STATE ACTION PLAN ON CLIMATE CHANGE
FOR
ANDHRA PRADESH

Submitted

to

Ministry of Environment and Forests
Government of India, New Delhi

EPTRI

Environment Protection Training and Research Institute
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C O N T E N T S

LIST OF EXHIBITS

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ABBREVIATIONS

APPCB	Andhra Pradesh Pollution Control Board
A.P.	Andhra Pradesh
ANGRAU	Acharya N G Ranga Agricultural University
AOGCMs	Atmosphere-Ocean-General Circulation Models
APGENCO	Andhra Pradesh Power Generation Corporation
APRLP	Andhra Pradesh Rural Livelihood Project
APSRAC	Andhra Pradesh State Remote Sensing Centre
APSRTC	Andhra Pradesh State Road Transport Corporation
ATR	Action Taken Reports
BMTPC	Building Materials and Technology Promotion Council
BRT	Bus rapid transit
CAD	Command Area Development
CAP	Coastal Andhra Pradesh
CC	Climate Change
CCAP	Climate Change Action Plan
CDM	Clean Development Mechanism
CFLs	Compact Fluorescent Lamps
CFM	Community Forest Management
CMAP	Combined Merged Analysis of Precipitation
CNG	Compressed Natural Gas
COMAPS	Coastal Ocean Monitoring & Prediction Systems
COPD	Chronic Obstructive Pulmonary Disease
CRIDA	Critical Research in Digital Architecture
CRZ	Coastal Regulation Zone
CWC	Cyclone warning centers
DCA	Drug Control Administration
DDA	Delaware Department of Agriculture
DH	Directorate of Health
DPAP	Drought Prone Areas Programme
EBIC	Environmentally Balanced Industrial Complexes
EFS&T	Environment, Forests, Science & Technology
EPTRI	Environment Protection Training and Research Institute
GDP	Gross Domestic Product
GHG	Green House Gas
GISs	Geographical Information Systems
GoAP	Government of Andhra Pradesh
GSDP	Gross State Domestic product

HadCM3	Hadley Centers Regional Climate Model
HDI	Human Development Index
HTL	High Tide Line
HUDA	Hyderabad Urban Development Authority
IAEP	Integrated Afforestation & Eco-development Project
IAS	Invasive alien species
ICDP	Integrated Cotton Development Programme
ICRISAT	International Crops Research Institutes for the semi-Arid Tropics
ICT	Information and Communication Technology
ICZM	Integrated Coastal Zone Management
IITM	Indian Institute of Tropical Meteorology, Pune
IMD	India Meteorological Department
INCCA	Indian Network for Climate Change Assessment
INCOIS	Indian National Center for Ocean Information Service
INM	Integrated Nutrient Management
IPCC	Intergovernmental Panel on Climate Change
IPM	Institute of Preventive Medicine
ISOPOM	Integrated Scheme for Oils, Pulses, Oil Palm and Maize
IT	Information Technology
IWMI	International Water Management Institute
JFPC	Joint Forest Protection Committee
JGSY	Jawahar Gram Samridhi Yojna
JI	Joint Implementation
JNNURM	Jawaharlal Nehru National Urban Renewal Mission
JRA-25	Japanese Reanalysis
LEDs	Light Emitting Diode
LPG	Liquid Petroleum Gas
LULUCF	Landuse , Landuse change and Forestry
M&E	Monitoring & Evaluation
MA & UD	Municipal Administration & Urban Development
MARSIS	Marine Satellite Information Service
MoEF	Ministry of Environment & Forests
MoHA	Ministry of Home Affairs
MS	Mandal Samakhya
MW	Mega Watt
NAIS	National Agriculture Insurance Scheme
NAPCCC	National Action Plan on Climate Change
NCAR	National Centre for Atmospheric Research

NCEP	National Centre for Environmental Prediction
NDMA	National Disaster Management Authority
NE	Northeast
NGO	Non Governmental Organization
NMT	Non Motorized Transport
NSAP	National Social Assistance Programme
OECD	Organization for Economic Co-operation and Development
P&T	Postal and Telegraph's
PAT	Performance Achieve and Trade
PCPIR	Petroleum Chemical and Petrochemical Investment Region
PHCs	Primary Health Centers
PRECIS	Providing Regional Climates for Impacts Studies
PWD	Public Works Division
REIA	Rapid Environmental Impact Assessment
RKVY	Rashtriya Krishi Vikas Yojana
RWA	Residential Welfare Association
SAPCC	State Action Plan on Climate Change
SELMAM	Sea Level Monitoring and Modeling
SEZ	Social Economic Zone
SGRY	Sampoorna Grameen Rozgar Yojana
SHG	Self Help Group
SRES	Special Report on Emission Scenarios (A1, A2, B1, B2 and A1B)
SSP	Social Security Pensions
SVPs	Sector Vulnerability Profiles
SW	Southwest
TERI	The Energy and Resource Institute
ULB	Urban Local Bodies
UNDP	United Nations Development Programme
UNFCCC	United Nation Framework Convention on Climate Change
VO	Village Organization
VSS	Vana Samraksha Samities
WHO	World Health Organisation
WMO	World Meteorological Organization
WRP	Work Participation Rate

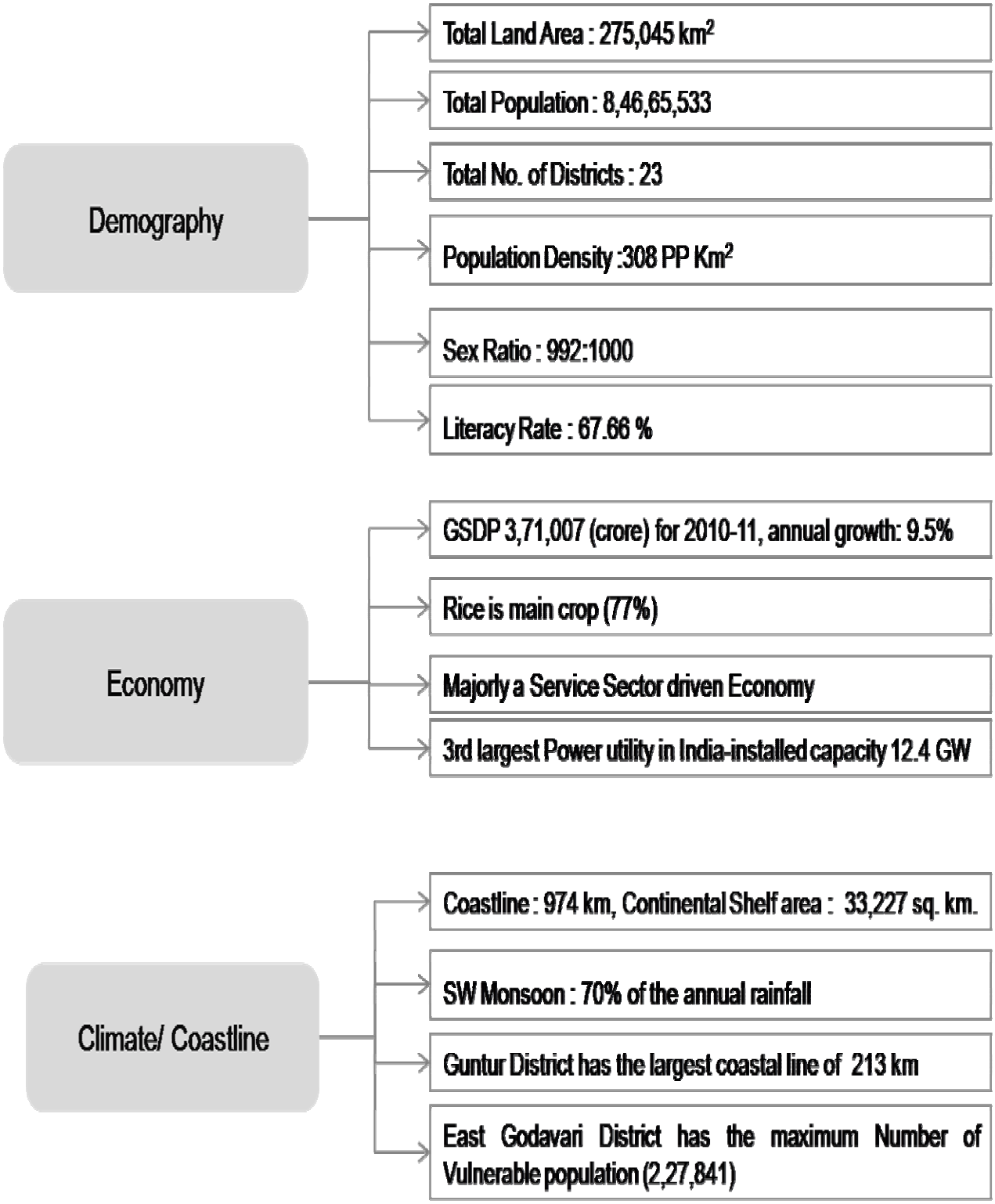
EXECUTIVE SUMMARY

Background

Living and coping with the impacts of climate change is no longer a choice; it is essential for our survival. Climate change poses a challenge to sustainability of social and economic development, livelihoods of communities and environmental management in India. India has pursued a strong domestic agenda to adapt to climate change while maintaining its growth objective and engaging constructively with the international community. The Government of India released the National Action Plan on Climate Change (NAPCC) in 2008 as part of an ambitious domestic action plan to address climate change. The NAPCC focuses on adapting to climate change (CC) and protecting the vulnerable sections of society through an inclusive and sustainable development strategy that also enhances ecological sustainability and innovation. It identifies eight missions in the area of Solar Energy, Enhanced Energy Efficiency, Sustainable Agriculture, Sustainable Habitat, Water, Himalayan Ecosystem, Green India and Strategic Knowledge on CC. In line with the NAPCC, India's Five Year Plans intend to include a strategy for sustainable growth which will help the country to transform to a low carbon economy.

Although the Central Government is the key authority in shaping the climate change policy and creating the institutional mechanism necessary for its implementation, involvement of the State Governments in this process is crucial. With the formulation of a national policy on CC, it has become imperative to achieve coherence between strategies and actions at national and State levels. Most of the adaptation challenges such as coastal zone disasters, droughts, adverse effect on human health, depleting water resources, are experienced at the State level and programmes aimed at improving the adaptive ability are also undertaken and implemented at State level. For certain sectors like industries and energy, part of the solution lies in implementing mitigation interventions at the State level. In this context, the State Government of Andhra Pradesh has taken this initiative to prepare the State Level Action Plan on Climate Change (SAPCC) to enable it to address existing and future climate risks and vulnerabilities.

Baseline Profile of Andhra Pradesh



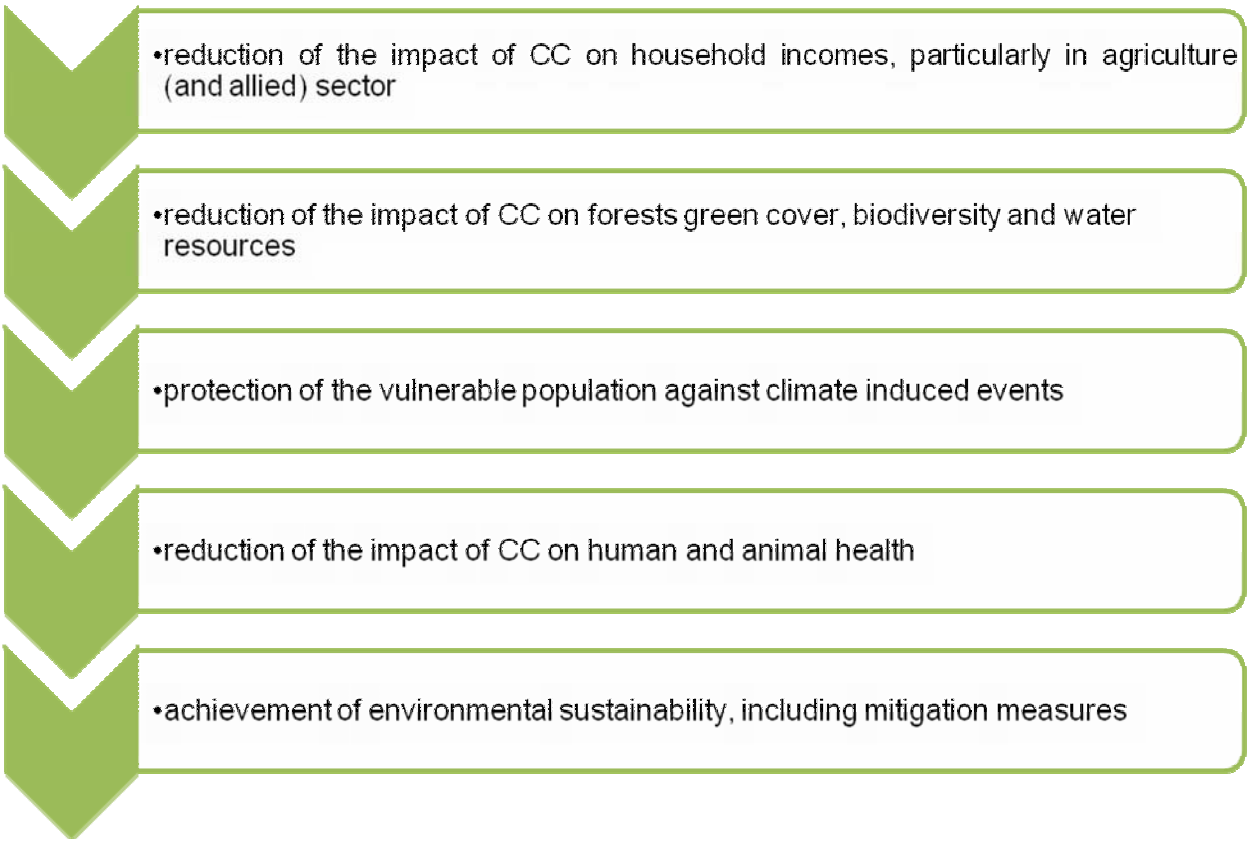
Objectives of SAPCC

- Inclusive and sustainable development of the State that protects the vulnerable sections of society from adverse effects of CC
- Improved ecological sustainability
- Provide a framework to undertake actions that deliver benefits for growth and development while mitigating and adapting to CC
- Prioritize adaptation/mitigation options for the State and identify financing options
- Engineering new and innovative policies/mechanisms to promote sustainable development

Major CC issues for the State arise in the agriculture and forestry sectors and in relation to the long coastline. Agriculture is severely affected by variability in rainfall and temperature patterns, while rising sea levels and extreme events of marine origin, such as cyclones, pose problems for the coastal areas. Besides these, other critical areas of concern are food security, increasing number of climate vulnerable habitats (like slums or village dwellings) and climate vulnerable infrastructure (like roads and bridges which may be washed away by floods).

The SAPCC has been designed around the existing policies of the State Government by taking into consideration ongoing programmes and schemes being implemented at the State level, as well as the NAPCC. The existing policies of the State Government include ISOPOM (integrated scheme for oils, pulses, oil palm and maize), ICDP, Polambadi, National Agriculture Insurance Scheme (NAIS), Rashtriya Krishi Vikas Yojana (RKVY), Jalayagnam, A.P. Integrated Rural Development Program, Rajiv Awas Yojana etc. The SAPCC would be integrated into the State level planning process, so that the resource allocation for implementation of the identified adaptation/mitigation interventions can be made with the objective of achieving the development goals of the State Government.

Goals of SAPCC



The SAPCC is a dynamic and flexible policy framework which will follow a continuous and interactive process to reflect the changes and developments happening at the national, State and local levels. The stakeholders' consultation process is an important aspect of SAPCC. Stakeholder engagement and consultation aligns them into the planning framework, and broadens and deepens perspectives and involvement in implementation of the State Action Plans for building a climate resilient economy. This SAPCC has been designed following stakeholders' concerns and issues.

The SAPCC has followed a structured approach to formulate and implement adaptation strategies, policies and measures to ensure human development in the face of climate variability and change.

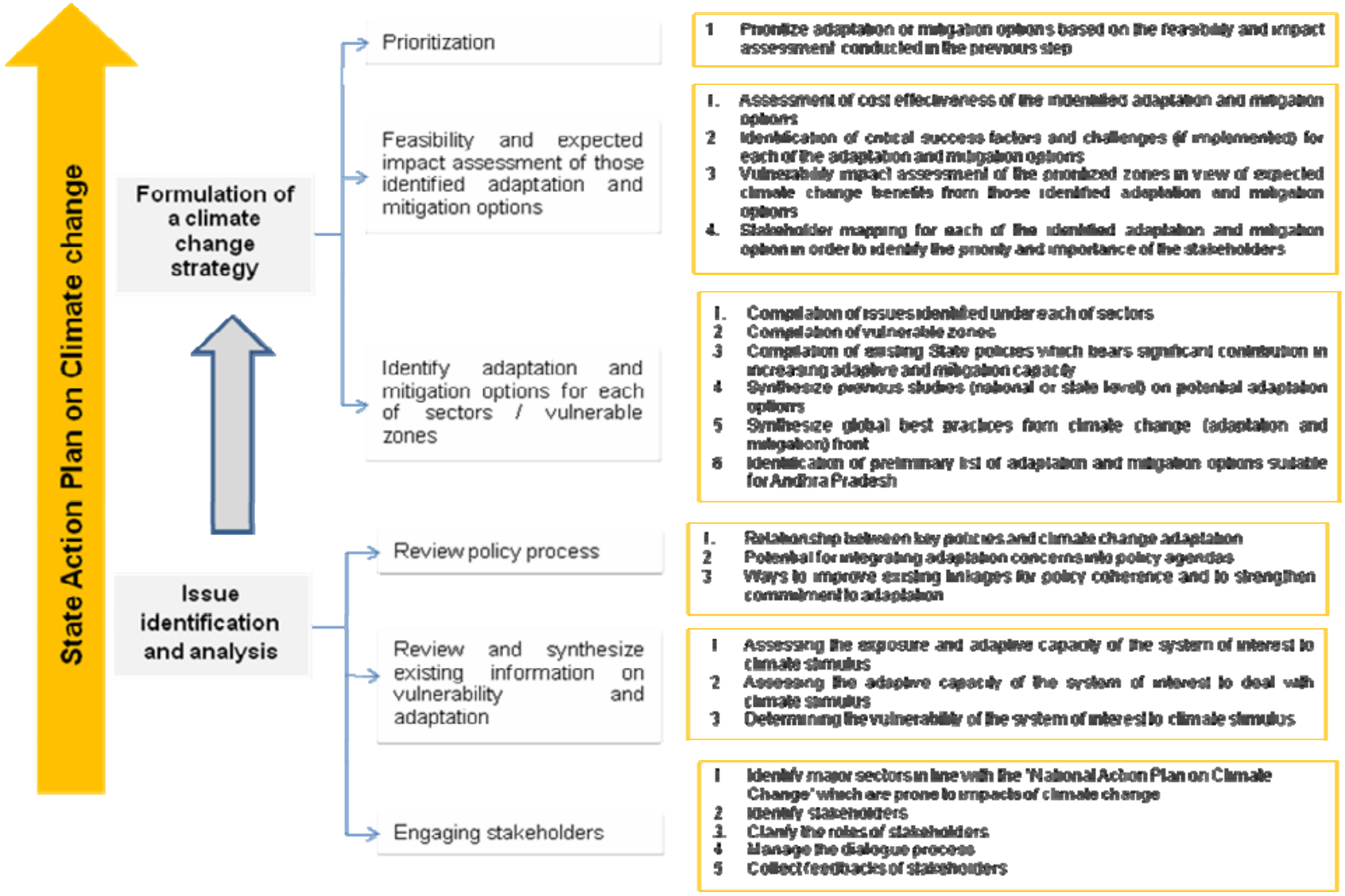
Principles of SAPCC

- Adaptation to short-term climate variability and extreme events serves as a starting point for reducing vulnerability to longer-term climate change.
- Adaptation policies and interventions are assessed in the State developmental context.
- Adaptation occurs at different levels in society, including the local level.
- The adaptation strategy and the process by which it is implemented are equally important.
- Mitigation measures, in line with the NAPCC, are proposed in certain key sectors.

Implementing the SAPCC will be characterized by:

- Strong stakeholder engagement.
- Assessing the vulnerability of districts and enhancing their adaptive capacity.
- Analysis of adaptation/mitigation options to cope with current and future climate change.
- A programme to monitor, evaluate and improve the impact of the adaptation/mitigation activities.

Approach followed to develop State Action Plan on Climate Change



A detailed diagnostic study, following the UNDP methodologies (UNDP Adaptation Policy Framework and Human Development Index) has been performed to assess the climate change vulnerability profile of Andhra Pradesh. It is based on the basic hypothesis that climate change vulnerability of a region is a function of two key variables:

- adaptive capacity of the region
- physical exposure of the region to climatic events

An index has been developed to estimate these two parameters. 11 major sectors which are seriously impacted by CC have been identified for the State. The issues, concerns and specific interventions for these sectors have been discussed. Adaptation interventions have been designed for these sectors such as agriculture, coastal zone management, rural development, transport, tourism, forestry and biodiversity, urban development, health and family welfare, irrigation and water while mitigation options have also been identified for energy, industry and transport. An indicative list of sectoral concerns, adaptation/mitigation interventions and corresponding challenges has been tabulated here.

Key Sectors identified for SAPCC

1. Agriculture
2. Coastal Zone Management
3. Forestry & Biodiversity
4. Energy
5. Industries (including mining)
6. Transportation
7. Health
8. Urban development
9. Tourism
10. Rural Development
11. Research in Climate Change

Critical Sectoral Issues	Key Interventions
1. Agriculture	
• Decrease in winter rainfall has a negative impact on winter crops (Rabi crops), especially in the rainfed areas • Temperature fluctuations affect Rabi crops severely • Decrease in area under crops on account of insufficient rainfall, particularly in the South- West Monsoon period • Dryland areas of the State have annual rainfall less than 550 mm and farming is not viable • Loss in fertility of soil in many areas due to excessive use of fertilizers and pesticides.	• Development and dissemination of new crop varieties resilient to heat, photo and water stress • Replacement of inorganic fertilisers by bio-fertilisers • Assured credit facility, including for tenant farmers • Insurance against crop failures (not just for the bank loan component) • Extension work for change of cropping timings and patterns, efficiency of water use, weather advisories to farmers, information on market prices etc. • Intensive research work on stable agriculture in the context of climate change, in all its aspects • Establishment of field centres, data banks and germplasm banks • Standardization of fuel efficient irrigation pump sets • Retrofitting existing pump sets for higher energy efficiency
2. Coastal Zone Management	
• Increase in the number and severity of cyclones in the State • Loss of life and infrastructure due to cyclonic events • Losses due to Cyclones, Floods, Tsunamis and similar events • Coastal erosion and severe marine pollution due to setting of thermal power plants, pharmaceutical plants ports, ship breaking units and sand mining activities	• Provision of cyclone shelters and all-weather connectivity to all vulnerable habitations along the coast • Establishment of a Disaster Rapid Response Force, with equipment, communication systems etc. • Systems for dissemination of cyclone and tsunami warnings • Protection works on rivers and seacoasts, such as flood banks, groynes, dykes etc.

Critical Sectoral Issues	Key Interventions
	• Inter-State coordination of various canal and river management agencies to manage flood flows
3. Forestry and Biodiversity	
• Deforestation, degradation of forests and excess of soil erosion in degraded forests • Cyclonic storms and tidal waves cause damage to forests • Increasing acidity of sea water imperils the growth and survival of plankton which endangers the marine biodiversity • Disturbance in the timing of flowering and appearance of pollinators and excessive use of pesticides/insecticides, loss of forests, air pollution etc have also decreased the appearance of pollinators	• Soil and Water Conservation in forest lands • Restoration of mangroves • Afforestation and eco-development through community based programmes (like Joint Forest Management) • Creation of forests in degraded/public lands, including such lands in and around cities and towns • Documentation of biodiversity, including genetic fingerprinting Preservation of rare/threatened germplasm shelter belt plantation in coastal regions to reduce damage from cyclone
4. Energy	
• Increasing use of fossil fuel by energy sector • Incentivizing cleaner energy technologies • Promotion of renewable energy in the State • Demand side management to reduce consumption • Subsidization of new clean technologies	• Improve the efficiency of thermal power generation • Improve the efficiency of transmission, including elimination of pilferage • Improve the efficiency of electrical equipment, including water pumping equipment used in agriculture • Promotion of affordable alternative energy sources i.e. solar home systems, solar street lights, solar thermal systems • Rationalisation of power tariff for currently subsidized sectors • Electricity generation using non-conventional sources

Critical Sectoral Issues	Key Interventions
5. Industries	
• Increasing fossil fuel consumption and GHG emissions from the industries • Increasing number of industries in state and their improper waste management practices • Fisheries sector is highly vulnerable to climate change effects and extreme weather condition. • Agro-business and food processing industries are vulnerable to extreme weather events like flood, cyclone etc. • Protecting agro industry through mapping and shifting the supply chain towards less climate change vulnerable zone • Depletion and degradation of surface water, aquifers and leaching from dumps causing acid mine drainage • Land degradation and large scale deforestation, noise and vibration, destruction of habitat, loss of bio-diversity • The activities in open cast mining like blasting, drilling, excavation, truck loading and transportation are responsible for the increase of suspended particulate matter in the air • Dislocation of human communities and health impacts on the community living in close proximity to the mine areas	• Enforce 'cleaner production processes' and waste minimisation across industries, in partnership with the Central and State Pollution Control Boards • Assess the vulnerability of major industrial hubs to climate related risks • Protection and disaster mitigation works to minimise risks to industrial hubs (e.g. seawalls, alternate rail and road access, improving drainage, alternate water supply sources etc.) • Minimise environmental damage including GHG emissions, caused by industrial and mining activities • Promote diversified and dispersed industries, including small/medium scale agro processing, to stabilise agricultural livelihoods • Intensive research for the biological methods of metal extraction from mine spoils to prevent acid mine drainage • Pollution prevention measures to reduce prevent air pollution during open cast mining activities • Implementation of resettlement and rehabilitation plans for affected population • Compensatory afforestration activities on a large scale

Critical Sectoral Issues	Key Interventions
6. Transportation	
• Growth of cities and large-scale rural-urban migration has increased the population and density, thus vehicles density • The share of public transport is low in State, far below the global best practices • Road congestion resulting in poor fuel economy • Penetration of alternate fuel usage is negligible in transport sector • Lack of organized efforts to promote fuel efficiency improvement and eco-driving habits for 'vehicles in use' among drivers or owners of the vehicles (private or governmental)	• Enhance the share of public transport in the total transportation mix • Enhance the share of low emission/fuel-efficient vehicles and vehicles that run on alternate fuels • Encourage non-motorised transport like walking and cycling • Design or redesign road networks so as to facilitate smooth traffic movement • Interlink private and public transport modes so as to minimise the use of private transport
7. Health	
• The changing patterns of rainfall, temperature and humidity are increasing the cases of vector borne diseases in the State • Excess of air pollution in towns is increasing the respiratory problems and lung infection cases • Health problems due to extreme heat and cold climate	• Undertake longer-term studies to investigate links between climate change and disease patterns, as also between pollution loads and disease patterns • Strengthen detection and early warning systems for outbreaks of diseases • Public education on prevention of diseases related to climate change and resulting from environmental pollution • Health Surveillance • Research on development of low cost vaccines, particularly those related to vector borne diseases • Development of rapid response capabilities to handle the impact of climate change related events

Critical Sectoral Issues	Key Interventions
8. Urban Development	
• Drainage of cities not adequate to accommodate the precipitations during heavy rains • Demand on water resources due to the growth in the urban population and therefore increased pressure on the water supply infrastructure • Generation of large quantity of sewage • Generation of huge quantum of solid waste • Increased private transportation leading to huge pressure on the road infrastructure and increased emissions in urban areas	• Safe water supply as per norms to the entire urban population • 100% coverage of sewerage and sanitation for the urban population • Study and remodel existing water supply, sanitation and sewerage systems to reduce climate change vulnerability • Protection and restoration of existing water bodies in urban areas, creation of new waster bodies • Scientific management of municipal solid waste in all municipalities and corporations • Restoring efficiency of drainage network of all municipalities to enable quick evacuation of water and to avoid flooding • Mandatory rainwater harvesting in Government buildings, larger homes and apartment blocks, commercial establishments, offices, schools/colleges, academic/research establishments and industrial units • Incentives for rooftop solar power generation and provision of grid connectivity • Rail based MRTS in emerging cities and expansion of existing MRTS • Provision of safe footpaths, cycle tracks etc to promote non-motorised transport • Recovery of phosphates nitrates etc. from wastewater

Critical Sectoral Issues	Key Interventions
9. Tourism	
• Habitat loss and degradation, caused by logging for firewood and timber materials, are major threats to restricted-range species • Poaching, hunting and unsustainable exploitation threaten both flora and fauna Changes in coastal and marine systems, species and ecosystem services, damage to infrastructure, water shortages and water contamination due to sea level rise, global warming and ocean acidification. coral reef destruction, mangrove destruction. Tourism transportation and usage of high carbon intensive fuels in resort/tourist spots cause high levels of CO_2 emissions which increase the pollution levels	• Promote low emission/fuel-efficient mass transportation, to and within tourist areas e.g. battery operated vans • Promote energy efficiency lighting, climate control equipment etc. in hotels and other areas where tourists congregate • Promote eco-tourism to enhance environmental consciousness • Enforce cleanliness in tourist areas • Protect both built and natural heritage against climate related damage.
10. Rural Development	
• Deterioration of natural water resources and other ecological resources impacting the livelihood of rural population • Due to lack of opportunities in the rural areas, there is large migration of rural population to urban areas, is in turn putting pressure on the urban infrastructure • The poor living along the coastal line are most vulnerable to disasters like floods and cyclones. The housing is mostly *kutcha* in nature	• Safe Water Supply as per norms to the entire rural population and entire coverage of sewerage and sanitation for the rural population • Study the climate change vulnerability of existing water supply and sewerage/sanitation systems • Remodel or strengthen existing water supply and sanitation/sewerage systems to reduce vulnerability to climate change • All-weather road connectivity to all habitations for access to goods and services, and for evacuation in emergency

Critical Sectoral Issues	Key Interventions
	• Increasing energy efficiency in street lighting and water pumping by Panchayats • Micro credit facility for subsdising livelihood • Creation of new water bodies and restoration of existing water bodies • Public education on climate change and its impacts
11. Research in Climate Change	
• Higher vulnerability of the State towards climate change due to second largest coastline among Indian States. • The river basins and coastal areas are prone to climate change impacts due to changing precipitation and temperature patterns. • Industrial hubs are prone to climate change impacts due to unscientific construction and water and electricity scarcity. • Majority of rural and urban population is not aware about the climate change issues and impacts. • Lack of Climate Change knowledge center in the State	• Setting up of Climate Change knowledge center at EPTRI • Climatic vulnerability studies in major river basins of the State • Climatic and socio-economic vulnerability studies in industrial hubs prone to floods, erosions and scarcity of water and electricity. • Climatic baseline studies in ULBs and municipal corporation. • Demonstration projects at ULB and major Gram Panchayat levels

The SAPCC for Andhra Pradesh provides a common and generic framework to usher an era of climate resilient sustainable development for the State. The five key strategies for the State can be summarized as:

- Address State specific priority issues while creating appropriate environment for implementation of NAPCC at State level
- Mobilize stakeholders/institutions to work in a collaborative manner towards an integrated solution to CC through inter-departmental consultations, stakeholder involvement, regular planning and budgetary processes
- Mainstream CC Adaptation into State level planning and development in order to enhance climate resilience of the State economy
- Give importance to key economic drivers, food security, health and human settlements
- Safeguard natural resources and biodiversity from CC impacts

Coordination between local Panchayati Raj institutions, district administration, State Departments and Central Government would ensure successful implementation of adaptation and mitigation interventions and meet the objectives of the NAPCC at the State level.

1. INTRODUCTION

1.1 Background

Climate change refers to a change in the state of the climate that can be identified by changes that persist for an extended period, usually decades or longer. It refers to any change in climate over time, whether due to natural variability or as a result of human activity. Climate change resulting from carbon dioxide (CO_2) and other greenhouse gas (GHG) emissions viz. methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons and sulphur hexafluoride is the gravest environmental challenge ever faced by the humanity. The global atmospheric concentration of CO_2 has increased from pre-industrial level of 280 parts per million (ppm) to 379 ppm in 2005. Consequently, the global average surface temperature has already increased by 0.74°C from above pre-industrial times. IPCC Fourth Assessment Report projects that even if the concentrations of all greenhouse gases and aerosols are kept constant at year 2000 levels, a further warming of about 0.1°C per decade would be expected and in different emission scenarios, a further warming of 1.1ºC to 6.4ºC over the 21st century (best estimates: 1.8ºC - 4ºC) is likely to happen. Scientists warn that the impact of this increase on the ecosystem and human welfare would be severe, especially in the developing countries. With these facts in the background, the world is currently negotiating the targets and the burden-sharing mechanism to reduce the global GHG emissions post 2012.

1.2 Climate Change and Global Initiatives

The first major step taken globally in the year 1988 was the setting up of the *Intergovernmental Panel on Climate Change (IPCC)*. The panel was set up by the United Nations and World Meteorological Organization (WMO) to assess the technical issues that were being raised in debates on climate change, so policy makers are armed with facts from collective scientific endeavour. The IPCC comprises representatives from about 140 governments to consider the science that is currently known about climate change. The IPCC publishes reports that provide governments with a sound summary of knowledge and facts.

The other notable global action was taken by conducting the *United Nations Framework Convention on Climate Change (UNFCCC)* at Rio, Brazil in the year 1992, to combat climate change.

The Convention aimed at the stabilization of GHG concentrations in the atmosphere at a level that would prevent dangerous anthropogenic (man-made) interference with the climate system. This should be achieved within a time-frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not

threatened, and to enable sustainable economic development. The convention concluded with the framing of the Kyoto Protocol. The Kyoto Protocol talks set binding targets for 37 industrialized countries and the European Community for reducing greenhouse gas (GHG) emissions. This amounts to an average of five per cent against 1990 levels over the five-year period 2008-2012.

*The Kyoto Protoco*l was adopted in Kyoto, Japan, on 11 December 1997 and entered into force on 16 February 2005. The Kyoto mechanisms are the major attraction of the protocol, and have attained importance and attention in the market economy. The Kyoto Protocol offers an additional means of meeting their targets by way of three market-based mechanisms. The Kyoto mechanisms are 'Emissions Trading' – known as "the carbon market", 'Clean Development Mechanism' (CDM) and 'Joint Implementation' (JI). The mechanisms stimulate green investment and help Parties meet their emission targets in a cost-effective way.

The United Nations Climate Change Conference (COP 16) was held at Cancún, Mexico, from 29 November to 10 December 2010. The outcome of the summit was an agreement adopted by the Parties that called for a large "Green Climate Fund," and a "Climate Technology Center" and network. It looked forward to a second commitment period for the Kyoto Protocol.

1.3 India's Response to the Global Initiatives

- India is the world's fourth largest economy and fifth largest GHG emitter with a total GHG emission of 1727.71million tons (with LULUCF) for the year 2007.
    - CO_2 emissions were 1221.76 million tons;
    - CH_4 emissions were 20.56 million tons; and
    - N_2O emissions were 0.24 million tons
- Vulnerable to climate change, among other causes because of the existence of a large and densely habitated costal belt.
- GHG emissions from Energy, Industry, Agriculture, and Waste sectors constituted 58%, 22%, 17% and 3% of the net CO_2 eq. emissions respectively.
- India is dependent on agriculture and forest resources.
- The monsoons are shifting westwards making central India drier. The number of rainy days is decreasing and amount of rainfall in a single day is increasing.
- The mean and maximum temperatures analysed for 12 of the major Indian cities show an increase, as do the sea temperatures and the droughts, which have increased over the past 3 decades. The projections for the last quarter of the

20th century show more variations in northern India and over Himalayas that puts the Himalayan glaciers at threat.[1]

India has in place a number of statutes, institutions, policies and programs that provide a framework for GHG abatement. While there is no single comprehensive low carbon policy or programme, there are policies and programs, which address CC issues directly or indirectly.

Many of these policies are contained in the Five Year Plans developed by the Planning Commission to guide economic policy in India. For instance, one of the objectives of the Eleventh Plan is to reduce the energy intensity per unit of GHG by 20% from the period 2007–08 to 2016–17. The Eleventh Plan also seeks to boost access to cleaner and renewable energy by exploiting existing resources (e.g., hydropower and wind power) developing nuclear power, and also supporting research in newer areas such as bio fuels from agro-waste and solar energy.[2]

Other policies are found in the Integrated Energy Policy approved by the Planning Commission in 2006 with the broad objective of meeting energy demand "at the least cost in a technically efficient, economically viable and environmentally sustainable manner."

In December 2005, the Government of India launched the Jawaharlal Nehru National Urban Renewal Mission (JNNURM) to encourage reforms and fast track planned development of 63 identified cities. JNNURM funds these cities to undertake land-use planning, build infrastructure like urban transport and undertake water, sanitation and solid waste management projects. Many cities are implementing co-benefit projects under JNNURM to reduce their GHG emissions.

1.4 National Action Plan on Climate Change

India has a strong domestic agenda to counter climate change while constructively engaging with the international community to address global warming. However, in doing so India is facing the challenge of sustaining its rapid economic growth rate. India's National Action Plan on Climate Change (NAPCC), released on 30th June, 2008, was the first major milestone to achieve the objectives of a socially inclusive and sustainable economic growth. The primary objective of this national action plan was to maintain a high growth rate, while protecting the poor and vulnerable sections of society and achieve ecological sustainability.

[1] Indian Institute of Tropical Meteorology (IITM),2010
[2] Eleventh Five Year Plan, Planning Commission, Government of India, 2008

The NAPCC identifies eight National Missions to provide a multi-pronged and integrated framework for addressing climate change. The focus of NAPCC is on adaptation and mitigation, energy efficiency and natural resource conservation and capacity building/stakeholder involvement on climate change issues.

The eight missions under NAPCC are: National Solar Mission, National Mission for Enhanced Energy Efficiency, National Water Mission, National Mission on Sustainable Habitat, 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.

1.5 State Action Plan on Climate Change (SAPCC)

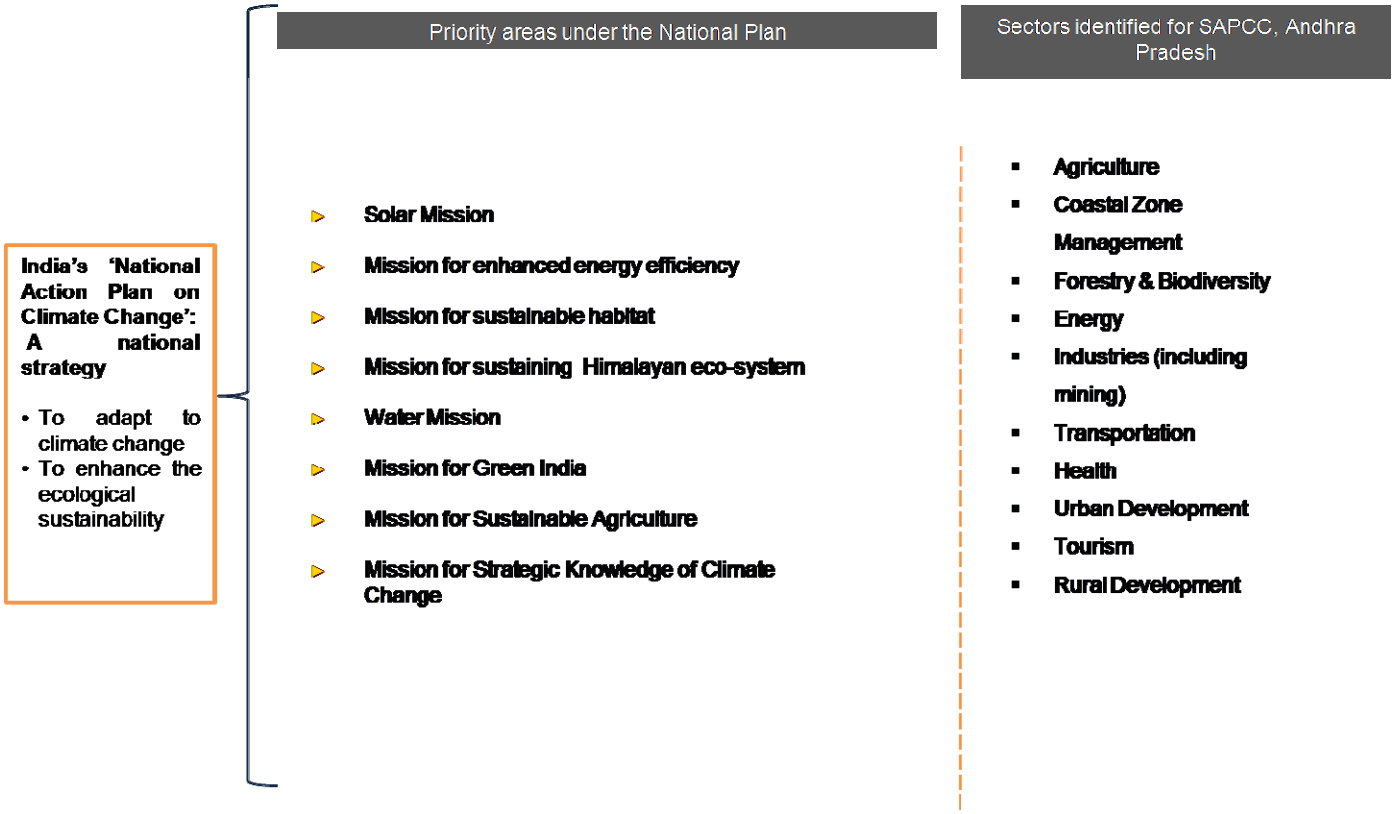
In 2009, the Ministry of Environment and Forests called upon the States to expeditiously prepare the State Action Plans on Climate Change consistent with the strategy outlined in National Action Plan on Climate Change.

The Government of Andhra Pradesh is in the process of developing the SAPCC. In doing so, prioritization blocks have been identified. A snapshot of priorities is presented in Exhibit 1, depicting focus areas under national action plan and corresponding areas identified for Andhra Pradesh where State Government could contribute substantially.

Some of the priority blocks are major contributors to climate change, where policy intervention is needed to mitigate climate change. At the same time there are a few priority blocks which are exposed to the physical risks of climate change and here State Government has to be proactive in developing adaptation strategies. Strategy formulation has to be preceded by identification and analyzing the issues.

The aim of preparing the SAPCC for Andhra Pradesh is to get an idea about how the State's key sectors would be affected due to CC and what adaptation/mitigation interventions need to be taken.

Exhibit - 1 : Priorities under NAPCC



1.6 Objectives of SAPCC

- Inclusive and sustainable development of the State that protects the vulnerable sections of society from adverse effects of CC
- Improved ecological sustainability
- Provide a framework to undertake actions that deliver benefits for growth and development while mitigating and adapting to CC
- Prioritize adaptation/mitigation options for the State and identify financing options
- Engineering new and innovative policies/mechanisms to promote sustainable development

1.7 SAPCC : Steering Committee

The Steering Committee on the SAPCC was headed by the Chief Secretary, Andhra Pradesh with the following members:

1. Chief Secretary - Chairman
2. Special Chief Secretary, EFS&T Department - Member

3. Special Chief Secretary, Agriculture Department	-	Member
4. Principal Secretary, Planning Department	-	Member
5. Principal Secretary, Energy Department	-	Member
6. Special Chief Secretary, Animal Husbandry and Fisheries	-	Member
7. Special Chief Secretary, Health, Medical and Family Welfare		Member
8. Special Chief Secretary, Finance Department	-	Member
9. Principal Chief Conservator of Forests	-	Member
10. Vice Chancellor, ANGRAU	-	Member
11. Principal Secretary, Industries and Commerce	-	Member
12. Principal Secretary, Transport	-	Member
13. Principal Secretary, MA&UD	-	Member
14. Principal Secretary, Irrigation and Command Area Development	-	Member
15. Commissioner, Disaster Management & E.O. Principal Secretary	-	Member
16. Secretary, Tourism	-	Member
17. Member Secretary, A.P. Pollution Control Board	-	Member
18. Director General, EPTRI & Special Chief Secretary to Government	-	Member - Convener

The Steering Committee finalised and approved the sectors to be covered in the Action Plan on Climate Change, and gave their valuable guidance.

The Working Group headed by the Director General, EPTRI with the following members:

1. Director General, EPTRI	-	Chairman
2. Additional Principal Chief Conservator of Forests (Sri Ramesh Kalgati)	-	Member
3. Principal Secretary, Planning Department	-	Member
4. Chairman and Managing Director, APGENCO	-	Member
5. Director, Animal Husbandry	-	Member
6. Commissioner of Industries	-	Member
7. Director, Health & Family Welfare	-	Member
8. Commissioner, Transport	-	Member
9. Commissioner, Rural Development	-	Member
10. Commissioner & Director Municipal Administration	-	Member
11. Director of Mines & Geology	-	Member
12. Director, CRIDA	-	Member
13. Director, Indian National Centre for Ocean Information Services (INCOIS)	-	Member

14. ICRISAT Representative	-	Member
15. Representative of APPCB	-	Member
16. Principal Scientist (Agromet), ANGRAU	-	Member
17. Special Invitees (to be identified)		
18. Head, Environment and Sustainable Development Division, EPTRI	-	Member - Convener

The Working Group is responsible to chalk out the plan of work with timelines, guide the field functionaries on identification of institutions/organisations working in the State / country on Climate Change for collection of data, data analysis and report writing. The Working Group also reviewed the progress of work and provided inputs for completion of SAPCC.

1.8 Guiding Principles in Strategy & Action Plan Formulation

The climate change strategy and action plan have been based on 5 main guiding principles:

- *Pursue pragmatic solutions, in line with the national development agenda*: The strategy is focused around supporting the objective of the Central Government on NAPCC, inclusive growth and ensuring economic sustainability in the longer term. Actions would be undertaken which deliver benefits for growth and development, while adapting to climate change and ensuring ecological sustainability.
- *Initiate process to mobilize significant investments*: An estimation of additional resource requirements and exploration of existing and new carbon finance potential has to be carried out. Linking national policies and programmes for consistency and financial/policy support would be another major action point.
- *Mobilize people/institutions to work towards integrated solutions*: This would involve building broader stakeholder engagement to widen perspectives and involvement in implementation. Considering governance and institutional contexts, appropriate institutional arrangements and building capacities have to be ensured, keeping in view the coordination between departments, various stakeholders and integration with regular planning and budgetary processes.
- *Harness the expertise and knowledge already available in the State and the country on adapting to climate change*: Investment in knowledge and research is essential to reduce climate related uncertainty and improve knowledge about appropriate responses.

- *Contribute towards developing the State*: State specific issues have to be considered and prioritized while creating appropriate enabling environment for implementation of NAPCC at State level.

Success and sustainability of the investments are of critical importance. All of the thrusts of Andhra Pradesh's development framework show vulnerabilities to climate change. Adaptive measures will be necessary to ensure their long term resilience and sustainability in the face of climate change. In order to effectively align Andhra Pradesh's developmental objectives with the sustainability agenda, this strategic action plan aggregates findings across sectors, and addresses them in an integrated manner which reflects the national priorities articulated through the NAPCC.

1.9 State Profile

Andhra Pradesh is situated on the southeastern coast of India. It is India's fourth largest State by area and fifth largest by population. Its capital and largest city by population is Hyderabad. The State has the second-longest coastline of 974 km among all the States in India. The State is divided into three major regions, namely Coastal Andhra, Rayalaseema and Telangana, and has 23 districts. The district map of Andhra Pradesh is given in Exhibit 2.

Exhibit - 2 : District Map of Andhra Pradesh

1.9.1 Geography and Climate

Andhra Pradesh lies between 12°41' and 22° N latitude and 77° and 84°40' E longitude, and is bordered by Maharashtra, Chhattisgarh and Orissa in the north, the Bay of Bengal in the east, Tamil Nadu to the south and Karnataka to the west. The South-west monsoon accounts for about 70% of the annual rainfall in the State. The State generally receives reasonably widespread rainfall across various districts.

1.9.2 Demographic Overview

Andhra Pradesh occupies a total land area of 275,045 lakh hectares. The State has a total population of 8,46,65,533. The population density is 308 persons per sq. km. The male population is 4,25,09,881 and the female population is 4,21,55,652, forming a sex ratio of 992:1000. The literacy rate of the State is 67.66 %.[3]

1.9.3 Ecological overview

1.9.3.1 Natural Resources

In the State as a whole, three distinct physical zones can be discerned, viz., i) the coastal plains, ii) the Eastern Ghats and iii) the Western pen plains. The coastal plains stretch along the State's coast from the northernmost point in Srikakulam district to the southernmost point in Nellore district. In the middle of this region is located the shallow fresh water lake of Kolleru covering an area of about 260 sq. km. during rainy season.

- *Forests*

Forests constitute one of the major natural resource of the State. The 'forest area' is the area recorded as forests by the Government as per revenue records. However; 'forest cover' refers to all lands more than one hectare in area, having a tree canopy density of more than 10%. Thus, the term 'forest area' denotes the legal status of the land as per the Government records, whereas the term 'forest cover' indicates presence of trees over any land.

The State has 63,821 sq. km. of forest area constituting 23.2% of the total geographical area. The total forest cover of the State is recorded to be 44,419 sq. km. which is 16.15% of the total geographical area of the State. Exhibits 3 and 4 below give the distribution of forest into different classes in Andhra Pradesh and corresponding forest

[3] Census 2011

distribution across the State. Timber, Bamboo, Firewood, Charcoal, Beedi leaves etc are the major forest products of economic value.

Exhibit - 3: Classification of Forests in Andhra Pradesh[4]

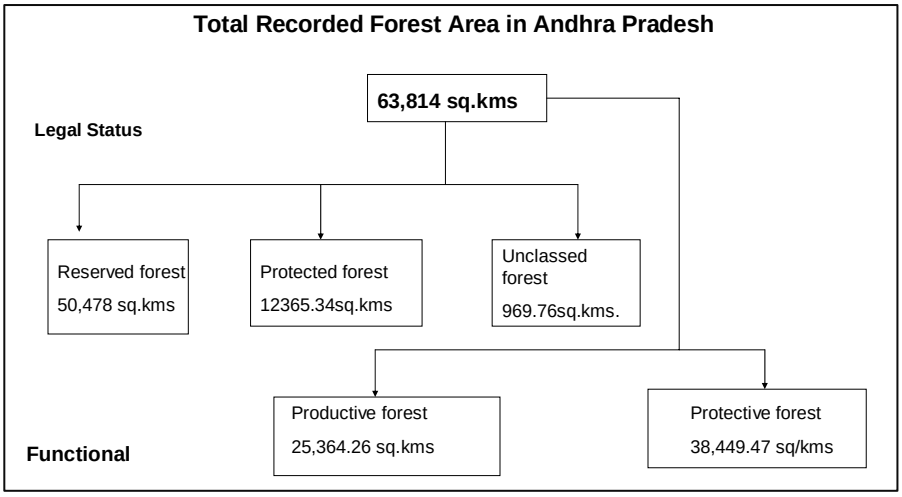
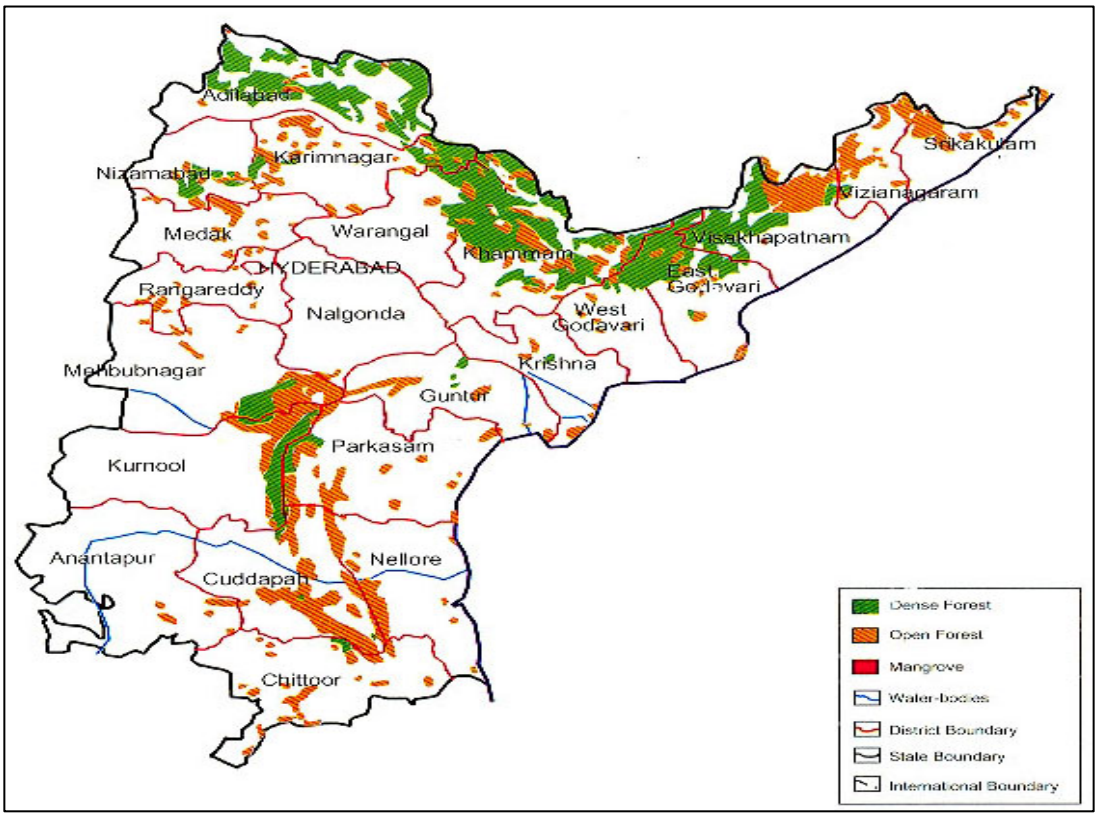


Exhibit 4: Geographical distribution of forests in A.P.



[4] State of Environment Report, GoAP, 2010

- *Medicinal and aromatic plants*

The State is rich in variety of medicinal and aromatic plants and 1800 species of such plants are cultivated on about 10,000 hectares in the State. Large scale cultivation of plants of medicinal value is carried out in the districts of Visakhapatnam, Prakasam, Guntur and Anantapur. Amla, (*Emblica officinalis*), Vasa (*Adhatoda beddomei*), Aloe Vera, Nelavemu (*Andrographis paniculata*), Aswagandha (*Withania somnifera*) and Coleus are the major medicinal plants cultivated in the State.

- *Flora and Fauna*

With its strategic positioning in the central region of the Indian subcontinent, The State's favorable climatic conditions support a variety of flora and fauna. Besides the favorable climatic conditions Andhra Pradesh's varied topography ranging from the hills of Eastern Ghats and the Nallamalla hills to the shores of Bay of Bengal supports varied ecotypes, in turn supporting a rich diversity of flora and fauna. Andhra Pradesh's forests can be divided into four major groups based on the biotic characteristics namely: Deccan Plateau (53%), Central Plateau (35%), Eastern Highlands (11%) and Eastern Coastal Plains (1%). Dry deciduous trees like *Teak, Terminalia, Dalbergia, Pterocarpus, Anogeissus* constitute the tree species found in the forests of Andhra Pradesh. Besides these deciduous trees, some rare endemic plants like *Cycas beddomei*, *Pterocarpus santalinus*, *Terminalia pallida*, *Syzygium alternifolium*, *Shorea tumburgia*, *Psilotum nudam* etc are also found in the State.

The Double banded or the Jerdon's Courser (*Rhinoptilus bitorquatus*), the endangered, nocturnal and elusive bird is found in its last known habitat in Andhra Pradesh. Similarly, the Great Indian Bustard, a highly endangered species, is found in Rollapadu Wildlife Sanctuary in Kurnool, the lone ideal habitat of this large handsome bird in Andhra. The Golden Gecko and the Slender Loris are the other endemic and endangered species found in the State.

The hills of Eastern Ghats house a rich biological diversity of flora and fauna. It provides a natural habitat for a diversity of fauna ranging from Tiger, Panther, Wolf, Wild Dog, Hyena, Sloth Bear, Gaur, Black Buck, Chinkara, Chowsingha, Nilgai, Cheetal, Sambar and a number of birds and reptiles.

The coastal region of Andhra Pradesh provides a breeding ground for endangered sea turtles and a variety of fish species like *Oil Sardine*, *Anchovy*, *Lesser Sardines*, *Penaeid Prawn*, *Mackerel*, Ribbon Fish, *Carangidae*, Croakers, Perches and Crabs. The backwaters of Pulicat Lake are feeding grounds for rare bird species like Flamingo and

Grey Pelican. Mangrove forests housing the Fishing Cat and Otters can be found spread over the estuaries of Krishna and Godavari rivers. The dominant mangrove vegetation comprises *Rhizophora mucronata*, *R. apiculata*, *Avicennia marina*, *Avicennia alfa, Avicennia officinalis*, *Ceriops decandra*, *Bruguiera gymnorrhiza*, *Lumnitzera racemosa*, *Sonneratia apetala*, *Excoecaria agallocha*, *Acanthus ilicifolius, Xylocarpus moluccensis, Suaeda nudiflora*[5].

1.9.3.2 River Basins

Andhra Pradesh is popularly referred to as a 'River State'. Nearly 75% of the State's territory is covered by the basins of three major rivers - Godavari, Krishna and Pennar and their tributaries. In addition, there are 17 other rivers like Sarada, Nagavali, Musi and other streams. The Godavari with its 1464 km length, of which about 772 km lies within the State, is the longest and the broadest river in South India.

1.9.3.3 Agro Climatic Zones

The State experiences tropical climate with slight variations depending on the elevation and maritime influence and varies according to the three regions. The rainfall is received from both the South-West and North- East monsoons, predominantly the former, but precipitation varies across the State.

The districts of the State can be divided into 9 agro-climatic zones, as shown in Table-1.

Table - 1: Agro-climatic zone wise division of the State

Sl. No.	Name of the Zone	Districts	Geographical area (lakh ha)	No. of Mandals
I	High altitude and Tribal areas Zone	High altitude and Tribal areas of Srikakulam, Visakhapatnam, East Godavari, Khammam and Adilabad districts	18	40
II	North Coastal Zone	Srikakulam, Vizianagaram, Visakhapatnam	18.5	88
III	Godavari Zone	East Godavari, West Godavari	17.5	96
IV	Krishna Zone	Krishna, Guntur, Prakasam	37.7	161
V	Southern Zone	Chittoor, Kadapa, Nellore	41.7	161
VI	Northern Telangana Zone	Karimnagar, Nizamabad, Adilabad	35.5	144

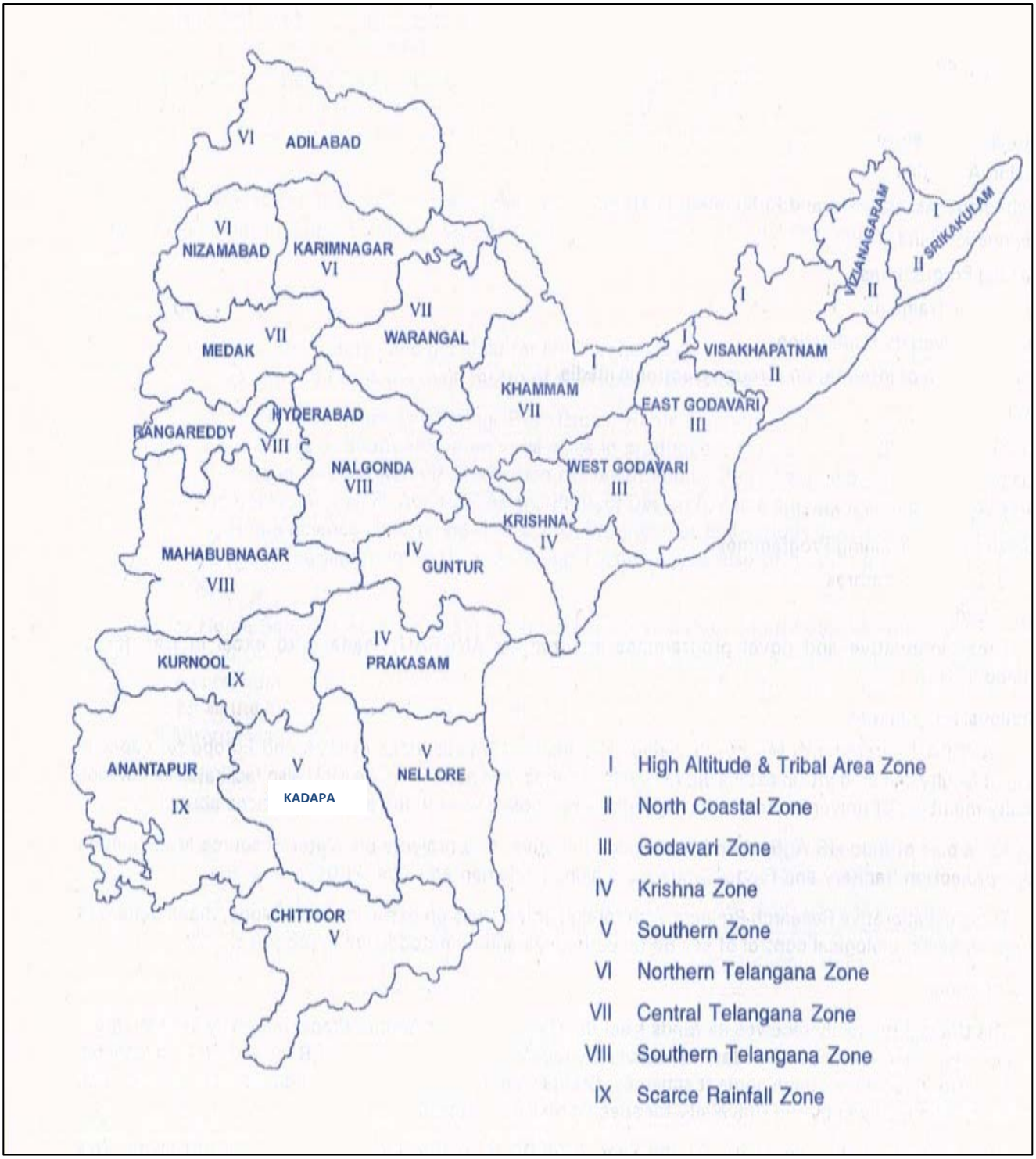
[5] Central Marine Fisheries Research Institute, (CMFRI),2008

Sl. No.	Name of the Zone	Districts	Geographical area (lakh ha)	No. of Mandals
VII	Central Telangana Zone	Warangal, Khammam, Medak	30.6	132
VIII	Southern Telangana Zone	Mahabubnagar, Nalgonda, Rangareddy (+ Hyderabad)	39.3	164
IX	Scarce Rainfall zone	Kurnool, Anantapur	36.2	117

It is an agriculturally-prosperous State and has districts rich in mineral resources, with a gross irrigated area of over 60 lakh hectare.

The nine agro-climatic zones based on the agro-ecological conditions are illustrated in Exhibit 5.

Exhibit - 5: Agro Climatic Zones of AP[6]



[6] Acharya N.G Ranga Agriculture University Handbook, 2009

1.9.4 Land Use Patterns

Land use pattern change influence the environment, and thus plays a major role in determining the climatic change impacts of a State. The land-use patterns in the State in last decade are give in Table 2.

Table - 2: Land utilization in Andhra Pradesh from 1990-91 to 2009-10 (Area in Lakh Hectare)[7,8]

Land Use	1990-91	1994-95	1999-00	2004-05	2009-10
Total Geographical Area	274.409	274.409	274.409	274.409	275.045
Forest Area	62.680	62.454	61.992	61.992	62.100
Barren Land	20.964	20.701	21.065	20.837	20.430
Land put to Non-Agricultural Purposes	23.067	25.002	25.116	26.078	26.720
Permanent Pastures	8.430	7.626	6.817	6.761	5.660
Miscellaneous Trees	2.619	2.469	2.426	2.778	2.950
Culturable Waste	7.803	7.788	7.813	6.944	6.470
Other Fallows	13.775	17.450	14.520	16.507	16.260
Current Fallows	24.845	27.263	27.607	28.186	33.690
Net Sown Area	110.218	103.647	106.100	103.275	100.850
Area Sown More than Once	21.709	24.184	24.130	21.911	28.110
Total Cropped Area	131.927	12.781	130.230	125.185	135.670

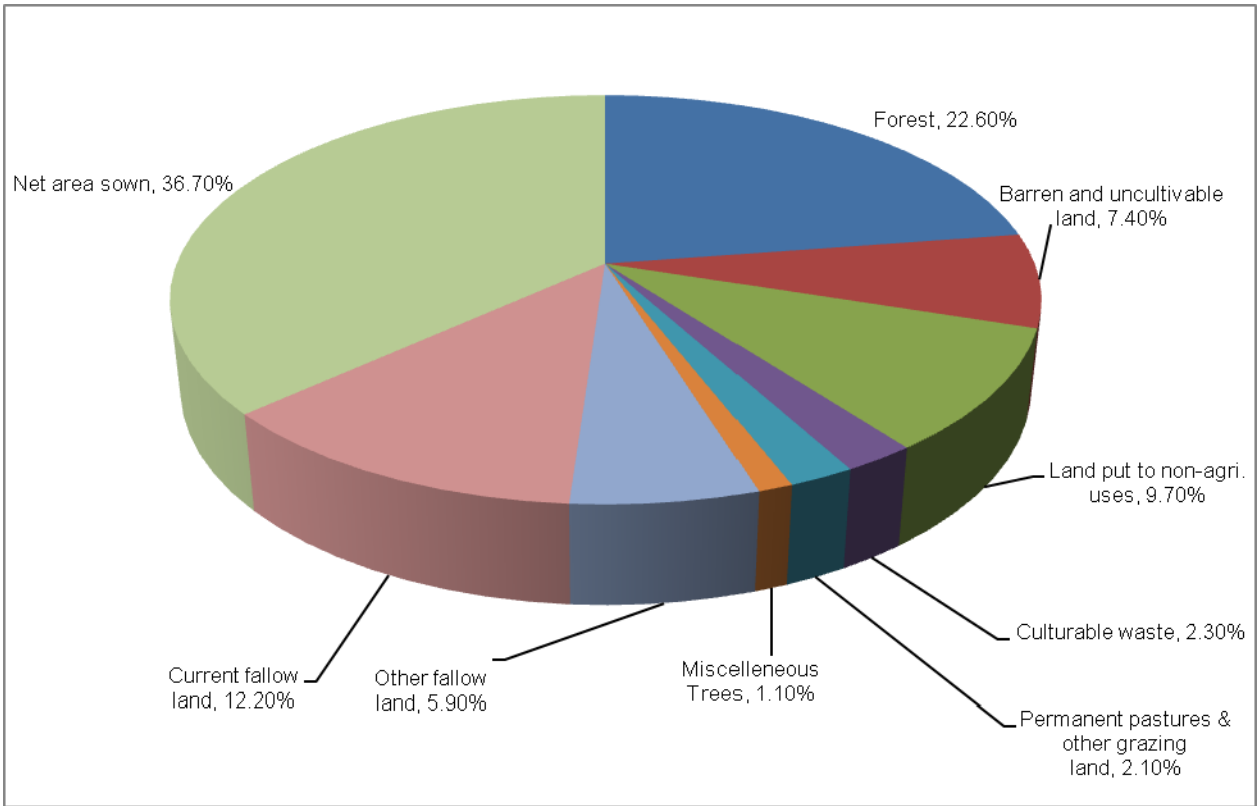
The above table clearly depicts that the land put to non-agricultural use increased by 14% from 23.06 lakh ha in 1990-91 to 26.72 lakh ha in 2009-10. The current fallows also increased from 24.84 lakh ha to 33.69 lakh ha in the same period. As per the Land Utilization Statistics for the year 2009-2010, out of the total geographical area of 275.04 lakh hectares in the State, Net Area Sown including fish culture was 100.85 lakh hectare constituting 36.7% and area under forest was 62.10 lakh hectare which accounted for 22.6%. During the year 2009-2010 the Net Area Sown (including Fish Culture) decreased to 100.85 lakh hectares from 109.58 lakh hectares in 2008-2009, showing a decrease of 7.97%.

[7] Compendium of Area and Land Use Statistics of Andhra Pradesh, 1955-56 to 2004-05, Directorate of Economics and Statistics

[8] An Outline of Agricultural Situation in Andhra Pradesh 2007-08, DES, Hyderabad

The percentage land utilization pattern of Andhra Pradesh for the year 2009-2010 is depicted in the following exhibit:

Exhibit 6: Land use Pattern of Andhra Pradesh during 2009-2010[9]



1.9.5 Economic overview

The GSDP of the State for the year 2010-11 at constant (2004-05) prices as per revised advance estimates is Rs. 3,71,007 crore as against Rs. 3,40,712 crore for 2009-10 (Quick Estimates) reflecting a growth of 8.89% which is higher than the all India average GDP growth rate of 8.58% during 2010-11. The sectoral growth of GSDP comprises 8.39% in Agriculture sector, 7.79% in Industries sector and an impressive growth of 9.61% in the Services sector.[10] The State has performed well, overcoming all odds like global recession and natural calamities like heavy and untimely rains, floods etc and is targeting a higher average annual growth target of 10 per cent.

[9] Agricultural statistics at a glance , AP 2009-10
[10] AP Economic Survey, 2010, Planning Department, GoAP

Table - 3 : Growth of GSDP and per capita income growth of AP and India[11]

	Growth of GSDP/GDP (2010-11)	Growth of per capita Income (2010-11)* *(A)*
AP	8.89 %	18.00 %
All India	8.58 %	17.30 %

(A): Advance

Table - 4: Growth Rate of GSDP of Andhra Pradesh at Constant (2004-05) Prices[11]

S. No.	Sector	GSDP					
		2005-2006	2006-2007	2007-2008 (R)	2008-2009 (P)	2009-2010 (Q)	2010-2011 (A)
1.	Agriculture Sector	6.12	1.97	17.38	1.79	1.09	8.39
2.	Industry Sector	10.05	17.60	10.87	1.51	7.10	7.79
3.	Services Sector	11.04	12.48	10.30	8.26	7.20	9.61
Gross GSDP		**9.57**	**11.18**	**12.02**	**5.02**	**5.79**	**8.89**

(R): Revised, (P): Provisional, (Q): Quick, (A): Advance

1.9.5.1 Sectoral Performance

- *Agriculture sector*

As per the GSDP Revised Advance Estimates of 2010-11, agriculture alone has registered a growth rate of 8.39%. Among the sectors allied to Agriculture, the Livestock sector and Forestry & Logging sectors have registered growth rates of 6.94% and 2.75% respectively, while the Fishing sector registered a growth rate of 12.88% during 2010-11 due to the increase in the production of inland and marine fish and fresh water prawns.

- *Industry Sector*

Industry sector comprising Mining and Quarrying, Manufacturing (Registered and Unregistered), Electricity, Gas & Water Supply and Construction, registered a growth rate of 7.79% during 2010-11. Among the sub-sectors, Mining and Quarrying, Construction and Registered Manufacturing showed relatively better growth rates. In the State, industries like Pharmaceuticals, Iron & Steel, IT Industry, Travel and Tourism,

[11] Directorate of Economic & Statistics, A.P. and C.S.O., New Delhi

Food and Beverage and various other types of industries are coming to the forefront. Table 5 shows the distribution of various manufacturing/industrial establishment in State.

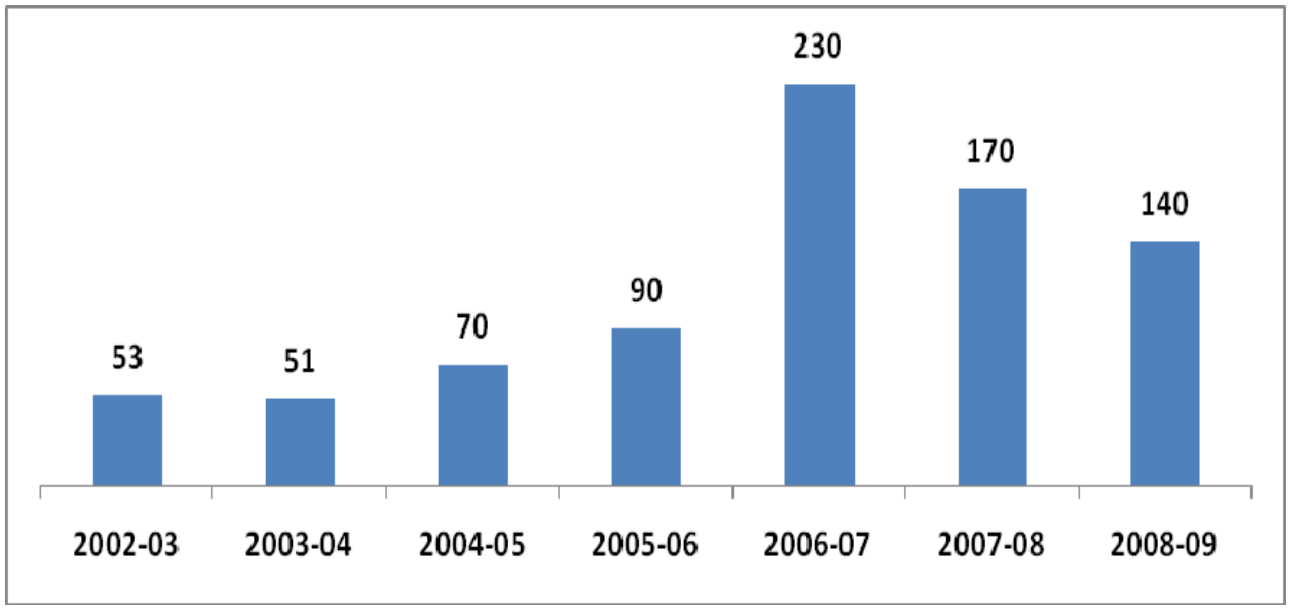
Table - 5: Distribution of Manufacturing/Industrial Establishments in A.P

Number of Registered factories in the State	1,62,499
Large scale enterprises	4,099
Micro and small enterprises	1,58,128
Industrial Estates/development areas	272

(Source: APIDC, 2009)

District wise data analysis shows that the highest numbers of factories are registered in Guntur district followed by Ranga Reddy district. As evident from Exhibit 7 below showing the number of newly established units over last few years, there has been a fillip to growth of industry in the State after 2006-07. The year 2006-07 saw the highest growth of newly established units, in the recent years.

Exhibit - 7: Number of newly established units from 2002-03 to 2008-09 in A.P.



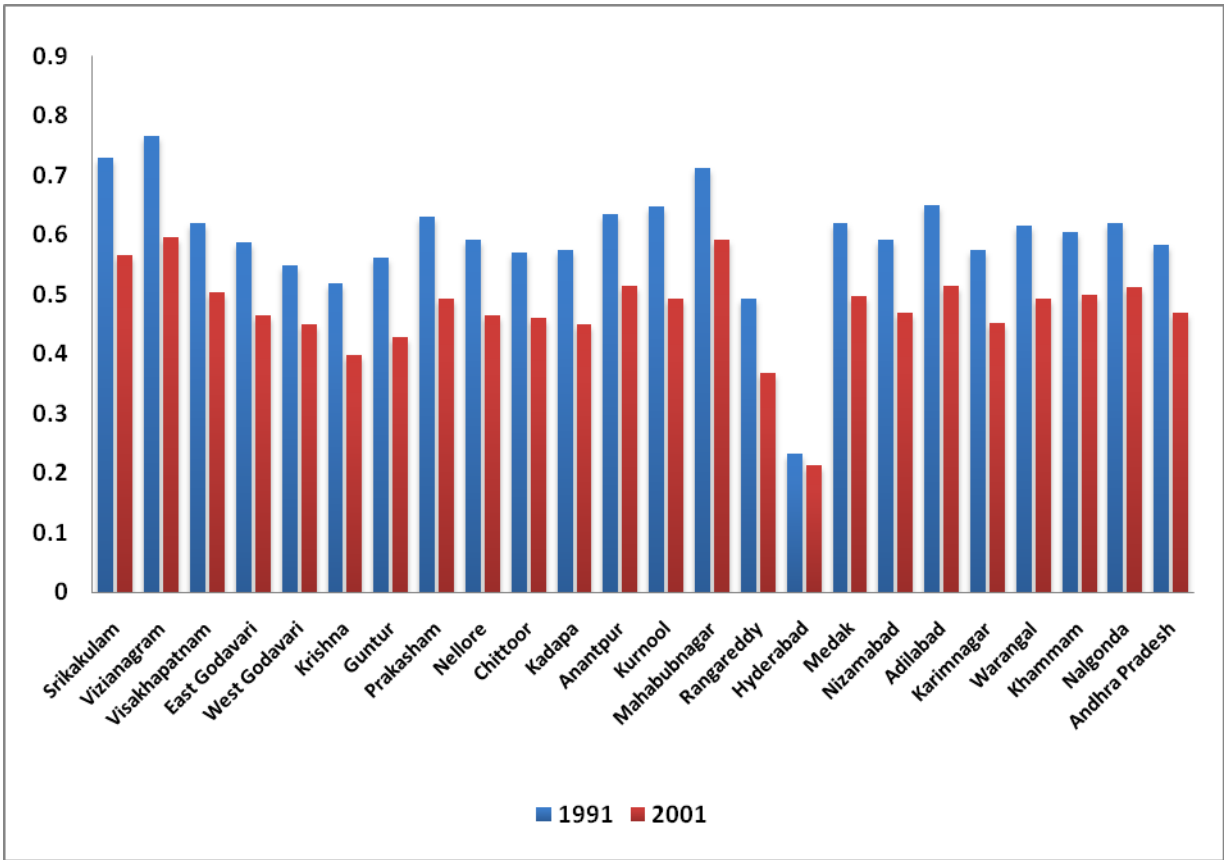
Source: Commissioner of Industries, Hyderabad

- *Service Sector*

Service Sector comprising Trade, Hotels and Restaurants, Transport by other means and Storage, Communications, Banking and Insurance, Real Estate & Business Services and Community, Social and Personal services registered a growth rate of 9.61% during the year 2010-11. Among the subsectors, Public Administration, Real Estate, Ownership of Dwellings and Business Services and Transport by other means and storage have shown significant growth. Within the service sector, employment in

information and communication technology (ICT) related activities has been growing fast in Andhra Pradesh. More than 90% of the employment generated in this sector (ICT) is located in urban areas, especially in big cities like Hyderabad and Visakhapatnam. The estimated growth in GSDP for the Public Administration, Real estate, Ownership of dwellings and Business services and Transport by other means and storage during 2010-11 is 17.32, 11.76 and 10.85 respectively. The contribution from Public Administration is expected to rise due to the increase in Government expenditure on salaries and wages.

Exhibit - 8: District wise Human Poverty Index of districts of Andhra Pradesh



Human Poverty Index[12] is developed considering the following socio economic indicators: adult illiteracy rate and percentage of children (6-14 age) not attending school for education; infant mortality rate for health; and percentage of household without access to basic amenities like drinking water, housing, sanitation, cooking fuel and electricity for command over resources. From the above graph (Exhibit – 8) it can be concluded that between 1991 and 2001 the deprivation levels were brought down in all the districts. Importantly, the rate of decline during 1991-2001 in the level of deprivation

[12] Human Development Report 2007, Andhra Pradesh 2007

was higher in those districts where levels of deprivation were relatively higher in 1991. Mahabubnagar was an exception and this was one backward district with the lowest rate of change during the period. However, the relative position of many districts did not change. The three most backward districts and relatively the most deprived ones were Vizianagaram, Srikakulam and Mahabubnagar. Hyderabad, Rangareddy, Krishna and Guntur were districts that were the least deprived.

2. PAST AND ONGOING CLIMATE CHANGE TRENDS & ACTIONS TAKEN

2.1 Background

Managing climate risks is a major challenge of today and for the future. Climate-related disaster risk is increasing. The number of reported hydro-meteorological hazards (droughts, floods, wind storms, forest fires or landslides) has significantly increased in recent decades, causing deaths and economic losses. Extreme climate events affect multiple sectors including agriculture, food security, water resources and health. Climatic variability can trigger crop failures, shortages of water for irrigation, food insecurity and hunger. Impacts of extreme events such as droughts, floods and cyclones frequently accumulate into setbacks to development gains and towards achieving the MDGs related to poverty, hunger and human health.

The emerging patterns of climatic hazard risk are presumably associated with climate change. The study of the past and ongoing trends become essential as these help us in understanding the trend of these events and their impacts on the environment.

2.2 Observed Climatic Changes

2.2.1 Climate and Temperature

The State has a tropical climate with moderate to subtropical weather. Humid to semi humid conditions prevail in the coastal areas while arid to semi-arid situations are prevalent in the interior parts of the State, particularly Rayalaseema and some districts of Telangana. The areas covered by the Deccan Plateau are characterized by hot summers with relatively mild winters. Summer temperatures range from a mean maximum of 40°C to a mean minimum of 30°C, while winter temperatures range from 22°C to 14°C[13]. The monsoon season from June to December registers rainfall of about 89 cm. In coastal areas, the mean maximum temperature ranges from 27^{o}C to 30^{o}C in January and from 34^{o}C to 41^{o}C in May which is the hottest month. The mean minimum temperature varies from 17^{o}C to 20^{o}C in December, which is the [14]coolest month, to 27^{o}C or 28^{o}C in May and June. In Rayalaseema region, the mean maximum temperature ranges from 30^{o}C in December to 40^{o}C in May. Maximum temperature even up to 47^{o}C has also been recorded though for few days. In Telangana region, the mean maximum temperature varies between 40^{o}C and 43^{o}C in May and the mean minimum temperature is 13^{o}C to 17^{o}C in December and January. The minimum temperature falls rapidly after October, and less than 10^{o}C has also been recorded on certain days.

[13] Draft Andhra Pradesh State Disaster Management Plan, Volume 1 (August 2010) , Government of AP
[14] State of Environment Report for Andhra Pradesh (2009) Submitted to MoEF

2.2.2 Rainfall

The State receives rainfall from South-West (June-September) and North-East (October-November) monsoons; however, there is large variation in the distribution of rains. While the Rayalaseema region is a zone of precarious rainfall, Telangana receives modest rainfall and the Coastal area generally receives highest average rainfall in the State. The annual rainfall variability is 20 to 25% for Telangana and the northern half of the coastal belt and 25 to 30% for Rayalaseema and the rest of the coastal belt. The annual rainfall in the coastal region is 70 to 150 cm. The rainfall over the western part of Rayalaseema region is less than 60 cm. This is the driest part of the State, getting 30 to 50 cm of precipitation mostly from south-west monsoon The annual rainfall in Telangana region is mostly from the south-west monsoon (June to September).

Table - 6: Season-wise rainfall data, 2008-09 (in millimeters)[15]

District	South West Monsoon (June –September)		North-East Monsoon (October-December)	
	Actual	Normal	Actual	Normal
Srikakulam	763.5	705.7	29.8	276
Vizianagaram	812.1	692.7	37.7	245.8
Visakhapatnam	672.4	712.6	81.8	297.2
East Godavari	807.2	751.7	171.6	319.6
West Godavari	948.6	785	151.4	245.4
Krishna	905.9	685.1	185.9	249.4
Guntur	633.9	525.8	194.5	228.9
Prakasam	288.7	388.3	418.4	393.7
Nellore	251.3	331.3	675.8	661.4

2.2.3 Humidity

Humidity is high in the coastal belt throughout the year with an average of 70 to 80% in the morning but decreases in the afternoon by 10 to 15% in the areas away from the coast. In the interior, the afternoon values are low and the humidity drops sometimes even below 30%. High humidity[16] (70 to 80%) also prevails in the morning over Rayalaseema from July to November. The humidity is 50 to 60% in the morning and 25 to 35% in the afternoon from February to May. March is the driest month, when the relative humidity drops down to less than 20% in the afternoon. In Telangana, humidity is as high as 80% during monsoon months (July-September). In the dry months of March, April and May, humidity is generally low with an average of 25 to 30%.

[15] Source: Statistical Abstract, AP 2009
[16] State of Environment Report for Andhra Pradesh (2009) Submitted to MoEF

2.2.4 Cyclones

Along the Andhra Pradesh coast, the section between Nizampatnam and Machilipatnam is most prone to storm surges. Andhra Pradesh coast between Ongole and Machilipatnam is recognized as being vulnerable to high surges among the segments of the east coast. The severity of cyclones and storm surges is expected to increase as a consequence of climate change.

Table - 7: District-wise distribution of cyclones crossing AP coast (1891-2009)[17]

Sl. No	District	No of Cyclones	
		Severe Cyclone	Medium-Normal Cyclone
1	Nellore	11	21
2	Krishna	8	15
3	East Godavari	4	11
4	Srikakulam	4	10
5	Visakapatnam	3	7
6	Prakasam	2	4
7	Guntur	1	2
8	West Godavari	0	0
9	Vizianagaram	0	0

[17] Revenue (DM) Department, Government of Andhra Pradesh

Table - 8: Human, livestock and crop losses recorded between 2000 and 2010

Type of Calamity	Date	No. of Districts affected	Population affected (lakh)	Human casualty (no.)	Livestock losses (no.)	Houses damaged (no.)	Cropped area damaged (hectare)	Estimated value of loss (Rs. Crore)
Heavy rain/Flash flood	Aug, 2000	17	1.98	207	6156	99800	178000	966.15
Heavy rain/Flash flood	Oct, 2001	5	-	119	-	111340	-	-
Cyclone Storm / Flash Floods	Dec, 2003	6	42.68	44	102324	17147	265741	765.92
Heavy rain/Flash flood	Sep, 2005	10	350	107	14416	118618	551966	2697.97
Cyclone Storm / Floods	Aug-06	10	13.84	165	20530	276567	219897	3455.23
Heavy Rains	Sep, 2006	8	0.23	52	4849	29837	219950	188.44
Ogni Cyclone	Oct-Nov, 2006	5	13.85	41	350000	95218	384550	7173.25
Heavy Rains	June, 2007	16	8.35	50	47172	195456	51587	1296.2
Heavy Rains/Floods	Sep, 2007	15	2.4	77	745	33241	62000	1156.11
Heavy Rains/Floods	Oct, 2007	6	0.94	9	3126	9246	16405	
Heavy Rains/Floods	Oct-Nov, 2007	4	27.32	36	0	611907	23000	
Heavy Rains/Floods	Feb, 2008	11	0.13	4	3000	122	292854	741.47
Consequent Floods	March 2008	22	0.014	36	1643	3556	227507	929.88
Heavy Rains/ Floods	Aug, 2008	15	44.28	130	6692	44364	196038	1116
Khaimuk Cyclone	Nov, 2008	9	1.0	0	37	1190	59287	36

Type of Calamity	Date	No. of Districts affected	Population affected (lakh)	Human casualty (no.)	Livestock losses (no.)	Houses damaged (no.)	Cropped area damaged (hectare)	Estimated value of loss (Rs. Crore)
Nisha Cyclone	Nov, 2008	5	1.0	9	28	8258	220000	80
Floods due to unprecedented Rains	Sept-Oct, 2009	13	20.72	90	49686	259095	226092	12455.75
Laila Cyclone	May, 2010	14	17.80	22	2075	14298	26685.83	1603.22
Heavy Rains/ Floods	June- Sep, 2010	22	8.95	65	7236	11022	277000	5776.60
Heavy Rains/ Floods/Jal Cyclone	Oct-Nov, 2010	13	16.98	63	1140	20554	483000	2496.98
Heavy Rains/ Floods	Dec, 2010	15	8.16	21	3026	3169	1208000	2739.33

Source: Revenue (Disaster Management) Department, GoAP

An analysis of the frequencies of cyclones on the East of India during 1891- 1990 shows that nearly 262 cyclones occurred (92 severe) in a 50 km wide strip on the East Coast[18], The recorded frequency of cyclones per year along the Bay of Bengal is four and one of the four usually transforms into a severe cyclone causing human and property losses. Severe cyclones have become common events occurring every two to three years. Out of 31.57 million people living in the coastal districts of A.P., approximately 2.9 million are vulnerable to cyclones[19]. Loss of lives and livestock is compounded by the loss of agricultural crops. The nine coastal districts of Andhra Pradesh are severely vulnerable to cyclonic storms and damages resulting due to cyclones. Agricultural crop losses could be devastating.

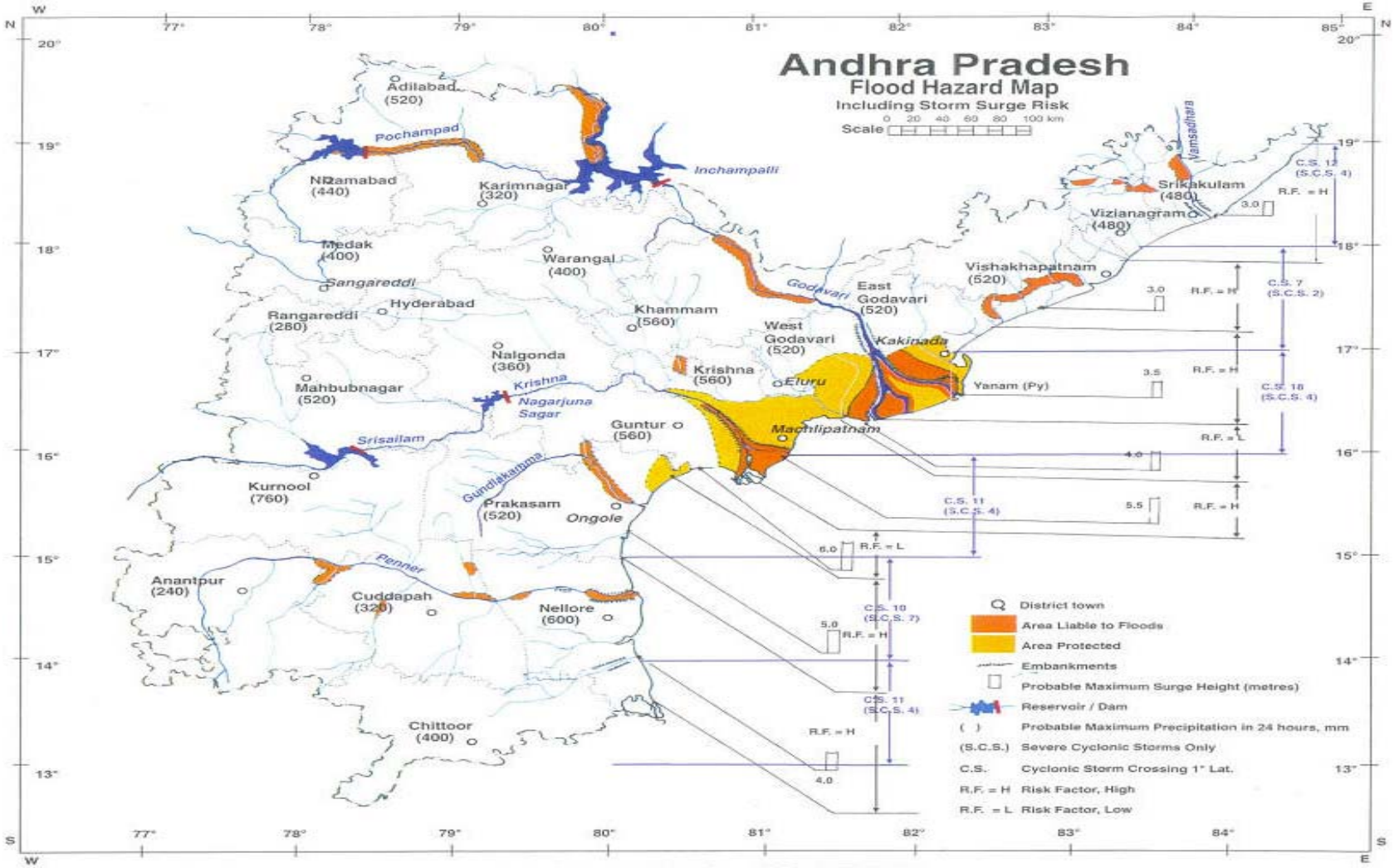
2.2.5 Floods

Floods by nature depend on several factors; one being incessant rains, cyclonic rains in a short period of time crippling natural drainage. However, other factors such as nature of the collecting basin, nature of the streams, type of soil, natural and man-made vegetation, amount of rainfall, obstruction to natural drainage etc. determine the type and extent of floods.

The Godavari and the Krishna rivers have well-defined stable courses; their natural and manmade banks are capable of carrying flood discharges, with the exception of their delta areas. Floods are often caused by unplanned growth, improper upkeep of drainage systems and mismanagement of discharges from dams, though floods are erroneously thought to be always of natural origin.

[18] State Disaster Management Plan, 2010, GoAP
[19] Revenue (Disaster Management II) Department, GoAP

Exhibit - 9: Flood hazard map of the State[20]

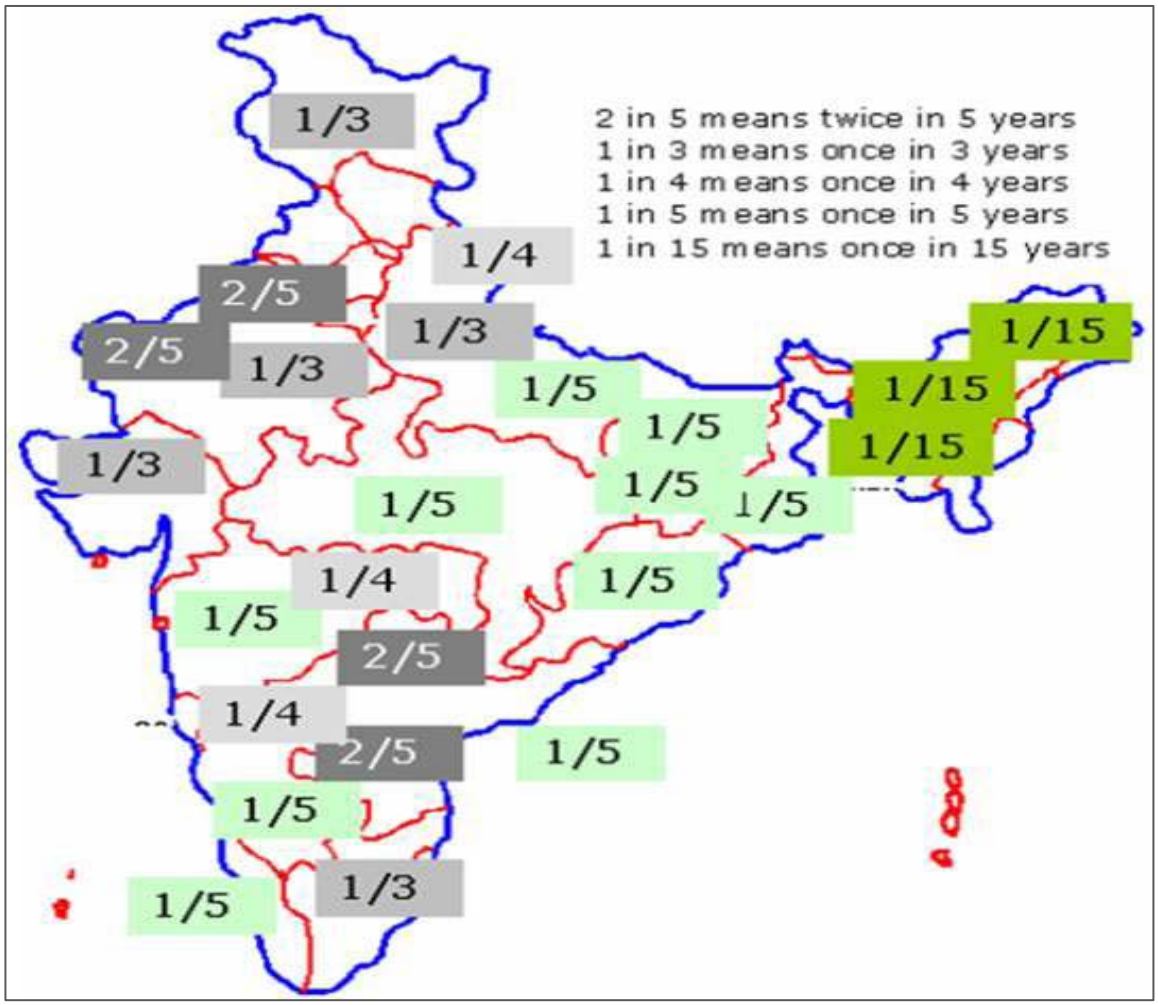


[20] Source: BMPTC, MoHUPA, Vulnerability Atlas of India

2.2.6 Droughts

Revenue (Relief) Department, Government of Andhra Pradesh defines drought as a condition arising out of scarce rainfall. The Central Water Commission defines drought as a situation occurring when the annual rainfall is less than 75% of the normal (defined over 30 years average). Drought is a normal, recurrent feature of climate. It occurs in virtually all climatic zones, but its characteristics vary significantly from one region to another. Andhra Pradesh has historically been prone to drought conditions especially in Rayalaseema, Telangana, parts of Andhra region and has been third highest drought prone State after Rajasthan and Karnataka[21].

Exhibit - 10: Periodicity of occurrence of Drought in various parts of the country[22]



[21] Drought in Andhra Pradesh: Long term impacts and adaptation strategies, South Asia Environment and Social Development Department, World Bank, September 2005
[22] Crisis Management Plan - Drought, Ministry of Agriculture, Government of India

2.2.7 Heat Waves

A heat wave is a climatologically extreme event involving abnormally higher temperature relative to normal[23] during the summer, i.e. the months of April-June. During the year 2003 (between May and June) heat wave conditions in Andhra Pradesh claimed more than 3,000 lives.

2.3 Risk Management Actions by State

The State has been active in taking initiatives to overcome climate change impacts. The State has implemented a number of interventions in various sectors for enhancing and adaptive and mitigative capacity of the State towards climate change.

2.3.1 Implemented adaptation interventions for Health Sector

- National Vector Borne Diseases Control Programme
- Revised National TB Control Programme
- Maternal and Infant deaths control programme
- Education and literacy are the major adaptation moves

2.3.2 Implemented adaptation interventions for Coastal Habitat

- Cyclone shelters have been constructed in coastal villages that are prone to cyclones. There is also a major NDMA and World Bank funded programme for cyclone shelters.

Table - 9: Existing cyclone shelters district wise

District	No of villages with cyclone shelters
Srikakulam	139
Vizianagaram	42
Visakhapatnam	146
East Godavari	170
West Godavari	66
Krishna	166

[23] Draft Andhra Pradesh State Disaster Management Plan, Volume 1 (August 2010), Government of AP

District	No of villages with cyclone shelters
Guntur	120
Prakasam	90
Nellore	191
Khammam	6

- India Meteorological Department has a well established organizational setup for cyclone observation, tracking, forecasting and issuing cyclone warning through its cyclone warning center located in Visakhapatnam.
- Restoration of over 500 hectares of mangroves in India's Andhra Pradesh region has cost $3 million over seven years, but has increased the population of edible crabs and fodder for livestock, thereby boosting local incomes while increasing biodiversity such as otter and birds.[24]
- Andhra Pradesh has a strong flood monitoring system.
- Weather monitoring network of APSRAC.
- Water harvesting measures and building infrastructures to control the consequences of drought.
- Coastal Regulation Zone Notification 2011, envisages prohibition of certain activities and regulation of certain other activities over 500 m width of the coast from High Tide Line (HTL).
- In 1998, the Department of Ocean Development established the Integrated Coastal Zone Management (ICZM) Project Directorate. Preparation of Integrated Coastal Zone Management Plan, Coastal Vulnerability Maps is completed.
- About 4 lakh cu. mts. of sand is being pumped for the beach nourishment every year at Visakhapatnam port by incurring an expenditure of about INR 6.00 crore[25].
- A number of monitoring and modeling exercise are undertaken by C**e**ntral Government e.g. :

  Sea Level Monitoring and Modeling (SELMAM)
  Marine Satellite Information Service (MARSIS)
  Coastal Ocean Monitoring & Prediction Systems (COMAPS)

[24] Nellemann, C., E. Corcoran (eds). 2010. Dead Planet, Living Planet – Biodiversity and Ecosystem Restoration for Sustainable Development. A Rapid Response Assessment. United Nations Environment Programme, GRID-Arendal. www. grida.no

[25] http://www.vizagport.com/Favourites/Environment.aspx

2.3.3 Implemented adaptation interventions for Agriculture Sector

- Financial support to the farmers in the event of crop failure as a result of drought, cyclone, incidence of pest and diseases etc.
- Crop Insurance
- Adoption of inter cultivation
- Stocking of quality seeds well in[26] advance for immediate distribution for re-sowing in the areas affected by drought and floods.
- Encourage the farmers to adopt progressive farming practices, high value in-puts and higher technology in agriculture.
- Insurance is provided to small and marginal farmers since 2000 under National Agriculture Insurance Scheme (NAIS) in order to recover the loss occurred during Kharif season, 20 crops were covered under NAIS insurance in 2010.
- A major initiative in irrigation is Jalayagnam. This consists of several new projects, expansion of older projects[27] and completion of incomplete projects to bring 28.33 lakh hectares of land (additional) under irrigation in five years.

2.3.4 Implemented adaptation interventions for Forestry and Biodiversity Sector

- Soil and Moisture Conservation Programme
- Development of Ecotourism sites
- Joint Forest Management (JFM): The State, in a pioneering move constituted 8,499 Vana Samraksha Samities (VSSs) managing 2.39 million ha of forest area that is around 36% of the forest area of the State.
- Methods of conservation adopted in the State: The conservation methods adopted in the State are 'INSITU' and 'EXSITU' conservation. 'INSITU' conservation includes initiatives such as declaring biological heritage sites under section 37 of the Biological Diversity Act, 2002. **'**EXSITU' conservation initiatives such as botanical gardens, crop diversity parks etc. are also present in the State.

2.3.5 Implemented adaptation interventions for Habitats (rural and urban)

- Subsidised housing for the rural and urban poor
- Water supply and sanitation schemes
- Reasonably priced housing for the middle class
- Integrated management of municipal solid waste
- Livelihoods for the rural and urban unemployed

[26] Website of Department of Agriculture (Government of AP)
[27] State of Environment Report for Andhra Pradesh (2009) Submitted to MoEF

2.3.6 Implemented adaptation interventions for Transportation Sector

- Andhra Pradesh State Road Transport Corporation (APSTRC) has been selected to pilot-test the new fuel-efficiency guidelines which have been developed in collaboration with World Bank
- Policy and regulation: Green Taxes are imposed on transport vehicles which have completed 7 years from the date of registration
- Use of alternate fuel (replacing diesel with LPG in auto rickshaws, cars)

3. ASSESSMENT OF VULNERABILITY OF STATE TO CLIMATE CHANGE

This section addresses the assessment and enhancement of the adaptive capacity of both the social and physical systems of the different districts of the State, so that these systems are better equipped to cope with climate change, including variability. The assessment of adaptive capacity would help the system to cope with the vulnerabilities arising out of the climate change.

3.1 Assessment of Adaptive Capacity of the State

Adaptive capacity is the property of a system, either social or physical, to adjust itself and expand its coping range under existing climate variability, or future climate conditions. In practical terms, adaptive capacity is the ability to design, implement and maintain an effective adaptation strategy for each of the social or physical aspects of the system, or to develop the ability to react to evolving hazards. The objective behind enhancement of the adaptive capacity is to reduce the stresses on the system due to the occurrence and/or the magnitude of harmful outcomes resulting from climate-related hazards. The adaptation process requires the capacity to learn from previous experiences to cope with current climate, and to apply these lessons to cope with future climate change and any other consequences.

3.1.1 Identification of determinants and indicators

The' Adaptive Capacity' for the different districts of the State of the Andhra Pradesh has been developed on the basis of the following key determinants of the adaptive capacity of each district:

- Economic status
- Demographic status
- Infrastructure status
- Education status
- Health status

These key determinants were estimated based on a set of determinants/factors which are already estimated by the Human Development Report, 2007.

3.1.1.1 Economic Status

The economic status is an indication of the capability of a district to adapt to the adverse effects of CC and therefore, higher economic status means higher adaptive capacity. There are a number of separate determining parameters which can give an overview of

the economic status of the district. Two parameters were used in this report namely per capita GDP and percentage of agricultural workers.

3.1.1.2 Demographic Status

The Demographic status of the district denotes the position of the district in terms of the area, population, density and percentage of urban slum population. This gives an indication of the difficulty that the district may face to implement any adaptive interventions due to high population or high population density.

3.1.1.3 Infrastructure Status

Development of infrastructure is important to enhance the climate resilience of a district or State. Therefore, with a higher infrastructure facility and better access to these facilities, the district can have a better adaptability to climate change. In this aspect also there are a number of parameters which aggregate to give an overview of the Infrastructure Indices of the district relative to the other districts of the State.

3.1.1.4 Education Status

Access to education is a major factor to develop CC adaptability through human capital endowment. Higher the literacy rate of the district, the easier is it to disseminate knowledge of climate change and build awareness amongst the population.

3.1.1.5 Access to Health Infrastructure

Climate change is always associated with a number of health issues. Therefore access to better health infrastructure helps the population to adapt to health problems arising out of the adverse effects of climate change. Therefore, better the health infrastructure and access to health, higher will be the Adaptive Capacity.

3.1.2 Other Determinant(s)

Apart from these parameters, there are a number of the other parameters which also contribute to the development of the adaptive capacity, having either a positive or negative impact on the adaptive capacity. Therefore a few pre-calculated determinant(s) have been used for the calculation of the Adaptive Capacity.

Table - 10: Indicators identified for the aspects of Adaptive Capacity

Determinant	Indicator	Explanation
Economic Status	Per capita GDP of the district	This aspect demonstrates the economic capability of the district. Higher the determinant, higher is the adaptive capacity.
	Percentage of Agricultural workers	This determinant helps us to understand the percentage of the total workforce involved in agricultural activities. Since agriculture is highly prone to CC vulnerability, the higher the percentage of agricultural workforce, lower will be the adaptive capacity.
Demographic Status	Area of the District	Larger the area, higher the investment required and hence lower is the adaptive capacity.
	Population and Population Density	This determines the density of the population in a district. Higher the value of population density, higher the number of affected people and higher will be the requirement of economic resources to fight any event. Therefore, a higher value of this indicator denotes a lower adaptive capacity.
	Percentage of the urban population in slums	The urban population is disaggregated into urban poor and urban resilient. Higher the populations in the urban slums, lower will their access to the infrastructure and basic amenities. Therefore, this will lower the adaptive capacity.
Infrastructure Status	Road density	The road density denotes the access of the population to the roadways. This will improve the ways to commute and therefore contribute to a higher adaptive capacity.

Determinant	Indicator	Explanation
	Percentage of population which has access to amenities like Bank and Post Office	The access to the basic amenities like banks and post office would improve the adaptive capability of the population by increasing the access to credit, savings and communications.
	Percentage of population who have access to telephones	Telecommunication facilities may be used as an effective system for issuing an early warning, providing updated weather information, agricultural information. Therefore, better telecommunication facility will contribute to a higher adaptive capacity.
	Percentage of population living in kutcha houses	Better housing for the poor improves the adaptive capacity.
Education Status	Percentage of population served by schools.	Higher the schooling and literacy rate of the districts, easier it will be to create climate change awareness. Therefore, the adaptive capacity is directly proportional to the literacy rate.
	Literacy Rates of males and females.	
Access to Health Infrastructure	Percentage of population served by Primary Health Centers and Hospitals	Access to health care improves the capability of the population to have better health. This therefore improves the adaptive capacity, since the population is equipped to withstand any outbreak of diseases as an effect of climate change
Environmental Determinants	Land, Forest, Water	These indices are taken from the Human Development Report 2007 developed by the Govt. of A.P. The higher the indices, better the adaptive capacity of the district.
	Safe Drinking Water, Sanitation and Fuel	

3.2 Approach for estimating the Adaptive Capacity

Each aspect of the determinant has been converted to a normalized index value. Each normalized index value of the aspects has been aggregated to obtain the determinant value and these determinant values have been again aggregated into an overall index of adaptive capacity. The main conceptual challenge in such an exercise is the disparate units for each of the individual indicators that make up each determinant. There are various ways for normalizing values of disparate units. One of the most notable was the normalization procedure applied for the Human Development Index (HDI) reported annually by the United Nations Development Programme (UNDP). The HDI combines different indicators of overall index of development.
The procedure for normalization is as follows:

$$\text{Normalized Value} = \frac{(\text{Value of District} - \text{Minimum Value of the District})}{(\text{Maximum Value of the District} - \text{Minimum Value of the District})} \quad \text{- (1)}$$

In the context of the Adaptive Capacity, the maximum and minimum values of each of the aspects of the determinant have been determined on the basis of the districts included in the index. This type of normalization process has been adopted due to its simplicity and relevance, particularly for indices whose purpose is to provide relative information.

In the context of climate change vulnerability assessment, such a normalization procedure was used in India by O'Brien et al. (2004). In the context of our adaptive-capacity index, the normalization procedure used is based on the above citations and presented below as equations.

$$\text{Normalized Value} = \frac{(\text{Value of District} - \text{Minimum Value of the District})}{(\text{Maximum Value of the District} - \text{Minimum Value of the District})} \quad \text{- (2a)}$$

(Where in the higher the value better the adaptive capacity)

$$\text{Normalized Value} = 1 - \frac{(\text{Value of District} - \text{Minimum Value of the District})}{(\text{Maximum Value of the District} - \text{Minimum Value of the District})} \quad \text{- (2b)}$$

(Where in the lower the value better the adaptive capacity)

The two preceding equations were used to calculate normalized values for each of the determinant indicators relative across the different districts. Each indicator within a determinant was considered to be of equal importance and hence assigned equal weightage. Based on this equal weighting, a single aggregated value for the determinant was arrived as the average of the normalized indicator values. Also, each determinant was considered to be of equal importance in calculating the overall adaptive capacity index for each district. Based on this assumed weighting, adaptive capacity index for each district was calculated as the average of the aggregated determinant values.

The following formula denotes the estimation of the Adaptive capacity based on the averaging method mentioned above:

$$\text{Adaptive Capacity} = \frac{\sum_{i=1}^{n} I_{ij}}{n} \qquad \text{----- (3)}$$

Where,

Iij – The indicator for the ith Indices for the jth district
n – Total number of the Indices considered for the Adaptive Capacity calculation.

3.3 Results

The capacity of each district to adapt to climate shocks and stresses is a major determinant of the sustainable and climate-resilient development of the State. The higher the adaptive capacity, the better the district is equipped to face the climate change exposures. However, the analysis and determination of the Adaptive Capacity is best undertaken from a relative perspective, wherein the adaptive capacity of a district is compared with the rest and also with the physical exposure of the district to climate variation. It is also important to remember that the indicator values are normalized scores of the actual original indicator aspect value i.e., they are scores which are relative to the value of the indicator in all other districts. These scores are numbers between 0 and 1 with a score of 1 signifying that a district has the highest value for this indicator compared to all other districts, while a score of 0 signifies that a district has the lowest indicator compared to the rest.

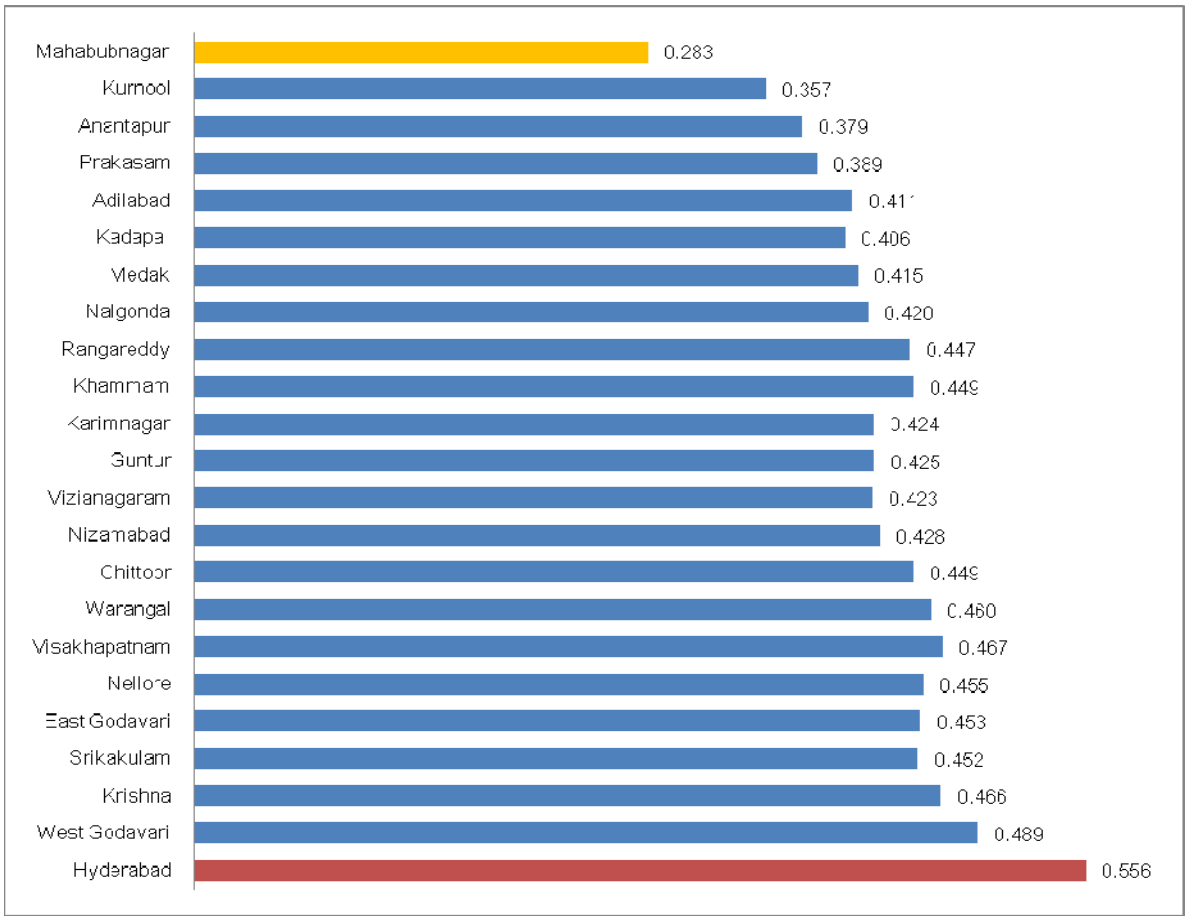
With development of the Adaptive Capacity index of the districts, the risks of the systems have been identified and the same should be considered while designing an adaptation project. For projects using the adaptive-capacity approach, it is possible to develop an adaptive capacity baseline. Since there are few clear, quantitative indicators of adaptive capacity, this baseline can generally be constructed from qualitative indicators. Based on the existing adaptive capacity an adaptation strategy for each district can be developed

to improve their coping capability over and above the baseline. Policies should provide individuals, communities and organizations with sufficient flexibility to pursue adaptation strategies appropriate to their circumstances depending on their existing adaptive capacity index. New policies should be assessed in terms of their potential impacts on adaptive capacity, particularly for groups and systems that already exhibit high vulnerability and/or exposure to climate hazards.

3.4 District wise adaptive capacity of the State

The adaptive capacity is the measure of the capability of a particular region/State/district to cope with climate change. The 'Adaptive Capacity' is however an aggregate of several determinant indices as explained above. The bar chart below indicates that Hyderabad, Khammam, West Godavari have the high adaptive capacity; Districts like Mahabubnagar and Kurnool have the least. The ones which have low adaptive capacity also have large tribal population. The Adaptive Capacity is influenced by a number of parameters and therefore, with hard (i.e. infrastructure) and soft (i.e. social, educational, health related) interventions from the Government, there could be significant change in the adaptive capacity of the district/State.

Exhibit - 11: Adaptive Capacity Index for Districts of A.P.



3.5 Vulnerability of State to Climate Change

3.5.1 Methodology for vulnerability assessment

Vulnerability varies widely across communities, sectors and regions of the State. Comparisons of vulnerability tend to focus on local indicators, e.g., to groups of less developed regions or communities or to compare progress in human development among regions with similar economic conditions. At State level the vulnerability assessment can contribute to setting development priorities and specifying policy actions.

Sectoral assessments provide detail and targets for strategic development plans. At a local or community level, vulnerable groups can be identified and adaptation measures can be designed and implemented.

As a part of the development of the State Level Action Plan on Climate Change, it is planned to develop a Vulnerability Map for the State. This will clearly demarcate the State into zones, which are prone to climate change vulnerability and therefore would require special interventions by the State government to develop climate change resilience in those areas. Apart from identifying the vulnerabilities of different regions of the State towards exposure to climate change, the sensitivity of different sectors towards climate change was also assessed.

The ordinary use of the word 'vulnerability' refers to the capacity to be wounded, *i.e.,* the degree to which a system is likely to experience harmful effects due to exposure to a hazard. The vulnerability of a socio-economic and environmental system to climate change is conceptualized as a function of a system's exposure to climate change effects and its adaptive capacity to deal with those effects. The more exposed a system is to a particular climate stimulus, the greater the system vulnerability; conversely, the greater the adaptive capacity of the system to a given climate event, the lower its vulnerability.

$$V = f(E, A) \quad \text{------} \quad (1)$$

Where

V = Vulnerability of system to climate stimulus in a period of time
E = Exposure of system to climate stimulus in a period of time
A = Adaptive capacity of system to deal with climate stimulus in a period of time

The emergence of the 'vulnerability' approach coincides with the realization that experiences and lessons learned building resilience to existing climate stresses are important prerequisites for future adaptation. The selection of a framework was also

constrained by the availability of data. Primary data collection was not an option, given that the interest lay in analyzing adaptive capacity across all districts of the State and aggregate them to develop the adaptive capacity of the 9 Agro Climatic regions identified. Selection of indicators was therefore constrained by data that already existed in the public domain and official statistical records of the State.

3.5.2 Assessment of Physical Exposure

The physical exposure of the districts for the State of the Andhra Pradesh is a function of the climate variability, represented by the occurrences of the climatic disorders like drought, flood and cyclones. The physical exposure for the different districts of the State of Andhra Pradesh was calculated on the basis of the following parameters:

- Normal distribution of Rainfall – The deviation in the rain fall pattern from the normal rainfall distribution calculated for a period of 10 years. The deviation for each of the districts is normalized to develop an index.
- Areas affected by heavy Rainfall – The total area of each district affected by heavy rainfall are obtained for a period of 8 years. It is again converted to a representative normalized index.
- Drought effected Mandals in each Districts – The number of Mandals of each district declared drought affected has been used to analyze the effect of the drought over the entire State of Andhra Pradesh

The physical exposure of each district is estimated on the basis of the index developed with the above indicators.

Exhibit - 12: Districts with high Exposure to Coastal Disasters like Floods and Cyclones

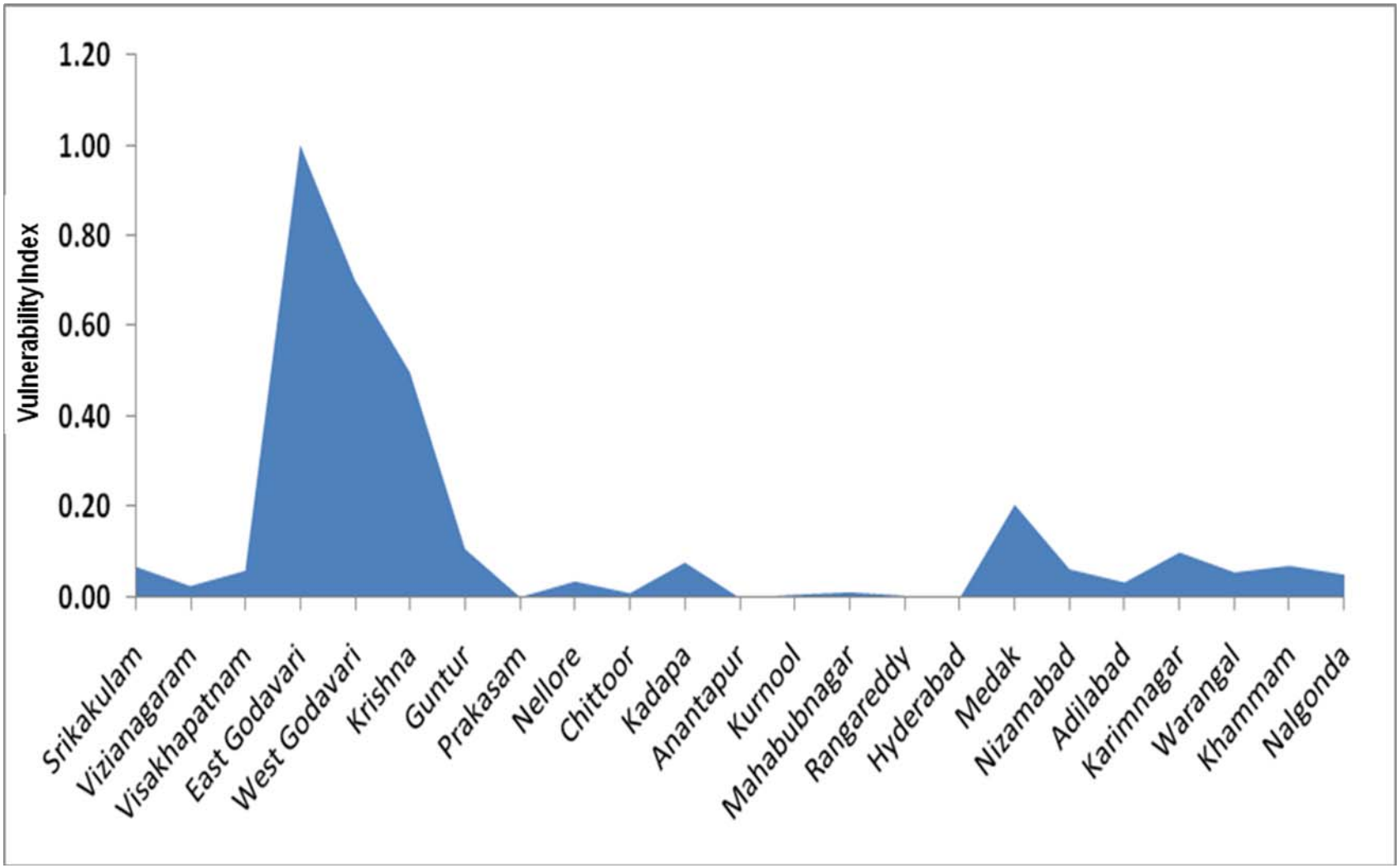
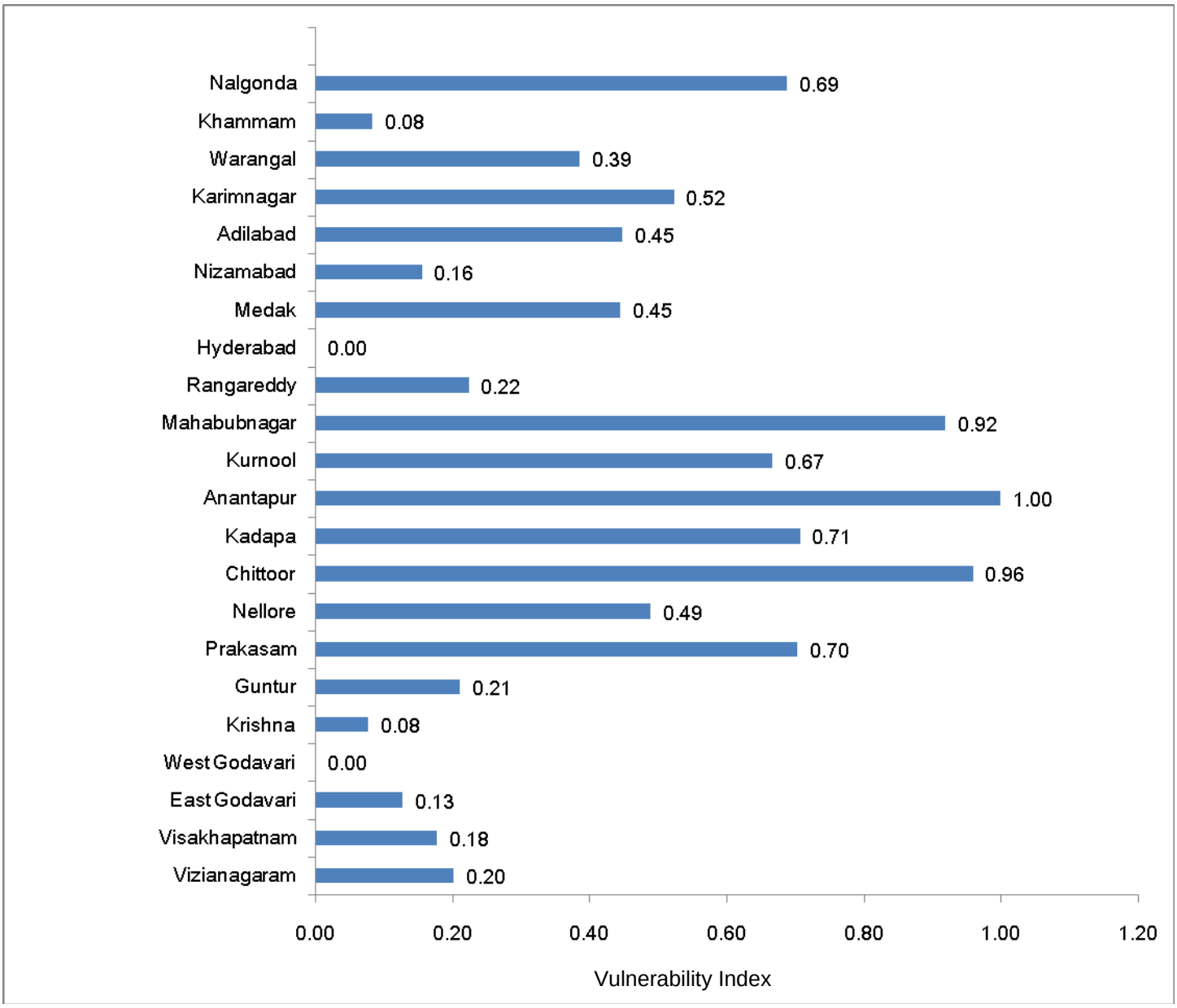


Exhibit - 13: Districts with high Exposure to Drought



Districts like Visakhapatnam, East Godavari, West Godavari, and Krishna have high exposure to floods and cyclones, mainly due to their geographic location and the influence of parameters like deviation of rainfall and exposure to oceanic disturbances. Some of the districts which have high exposure to droughts are the dry regions like Anantapur, Mahabubnagar, Chittoor and Kadapa.

4. PROJECTING CLIMATE CHANGE AND FUTURE SCENARIOS OVER ANDHRA PRADESH

4.1 Introduction

GHGs are now known to cause global warming and lead to climate change. 'Global warming' is the increase of earth's average surface temperature due to buildup of GHGs in the atmosphere, while 'Climate change' is a broader term that refers to a long term changes in climate including average surface temperature, rainfall etc. The IPCC obtained evidence of modern global warming data from surface based recording stations yielding a temperature rise of 0.74°C during the period 1905-2005; it also predicts that warmer planet will alter the tropical monsoon activity and create more frequent extreme weather events. Of the twelve warmest years in India during the period 1901-2009, eight warmest years occurred in last decade only according to the report of the IMD, 2009. The Maplecroft Climate Change Report of year 2010 has indicated that India is the World's most vulnerable country apart from Bangladesh based on the vulnerability index. Indian agricultural production and consequently, the country's GDP show a strong link with monsoon rainfall. Temperature variations play an equally critical role in crop production.

The IPCC places confidence in the ability of AOGCMs to simulate future climate to attribute the observed climate change to the anthropogenic emission of GHGs. The scientific assessments reports (IPCC 1996, 2001 & 2007) have documented the rapid growth in the skills of AOGCMs, whose current versions provide reliable simulation of the features of the present-day climate on continental and global scales. Global atmosphere-ocean coupled models have provided good representations of the planetary scale features but their application to regional studies is often limited by their coarse (~300 km) spatial resolution. For example these models do not represent realistic topographical features (like Western Ghats along the west coast of India and mountains in the Northeast region) and consequently fail to reproduce their predominant influence on the monsoon rainfall patterns. Regional model is helpful by downscaling of AOGCMs output for detecting extreme events due to temperature contrast and variability of monsoon rainfall etc.

The climate of India is locally driven by topography (Eastern and Western Ghats), location and its proximity of the area to the Sea. India is fully exposed to the hazards of global warming and Andhra Pradesh is not exempted. An attempt is made in this chapter to study climate change for baseline period and its future scenarios for 2020s, 2050s and 2080s over Andhra Pradesh as simulated by a PRECIS regional climate model. This

model outputs are taken from the IITM, Pune to assess the climate change and their future projections in terms of temperature, rainfall, relative humidity over Andhra Pradesh.

PRECIS Model

The PRECIS model is the state-of-the-art regional climate modeling system developed by the U K Met office Hadley Centre; it is composed of atmosphere and land surface model of limited area and with high resolution over any part of globe. It requires prescribed surface and lateral boundary conditions. Surface boundary conditions needs time dependent SSTs and Ice extent, while lateral boundary conditions provide dynamical atmospheric information at latitudinal and longitudinal edges of the model domain. The lateral boundary conditions comprise the standard atmospheric variables of surface pressure, horizontal wind components and measures of atmospheric temperature and humidity. There is no prescribed constraint at the upper boundary of this model.

The model requires five prognostic variables to simulate the distribution of sulphate aerosol. These are incorporated into the sulphur cycle in this model. This atmospheric sulphur cycle and set of additional boundary conditions are included. Next, boundary conditions are updated for every 6 hrs, while surface boundary conditions are updated every day. Thus, dynamics of sulphur cycle and physical parameterization processes play a dominant role in PRECIS model.

This model provides an opportunity to dynamically downscale global model simulations to superimpose the regional model details of specific regional interest (in this case Andhra Pradesh). Development of high resolution climate change scenarios help in 1) a realistic simulation of the current climate by taking into account of fine-scale features of topography, 2) detailed prediction of future climate changes taking into account local features and response; 3) representation of detailed regional data to drive other regional-specific models for local-scale impacts. The future climate change simulations are carried out for a set of future GHGs emission scenarios projected by the IPCC. Prominent among the scenarios are based on the projected emissions from the plausible socio-economic scenarios formulated under the IPCC SRES.

4.2 Future Climate Projections

A Climate Scenario is the plausible representation of future climate that is constructed for explicit use in investigating the potential impacts. Climate scenarios often make use of climate projections, by the diagnostics of model outputs and evaluating them with the observed climate data. Climate projection is calculated in response of climate system to

emissions or concentrations of GHSs and aerosols. The IPCC publishes Reports that summarize the state of the science on Climate Change and Special Reports on specific issues like the Emission Scenarios (SRES). The primary purpose of developing multiple scenario families is to explore the uncertainties behind political trends in global developments and GHG emissions, as well as the key drivers that influence these. The four scenario families below are representative of a broad range of scenarios found.

The **A1** scenario family describes a future world of very rapid economic growth, low population growth and the rapid introduction of new and more efficient technologies. Major underlying themes are convergence among regions, capacity building and increased cultural and social interactions, with a substantial reduction in regional differences in per capita income. The A1 scenario family develops into four groups that describe alternative directions of technological change in the energy system.

The **A2** scenario family describes a very heterogeneous world. The underlying theme is self-reliance and preservation of local identities. Fertility patterns across regions converge very slowly, which results in high population growth. Economic development is primarily regionally oriented and per capita economic growth and technological changes are more fragmented and slower than in other scenarios.

The **B1** scenario family describes a convergent world with the same low population growth as in A1 scenario family, but with rapid changes in economic structures toward a service and information economy, with reductions in material intensity and the introduction of clean and resource-efficient technologies. The emphasis is on global solutions to economic, social and environmental sustainability including improved equity, but without additional climate initiatives.

The **B2** scenario family describes a world in which the emphasis is on local solutions to economic, social and environmental sustainability. It is a world with moderate population growth, intermediate levels of economic development, and less rapid and more diverse technological change than in the B1 and A1 scenarios. While the scenario is also oriented toward environmental protection and social equity, it focuses on local and regional levels.

At present, the climate projections are based on regional model using a single socio-economic scenario **A1B** SRES. The A1B scenarios assume significant innovations in energy technologies, which improve energy efficiency and reduce the cost of energy supply. A1B assumes drastic reductions in power generation costs through use of renewable energies. An assessment of impact of climate change is on four key sections of Indian economy, (Agriculture, Water, Natural Ecosystem, Bio-diversity and Health). Presently the climate projections are based on PRECIS regional model using socio-

economic scenarios. The main climate change future scenarios are constructed for 2020s (Year 2011 to Year 2030), 2050s (Year 2041 to Year 2070) and 2080s (Year 2071 to Year 2090) in the present study.

4.3 Results

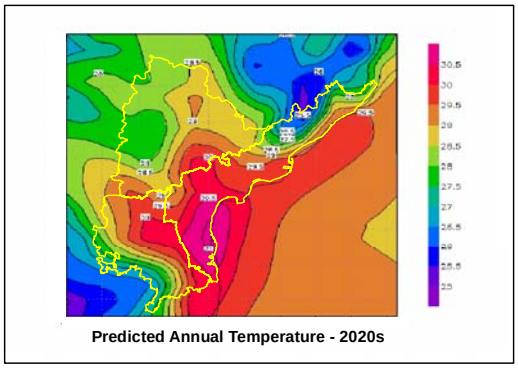
4.3.1 Experiment-1: PRECIS A1B SRES scenarios for surface-air-temperatures

4.3.1.1 Projected mean annual surface-air-temperature variability over Andhra Pradesh

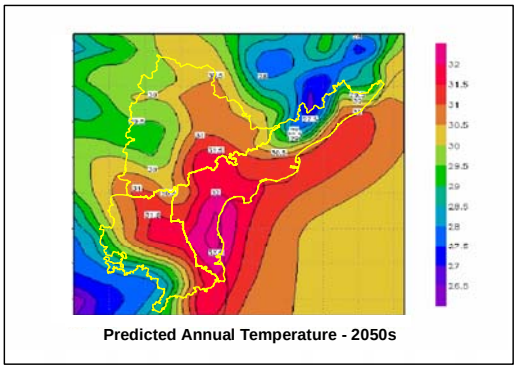
The mean annual surface-air-temperature projections are evaluated by considering mean monthly temperature from January to December. The warming in the annual mean temperature is generally maintained by the post-monsoon and winter seasons. The mean annual surface-air-temperatures are simulated by the PRECIS model is shown in Exhibit 14 and 15. Mean annual predicted temperature varies from 24.5° to 31^{0}C for the projected period, 2020s and it varies from 26.0° to 32.5^{0}C in 2050s (Exhibit-14 and 15). There is further rise in the range of temperature from 27.0° to 33.5^{0}C in 2080s. The highest temperature pocket (warm bias) is focused over South CAP (Nellore and Prakasam districts). The projected change of temperatures is about 2.5°C towards 2080s over CAP compared to 2020s.

Over Telangana region, the temperature range is 27.5° to 30.0^{0}C for the projected period, 2020s. In 2050s, surface-air-temperature is projected to 29.0° to 31.5^{0}C over the same region. It is interesting to note that Nalgonda district is the hub of heat source in 2050s and it is further strengthened (31.5° to 32.5^{0}C) in 2080s.

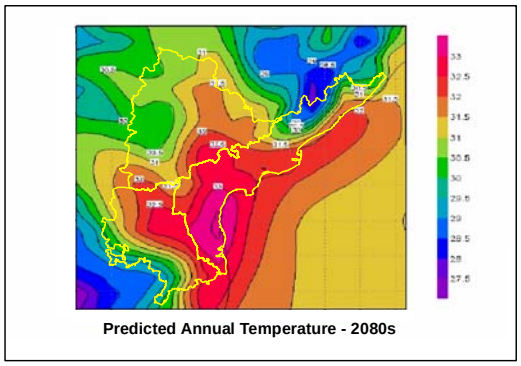
Exhibit – 14: Annual Temperature (in ^{0}C)Projections (2020s, 2050s and 2080s) over regions of Andhra Pradesh



Predicted Annual Temperature - 2020s

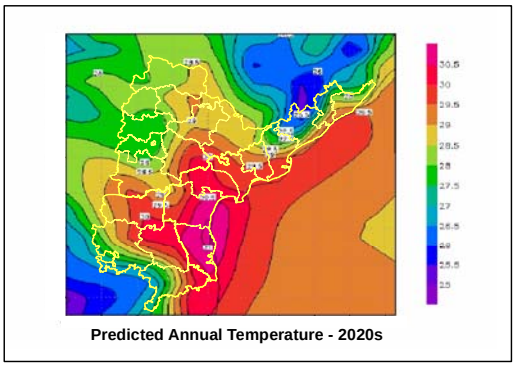


Predicted Annual Temperature - 2050s

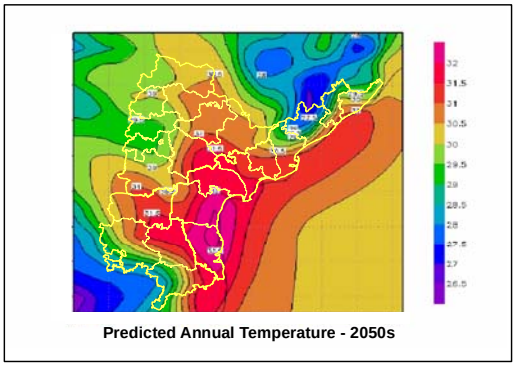


Predicted Annual Temperature - 2080s

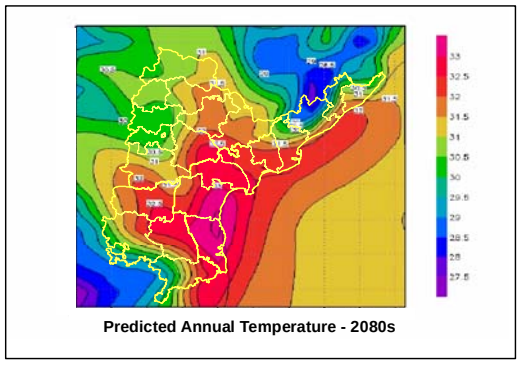
Exhibit -15: Annual Temperature (in ^{0}C) Projections (2020s, 2050s and 2080s) over districts of Andhra Pradesh



Predicted Annual Temperature - 2020s



Predicted Annual Temperature - 2050s



Predicted Annual Temperature - 2080s

The projected surface-air-temperatures has ranged from 26.5° to 30°C, for 2020s, 28° to 31.5°C for 2050s and 29.5° to 32.5°C for 2080s over Rayalaseema region. Anantapur and Kadapa districts are identified as the strongest heat pockets in Rayalaseema. The projected temperatures increased by about 2.5°C from 2020s to 2080s. Thus, the model projections indicate that significant warming conditions continue over Andhra Pradesh towards the end of the 21st century.

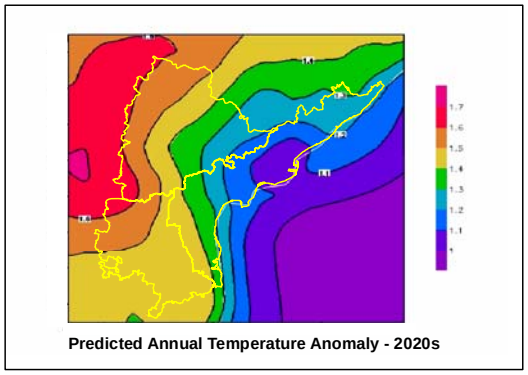
4.3.1.2 Anomaly Projected annual temperature over A.P. State

The projected anomaly of annual temperatures (Projected minus Baseline) is evaluated for three meteorological regions over Andhra Pradesh (Exhibit–16 and 17). In CAP meteorological region, the annual temperature range varied from 1.0° to 1.5°C. Minimum change is centered over East Godavari district while maximum temperatures are predicted over extreme north and south of this region for 2020s. In 2050s, the anomaly of temperature varies from 2.6° to 3.1°C, which is nearly doubled of the projections of 2020s. During 2080s, the annual anomaly temperature has reached to a maximum range of all the projections (3.5° to 4.0°C).

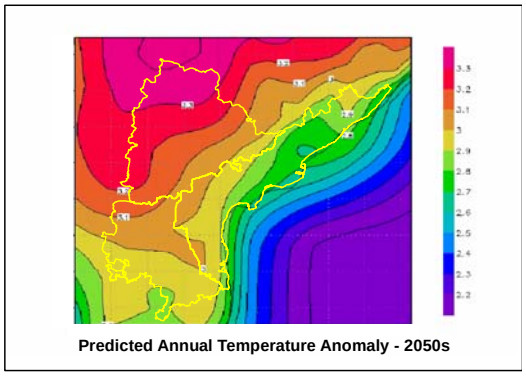
Over Telangana region, the anomaly is ranging between 1.1° to 1.7°C. Adilabad, Nizamabad and Karimnagar districts are marked as maximum heat sources for 2020s. From 2050s predictions, the anomaly of temperature varied in between 2.9° to 3.3°C with high intensity of temperature over Adilabad, Nizamabad and Karimnagar districts. The annual variation of temperature is in the range of 3.9° to 4.2°C. The highest amount of temperature variation is observed in Mahbubnagar district (>4.1°C rise).

The predicted annual anomaly of temperature in Rayalaseema meteorological region varied from 1.4°C to 1.6°C for 2020s, whereas the 2.9°c to 3.1° is predicted for 2050s. The variation of annual temperatures is in the range of 3.9° to 4.1° for 2080s. The highest temperature variation is observed in Kurnool and Anantapur districts for 2080s over this meteorological rainfall subdivision.

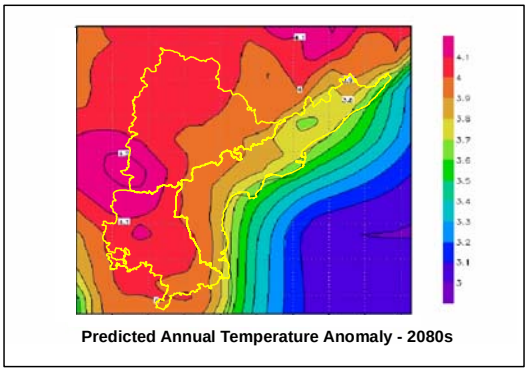
Exhibit – 16: Anomaly of annual Temperature (in ^{0}C) Projections (2020s, 2050s and 2080s) over regions of Andhra Pradesh



Predicted Annual Temperature Anomaly - 2020s

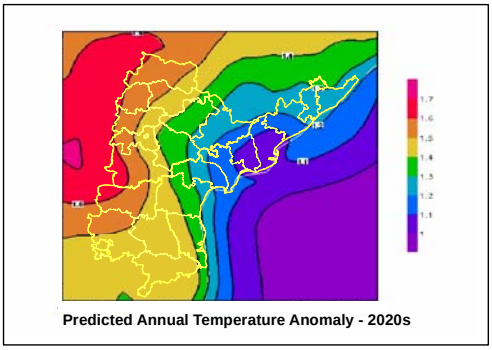


Predicted Annual Temperature Anomaly - 2050s

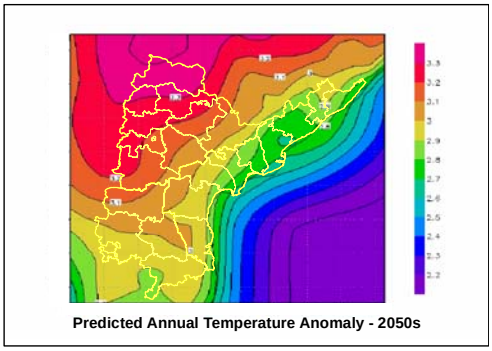


Predicted Annual Temperature Anomaly - 2080s

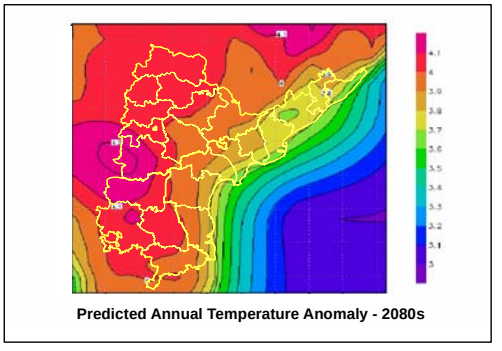
Exhibit – 17: Anomaly of annual Temperature (in ^{0}C) Projections (2020s, 2050s and 2080s) over districts of Andhra Pradesh



Predicted Annual Temperature Anomaly - 2020s



Predicted Annual Temperature Anomaly - 2050s



Predicted Annual Temperature Anomaly - 2080s

4.3.1.3 Projected spatial distribution of summer surface-air-temperature over Andhra Pradesh

During summer season (March, April and May), the mean temperature over CAP varies from 31° to 35^{0}C. The PRECIS model simulated mean summer temperatures over three regions with districts are depicted in exhibit- 18 and 19. The primary maximum surface-air-temperatures (>35°C) is mainly projected over Nellore, Prakasam and Guntur districts, while secondary maximum temperature (>34°C) is observed over Srikakulam, Vizianagaram and Krishna districts for 2020s over CAP. In between the north and south CAP region, there is a concentration of projected temperatures to a tune of 33° to 34°C. The increasing temperature scenario is further continued for 2050s and 2080s by more than 3^{0}C from the base line projections.

In Telangana, the temperature projection ranges from 33° to 35^{0}C with maximum concentration over four districts (Adilabad, Karimnagar, Warangal and Nalgonda) for 2020s. The same scenario is further continued for 2050s and 2080s with an increment of temperature upto 3^{0}C.

Over Rayalaseema, the temperature ranges between 32°to 35°C for 2020s. The same pattern is extended for the projected periods of 2050s and 2080s with an increment about 2^{0}C.

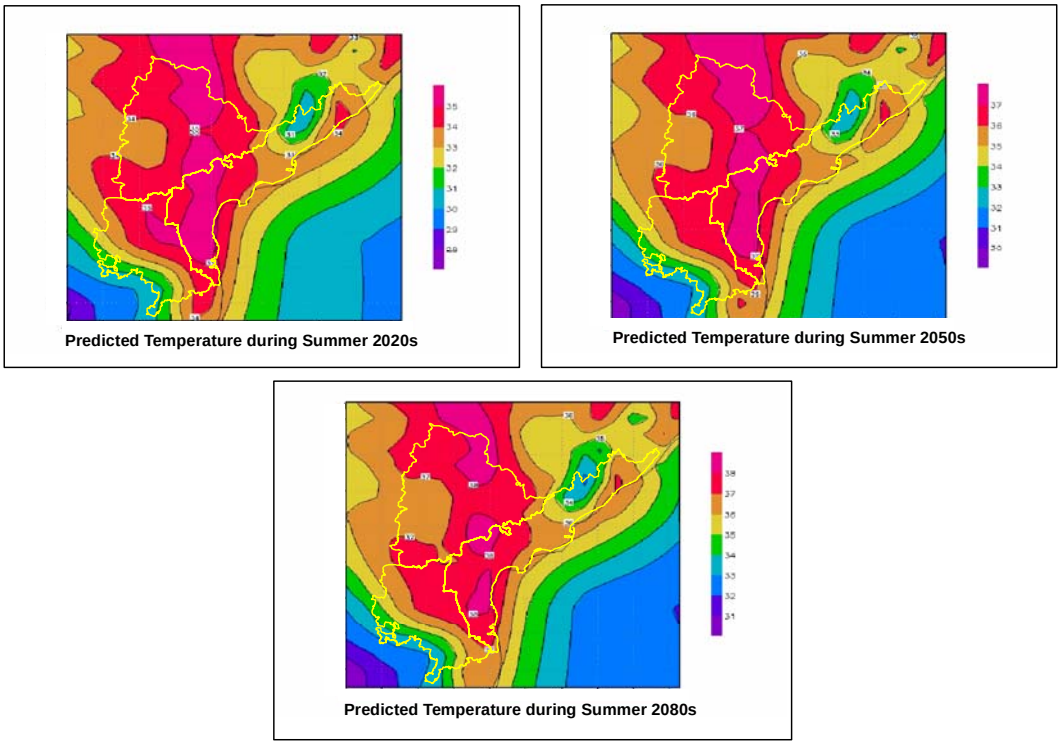
4.3.2 Experiment -2: PRECIS A1B SRES scenarios for monsoon rainfall

4.3.2.1 Projected spatial distribution of Southwest monsoon rainfall

Southwest monsoon rainfall (June through September) for three meteorological regions has been analyzed for the projected periods of 2020s, 2050s and 2080s (Exhibit- 20 and 21). In CAP, the projected mean southwest monsoon rainfall ranges from 2-16 mm/day during 2020s and 2050s, while it would be 2-18 mm/day during 2080s. It is interesting to note that the mean rainfall of 4-6 mm/day is extended over north CAP to central CAP (Krishna district). The maximum mean rainfall is occurring more in parts of Visakhapatnam district during all the projected periods. The southwest monsoon rainfall is further enhanced for 2080s compared with the projections of 2020s and 2050s.

In Telangana region, southwest monsoon rainfall varies from 2 mm/day (parts of Mahabubnagar district) to 14 mm/day (parts of Karimnagar and Adilabad districts) for 2020s, 2050s and 2080s without much change. However there is an increase in coverage area of 2 mm/day intensity over Mahabubnagar district only. Thus, the projected rainfall indicates possible drought situation over Mahabubnagar district for 2080s.

Exhibit – 18: Summer Period Temperature (in ^{0}C) Projections (2020s, 2050s and 2080s) over regions of Andhra Pradesh

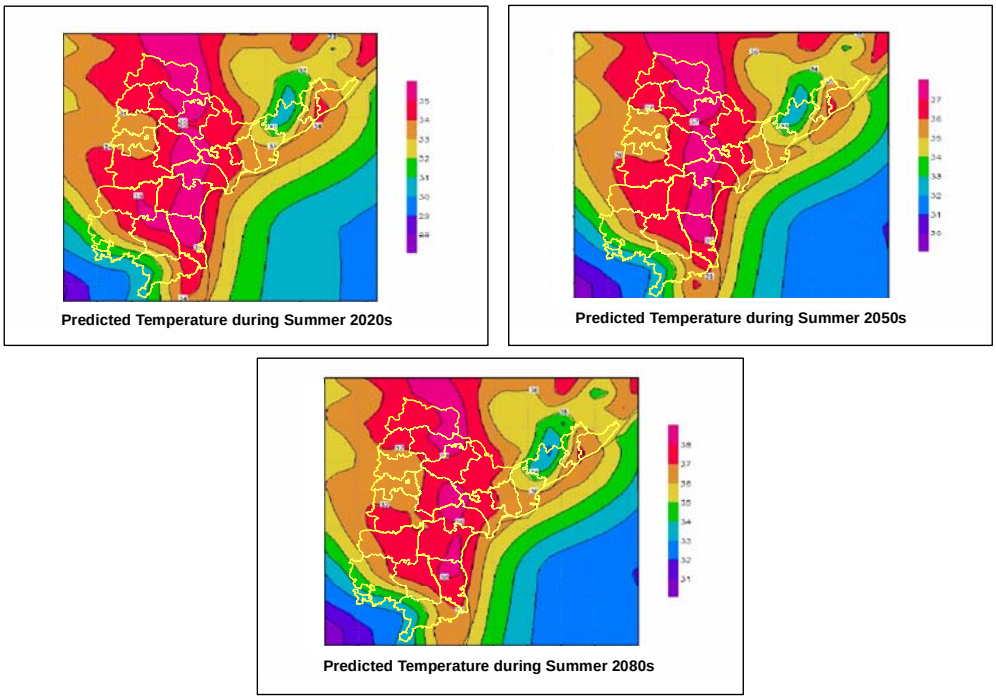


Predicted Temperature during Summer 2020s

Predicted Temperature during Summer 2050s

Predicted Temperature during Summer 2080s

Exhibit – 19: Summer Period Temperature (in ^{0}C) Projections (2020s, 2050s and 2080s) over districts of Andhra Pradesh

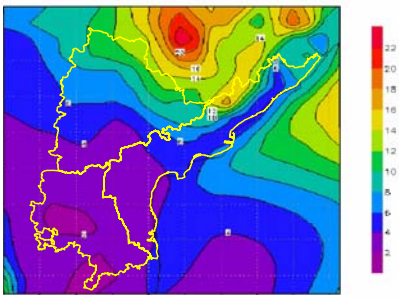


Predicted Temperature during Summer 2020s

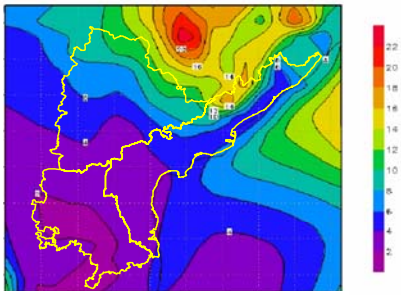
Predicted Temperature during Summer 2050s

Predicted Temperature during Summer 2080s

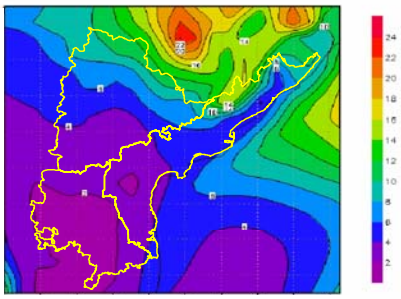
Exhibit – 20: Rainfall (mm/day) during South-west monsoon period Projections (2020s, 2050s and 2080s) over regions of Andhra Pradesh



Predicted Rainfall during South West Monsoon 2020s

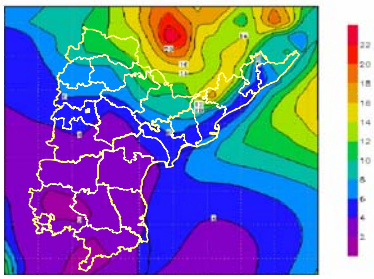


Predicted Rainfall during South West Monsoon 2050s

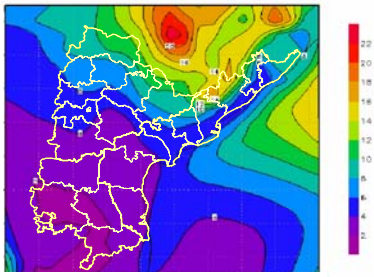


Predicted Rainfall during South West Monsoon 2080s

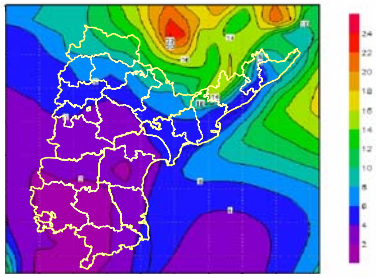
Exhibit – 21: Rainfall (mm/day) during South-west monsoon period Projections (2020s, 2050s and 2080s) over districts of Andhra Pradesh



Predicted Rainfall during South West Monsoon 2020s



Predicted Rainfall during South West Monsoon 2050s



Predicted Rainfall during South West Monsoon 2080s

The southwest monsoon rainfall is varied from 2.0 to 4.0 mm/day for the projected periods 2020s and 2050s over Rayalaseema. The extent of 2 mm/day intensity rainfall is observed over few parts of Anantapur district in 2020s and later this area is extended over to other parts of Anantapur district and some parts of Chittoor district also in 2080s.

Thus, the PRECIS model has projected the enhancement of southwest monsoon rainfall over CAP, while no change is observed over Telangana region for the projected periods 2020s, 2050s and 2080s. There is a drastic reduction of southwest monsoon rainfall over Rayalaseema by 2080s.

4.3.2.2 Projected anomaly of Southwest Monsoon rainfall

During southwest monsoon season, the difference of the projected and baseline period (1970s) (which is termed 'anomaly') of rainfall is evaluated and presented in Exhibit – 22 and 23. The southwest monsoon rainfall raised upto 1.5 mm/day for 2020s, 2050s and 2080s in northern parts of CAP. There is reduction of rainfall upto 0.5mm/day covering parts of SPS Nellore and Prakasam districts.

In Telangana region, there is a maximum increase of rainfall (+1.5mm/day) over Adilabad district, while there is an increase in rainfall over Nizamabad, Karimnagar and Warangal districts for 2020s. There is increase of southwest rainfall (+0.5 mm/day) over Adilabad and Karimnagar district for 2050s, while there is decrease in rainfall (-0.5 mm/day) over the same region for 2080s. The worst hit district is Nalgonda in this region (– 1.0 mm/day) during 2080s.

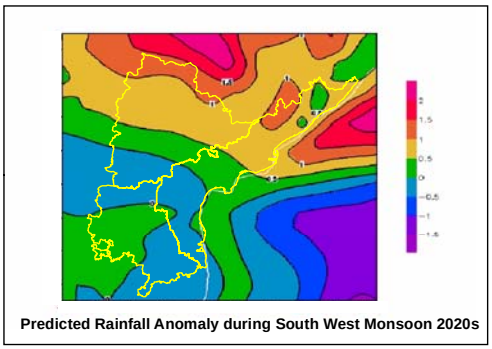
Over Rayalaseema region, the southwest rainfall is in the range of -0.5 to 0.5 mm/day for 2020s 2050s and 2080s. There is decrease in the southwest monsoon rainfall over this region from 2020s to 2080s. There is drastic decrease of southwest rainfall over Anantapur and Kadapa districts.

4.3.2.3 Projected spatial distribution of Northeast monsoon rainfall over A.P.

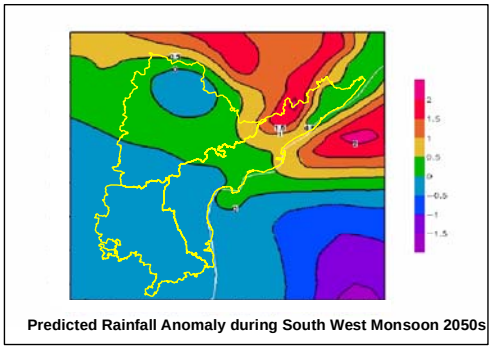
The projected Northeast monsoon rainfall (October through December) over three regions for projected periods 2020s, 2050s and 2080s from PRECIS model output is shown in Exhibit –24 and 25.

In CAP, the northeast monsoon rainfall ranges from 1.0 to 3.5 mm/day for 2020s**.** The rainfall is enhanced upto 4 mm/day for 2050s and is also in area of extent over northern CAP districts. In 2080s, there is an increase of rainfall, which ranges from 1.5-4.5 mm/day. The majority of the area in this region is dominated by 3 mm/ day. Over Telangana region, there is slight increase of rainfall by 1.0-2.0 mm/day for the projected periods 2020s, 2050s and 2080s

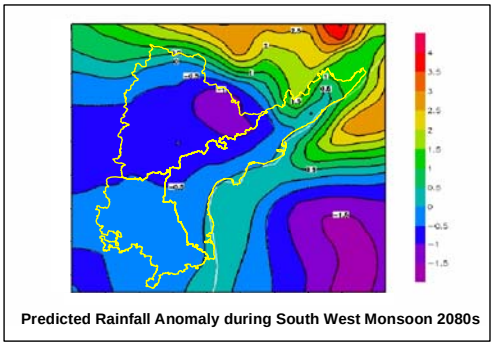
Exhibit – 22: Anomaly of Rainfall (mm/day) during South-west monsoon period Projections (2020s, 2050s and 2080s) over regions of Andhra Pradesh



Predicted Rainfall Anomaly during South West Monsoon 2020s

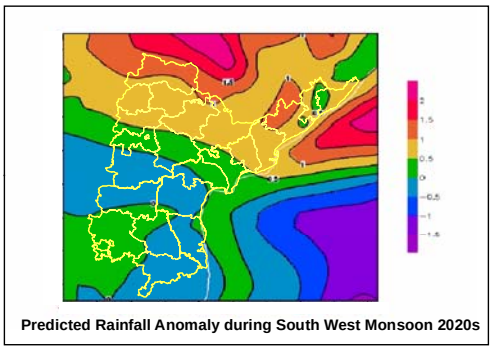


Predicted Rainfall Anomaly during South West Monsoon 2050s

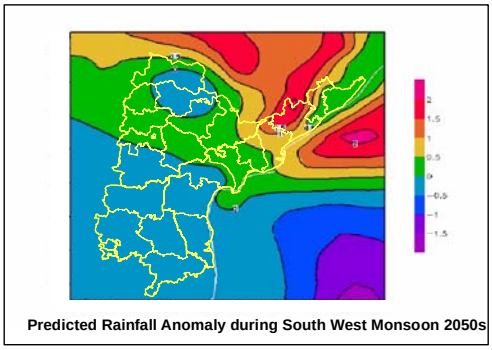


Predicted Rainfall Anomaly during South West Monsoon 2080s

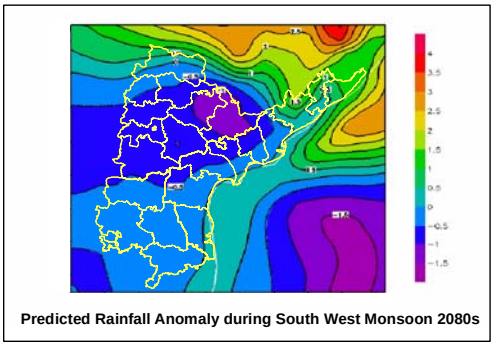
Exhibit – 23: Anomaly of Rainfall (mm/day) during South-west monsoon period Projections (2020s, 2050s and 2080s) over districts of Andhra Pradesh



Predicted Rainfall Anomaly during South West Monsoon 2020s



Predicted Rainfall Anomaly during South West Monsoon 2050s



Predicted Rainfall Anomaly during South West Monsoon 2080s

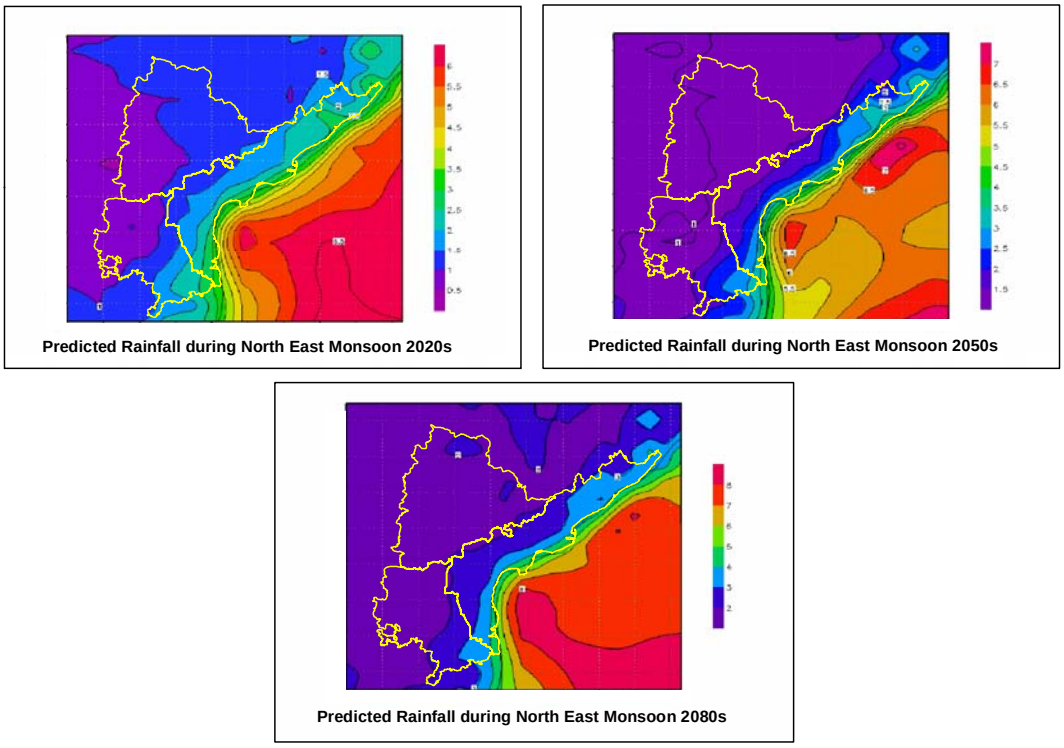


Exhibit – 25: Rainfall (mm/day) during North-east monsoon period Projections (2020s, 2050s and 2080s) over districts of Andhra Pradesh

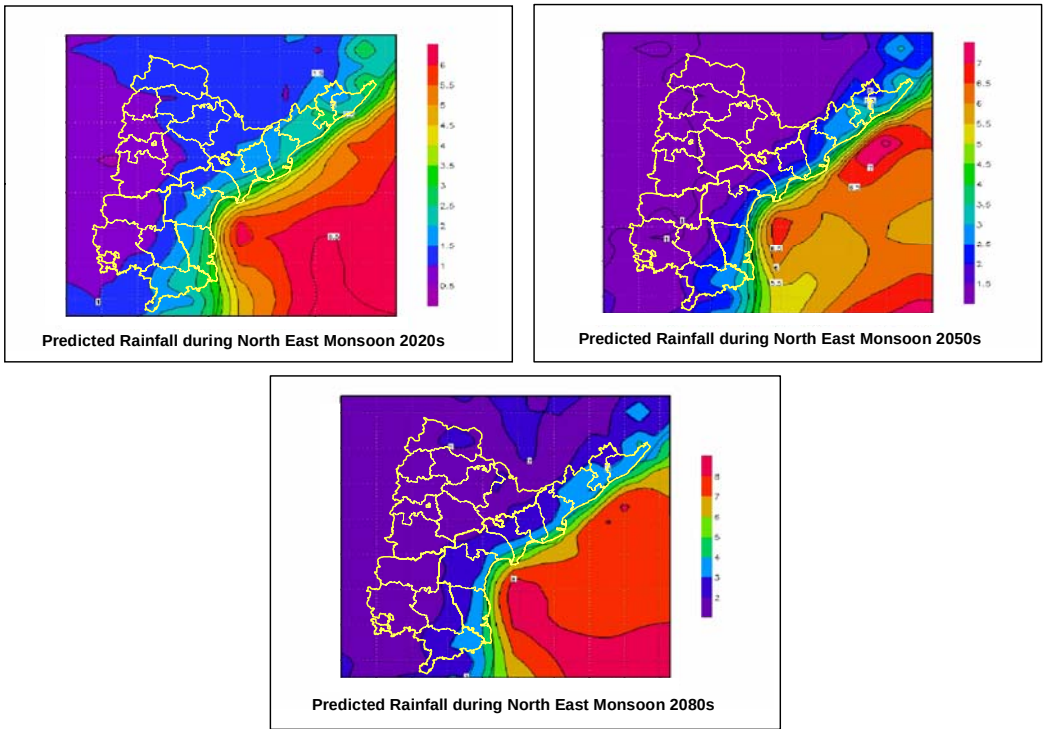


Exhibit – 24: Rainfall (mm/day) during North-east monsoon period Projections (2020s, 2050s and 2080s) over regions of Andhra Pradesh

In Rayalaseema region, the projected rainfall varies from 0.5-3.0 mm/day for 2020s, while it is increased upto 4.0 mm/day over Chittoor district for 2050s. There is a moderate increase in the rainfall towards 2080s (1.5-3mm/day) around Chittoor district in the extreme southeastern portion of this Rayalaseema region.

4.3.2.4 Projected anomaly of Northeast rainfall

There is an overall rise of rainfall by 0.2 mm/day over CAP for 2020s except some parts of Srikakulam and Vizianagaram where it is decreased by 0.4 mm/day. The rainfall anomaly is ranged between -0.5 to 2.0 mm/day during 2050s and thus there is an overall increase of rainfall when compared with the projections of 2020s (Exhibit –26 and 27).

There is an abnormal rise of rainfall for 2080s i.e. by four times when compared with the projections of 2020s in Telangana region. There is a increase of rainfall by 0.2 mm/day (northern part) over Telangana region, while a slight decrease (-0.2 mm/day) is observed over southwestern parts of Telangana (Mahabubnagar district) for 2020s, when compared with baseline period. A moderate enhancement of rainfall is observed in 2050s and 2080s in this region.

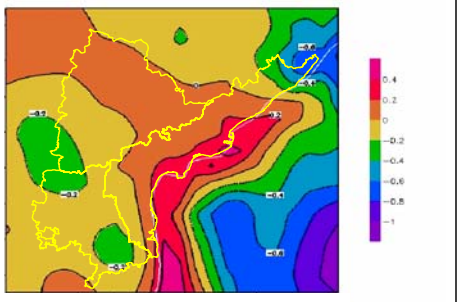
Over Rayalaseema region, there is decrease of rainfall (-0.2 mm/day) in Kadapa and Chittoor districts while considerable enhancement of rainfall (0.5mm/day) is observed in projected periods of 2050s. Further, rainfall enhancement of about 0.6 mm/day is observed in 2080s in most parts of the region when compared with baseline.

4.3.3 Experiment -3: Baseline experiment for 1970s (1961-1990)

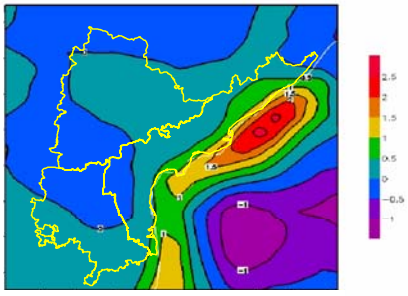
The baseline period is constructed for 30-years from 1961 to 1990. This baseline period of rainfall and temperature is validated with the available datasets. The temperature projection data for annual and summer season are constructed for validation. The study is extended for southwest and northeast monsoon rainfall using PRECIS precipitation data. The annual surface-air-temperature using PRECIS model is in the range of 31°-34°C for baseline period

The projected temperatures over CAP, Rayalaseema and Telangana are in the ranges of 32°-34°C, 31°-33°C and 31°-34°C respectively. But JRA-25 reanalysis model shows that the annual variation of temperature is relatively less when compared with the PRECIS model. The PRECIS model overestimates slightly. In summer season, the PRECIS model output has shown that CAP, Rayalaseema and Telangana regions received temperature in the range, 29°-34°C, while JRA-25 represents 28°-32°C. Thus, the model overestimates the summer season surface-air-temperatures.

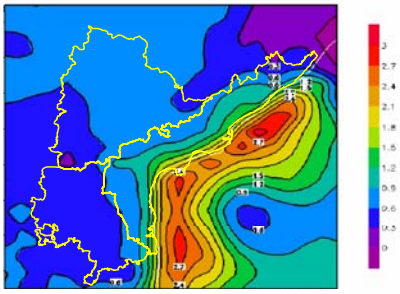
Exhibit – 26: Anomaly of Rainfall (mm/day) during North-east monsoon period Projections (2020s, 2050s and 2080s) over regions of Andhra Pradesh



Predicted Rainfall Anomaly during North East Monsoon 2020s

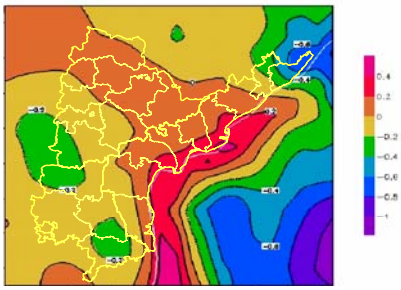


Predicted Rainfall Anomaly during North East Monsoon 2050s

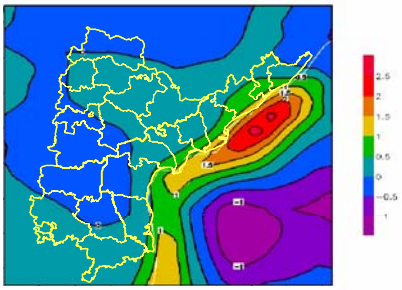


Predicted Rainfall Anomaly during North East Monsoon 2080s

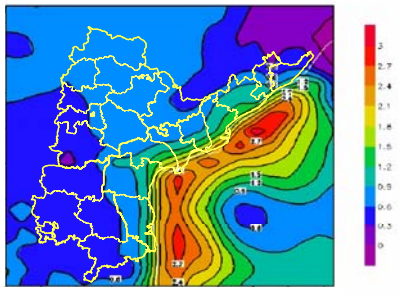
Exhibit – 27: Anomaly of Rainfall (mm/day) during North-east monsoon period Projections (2020s, 2050s and 2080s) over districts of Andhra Pradesh



Predicted Rainfall Anomaly during North East Monsoon 2020s



Predicted Rainfall Anomaly during North East Monsoon 2050s



Predicted Rainfall Anomaly during North East Monsoon 2080s

During southwest monsoon season the PRECIS model projected rainfall is in the range between 2-18 mm/day, whereas satellite derived product, CMAP derived rainfall is in the range of 2 -19 mm/day and thus there is a difference of 1 mm/day. Thus, the PRECIS model underestimates rainfall by 1 mm/day during southwest monsoon season over CAP for 1970s. Rayalaseema receives 1-4 mm/day as per PRECIS model; while CMAP derived rainfall of 1-5 mm/day with a difference of 1 mm/day. Thus, the PRECIS model underestimates the rainfall (1 mm/day) during southwest monsoon over Rayalaseema region. PRECIS model shows 2-10 mm/day over Telangana region, while the CMAP derived rainfall shows 2-7 mm/day. The difference between them is 3 mm/day. Thus, PRECIS model overestimates rainfall over Telangana region, when compared with the satellite derived CMAP data.

The A.P. regions CAP, Rayalaseema and Telangana received 1.5-3.0, 1.0-2.5 and 1.5 mm/day respectively during northeast monsoon season, while the CMAP data has shown 2.0-4.0 mm/day over CAP, 1.0-4.0 mm/day over Rayalaseema and 1.0-2.0 mm/day over Telangana. Thus the model underestimated rainfall over CAP and Rayalaseema, while it is overestimated over Telangana region slightly. Thus baseline experiments have clearly demonstrated that the PRECIS is satisfactorily projecting temperatures and rainfall for the projected periods over Andhra Pradesh.

4.4 Summary and Conclusions

For understanding the future climate change in the 21st century, PRECIS model simulations corresponding to different IPCC SRES emission scenarios are analyzed. A comparison of observed (baseline period) and model simulated features in annual mean surface-air-temperatures and monsoon rainfall over A.P. provides an evidence of model skills. Majority of the PRECIS model outputs projected a modest increase in the monsoon rainfall in the future compare to the present day climate while the temperature changes appeared more coherent across the model outputs around 4° for different emission scenarios. Considering the climate changes that could possibly occur, suitable adaptation plans need to be designed.

5. STAKEHOLDER IDENTIFICATION AND CONSULTATION WORKSHOP

5.1 Identification of main stakeholders

Analyzing and understanding the capacity of various stakeholders to cope with and adapt to climatic events is fundamental in characterising current and possible future vulnerability. Understanding the role of stakeholders in the decision-making process can assist in the implementation of adaptation policies. A participatory approach has been adopted for preparation of the SAPCC comprising a range of stakeholders as well as individual consultations. Over 200 stakeholders representing a cross section of Government and quasi Government organisations, administrators, NGOs, professionals, and academia covering a wide range of sectors were engaged in the process. Stakeholder capacity building workshops were organized at Hyderabad, Tirupati, Visakhapatnam and Vijayawada. Stakeholder representatives also discussed and communicated their views and opinions on sectoral climate change issues.

Participatory initiatives are more likely to be sustainable because they build on local capacity and knowledge, and because the participants have “ownership” of any decisions made and are thus more likely to comply with them. Participatory initiatives are thus more likely to be compatible with long-term development plans. This can help decision-makers gain greater insight into the communities they serve, enabling them to work more effectively and produce better results. In turn, the communities can learn how the decision-making process works and how they can influence it effectively.

The process of working and achieving things together can strengthen communities and build adaptive capacity through developing awareness of the issues within the community, as well as finding ways to address them. It can reinforce local organizations, and build up confidence, skills and the capacity to cooperate. In this way it increases people’s potential for reducing their vulnerability. This, in turn, empowers people and enables them to tackle other challenges, individually and collectively. The SAPCC has been designed with stakeholder participation, through priority-setting and voicing preferences, and in accordance with people’s right to participate in decisions that affect their lives. Processes of engagement can improve the likelihood of equity in decision-making and provide solutions for conflict situations.

5.2 Stakeholders’ Workshop

In line with the National Action Plan for Climate Change, guidance on development of State Action plan for Climate Change, EPTRI conducted four workshops for stakeholder consultation at various centers across the State to identify the key climate change related issues faced by various strata of society. Participants ranging from

academicians, researchers, Government officials, private sector employees, NGO professionals, social activists, students, and local citizens were invited, for proper representation of stakeholders.

Public sector/Government Department officials working at State/district levels from various government bodies like municipalities, Groundwater Department, Forestry Department, Industries Department, Animal Husbandry Department, Mines & Geology Department, Panchayat Raj, Transport Department, Sericulture Department, Health Department, Pollution Control Board, Public Health Engineering Department etc were among the participants of the stakeholder consultation. Officials invited for the stakeholder consultation ranged from higher level executives like Directors, District level Heads of Department etc involved in planning and execution of various social and infrastructural schemes, to mid level professionals like municipal engineers, site engineers and electricity department engineers etc. who are actively involved in day to day execution of various schemes run by the Government. Presence of the mix of officials from Government Departments ensured better coverage of challenges faced by government from planning and strategy development phase to execution phase.

Representatives from private sector included those from cement industry, steel industry, power sector, metallurgy, chemical manufacturing, sugar industry, tiles, food packaging, distilleries, engineering product manufacturer, pharmaceutical manufacturing etc. The presence of officials from these private sector entities provided an insight into the environmental impacts caused by these industries, the mitigation and adaptation actions being taken by the industries, and emphasized the need for a strong regulatory mechanism.

Besides the abovementioned stakeholders, social activists and representatives of NGOs involved in various micro level social upliftment and climate change related activities like biodiversity conservation, literacy, environmental activism, human rights activism, leprosy eradication, rural development, women development etc. also participated. Feedbacks received from them were generally focused on socio economic disparity and unregulated pollution discharge from industries. Academicians participating included lecturers, professors from local State run and private colleges, research scholars and students from various technical Institutes and Universities. They emphasized promotion of research and capacity building for developing the adaptive capacity of the affected population. Retired government officials, local residents, villagers were also part of the stakeholder consultations. Their primary concerns were the provision of services like drainage and waste handling infrastructure, efficient transportation etc.

5.3 Proceedings of the Workshops

The workshops highlighted the 8 National Missions under NAPCC and the objectives of the SAPCC. The flow of events at the workshop is presented below:

- An indicative matrix (degree of impact vs. probability) of climate sensitive sectors was presented to the stakeholders.
- Climate risks and opportunities identified for key sectors were presented to stakeholders.
- Feedback from stakeholders was taken through questionnaire and group discussions.

5.4 Feedback from the Stakeholders

The feedback included:

- Increase in awareness level about climate change and impact.
- Climate change experiences of local population.
- Local risks envisaged in the future for various sectors.
- Expectations of stakeholders of local bodies, State Government and SAPCC in mitigating and adapting to climate change.

Stakeholder workshops were organized at the centers named below on the mentioned dates:

Table - 11: Stakeholder consultation schedule

Location	Date	No. of participants	Profile of participants
Hyderabad	23rd December 2010	29	Academicians, Government and public sector officials, private sector executives, NGOs, civilians, students
Tir upati	27th December 2010	76	
Visakhapatnam	18th December 2010	54	
Vijayawada	20th December 2010	92	

Exhibit - 28: Stakeholder profile from different centers

The chart below depicts the profile of participants in the four stakeholder consultation workshops.

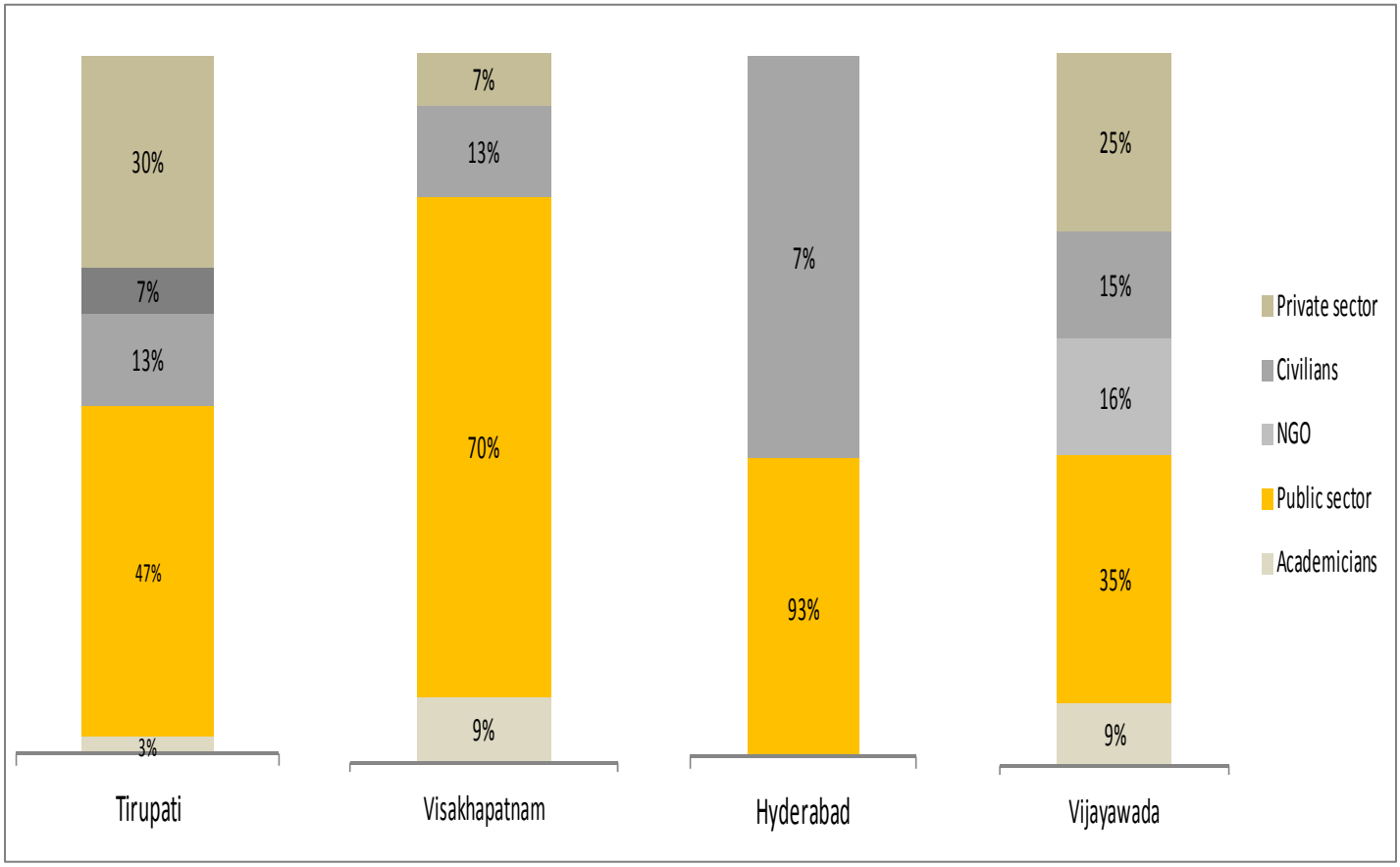
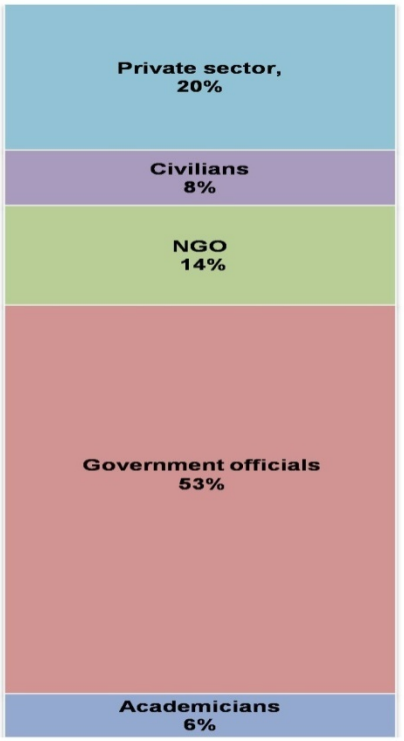


Exhibit - 29: Stakeholder Consultation workshop



Key concerns/ suggestions

- Restrict cars /sales of vehicles and promotion of cleaner fuels for vehicles
- Developing environmentally balanced industrial complexes (EBIC)
- Forest conservation and restoration

- Better municipal waste management and drainage system
- Development of efficient public transportation system
- Control of vector borne disease

- Promotion of Indian medicine system as a means to alternative livelihood for agro-based communities
- Promotion to usage of public transport and subsidies to electric vehicles, removal of old vehicles

- Enhanced use of micro irrigation, drip-sprinkler system etc
- Green tax is to be collected and utilized for raising trees
- Conservation of endangered fish species
- Disaster warning system implementation
- Improving transport infrastructure in order to promote public transport usage
- Research & development to develop climate resistant crop and livestock varieties
- Promoting energy saving measures in industries and in domestic use
- Implementation of efficient municipal waste management programme i.e., solid, waste water handling etc.
- Better regulatory framework for industrial waste disposal and treatment
- Introducing more NGOs to create awareness at low level/village level meetings

- Promoting the concept of 3R: reduce, recycle, reuse
- Implementation of cost effective waste water treatment methods using natural processes
- Reduced use of plastic
- Promoting cleaner fuels like CNG/LPG for transportation and mileage based cost mechanism for vehicles
- Strict norms to check marine water pollution

Common concerns/suggestions include:

- **Promotion of renewable energy, alternate fuels, water management practices (groundwater recharging or rain water harvesting) and sustainable agriculture practices (like organic farming)**
- **Awareness enhancement and capacity building programs on CC at community level**
- **Forest conservation and afforestation activities**
- **Restrict polluted industries to particular zones and implement more stringent pollution norms**

5.5 Prioritization of the Sectors

Based on the feedbacks received from various stakeholders on various sectors influenced by climate change and anthropogenic activities the major areas of prioritization and concern are summarized below:

5.5.1 Agriculture and livestock

- Promotion of organic farming reducing dependence on chemical fertilizers and pesticides
- Development of temperature resistant, flood and drought resistant varieties of crops and temperature resistant breeds of livestock
- Implementing micro irrigation schemes, constructing more check dams etc.
- Awareness and training dissemination of sustainable practices in agriculture
- Insurance for crop failure
- Reduction in plastic usage
- Research and training centers for producing natural fertilizers and pesticides
- Promoting farm mechanization
- Financial support through micro financing
- Protection against seasonal diseases in crops and animals
- Review of subsidies to pesticides and fertilizers and subsidies to organic agriculture
- Establishing village level agro meteorology centers
- Better solid waste management practices like recycling and reuse
- Promotion of watershed development programmes
- Promotion of less water intensive crops and crop varieties

5.5.2 Health

- Impart awareness about preventive measures
- Better bio medical waste handling
- Encouragement to traditional medical systems like yoga and ayurveda
- Better health services in rural areas and urban slum areas
- Alert system against viral infections and water pollution
- Promotion of family planning
- Awareness of hygiene, healthy practices, sanitation and spread of communicable diseases
- Training programs through local bodies like panchayats
- Prevention against seasonal disease spread by mosquitoes
- Increasing number of hospitals and improving facilities in existing hospitals

- Improving sanitation conditions to curb spread of water borne disease like cholera, typhoid etc.
- Allocating a dedicated fund for training and awareness programs
- Curbing pollution due to industries and vehicular emissions

5.5.3 Energy

- Promotion of renewable energy like solar, biomass, hydro and wind
- Improving power availability in rural areas
- Generation of power using waste
- Promoting usage of energy efficient equipments
- Air pollution produced by the thermal power plants and other energy producing plants should be closely monitored and strict implementation of regulatory emission standards
- Micro level penetration of non conventional energy resources
- Subsidy on solar power systems and LED lighting systems
- Development of non conventional sources like geothermal and tidal energy
- Promotion of nuclear energy for power generation instead of coal based technologies
- Promoting biomass based energy generation in villages
- Making energy audits in industry a norm

5.5.4 Marine and fisheries

- Controlling water pollution due to industrial discharge to the sea
- Preserving endangered species
- Promotion of mangrove plantation
- Conservation of coastlines
- Provision of financial aid to fishermen
- Training in newer fishing technologies
- Putting a check on ring net usage, which causes large scale destruction of marine habitats
- Establishing monitoring systems to check pressures on marine system due to climate change
- Imparting training to fishermen on sustainable fishing practices
- Artificial breeding through introduction of cultured seeds into marine waters
- Cyclone warning systems for fishermen
- Development of green belt across CRZ regulated regions
- Insurance for fishermen
- Encouraging marine transport

5.5.5 Irrigation and water supply

- Water conservation and proper drainage facilities
- Promoting rain water harvesting and ground water recharge
- Promotion of organic farming, reducing water pollution problems
- Encouraging micro irrigation systems
- Check on industrial discharge into municipal drainage system
- Training and awareness programs
- Measures to prevent ground water pollution and contamination
- Promoting better irrigation techniques like drip irrigation and sprinklers etc
- Regular de-silting of canals and other water retaining bodies like dams, check dams etc.

5.5.6 Manufacturing

- Stringent pollution control measures
- Proper management of manufacturing waste
- Ban on ozone depleting chemical usage in industries
- Energy and material optimization technique implementation
- Proper zoning / setting of industries
- Promoting alternatives to plastic
- Promoting the zero discharge and environmentally balanced industrial complexes (EBIC)
- Implementing energy efficient technologies
- Promoting small and medium scale industries
- Promotion of non conventional energy usage
- Implementing reduce-recycle-reuse based manufacturing units
- Introducing energy/carbon tax

5.5.7 Transport

- Promoting public transport and its usage
- Promoting electric vehicles by giving subsidies
- Providing dedicated cycle lanes
- Switching public transport to lower carbon fuels like CNG, LPG and electricity
- Promotion of bio diesel blending
- Phase out old vehicles from road
- Discouraging inefficient vehicles by imposing carbon tax

5.5.8 Forestry

- Increasing forest area
- Promoting roadside plantation of trees
- Promoting recycling of paper
- Curbing wood smuggling from forests
- Promoting afforestation in urban areas
- Enhancing public participation in afforestation activities
- Curb the loss of forests to industry, mining etc.

6. SECTORAL ISSUES AND INTERVENTIONS

11 key sectors have been identified under SAPCC in Andhra Pradesh, chosen on the basis of their relevance to climate change. A few key issues in each sector have been identified. These identified issues form the base of framing the adaptive strategies for the State. Through mitigation is not the primary objective of the SAPCC, certain mitigation actions inevitably find place in SAPCC.

6.1 Agriculture

6.1.1 Background

The role of the agricultural sector in the State economy is very significant. The State has 62.17% of the working population still dependent on agriculture. Agriculture in Andhra Pradesh is mostly dependent on rainfall, and nearly 60% area under rainfed farming. Different types of soils exist in the State, major types being red and black soils. These soils are generally low to medium in organic carbon, coarse to medium in texture and low in biological activity. In most of the State, modest quantities of organic residues recycled to soil are rapidly oxidized due to high temperature prevalent in the arid and semi-arid regions, allowing little humification of the added organic matter. Erosion with depletion of nutrients under continuous cropping without adequate addition of nutrients and organic matter over the years has resulted in soil degradation. Wide-spread deficiencies of macro, micro and secondary nutrients have been reported in the rainfed areas, which need to be addressed through integrated nutrient management to achieve balanced nutrition of crops.

6.1.2 Crops

Rice, coarse cereals, cotton, and groundnuts are the major traditional crops grown in Andhra Pradesh. Among all crops rice is the large contributor to Andhra Pradesh's economy, contributing a quarter of agricultural GSDP. Cropping intensity is one of the indices for assessing the efficiency of the agriculture sector. The cropping intensity i.e. the ratio of gross area sown to net area sown is 1.26 in 2009-2010. The level of cropping intensity moves in consonance with the behaviour of the monsoon and availability of irrigation water. Of the total geographical area of 27 million ha in the State, 39 percent is net sown area. Andhra Pradesh is very well placed in rice production, its climate is well suited to growing rice and it is one of the top three Indian States in rice production.

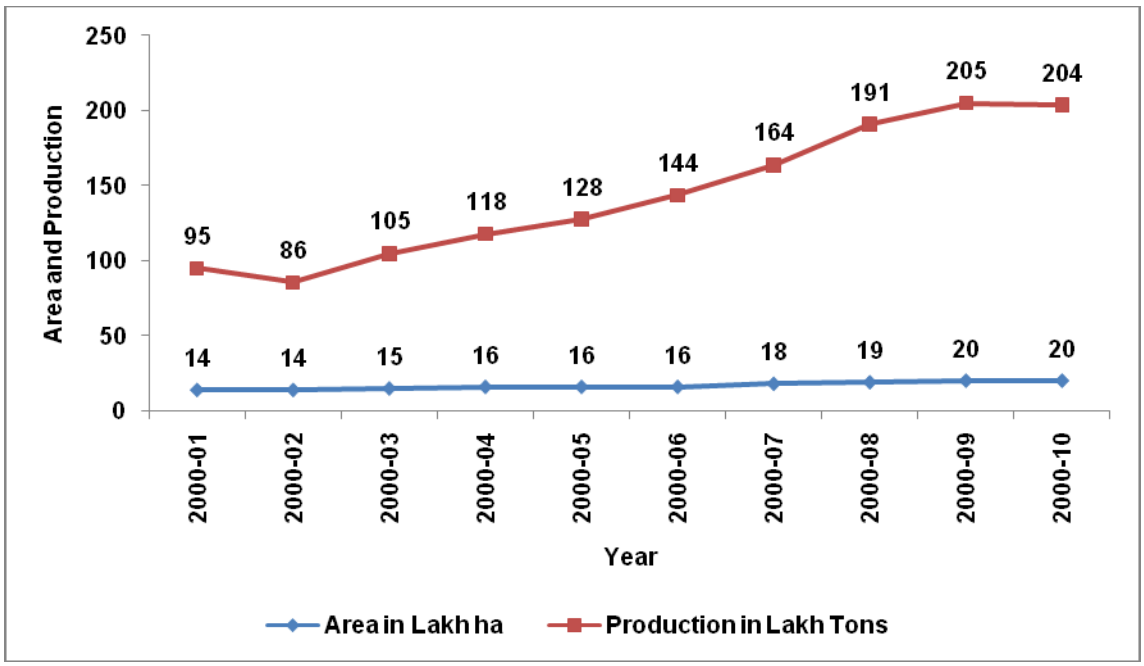
6.1.3 Poultry

Andhra Pradesh is known as the poultry capital of India. The poultry industry is one of the fastest growing industries in the State. Between 1992 and 1999, broiler production grew at 11.3% per year. Poultry meat accounts for more than 50% of total meat production in the State. Egg production too grew impressively at 13% per year between 1993 and 2004, as against 6% at the all-India level. In 2004, the State produced 15,804 million eggs, accounting for 35% of total egg production in the country. The annual per capita availability of eggs in the State increased from 64 in 1993 to 199 in 2004. Poultry meat and egg production is closely related to urbanization; the poultry sector is expanding far more rapidly in urban and peri-urban areas than in the hinterlands. From the regional perspective, the districts belonging to Telangana dominate in poultry meat production.

6.1.4 Horticulture

Horticulture has emerged as an indispensable and growing part of Agriculture, offering a wide range of choices to the farmers for crop diversification. It also provides ample opportunities for sustaining large number of agro-industries which generate substantial employment opportunities. Horticulture is showing remarkable signs of progress in Andhra Pradesh with an increased area from 3.70 lakh ha. in 1982 to 19.60 lakh ha.by 2009-10. Over the past decade, while the area has increased about 43%, the production has increased remarkably by about 115% in the State which represents increase in productivity of different horticultural crops. Exhibit 16 depicts the increasing area and productivity of horticulture in last decade.

Exhibit - 30 : Horticulture area and production in Andhra Pradesh



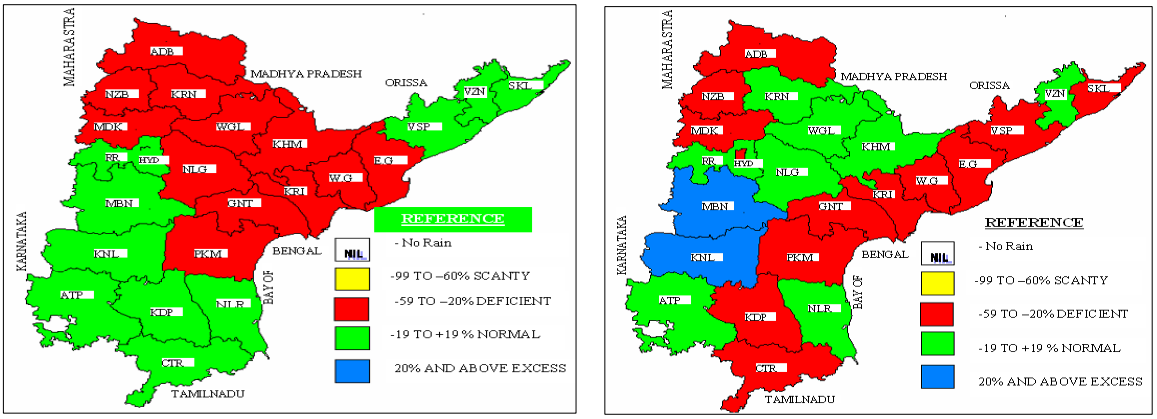
6.1.5 Agriculture Inputs likely to be affected by Climate Change

Agriculture in rainfed areas is likely to be affected by climate change. The major agriculture inputs that are directly affected by climate change and can affect agricultural production and productivity are:

6.1.5.1 Rainfall

The State receives an average rainfall of 940 mm out which the contribution of SW monsoon and NE monsoon is 624 mm and 224 mm respectively. The observed normal winter and summer period rainfall is 14 mm and 78 mm respectively. In recent years a deviation is been noticed in the NE Monsoon. It deviated from normal by -45% in 2008-09, -27% in 2006-07 and 45% in 2005-06. Rainfed agriculture is risky due to unpredictable rains. The State also recorded a substantial decrease of 23.61% in food grain production from year 2008-09 to 2009-10 due to inadequate rainfall and unfavorable seasonal conditions. Erratic and decreased rainfall, especially winter rainfall, has a negative impact on winter crops (Rabi crops).

Exhibit - 31 : Cumulative rainfall scenario for SW and NE monsoon in Andhra Pradesh (2009-2010)



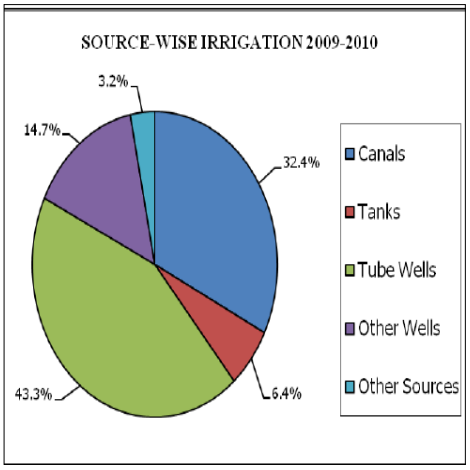
6.1.5.2 Temperature

The climate of Andhra Pradesh is generally hot and humid. The summer temperatures vary from 20^0C to 40^0C, while in winter it is between 13^0C and 32^0C. Temperature plays a significant role in the growth and productivity of agriculture. Higher maximum daytime temperature accelerates crop maturity, resulting in reduced grain filling, while higher minimum night time temperature increases respiration losses. Temperature fluctuations and high night temperature can severely affect the Rabi crops. Studies show that every 1^0C rise in temperature can reduce wheat production by 4-5 million tons on a national scale. Heat waves result in permanent and irrecoverable dehydration of plants. Damaging effect appears to be caused by rapid dissipation of reserve carbohydrates that slow down new leaf production and poor recovery from defoliation.

6.1.5.3 *Irrigation*

Irrigation is one of the major inputs in agriculture. The major source of irrigation in the State is tube wells followed by canals. The water utilization by agricultural sector in the State is estimated to increase from the present level of 2268 tmc to 3814 tmc by 2025. Rice is the predominant crop in Andhra Pradesh and more than 95 per cent of rice area is under irrigated conditions, consuming 67 per cent of irrigation water in the State.

Exhibit - 32 : Irrigation Sources in Andhra Pradesh



The gross area irrigated in the State during the year 2009-2010 is 57.65 lakh hectares which has decreased by 14.48% from the previous years. The irrigation intensity i.e. the ratio of Gross Irrigated Area to Net Irrigated Area is 1.37 for year 2009-2010. The role of irrigation becomes much more important due to the drought vulnerability of the State.

6.1.5.4 Power availability for agricultural purposes

Farm power intensity in the State is yet to achieve the envisaged level due to relatively slow adoption of tractors and other mechanical devices. The Government has a target of 3.2kWh/ha, 3.6 kWh/ha and 4 kWh/ha in 2009-10, 2010-11 and 2011-12 respectively. Dependency and vulnerability of the sector on natural climatic events has caused crop failures and distress among the farmers. Farm mechanization can reduce the cost of cultivation and drudgery.

6.1.6 Key sectoral issues and concerns

- Decrease in winter rainfall has a negative impact on winter crops (Rabi crops), especially in the rainfed areas.
- Temperature fluctuations affect Rabi crops severely.
- Heat waves result in dehydration of plants.
- There is decrease in area under crops on account of insufficient rainfall, particularly in the South- West Monsoon period.[28]
- Rainfed agriculture has become risky due to unpredictable rains.
- Due to loss in vegetation, heavy run-off takes place resulting in wastage of water and soil erosion.
- Dryland areas (parts of Anantapur, Kurnool, Kadapa, west Guntur, east Mahabubnagar, Prakasam, Nalgonda) exist in the State where annual rainfall is less than 550 mm and rainfed farming is not viable[29].
- Loss in fertility of soil in many areas due to excessive use of fertilizers and pesticides.

6.1.7 Interventions and Strategies

Being a State with 60% population still dependent on agriculture, various initiatives at village, regional and State level are required to adapt to the impacts of climate change on agriculture. Some important interventions and strategies to address climate change are given in the box below.

[28] Agriculture statistics 2009-10
[29] http://agri.ap.nic.in/action/AgricultureActionPlan%202009-10.html page 6

- Development and dissemination of new crop varieties resilient to heat, photo and water stress
- Replacement of inorganic fertilisers by bio-fertilisers
- Reducing the use of synthetic pesticides and weedicides, and promoting the use of bio-pesticides
- Assured credit facility, including for tenant farmers
- Insurance against crop failures (not just for the bank loan component)
- Increase the efficiency of water use
- Extension work for change of cropping timings and patterns, efficiency of water use, weather advisories to farmers, information on market prices etc.
- Intensive research work on stable agriculture in the context of climate change, in all its aspects
- Establishment of field centres, data banks and germplasm banks
- Use of energy efficient pump sets and other agricultural equipments
- Retrofitting existing pump sets for higher energy efficiency
- Improved animal fields and digesters
- Reuse of domestic wastewater for horticulture crops and crops with minimum risk of contamination
- Soil health improvement and Integrated Nutrient Management (INM)
- Increase the efficiency of water use by micro-water shed development, catchment area systems and water management practices
- Strict regulation of ground water abstraction
- Minor irrigation works and other engineering solutions to recharge groundwater aquifers

6.2 Coastal Zone Management

6.2.1 Background

Andhra Pradesh is one of the six States/ U.Ts of India adjoining the Bay of Bengal with a coastline of 974 km and continental shelf area of 33,227 sq. km. The average width of the productive continental shelf area is 32 km with rich pelagic and demersal fisheries. The continental shelf area narrows from north to south.[30]

[30] State of Environment Report A.P, 2009

6.2.2 Key sectoral issues and concerns

- More than 103 cyclones have affected A.P. this century, of which 31 were severe cyclones. Scientific prediction says that both the frequency and severity of cyclones will go up due to CC.
- The east coast of India is considered to be one of the most cyclone prone areas of the world. An analysis of the frequencies of cyclones on the east and west coasts of India during 1891- 1990 shows that nearly 262 cyclones occurred (92 severe) in a 50 km wide strip on the east coast.
- In coastal Andhra Pradesh, huge requirement of water for aquaculture and lack of irrigation facilities have caused dependence on groundwater, reportedly resulting in seawater intrusion.
- Out of 31.57 million people living in the coastal districts of Andhra Pradesh, approximately 2.9 million are vulnerable to cyclones. According to an estimate by the Department of Disaster Management, Government of Andhra Pradesh, about 44 percent of the State is vulnerable to tropical storms and related hazards.
- There is an increase in average earth temperature and corresponding increased sea-surface temperature, resulting in volumetric expansion of sea surface leading to build up of more frequent and intensified cyclonic activity and associated storm surges in the coastal zone. Table 12 provides the record of maximum height of storm surges experienced by various coastal regions of Andhra Pradesh.

Table - 12: Maximum height of storm surge of sea waves[31](1891-2009)

Place	Maximum height
Kalingapatnam	2.8 m
Visakhapatnam	2.6 m
Kakinada	3.0 m
Machilipatnam	5.5 m
Ongole	4.5 m
Nellore	2.8 m

- Lack of irrigation facilities, large scale aquaculture is leading to heavy dependence on groundwater reportedly resulting in seawater intrusion into the fresh water aquifers in the east coast.[32,33, 34] This is increasing salinity of soil and affecting agricultural productivity.

[31] Revenue (Disaster Management) Department, GoAP
[32] Nageswara Rao,K.(2005), Seawater intrusion due to freshwater draft in coastal aquifers, Jalvigyan Sameeksha, Vol.20
[33] Mahesha, A. (1995) Parametric studies on the advancing interface in coastal aquifers due to linear variation of freshwater level. Water Resource. Res., 31(10), 2437-2444.

- Visakhapatnam port appears in the OECD list of port cities on high risk and vulnerability to extreme climate change events[35]
- Construction of thermal power plants, pharmaceutical plants, ports, ship breaking units and sand mining activities are causing coastal level erosion and severe marine pollution. As a result, the number of dead zones in the sea (i.e. area in the sea where no fish is found) and migration of fishes to deeper waters, have increased manifold in the past few years pressing fishing communities to distress and insecurity.[36] Pronounced coastal erosion is mainly attributed to anthropogenic forcing[37,38,39] like destruction of mangrove belt, extensive aquaculture, shrimp farming and black sand mining along the east coast of India.
- Increasing acidity of sea water (due to higher dissolution of CO_2) imperils the growth and survival of plankton (i.e. fish food) which in turn leaves many fishes foodless. This also endangers the marine biodiversity of the State.
- As an estimate 9.2 km length of Andhra Pradesh coast is affected by erosion.[40] Erosion of the coastline is noticed along the Bay of Bengal at Uppada, Visakhapatnam, Bheemunipatnam and on the northern side of the Godavari River, i.e., from the Godavari River mouth to the tip of Hope Island.[41] Elongation and enlargement of Hope Island in the north and northwest directions is remarkably visible from the increase in the length of sand spit in last century as tabulated below:

[34] Bithin Datta , Harikrishna Vennalakanti, Anirban Dhar" Modeling and control of saltwater intrusion in a coastal aquifer of Andhra Pradesh, India" Journal of Hydro-environment Research 3 (2009) 148-159
[35]Nicholls, R. J. et al. (2008), "Ranking Port Cities with High Exposure and Vulnerability to Climate Extremes: Exposure Estimates", OECD Environment Working Papers, No. 1, OECD Publishing. doi: 10.1787/011766488208
Nicholls, R. J. et al. (2008), "Ranking Port Cities with High Exposure and Vulnerability to Climate Extremes: Exposure Estimates", OECD Environment Working Papers, No. 1, OECD Publishing. doi: 10.1787/011766488208
-andhra-pradesh/
[37] Baskaran R (2004) Coastal erosion. Current Science, Vol., 86,p. 25
[38] Hema Malini, B. and Nageswara Rao, K., 2004. Coastal erosion and habitat loss along the Godavari delta front – a fallout of dam construction (?). *Current Science*, Vol., 87, pp.1232-1236
[39] Nageswara Rao, K. Subraelu, P., Venkateswara Rao, T., Hema Malini, B., Ratheesh, R., Bhattacharya, S., Rajawat, A.S. and Ajai, 2008. Sea-level rise and coastal vulnerability: an assessment of Andhra Pradesh coast, India through remote sensing and GIS, Journal of Coastal Conservation, Vol. 12, pp. 195-207, DOI: 10.1007/s11852-009-0042-2
[40] National Hydrographic Office, Dehradun
[41] R. Ramasubramanian, L. Gnanappazham, T. Ravishankar and M. Navamuniyammal," Mangroves of Godavari – analysis through remote sensing approach" Wetlands Ecology and Management (2006) 14: 29–37

Table - 13: Increase in length of Hope Island spit

Year	Length of Hope Island Spit, km
1937-1938	15.60
1975-1976	16.33
1986	16.93
1996	17.75
1998	18.00
2001	18.20

6.2.3 Interventions and Strategies

The coastal areas are prone to the adverse impact of climate change. Andhra Pradesh having a very long coastline needs to take immediate steps to overcome the impacts of climate change, and thus adapt to reduce the vulnerability of the coastal population.

- Provision of cyclone shelters and all-weather connectivity to all vulnerable habitations along the coast
- Establishment of a Disaster Rapid Response Force, with equipment, communication systems etc.
- Systems for dissemination of cyclone and tsunami warnings
- Early flood warning system, including communication
- Protection works on rivers and seacoasts, such as flood banks, groynes, dykes etc.
- Strengthen disaster mitigation policies/manuals/drills for State and districts
- Interstate coordination of various canal and river management agencies to manage flood flows

6.3 Forestry and Biodiversity

6.3.1 Background

The average forest area per capita is 0.07 hectare, one of the lowest proportions in the world.[42] Forest area constitutes 23.2% of the total geographical area of the State. Out of the total forest area, Reserved Forest area accounts for 50,478 sq. km and Protected

[42] http://www.unep-wcmc.org/forest/restoration/docs/India.pdf

Forest for 12,365 sq. km. The forest products in the state include timber, bamboo, firewood and charcoal, beedi leaves and miscellaneous. The income accrued from forestry sector in the State was Rs. 103.37 crore in 2009-10 and Rs. 45.11 crore in 2010-11 (upto September 2010).

6.3.2 Key sectoral issues and concerns

- Wind erosion: Soil is eroded due to strong winds, especially in deforested areas. The areas susceptible to soil erosion are situated near the forested hills and water flows through these areas through innumerable gullies, nallas etc to finally join a river. Flooding could further contribute to soil erosion, but could also deposit silt, leading to creation of fertile floodplains over time.
- Cyclonic storms and tidal waves cause damage to forests, especially in the 9 coastal districts of the State.
- The area of degraded forest has shown a decreasing trend from 35044 sq. km. in 1996 to 27681 sq. km. in 2000 and 22775 sq. km. in 2006. According to recent report, the State has a degraded forest area of 20915 sq. km for the year 2009-2010.[43,44] The forest cover of the State has increased from 44229 sq. km. to 45102 sq. km. from year 1999 to 2009 mainly because of the effect of improved protection and development of forests by more than 7,718 Vana Samrakshana Samities (VSSs) or JFPCs in the State. 23.8 % of forest area, is under Community Forest Management (CFM) with involvement of approximately 1539 thousand members.
- Due to changes in climate, there is a disturbance in the timing of flowering and appearance of pollinators. Moreover, excessive use of pesticides/insecticides, loss of forests (natural habitats for pollinators), air pollution etc. have also decreased the appearance of pollinators.

[43] State of Forest Report-2008: Andhra Pradesh, Principal Chief Conservator of Forests, Hyderabad, page 4
[44] State of Forest Report-2011, GoAP.

6.3.3 Interventions and Strategies

- Protection and Conservation of forests, including fire protection
- Soil and Water Conservation in forest lands
- Restoration of mangroves
- Afforestation and eco-development through community based programmes (like Joint Forest Management)
- Creation of forests in degraded/public lands, including such lands in and around cities and towns
- Documentation of biodiversity, including genetic fingerprinting
- Public awareness programmes on conservation of forests and biodiversity
- Preservation of rare/threatened germplasm (e.g. under cryogenic or other controlled conditions)
- Plantation for sustainable commercial utilisation to reduce pressure on natural forests
- Shelter belt plantation in coastal regions to reduce damage from cyclone

6.4 Energy

6.4.1 Background

[45]The installed power generation capacity in the State up to the end of September 2010 (including share from Central Sector) was 14,769.96 MW. The electrical energy available from various sources for use during 2010-11 was 37877 MU. The number of consumers served has increased from 218.27 lakh to 223.53 lakh to the end of September 2010. The per capita consumption has reached 929 KWh during 2009-10. 4197 sub-stations and 7,59,931 distribution transformers exist presently. During 11th five year plan i.e. 2007-12, 2736 MW was already added to the 2010-11 installed capacity (ie. 1336 MW under State sector, 108 MW is under Central sector, 1128 MW is under private, 164 MW is under non conventional energy projects).

[45] Socio-Economic Survey, Report of A.P. 2009-10

Table - 14: Installed Capacity (in MW) of power in A.P. (as on 31st May 2010)

State	Owner-ship Sector	Modewise breakup				Nuclear	Hydro (Renew-able)	RES** (MNRE)	Grand Total
		Thermal			Total Thermal				
		Coal	Gas	Diesel					
Andhra Pradesh	State	4382.50	0.00	0.00	4382.50	0.00	3617.53	188.43	8188.46
	Private	0.00	2580.40	36.80	2617.20	0.00	0.00	523.26	3140.46
	Central	2377.38	0.00	0.00	2377.38	214.28	0.00	0.00	2591.66
	Sub-total	6759.88	2580.40	36.80	9377.08	214.28	3617.53	711.69	13920.58

Source : Socio-economic Survey, 2010-2011, Planning Department, GoAP

6.4.2 Key sectoral issues and concerns

- Use of fossil fuel is the principal contributor to climate change
- Incentivising cleaner energy technologies
- Promotion of renewable energy
- Demand side management to reduce consumption
- Availability and investment in renewable energy sources
- Subsidisation of clean technologies

6.4.3 Interventions and Strategies

- Improve the efficiency of thermal power generation
- Improve the efficiency of transmission, including elimination of pilferage
- Improve the efficiency of electrical equipment, including water pumping equipment used in agriculture
- Promotion of affordable alternative energy sources i.e. solar home systems, solar street lights, solar thermal systems
- Rationalisation of power tariff for sectors that are currently subsidised
- Decentralised rural electrification using woody or agricultural residue

6.5 Industries (including mining)

6.5.1 *Background*

[46]After introduction of the Industrial Policy in 1991, so far 3,012 large scale industries have gone into production with an investment of Rs. 63,483 crore providing employment

to 4,55,129 persons. During the years 2009-10 and 2010-11, about 10,728 Micro, Small and Medium Enterprises are established providing employment to 1,81,375 persons involving an investment of Rs. 7053.17 crore Government of Andhra Pradesh have announced Industrial Investment Promotion Policy 2010-2015, in the year 2010 extending various incentives for the MSME Sector and Large Industries. There are 113 SEZs approved by the Government of India, of which 74 are notified and 27 are operationalised. Department of Chemicals & Fertilizers, Government of India, has accorded approval in March 2009 for development of Petroleum Chemical and Petrochemical Investment Region (AP PCPIR) in Visakhapatnam – Kakinada Region over an extent of 604 sq.km.

[47]The State produces 100 to 110 million tonnes of industrial minerals and 200 million cubic meters of dimensional stones and building materials. There are 1966 Mining Leases and 8959 Quarry Leases for Major Minerals (industrial minerals) and Minor Minerals (construction minerals) with an extent of 37,031 hectares and 13,189 hectares respectively.The State is endowed with a number of minerals such as Limestone (34% of the national deposit), Coal (10% of the national deposit), Mica (86% of the national deposit), Dolomite (11% of the national deposit), Bauxite (40% of the national deposit), Barytes (96% of the national deposit), Clays (30% of the national deposit), heavy mineral beach sands (40% of the national deposit). Most of the mining activity in the State is concentrated in Khammam, Warangal, Adilabad, Karimnagar, Prakasam and Anantapur districts.[48]

6.5.2 Key sectoral issues and concerns

- Increasing fossil fuel consumption and GHG emissions from the industries
- Increasing number of industries in State and their improper waste management practices
- Agro business and food processing industries are vulnerable to extreme weather events like flood, cyclone etc., on account of both location and raw material supply
- Depletion and degradation of surface water , aquifers and leaching from dumps
- Land degradation and large scale deforestation, noise and vibration, destruction of habitat, loss of bio-diversity etc.
- The activities in open cast mining like blasting, drilling, excavation, truck loading and transportation are responsible for the increase of suspended particulate matter in the air

[47] Socio-Economic Report of AP 2009-10
[48] State of environment report , AP , 2009

- Dislocation of human communities and health impacts on the community living in close proximity to the mine areas

6.5.3 Interventions and Strategies

- Enforce 'cleaner production processes' and waste minimisation across industries, in partnership with the Central and State Pollution Control Boards
- Assess the vulnerability of major industrial hubs to climate related risks
- Protection and disaster mitigation works to minimise risks to industrial hubs (e.g. seawalls, alternate rail and road access, improving drainage, alternate water supply sources etc.)
- Minimise environmental damage including GHG emissions, caused by industrial and mining activities, including mining
- Promote diversified and dispersed industries, including small/medium scale agro processing, to stabilise agricultural livelihoods
- Intensive research for the biological methods of metal extraction from mine spoils to prevent acid mine drainage
- Pollution prevention measures to reduce prevent air pollution during open cast mining activities
- Implementation of resettlement and rehabilitation plans for affected population
- Compensatory afforestration activities on a large scale to prevent biodiversity losses in the forest area

6.6 Transportation

6.6.1 Background

The Transport Department plays a key role in licensing of drivers, registration of motor vehicles, issue of transport permits, levy and collection of motor vehicle tax and enforcement. It acts as the nodal agency for road safety and motor vehicles pollution control. As on 15-11-2010, the State has a registry of 95.89 lakh vehicles. About 72% of the vehicles on road are two wheelers, followed by cars, three wheelers, buses and trucks. The growth of vehicles in A.P. is approximately around 10% over a period of 10 years from 2000-2010. The registered motor vehicles on road are shown in Table 15.

The Transport Department collects revenues from the issue of driving licenses, registrations, permits and taxes. The growth of revenue is shown in Table 16.

Table - 15: Registered motor vehicles on roads[49]

Sl. No	Class of Vehicle	As on April- 2000	As on April- 2005	As on Nov-2010
1.	Auto-Rickshaws	62248	191313	482819
2.	Contract Carriage Vehicles	1342	2810	5277
3.	Educational Institute Vehicles	5764	12866	24745
4.	Goods Carriage Vehicles	148208	242312	498669
5.	Maxi Cabs	4176	13155	25048
6.	Mopeds and Motor Cycles	2222674	3781537	6922747
7.	Motor Cars	274278	468822	905770
8.	Motor Cabs	23332	41048	88665
9.	Private Service Vehicles	1910	3984	5678
10.	Stage Carriage Vehicles	12241	20216	25375
11.	Tractor and Trailers	200355	292330	545343
12.	Others	34191	41607	59028
Total		**2990719**	**5112000**	**9589164**

Table - 16 : Growth of Revenue of Transport Department

Year	Total Revenue (Rs. Crore)
2001-02	950.92
2002-03	918.69
2003-04	1095.85
2004-05	1096.49
2005-06	1354.19
2006-07	1371.96
2007-08	1591.61
2008-09	1846.52
2009-10	2007.70
2010-11 (Upto October 2010)	1595.86

6.6.2 Key sectoral issues and concerns

- The growth of cities and large-scale migration of rural population to urban areas has increased the population and population density. The urban population is disproportionate to the available infrastructural facilities[50]. Higher population and

[49] Socio-economic Survey, 2010-2011, GoAP
[50] Report published on Hyderabad city by Centre of Science and Environment

rising income levels have increased the vehicular population multi-fold (almost 200% in the last 10 years).

- The transport sector has a large share in anthropogenic climate change impacts. After energy, the transport sector (mainly road transport) is the main source of increasing CO_2 levels in the atmosphere.
- The share of public transport is low; share of public transport in Hyderabad is 44% which is far below the global best practices.
- Because of the high vehicle population in urban areas, road congestion has become a major problem, resulting in poor fuel economy.
- Although incentive program is there in place (like tax exemption for battery / compressed natural gas / solar power driven vehicles) penetration of low carbon fuel vehicles usage is negligible.
- Andhra Pradesh holds tremendous potential in Natural Gas availability. However In comparison to the potential, mobilization of CNG in transportation sector is not adequate (In Hyderabad 1623 vehicles are CNG driven; a mere 0.08% of the total vehicle population of Hyderabad[51]).
- Lack of organized efforts to promote fuel efficiency improvement and eco-driving habits for 'vehicles in use' among drivers or owners of the vehicles (private or governmental).

6.6.3 Interventions and Strategies

- Enhance the share of public transport in the total transportation mix
- Enhance the share of low emission/fuel-efficient vehicles and vehicles that run on alternate fuels
- Encourage non-motorised transport like walking and cycling
- Design or redesign road networks so as to facilitate smooth traffic movement
- Interlinking of private and public transport modes so as to minimise the use of private transport

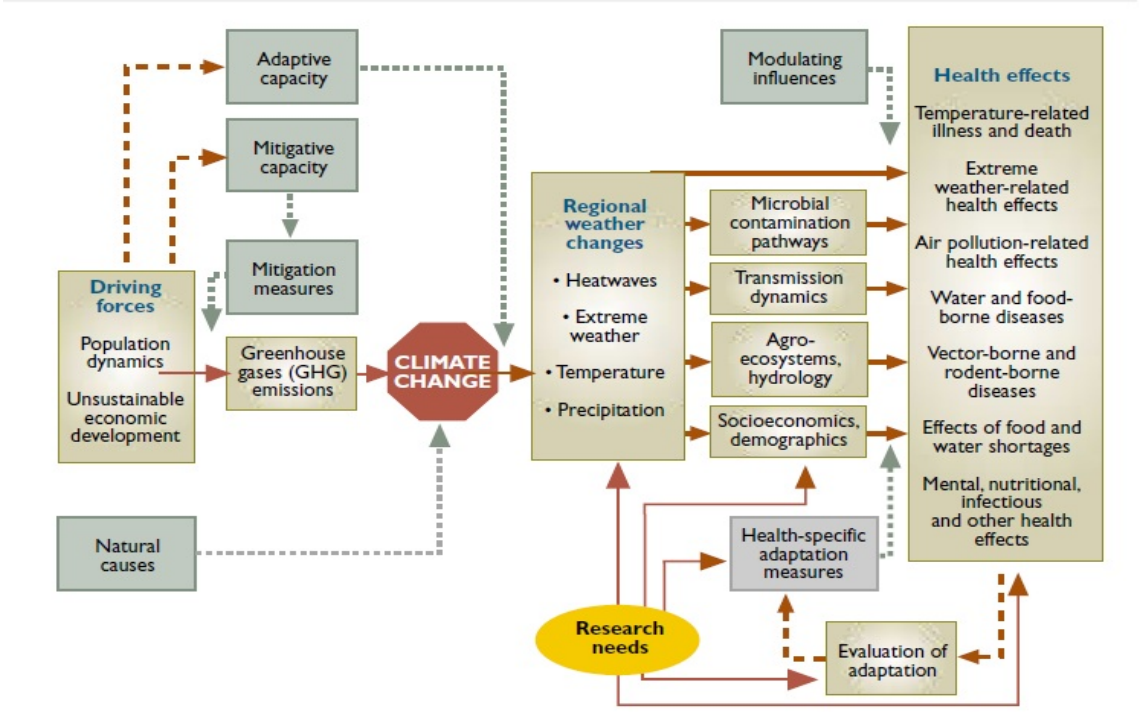
[51] Source: http://www.eai.in/ref/fe/nag/nag.html

6.7 Health

6.7.1 Background

Climate change is already having a discernible influence on the global burden of disease and particularly on the health of the most impoverished in the society.[52] Pathways by which aspects of climate change ranging from heat waves to precipitation lead to adverse health impacts are illustrated by the WHO diagram which is reproduced below. However, research on health impacts of climate change in India is limited. The likely health impacts in Andhra Pradesh have been extrapolated from global research evidence. Exhibit 19 illustrates the driving forces triggering off a series of events that cause climatic changes and adversely affect health in turn.[53]

Exhibit - 33 : Health and Climate Change



The State of Andhra Pradesh has three main geographical zones: the coastal strip, mountains and the Deccan Plateau. The Deccan Plateau is a semi arid region and susceptible to frequent droughts, while the coastal belt receives heavy rainfall brought by the South-west and the North-east monsoons.[54]

[52] INCCA, 2010
[53] WHO, 2003
[54] World Bank, 2001

6.7.2 Environmental Health in Andhra Pradesh

A 2001 study conducted by the World Bank highlighted that about 20 percent of the burden of ill health in Andhra Pradesh was attributable to environmental causes. Over 90 percent of this was associated with traditional environmental risks such as lack of access to safe water and sanitation and indoor air pollution resulting from the use of biomass fuels. Although urban households have a higher level of access to water and sanitation and cleaner cooking fuels than their rural counterparts, they are more at risk from the environmental pollution resulting from vehicular transport and industrialization which may increase exposure to biological, chemical and toxic wastes. Climate change is adding to the health impacts associated with these traditional environmental risks.[55] The disease prevalence as per the mode of communication will be further discussed.

6.7.2.1 Water borne diseases

Water borne diseases from faecal contamination of drinking water remain a major public health challenge in India.[56] Malnutrition increases the vulnerability to water borne diseases. Acute gastroenteritis, Hepatitis A and cholera are known to be endemic to Andhra Pradesh. About 19 percent of all deaths in children aged between 0 and 4 years in A.P. are due to diarrhoeal diseases. The 2009 cholera outbreak highlighted the urgent need to improve access to safe water and sanitation.

As a result of climate change, excessive rainfall in the coastal districts of Krishna and Godavari has led to flooding and consequently, the bacterial contamination of water. In contrast, frequent droughts in the districts of Karimnagar, Ranga Reddy and Hyderabad have compelled many people to consume any water that is available, including that from contaminated sources. It is estimated that between 8.8 and 17 million people in Andhra Pradesh are exposed to water borne pathogens[54].

Water borne diseases are also linked to heavy metal contamination of water, due to industrial, agricultural and biological effluents. About 6 million people in Andhra Pradesh (including over 100,000 infants) are estimated to be exposed to agricultural and biological nitrates. There is a perception that consumption of water contaminated with agricultural pesticides has been associated with a number of skin and eye problems as well as foetal defects.[54] The World Bank study confirmed that the districts of Karimnagar, Prakasam, Ranga Reddy, and Kurnool have the highest proportion of population exposed to water contamination.

[55] World Bank, 2001
[56] EPTRI, 2009

6.7.2.2 Vector borne diseases

The major vector-borne diseases prevalent in Andhra Pradesh are malaria, dengue, filariasis and chikungunya. An epidemic of chikungunya was reported in the State between 2005 and 2006. The moist coastal areas of Prakasam, Kadapa, East Godavari and Visakhapatnam and the semi-arid regions of Khammam and Nalgonda have a greater incidence of vector borne diseases compared with other parts of the State.[57]

The endemicity of malaria in Andhra Pradesh is attributed to the pollution of water bodies and water logging.[58] It is a climate sensitive disease and its transmission continues almost throughout the year owing to the relatively humid climate. It is also estimated that an increase in the temperature by 2-3^{o}C may increase the incidence of malaria by about 3-5%.[59] Although the disease is more prevalent in rural Andhra Pradesh, the Health and Family Welfare Department data confirm that approximately 10.6 percent of malaria cases in 2001 were recorded in urban Andhra Pradesh.[60]

6.7.2.3 Air borne diseases

There are many sources of outdoor air pollution including factories, refineries, power plants and vehicular exhaust. Toxic air pollutants include benzene, toluene, methylene, chlorides and dioxins released in degradation of plastics and asbestos, and metals such as cadmium, mercury and lead. Indoor air pollution is contributed by cigarette smoke, nitrogen dioxide, fuels such as oil, gas, kerosene and coal; cooling systems, such as air conditioners and humidification devices and cleaning agents.[56]

Climate change is an important determinant of air quality. Some weather patterns may increase the levels of chemical pollutants in air. The formation of ground level ozone which is a constituent of urban smog depends on bright sunshine with high temperatures. Its concentration may therefore increase with higher ambient temperatures. Climate change may also increase concentrations of other air pollutants such as fine particulate matter. Adverse health effects of air pollution include mainly heart disease, cancer and respiratory disease including asthma and chronic obstructive pulmonary disease (COPD). Andhra Pradesh districts of Kurnool and Anantapur recorded the highest incidence of bronchitis between the years 2006 and 2007. The districts of Khammam and Prakasam had the highest incidence of asthma between the years 2007 and 2008 (EPTRI, 2009). In keeping with global projections, the health impacts of air pollution and their exacerbation due to climate change are likely to increase.

[57] EPTRI, 2009
[58] World Bank, 2001
[59] INCCA, 2010
[60] Directorate of Health, 2001

6.7.2.4 Agriculture, Drought, Nutrition and Food Security

For decades the overexploitation of land for the purpose of agriculture has resulted in deforestation and loss of the binding capacity of soil, leading to erosion and depletion of nutrients. 'Agriculture is the mainstay of nutrition and livelihood in India'. Despite this dependency, the indiscriminate use of land for agriculture with a lack of mixed cropping or crop rotation has led to a significant problem of micronutrient deficiency in the soil and as a consequence, micronutrient deficiency in women and children. In Andhra Pradesh, the arid regions are deficient in Ca, Zn and Mn, while the coastal regions have recorded a low content of Ca, P, Cu and Zn.[61]

Poor rainfall and excessive dependence on ground water for irrigation in the districts of Anantapur and Chitoor have reduced water availability to crisis levels. The rates of transpiration and evaporation have been recorded to be three times that of the rainfall. These climatic changes and resulting decline in crop yields have led to income volatility among farmers.[62] It is projected that the small rainfed farms may become unsustainable. A study carried out by the Central Research Institute of Dryland Agriculture projected that by 2070-2099, the south-west region of Andhra Pradesh will experience excessive flooding and cyclones, while the arid regions will have a decreasing trend in rainfall.[63]

According to the Indian Network for Climate Change Assessment[64], climate change is projected to affect the yield of crops in the majority of the coastal districts by the 2030s, and the effects may be both positive and negative. In some coastal districts of northern Andhra Pradesh the rice yield is projected to marginally increase by 5%, while in the rainfed rice areas it may increase upto 15%. Impacts of climate change on the irrigated maize in coastal districts of Andhra Pradesh are projected to show a likely increase of 10%. The yield of coconut in the north coastal districts of Andhra Pradesh may also increase by about 10%. Even though the coastal areas are likely to experience an increase in crop yield, many of the tropical fishes (e.g. Indian mackerel) are being displaced to the deeper waters from the pelagic realm and many face extinction due to warming of the surface water reducing the availabilty of fish in the coastal areas of AP. Though sparsely investigated, phenological changes such as seasonal shift in spawning season are now evident in Indian seas. Although there are considerable uncertainties, it is suggested that these changes may leave the species more vulnerable to predator and parasite attack, resulting in consequent reductions in fish. The health impacts of these changes are likely to be mixed, with increased availability of some foods such as rice and reduction in others.

[61] Singh, 2009
[62] World Bank, 2008
[63] Venkateswarlu, 2011
[64] INCCA, 2010

6.7.3 Impact of extreme weather events on Health

Extremes of both hot and cold waves have been shown to result in excess morbidity and mortality). According to the Indian Network for Climate Change Assessment[65] the southeast coast of India, especially Andhra Pradesh, is likely to experience severe heat stress by 2030. Heat waves are projected to become more common, resulting in increased risk of heat stress, stroke and death, particularly in vulnerable populations, such as the very old and very young. The lack of drinking water is likely to cause heat strokes and increase mortality. Andhra Pradesh is also projected to experience more frequent and severe floods and hurricanes which may result in deaths disease and injury due to drowning, lack of sanitation and safe drinking water and exposure to dangerous chemical contaminants. Vector borne disease may also increase. Extreme weather events and the impact of coastal erosion may result in enormous economic and physical damage and is likely to be associated with severe mental distress.[66]

6.7.4 Existing Policy and Legislation for health problems caused by environmental changes

A number of measures have been introduced to enable the population, particularly those living below the poverty line, to adapt to climate change. The Deccan Development Society has taken a number of initiatives to enable subsistence farmers, especially women to address issues such as maintaining crop yields against a background of reduced rainfall.[67]

The Rajiv Aarogyasri health insurance scheme which aims to improve equity of access to healthcare for the poor, may experience increasing demands for healthcare services resulting from climate related ill health. Monitoring of these trends will enable the Government of Andhra Pradesh to develop preventive measures such as heat wave warnings which would enable the vulnerable population such as outdoor workers to take appropriate precautions against heat stress.

A National Vector Borne Disease Control Programme was started during the Tenth Plan and furthered strengthened during the Eleventh Plan. The programme aimed at converging the programmes focused on malaria, kala-azar, filariasis, Japanese encephalitis, and dengue. An Enhanced Malaria Control Project was started under this plan in 100 districts of 8 States which included Andhra Pradesh districts, predominantly

[65] INCCA, 2010
[66] WHO, 2005
[67] People's Coalition On Climatic Change, 2009

inhabited by tribal populations. These areas reported a 45% decline in malaria cases as a consequence of the increased surveillance.[68] The programme will need to maintain close monitoring and surveillance to be able to identify climate related changes to vector borne disease trends and instigate prompt corrective action.

The Government of Andhra Pradesh has established a number of programmes to improve safe water provision and living conditions, and reduce poverty and malnutrition.[69] The prevalence of malnutrition among children has shown a steady decline from 45 percent in 1992-93 to near 36 percent in 2005-06.[70] The challenge will be to maintain a strong public health programme to continue to improve health despite the adverse impacts of climate change.

6.7.5 Key sectoral issues and concern

- Impacts of Vector Borne Diseases
- Impacts of Water- Borne Diseases
- Impacts of Air pollution related health effects
- Impacts of extreme weather related health effects

6.7.6 Interventions and Strategies

- Undertake longer-term studies to investigate links between climate change and disease patterns, as also between pollution loads and disease patterns
- Strengthen detection and early warning systems for outbreaks of diseases
- Health Surveillance
- Public education on prevention of diseases related to climate change and resulting from environmental pollution
- Research on development of low cost vaccines, particularly those related to vector borne diseases
- Development of rapid response capabilities to handle climate related disasters such as exposure to sun, floods, cyclones and prolonged droughts

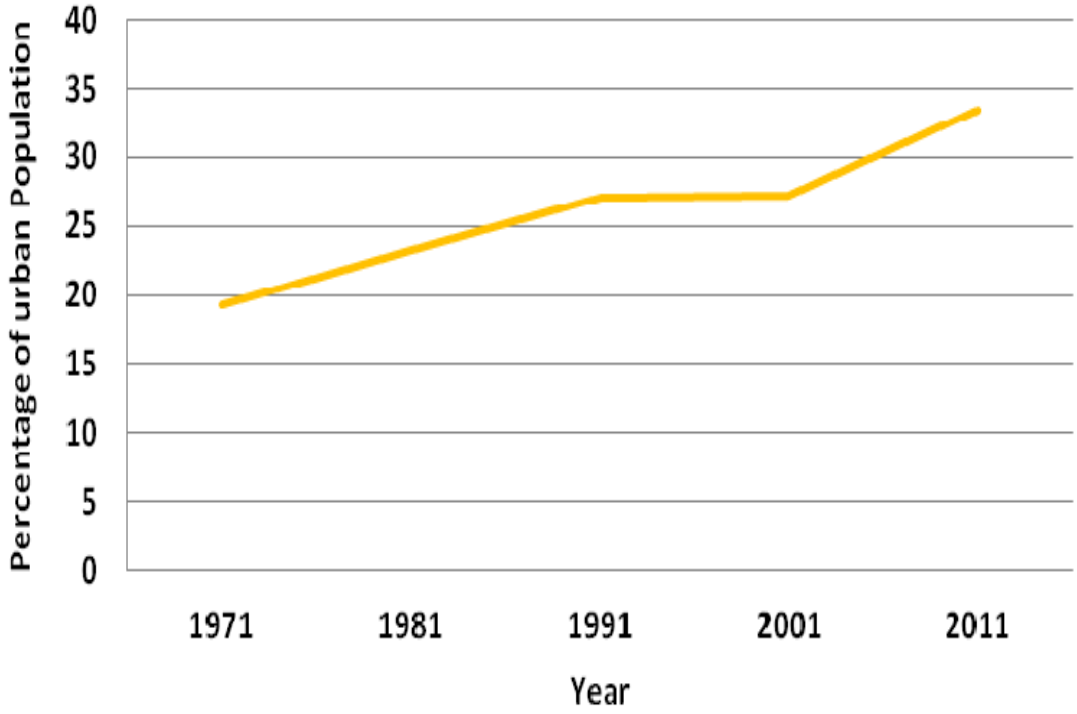
[68] Planning Commission, 2011
[69] World Bank, 2001
[70] EPTRI, 2009

6.8 Urban Development

6.8.1 Background

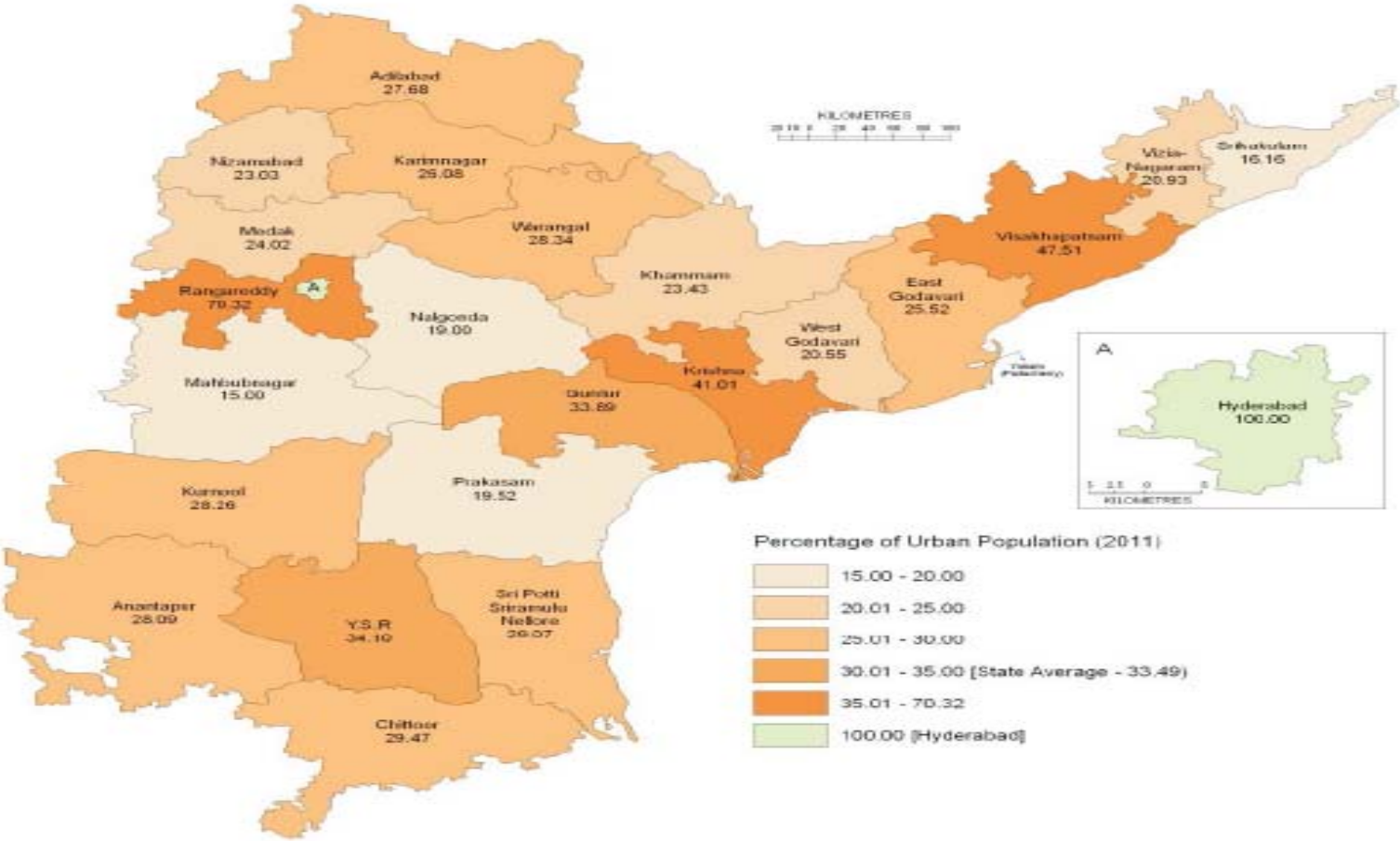
Indian cities are predicted to be at high risk due to climate change. This situation may be accentuated due to the 500 million people who are predicted to be added in 7000 urban settlements by 2060[71]. Andhra Pradesh has also shown a large population shift to the urban areas over the last 100 years. The urban population in the State as per 2011 Census is 2,83,53,745 constituting 33% of total population.

Exhibit - 34: Trends in urban population of Andhra Pradesh



[71] McGranahan and Mercutollio, 2007

Exhibit - 35: Percentage of Urban Population in Andhra Pradesh



A major part of the urbanization in Andhra Pradesh resulted from the development triggered by the formation of Hyderabad Urban Development Authority (HUDA) in Sept. 1975. The above graph indicates that the percentage of urban population has constantly increased from around 20% in 1971 to 31.16% in 2011. Also,[72] in 1991, Class I towns and cities with a population of over one lakh accounted for 67% of total urban population which rose to 75% by 2001 Census. Exhibit 20 shows the distribution percentage of urban population in different districts of Andhra Pradesh (2011). It indicates that the districts namely Rangareddy, Krishna and Visakhapatnam are the ones with high urban population.

Vulnerabilities of the urban poor can be a direct result of climate change, such as flooding or drought, or an indirect result, such as higher incidence of disease or an increase in food prices. The impact of climate change on the urban poor is thus often disguised and entangled with other socio-economic and urban issues.

6.8.2 Key sectoral issues and concerns

- Increasing energy use in the urban areas due to the changing pattern of urban livelihood
- Increasing average temperature/extended summer every year
- Drainage of the cities not adequate to accommodate the precipitations during the heavy rains
- Demand on water resources due to the growth in the urban population and therefore increased pressure on the water supply infrastructure
- Consequent generation of large quantity of sewage
- Generation of huge quantum of solid waste
- Increased threat to urban health due to vector borne diseases
- Increased private transportation leading to huge pressure on the road infrastructure and the increased emissions

[72] SOE , AP, 2009

6.8.3 Interventions and Strategies

- Safe water supply as per norms to the entire urban population (projected population of 2022)
- 100% coverage of sewerage and sanitation for the urban population (projected as of 2022)
- Study and remodel existing water supply, sanitation and sewerage systems to reduce climate change vulnerability
- Protection and restoration of existing water bodies in urban areas
- Creation of new water bodies in urban areas
- Scientific management of municipal solid waste in all municipalities and corporations (population and number of municipalities projected as of 2022)
- Restoring efficiency of drainage network of all municipalities to enable quick evacuation of water and to avoid flooding
- Enforce spatial planning in cities and towns to reduce vehicular movement
- Mandatory rainwater harvesting in Government buildings, commercial establishments, offices, schools/colleges, academic/research establishments and industrial units
- Policy and incentives for rooftop solar power generation and provision of grid connectivity
- Rail based MRTS in emerging cities and expansion of existing MRTS
- Provision of safe footpaths, cycle tracks etc to promote non-motorised transport
- Recovery of phosphates nitrates etc., from wastewater

6.9 Tourism

6.9.1 Background

Andhra Pradesh attracts the largest number of domestic tourists among all the States of India. Recognition of the importance of tourism for sustainability of local communities and heritage has led to theme-based and specialized forms of tourism. Prominent eco-tourism sites include Araku Valley, Borra Caves, Ananthagiri Hills in Visakhapatnam, and Horseley Hills in Chittoor District. In 2009, 157[73] million domestic tourists visited Andhra Pradesh. This marks an increase of 14% over 2008. Because of its close

[73] Tourism Policy 2010

connections to the environment and climate, tourism is considered to be a climate-sensitive[74] economic sector like agriculture and transportation. Tourism is affected by a very wide range of environmental and socio-economic factors, and has been continuously adapting to challenges and crisis situations, such as natural disasters, epidemics, economic downturns, political events etc showing great resilience. Therefore, the capacity of the tourism sector to adapt to climate change is thought to be relatively high due to its dynamic nature.

6.9.2 Key sectoral issues and concerns

- Habitat loss and degradation, caused by logging for firewood and timber materials, are major threats to restricted-range species[75]
- Poaching , hunting and unsustainable exploitation threaten both flora and fauna
- Changes in coastal and marine systems, species and ecosystem services, damage to infrastructure, water shortages and water contamination, global warming and ocean acidification, coral reef destruction, mangrove destruction
- Tourism transportation and usage of high carbon intensive fuels in resort/tourist spots cause high levels of CO_2 emissions which increase the pollution levels in tourist places like Tirupati, Hyderabad etc. [76]

6.9.3 Interventions and Strategies

- Promote low emission/fuel-efficient mass transportation, to and within tourist areas (e.g. battery operated vans operating around the Taj Mahal)
- Promote energy efficiency lighting, climate control equipment etc. in hotels and other areas where tourists congregate
- Promote eco-tourism to enhance environmental consciousness
- Enforce cleanliness in tourist areas
- Protect both built and natural heritage against climate related damage (e.g. damage from high temperature, water accumulation, pests etc.)

[74] Climate Change and Tourism-UNEP
[75] The Peacock Parachute Tarantula (Poecilotheria metallica) is a very rare, Critically Endangered spider known from a single location in the Eastern Ghats of Andhra Pradesh, India.
[76] Balaji Colony, Gandhi Road and railway station with SPM recorded at around 350 µg/m^3units in Tirupati. Increased pollution levels in Hyderabad have increased the incidence of respiratory disorders among the traffic police personnel from 0.36% in 2003 to around 3.5% in 2009 (APPCB, Hyderabad).

6.10 Rural Development

6.10.1 Background

The rural population as per 2011 census in the State is 5,63,11,788 constituting 67% of total population. Rural Development Programmes viz., Watershed Development Programme, Self Help Groups and related programmes and Employment Guarantee Schemes are being implemented. There are 109.79 lakh Self Help Group members in 9.75 lakh SHGs organized into 38,334 Village rganizations (VOs) and 1,099 Mandal Samakhyas (MSs). In addition to the above, there are 138 Mandal Vikalangula Sangams, 17 Chenchu Mandal Samakhyas, 7 Fishermen Mandal Samakhyas and 20 Yanadi Mandal Samakyas.

6.10.2 Key sectoral issues and concerns

- Deterioration of natural water resources and other ecological resources impacting the life and livelihood of rural population
- Due to lack of opportunities in the rural areas, there is large migration of rural population to urban areas, is in turn putting pressure on the urban infrastructure
- The poor living along the coastal line are most vulnerable to disasters like floods and cyclones, and housing is largely *kutcha* in nature

6.10.3 *Interventions and Strategies*

- Safe water supply as per norms to the entire rural population (projected population of 2022)
- 100% coverage of sewerage and sanitation for the rural population (projected as of 2022)
- Study the climate change vulnerability of existing water supply and sewerage/sanitation systems
- Remodel or strengthen existing water supply and sanitation/sewerage systems to reduce vulnerability to climate change
- All-weather road connectivity to all habitations (projected as of 2022) for access to goods and services, and for evacuation in emergency
- Creation of new water bodies (lakes, tanks, kuntas etc.) and restoration of existing dilapidated water bodies
- Water shed development, catchment area system and water management systems
- Micro credit facility for promoting livelihoods

6.11 Research in Climate Change

6.11.1 Background

Various aspects of climate change directly or indirectly affect the sensitivity and stability of the environment. Research would deal with the changes in the greenhouse gases, aerosols, solar irradiance, rainfall and monsoon, incidence of natural calamities, land use changes, knowledge and awareness of the people, and the vulnerability of various sectors to climate change and its consequences. The research would focus on the long and short term studies on areas and populations prone to climate change. Due to observed changes in the rainfall patterns and incidence of natural calamities in the State, climate related research studies on river basins, industrial hubs, Urban Local Bodies (ULBs) etc has become an imperative.

Andhra Pradesh being the State with second largest coast line in country, is particularly vulnerable to climate change and adverse climatic events. The three major river basins of the State are Godavari, Krishna and Pennar and their tributaries. The State is dependent on these rivers for agriculture, domestic and commercial usage of water. Hydrological modeling studies carried on the Pennar river basin has predicted reduction in run off from 150mm to 110mm per year which can cause serious problems of water supply in southern Andhra Pradesh.[77] Further such studies on vulnerability of river systems in State are required to prepare the baseline scenario and predict the future changes in the water availability in the State. Such research projects can help to develop adaptation methods/tools and strategies that will help in addressing the climate change impacts on hydrological regimes.

The State is transforming into a dynamic industrial economy. With the friendly investment atmosphere, the State has become an attractive choice for investment and has witnessed high industrial growth. The industrial sector has notified 7.79% of growth rate for the year 2010-2011 and is expected to increase in near future. The industrially developed areas generally have inadequate vegetation, and are unplanned as well as haphazardly and unscientifically developed, making them prone to erosion and flood hazards. The risks and vulnerability further increase due to the concentration of industries in a narrow strip along the eastern coast. The industrial hubs are also facing water scarcity problems and impact of climate changes on industrial water supply needs to be investigated.

[77] Overcoming Drought : Adaptation Strategies for Andhra Pradesh, World Bank, 2006

The State has recorded a high rate of urbanization. The urban population has increased from 27.3% in 2001 to 33.5% in 2011. The decadal urban population growth of the State has been recorded to be 36.26% whereas the rural decadal population growth has been observed to be just 1.64%.[78] The State has presently 167 Urban Local Bodies (ULBs) including 17 Municipal Corporations. Lack of knowledge and awareness among people about the climate change issues and consequences is a major issue that need to strengthened by knowledge management through training and capacity building programmes. The dissemination of quality research on climate change through projects at ULBs and major gram panchayats and research and analysis on combating climate change with the help of local organisations, NGOs, SHGs, RWAs etc. are required.

Studies need to be carried out both in urban and rural areas to adapt to and mitigate the impacts of climate change. In rural areas pilot projects on energy efficiency by embarking on locally suitable renewable energy technologies, integrated farming, water resource management, rural development and waste management can be started with the help of Panchayat Raj Department. The Urban Local Bodies need to focus on projects to achieve the overall reduction in conventional energy consumption by promoting renewable energy technologies in street lighting, lighting in public places, water heating, zero waste management, integrated water resource management, green cover and city climate protection campaign. Pilot studies in these areas can focus on baseline survey, identification of technologies, preparation of project implementation plan, stakeholder specific capacity building programmes and monitoring and evaluation.

The Environment Protection Training and Research Institute (EPTRI) is being a renowned organisation of the State and notified Nodal Agency for Clean Development Mechanism (CDM) and center for Climate Change in Andhra Pradesh. It has a large complement of scientists and engineers. It is proposed to establish a Climate Change Knowledge Centre at EPTRI. The institute is presently working in a number of environmental research consultancy and training projects, and is uniquely placed to host the Climate Change Knowledge Center not only in A.P., but for the Southern zone or even nationally.

6.11.2 Key sectoral issues and concerns

- Higher vulnerability of the State towards climate change, inter alia due to second largest coastline among Indian States
- The river basins and coastal areas are prone to climate change impacts due to changing precipitation and temperature patterns

[78] Census 2011

- The major industrial hubs are prone to climate change impacts
- The majority of rural and urban population is not aware about the climate change issues, impacts and consequences to their lives
- Need for a Climate Change Knowledge Centre

6.11.3 Interventions and Strategies

- Setting up of Climate Change Knowledge Center at EPTRI
- Agro-climatic vulnerability studies in major river basins of the State
- Climatic and socio-economic vulnerability studies in major industrial hubs
- Climatic baseline studies in ULBs and municipal corporations
- Demonstration projects at ULBs and major Gram Panchayats

7. BUDGET FOR INTERVENTIONS

The majority of the interventions that would increase the 'adaptive capacity' to climate change, are neither new nor novel. These interventions have formed significant parts of the programmes of State Departments of Agriculture, Rural Development, Urban Development, Forests, Disaster Management etc. for years if not for decades. However, these interventions have always been viewed more from the social and economic impact on communities and classes of people, rather than the adaptation to climate change.

These interventions now need to be seen as contributors to the adaptation to climate change, in addition to their social and economic impacts. It is possible that the change of view would cause some modifications to the designs of the various programmes and more importantly, require faster or more intense implementation, to be of use for adaptation.

The Departments concerned of the Government of Andhra Pradesh had been requested to assess the budgetary requirements for the identified interventions, including those interventions that are in the nature of mitigation. The Forest Department has conveyed its budgetary requirements, and those are shown in Table-20. Agriculture Department has been able to assess its requirements partly, but excluding the allied sectors which is given in Table-17. Energy Department has also furnished their budgetary requirements which are given in Table - 21. Other Departments are yet to assess and convey their budgetary requirements. The likely causes of their inability to assess the budgetary requirements might be related to:

- Inadequate information on likely allocations in XII Five Year Plan, as the budgeting process is on.
- Inability to assess the additional resources required to enhance the content or compress in time, the ongoing interventions.
- Lack of expertise in translating macro targets into budgetary requirements.
- Lack of baseline data, or difficulty in accessing such data in usable form.
- Lack of any basis or unit costs for new interventions.

Insufficient information or usably organised information, and lack of expertise in this new and emerging scientific-technical area are evidently constraints on planning. It is foreseen that a substantial amount of research and documentation would be needed. A total requirement of Rs. 12.38 crore and 92.40 crore is made (plan period 2012-2017) in Table-29 and Table-30 for setting up of Climate Change Knowledge Center and

research related to climate change respectively for climate change impacts, adaptation strategies and mitigation measures.

Table- 17 : Budget estimates for Agriculture Department

Sl. No	Name of Interventions	Estimate for 2012 - 2017 (Rs.Crore)	Estimate for 2017 - 2022 (Rs.Crore)
1	Development and dissemination of new crop varieties resilient to heat, photo and water stress	30.00	45.00
2	Replacement of inorganic fertilizers by bio-fertilizers	11.905	16.575
3	Reducing the use of synthetic pesticides and weedicides, and promoting the use of bio-pesticides	21.40	31.90
4	Assured credit facility, including for tenant farmers	289380	347256
5	Insurance against crop failures (not just for the bank loan component)	2000	2500
6	Intensive research work on stable agriculture in the context of climate change, in all its aspects	50.00	75.00
7	Extension work for change of cropping timings and patterns, efficiency of water use, weather advisories to farmers, information on market prices etc.	75.00	145.00
8	Establishment of field centres, data banks and germplasm banks	20.0	30.0
9	Improved animal fields and digesters		
10	Increase the efficiency of water use by micro-water shed development, catchment area systems and water management practices		
11	Soil health improvement and Integrated Nutrient Management (INM)	20.00	30.00
12	Reuse of domestic wastewater for horticulture crops and crops with minimum risk of contamination		
13	Retrofitting existing pump sets for higher energy efficiency		
	Grand Total	**291628.3**	**350129.5**

Table- 18 : Budget estimates for Irrigation and CAD Department

S.No	Interventions	Estimate for 2012 - 2017 (Rs.Crore)	Estimate for 2017 - 2022 (Rs.Crore)
1	Full utilisation of the sustainable surface water irrigation potential, to stabilise agricultural production		
2	Utilisation of the sustainable groundwater potential, to stabilise agricultural production		
3	Minor irrigation works and other engineering solutions to recharge groundwater aquifers		
4	Monitoring and early warning of river flows, to minimise flood damage		
5	Strict regulation of ground water abstraction	Policy / Enforcement	
6	Treatment and recovery of wastewater (agricultural, municipal and industrial) for reuse		
7	Recovery of minerals and phosphates, nitrates etc. from wastewater		
8	Inter-state coordination of river management agencies to manage flood flows		
	Grand Total		

Table- 19 : Budget estimates for Revenue (Disaster Management) Department

Sl. No	Interventions	Estimate for 2012 - 2017 (Rs.Crore)	Estimate for 2017 - 2022 (Rs.Crore)
1	Provision of cyclone shelters and all-weather connectivity to all vulnerable habitations along the coast		
2	Establishment of a Disaster Rapid Response Force, with equipment, communication systems etc.		

Sl. No	Interventions	Estimate for 2012 - 2017 (Rs.Crore)	Estimate for 2017 - 2022 (Rs.Crore)
3	Systems for dissemination of cyclone and tsunami warnings		
4	Early flood warning system, including communication		
5	Protection works on rivers and seacoasts, such as flood banks, groynes, dykes etc.		
6	Strengthen disaster mitigation policies/manuals/drills for State and districts	Policy / Enforcement	
	Grand Total		

Table- 20 : Budget estimates for Forest Department

S.No	Interventions	Estimate for 2012 - 2017 (Rs. Crore)	Estimate for 2017 - 2022 (Rs. Crore)
1	Protection and Conservation of forests, including fire protection	27.45	32.94
2	Soil and Water Conservation in forest lands	40.00	48.00
3	Restoration of Mangroves	15.00	18.00
4	Afforestation / Eco-Development through JFM	534.00	640.80
5	Creation of forests in degraded/public lands, including such lands in and around cities and towns, Plantation for commercial utilisation to reduce pressure on natural forests, Shelter belt plantation in coastal regions to reduce damage from cyclone	65.70	78.84
6	Documentation of biodiversity, including genetic fingerprinting		
7	Public awareness programmes on conservation of forests and biodiversity	35.25	42.30
8	Preservation of rare/threatened germplasm(eg. Under cryogenic other or controlled conditions)	210.00	252.00
	Grand Total	**927.4**	**1112.88**

Table- 21 : Budget estimates for Energy Department

Sl. No.	Interventions	Estimate for 2012 - 2017 (Rs.Crore)	Estimate for 2017 - 2022 (Rs.Crore)
1	Improve the efficiency of thermal power generation	Pertains to AP Genco	
2	Improve the efficiency of transmission, including elimination of pilferage	10700	10900
3	Improve the efficiency of electrical equipment, including water pumping equipment used in agriculture	16130	18000
4	Promotion of affordable alternative energy sources i.e. solar home systems, solar street lights, solar thermal systems	Pertains to NREDCAP	
5	Rationalisation of power tariff for sectors that are currently subsidised		
6	Decentralised rural electrification using woody or agricultural residue	Pertains to NREDCAP	
7	Electricity generation using Non- conventional sources like agricultural residues, municipal solid waste, flows in irrigational canals, Tide, wind and solar	Pertains to NREDCAP	
	Grand Total	**26830**	**28900**

Table- 22 : Budget estimates for Industries Department

Sl. No.	Interventions	Estimate for 2012 - 2017 (Rs.Crore)	Estimate for 2017 - 2022 (Rs.Crore)
1	Enforce 'cleaner production processes' and waste minimisation across industries, in partnership with the Central and State Pollution Control Boards		
2	Assess the vulnerability of major industrial hubs to climate related risks		
3	Minimise environmental damage including GHG emissions, caused by industrial and mining activities.	Policy / Enforcement	
4	Promote diversified and dispersed industries, including small/medium scale agro processing, to stabilise agricultural livelihoods		
	Grand Total		

Table- 23 : Budget estimates for Transportation Department

Sl. No.	Interventions	Estimate for 2012 - 2017 (Rs.Crore)	Estimate for 2017 - 2022 (Rs.Crore)
1	Enhance the share of public transport in the total transportation mix		
2	Enhance the share of low emission/fuel-efficient vehicles and vehicles that run on alternate fuels	Policy / Enforcement	
3	Design or redesign road networks so as to facilitate smooth traffic movement		
4	Interlinking of private and public transport modes so as to minimise the use of private transport		
	Grand Total		

Table- 24 : Budget estimates for Health, Medical & Family Welfare Department

Sl. No.	Interventions	Estimate for 2012 - 2017 (Rs.Crore)	Estimate for 2017 - 2022 (Rs.Crore)
1	Undertake longer-term studies to investigate links between climate change and disease patterns, as also between pollution loads and disease patterns		
2	Research on development of low cost vaccines, particularly those related tovector borne diseases		
3	Public education on prevention of diseases related to climate change and resulting from environmental pollution		
4	Strengthen detection and early warning systems for outbreaks of diseases		
5	Health Surveillance		
6	Development of rapid response capabilities to handle the impacts of climate related floods, cyclones and prolonged droughts		
	Grand Total		

Table- 25 : Budget estimates for Municipal Administration & Urban Development

Sl. No.	Interventions	Estimate for 2012 - 2017 (Rs.Crore)	Estimate for 2017 - 2022 (Rs.Crore)
1	Safe water supply as per norms to the entire Urban population		
2	100% coverage of sewerage and sanitation for the urban population		
3	Study and remodel existing water supply, sanitation and sewerage systems to reduce climate change vulnerability		
4	Protection & restoration of existing water bodies in urban areas.		
5	Scientific management of municipal solid waste in all municipalities and corporations		
6	Restoring efficiency the drainage network of all municipalities to enable quick evacuation of water and to avoid flooding		
7	Mandatory rainwater harvesting in Government buildings, commercial establishments, offices, schools /colleges, academic/research establishments and industrial units	Policy / Enforcement	
8	Policy and incentives for rooftop solar power generation and provision of grid connectivity	Policy / Enforcement	
9	Rail based MRTS in emerging cities and expansion of existing MRTS		
10	Provision for safe footpaths, cycle tracks etc to promote non-motorised transport		
11	Recovery of phosphates nitrates etc., from waste water		
12	Enforce the laws on management of municipal solid waste and plastic waste		
	Grand Total		

Table- 26 : Budget estimates for Tourism Department

Sl. No.	Interventions	Estimate for 2012 - 2017 (Rs.Crore)	Estimate for 2017 - 2022 (Rs.Crore)
1	Promote low emission/fuel-efficient mass transportation, to and within tourist areas (e.g. battery operated vans operating around the Taj Mahal)	Policy / Enforcement	

Sl. No.	Interventions	Estimate for 2012 - 2017 (Rs.Crore)	Estimate for 2017 - 2022 (Rs.Crore)
2	Promote energy efficiency lighting, climate control equipment etc. in hotels and other areas where tourists congregate	Policy / Enforcement	
3	Promote eco-tourism to enhance environmental consciousness		
4	Enforce cleanliness in tourist areas	Policy / Enforcement	
5	Protect both built and natural heritage against climate related damage (e.g. damage from high temperature, water accumulation, pests etc.)		
	Grand Total		

Table- 27 : Budget estimates for Panchayati Raj Department

Sl. No.	Interventions	Estimate for 2012 - 2017 (Rs.Crore)	Estimate for 2017 - 2022 (Rs.Crore)
1	Safe water supply as per norms to the entire rural population		
2	Sewerage and sanitation		
3	Study on the climate change vulnerability of existing water supply and sewerage/sanitation systems		
4	Remodel or strengthen existing water supply and sanitation/sewerage systems to reduce vulnerability to climate change		
5	Creation of new water bodies (lakes, tanks, kuntas etc.) and restoration of existing dilapidated water bodies		
6	Water shed development , catchment area system and water management systems		
7	Micro credit facility for promoting livelihood		
8	Increasing energy efficiency in street lighting and water pumping by Panchayats		
9	Public education on climate change and its effect on various sectors		
	Grand Total		

Table - 28 : Budget estimates for Andhra Pradesh Pollution Control Board

Sl. No.	Interventions	Estimate for 2012 - 2017 (Rs.Crore)	Estimate for 2017 - 2022 (Rs.Crore)
1	Monitor emissions, including GHGs		
	Monitor effluents		
2	Enforce cleaner production techniques and penalise 'dirty production'		
3	Enforce energy audit in industries generally (or selected industries or classes of industries	Policy / Enforcement	
	Grand Total		

Table- 29 : Setting up of Climate Change Knowledge Centre at EPTRI

Sl. No.	Interventions	Estimate for 2012 - 2017 (Rs. Crore)	Estimate for 2017 - 2022 (Rs. Crore)
1	Setting up of Climate Change Knowledge Center at EPTRI	12.38	13.87
	Grand Total	**12.38**	**13.87**

Table- 30 : Research Studies in Climate Change

Sl. No.	Interventions	Estimate for 2012 - 2017 (Rs.Crore)	Estimate for 2017 - 2022 (Rs.Crore)
1	Agro-climatic vulnerability studies in three major river basins of the State	19.00	21.28
2	Climatic and socio-economic vulnerability studies in major industrial hubs	25.00	28.00
3	Climatic baseline studies in 167 ULBs including 17 municipal corporations	18.40	20.61
4	100 demonstration projects at ULBs and major Gram Panchayat levels	30.00	33.60
	Grand Total	**92.40**	**103.49**

8. MONITORING AND EVALUATION

8.1 Background

Monitoring and Evaluation (M&E) is the key for measuring the effectiveness of implementation of the State Action Plan on Climate Change. Apart from measuring the degree of success of the key interventions, M&E would enable appropriate short-term and mid-term changes to the identified adaptation and mitigation strategies, correcting past mistakes and improving practices. Corrective actions might be required, for example, in the event of:

i) Impacts being more or less severe than anticipated.
ii) Key targets not being attained in time.
iii) Planned interventions not having the desired effect.

In the context of Andhra Pradesh, the aspects that would require monitoring and evaluation would be in terms of:

- State developmental goals vis-à-vis their integration of climate concerns in planning for achieving these goals.
- Sectoral level climate policies, programmes and actions.
- Interventions undertaken to achieve the objectives of the SAPCC.

8.2 Development objectives

It is important to monitor and evaluate the policies governing the State developmental goals, as many of them are likely to be affected by climate change. For example, the goal of reducing poverty may be affected by variability of rain fall, increase in ambient temperature, increase in extreme events etc. that reduce agriculture production, increase spread of diseases, deplete forest products etc., leading to loss of livelihoods. Therefore, devising climate sensitive policies for each of the developmental sectors is a necessity. It is equally important that monitoring and evaluation of the implementation of the policies is put in place to record the achievements, as well as to take corrective action.

8.3 Sectoral / Departmental level

The Andhra Pradesh SPACC has identified a set of ‘Interventions’ aimed primarily at enhancing the ‘Adoptive Capacity’ of vulnerable areas and populations. Some of the interventions are also in the nature of mitigation efforts at the level of production units, cities/towns and villages. The proposed interventions, which have been concurred to (at

this stage of development) by the Government Departments concerned, follow the National Missions that form part of the National Action Plan on Climate Change (NAPCC).

The sectoral interventions have been organised according to the implementing Departments, to be consistent with the division of responsibilities within the State Government. While each of these interventions would need to be monitored by an array of monitoring tools, both financial and physical, only one or two key 'Monitoring Indicators,' in the nature of output or outcome, have been selected and listed for each of the interventions, in the SAPCC. A monitoring frequency appropriate to each of the monitoring indicators, insofar as the SAPCC is concerned, has also been suggested. The indicators and monitoring frequencies are shown as a 'Monitoring Matrix' against the interventions and related 'key issues'. To the extent possible, the 'Monitoring Indicators' are selected from those that are routinely monitored by the Department concerned, to integrate better with Departmental systems, and at lower cost.

There is at present no State level agency charged with the responsibility of measuring GHG emissions, preparing an inventory of GHGs emitted, and enforcing mitigation measures. Among existing agencies, the State Pollution Control Board would be the obvious choice, and a few suggested interventions in the hands of the APPCB are also presented in the 'Monitoring Matrix' that follows.

Exhibit - 36: A Flow Diagram of Monitoring and Evaluation of SAPCC

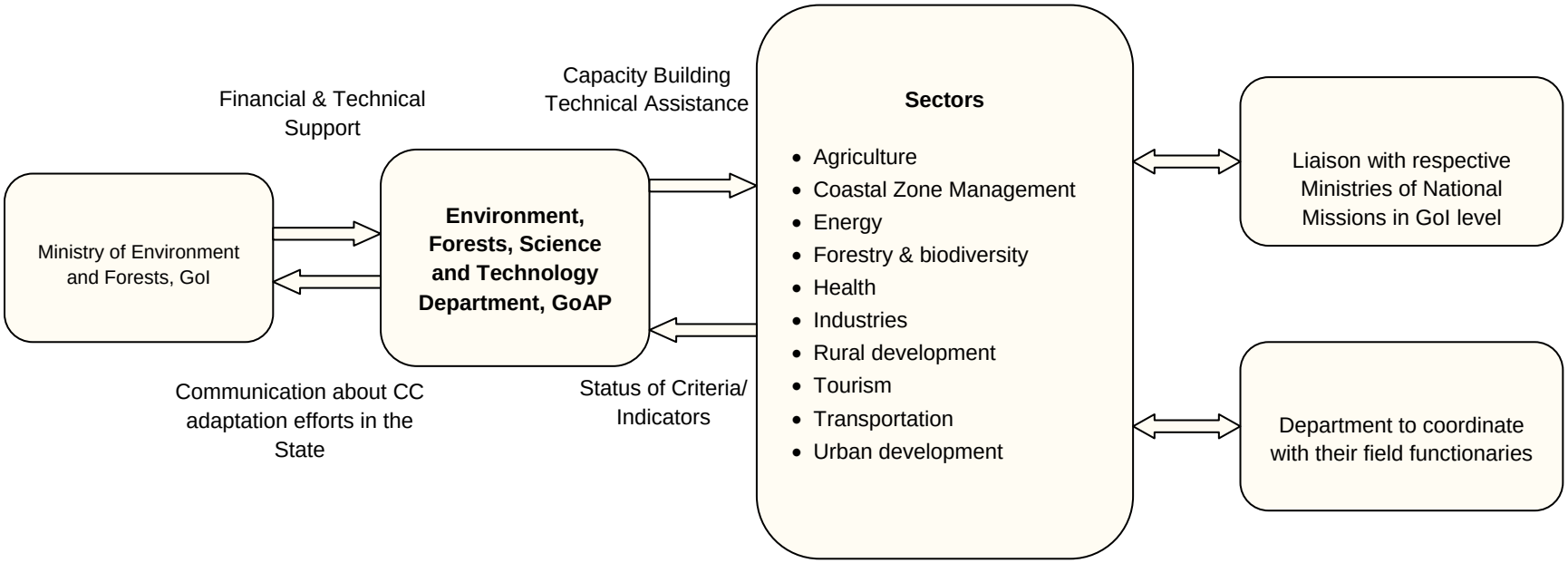


Table- 31 : Monitoring of Interventions related to the Andhra Pradesh Action Plan on Climate Change

Sl. No.	Intervention	Related Key Issue(s)	Monitoring Indicator(s)	Monitoring Frequency (months)
	Rural Development (Panchayat Raj Engineering Department)			
1	Safe Water Supply as per norms to the entire rural population (projected population of 2022)	Enhancement of adaptive capacity (adequacy of water supply and quality of water, public health)	Per capita water supply (litres per day) available to the current population	As of every financial year end (12)
			Percentage of water supply conforming to standards (percentage of conforming samples, number of samples required to be defined based on population)	Over each financial year (12)
2	100% coverage of sewerage and sanitation for the rural population (projected as of 2022)	Enhancement of adaptive capacity (safe sanitation, scientific disposal of liquid waste, public health)	Percentage of current population having access to sewerage and sanitation	As of every financial year end (12)
			Percentage of estimated liquid waste captured and treated	Over each financial year (12)
3	Study the climate change vulnerability of existing water supply and sewerage/sanitation systems	Documenting the impact of climate change on basic municipal services	Disruptions or shortfalls in services as compared to the potential	Review every financial year end (12)
				Research and studies (occasional)

Sl. No.	Intervention	Related Key Issue(s)	Monitoring Indicator(s)	Monitoring Frequency (months)
4	Remodel or strengthen existing water supply and sanitation/sewerage systems to reduce vulnerability to climate change	Enhancement of adaptive capacity (securing basic municipal services)	Work done during the year in comparison to identified need for remodelling or strengthening of systems	Review at end of every financial year (12)
5	All-weather road connectivity to all habitations (projected as of 2022) for access to goods and services, and for evacuation in emergency	Enhancement of adaptive capacity (road density)	Percentage of current population having access to all-weather road connectivity	As of every financial year end (12)
	Creation of new water bodies (lakes, tanks, kuntas etc.) and restoration of existing water bodies	Enhancement of adaptive capacity (stabilization of agriculture by enhancing potential for surface water storage and ground water recharge)	Thousand acre-feet or thousand hectare-metre storage capacity added in the financial year	As of every financial year end (12)
6	Increasing energy efficiency in street lighting and water pumping by Panchayats	Mitigation effort	Energy annually consumed by the Panchayat on public services per thousand population	Over each financial year (12)
	Panchayat Raj Department			
1	Increasing energy efficiency in street lighting and water pumping by Panchayats	-do-	-do-	-do-

Sl. No.	Intervention	Related Key Issue(s)	Monitoring Indicator(s)	Monitoring Frequency (months)
2.	Introduce spatial planning in rural areas to reduce and streamline vehicular movements	Mitigation effort	Percentage of current area of each panchayat covered by master plan	End of each Plan period (60)
3.	Public education on climate change and its effect on various sectors	Enhancement of adaptive capacity (dissemination of knowledge and behavioural change)	Number of person – hours of instruction	Over each financial year (12)
	Municipal Administration & Urban Development Department			
1.	Safe water supply as per norms to the entire urban population (projected population of 2022)	Enhancement of adaptive capacity (adequacy of water supply and quality of water, public health)	Per capita water supply (litres per day) available to the current population	As of every financial year end (12)
			Percentage of water supply conforming to standards (percentage of conforming samples, number of samples required to be defined based on population)	Over each financial year (12)
2.	100% coverage of sewerage and sanitation for the urban population (projected as of 2022)	Enhancement of adaptive capacity (safe sanitation, scientific disposal of liquid waste, public health)	Percentage of current population having access to sewerage and sanitation	As of every financial year end (12)
			Percentage of estimated liquid waste captured and treated	Over each financial year (12)

Sl. No.	Intervention	Related Key Issue(s)	Monitoring Indicator(s)	Monitoring Frequency (months)
3.	Study and remodel existing water supply, sanitation and sewerage systems to reduce climate change vulnerability	Documenting and adapting to the impact of climate change on basic municipal services	Reduction of disruptions or shortfalls in services as compared to the potential	Review every financial year end (12)
				Research and studies (occasional)
4.	Protection and restoration of existing water bodies in urban areas	Enhancement of adaptive capacity (enhanced potential for surface water storage and ground water recharge)	Volumetric storage capacity restored (from disuse or dilapidation) or recovered (from encroachments) etc.	As of every financial year end (12)
5.	Creation of new water bodies in urban areas		Volumetric storage capacity newly created during the year	As of every financial year end (12)
6.	Scientific management of municipal solid waste (MSW) and plastic waste in all municipalities and corporations (population and number of municipalities projected as of 2022)	Enhancement of adaptive capacity (safe disposal of MSW/PW, public health)	Tonnage of MSW / PW collected and treated compared to tonnage generated in the ULB	Over each financial year (12)
		Mitigation effort through capture of CH_4	Population covered by the system and its percentage to the total of the ULB	

Sl. No.	Intervention	Related Key Issue(s)	Monitoring Indicator(s)	Monitoring Frequency (months)
7.	Restore to efficiency the drainage network of municipalities and corporations to enable quick evacuation of water and to avoid flooding	Enhancement of adaptive capacity (reduced potential for flood damage in the cities and towns)	Volumetric improvement in the carrying capacity of the drains of the city or town	End of each Plan period (60)
			Critical review of episodes of flooding over the review period	Research and studies (occasional)
8.	Mandatory rainwater harvesting in Government buildings, larger homes and apartment blocks, commercial establishments, offices, schools/colleges, academic/research establishments, industrial units and homes or clusters of homes	Enhancement of adaptive capacity (increased ground water recharge and reduced runoff)	Capacity created (this information can be captured and compiled from an appropriate query in the application for the 'Occupancy Certificate' for the building	End of each Plan period (60)
9.	Policy and incentives for rooftop solar power generation and provision of grid connectivity	Mitigation effort (low carbon generation of electricity)	Generation capacity (MW) created and linked to the grid	End of each Plan period (60)
10.	Rail based MRTS in emerging cities and expansion of existing MRTS	Mitigation effort (low carbon transportation)	Transportation system created (km or population served)	End of each Plan period (60)
			Utilisation in terms of passenger-km or revenue earned	

Sl. No.	Intervention	Related Key Issue(s)	Monitoring Indicator(s)	Monitoring Frequency (months)
11.	Provision of safe footpaths, cycle tracks etc. to promote non-motorised transport	Mitigation effort (promoting low carbon modes of transportation)	Kilometre of dedicated non-motorised vehicle tracks created or restored	End of each Plan period (60)
12.	Recovery of phosphates, nitrates etc. from wastewater (by either chemical or biological process)	Adaptation action (reduced downstream need for freshwater, recovery of useful chemicals)	Quantities of phosphates, nitrates, nitrites etc. recovered	End of each Plan period (60)
		Mitigation effort through reduced NO_x emissions		
	Forest Department			
1.	Protection and Conservation of forests, including fire protection	Adaptation (source of food, fuel and fodder, preservation of local climate and biodiversity, protection against extreme climatic events)	Extent and density of forests	Biennial as per existing practice (24)
		Mitigation (carbon sink)		

Sl. No.	Intervention	Related Key Issue(s)	Monitoring Indicator(s)	Monitoring Frequency (months)
2.	Soil and Water Conservation in forest lands	Adaptation (increased ground water recharge and reduced runoff for stabilisation of green cover)	Increase in ground and surface water levels and changes in extent and density of vegetative cover	Biennial as per existing practice (24)
3.	Restoration of mangroves	Adaptation (protection against marine-origin disasters, preservation of fishing areas and biodiversity) Mitigation (carbon sink)	Extent and density of mangroves	Biennial as per existing practice (24)
4.	Afforestation and eco-development through community based programmes (like Joint Forest Management) in forest lands	Adaptation (source of food, fuel and fodder, preservation of local climate and biodiversity, protection against extreme climatic events like drought, cyclones, storms, heavy rainfall)	Extent and density of forest and tree cover	Biennial (24)
5.	Creation of forests in degraded/public lands, including such lands in and around cities and towns			Biennial as per existing practice (24)
6.	Plantations for sustainable commercial utilisation to reduce pressure on natural forests	Mitigation (carbon sinks)	Production	Over each financial year (12)

Sl. No.	Intervention	Related Key Issue(s)	Monitoring Indicator(s)	Monitoring Frequency (months)
7.	Shelter belt plantation in coastal regions to reduce cyclone impact		Extent and density of shelterbelts	Biennial (24)
8.	Public awareness programmes on conservation of forests and biodiversity	Increase in adaptive capacity (dissemination of knowledge)	Number of participants/programs/frequency	Biennial (24)
9.	Documentation of biodiversity, including genetic fingerprinting	Documentation and adaptation to the impact of climate change	Diversity indices	End of each Plan period (60)
10.	Preservation of rare/threatened germplasm (e.g. under cryogenic or other controlled conditions)		Number of samples/species	End of each Plan period (60)
	Revenue (Disaster Management) Department			
1.	Provision of cyclone shelters and all-weather connectivity to all vulnerable habitations along the coast	Enhancement of adaptive capacity (disaster prevention, preparedness and management of impact)	Percentage of identified coastal vulnerable population covered	As of every financial year end (12)
2.	Establishment of a Disaster Rapid Response Force, with rapid deployment capability, equipment, communication systems etc.		Number of units deployed and equipped vis-à-vis the assessed need	As of every financial year end (12)
			Test runs (disclosed or surprise)	Periodically as decided by the management

Sl. No.	Intervention	Related Key Issue(s)	Monitoring Indicator(s)	Monitoring Frequency (months)
3.	Systems for dissemination of cyclone and tsunami warnings		Extent to which system deployed and functional, vis-à-vis the plan	As of every financial year end (12)
			Test runs (disclosed or surprise)	Periodically as decided by the management
4.	Early flood warning system, including communication		Extent to which system deployed and functional, vis-à-vis the plan	As of every financial year end (12)
			Test runs (disclosed or surprise)	Periodically as decided by the management
5.	Protection works on rivers and seacoasts, such as flood banks, groynes, dykes etc.		Works done in the financial year, vis-à-vis the annual plan	Over each financial year (12)
6.	Strengthen disaster mitigation policies/manuals/drills for State and districts		Completion of initial drafting and issue, periodical reviews thereafter	Initial issue
				Revision/review as decided (3-5 years)
	Agriculture & Cooperation Department			
1.	Development and dissemination of new crop varieties resilient to heat, photo and water stress	Enhancement of adaptive capacity (research and dissemination for agricultural security)	Varieties developed, results of field trials, acreage planted, consumer acceptance	End of each Plan period (60)
				Evaluation studies (occasional)

Sl. No.	Intervention	Related Key Issue(s)	Monitoring Indicator(s)	Monitoring Frequency (months)
2.	Replacement of inorganic fertilisers by bio-fertilisers (including urban compost and recovered PO_4, NO_3 etc.)	Enhancement of adaptive capacity (research and dissemination for agricultural security)	Bio-fertilisers and bio-weedicides/pesticides developed, results of trials, sales, consumer acceptance,	End of each Plan period (60)
3.	Reducing the use of synthetic pesticides and weedicides, and promoting the use of bio-pesticides	Mitigation effort by reducing NO_X emissions		Evaluation studies (occasional)
4.	Assured credit facility, including for tenant farmers	Enhancement of adaptive capacity (stabilisation of agriculture for agricultural security)	Indicators exist for measuring the disbursement and utilisation of agricultural credit	Over each financial year (12)
5.	Insurance against crop failures (not just for the bank loan component)	Enhancement of adaptive capacity (stabilisation of agriculture for agricultural security)	Indicators exist for measuring the coverage, efficacy, efficiency and client-friendliness of insurance	Over each financial year (12)
6.	Increase the efficiency of water use	Enhancement of adaptive capacity (research and dissemination for agricultural security)	Water used per unit crop produced (for various crops)	Over each agricultural year (12)
7.	Extension work for change of cropping timings and patterns, efficiency of water use, weather advisories to farmers, information on market prices etc.		Indicators exist for measuring the performance of agricultural extension staff and results achieved.	Over each financial year (12)

Sl. No.	Intervention	Related Key Issue(s)	Monitoring Indicator(s)	Monitoring Frequency (months)
8.	Intensive research work on stable agriculture in the context of climate change, in all its aspects	Enhancement of adaptive capacity (research and dissemination for agricultural security)	*This is a new area of work in the State. Suitable indicators have to be developed.*	*To be decided*
9.	Establishment of field centres, data banks and germplasm banks	Enhancement of adaptive capacity (protection of biodiversity related to agriculture)	*This is a new area of work in the State. Suitable indicators have to be developed.*	*To be decided*
10.	Use of fuel or energy efficient irrigation pump sets and other agricultural equipment	Mitigation effort (reduced CO_2 emissions)	Number of efficient pumpsets or efficient agro-equipment sold (can also be compared to an annual target)	Over each financial year (12)
11.	Retrofitting existing pump sets for higher energy efficiency		Number of pumps retrofitted (can be compared to an annual target)	
	Transport Department			
1.	Enhance the share of public transport in the total transportation mix	Mitigation effort (reduced CO_2 emissions)	Share of public transport in total passenger-kilometre travelled	End of each Plan period (60)
2.	Enhance the share of low emission/fuel-efficient vehicles and vehicles that run on alternate fuels	Requires major policy decisions, investments and public-private partnerships	Number of low-emission vehicles in the total (from vehicle registration data)	As of every financial year end (12)

Sl. No.	Intervention	Related Key Issue(s)	Monitoring Indicator(s)	Monitoring Frequency (months)
3.	Encourage non-motorised transport like walking and cycling		Share of non-motorised transport in total passenger-kilometre travelled	End of each Plan period (60)
4.	Design or redesign road networks so as to facilitate smooth traffic movement and non-motorised transport	Also requires changes to spatial planning of cities	*Suitable indicators have to be developed*	End of each Plan period (60)
5.	Interlink private and public transport modes so as to minimise the use of private transport		Share of public transport in total passenger-kilometre travelled	End of each Plan period (60)
	Health, Medical and Family Welfare Department			
1.	Undertake longer-term studies to investigate links between climate change and disease patterns, as also between pollution loads and disease patterns	Enhancement of adaptive capacity (understanding and documenting the links between climate change and health)	Research papers published, policy inputs provided	End of each Plan period (60)
2.	Research on development of low cost vaccines, particularly those related to vector borne diseases	Enhancement of adaptive capacity (preventive public health measures)	Vaccines developed, tested and released for use in the public health system	End of each Plan period (60)
3.	Public education on prevention of diseases related to climate change and resulting from environmental pollution	Enhancement of adaptive capacity (preventive public health measures)	Indicators exist for measuring the efficacy of public health education	Over each financial year (12)

Sl. No.	Intervention	Related Key Issue(s)	Monitoring Indicator(s)	Monitoring Frequency (months)
4.	Strengthen detection and early warning systems for outbreaks of diseases	Enhancement of adaptive capacity (detection of threats to public health, warning and response)	Extent to which system deployed and functional, vis-à-vis the plan	As of every financial year end (12)
5.	Health Surveillance		Test runs (disclosed or surprise)	Periodically as decided by the management
6.	Development of rapid response capabilities to handle the impacts of climate related events such as exposure to sun, floods, cyclones and prolonged droughts		Extent to which system deployed and functional, vis-à-vis the plan	As of every financial year end (12)
			Test runs (disclosed or surprise)	Periodically as decided by the management
	Energy Department			
1.	Improve the efficiency of thermal power generation	Mitigation effort (reduced GHG emissions)	Indicators exist for measuring the efficiency of thermal power generation	As decided by the utility management or electricity regulatory authority
2.	Improve the efficiency of transmission, including elimination of pilferage	Mitigation effort (reduced GHG emissions)	Indicators exist for measuring the efficiency of transmission	As decided by the utility management or electricity regulatory authority

Sl. No.	Intervention	Related Key Issue(s)	Monitoring Indicator(s)	Monitoring Frequency (months)
3.	Improve the efficiency of electrical equipment, including water pumping equipment used in agriculture	Mitigation effort (reduced GHG emissions) by enforcing efficiency	Indicators exist for measuring the efficiency of electrical equipment, ratings also exist	As decided by the Government, or by the Bureau of Energy Efficiency
4.	Promotion of affordable alternative energy sources i.e. solar home systems, solar street lights, solar thermal systems	Mitigation effort (reducing GHG emissions)	Indicators exist under the renewable energy programme of the Government	As decided by the Government
5.	Rationalisation of power tariff for user segments that are currently subsidised	Mitigation effort (reducing GHG emissions) through efficiency	Policy decisions	Monitoring frequency cannot be set in advance
6.	Electricity generation using non-conventional sources like agricultural residues, municipal solid waste, flows in irrigation canals, tide, wind and solar	Mitigation effort (reducing GHG emissions by promoting renewable energy sources)	Indicators exist under the renewable energy programme of the Government	As decided by the Government
	Tourism Department			
1.	Promote low emission/fuel-efficient mass transportation, to and within tourist areas (e.g. battery operated vans operating around the Taj	Mitigation effort (reducing GHG emissions)	Vehicle trips replaced by energy-efficient transportation	End of each Plan period (60)

Sl. No.	Intervention	Related Key Issue(s)	Monitoring Indicator(s)	Monitoring Frequency (months)
	Mahal)			
2.	Promote energy efficient lighting, efficient climate control equipment etc. in hotels and other areas where tourists congregate	Mitigation effort (reducing GHG emissions)	Indicators exist for measuring the efficiency of electrical equipment, ratings also exist	As decided by the Government, or by the Bureau of Energy Efficiency
3.	Promote eco-tourism to enhance environmental consciousness	Enhancement of adaptive capacity (dissemination of knowledge and behavioural change)	*This would be a new area of work in the State. Suitable indicators have to be developed*	End of each Plan period (60)
4.	Enforce cleanliness in tourist areas	Mitigation effort + Adaptation (reduce GHG emissions, public health measure, reduce pollution)	Observations, customer feedback, site specific evaluation studies	Periodicity of evaluation to be decided by authorities concerned
5.	Protect both built and natural heritage against climate related damage (e.g. damage from high temperature, water accumulation, pests etc.)	Adaptation (reduce climate induced damage and restore damage already occurred)	Damage prevented, ascertained by site specific evaluation	Periodicity of evaluation to be decided by authorities concerned

Sl. No.	Intervention	Related Key Issue(s)	Monitoring Indicator(s)	Monitoring Frequency (months)
	Industries Department (both Mines and Industries)			
1.	Enforce 'cleaner production processes' and waste minimisation, including reduction of water consumption, across industries, in partnership with the Central and State Pollution Control Boards	Adaptation (reduction of waste and pollution) + Mitigation effort (to reduce GHG emissions)	Carbon intensity of State Domestic Product (in line with national policy)	End of each Plan period (60)
2.	Minimise environmental damage including GHG emissions, caused by industrial and mining activities		Number of industrial units adopted cleaner production / waste minimisation or value of production using such processes	End of each Plan period (60)
3.	Assess the vulnerability of major industrial hubs to climate related risks	Enhancement of adaptive capacity (reduce the threat from extreme climate events to industries, production capacity and infrastructure)	Monitoring against the targets and schedules set in the adaptation plan for industries	End of each Plan period (60)
4.	Protection and disaster mitigation works to minimise risks to industrial hubs (e.g. seawalls, alternate rail and road access, improving drainage, alternate water supply sources etc.)			

Sl. No.	Intervention	Related Key Issue(s)	Monitoring Indicator(s)	Monitoring Frequency (months)
5.	Promote diversified and dispersed industries, including small/medium scale agro processing, to stabilise rural livelihoods	Enhancement of adaptive capacity (dispersal of industry to reduce risk, stable livelihoods, value addition to agriculture)	Increments in (i) per capita GDP (ii) employment in organised sector (iii) other economic indicators in districts having low adaptive capacity	End of each Plan period (60)
	Irrigation & Command Area Development Department			
1.	Full utilisation of the sustainable surface water irrigation potential, to stabilise agricultural production	Enhancement of adaptive capacity (stabilisation of agriculture and agricultural livelihoods)	Indicators and mechanisms exist for monitoring the gross and net surface irrigation	As of every financial year end (12)
2.	Utilisation of the sustainable groundwater potential, to stabilise agricultural production		Indicators and mechanisms exist for monitoring the utilisation of groundwater and its sustainability	As of every financial year end (12)
3.	Strict regulation of ground water abstraction	Enhancement of adaptive capacity by ensuring the sustainability of groundwater use	Law, enforcement mechanism, indicators and monitoring mechanisms exist	As of every financial year end (12)
4.	Minor irrigation works and other engineering solutions to recharge groundwater aquifers	Enhancement of adaptive capacity (recharging groundwater aquifers and stabilising agriculture)	Indicators and mechanisms exist for monitoring the progress of works and impact on groundwater storage	As of every financial year end (12)
5.	Monitoring and early warning of river flows, to minimise flood damage	Adaptation action of preventive nature to reduce the risk to life and property	This is an ongoing work, and would be monitored against targets / objectives set in the plan	As of every financial year end (12)

Sl. No.	Intervention	Related Key Issue(s)	Monitoring Indicator(s)	Monitoring Frequency (months)
6.	Inter-State coordination of river management agencies to manage flood flows			As of every financial year end (12)
7.	Assured water supply to urban centres and industrial hubs	Enhancing adaptive capacity by assuring the supply of raw water	Indicators exist for monitoring the availability of raw water vis-à-vis demand	Over each financial year (12)
8.	Treatment and recovery of wastewater (agricultural, municipal and industrial) for reuse	Adaptation action by reducing the demand for fresh water	Quantum of wastewater reused	Over each financial year (12)
9.	Recovery of minerals and phosphates, nitrates etc. from wastewater	Adaptation action (reduced downstream need for freshwater, recovery of useful chemicals)	Quantities of phosphates, nitrates, nitrites etc. recovered	End of each Plan period (60)
		Mitigation effort through reduced NO_x emissions		

Sl. No.	Intervention	Related Key Issue(s)	Monitoring Indicator(s)	Monitoring Frequency (months)
	Andhra Pradesh Pollution Control Board			
1.	Monitor emissions, including GHGs	Detection, measurement and documentation of emissions and effluents; inventorisation of GHGs	Monitoring of emissions and effluents is an ongoing activity and well established indicators exist. Inventorisation of GHG emissions, if required by the Government, would be a new activity.	As per legal requirements or CPCB norms
2.	Monitor effluents			
3.	Enforce cleaner production techniques and penalise 'dirty production'	Adaptation (reduction of waste and pollution) + Mitigation effort (to reduce GHG emissions)	Carbon intensity of State Domestic Product (in line with national policy)	End of each Plan period (60)
			Number of industrial units adopted cleaner production / waste minimisation or value of production using such processes	
4.	Enforce the laws on management of municipal solid waste and plastic waste (the PCB is a statutory authority in this matter)	Enhancement of adaptive capacity (safe disposal of MSW/PW, public health)	Tonnage of MSW / PW collected and treated compared to tonnage generated in the ULB	Over each financial year end (12)
		Mitigation effort through capture of CH_4	Population covered by the system and its percentage to the total of the ULB	

Sl. No.	Intervention	Related Key Issue(s)	Monitoring Indicator(s)	Monitoring Frequency (months)
5	Enforce energy audit in industries generally (or selected industries or classes of industries)	Mitigation effort	Percentage of industries conducting the audit among those required to Energy saved as a result of action following from the audit	As per legal requirements or statutory norms