in Punjab

Location	Product/cluster	units	Estimated Total Energy Consumption MUs/ (TOE)	% Savings Potential Assessed	Annual Energy Saving Potential Assessed
Batala	Foundry	300	252.3 MU 63075 TOE	10 15	25.23 MU 9461 TOE
Jalandhar	Handtools	400	1902.8 MU 475700 TOE	5 20	95.14 MU 95140 TOE
Ludhiana	Auto Components	400	343.2 MU 85800 TOE	7 10	24.02 MU 8580 TOE
Ludhiana	Hosiery	530	128.4 MU 32100 TOE	10 25	12.84 MU 8025 TOE
Ludhiana	Dyeing	150	264.6 MU 66150 TOE	7 15	18.52 MU 9923 TOE
TOTAL			2891.3 MU 722825 TOE		175.75 MU 131129 TOE

Source: BEE/NPC, 2009

Table 10.2 Energy consumption pattern in the urban domestic sector in Punjab

Sl. No.	Appliances	Energy consumption in %
1	AC & refrigeration	56 %
2	Lights & fans	24%
3	Coolers, TV, Washing machine sets	16%
4	Others	4%

Source: BEE/NPC, 2009.

he savings potential in urban segment by adopting BEE star rated products is 15-20%. Considering that 80% of electricity consumption is by the urban sector, therefore the energy saving potential in the urban sector in Punjab is around 1.1 BU.

Industries

The annual electricity sales to the industry sector including low & medium voltage consumers (SME) and high voltage consumers (large industries) is 17.384 BU and works out to 37 % of the total electricity sold. The larger industries segment is covered for energy efficiency under the mandates of EC Act as designated consumers, while SME segment is being addressed for energy efficiency through cluster based initiatives by Bureau of Energy Efficiency.

Based on several studies & energy audits, the electrical energy saving potential in industry sector varies from 7-10% (BEE/NPC, 2009). The energy savings potential for the sector is assessed to be 1.217 BU.

Summary of the total energy saving potential in Punjab is given Table 10.3

Table 10.3: Total energy saving potential in Punjab as of 2010-11

Sector	Estimated Annual Saving Potential (MU) as of 2010-11
Agriculture	4360
Commercial	114.87
Domestic	1217
Municipalities	157
SME Cluster	-
Industrial	1217
TOTAL	7065.87

10.3 POLICIES AND PROGRAMS FOR PROMOTING ENERGY CONSERVATION AND ENERGY EFFICIENCY IN THE STATE

Conservation of energy in domestic, commercial, agriculture, municipalities, and industrial sectors can lead to major savings in terms of reduced energy consumption thereby leading to bridge the energy demand supply gap in the state. Additionally energy saving in the transport sector is an avenue of reducing significant amount of energy consumption in the state. There is a potential for energy saving up to 20-25% in different sectors of the economy in the state (Pb NRSE, 2012).

Punjab Energy Development Agency (PEDA) is the State Nodal Agency responsible for spearheading Energy Efficiency efforts to identify and oversee energy conservation programs, including those mandated by Bureau of Energy Efficiency. In addition to planning, overseeing and guiding the activities, PEDA will coordinate, regulate and enforce the provisions of the EC Act 2001.

An energy conservation action plan team has been constituted under the chairmanship of Principal Secretary, Science & Technology, Environment and Non-Conventional Energy Sources which reviews implementation of various energy conservation programmes in the State.

Punjab Energy Conservation Action Plan

As part of the Eco-II project, Punjab has developed Energy Conservation Action Plan (ECAP) which aims:

- To proactively fulfill all the mandates of EC act, in co-ordination with BEE and State Government, and other stakeholders.
- To promote the cause of energy efficiency addressing all commercial energy sources (e.g. coal, liquid petroleum gas, oil and electricity).
- Reduce energy consumption in generation, transmission, distribution through end use DSM (Demand Side Management) programs and large scale end use energy efficiency improvements, rational and judicious use.
- Address the concerns of utilities such as demand shortage as well as power shortages through focused DSM initiatives.
- Promote reduction of GHG emissions in the State of Punjab.
- Promote use of energy efficient technologies, equipment, processes and appliances.
- Promote awareness in respect of EC Act, energy efficiency, standards, best practices, etc.
- Create awareness in the state regarding national energy efficiency programs such as Energy Conservation Building Code to promote energy efficiency in buildings and Standards & labeling to promote manufacture and use of energy-efficient appliances.
- Reduce energy consumption in Domestic Sector through User Education and awareness creation.

It has a programmatic approach with the following sub components:

Programme A: Energy efficiency improvement in major sectors

A1	Large Consumers and Textile Industry
A2	Small and Medium Enterprises
A3	Municipalities, Urban and Local Bodies
A4	New and Existing Buildings

Programme B: Capacity Building and Institutional Strengthening

B1	Public Awareness, Outreach & Knowledge Sharing
B2	PEDA Capacity Building
B3	Stakeholders Capacity Building

Capacity building programmes

The role of PEDA as SDA (State Designated Agency) is to create general awareness among masses about the importance and benefits of energy conservation measures and also to institutionalize the energy efficiency project implementation in the industry, govt. buildings & commercial buildings. The purpose of the state Energy Conservation Action Plan is to pursue a harmonious growth in energy efficiency ethos by intensifying these efforts in different consumers in the state of Punjab in line with those advocated by Bureau of Energy Efficiency and practiced in India and other countries.

Formation of Energy Conservation Action Plan Team (ECAT)

State Level Energy Conservation Action Plan Team (ECAT) has been constituted under Energy Conservation Act, 2001 to enable harmonization of Energy Conservation Policy across different sectors in the state.

The Mandatory measures include:

- Mandatory use of Compact Fluorescent Lamps (CFLs) in Govt. buildings/Govt. Aided Institutions /Boards /Corporations. (State Govt. Directive issued on 22.8.2007 to replace incandescent bulbs with CFLs in all Govt. buildings and offices, including Govt. Guest Houses, Offices of Boards, Corporations, Cooperative Organizations and Municipalities not later than three months from the date of issue).
- Mandatory use of compact fluorescent lamps for Agricultural consumers. Punjab is the first State in the country to have issued such a directive. It is mandatory to use CFLs (20 W maximum) at each of the 2 No. lighting points allowed at each consumer tube well kothas w.e.f. 15.4.2008.
- 07.10.2011 – Mandatory use of minimum BEE 4 star labeled and ISI marked motor pump sets, Power capacitors, Foot/Reflex valves in Agriculture Sector
- 30.05.2013 – Mandatory adoption of Threshold Star Rating for procurement of energy efficient electrical appliances in all the Govt. Departments / Organizations endorsing office memorandum issued by MOF, GOI .
- 25.10.2013 – Provision of Renewable Energy Systems and use of Punjab ECBC in building bye-laws vide notification issued by Deptt. of Housing & Urban Development Govt. of Punjab.

Energy Conservation Building Code (ECBC)

Energy Conservation Building Code (ECBC) was launched on 27.5.2007 by Bureau of Energy Efficiency, Ministry of Power, Govt. of India and it has been circulated to all concerned departments of Punjab for its implementation on voluntary basis. In this regard, a State level ECBC awareness workshop was organized at CII, Chandigarh on 4th December, 2007 under USAID/IRG ECO-III project. The Punjab ECBC-2013 has been developed by amending ECBC for the composite climate zone applicable to the state of Punjab.

Lighting And Awareness Program

- 8000 Street lights have been changed with energy efficient lights in Municipal corporation area of Amritsar (Source: PEDA)
- Replacement of incandescent lamps (100 watt) with LED lamps (10 watt) for home lighting application at village Chunni Khurd, District Fatehgarh Sahib. Maximum three lamps installed in a household (90% saving in electricity).

- 170 LED street lights (30 watt & 40 watt) have been installed at Municipal Council, Majitha, having annual energy savings of 0.79 lacs Units (80%).
- Demo project of LED area/street lighting of Sirhind Mandi sanctioned by BEE with financial assistance is under implementation through Punjab Mandi Board.
- 126 nos. public street lights have been replaced with energy efficient LED lights from PCL chowk to Chandigarh boundary Phase-2, Mohali under demo project of BEE.

PSEB is in the process of procurement of energy efficient lights to replace existing lighting fixtures in all their offices, guest houses, colonies and thermal power station.

Energy Conservation awareness campaign launched in 250 schools / colleges by imparting lectures through field staff and displaying energy conservation tips.

Continuous mass awareness being created among the people through display of Mobile Exhibition Van.

Table 10.4: Key achievements in energy conservation in Punjab

Sr.No.	Description	Scope of work/ Achievement
1.	Reduction in T&D Losses	Shifting of 32 lac meters outside consumer premises.
		In Distribution network 1513 overloaded feeders were de-loaded by June 2011.
		34822 no. overloaded distribution transformers were de-loaded by June 2011.
		IT lines in the urban areas, augmented with higher size conductor by March, 2012.
2.	Energy Conservation	Installation of energy efficient pump sets.
		Conserved 29 mKWH through CFL & Star labeled Appliances.
		Conducted energy audits in 27 Govt. and public sector buildings.
		Taken out notification for compulsory SWHS, CFL, ISI Marked Pumps and EE building design.
		Saved 72MkWh in large industries/Designated Consumers.
		Energy audit has been undertaken in 24 SMEs.
		10% energy saved in brick, cupola and rolling through improved technology.
		By 2010-11, about 5.50 lac incandescent lamps have been replaced with CFLs. Besides, about 1.60 lac incandescent lamps have been replaced on agricultural tube well kothas.

Source: SAP, 2011

10.4 NATIONAL MISSION ON ENHANCED ENERGY EFFICIENCY

The National Mission on energy efficiency was first enunciated as a part of the NAPCC in 2008. The different elements of the Mission are being implemented through programmes and schemes and are described below.

The EC Act was amended in 2010 to accommodate the objectives of the NMEEE (National Mission on Enhanced Energy Efficiency) and the main amendments of the Act are:

- The Central Government may issue the energy savings certificate to the designated consumer whose energy consumption is less than the prescribed norms and standards in accordance with the procedure as may be prescribed.

- The designated consumer whose energy consumption is more than the prescribed norms and standards shall be entitled to purchase the energy savings certificate to comply with the prescribed norms and standards.
- The Central Government may, in consultation with the Bureau, prescribe the value of per metric ton of oil equivalent (toe) of energy consumed.
- Commercial buildings which are having a connected load of 100 kW or contract demand of 120 kVA and above come under the purview of ECBC under EC Act.

Perform Achieve and Trade (PAT scheme)

It is a nationally implementable market based mechanism to enhance cost effectiveness of improvements in energy efficiency in energy-intensive large industries and facilities, through certification of energy savings that could be traded. The scheme is being used to unlock energy efficiency opportunities in the country, estimated to be about Rs. 74,000 Crores. By 2014-15 the scheme envisages to achieve Annual fuel savings in excess of 23 million toe and cumulative avoided electricity capacity addition would be of the order of 19,000 MW with 98 million tons per year, CO_2 emission mitigation as a co-benefit. See **Box 10.1** for a brief on PAT in Punjab.

Box 10.1: PAT scheme implementation in Punjab

Out of the 60 units notified in Northern India, 22 units are in Punjab. They are 2 chlor alkali making units, 2 fertilizer plants, 3 power plants, 3 pulp and paper units, 11 textile units and 1 cement unit. These units have energy consumption exceeding 30,000 MT of oil equivalent and have been identified under the Phase-I of PAT scheme and governed by the Energy Conservation Act, 2001 with amendment in 2010. The scheme is being implemented from April 1, 2011. Industries which exceed their energy efficiency improvement targets will receive Energy Saving Certificates (ESCs) equivalent to their excess savings and industries which fail to meet their targets may either face penalties or purchase ESCs.

Source: PEDA

The MTEEE Programme

Market Transformation for Energy Efficiency – MTEE is another scheme launched by BEE to achieve the aim of the National Mission on Enhanced Energy Efficiency. The scheme aims to accelerate the shift to energy efficient appliances in designated sectors through innovative measures and to make the products more affordable. Two sub programmes are now operational and they are the BLY (Bachat Lamp Yojana) and the SEEP (Super Efficient Equipment Programme).

BLY was officially launched in February 2009. The BEE is coordinating the Small-Scale Programme of Activities (SSC-PoA) through its state designated agencies such as PEDA in Punjab and will support the project implementer(s) in implementing the CDM Programme Activities (CPAs) in India through collaboration with Electricity Distribution Companies (DISCOMs). The scheme after implementation will result in reducing GHG emissions (CO_2) from power plants connected to the grid.

Box 10.2: Bachat Lamp Yojana in Punjab (BLY)

To save electricity, Punjab has introduced a "Bachat Lamp Yojna" in seven circles, Gurdaspur, Hoshiarpur, Nawanshahr, Ludhiana Suburban, Khanna, Sangrur and Faridkot. The distribution of CFLs started in May 2011, to replace the incandescent lamps. Compact Fluorescent Lamps (CFLs) are being provided to the consumers at subsidized rates. It is being implemented through the Punjab State Power Corporation Limited (PSPCL).

Source: PSPCL

Under the BLY scheme quality long-life CFLs are distributed by SSC-CPA implementer(s) to grid-connected residential households in exchange of an incandescent lamp (ICL) and INR 15. Once the CFLs have reached their end of life or any CFLs which have failed prematurely during the project period, the SSC-CPA implementer(s) would arrange for the collection and disposal of CFLs as per applicable environmental norms.

To bridge the cost differential between the market price of the CFLs and the price at which they are distributed to households, the Clean Development Mechanism (CDM) is harnessed. The SSC-CPA implementer(s) would cover the project cost through sale of GHG emission reductions achieved in their respective CPA areas.

BEE has conceptualized the **Super Energy Efficient Products (SEEP**) **programme** that offers manufacturers incentives to produce appliances that are 30-50% more efficient than five-star labeled goods, considered to be most energy efficient in the country. Coming under the purview of the Market Transformation for Energy Efficiency (MTEE) initiative of NMEEE, the primary objective of the SEEP is to encourage innovation in the manufacturing sector in India and to accelerate the shift to energy efficient appliances in designated sectors so that products of mass consumption become more affordable for the Indian consumers. BEE will kick off the SEEP initiative by providing incentives to ceiling fan manufacturers to produce fans that are 50% more efficient than the ones now prevalent in the market.

Energy Efficiency Financing Platform (EEFP)

The national Mission on Enhanced Energy Efficiency aims to create a mechanism that would help finance, demand side management programmes in all sectors by capturing future energy savings. The finance costs will be recovered from the energy savings, which will also reduce the subsidy bill of the state government. EEFP will provide instruments like bankable detailed project reports and other risk mitigation measures to enhance comfort for lenders towards aggregated energy efficiency projects.

The BEE has undertaken the following measures, in addition to those related to implementing demonstration projects in government buildings, in order to stimulate the market:

- Putting in place a government-supported standard guidelines (ECBC) methodology that covers the entire project chain from audit to performance measurement and verification.
- Designing a standard performance contract.
- Designing appropriate financial mechanisms to fund projects.
- Implementing projects and evaluating their impact.
- Building capacity in ESCOs and project owners.

In an effort to provide the EEFP, MoUs with PTC India Ltd, Small Industries Development Bank of India (SIDBI) and HSBC have been signed by BEE. PTC India Ltd. has commenced financing of several Building Energy Efficiency projects in Rashtrapati Bhavan Estate, ESIC (Employees' State Insurance Corporation), Hospitals in Rohini and East Delhi, All India Institute of Medical Sciences (AIIMS), and Safdarjung Hospital. SIDBI has taken up project preparation of energy efficiency in 25 small and medium enterprises (SME) clusters, which will then be offered financing. Further, investment grade energy audits have been completed for large public buildings in the country. Based on the recommendations of these audits, iconic buildings in the states will be taken up for implementation through ESCO route.

Framework for Energy Efficient Economic Development (FEEED)

The Enhanced Energy Efficiency mission aims to develop Fiscal instruments to promote energy efficiency in a way that allows for the creation of mechanisms to help finance demand side management programmes in all sectors by capturing future energy savings. The **Framework for Energy Efficient Economic Development (FEEED**), has been conceptualized to achieve this objective and two fiscal instruments to promote energy efficiency - **the Partial Risk Guarantee Fund (PRGF) and Venture Capital Fund for Energy Efficiency (VCFEE)** are being developed.

10.5 PUNJAB MISSION FOR ENHANCED ENERGY EFFICIENCY

The National Programmes and schemes under the NMEEE (National Mission on Enhanced Energy Efficiency) are being implemented by the Punjab State as indicated in the section above.

The state, however, needs to implement its own mission in line with the Action plan, prepared by PEDA as part of the ECO-III project but aligned with the NMEEE objectives.

The Following strategies are envisaged for Punjab:

Strategy 1: Achieve 15-20% energy efficiency in small and medium enterprises (SMEs).

Strategy 1	**12th plan**	**13th Plan**	**Total**
Cost in each plan	Ra 5.00 Cr	Rs 5.00 Cr	Rs 10.00 Cr

Strategy 2: Achieve energy efficiency of the order of 15-35% in buildings (Commercial & Institutional buildings such as Hotel, Malls and Govt. buildings based on ECBC/GRIHA norms.

Strategy 2	**12th plan**	**13th Plan**	**Total**
Cost in each plan	Rs 1.5 Cr	Rs. 1.5	Rs 3.00 Cr

Strategy 3: Achieve energy efficiency in street lighting by replacing conventional street lights with LEDs.

Strategy 3	**12th plan**	**13th Plan**	**Total**
Cost in each plan	Rs 1826.00 Cr	Rs 1826.00 Cr	Rs 3652.00 Cr

Strategy 4: Promote energy efficiency in consumer appliances.

Strategy 4	**12th plan**	**13th Plan**	**Total**
Cost in each plan	Rs 9.25 Cr	Rs. 7.5 Cr	Rs 16.75 Cr

Strategy 5: Achieve 3-7% improvement in energy efficiency in large energy consumers not designated by BEE under PAT scheme such as food processing, Chemicals and Ceramics.

Strategy 5	**12th plan**	**13th Plan**	**Total**
Cost in each plan	Rs 13.5 Cr	Rs 7.5 CR	Rs 21.00 Cr

Strategy 6: Create demand for energy efficient appliances, technologies and programs by educating the public and private sector on their options.

Strategy 6	**12th plan**	**13th Plan**	**Total**
Cost in each plan	Rs 7.00 Cr	Rs 5.00 Cr	Rs 12.00 Cr

Strategy 7: Conduct education and training of key stake holders – energy managers and energy auditors on implementation of EC measures, e- filing on annual reporting energy data and e-learning in consonance with BEE's mission on the EC Act and for monitoring and evaluation.

Strategy 7	**12th plan**	**13th Plan**	**Total**
Cost in each plan	Rs15.00 Cr	Rs15.00 Cr	Rs30.00 Cr

Total cost of the mission:

12th Plan	Rs 1877.25 Cr
13th Plan	Rs 1867.50Cr
Total	Rs 3744.75 Cr

See Annexure 3 for details of actions, targets, budgets and timelines.

REFERENCES

1. BEE/NPC, 2009. State wise electricity consumption and conservation potential in India, Prepared by National Productivity Council for BEE. Accessed from http://www.emt-india.net/eca2009/14Dec2009/CombinedSummaryReport.pdf in Dec 2012.
2. BEE/TUV SUD, 2010. Pilot Agricultural Demand Side Management (Ag- DSM) Project at Muktsar & Taran Taran, Punjab. Prepared by TUV SUD South Asia for BEE. Accessed from http://202.164.52.148/pdf/rfp_04_dsm_2011_12_detailed.pdf in Feb 2013.
3. CEA, 2011. Load Generation Balance Report, 2010-2011. Central Electricity Authority, Government of India.
4. CEA, 2012. Load Generation Balance Report, 2011-2012. Central Electricity Authority, Government of India.
5. SAP, 2010. Statistical Abstract of Punjab. Issued by Economic Advisor to Govt. of Punjab. Economics and Statistical Organisation, India.
6. SAP, 2011. Statistical Abstract of Punjab. Publication no. 930. Issued by Economic Advisor to Govt of Punjab. Economics and Statistical Organisation, India.

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11. Mission on Strategic Knowledge Management

HIGHLIGHTS

- National Mission on Strategic Knowledge on Climate Change
- Punjab Mission on Strategic Knowledge Management- The Vision

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11.1 NATIONAL MISSION ON STRATEGIC KNOWLEDGE ON CLIMATE CHANGE

Negative effects of climate change are already observed at the current global mean temperature increase of 0.8°C, above pre-industrial levels. Global mean temperature increase of up to 2°C (relative to pre-industrial levels) are likely to allow adaptation to climate change for many human systems at globally acceptable economic, social and environmental costs. However, the ability of many natural ecosystems to adapt to rapid climate change is limited and may be exceeded before a 2°C temperature increase is reached. A global mean temperature increase greater than 2°C will result in increasingly costly adaptation and considerable impacts that exceed the adaptive capacity of many systems and an increasing and unacceptably high risk of large scale irreversible effects.

Climate change has thus become a matter of strategic importance for all countries as they need to preserve and protect their natural resources, adapt to the changing climate and help contain the concentration of greenhouse gases in the atmosphere at a level that does not dangerously alter the climate system and jeopardise the security of human well beingvis a vis its food security, economic security and environmental sustainability.

In this context, therefore, it is highly important for the Indian government and for all its states to understand the nature of climate change and the drivers of this change and design appropriate strategies to ensure sustainability of its natural resources in the face of likely adverse impacts.

With this in the background, the Strategic Mission on climate change aims to

- Formulate knowledge networks among the existing knowledge institutions engaged in research and development relating to climate science and facilitate data sharing and exchange through a suitable policy framework and institutional support.
- Establish global technology watch groups with institutional capacities to carry out research on risk minimized technology selection for developmental choices.
- Develop national capacity for modeling the regional impact of climate change on different ecological zones within the country for different seasons and living standards.

- Establish research networks and encourage research in the areas of climate change impacts on important socio-economic sectors like agriculture, health, natural ecosystem, bio-diversity, coastal zones, etc.
- Generate and develop the conceptual and knowledge basis for defining sustainability of development pathways in the light of responsible climate change related actions.
- Provide an improved understanding and awareness of the key climate processes and the resultant climate risks and associated consequences.
- Complement the efforts under the other national missions, strengthen indigenous capacity for the development of appropriate technologies for responding to climate change through adaptation and mitigation and promote their utilization by the Government and societies for sustainable growth of economies.
- Create institutional capacities for research infrastructure including access to relevant data sets, computing and communication facilities and awareness to improve the quality and sector specific scenarios of climate change over the Indian subcontinent.
- Ensure the flow and generation of human resources through a variety of measures including incentives to attract young scientists to climate science.
- Build alliances and partnerships through global collaboration in research & technology development on climate change under International and bilateral S&T cooperation arrangements.

11.2 PUNJAB MISSION ON STRATEGIC KNOWLEDGE MANAGEMENT - THE VISION

Objective

The Punjab Mission on Strategic Knowledge aims to build a greater understanding of the climate change processes, its implications on various sectors, and vulnerabilities associated with the same to enable sustainable adaptation to climate change and mitigation of drivers of climate change (greenhouse gases emitted from anthropogenic sources). Punjab being an agriculture intensive state, the focus will be mainly on agriculture and water issues. However, other related climate change issues will also be addressed to facilitate the development of a climate proofed society.

Strategies and Actions

Strategy 1

Develop a Centre for excellence in an existing R&D body to address all research and technology development and demonstration issues related to climate change, and Establish a climate change cell within the government that will coordinate and provide policy guidance on climate change in the state.

The Centre of excellence is proposed to be housed within the Punjab Agriculture University (PAU) and the Climate Change Cell within the Deptt. of Science, Technology & Environment, Govt. of Punjab/Punjab State Council for Science and Technology (PSCST). The Implementation arrangement is shown in Figure 11.1.

Estimated requirement of funds shall be to the tune of Rs.82 crore during 12th plan and Rs.65 crore during 13th plan period as given below :

Strategy 1	**12th plan**	**13th Plan**	**Total**
Cost in each plan	Ra 82.00 Cr	Rs 65.00 Cr	Rs 147.00 Cr

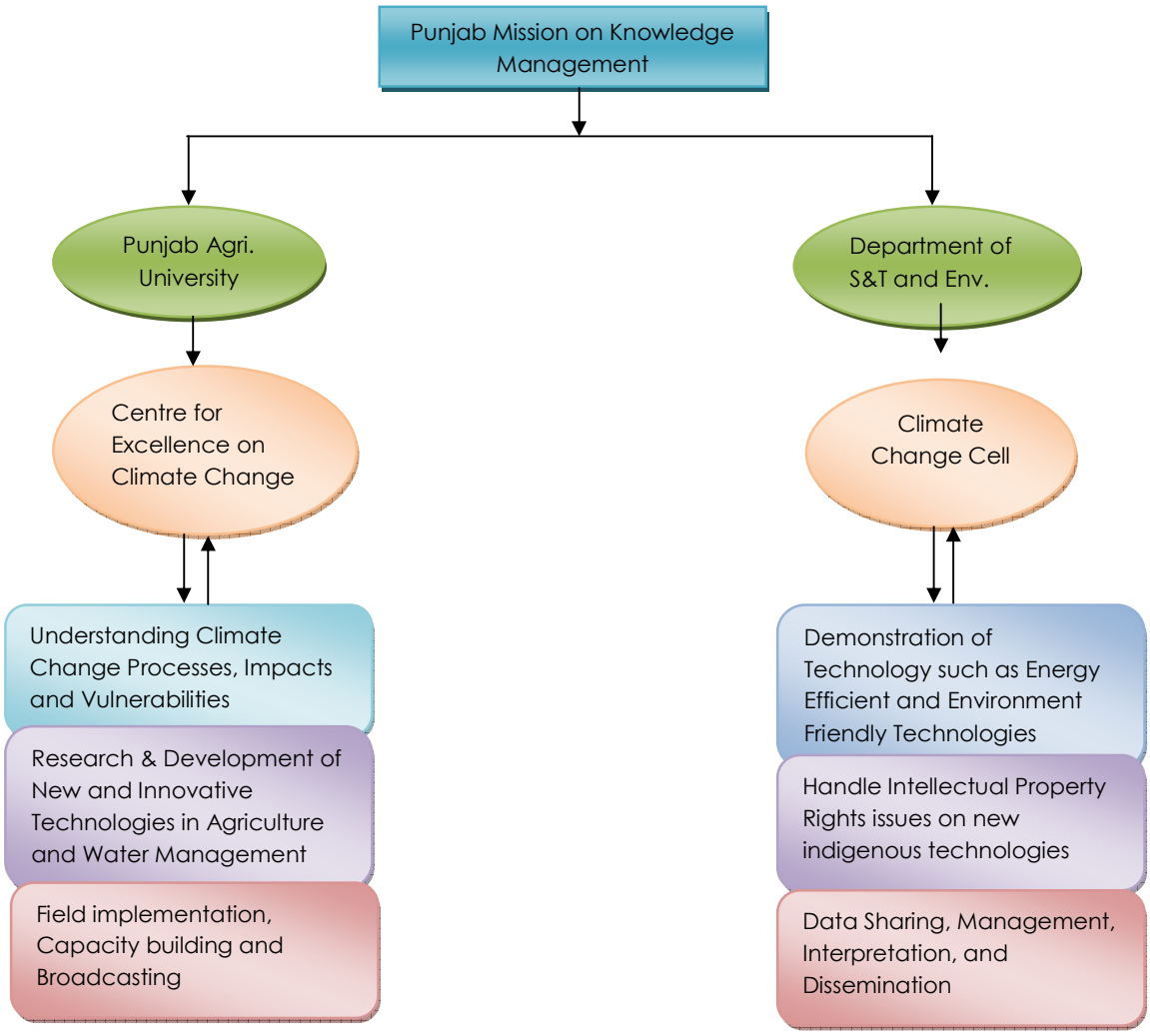

Figure 11.1: Proposed arrangement for implementing Punjab Mission on Strategic Knowledge for Climate Change

Strategy 2

Develop a deeper understanding of climate change issues

Punjab aims to build on the existing knowledge to further understand the key climate processes and the anthropogenic drivers of climate change. While doing so, it aims to develop a bouquet of climate change scenarios at high spatial resolutions within which planning can be implemented effectively. The present document is based on PRECIS regional climate model run on IPCC A1B scenario, whereby the projections are available at only 50 km x 50 km spatial scale. It is expected that alternative scenarios developed in the future will provide a deeper understanding of the climate change processes. Further, it aims to understand all the possible scenarios of manifestation of

climate change on various sectors and identify associated vulnerabilities for developing appropriate deliverable adaptation strategies. The various aspects of research can be summarised as follows:

i. Understanding the current climate and climate change: The centre will use IMD data, agro-meteorological data, and if necessary, install automatic weather monitoring stations wherever necessary. Further it will acquire various AOGCMs (Atmosphere-Ocean Global Circulation Models) and regional climate models in collaboration with different institutions/universities within the country or outside. Develop a pool of researchers who will work on these models and also indigenize the same. The centre will generate scenarios that can be used by other states as well.

ii. The Centre will develop socio economic scenarios appropriate for Punjab and run above mentioned models using these scenarios and make projections of climate for the spatial domain within Punjab.

iii. The centre will access/develop and run biophysical models to understand the impacts of climate change on crop yields (e.g. INFOCROP[1]-), water (e.g. SWAT- Soil Water Assessment Tool), forests (e.g. IBIS – Integrated Biosphere Simulator Model), biodiversity, energy, etc. This will also enable the centre to identify associated vulnerabilities.

Strategy 3

Undertake Research and Development of New and Innovative Climate Friendly Technologies

The state is keen to undertake research to develop new and innovative indigenous climate friendly technologies suitable for Punjab situation. Also it would adopt latest state–of–the-art technologies that can be easily indigenized and be replicated. The focus would be, but not limited to, technologies that can:

i. Sustainably manage water resources and agriculture.
ii. Protect and preserve biodiversity and commercialize indigenous crops.
iii. Increase the share of renewables (solar and biomass) in the state's total energy mix.
iv. Develop technologies for carbon/CO_2 capture and use in agriculture, pest control and grain storage.
v. Enhance efficiency of systems in agriculture and industry including in SMEs to reduce specific energy consumption.
vi. Develop technologies for efficient and sustainable waste management, transport, and climate proofed buildings.
vii. Develop technologies that reduce pollutant loads in air and water in a changing climate scenario in rural and urban settings.

Strategy 4

Undertake Technology Demonstration, Field Implementation & Extension

An important aspect of large scale deployment of technologies is trying out the same at a small scale in a pilot mode and depending on the success of the pilot then broadcasting it at a wider scale. The process requires scientific step by step implementation of the technology and massive outreach activities that help build capacity to absorb the technology that is developed. Therefore, this is an important element of knowledge management for the state; as a large number of technologies are expected to climate proof all economic activities of the state. The Department of Science, Technology and Environment will undertake demonstration, dissemination and capacity building for absorption of sustainable green energy and climate friendly pollution control technologies. The PAU will undertake field trials, broadcast, and develop capacity building programmes for adoption of agriculture and water management technologies by the stakeholders (farmers).

[1]InfoCrop, a generic crop model, simulates the effects of weather, soil, agronomic management (planting, nitrogen, residues and irrigation) and major pests on crop growth, yield, soil carbon, nitrogen and water, and greenhouse gas emissions.

Strategy 5

Address IPR Issues

Intellectual Property Rights of the new and innovative technologies will need to be protected. A Patent Information Center (to assist academic and R&D bodies) and an Intellectual Property Facilitation Centre (to assist MSMEs) have already been set up at the PSCST. In line with the subject areas to be addressed in the context of climate change, PSCST can extend the facilitation to these areas as well.

Strategy 6

Manage, Interpret & Disseminate Data and Information

Climate change being a multi disciplinary subject, access to different types of datasets is required to interpret the trends not only of climate but the drivers of climate change as well. These data are already being generated by various departments of the state and their institutions as a part of their respective mandates. Considering that The National Data Sharing Policy has come into effect in February 2012, this can facilitate Research and help synthesise, analyse and visualize data to help planners and policy makers to interpret and make informed decisions.

The data base that would be required to be accessed would include but not limited to data on

- Different activities (such as Land use data, production data, pollution data, data on infrastructure, natural resources, population, economy, etc.)
- Relevant details of programmes and projects being implemented nationally as well as internationally
- Policies, acts and notifications governing the programmes related to climate change
- Institutional mechanisms for managing the various sectoral programmes
- Relevant R&D results
- Description and sources of various technologies for mitigation and adaptation within and outside the national domain and
- Any technology development being done through international cooperation

Box 11.1: National Policy on Data Sharing

The policy has come in to effect since February 2012. The objective of this policy is to facilitate the access to, Government of India owned, shareable data and information in both human readable and machine readable forms through a network all over the country in a proactive and periodically updatable manner, within the framework of various related Policies, Acts and Rules of Government of India, thereby permitting a wider accessibility and use of public data and information.

The National Data Sharing and Accessibility Policy will apply to all data and information created, generated, collected and archived using public funds provided by Government of India directly or through authorized agencies by various Ministries / Departments/Organizations / Agencies and Autonomous bodies.

It will be created in collaboration with state departments and their institutions, universities and other local institutions, local bodies such as the Panchayats or the Urban Local bodies, etc. Further, access to data bases of national institutions such as the Planning Commission, the Line Ministries, their departments and institutions such as Census, NSSO (National Sample Survey Organisation), ICAR (Indian Council of Agricultural Research), DST (Department of Science and Technology), CSIR (Council of Scientific and Industrial Research, Industry Associations, and National Universities need to be available. The data base also needs to have access to International data bases such as the IPCCDDC (Intergovernmental Panel on Climate Change- Data Dissemination Centre), WMO (World Meteorological Organisation), FAO (Food

and Agriculture Organisation), IEA (International Energy Agency), BP (British Petroleum)etc. and information on Programmes and projects carried out by Bilaterals and Multilaterals for Punjab.

It has to be clear that the data available through this platform has to be at different levels for different category of stakeholders. Types of access will be categorized as follows:

- **Open Access -**Access to data generated from public funding should be easy, timely, user-friendly and web-based without any process of registration / authorization.
- **Registered Access -** Data sets which are accessible only through a prescribed process of registration / authorization by respective departments / organizations will be available to the recognized institutions / organizations / public users, through defined procedures.
- **Restricted Access -** Data declared as restricted, by Government of India policies, will be accessible only through and under authorization.

It will be created in collaboration with agencies

- within the state (All line Departments including the Punjab Remote Sensing Center, research Institutions, local bodies, etc.) that generate primary data and,
- link it with the data bases of national agencies (Planning Commission, Line Ministries, their departments and institutions such as Census, NSSO, ICAR, ISRO, CSIR, Industry Associations; National research institutions, National universities) and,
- International data bases (IPCCDDC, WMO, FAO, IEA, BP, etc.)
- Programmes and projects carried out by Bilaterals and Multilaterals for Punjab.

SOME DATA SOURCES

1. IPCC-DDC (http://www.ipcc-data.org/)
2. WMO (http://www.wmo.int/datastat/wmodata_en.html)
3. FAO (http://faostat.fao.org/)
4. UN data base on disasters (http://www.unisdr.org/we/inform/disaster-statistics)
5. IEA (http://www.iea.org/statistics/)
6. BP (http://www.bp.com/en/global/corporate/about-bp/statistical-review-of-world-energy-2013/statistical-review-1951-2011.html)

All accessed on 26th Sept 2013.

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12. Way Forward

HIGHLIGHTS

- Institutional Arrangement for Implementation of SAPCC
- Monitoring &Evaluation Framework
- Taking the Action Plan Forward

The government of Punjab considers climate change as one of the most important strategic areas that need to be integrated into its developmental planning as the projected changes in climate are likely to have adverse impacts on its natural resources and hence on the economic sectors directly dependent on the same. The Punjab SAPCC has thus been designed for developing strategies for ameliorating vulnerabilities due to climate change across sectors. An inter-sectoral approach for implementation of the strategies suggested in the SAPCC is vital whereby departments of the government will need to implement the strategies through inter-departmental coordination and in collaboration with technical expertise and guidance drawn from within the state and from national and international institutions. The following section briefly describes the proposed institutional arrangement for implementation of the project, an M&E framework and implementation arrangement and the way forward.

12.1INSTITUTIONAL ARRANGEMENT FOR IMPLEMNTATION OF SAPCC

The strategies in the SAPCC have been developed in consultation with all stakeholders concerned as per national framework and are based on criteria such as severity of impacts of climate change, urgency of implementation, feasibility of implementation, robustness and sustainability, equity, consistency with national and state programmes and policies, cost effectiveness and social and environmental benefits likely to be accrued. However, indepth feasibility studies wherever required will be carried out. Departments/Agencies responsible for carrying out each action within different strategies have been identified and are mentioned in the Annexure containing Strategies and Budget (Annexure 3) for different missions.

It is proposed that the actions taken by each of the departments/institution, will receive technical guidance from the State Steering Committee, Technical committee and eight mission specific Expert Working Groups.

The Steering Committee of the SAPCC will continue to operate and oversee the implementation of the strategies and actions suggested in the present document. The SAPCC being a dynamic document, it will be regularly reviewed by the Steering Committee keeping in view the latest developments in science of climate change and policy needs so as to take timely initiative to identify and introduce new strategies/revise existing strategies and actions, if required. **Figure 12.1** shows schematically the proposed implementation arrangement of the Punjab SAPCC.

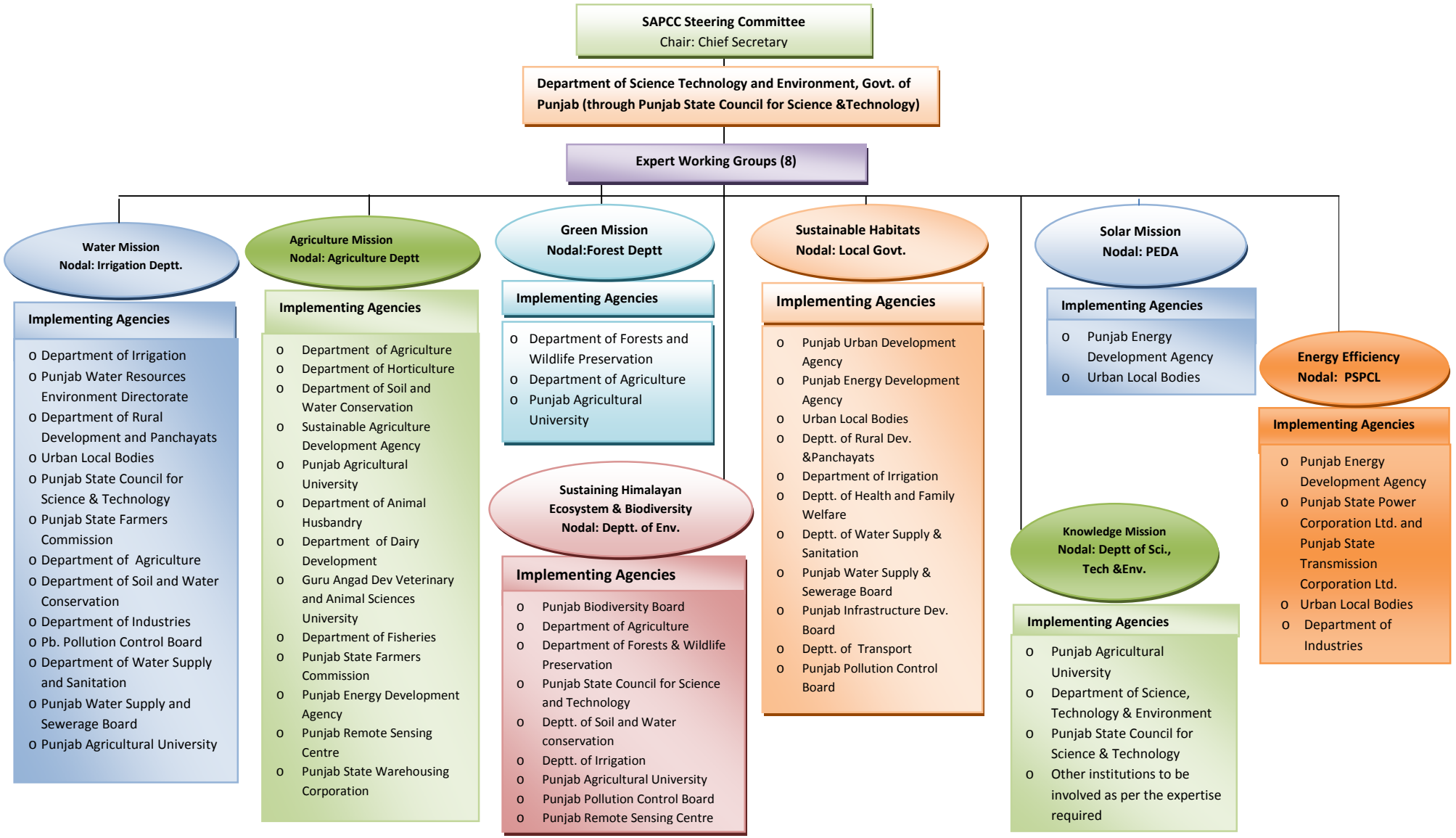

Figure 12.1: Implementation Arrangement of Punjab SAPCC

12.2 MONITORING & EVALUATION FRAMEWORK

It is important to regularly monitor actions within each strategy to ensure timely achievement of targets as set out under each mission, evaluate status of implementation process, understand overall impact of programmes and design relevant/desirable new strategies and actions keeping in view long term sustainable developmental issues in Punjab under changing climate scenario. The conceptual framework for M&E and the implementation arrangement is shown in **Figure 12.2**.

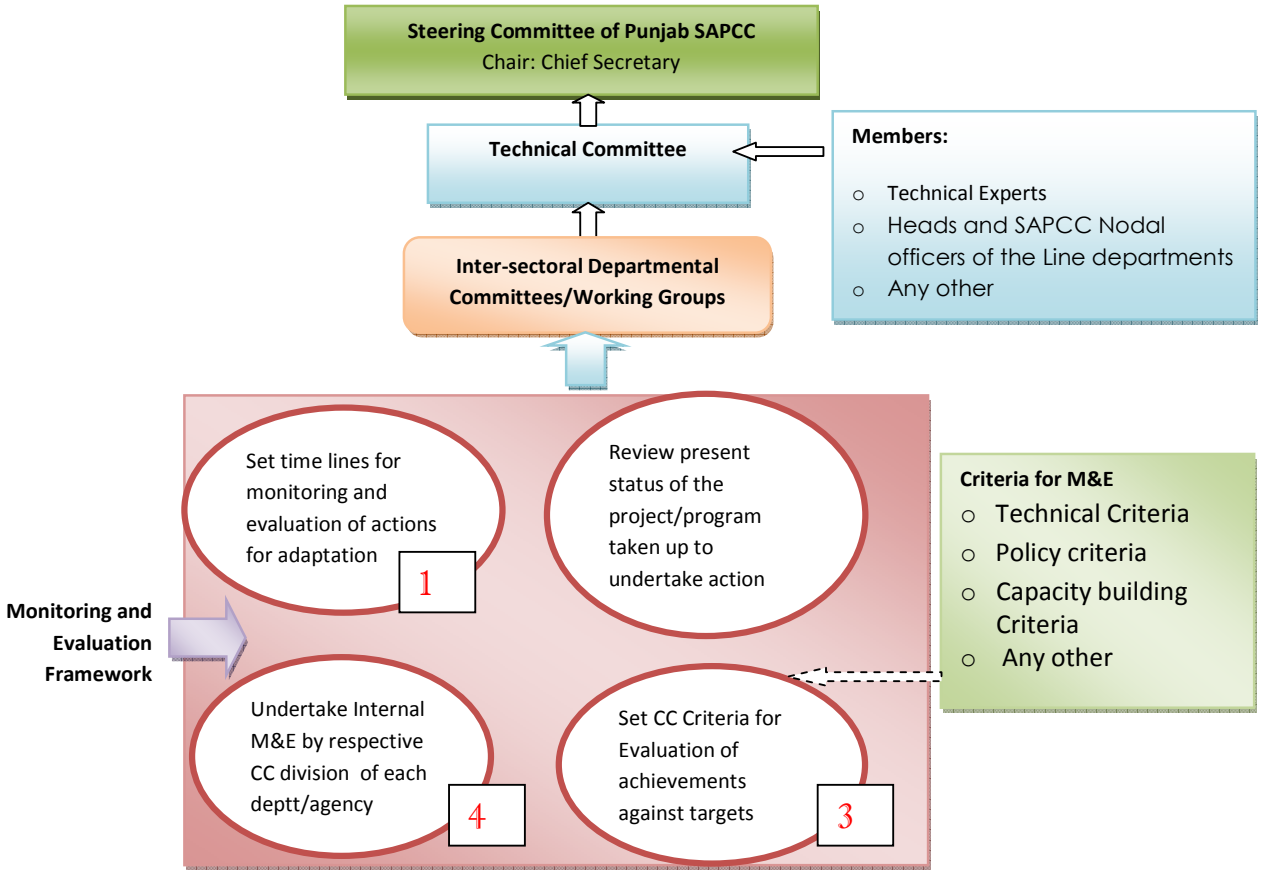

Figure 12.2: Monitoring and Evaluation Framework and Implementation Arrangement

The M&E activities will also be overseen by the Steering Committee of the SAPCC, which will review the progress of action as per the strategies and will direct the implementing agencies to undertake mid-course correction if necessary keeping in view the inputs provided by the Technical Committee.

The Technical Committee comprising of relevant technical experts and heads of departments/ nodal officers of SAPCC from line departments will have an advisory role which will review the progress of the actions. The monitoring of the actions will be done regularly by this committee by reviewing achievement as per scope at the starting of the projects, in the midway and at the end of the project cycle.

To ensure successful implementation of the projects under defined strategies /programmes the concerned departments/agencies will establish Climate Change Working Groups in their respective departments implementing inter-sectoral programme involving SAPCC nodal officers from other departments wherever required. This will continuously monitor the progress of achievement of targets and report the same to the Technical Committee.

12.3 TAKING THE ACTION PLAN FORWARD

The strategies and actions enumerated in this document have been formulated in consultation with various departments of the Govt. of Punjab and have been aligned with the objectives of the eight Missions of the National Action Plan on Climate Change. It is envisaged that each of these strategies and actions will be implemented by the departments that have been identified and cases where necessary, integrated approaches for implementation will be undertaken to address inter-sectoral and cross cutting issues.

This is the first comprehensive document bringing forth the implications of climate change on Punjab. It is envisaged that as science evolves and new technologies are available in the future the strategies will also evolve accordingly to address the long and short term state specific vulnerabilities due to climate change.

In order to formulate policies to climate proof Punjab's economy and ensure a sustainable development in the future, knowledge of climate change and its impacts is essential. As climate change impacts cut across all economic activities, therefore, effective coordination across sectors is a must. Further, upscaling technical capacities of staff in each department will form a strong base to achieve sustainability in the long term. These and formulation of detailed design documents for envisaged programme/project for each activity under different adaptation and mitigation strategies specified in the SAPCC with steps for monitoring and evaluation will enable achievement of the objective towards climate proofing. Last but not the least, no work in isolation can achieve the desired objective unless state of the art solutions for adaptations are sought through collaborations for:

(i) Enhancing Scientific knowledge: It is envisaged to establish a centre of excellence on climate change that will especially address the climate concerns of the agriculture sector, which is a key economic sector of the state. This centre will look into science of climate change, its impact on various sectors, ascertain the associated vulnerabilities, devise strategies for amelioration and implement the same on a pilot basis, thereby influencing current policies towards climate resilience.

(ii) Coordination of SAPCC activates within the state: Climate change impacts encompass all resources affecting multiple sectors. Therefore, adaptation to climate change necessarily requires a multi-sectoral integrated approach. Therefore it is hereby proposed that a Climate Change Cell (CCC) be established in the Department of Science, Technology and Environment, Punjab State Council for Science & Technology that will coordinate the state specific activities identified in the SAPCC.

(iii) Establish technical capacities to implement climate change projects: It is highly important that the departments receive technical support for formulation of projects and take steps towards training of existing staff enabling them to implement projects and programmes that address climate change concerns. This would require extensive training of the staff on climate change science, impacts, vulnerabilities, and technical knowledge for formulating and implementing adaptation and mitigation projects or programmes.

(iv) Formulation of project/programme design documents: As a prioritisation of activities to be taken up within each strategy is already done, the responsible departments can immediately take up the task for preparation of the PDDs.

(v) In-depth review of the state plan funds: It is necessary to undertake an indepth review of the plan budgets given in 12th plan which are aligned towards adaptation to climate change to

check the overlaps in the funds sought through the SAPCC. Preliminary review suggests that some of the activities are already directed towards climate proofing however, the activities suggested in the SAPCC are either over and above the actions in the 12th plan or are an extension of the same activity, which if implemented would require higher allocation as indicated the SAPCC document.

(vi) Seeking financial and technical collaborations: The additional financial support for adaptation and energy efficiency will be sought by seeking convergence with existing financial instruments available with the Punjab government i.e. from within its ongoing programmes and the programmes, schemes, and funds the Government of India. Also the government can look at the Carbon fund of the Ministry of finance for financing green technologies. Support for technologies that originate outside the state, can be sought from bilaterals and multilaterals. Further collaboration with Indian agencies like the ICAR, CSIR, DST, DBT systems that are involved in development of innovative technologies domestically can be explored.
