KARNATAKA STATE
ACTION PLAN ON CLIMATE CHANGE

1ST ASSESSMENT

FUNDED BY
DEPARTMENT OF ECOLOGY & ENVIRONMENT,
GOVERNMENT OF KARNATAKA

PREPARED BY
ENVIRONMENTAL MANAGEMENT & POLICY RESEARCH INSTITUTE
AND THE ENERGY AND RESOURCES INSTITUTE (TERI)

RESUBMITTED ON
DECEMBER 09, 2013

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Suggested citation: Environmental Management & Policy Research Institute (EMPRI) and The Energy and Resources Institute (TERI), (2012). Karnataka State Action Plan on Climate Change, 1st Assessment

FOREWORD

Intergovernmental Panel on Climate Change (IPCC), in its 2007 assessment report warned about significant changes of the climate world over which may have adverse impact on agrarian-dominated countries such as India. For South Asia and India, IPCC projects a rise in temperatures by 3.3°C by the end of the 21st century. Responding to this threat, the Prime Minister's Council on Climate Change released the National Action Plan on Climate Change (NAPCC) in June 2008. It envisaged eight national missions to elucidate a roadmap for India that fosters sustainable development with climate co-benefits.

The Ministry of Environment and Forests, Government of India requested the states to prepare corresponding State Action Plans on Climate Change. The present document provides Karnataka's first comprehensive assessment of sectors that could be significantly affected by climate change. Its preparation was informed by a thorough review of prior studies and extensive consultations with more than 25 government departments.

The Karnataka State Action Plan on Climate Change discusses climate trends, projected vulnerabilities, adaptation and mitigation priorities. It includes a review of policies and programmes for possible mainstreaming of climate change. The report covers the key sectors in detail, including agriculture, animal husbandry, water resources, biodiversity, forestry, the coastal zone, urbanisation and health. The document concludes with an action plan comprising of about 200 actions, 31 of which have been identified as priorities. Needless to mention, the Action Plan and priorities defined may undergo changes as new research input comes in and assumptions are firmed up. This would mean that the SAPCC remains a dynamic document requiring periodic updation.

In implementing this Action Plan the Government of Karnataka solicits broad support from the civil society, research organisations, NGOs and all other informed groups. In fact every citizen has to contribute in mitigating aspect and to face this challenge and convert adverse forms of the challenge into opportunities.

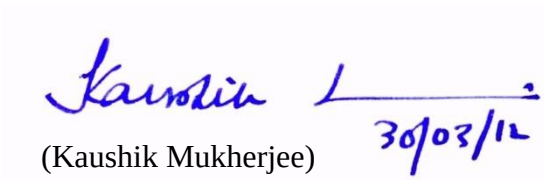
(S.V. Ranganath)
Chief Secretary,
Government of Karnataka

PREFACE

The Karnataka State Action Plan on Climate Change places before us a realistic assessment of climatic trends and projections. It investigates possible impacts on natural resources and livelihoods in our main areas of concern namely, agriculture, animal husbandry, fisheries, water resources, forests, biodiversity, wildlife, urbanisation, health, and energy and greenhouse gas emissions. It touches virtually every sphere of our life and pursuits in as much as we stand connected to our natural environment. Specific attention is given to the sensitive and fragile eco-zones of the Western Ghats, the coastal belt as well as to the semi-arid zone of north eastern Karnataka.

The document is structured around key sectors which are the responsibility of specific government departments. Each chapter outlines the sector's significance for the state, followed by an analysis of trends and an assessment of projections vis-à-vis possible impacts of climate change and emerging vulnerabilities. Likewise, actions of Government of Karnataka and its policies that have a bearing on the way climate change may impact the respective sector are reviewed, leading to an identification of areas where intervention is needed.

The "Action Plan" comprises a comprehensive action plan spanning all the sectors identified. It defines more than 200 action points necessary to enhance Karnataka's preparedness for climate change. Many of these would help enhance resilience in pursuing sustainable development while exploiting opportunities that could come with climate change. My heart-felt congratulations go out to the DG and the staff of the EMPRI for this excellent document.



(Kaushik Mukherjee)
Additional Chief Secretary,
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CONTENTS

TABLES

FIGURES

A

A1	→ Refer SRES A1 in this section
A1B	→ Refer SRES A1B in this section
A2	→ Refer SRES A2 in this section
AMDP	Accelerated Maize Development Programme
ANM	Auxiliary Nurse Midwife
ASHA	Accredited Social Health Activist
AT&C	Aggregate technical and commercial (losses)
ATF	Aviation turbine fuel
ATI	Administrative Training Institute, Mysore

B

B1	→ Refer SRES B1 in this section
B2	→ Refer SRES B2 in this section
BBMP	Bruhat Bengaluru Mahanagara Palike
BCCI-K	Bangalore Climate Change Initiative – Karnataka
BDA	Bangalore Development Authority
BEE	Bureau of Energy Efficiency
BESCOM	Bangalore Electricity Supply Company
BMRDA	Bangalore Metropolitan Region Development Authority
BMTC	Bangalore Metropolitan Transport Corporation
BMW	Biomedical waste
BOD	Biological oxygen demand
BORDA	Bremen Overseas Research & Development Association, Germany
BPL	Below (the) poverty line
BWSSB	Bangalore Water Supply and Sewerage Board

C

CAMPA	Compensatory Afforestation Fund Management and Policy Action
CBO	Community based organisation
CDM	Clean Development Mechanisms
CEA	Central Electricity Authority
CER	Carbon Emission Reductions
CESC	Chamundeshwari Electricity Supply Corporation Limited
CETP	Common effluent treatment plant
CFL	Compact fluorescent lamp
CGCM3	Coupled Global Climate Model version 3 (a model of the Canadian Centre for Climate Modelling and Analysis)
CGWB	Central Ground Water Board
CH_4	Methane
CHC	Community Health Centres

CiSTUP	Centre for infrastructure, Sustainable Transport and Urban Planning
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora (also known as the Washington Convention)
CMC	City Municipal Council
CNG	Compressed natural gas
CO_2	Carbon dioxide
CO_2-eq	Carbon dioxide-equivalent
CoP	Conference of Parties
crore	(unit in the South Asian numbering system. 1 crore = 10 million = 10,000,000)
CRZ	Coastal Regulation Zone
CSD	Centre for Sustainable Development, Bangalore
CSTEP	Centre for Study of Science, Technology and Policy

D

DEWATS	Decentralised wastewater treatments system
DG set	Diesel generator set
DMA	Directorate of Municipal Administration
DMC	Drought Monitoring Cell
DMS	Dimethyl sulphide
DSM	Demand side management
DULT	Directorate of Urban Land Transport

E

ECBC	Energy Conservation Building Code
EDC	Eco-Development Committee
EIA	Environmental impact assessment
EMPRI	Environmental Management & Policy Research Institute, Bangalore
EMRI	Emergency Management Research Institute, Secunderabad
ESCOM	Electricity supply company

F

FCI	Food Corporation of India
FRLHT	Foundation for the Revitalisation of Local Health Traditions
ft	Foot

G

GCM	Global circulation model
GEF	Global Environmental Facility
GESCOM	Gulbarga Electricity Supply Company
GHG	Greenhouse gas
GIS	Geographic information system
GKVK	Gandhi Krishi Vignana Kendra, Bangalore
GO	Government Order
GoI	Government of India
GoK	Government of Karnataka
GPRS	General packet radio service

GRIHA	Green Rating for Integrated Habitat Assessment
GSDP	Gross State Domestic Product
GWP	Global warming potential

H

ha	Hectare
HadCM3	Hadley Centre Coupled Model, version 3 (a coupled atmosphere-ocean general circulation model developed by the Hadley Centre of the Met Office, United Kingdom)
HadRM2	Hadley Centre Regional Model, version 2 (a high resolution atmospheric model developed by the Hadley Centre of the Met Office, United Kingdom)
HadRM3	Hadley Centre Regional Model, version 3 (a high resolution atmospheric model developed by the Hadley Centre of the Met Office, United Kingdom)
HAM	Hectare metre (1 HAM = 10,000 m^3)
HESCOM	Hubli Electricity Supply Company Limited
HFC	Hydrofluorocarbons
HIS	Hydrological Information System
HOPCOMS	Horticultural Producers' Co-operative Marketing and Processing Society Limited
HSD	High speed diesel
HYV	High yielding variety
HYVP	High Yielding Varieties Programme

I

ICAR	Indian Council of Agriculture Research
ICEF	India-Canada Environment Facility
IISc	Indian Institute of Science
IITM	Indian Institute of Tropical Meteorology, Pune
IMD	India Meteorological Department
INCCA	Indian Network for Climate Change Assessment
INM	Integrated Nutrient Management
INR	Indian Rupee
IP	Irrigation pump
IPCC	Intergovernmental Panel on Climate Change
IPCC IS92a	(One among the global energy scenarios of IPCC's Supplementary Report (1992): Business-as-usual in which policy fails to acknowledge the need to mitigate climate change)
IPM	Integrated Pest Management
IREDA	Indian Renewable Energy Development Agency
IS92a	→ Refer IPCC IS92a
ISEC	Institute for Social and Economic Change, Bangalore
ISI	Indian Standards Institution
ISOPOM	Integrated Scheme for Oilseeds, Pulses, Oil Palm and Maize
ISWM	Integrated Solid Waste Management
IT	Information Technology
ITES	Information Technology Enabled Services
IUCN	International Union for Conservation of Nature

J

JFM	Joint Forest Management
JFPM	Joint Forestry Planning & Management
JNNURM	Jawaharlal Nehru National Urban Renewal Mission

K

KASSIA	Karnataka Small-Scale Industries Association
KBB	Karnataka Biodiversity Board
KERC	Karnataka Electricity Regulation Commission
KFD	Karnataka Forest Department
KHB	Karnataka Housing Board
km	Kilometre
KPCL	Karnataka Power Corporation Limited
KREDL	Karnataka Renewable Energy Development Limited
KSBDB	Karnataka State Bio-fuel Development Board
KSNDMC	Karnataka State Natural Disaster Monitoring Centre
KSPCB	Karnataka State Pollution Control Board
KSWDC	Karnataka Sheep and Wool Development Corporation
KUIDFC	Karnataka Urban Infrastructure Development Finance Corporation
KUIDP	Karnataka Urban Infrastructure Development Project
kV	Kilovolt
kWh	Kilowatt hour

L

lakh	(unit in the South Asian numbering system. 1 lakh = 0.1 million = 100,000)
LCA	Life cycle assessment
LPCD	Litres per capita per day
LPG	Liquefied petroleum gas
LT	Low tension

M

MDGs	Millennium Development Goals
MESCOM	Mangalore Electricity Supply Company
MLD	Million litres per day
mn	Million
MNAIS	Modified National Agricultural Insurance Scheme
MNRE	Ministry of New and Renewable Energy
MoEF	Ministry of Environment and Forests
MSW	Municipal solid waste
MTEE	Market Transformation for Energy Efficiency

N

N-P-K	Nitrogen, phosphorus, and potassium (fertilisers)
N_2O	Nitrous oxide
NAC	Notified Area Council

NAIS	National Agricultural Insurance Scheme
NAPCC	National Action Plan on Climate Change
NATCOM	(India's) National Communication (to the United Nations Framework Convention on Climate Change)
NBC	National Building Code
NBCI	National Biomass Cookstoves Initiatives
NCEP	National Centres for Environmental Prediction
NDMA	National Disaster Management Authority
NEERI	National Environmental Engineering Research Institute
NFSM	National Food Security Mission
NGO	Non-government organisation
NHM	National Horticulture Mission
NIDM	National Institute of Disaster Management
NIPCC	Nongovernmental International Panel on Climate Change
NLCP	National Lake Conservation Programme
NPDP	National Pulses Development Project
NPP	Net primary productivity
NRCP	National River Conservation Programme
NREGA	National Rural Employment Guarantee Act
NRHM	National Rural Health Mission
NTFP	Non-timber forest products
NVBDCP	National Vector Borne Disease Control Programme

O

OPDP	Oil Palm Development Programme

P

PAT	Perform Achieve and Trade
PBR	People's Biodiversity Register
PFC	Perfluorocarbons
PHC	Primary Health Centre
PHED	Public Health Engineering Department
ppb	Parts per billion
ppm	Parts per million
PPP	Public-private partnership
PRECIS	Providing Regional Climate for Impact Studies (a regional climate model developed by the Hadley Centre of the Met Office, United Kingdom)
PSB	Phosphorus solubilising bacteria
PUC	Pollution Under Control
PV	Photovoltaic
PWD	Public Works Department

R

R-APDRP	Restructured Accelerated Power Development and Reform Programme
R&D	Research and development
RDPR	Department of Rural Development and Panchayat Raj
REC	Renewable Energy Certificates

RET	Rare, endemic or threatened
RGRHC	Rajiv Gandhi Rural Housing Corporation Limited
RKBY	Rashtriya Krishi Bima Yojana
RKVY	Raskhtriya Krishi Vikas Yojana
RPO	Renewable Purchase Obligations
RSPM	Respirable suspended particulate matter
RWA	Residents' Welfare Association
RWH	Rainwater harvesting

S

SAPCC	State Action Plan on Climate Change
SAR	Second Assessment Report (of IPCC published in 1995)
SC/ST	Scheduled Casts/Scheduled Tribes
SEZ	Special Economic Zone
SF_6	Sulphur hexafluoride
SHG	Self-help groups
SLEIAA	State Level Environmental Impact Assessment Authority
SME	Small and medium enterprises
SOP	Standard operating procedure
SPM	Suspended particulate matter
SPV	Special purpose vehicle
SRES	Special Report on Emission Scenarios (a reporting instrument for emission projections published by IPCC in 2000)
SRES A1	(Member of the family of greenhouse gas scenarios formulated by IPCC's Special Report on Emission Scenarios (2000). It stands for rapid economic growth in a globalising world)
SRES A1B	(Marker scenario based on the A1 greenhouse gas scenarios formulated by IPCC's Special Report on Emission Scenarios (2000). It stands for rapid economic growth in a globalising world and balanced (B) emphasis on all energy sources)
SRES A2	(Member of the family of greenhouse gas scenarios formulated by IPCC's Special Report on Emission Scenarios (2000). It stands for rapid regionally oriented economic development)
SRES B1	(Member of the family of greenhouse gas scenarios formulated by IPCC's Special Report on Emission Scenarios (2000). It stands for global environmental sustainability)
SRES B2	(Member of the family of greenhouse gas scenarios formulated by IPCC's Special Report on Emission Scenarios (2000). It stands for local environmental sustainability
SWAT	Soil and Water Assessment Tool

T

T&D	Transmission and distribution
TERI	The Energy and Resources Institute
TMC	Thousand million cubic feet (1 TMC = 28,316,847,000 m^3 = 28.3 million m^3)
TMC	Town Municipal Council
ToT	Training of trainers

U

UAS	University of Agricultural Sciences, Bangalore
UFW	Unaccounted-for water
UGD	Underground drainage
ULB	Urban local bodies
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change
UO	Unofficial
UPS	Uninterrupted power supply

V

V/C	Volume to capacity (a ratio)
VFC	Village Forest Committee

W

W	Watt
W_P	Watt peak
WBCIS	Weather Based Crop Insurance Scheme
WHO	World Health Organization
WISE	World Institute of Sustainable Energy
WRDO	Water Resources Development Organisation
WRIS	Water Resources Information System

EXECUTIVE SUMMARY

About this document

This document represents the first action plan on climate change adopted by Government of Karnataka. Assessments and conclusions presented are based on published research and data. The present knowledge on how climate change is anticipated to impact Karnataka is limited. This needs to be kept in clear view while reviewing conclusions drawn in this document. Certain climatic trends have been observed in Karnataka but neither has it been ascertained to what degree these result from anthropogenic activities and natural variability nor are they undisputed.

Climate and projections cited belong to the period 2004 to 2011. They rely on models that are based on our present ability to describe the complex interplay of climatic variables with our environment. An intrinsic weakness of these is that results tend to amplify observed climate variability, manmade or natural, over decades to come. Projections cited therefore are not authoritative but indicative of the range of possibilities to reckon with. It is not known where exactly, when and to what degree climatic changes may affect Karnataka. While projections cited are arguably worrisome it would be inappropriate to paint an alarmist picture at this juncture. Further rigorous studies, especially of longer-term nature need to be commissioned. Until further and more reliable projections are available, a rush into drastic actions appears impulsive.

Besides outlining further research, this document identifies scope for immediate actions. Around 200 actions have been defined and 31 of these are tagged as priorities or entry points. In all these cases the benefit is evident considering their contribution to sustainable development, unencumbered by uncertainties attached to climate change projections. For instance, it emerges with great clarity that an improvement of institutional preparedness is both desirable and necessary. Likewise, a further improvement of the performance of programmes currently implemented by Government of Karnataka would strengthen climate change preparedness. Even in the event of climatic changes unfolding at levels well below current predictions, enhanced implementation performance would strengthen the capacity of the state to manage key resources such as water, land, forestry and biodiversity sustainably.

Preparedness for changes of the climate cannot be achieved with a static plan. The planning process must stay informed of new findings and conclusions and assimilate their merit for furthering the objectives pursued with this document. The action plan therefore requires periodic and comprehensive revisions that assess and re-assess conclusions drawn in the light of our growing understanding, leading gradually to a more robust and dependable framework of assessments and actions.

Background

Climate change is considered the most serious global challenge of date. Changes in the atmosphere have been detected that could drastically alter the climate system and the balance of ecosystems. Atmospheric changes are linked to an increase in greenhouse gases (GHGs), chiefly on account of anthropogenic releases attributed to fossil fuel consumption, land use changes and deforestation, agriculture and animal husbandry. Research has established that carbon dioxide (CO_2) levels in the atmosphere have risen by

35% since the pre-industrial era. Rising CO_2 concentrations increase the energy retention of Earth's atmosphere, leading to a gradual rise of average temperatures and global warming.

Global warming is expected to severely impact ecosystems, precipitation and agriculture, rendering particularly agrarian economies vulnerable. For South Asia, a decrease in the fresh-water availability in river basins is projected for the 2050s while flooding risks and diarrhoeal diseases are expected to rise. As discussed in this document, these conclusions are not uncontested. Nevertheless, the evidence attributing climatic changes to human activities has considerable weight. This combined with the scale of projected changes warrant immediate action.

India responded to the challenge of climate change in 2008 with the National Action Plan on Climate Change (NAPCC). It sets out the pursuit of development goals that offer growth with long-term "climate change co-benefits". Through eight sectoral missions the NAPCC focuses on key sectors impacted by or impacting climate change, including agriculture, water, forestry, energy and urban planning. In furthering its objectives, the states were asked to prepare State Action Plans on Climate Change (SAPCCs). These should keep in view the creation of an implementation framework for the NAPCC and its alignment with specific development priorities by duly considering impacts, vulnerabilities and adaptation needs. In view of this, Government of Karnataka (GoK) formed a Coordination Committee as interdepartmental facilitator. The preparation of the Karnataka SAPCC was assigned to Environmental Management & Policy Research Institute, an autonomous body of Department of Forest, Ecology and Environment.

Climate trends

Karnataka's annual rainfall is 1,151 mm on average. Around 80% of it is received during the southwest monsoon, 12% in the post monsoon period, 7% during summer and 1% in winter. Within the state there are considerable variations. During the southwest monsoon rainfall is much higher in coastal locations on the windward side of the Western Ghats (3,350 mm) which drops sharply on the leeward side (600-700 mm). Northern interior regions by contrast have markedly semi-arid climates with low annual precipitation (500–600 mm). A recent study observed a declining trend in rainfall during the southwest monsoon: -1 mm per day per 100 years or 6% in 50 years. India Meteorological Department (IMD) by contrast holds that its own data is indicative of a slight rise in annual precipitation. Projections made for the period 2021 to 2050 under a SRES A1B scenario predict a decline in annual rainfall for the south-western and north-eastern regions of the state. A wide region from the north-western part of the state including the coastal districts to the south-east is projected to see significant increases.

A warming trend in Karnataka has been observed for the period June to September in northern interior Karnataka. Both minimum and maximum temperature were found to have risen by up to 0.6°C over the last 100 years. According to projections made (SRES A1B scenario), average temperatures may rise further by 1.7°C to 2.2°C by the 2030s. Projected increases are more pronounced in the northern districts.

It was inferred from a recent study that overall reduced precipitation and continuous warming is a possible, perhaps probable scenario for Karnataka. It is predicted that regions that already witness less rainfall and higher temperatures, such as northern Karnataka, will further experience lesser rainfall and increases in average temperatures.

However, as has already been pointed out, it should be noted that the models deployed have the tendency to amplify present climate variability, manmade or natural.

GHG emissions

Carbon dioxide (CO_2) is the major greenhouse gas. Other GHGs include methane (CH_4) and nitrous oxide (N_2O). Carbon dioxide is released from the combustion of fossil fuels (coal, oil, gas) but its flows also increase from the reduction and degradation of forests. Methane is emitted from ruminants (livestock holdings) and paddy cultivation while nitrous oxide is emitted from manure and agricultural soils.

For Karnataka, annual emissions of the major three greenhouse gases are estimated to amount to 80 million tons of CO_2-equivalent (or 4.6% of India's emissions). In this, CO_2 accounts for 73% of GHG emissions, methane for 23% and N_2O for 3.3%. In terms of sectoral distribution, electricity generation accounts for 35.9% of annual GHG emissions, industry for 22.6%, agriculture and allied sectors for 20.2%, transport for 10.4%, households (excluding electricity) for 7.3% and waste for 3.6%.

Agriculture and allied sectors

Farmers and agricultural labourers account for nearly 57% of the Karnataka's workforce. The state has ten agro-climatic zones and observes three growing seasons. Among these *kharif,* the monsoon season lasting from July to October, accounts for 70% of the annual food grain and oilseed production. An overall increase in production and yield of major corps has been observed over the last decade. Yet the introduction of high yielding varieties has progressively reduced the cultivation of traditional varieties in the state. The loss of agricultural biodiversity is a serious concern. Droughts affect agricultural production in the state to a great extent, so do floods, to which especially *kharif* crops are prone.

Agriculture is highly vulnerable to climate change because of its wide exposure to temperature, precipitation, pests and diseases. Studies predict that a number of districts may become vulnerable in respect of crops presently grown. Likewise opportunities emerge in terms of improving cultivation conditions for certain crops in certain areas. All in all, a net decline of -2.5% in agricultural production has been projected by a recent study over the next two to five decades with a major reduction in coastal regions. Challenges that this action plan seeks to address include (refer section 11.3):

- Present subsidies lack mechanisms for shifting cropping patterns;
- The knowledge of climatic changes is too limited to make focused predictions;
- Significant untapped minimisation potential in agro-chemicals;
- Security concerns over theft of distribution pipes impedes sprinkler irrigation;
- Agricultural and horticultural biodiversity is jeopardised;
- Livelihoods of farmers who are already vulnerable may be exposed further;
- There are significant unutilised portions of degraded land/arid land;
- Livestock resistance to vector borne diseases and heat stresses is insufficient;
- Insufficient promotion of indigenous climate tolerant cattle and buffalo breeds.

Water resources

Karnataka has seven river basins and receives a total of 236 billion m^3 of water every year, 92% of it through rainfall. Around 47% are 'lost' through evapo-transpiration and another 46% flow into the Arabian Sea, into Andhra Pradesh and Tamil Nadu. The state meets its requirement from the remainder of about 7.5% paired with groundwater. There are nearly 37,000 tanks and lakes with a water spread area of 6.9 lakh hectare and more than 20,000 irrigation tanks.

Groundwater provides for 45% of irrigation in the state and GoK places emphasis on its expansion. Karnataka experienced a decline in net annual groundwater availability by 3.2% between 2004 and 2009, attributed to groundwater extraction beyond replenishment. There are 8.6 lakh irrigation wells, 94% of which are equipped with electric pumps. Groundwater development stands at 68%. As much as 64 watersheds covering 35 of the 176 taluks of the state are over-exploited. It is projected that the Krishna basin may see a decline in rainfall while the Cauvery basin may experience an increase. Yet contrary to expectation, this may not lead to an increase in surface run-off. A net decline of 2% is projected because of the enhanced rate of evapo-transpiration. The Karnataka Groundwater Act 2011 now aids the protection of so far unprotected groundwater resources. Challenges that this action plan seeks to address include (refer section 11.3):

- Significant over-extraction of groundwater resources;
- Vast unutilised potential for collection of rainwater use and groundwater recharge;
- Urban water supply is highly inefficient, increasing the groundwater dependence;
- The reuse of treated water has been unable to make significant in roads;
- Low priced irrigation water is a substantial impediment.

Forestry, biodiversity and wildlife

About 20% of Karnataka's geographical area is under forest cover. Forests declined by about 2% between 2001 and 2007, especially dense forests were affected (-16%). The Western Ghats are among the 25 global biodiversity hotspots. Likewise the coastal area has a rich and diverse biodiversity. A large number of species are identified as rare, endemic or threatened in both biota.

It is widely accepted that higher CO_2 levels will stimulate carbon sequestration by plants and increase net uptake. Nevertheless, the prediction that climatic changes will impact *existing* vegetation and forests in particular is a concern. A recent study finds that about 38% of the present forest area, mostly in the central and northern parts of the Western Ghats, is predicted to experience shifts in respect of the forest type. Climatic threats are exacerbated by other threats that are mostly of human origin. Challenges that this action plan seeks to address include (refer section 11.3):

- Long-term carbon capture requires a return to timber as building material;
- Biodiversity hotspots such as the Western Ghats are insufficiently protected;
- Forests are degraded through the unplanned extraction of firewood, fodder, non-timber forest produce (NTFP), green manure etc;
- Biodiversity is compromised through the spread of alien species;
- Encroachments of forests contribute significantly to forest degradation;
- Vast tracts of forest fall victim to forest fires every year.

Coastal zone

Karnataka's has 320 kilometres of coastline lined with coastal plains and undulating hills of 50 to 80 km and high hills further east. Fishing is a major source of livelihood with about three lakh people directly or indirectly engaged. Within the agriculture sector, the share of fisheries is increasing albeit marine fish production has witnessed considerable variation. The per-unit effort and return on investment in marine fishery is declining. A study cited estimates that over the last 20 years the peak catch in the state was 0.22 million tons against a projected maximum sustainable yield of 0.15 million tons. There has been substantial increase in trawler trips in recent years. Particularly selective scooping exerted tremendous pressures on benthic organisms and their survival.

Though the coastal hinterland has an average height of 70 to 75 meters, studies have estimated that, if the present tend continues sea levels could rise by 25 cm in 100 years, inundating around 461 km^2 of coastal wetlands. Exacerbated by sand mining, erosion has been found to be significant. Likewise, encroachments and coastal pollution are notable. Challenges that this action plan seeks to address include (refer section 11.3):

- Coastal pollution has the potential to upset the fragile coastal ecological balance;
- In portions of the coastline the scale of marine fishing is unsustainable;
- Very limited research has investigated the link between climate change and fishes;
- A systematic mapping of Karnataka's 320 km coastline in respect of anticipated sea level rises has not been undertaken yet;
- Bengere, a coastal settlement near Mangalore, is completely unprotected;
- The mangrove ecosystem and coral reefs are insufficiently protected.

Energy

Karnataka has an installed power generation capacity of 9,702 MW not including central power plants and captive generation. In that hydropower accounts for 44%, thermal power for 30% and wind power for 17%. Though wind power constitutes a proud 17% of the state's installed capacity, its contribution to electricity generation is only about 5-6%. Karnataka Power Corporation Limited has 7,814 MW of generation capacity additions on the anvil, 45% of which is gas-based. This is commendable since gas power is less CO_2 intensive than coal or oil-based power and therefore considered an appropriate mid-term option while renewables are scaled up.

10.5% of Karnataka's renewable energy potential of 28,500 MW have been tapped so far. Rapid progress is expected here, driven in particular by Renewable Purchase Obligations notified as mandatory in 2011. Apart from the successful *Belaku* scheme, energy efficiency is still in an infancy stage. Challenges that this action plan seeks to address include (refer section 11.3):

- The power deficit is likely to remains unaddressed in the short and mid term;
- Free electricity to farmers impedes augmenting power sector investment;
- High transmission and distribution losses of currently 22%;
- Energy efficiency has largely failed to make substantial inroads;
- Nearly 90% of the potential of renewables remains untapped;
- Bio-fuels failed to make substantial inroads at scale.

Urbanisation

37% of Karnataka's 61.1 million population live in urban areas. The vehicular population rose by an alarming 70% in merely six years. Congestion, increased travel times, vehicular air pollution and noise have come to define urban standards. While efforts are being made to improve infrastructure and public transport – and successfully so – the rise of private motor vehicles is probably irreversible. Efforts are directed to promote non-motorised transport (walking, cycling) by creation of the necessary infrastructure as incentive. Likewise, attention is being paid to the better integration of public transport into mobility concepts and door-to-door solutions.

The management of Karnataka's 9,000 tons solid waste per day across 218 urban local bodies (ULBs) has seen frantic activities and tangible improvements. Plans adopted at ULB level are in the process of being completed. While some have achieved compliance with legislation, prerequisite land acquisitions are subject to court proceedings in other cases and timelines are thus difficult to define. Illegal dumping and uncontrolled burning of waste continues to elude efforts. Challenges that this action plan seeks to address include (refer section 11.3):

- Inadequacies in health, education, housing and employment in tier 2 and 3 cities;
- Storm water drains are unable to deal with water from moderately heavy rainfalls;
- Solid waste management is yet to be fully implemented;
- Significant inadequacies in sewage collection, treatment and reuse of water;
- Absence of a long-term planning perspective for rail-bound public transport;
- Basic needs of the urban poor in respect of water, sanitation and electricity unmet.

Human health

Karnataka is ahead of India average in respect of health indicators such as mortality, birth and death rates. However, more effort is needed to achieve performance at par with the best performing states. Areas of concern are moderately high infant mortality, maternal mortality, malnutrition among children and women, high incidence of childhood diseases, inadequacies in water supply and sanitation, and poor socio-economic status of women along with social discrimination.

Human health is vulnerable to climatic changes in multiple ways: Increases in the temperature can increase thermal stress. Increased incidence of floods and droughts would reduce crop productivity, affecting nutrition and consequently resistance to infections. Floods could contaminate drinking water causing outbursts of water borne diseases. Warming trends could also favour the spread of vector borne diseases (malaria, kala azar, dengue). The transmission window for malaria in the state is already 10-12 months though and hence further increase is impossible. Challenges that this action plan seeks to address include (refer section 11.3):

- Absence of a health status inventory;
- The link between human health and climate change is not well understood;
- Regions most vulnerable to health risks remain to be identified;
- Drinking water quality is often compromised.

Other attention areas

Other challenges that this action plan seeks to address include (refer section 11.3):

- The current level of knowledge on the spatial dimension, time scale and magnitude of climatic changes is extremely limited;
- There is no mechanism for sharing information on adaptation pilots, practices and experiences made across India. In absence of systematic communication, opportunities are lost for building on each others' experience;
- Without regular review and updation, this Action Plan is bound to loose its relevance within a span of years.

The action plan presented at section 11.3 responds to these challenges. It proposes actions that are capable of assisting the state in its pursuit of preparing for climate change while, at the same time, offering opportunities for sustainable development with climate co-benefits.

1. BACKGROUND

1.1. Global level

Recent research across the world established that climate change is the most serious global environmental challenge today. Changes in the chemical composition of the atmosphere and increasing concentrations of greenhouse gases (GHGs) pose a significant threat to the ecological balance and biogeochemical cycles including rainfall and temperature. It has been projected that changes in natural cycles will severely affect the socio-economic texture and environment at global as well as at regional levels. Changes in the rainfall pattern will most affect agriculture and water resources. Assessments carried out by Intergovernmental Panel on Climate Change (IPCC) highlighted that countries mostly affected by climate change would be agrarian-dominated, eco-sensitive economies. This group comprises mainly of developing and emerging economies. Here the inadequacies of infrastructure, low education and income levels, lessen the choices that can be exercised. In addition slower response mechanisms of these nations are compounding their natural vulnerabilities. By contrast, the causes of climate change are attributable largely to developed countries that have been emitting massive amounts of GHGs since the industrial revolution.

According to the 4th Assessment Report of the IPCC (2007),[1] the majority of the increase in the observed global average temperatures since the mid-20th century is very likely linked to the observed increase in anthropogenic GHG concentrations. The assessment concludes that discernible human influences have now extended to other aspects of climate, including ocean warming, temperature extremes and wind patterns. Projected scenarios indicate a rise in the global mean temperatures in the range between 1.1˚C and 6.4˚C by 2100. Global records of one and a half centuries reveal that earth has warmed by 0.74˚C during the last 100 years. By the end of the century the rise in temperature could be between 0.6˚C and 4.0˚C with respect to 1980-1999 levels. With respect to south-east Asia IPCC (2007) predicts:

- By the 2050s freshwater availability will decrease, particularly in large river basins;
- Coastal areas, especially heavily populated mega delta regions will be at greatest risk due to increased flooding from the sea and in some cases, flooding from rivers;
- Endemic morbidity and mortality due to diarrhoeal diseases associated with floods and droughts are expected to rise due to projected changes in the hydrological cycle.

However, the reliability of these projections has not remained uncontested. The Non-governmental Panel on Climate Change (NIPCC) for instance drew attention to limitations of IPCC (2007) while attributing observed climatic changes primarily to natural processes. In its report, 'Climate Change Reconsidered',[2] NIPCC argues that observed changes are dominated by changes in ecological cycles and not anthropogenic GHG emissions. NIPCC's major critique points on IPCC's findings include:

- The general circulation models used by IPCC in the 4th Assessment Report lack scientific validation resulting in uncertainties associated with predictions of especially cloud formation and cloud interactions;

[1] IPCC (2007). 4th Assessment Report; The Physical Science Basis

[2] Idso, C. and Singer, S.F. (2009). Climate Change Reconsidered, Report of the Nongovernmental International Panel on Climate Change (NIPCC). The Heartland Institute, USA

- IPCC dose not consider adequately the cooling effect of aerosols and ignores temperature-induced emissions of dimethyl sulfide (DMS) from oceans. Also iodo compounds produced by marine algae which have a cooling effect by acting as condensation nuclei for cloud formation and increase reflection are not considered;
- Surface-based temperature records as used by IPCC do not take into account non-greenhouse gas induced urban heat island corrections;
- Unlike stated in the IPCC report, the thinning of the Arctic sea ice is caused by changing ice dynamics and a shift of the atmospheric regime. Also the prediction and records on sea level rise are subject to uncertainties related to the world's water balance;
- NIPCC opines that several studies found that solar magnetic activity and solar irradiance is the major factor contributing to the changing climate and not anthropogenic CO_2 emissions. Also there exist strong correlations between solar activities and weather events such as rainfall, droughts, floods etc. around the world;
- Water use efficiency of plants increases with the CO_2 concentration in the atmosphere and increased CO_2 thus may not adversely affect plant growth. Increased CO_2 availability will induce higher photosynthesis and biomass production and also enhance plants' resistance to withstand harsh environmental conditions such as soil salinity, temperature stress etc. NIPCC suggests that global warming is likely to enhance carbon sequestration;
- According to NIPCC, IPCC's claim of increasing climate change threats to human health are unwarranted. It opines that several research findings have shown that rise in temperature reduces risk of cardio vascular and respiratory diseases when compared with lower temperatures;
- Due to increasing CO_2 concentration in the atmosphere and rising temperatures, crop productivity is expected to increase which will not only lessens the food shortage but also prevents encroachment of natural ecosystem for the same purpose.

In spite of limitations on the current scientific assessments and uncertainties, the weight of evidence attributing climatic changes to human activities is significant. Most governments therefore acknowledge the need for rapid action. Nonetheless, till date meetings of the Conference of the Parties (CoP) under the United Nations Framework Convention on Climate Change (UNFCCC) have not been successful in negotiating consensus on binding emission reductions. The chances for mitigating anthropogenic climate change are gradually diminishing. Failing to prevent it, it appears imperative to prepare for its impacts. Across the globe, governments are increasingly adopting national programmes to deal with the threat of climate change. India is one of them.

1.2. National level

With respect to India, IPCC (2007) projects an increase of 2.7˚C to 4.3˚C in temperature by the 2080s, an increase in rainfall of 6-8% and sea level rise of 88 cm by 2100.[1] The projected scenario would have dramatic consequences for livelihood – and possibly survival – of rural communities who depend on agriculture, fisheries and animal husbandry. Limitations of science aside, imminent vulnerabilities of an ecologically sensitive, developing and largely agrarian country like India cannot possibly be ignored. Projected trends in climatic changes pose a looming threat for the development of the country and

[1] IPCC (2007). 4th Assessment Report; The Physical Science Basis

compound the call for economic and inclusive growth. Acknowledging this challenge, the Prime Minister's Council on Climate Change in its first meeting on July 13, 2007, announced that "*A national document compiling action taken by India for addressing the challenge of climate change, and action it proposes to take should be prepared*." Accordingly, India's voluntary National Action Plan on Climate Change (NAPCC) was prepared and released in June 2008 by the Prime Minister's Council on Climate Change.[1]

As prudent for an emerging economy, India's plan does not sacrifice developmental goals for emission reduction targets. Instead it emphasises appropriately on long-term mitigation strategies promoting sustainable development and growth with climate "co-benefits". Intervention areas include renewable energy, energy efficiency, water management, agricultural resilience, afforestation, waste management and public transport. The emphasis lies on inclusive and sustainable development, especially for poorer sections. Through its eight sectoral missions the NAPCC provides a detailed road map for achieving these objectives. For each of these, a separate mission document, prepared by the concerned ministries, details the strategy. As Table 1 shows, four missions were accorded approval from the concerned ministry while till date only three received Cabinet approval.

Table 1: Status of mission documents under the NAPCC as of February 27, 2012

Missions under NAPCC	Draft release	Ministry approval	Cabinet approval
1. National Mission for Solar Energy	Yes	Obtained	Obtained
2. Mission for Enhanced Energy Efficiency	Yes	Obtained	Obtained
3. Mission for Sustainable Habitat	Yes	Obtained	Pending
4. National Water Mission	Yes	Obtained	Obtained
5. Mission for Sustaining the Himalayan Ecosystem	Yes	Pending	
6. National Mission for Green India	Yes	Pending	
7. National Mission for Sustainable Agriculture	Yes	Pending	
8. National Mission for Strategic Knowledge	Yes	Pending	

1.3. State level

The states play the major role in the implementation of the NAPCC. In an address on August 18, 2009, the Prime Minister called upon the states and union territories to initiate the preparation of state action plans. State level plans need to create an institutional and operational framework for implementing the missions of the NAPCC and aligning them with other developmental priorities of the state. To achieve this, Ministry of Environment and Forest (MoEF) prepared a set of guidelines for the states.[2] These acknowledge that interventions at state level needs to cover an even wider scope than the NAPCC laid out. Of greatest importance perhaps is the emphasises it lays on the need to identify impacts, vulnerabilities and adaptation needs, a crucial element which hitherto had not received much attention in the national strategy. Guiding principles of MoEF's framework include:

[1] Government of India, Prime Minister's Office (2008). National Action Plan on Climate Change (NAPCC)

[2] MoEF (2010). Framework the preparation of SAPCCs; Circular dated November 1, 2010

- Implementing an inclusive and sustainable development strategy, protecting poor and vulnerable sections of society from adverse effects of climate change;
- Undertaking actions that deliver benefits for growth and development while mitigating climate change;
- Ensuring and improving ecological sustainability;
- Building climate scenarios and investing in knowledge and research to reduce uncertainty and to improve knowledge about appropriate responses;
- Assessing the impact of climate change on existing vulnerabilities, and identifying and enhancing risk management tools for addressing climate change;
- Setting out mitigation and adaptation options and evaluating them in accordance with cost-effectiveness, cost-benefit and feasibility;
- Implementing state-planned and voluntary community-based adaptation measures while building broader stakeholder engagement;
- Addressing state-specific priority issues while creating an enabling environment for implementation of NAPCC at state level;
- Establishing appropriate institutional arrangements and building capacities, keeping in view coordination, inter-departmental consultations, stakeholder involvement and integration with regular planning and budgetary processes;
- Alignment with national policies and programmes for consistency and to identify financial and policy support that may be available.

In June 2009 Government of Karnataka (GoK) constituted a Coordination Committee to oversee the state's response to climate change (refer Annex 2[1]). It assigned the mandate to prepare the State Action Plan on Climate Change (SAPCC) to Environmental Management & Policy Research Institute (EMPRI), Bangalore (refer Annex 3). In the planning process, the committee emphasised the need to develop Karnataka SAPCC in close consultation with the government who would eventually own the action plan. This is reflected in the composition of the committee whose members are presented at Table 2.

Table 2: Members of the Coordination Committee

1. Additional Chief Secretary & Development Commissioner
2. Principal Secretary, Department of Forest, Ecology & Environment
3. Principal Secretary, Department of Urban Development
4. Principal Secretary, Department of Energy
5. Principal Secretary, Department of Health & Family Welfare
6. Principal Secretary, Department of Transport
7. Principal Secretary, Public Works Department
8. Principal Secretary, Water Resources Department
9. Principal Secretary, Housing Department
10. Principal Secretary, Revenue Department
11. Principal Secretary, Animal Husbandry & Fisheries Department
12. Secretary, Tourism Department
13. Secretary (Environment & Ecology), Department of Forest, Ecology & Environment
14. Secretary (Forest), Department of Forest, Ecology & Environment
15. Director, Town Planning Department
16. Member Secretary, Karnataka State Pollution Control Board
17. Representative of Development Alternatives, New Delhi
18. Representative of Ministry of Environment & Forests, New Delhi
19. Professor, Department of Civil Engineering, Bangalore University
20. Director General, Environmental Management & Policy Research Institute

[1] Government of Karnataka (2009). Government Order FEE 181 ENV 2007 dated June 20, 2009

1.4. Preparatory work

Work on Karnataka SAPCC was preceded with a rapid assessment of sectoral actions of Government of Karnataka. Directed by the Coordination Committee, this review solicited cooperation from 22 departments, 14 of which took part in the stocktaking exercise. They provided details of actions already taken and, in some cases, specific plans in respect of climate change. Actions taken or proposed were reviewed keeping in view the mandate and scope ensuing from the NAPCC as primary cornerstone. An initial report of findings was released in December 2010 as a precursor.[1] Its key findings are summarised here for reference.

- The rapid assessment found that the majority of actions reported address issues already pressing today. Leaving aside exceptions, most of the actions were not conceived in response to climate change but to developmental priorities. This finding is logical and unsurprising. Nevertheless, these action offer climate change co-benefits as envisaged by the NAPCC. The steps put forth are encouraging considering they were embarked upon in absence of a coordinated inter-departmental response to climate change. Specific mentioning deserve the initiatives of the Karnataka Forest Department (KFD) and Revenue Department. Both departments covered significant terrain in preparing for the challenge of climate change in a systematic way.
- It was noted with concern that no specific targets or timeframes were indicated for most initiatives at state level. Actions, strategies and intentions were promulgated chiefly in qualitative terms while the magnitude and depth of these interventions remain uncertain. Departments generally did not indicate the availability of funds for implementation. The absence of clear plans give rise to apprehensions that, irrespective of noble intentions, major achievements may not be realised if not planned for but merely *envisaged*.
- The scope and nature of actions are chiefly confined to mitigation options. Keeping in view Karnataka's climate may already have experienced changes going by the increased occurrence of floods and droughts, steps towards adaptation to a gradually changing climate and its consequences remain elusive.
- The existing sectoral initiatives of GoK are beneficial for the state's climate change response but have not in any way replaced the need for a comprehensive and coordinated action plan. Such plan needs to prioritise particularly the integration of impacts, vulnerabilities and adaptation requirements in the state. And considering that the SAPCC has many stakeholders, GoK being the most important one, the preparation process needs to be consultative and participatory.

1.5. Development process

This present report investigates sectoral governmental actions more thoroughly, although not exhaustively. It places actions and policies identified in the context of perceived vulnerabilities and options for mitigation and adaptation.

More than 80 relevant published and unpublished documents were identified and analysed. Among these the report of the Bangalore Climate Change Initiative – Karnataka (BCCI-K) played a significant role.[2] Its concise corroboration of relevant data paired with first projections for the state aided the preparation process. A review and systematic

[1] EMPRI (2010). SAPCC Karnataka – Rapid Assessment of Sectoral Actions Initiated

[2] BCCI-K (2011). Karnataka Climate Change Action Plan; Final Report

evaluation of literature begun in October 2010 and concluded with the establishment of a document repository to aid the identification of and access to relevant resources.

The development process was initiated with a brainstorming session with representatives of reputed institutions whose work relates to climate change. The magnitude of the sectoral reviews necessary for this report and the need to expedite the process made collaboration a preferable option. In order to expand on the existing institutional capacity for the preparation of this work an agreement with The Energy & Resources Institute (TERI) was established. An extensive consultation process with 24 departments of Government of Karnataka – the most important stakeholder – was held in March 2011 (refer Annex 1) and followed later with consultations with India Meteorological Department (IMD) and eventually the Coordination Committee constituted by GoK.

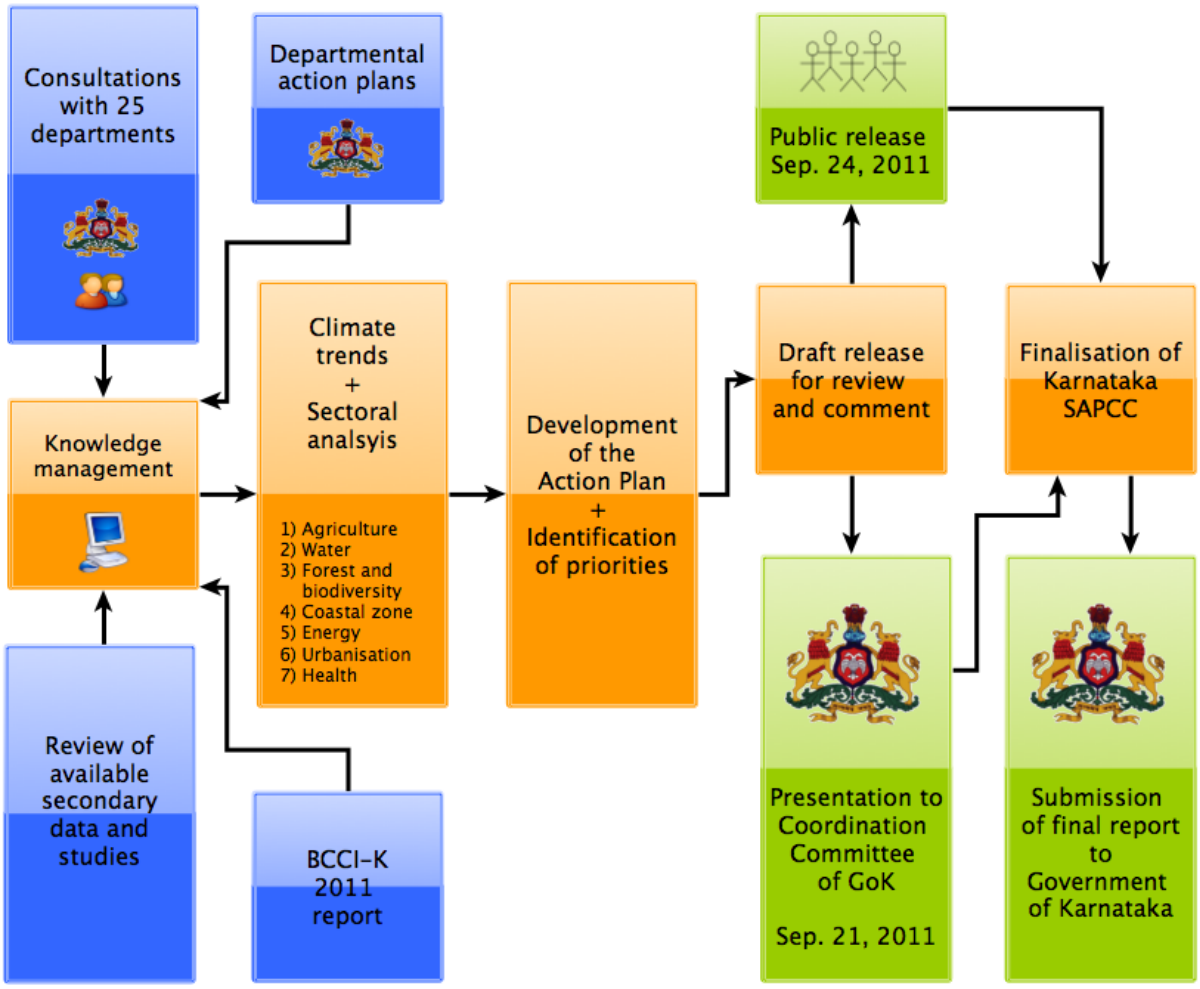

Figure 1: Process of preparation of the Karnataka SAPCC

A draft report was placed before the Steering Committee and the general public for comment. The release was accompanied by newspaper announcements in the Deccan Herald and Times of India (Karnataka editions) on September 24, 2011. The draft report was hosted on EMPRI's website for unrestricted access until replaced by the present final document. Comments received were addressed in their full scope to the extent factual information available permitted.

2. CLIMATE TRENDS

2.1. Overview of the state

The state of Karnataka, situated in the south-western part of the country, is India's eighth largest state in terms of geographical area with 191,791 km^2. According to the Provisional Census 2011, Karnataka's population is 61.1 million. The state has 176 taluks presently divided into 30 districts. The state has an urban population of 37%[1] and is currently ranked as the fifth most urbanized state in India. With 19.96% forest cover, the largest connected range of which is formed by the Western Ghats, the state also acts as carbon sink. A total of 104 lakh hectares land is under cultivation. The state has witnessed a high rate of urbanization and development in particularly the last two decades. In 2004-05 Karnataka's contribution to India's GDP was 5.2%, slightly more than its population share.

Table 3: Overview of Karnataka[2]

Indicators	Karnataka		Comparison with India
Area	191,791	km^2	5.82%
Population	61.10	million	5.05%
Rural population	34.85	million	4.58%
Total forest cover	38,284	km^2	4.91%
Gross cropped area	12,893,000	hectare	6.55%
Net Sown Area	10,419,000	hectare	7.38%
Livestock	32.8	million	6.20%
Food grain production	12,500,000	tonnes	6.00%
Rainfall (annual average)	1,151	mm	
Literacy rate	75.14	%	
Infant mortality	41	per 1,000	53
Population per hospital bed	1,319		1,503

Karnataka's economy[3]

- According to advance estimates of gross state domestic product (GDSP) at constant prices or state income is expected to grow by about 8.2% during 2010-11.
- The service sector continues to dominate in the economy, the tertiary sector contributing 55.17% to the GDSPs. The contribution of the secondary and primary sectors are 28.61% and 16.22% respectively.
- Per capita GDSP (or income) at current prices is likely to reach INR 67,253 during 2010-11 as against INR 58,852 in 2009-10.
- Food grain production increased to above 125 lakh tons in the current year from less than 110 lakh tons in 2009-10
- The cumulative irrigation potential likely to be created by the end of 2010-11 is 35.12 lakh hectares from all three categories of irrigation (major, medium and minor irrigation) projects.
- Software exports increased to INR 70,375 crore in 2008-09 from INR 59,500 crore in 2007-08. Exports from business process outsourcing companies increased to INR 15,014 crore in 2008-09 from INR 7,600 crore in 2007-08.

[1] BCCI-K (2011). Karnataka Climate Change Action Plan; Final Report

[2] Department of Planning, Programme Monitoring and Statistics (2010, 2011). Economic Survey 2009-10; 2010-11

[3] Department of Planning, Programme Monitoring and Statistics (2010, 2011). Economic Survey 2009-10; 2010-11

2.2. Physiography

Based on physiographic features Karnataka is commonly divided into four regions: (1) the coastal region, (2) The Malnad or hilly region, (3) the northern plateau and (4) the southern plateau. The state observes diverse climates from arid to semi-arid in the plateau regions, sub-humid to humid tropical in the Western Ghats and humid tropical monsoon climate in the west coast plains. About 77% of the total geographical area of the state, covering the interior part is arid or semi-arid with the state contributing 15% of the total semi-arid or 3% of the total arid areas of the country. Karnataka experiences a typical tropical climate comprising of four distinct annual seasons: Winter (January to February), summer (March to May), monsoon (June to September), and post-monsoon (October to December).[1]

Figure 2: Karnataka with its now 30 districts[2]

[1] Ramachandra, T.V. and Kamakshi, G. (2005). Bio-resource potential of Karnataka. Technical Report No. 109. Centre for Ecological Sciences, Indian Institute of Science

[2] PlaneMad/Wikipedia and EMPRI (2007 and 2012) http://en.wikipedia.org/wiki/File:Karnataka_locator_map.svg

2.3. Precipitation

The average rainfall received in the state during the year 2009-2010 was 1,343 mm, 17% more than the normal rainfall of 1,151 mm. 14 out of 30 districts experienced excess and remaining 16 districts normal rainfall.[1]

Krishnan (1984) has studied extensively the rainfall patterns of Karnataka. Of the average annual normal rainfall, the state receives 80% during the southwest monsoon period, 12% in the post-monsoon period, 7% in summer and only 1% in winter. The windward side of the Western Ghats, which is the coastal region, records 3,350 mm of rainfall during the southwest monsoon while on the leeward side rainfall drops to 600-700 mm. The humid Malnad region receives annual rainfall in the range of 1,000-3,800 mm. The north-eastern monsoon causes 30% of annual rainfall in the eastern part of south interior Karnataka, mainly between October to December. With annual rainfalls of 500–600 mm north interior Karnataka is a rainfall deficit area. This includes Bijapur, east Belgaum, north-east Dharwad, west Raichur, east Bellary, Chitradurga and a small portion of Tumkur district. Rainfall is low in the semi-arid regions and less than 140 mm in the centre of Dharwad district. Daily rainfall intensities range from 180-240 mm in north Bijapur, north Gulbarga and Bidar district. The rainy season is spread over a period of four months (June-September) in the coastal, Ghats, Malnad areas and in Bidar district, while over the *maidan* areas it is spread over a period of five to seven months.[2]

BCCI-K (2011) assessed trends based on daily weather data from Indian Meteorology Department (IMD), Pune for the period 1901 to 2008. The study observed a decline in annual rainfall: From 1,204 mm during 1901-1950 to 1,140 during 1951-2008. As shown in Table 4, annual as well as seasonal rainfall decreased or increased depending on the region of the state.

Table 4: Rainfall normal and trends during 1901-2008 in Karnataka[3]

District	Pre-monsoon (Jan -May)			Southwest monsoon (Jun- Sep)			Northeast monsoon (Oct- Dec)			Annual	
	Trend	mm	(%)	Trend	mm	(%)	Trend	mm	(%)	Trend	mm
South interior Karnataka											
Bangalore Rural	↑	141	18	↓	427	54	↓	222	28	↓	790
Bangalore Urban	↑	168	19	↑	466	53	↑	241	28	↑	875
Chamarajanagar	↓	239	29	↓	316	39	↑	261	32	↓	816
Chitradurga	↑	179	9	↑	1,505	79	↑	220	12	↑	1,904
Davanagere	↑	233	6	↑	3,338	85	↑	340	9	↑	3,911
Kolar	↑	247	9	↑	2,129	81	↑	266	10	↑	2,642
Mandya	↔	74	13	↓	385	66	↑	124	21	↑	583
Mysore	↓	191	26	↑	296	41	↑	235	33	↑	722
Tumkur	↓	191	22	↑	425	50	↓	236	28	↓	852
Chikkaballapur	↓	208	5	↔	3,669	88	↓	305	7	↓	4,182
Ramanagara	↓	148	5	↔	2,537	88	↑	200	7	↓	2,885
North interior Karnataka											
Bagalkote	↔	88	15	↓	360	62	↓	136	23	↓	586
Belgaum	↓	115	14	↑	560	68	↔	148	18	↔	823
Bellary	↓	103	16	↓	388	61	↓	145	23	↓	636

[1] Department of Planning, Programme Monitoring and Statistics (2010). Economic Survey 2009-10

[2] Ramachandra, T.V. and Kamakshi, G. (2005). Bio-resource potential of Karnataka. Technical Report No. 109. Centre for Ecological Sciences, IISc, Bangalore, India

[3] BCCI-K (2011). Karnataka Climate Change Action Plan; Final Report

District	Pre-monsoon (Jan -May)			Southwest monsoon (Jun- Sep)			Northeast monsoon (Oct- Dec)			Annual	
	Trend	mm	(%)	Trend	mm	(%)	Trend	mm	(%)	Trend	mm
Bidar	↑	75	8	↑	705	80	↓	105	12	↑	885
Bijapur	↑	73	12	↓	427	68	↓	131	21	↓	631
Dharwad	↔	130	20	↓	361	55	↔	166	25	↓	657
Gadag	↓	147	19	↑	480	61	↓	159	20	↓	786
Gulbarga	↑	115	18	↓	365	58	↓	150	24	↓	630
Haveri	↑	181	18	↓	584	59	↓	222	22	↓	987
Koppal	↑	133	18	↔	363	50	↑	227	31	↑	723
Raichur	↑	220	29	↓	335	44	↓	211	28	↓	766
Malnad region											
Chikkamagalur	n/a	113	15	↑	412	56	↑	217	29	↑	742
Hassan	↑	71	8	↑	640	76	↑	128	15	↑	839
Kodagu	↑	132	17	↓	485	62	↑	160	21	↔	777
Shimoga	↑	65	10	↑	480	70	↑	136	20	↑	681
Coastal region											
Dakshina Kannada	↑	118	21	↓	283	50	↑	169	30	↓	570
Udupi	↑	148	8	↓	1,484	82	↑	187	10	↓	1,819
Uttara Kannada	↑	144	20	↓	363	50	↑	212	29	↑	719
Karnataka		**142**	**12**		**820**	**71**		**190**	**17**		**1,152**

2.4. Temperature

Temperature is lowest in the month of January and increases thereafter gradually at first and rapidly after the middle of February or the beginning of March. The southern *maidan* region witnesses the highest temperature in April while in the northern *maidan* and the coastal areas, the highest temperatures occur in May. In January, the mean daily temperature is 31-32°C in the coastal areas and slightly above 30°C in the northern *maidan* area except in Bidar district where it is 28-29°C. In May, the maximum temperature reaches 43°C in the Gulbarga-Raichur region. In the Ghats and Malnad area it remains comparatively low i.e. about 20-24°C. It is seen that the mean annual range of temperature is least in the coastal region (6°C) and greatest in the Bellary-Raichur region. In the May-June north interior Karnataka also experiences incidents of heat waves.[1]

2.5. Trends and projections

2.5.1. Precipitation

In view of the absence of comprehensive studies on the likely impacts of climate change in Karnataka, Professor B. K. Chandrashekar established the Bangalore Climate Change Initiative – Karnataka (BCCI-K). This initiative brought together distinguished experts from Indian Institute of Science (IISc), Institute for Social and Economic Change (ISEC), University of Agricultural Sciences (UAS), and Centre for Study of Science, Technology and Policy (CSTEP). The group studied Karnataka's climate trends and made projections, in most cases based on a coupled atmosphere-ocean general circulation model known as HadCM3.[2] Data generated was downscaled to the regional level using the regional cli-

[1] Ramachandra, T.V. and Kamakshi, G. (2005). Bio-resource potential of Karnataka. Technical Report No. 109. Centre for Ecological Sciences, IISc, Bangalore, India

[2] Hadley Centre Coupled Model, Version 3 developed by the Hadley Centre, Met Office, United Kingdom

mate model PRECIS.[1] Projections of the BCCI-K (2011) study[2] were based on the SRES A1B scenario. This scenario, a marker scenario based on the SRES A1 greenhouse gas scenario formulated by IPCC's Special Report on Emission Scenarios (2000), stands for rapid economic growth in a globalising world and balanced emphasis on all energy sources. 35-year rainfall data (1971 to 2005) of IMD was used as baseline alongside monthly temperatures for last 102 years (1901-2002).

As shown in Figure 3, BCCI-K (2011) indentified a decline in rainfall of the southwest monsoon of -1 mm per day per 100 years for the period 1971 to 2005 (approx. 6% in 50 years).[3] The Pune office of India Meteorological Department (IMD) reported that its own studies show a significant increasing trend for both seasonal and annual rainfall in northern interior Karnataka, which BCCI-K appears to have noted as well (Figure 4).[4] It is worth noting however that IMD Bangalore, who provided the baseline data for the BCCI-K study, disagrees with the conclusion that rainfall in Karnataka has been declining. It holds that the period considered is too short to infer dependable conclusions. Longer-term data by contrast is said to indicate a slight rise in Karnataka's annual precipitation.[5] Regrettably, no data has yet been published to support this stance. IMD is however understood to be releasing soon an update to its 1984 publication "Climate of Karnataka" with the specific objective to investigate climatic changes observed.

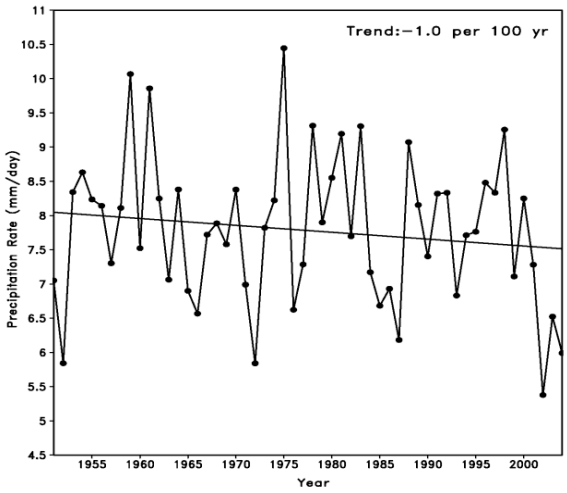

Figure 3: Precipitation trend during the monsoon season (Jun. to Sep.) over the area 11.5-18.5°North, 74.0–78.5°East[6]

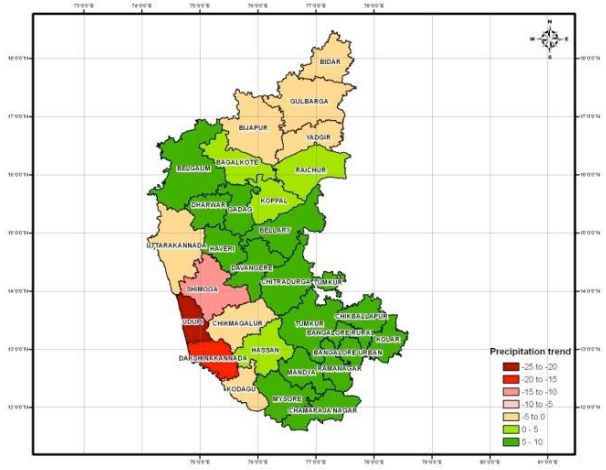

Figure 4: Precipitation trend (mm/day per 100 yr) of southwest monsoon season (Jun. to Sep.) for the period 1971-2005[7]

Figure 5 and Figure 6 show projections of BCCI-K (2011) of the change in annual rainfall for the summer monsoon season. The north-eastern and south-western parts of the state are projected to experience a decrease in the overall rainfall.

[1] Providing Regional Climates for Impacts Studies developed by the Hadley Centre, Met Office, United Kingdom

[2] BCCI-K (2011). Karnataka Climate Change Action Plan; Final Report

[3] BCCI-K (2011). Karnataka Climate Change Action Plan; Final Report

[4] India Meteorological Department (IMD), Pune (2011). Comments on "Impact of global warming and climate change in Karnataka"; Letter dated March 28, 2011

[5] India Meteorological Department (IMD), Bangalore (2011). Consultation held on November 3, 2011

[6] BCCI-K (2011). Karnataka Climate Change Action Plan; Final Report

[7] BCCI-K (2011). Karnataka Climate Change Action Plan; Final Report

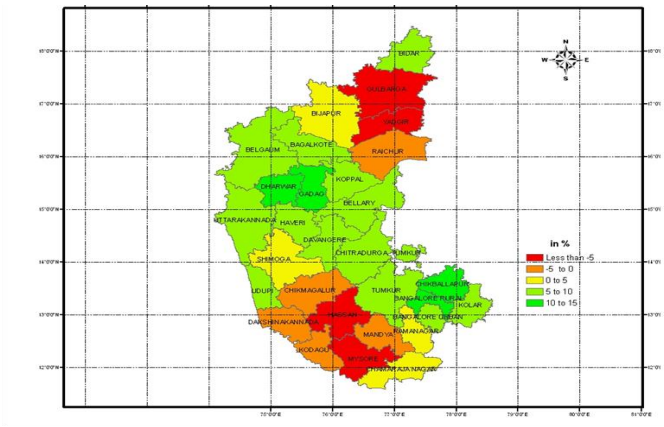

Figure 5: Projected change in annual rainfall for the period 2021-50 (A1B)[1]

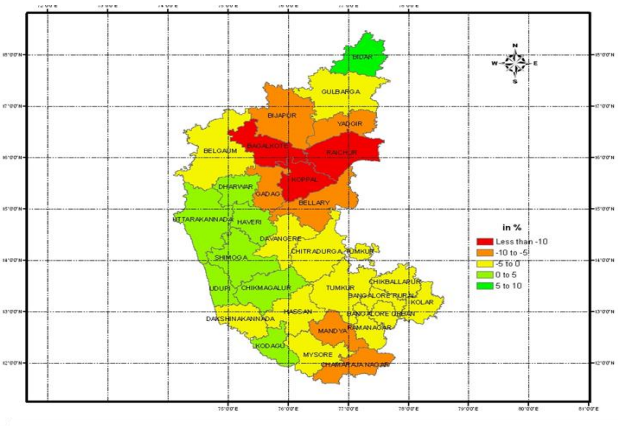

Figure 6: Projected change in Jun, Jul, Aug and Sep rainfall for the period 2021-50 (A1B)[2]

Table 5: Projected change in rainfall for 2021–50 (A1B), compared to the baseline of 1961–90 [3]

District	Change projected for JF months (%)	Change projected for MAM months (%)	Change projected for JJAS months (%)	Change projected for OND months (%)	Change in annual mean projected (%)
1. Bagalkote	-35.42	43.65	-10.47	16.87	1.38
2. Bangalore Rural	3.05	36.30	-2.31	9.61	3.56
3. Bangalore Urban	-15.11	29.92	-2.89	10.14	3.66
4. Belgaum	-6.25	20.34	-1.32	20.00	6.15
5. Bellary	-14.47	36.16	-8.11	6.87	0.52
6. Bidar	-71.30	22.29	6.89	50.76	27.03
7. Bijapur	-50.81	39.41	-9.81	12.54	0.60
8. Chamarajanagar	-8.51	16.55	-8.40	1.56	-1.85
9. Chikkaballapur	50.17	17.40	-2.40	3.21	0.97
10. Chikkamagalur	-44.13	2.86	0.14	11.63	3.62
11. Chitradurga	0.94	22.76	-3.98	14.46	6.50
12. Dakshina Kannada	-34.37	2.08	-0.43	8.28	0.87
13. Davanagere	0.00	24.07	-1.84	14.20	6.57
14. Dharwad	0.00	30.55	0.06	9.94	3.71
15. Gadag	0.00	37.48	-6.79	12.42	1.93
16. Gulbarga	-63.11	12.77	-1.44	9.49	4.26
17. Hassan	-53.02	-3.39	-3.72	11.94	2.45
18. Haveri	0.00	12.28	1.91	10.87	5.80
19. Kodagu	-30.65	-7.33	0.97	6.61	2.53
20. Kolar	4.80	22.75	-3.57	4.90	1.08
21. Koppal	-2.08	45.19	-12.35	8.81	-1.56
22. Mandya	-20.00	4.57	-7.00	10.40	1.40
23. Mysore	-22.93	-2.68	-4.91	2.90	-0.78
24. Raichur	-4.17	20.50	-10.99	-7.59	-6.79
25. Ramanagara	-21.75	22.77	-4.87	10.27	2.85
26. Shimoga	-12.50	10.55	4.31	8.03	5.27
27. Tumkur	13.76	21.77	-3.95	14.26	5.22
28. Udupi	-10.71	25.93	2.43	9.51	4.07
29. Uttara Kannada	0.00	10.62	4.87	6.80	5.40
30. Yadgir	-65.04	19.32	-7.14	-5.22	-4.07

[1] BCCI-K (2011). Karnataka Climate Change Action Plan; Final Report

[2] BCCI-K (2011). Karnataka Climate Change Action Plan; Final Report

[3] BCCI-K (2011). Karnataka Climate Change Action Plan; Final Report

Table 5 details the variation in annual rainfall for the districts of Karnataka in the SRES A1B scenario as projected by BCCI-K (2011). Precipitation during June, July, August and September is expected to reduce in almost all districts except Bidar, Chikkamagalur, Haveri, Kodagu, Shimoga, Udupi and Uttara Kannada.

Figure 7 compares projections of different global circulation models (GCMs) made by BCCI-K (2011). The study rightly observes that the HadCM3 results nearly approximates the average of all models taken together (see "All_GCM_avg"), at least over the next four decades, thus lending support to the selection of the HadCM3 over others.

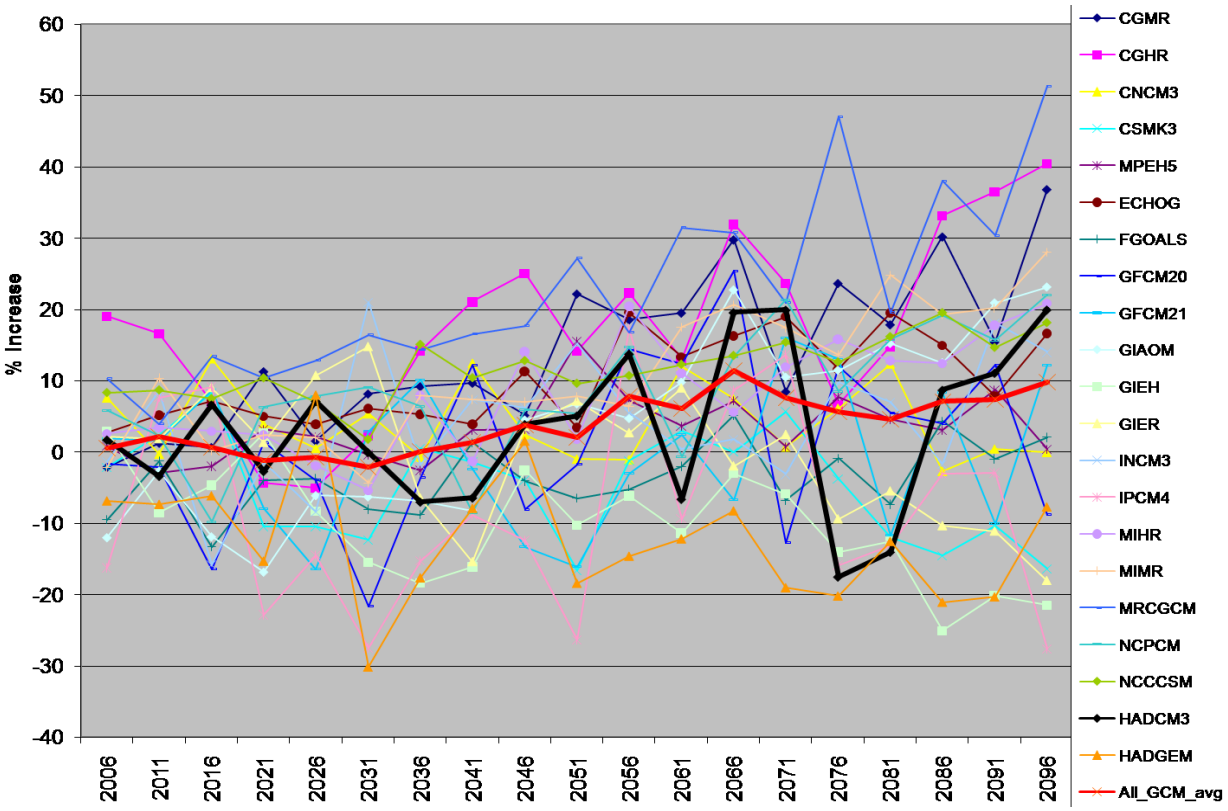

Figure 7: Projected change in rainfall in Karnataka with respect to 1975 (A1B)[1]

2.5.2. Temperature

A warming trend in Karnataka for the period June to September was observed by BCCI-K (2011). Districts of northern interior Karnataka (Bidar, Bijapur, Gulbarga, Yadgir and Raichur) experienced an increase of both the minimum and the maximum temperature by ≥ 0.6°C over the last 100 years (see Figure 8 and Figure 9). In terms of magnitude, this finding is 0.1°C higher than the 0.5°C annual increase IMD observed over the past 100 years for most parts of the country.[2]

The study also projects further warming: 1.7°C to 2.2°C by the 2030s. The projected increase of annual average temperatures for the northern districts is higher than the southern ones. Projected minimum temperature increases are slightly above those of the maximum temperatures (refer Table 6, Figure 10 and Figure 11).

[1] BCCI-K (2011). Karnataka Climate Change Action Plan; Final Report

[2] India Meteorological Department (IMD), Pune (2011). Comments on "Impact of global warming and climate change in Karnataka"; Letter dated March 28, 2011

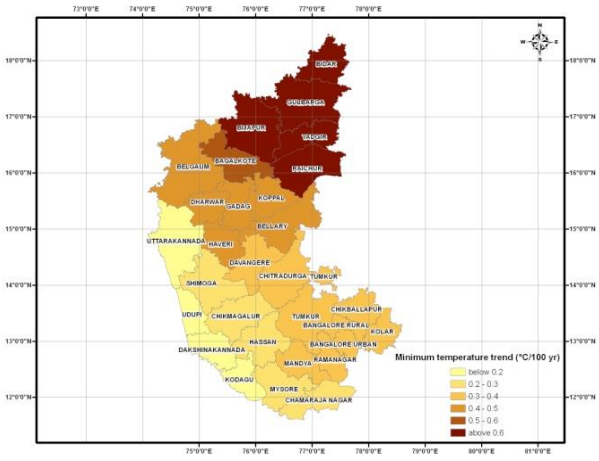

Figure 8: Minimum temperature trend in °C for Jun. to Sep. for the period 1901-2002[1]

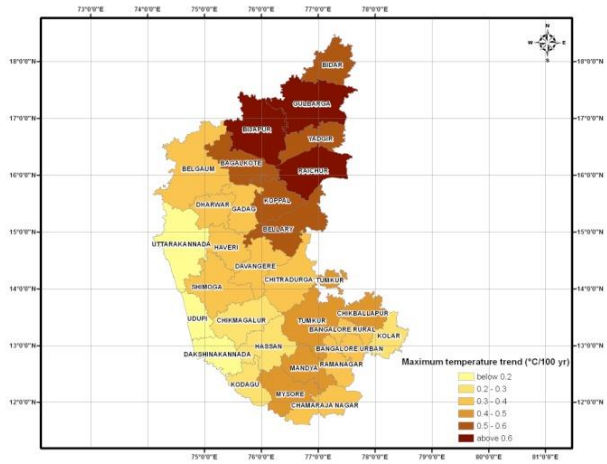

Figure 9: Maximum temperature trend in °C for Jun. to Sep. for the period 1901-2002[2]

Table 6: Projected change in annual temperature for 2021–50 compared to 1961–90 (A1B)[3]

	District	Projected change t_{AVG} in °C	Projected change t_{MIN} in °C	Projected change t_{MAX} in °C
1.	Yadgir	2.21	2.34	2.10
2.	Bijapur	2.20	2.32	2.11
3.	Raichur	2.20	2.31	2.12
4.	Gulbarga	2.19	2.33	2.04
5.	Bagalkote	2.15	2.25	2.10
6.	Koppal	2.14	2.21	2.09
7.	Bidar	2.12	2.30	1.93
8.	Bellary	2.08	2.16	2.03
9.	Gadag	2.08	2.15	2.05
10.	Belgaum	2.01	2.11	1.98
11.	Chitradurga	2.00	2.07	1.97
12.	Dharwad	2.00	2.08	1.97
13.	Mandya	1.99	2.03	2.00
14.	Tumkur	1.99	2.06	1.96
15.	Chikkaballapur	1.98	2.06	1.91
16.	Davanagere	1.98	2.05	1.98
17.	Bangalore Rural	1.97	2.06	1.91
18.	Haveri	1.97	2.04	1.97
19.	Ramanagara	1.97	2.05	1.92
20.	Bangalore Urban	1.96	2.06	1.88
21.	Chamarajanagar	1.96	2.03	1.94
22.	Kolar	1.96	2.06	1.87
23.	Mysore	1.95	1.99	1.98
24.	Hassan	1.92	1.96	1.95
25.	Shimoga	1.88	1.95	1.91
26.	Uttara Kannada	1.87	1.96	1.86
27.	Chikkamagalur	1.86	1.93	1.89
28.	Kodagu	1.79	1.86	1.81
29.	Dakshina Kannada	1.72	1.81	1.71
30.	Udupi	1.71	1.78	1.72

[1] BCCI-K (2011). Karnataka Climate Change Action Plan; Final Report

[2] BCCI-K (2011). Karnataka Climate Change Action Plan; Final Report

[3] BCCI-K (2011). Karnataka Climate Change Action Plan; Final Report

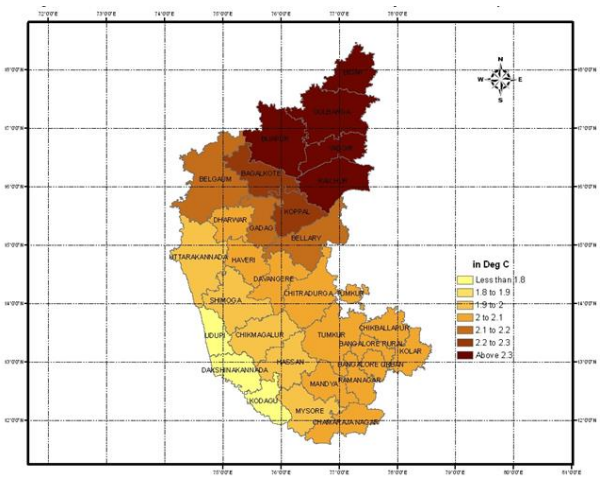

Figure 10: Projected increase in annual minimum temperature for 2021-50 compared to 1975 (A1B)[1]

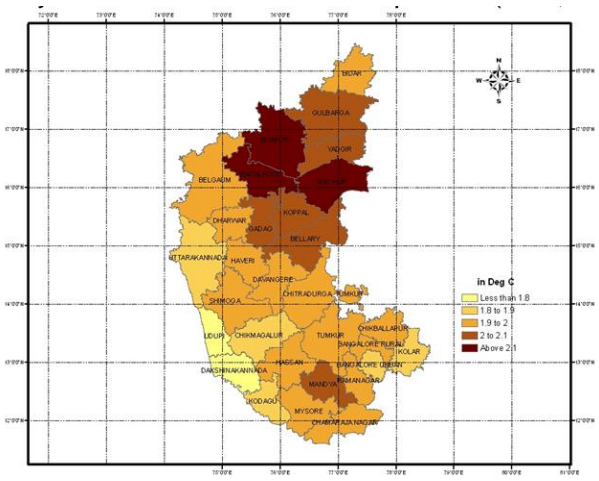

Figure 11: Projected increase in annual maximum temperature for 2021-50 compared to 1975 (A1B)[2]

As was done in the case of precipitation, BCCI-K (2011) also compared the HadCM3 results with that of other global circulation models. As Figure 12 shows, the results of others and the overall average (see "All_GCM_avg") are in close proximity to the initial HadCM3 projections, not just for the first four decades as in the case of precipitation but for almost the entire projection period.

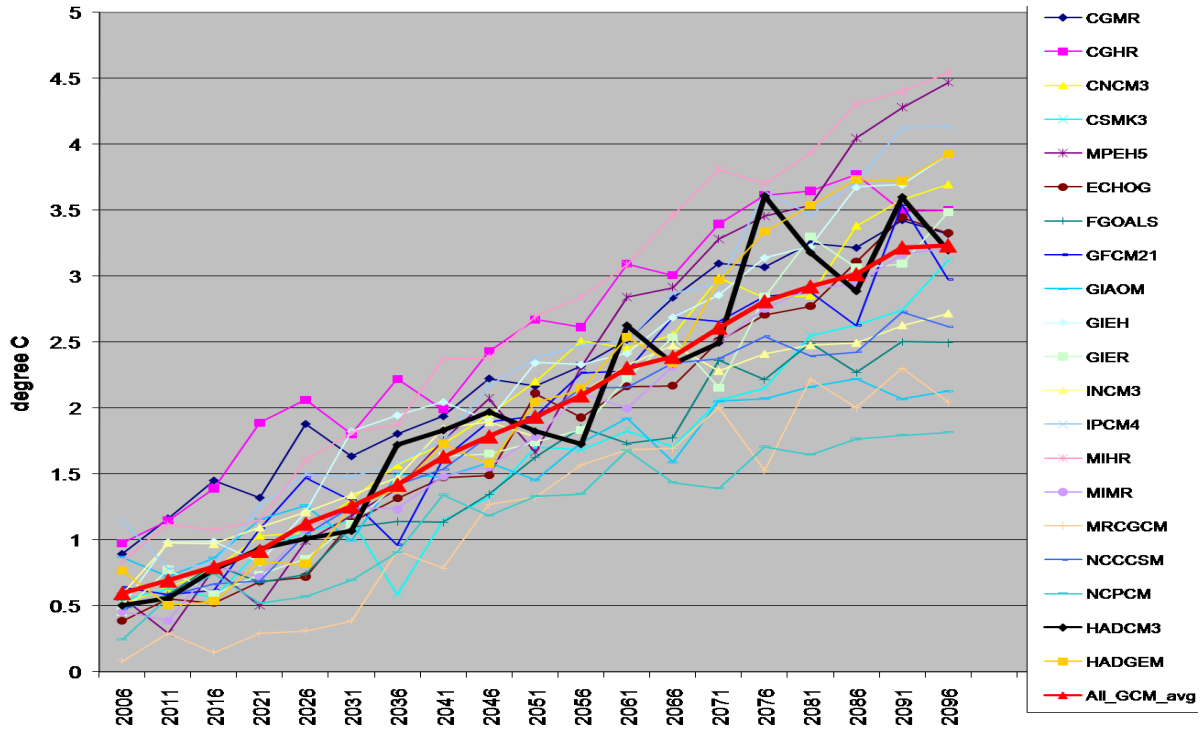

Figure 12: Projected temperature change for Karnataka relative to 1975 (A1B)[3]

[1] BCCI-K (2011). Karnataka Climate Change Action Plan; Final Report

[2] BCCI-K (2011). Karnataka Climate Change Action Plan; Final Report

[3] BCCI-K (2011). Karnataka Climate Change Action Plan; Final Report

In another study, Anandhi (2010)[1] selected monthly sequences of variables from data sets of National Centres for Environmental Prediction (NCEP) using the CGCM3 model of the Canadian Centre for Climate Modelling and Analysis. Seasonal stratifications were reviewed based on the selected predictors using a k-means clustering technique. The results of cluster analysis reveale an increase in the average wet season length in the SRES A2,[2] SRES A1B and SRES B1[3] scenarios towards the end of 21st century. The increase in season length was higher for the SRES A2 scenario and least for the SRES B1 scenario. However, no change in average warm and cold season length was observed across the four scenarios considered.

2.5.3. Droughts

Drought is an extended period, spanning months or years, witnessing deficiency in precipitation. Generally this occurs when a region receives consistently below average precipitation. Agricultural droughts are associated with the impact of meteorological conditions, focusing on precipitation shortages, differences between actual and potential evapo-transpiration, soil water deficits and reduced groundwater levels. For hydrological droughts precipitation shortfalls are linked to surface or subsurface waters. The frequency and severity of hydrological drought is often defined on a watershed basin scale. Drought is a threat to reckon with as two thirds of the state receive less than 750 mm rainfall per annum.

In terms of area prone to drought, Karnataka ranks second in India after Rajasthan. 54% of the geographical area is drought prone, affecting 88 of 176 taluks and 18 of the 30 districts. Taluks that have had droughts in 25% or more years are Chitradurga, Hosadurga, Sira, Madhugiri, Shorapur, Athani and Bagepalli. Taluks with the greatest percentage of drought years are Sira, Madhugiri, Korategere, Kadur, Kushtagi, Shorapur, Shahapur, Yadgir, Bangarpet, Mulbagal, Srinivasapur, Gudibanda, Bagepalli, Athani, Raibag, Saundatti and Gokak. The taluks of the northern drought-prone districts have in general, more years of moderate and severe drought than the taluks in the southern districts. There are some taluks in which drought occurred in three or more consecutive years. The largest continuous period of drought was eight years at Gubbi (Tumkur district) from 1920-27, at Athani (Belgaum district) from 1965-1972, at Chincholi (Gulbarga district) from 1965-72 and at Nargund (Dharwad district) from 1920-27.[4]

BCCI-K (2011) for their study defined as incidence of severe drought a period of absence of rainfall (daily less than 2.5 mm) for 40 or more continuous days. An increase in droughts was projected for the period 2021 to 2050 for the two growing seasons *kharif* and *rabi*. The results, as shown in Figure 13, indicate that most northern districts of Karnataka would have 10-80% increased drought incidences. For Koppal and Yadgir districts drought incidence during *kharif* season is projected to nearly double. For the eastern districts drought frequency has been projected to increase in the *rabi* season. The western parts of the state however may face a lesser number of droughts due to the projected increase in rainfall.

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[1] Anandhi, A. (2010). Assessing impact of climate change on season length in Karnataka for IPCC SRES scenario. Journal of Earth System Science, 119 (4), 447-460

[2] Member of the family of greenhouse gas scenarios formulated by IPCC's Special Report on Emission Scenarios (2000). It stands for rapid regionally oriented economic development

[3] Member of the family of greenhouse gas scenarios formulated by IPCC's Special Report on Emission Scenarios (2000). It stands for global environmental sustainability

[4] Ramachandra, T.V. and Kamakshi, G. (2005). Bio-resource potential of Karnataka. Technical Report No. 109. Centre for Ecological Sciences, IISc, Bangalore, India

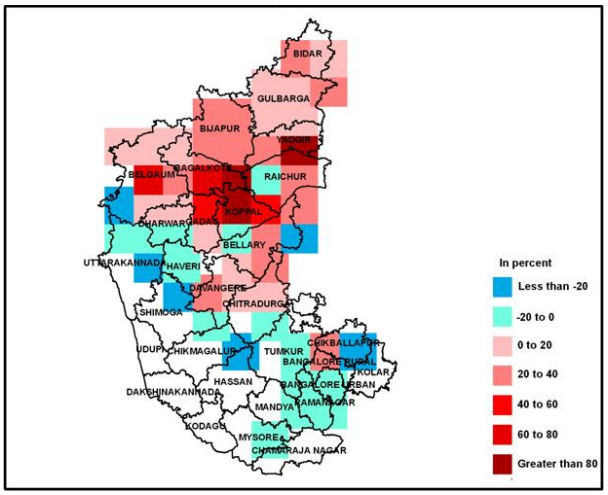

Figure 13: Projected increase in drought incidence in the *kharif* season for 2021-50 based on 1961-90 data[1] (A1B)[2]

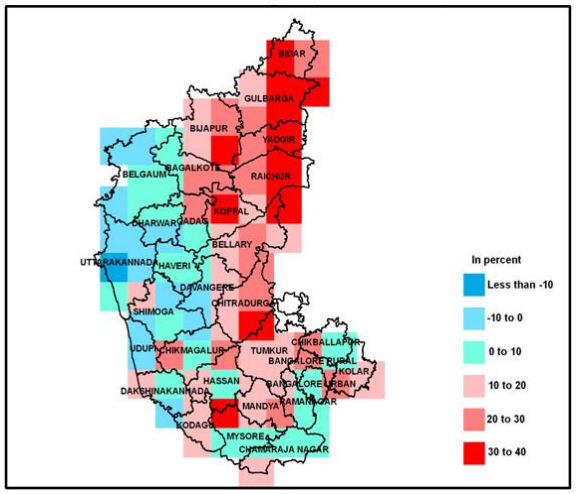

Figure 14: Projected increase in drought incidence in the *rabi* season for 2021-50 based on 1961-90 data[3] (A1B)[4]

2.5.4. Conclusions

It emerges from the discussions in this chapter that a changing weather pattern could severely impact the overall wellbeing of the state. The projected increase in rainfall and temperature is expected to cause changes in the cropping pattern and production, affect the availability of water and cause changes in the biodiversity profile of the state. It would possibly also reduce carbon sinks, affect the coastal zone due to sea level rises and higher water temperatures and lead to unemployment and migration of coastal communities. The transmission window for vector borne disease may widen. It is thus imperative to carefully analyse potential impacts of climatic changes, identify the most vulnerable sectors and increase preparedness and enhance resilience of the state to cope with changes.

Very few studies have been conducted that project changes in rainfall and temperature for Karnataka. From BCCI-K (2011) it is inferred that an overall reduced precipitation and continuous warming is a possible, perhaps probable scenario Karnataka may experience in decades to come. It is predicted that regions which already witness less rainfall and higher temperatures, such as northern Karnataka, will further experience lesser rainfall and an increase in average temperatures.

However it should be noted that the weakness of projections lies in the fact that models – as have been used to generate projections – have a strong tendency to amplify present climate viabilities, manmade or natural, over decades to come. The results should therefore be seen as a possibility whose likelihood and timeframes remain to be reassessed. In the face of existing knowledge gaps and uncertainties involved in projections at hand, it would be inappropriate to paint an alarmist picture at this juncture. While the projections are arguably worrisome, further rigorous studies, especially of longer-term nature, need to be commissioned and results thoroughly compared to obtain a clearer understanding where, how and when climatic changes are unfolding in Karnataka. Until fur-

[1] BCCI-K (2011). Karnataka Climate Change Action Plan; Final Report

[2] Assumed but not explicitly stated in source

[3] BCCI-K (2011). Karnataka Climate Change Action Plan; Final Report

[4] Assumed but not explicitly stated in source

ther and more reliable projections are available, a rush into drastic actions appears impulsive. Nevertheless, besides the need for further studies, it emerges with great clarity that that an improvement of institutional preparedness is both desirable and necessary. Even in the event of climatic changes unfolding at levels well below current predictions, this would strengthen the capacity of the state to pursue sustainable development in respect of vital resources such as water, land and biodiversity.

2.6. Actions, policies and institutional preparedness

2.6.1. Disaster management

Realising the importance of disaster management as national priority, Government of India (GoI) set up a high power committee in 1999 and another committee after the Gujarat 2002 earthquake for making recommendations on the preparation of disaster management plans. In 2005 GoI legislated the Disaster Management Act that prescribes the creation of an apex body, the National Disaster Management Authority (NDMA). Its purpose is to create an enabling environment for institutional mechanisms at state and district levels.[1] Government of Karnataka (GoK) developed an institutional framework to deal with natural disasters by forming several bodies.

▶ The **Karnataka State Disaster Management Authority**, headed by the Chief Minister, lays down the policies and prepare plans at state level.[2] It is entrusted with finalising and implementing a comprehensive disaster management plan. Although the authority was established only in or after 2008, it was already reconstituted in 2010.[3]

▶ The **Weather Watch Committee**, chaired by the Development Commissioner and ex officio Additional Chief Secretary, supervises the Calamity Relief Committee (CRF) and the subcommittees for the actions to be taken on priority basis.

▶ The **Empowered Committee**, chaired by the Chief Secretary, reviews and monitors the flood situation and the implementation of relief measures, rehabilitation plans in flood affected areas, approval and releases of funds for the purpose.

▶ The **Calamity Relief Committee (CRF)**, also chaired by the Chief Secretary, provides guidelines for calamity relief work and monitors and supervises the relief programme.

▶ The **State Executive Committee**, also chaired by the Chief Secretary, coordinates and monitors the implementation of the national policy, the national plan and the state plan and acts as coordinating and monitoring body for the disaster response in the state.

▶ The **District Level Implementation Committee**, chaired by the District-in-Charge Principal Secretaries or Secretaries, plans and supervises relief and rehabilitation programmes for flood affected areas in districts.

▶ The **District Disaster Management Authorities** are the district planning, coordination and implementation body for disaster management.

In 2001, before NDMA came into existence, Karnataka had had set up the Centre for Disaster Management at Administrative Training Institute (ATI), Mysore with funds from Ministry of Home Affairs and National Institute of Disaster Management (NIDM).

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[1] National Disaster Management Authority. http://ndma.gov.in/ndma/evolution.html accessed February 18, 2012

[2] Department of Revenue (2011). State action plan on climate change Karnataka – Initiatives in the field of Disaster Risk Reduction; submitted March 10, 2011

[3] The Hindu, Bangalore edition (June 11, 2010). Disaster response force for State

Through this centre GoK commenced training of government personnel, NGOs, elected representatives and civil society in operational management of both manmade and natural disasters. A similar mandate was later extended to ATI who prepared the first Karnataka Disaster Management Plan in 2010.

Now every district is believed to have its own Disaster Management Plan. Risk assessments for these were carried out using hazard mapping, including flood and drought vulnerabilities, with the help of resource inventories from the National Disaster Management Plan. Annual updation of these plans is required. Planning and capacity building for framing and implementation of the plan are funded by Revenue Department, which also strengthens the Emergency Operation Centres at the state, district, taluk and Panchayat levels.[1] For each natural disaster[2] separate standard operating procedures (SOPs) are under preparation. For manmade disasters (chemical, biological, radiological and nuclear) SOPs are also said to be under preparation.[3] An Andhra Pradesh-based institute, Emergency Management Research Institute (EMRI), has been signed up in August 2008 to help GoK improve its emergency response through provision of medically equipped emergency vehicles for villages. 150 of these have been inducted in the first phase for a budget of INR 20 core.[4] GoI has allocated INR 4 crore per annum for Karnataka for the State Disaster Relief Fund for the period 2010 to year 2015. An equal amount is also provided for capacity building.[5]

2.6.2. Drought and weather monitoring

Karnataka has the distinction of being India's first state to establish a Drought Monitoring Cell (DMC). Since 1988 it has been monitoring drought conditions to which the state is historically prone (refer to section 2.5.3). Realising the importance of monitoring other disasters such as floods, cyclones, tsunamis as well, the mandate of the cell was expanded in 2007, a change which is reflected in its new name Karnataka State Natural Disaster Monitoring Centre (KSNDMC).[6]

Among other things, the centre monitors rainfall, humidity, reservoir levels and flood levels. Monitoring stations are located in 747 *hoblis* and 750 Gram Panchayats and data is transmitted every 15 minutes to servers in Bangalore. As and when certain parameters exceed thresholds, severe whether conditions are transmitted in real-time. In its weekly briefing to the Weather Watch Committee, KSNDMC provides a detailed picture of weather conditions and advises higher-level decision-making bodies. In late 2011 the centre opened its Master Control Centre at Yelahanka, Bangalore to analyse real time data from telemetric rain gauges, satellites and GPRS-linked weather stations, Doppler weather radars, storm surge stations, earth quake monitoring stations 24x7 around the year. The centre also provides input for weather-based disaster risk reduction for farmers and an early warning system for weather related hazards for the crop insurance.[7]

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[1] Department of Revenue (2011). Points for interactive session on climate change; submitted on Mar 10, 2011

[2] Floods, droughts, earthquakes, forest fires, land slides and cyclones

[3] Department of Revenue (2011). Consultation held on March 10, 2011

[4] Department of Planning, Programme Monitoring and Statistics (2011). Economic Survey of Karnataka 2010-11

[5] Department of Revenue (2011). Points for interactive session on climate change; March 10, 2011

[6] Department of Revenue (2011). State action plan on climate change Karnataka – Initiatives in the field of Disaster Risk Reduction; Working paper March 10, 2011

[7] Department of Revenue (2011). State action plan on climate change Karnataka – Initiatives in the field of Disaster Risk Reduction; Working paper, March 10, 2011

2.6.3. Drought proofing

As a measure for drought proofing, the Department of Rural Development and Panchayat Raj promotes rainwater harvesting and sprinkler irrigation systems under the National Rural Employment Guarantee Act (NREGA). Quantitive achievements or the period of implementation were not available during discussions held. To help coping with the scarcity of drinking water, the department reverts to a diversion of canal water into small tanks used for storing drinking water. Also flood control measures are implemented under the scheme, focusing on the creation of *nallas*, establishments of drinking water tanks and construction of shelters for people in flood-prone areas. Implemented partly with funds of NREGA, GoK bears material, labour and administrative costs. Around 1 lakh houses in 80 villages have been identified as flood prone. An initiative has commenced to shift these dwellings out of affected areas but the allotment of suitable land is reportedly held up by conflicts with forest conservation.[1]

Faced with droughts, GoK pioneered the introduction of cloud seeding in the early '80s. The early results were controversial with critics claiming they had little verifiable impact.[2] However, in 2003, having faced droughts for three consecutive years in certain parts, cloud seeding was re-initiated to induce rains in 15 affected districts with apparently satisfactory results.[3]

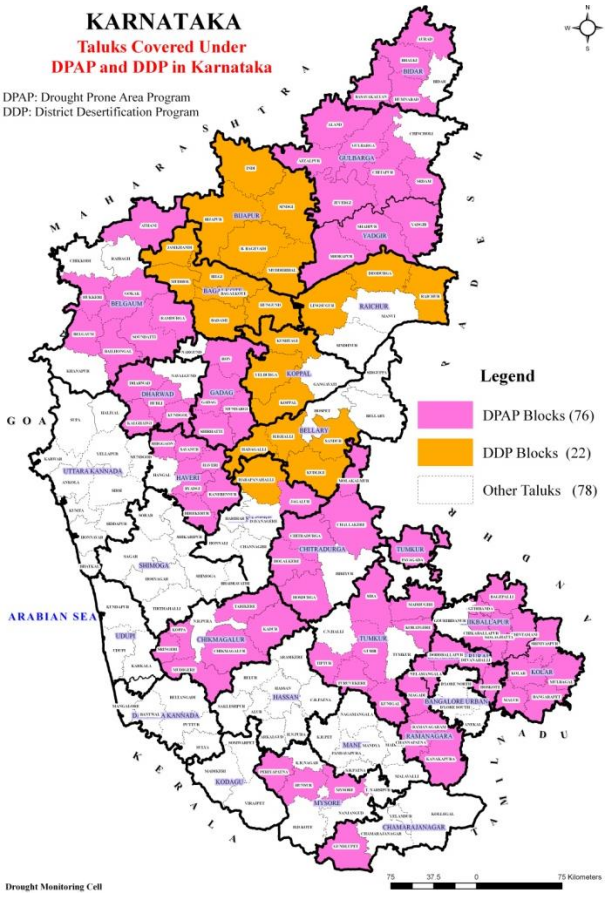

Figure 15: Taluks covered by the Drought Prone Area and District Desertification Programmes

[1] Department of Rural Development and Panchayat Raj (2011). Consultation held on March 9, 2011

[2] Hegde, Pandurang (2010). Clouds under attack; Article on www.d-sector.org accessed February 25, 2012

[3] Department of Forest, Ecology & Environment (2004). State of Environment Report Karnataka 2003

3. GHG EMISSIONS

Besides are carbon dioxide (CO_2) the main greenhouse gases (GHGs) include methane (CH_4), nitrous oxide (N_2O), sulphur hexafluoride (SF_6), hydrofluorocarbons (HFCs) and perfluorocarbons (PFCs). Increasing GHG concentrations in the atmosphere are changing the energy balance and send more infrared radiation to Earth, resulting in gradual global warming.

Carbon dioxide (CO_2) is the largest contributor to greenhouse gas emissions. Its levels rose from 280 parts per million (ppm) to 379 ppm between 1750 and 2005. In the same span, methane rose from 715 parts per billion (ppb) to 1,774 ppb.[1] The increase in CO_2 concentrations is primarily on account of the extensive consumption of fossil fuel paired with shrinking carbon sinks as a result of land-use changes. SF_6, HFCs and PFCs on the other hand are manmade and occur in the atmosphere only in traces. Their contribution to global warming however is still significant given their high global warming potential.

Table 7: Global warming potential of major gases[2]

Greenhouse gas	Global warming potential (SAR[3] value of 100-year time horizon)
Carbon dioxide (CO_2)	1
Methane (CH_4)	21
Nitrous oxide (N_2O)	310
Hydrofluorocarbons (HFC)	140 – 11,700
Perfluorocarbons (PFC)	6,500 – 9,200
Sulphur hexafluoride (SF_6)	23,900

India emitted 1,728 million tons of CO_2-equivalent[4] in 2007.[5] The energy sector is the largest contributor (58%) followed by industries (22%) and agriculture (17%). For Karnataka annual emissions of greenhouse gases are estimated to be around **80 million tons of CO_2-equivalent**,[6] accounting for 4.6% of India's emissions (refer Table 8).

Table 8: Greenhouse gas emissions of Karnataka

Greenhouse gas	Karnataka emissions in million t/a[7]	GWP (refer Table 7)	CO_2-eqivalent in million t/a
Carbon dioxide (CO_2)	58.770	1	58.77
Methane (CH_4)	0.886	21	18.61
Nitrous oxide (N_2O)	0.00853	310	2.64
Total			**80.02†**

† *The variance between the total and the value of 80.16 mn t/a at Table 9 are attributed to rounding*

1 IPCC (2007). 4th Assessment Report; The Physical Science Basis

2 IPCC (2007). 4th Assessment Report; The Physical Science Basis

3 Values of the 2nd Assessment Report (SAR) IPCC (1995) used for emission reporting under UNFCCC

4 GHG emissions are generally accounted for as CO_2-equivalent (or CO_2-eq for short). This is achieved by converting them into an amount of CO_2 having the same global warming effect.

5 MoEF and INCCA (2010). Climate Change and India: A 4x4 Assessment

6 BCCI-K (2011). Karnataka Climate Change Action Plan; Final Report

7 BCCI-K (2011). Karnataka Climate Change Action Plan; Final Report

3.1. Sectoral GHG emissions

More than 73% of Karnataka's GHG emissions are a result of fossil fuel consumption. As shown in Figure 16, the power sector is with 35.9% the single largest contributor. The state's well-developed transport sector contributes 10.4%. In the agriculture and waste sectors, GHG emissions consist largely of methane.

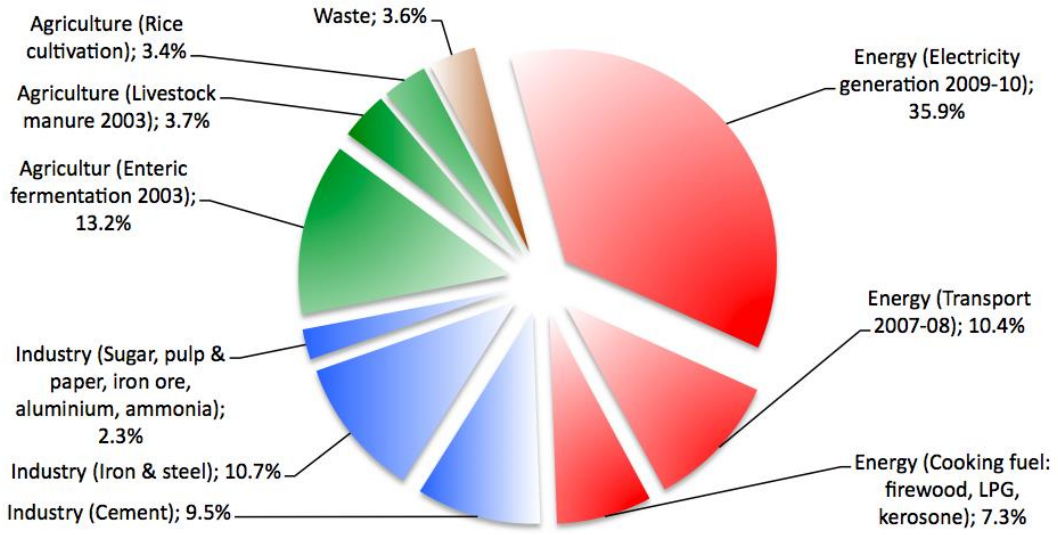

Figure 16: Sectoral breakup of Karnataka's GHG emissions (CO_2-eqivalent)[1]

Table 9: GHGs emission inventory of Karnataka[2]

Sector	Quantity		Emissions in million tons per annum			
			CO_2	CH_4	N_2O	CO_2-equivalent
Electricity Generation (2009-10)	11,495	MW	28.76	-	-	**28.76**
Transport (2007-08)	-	-	8.35	-	-	**8.35**
Residential (2007-08)	-	-	3.57	0.090	0.0012	**5.84**
Industry (2008-09)						
Cement	120.97	lakh t/a	7.64	-	-	**7.64**
Iron and steel	115.4	lakh t/a	8.59	-	-	**8.59**
Ammonia	2.36	lakh t/a	0.19	-	-	**0.19**
Aluminium	1.09	lakh t/a	0.18	-	-	**1.80**
Iron ore	423.14	lakh t/a	0.29	-	-	**2.91**
Pulp and paper	3.65	lakh t/a	0.38	-	-	**0.38**
Sugar	33.97	lakh t/a	0.82	-	-	**0.82**
Agriculture						
Enteric fermentation (2003)	25,617,000	animals	-	0.50	-	**10.54**
Livestock manure management (2003)	25,617,000	animals	-	0.04	0.00654	**2.93**
Rice cultivation (2007)	1.40	million ha	-	0.13	-	**2.75**
Waste	-	-	-	0.126	0.00079	**2.89**
Total			58.77	0.886	0.00853	**80.16**†

† *The variance between the total above and the value of 80.02 mn t/a at Table 8 are attributed to rounding*

[1] BCCI-K (2011). Karnataka Climate Change Action Plan; Final Report

[2] BCCI-K (2011). Karnataka Climate Change Action Plan; Final Report

A GHG inventory in line with the methodology prescribed by IPCC was not prepared for Karnataka yet. BCCI-K (2011) prepared what is believed to be the first comprehensive assessment for the state. However, two sectoral GHG inventories have been published by Karnataka State Pollution Control Board (KSPCB) earlier (refer to section 8.5.10).

3.2. Power

Karnataka's power sector emits **28.8 million tons CO_2-equivalent per year**[1] (2009-10). The sector accounts for 35.9% of the state's emissions (refer Table 9 at section 3.1).

An independent study by World Institute of Sustainable Energy (2010) computed CO_2 emissions from the power sector to be 30.6 million tons in 2010-11, slightly higher than BCCI-K's estimation. According their analysis (see Table 10), CO_2 emissions from coal power plants nearly doubled from 2006-07 to 2010-11. Emissions from private coal power plants increased seven fold in this period. Given that results are comparable in magnitude, the estimates of BCCI-K (2011) are used for this study to maintain integrity of data with that of other sectors.

Table 10: CO_2 emissions from fossil fuel based electricity generation in Karnataka[2]

Sectors	CO_2 emission (million tons per annum)			
	2006-07	2008-09	2009-10†	2010-11†
State coal	10.92	14.63	16.49	20.21
State diesel	0.54	0.54	0.54	0.54
Private coal	1.18	1.18	3.92	8.54
Private gas	0.78	0.78	0.78	0.78
Private diesel	0.50	0.50	0.50	0.50
Total	**13.93**	**17.64**	**22.23**	**30.57**

† Projection

3.3. Transport

The transport sector emits **8.4 million tons CO_2-equivalent per year**,[3] which account for 10.4% of the emissions of the state (refer Table 9 at section 3.1). Emissions arise from the combustion of petroleum products including petrol, diesel and aviation turbine fuel (ATF). The state recorded a rapid growth in the number of vehicles registered: 75.2 lakh in 2009 against 33.5 lakh in 2000.[4]

3.4. Household

The household sector emits a significant **5.8 million tons CO_2-equivalent per year**,[5] accounting for 7.3% of emissions of the state (refer Table 9 at section 3.1). BCCI-K (2011) arrived at this estimate considering LPG, kerosene and biomass consumption. Though biomass is considered carbon neutral, methane and nitrous oxide were taken into account. Data on biomass consumption in India, the share of population using bio-mass and the population of the state were used to estimate emissions. GHGs emissions

[1] BCCI-K (2011). Karnataka Climate Change Action Plan; Final Report

[2] WISE (2010). Clean Energy Technology Action Plan for Climate Mitigation for Karnataka

[3] BCCI-K (2011). Karnataka Climate Change Action Plan; Final Report

[4] WISE (2010). Clean Energy Technology Action Plan for Climate Mitigation for Karnataka

[5] BCCI-K (2011). Karnataka Climate Change Action Plan; Final Report

from electricity consumption in households are not been taken into account here as these are already covered under the power sector.

3.5. Industry

The industry sector emits **18.1 million tons CO_2-equivalent per year**,[1] contributing 22.6% to the state's overall emissions (refer Table 9 at section 3.1). The estimate prepared by BCCI-K (2011) considers the main energy consuming industry sectors: Cement, iron and steel, ammonia, aluminium, iron ore, pulp and paper and sugar industries. Emissions are arrived at considering production data and emission factors that were defined by IPCC. A point worth noting is that cement and iron and steel alone account for 90% of industrial emissions.

3.6. Agriculture and allied sectors

Because of the release of methane, agriculture and allied sectors are significant contributors to greenhouse gases. Methane is emitted from rice cultivation, from digestion processes of ruminants (enteric fermentation) and manure. Apart from N_2O emissions from manure, also agricultural soils emit N_2O, chiefly owing to the application of nitrogenous fertilizers, deposited manure, crop residues and sewage sludge.

Greenhouse gas emissions from the agriculture and livestock sector are estimated to be **16.2 million tons of CO_2-equivalent per year**[2] (refer Table 9 at section 3.1), contributing 20.2% to the state's emissions.

3.7. Waste

The anaerobic decomposition of waste generates methane while the protein contained in wastewater is responsible for the release of nitrous oxide. Considering only the urban population of 37% in the state in 2011, BCCI-K (2011) estimated that 70,000 tons of methane are emitted, assuming a per capita solid waste generation of 0.55 kg/d and person and assuming that only 70%[3] of the waste reaches landfill sites.[4] Treatment of sewage was estimated to generate around 19,000 tons of methane. However, since data on industrial effluents is unavailable, a total cannot be estimated in this way.

BCCI-K therefore proposed an approximation of the sector: 126,000 tons of methane and 0.79 tons of nitrous oxide per year. These were arrived at assuming Karnataka accounts for 5% of India's emissions (while section 3.1 shows that the actual value is 4.6%). Ignoring this minor deviation, the waste sector is estimated to emit **2.9 million tons of CO_2-equivalent per year**[5] (refer Table 9), contributing 3.6% to the state's emissions.

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[1] BCCI-K (2011). Karnataka Climate Change Action Plan; Final Report

[2] BCCI-K (2011). Karnataka Climate Change Action Plan; Final Report

[3] By contrast, as discussed in section 9.3.2, Directorate of Municipal Administration (DMA) holds that 91% of municipal solid waste is collected

[4] NEERI (2005). Assessment of Status of Municipal Solid Waste Management in Metro Cities, State Capitals, Class I Cities and Class II Towns

[5] BCCI-K (2011). Karnataka Climate Change Action Plan; Final Report

4. AGRICULTURE AND ALLIED SECTORS

Karnataka is divided in ten agro-climatic zones, taking into consideration the rainfall pattern, soil types, texture, depth and physio-chemical properties, elevation, topography, major crops and the type of vegetation (Figure 17). The state's rich and diverse agriculture contributes 28.6% to the Gross State Domestic Product (GSDP).[1] 64.6% of the geographical area of the state is under cultivation and farmers and agricultural labourers account for 56.5% of the Karnataka's workforce (Census 2001). Karnataka is the largest producer of coffee, raw silk, sandalwood, ragi (finger millet), sunflower, tomato and India's second largest producer of maize, safflower, grapes, pomegranate and onions. Horticultural crops with annual production of above 13 million tons, contributes to over 40% of the income from agriculture. In floricultural production, Karnataka occupies the second position in India.

1. **North Eastern Transition Zone**
   Pulses, *jowar*, oilseeds, *bajra*, cotton and sugarcane
2. **North Eastern Dry Zone**
   Rabi, *jowar*, *bajra*, pulses, oilseeds and cotton
3. **Northern Dry Zone**
   Maize, *bajra*, groundnut, cotton, wheat, sugarcane and tobacco
4. **Central Dry Zone**
   Ragi, *jowar*, pulses and oilseeds
5. **Eastern Dry Zone**
   (Ragi, rice, pulses, maize and oilseeds
6. **Southern Dry Zone**
   Rice, ragi, pulses, *jowar* and tobacco
7. **Southern Transition Zone**
   Rice, ragi, Pulses, *jowar* and tobacco
8. **Northern Transition zone**
   Rice, *jowar*, groundnut, pulses, sugarcane and tobacco
9. **Hilly Zone**
   Rice and pulses
10. **Coastal Zone**
    Rice and sugarcane

Figure 17: Agro-climatic zones of Karnataka

Table 11: Classification of land use in Karnataka[2]

Classification of land	Area in lakh ha	Classification of land	Area in lakh ha
Total geographical area	190.5	Uncultivated land	12.2
Forest	30.72	Fallow land	17.67
Land put to non-agricultural uses	13.6s9	Net area under sown	104.19
Barren and uncultivable land	7.88	Total cropped area	128.93
Cultivable waste land	4.15		

[1] Department of Planning, Programme Monitoring and Statistics (2010, 2011). Economic Survey 2009-10; 2010-11

[2] BCCI-K (2011). Karnataka Climate Change Action Plan; Final Report

70% of Karnataka's geographical area is classified as arid or semi arid. As of 2008-09, 32% of the cultivated area is irrigated.[1] The cultivable area of the state is 66.1%. This includes the net sown area (55.1%), cultivable wasteland (2.3%), current fallow lands (6.7) and other fallow lands (2.1%). Agriculture is mainly dependent on the southwest monsoon but spreads well over three seasons:

- ***Kharif*:** July to October; Accounting for 70% of the annual food grain and oilseed production; Major crops are millets, paddy, maize, pulses, groundnut, red chillies, cotton, soybean, sugarcane and *tumeric*; Cultivated area about 70 lakh hectares;
- ***Rabi*:** October to March; Accounting for 22% of the annual food grain and 15% of the oilseed production; Major crops are wheat, barley, mustard, sesame, and peas; Cultivated area about 30 lakh hectares;
- **Summer:** Accounting for 8% of the annual food grain and 15% of the oilseed production; Cultivated area about 6 lakh hectares.

The state mainly follows a rice-based cropping pattern. Major crop alternatives to rice are ragi, *bajra*, cotton, groundnut, *jowar* and maize.[2] Other important crops are wheat and minor millets and pulses like *tur*, Bengal *gram*, horse *gram*, black *gram*, green *gram*, cowpea etc. Oilseeds include groundnut, sesame, sunflower, soybean and sunflower. Commercial crops include sugarcane in the eastern region, cotton in the north-western region and tobacco. Cashew, coconut, areca nut (southern region), cardamom, and chillies are other important crops. The Western Ghats are well known for coffee and tea plantations while maize is grown mainly in the northern region of the state. Due to its climate, the coastal region is favourable for the cultivation of fruit orchards.

The area under cultivation of paddy, maize, pulses, sugarcane and tobacco has recorded exponential growth in the last five decades. While paddy increased from 10.28 lakh hectares in 1961 to 15.1 lakh ha in 2009, maize has seen a record increase from a mere 11,000 ha in 1961 to 12.9 lakh ha in 2009. *Jowar* saw a decrease in cultivation area from 29.7 lakh ha to around 17.8 lakh ha from 1961 to 2001. Over the past five decades, the net cropped area has seen a marginal decrease from 102.3 lakh ha (1961) to 101.7 lakh ha (2009) while the gross cropped area increased by nearly 17% from 105.9 lakh ha to 123.7 lakh ha in the same period.[3]

Horticulture covers 18.9 lakh ha with a production of 136.6 lakh tonnes. Fruits (mango, banana, papaya, grapes, *sapota* etc.) contribute 41.9%; vegetables (potato, tomato, onion, *brinjal* etc.) 45.3%; spices (ginger, dry chillies etc.) 6.1%; while the rest is shared by plantation crops (coconut, areca nut etc.) and flowers (marigold, jasmine, rose etc.).

Table 12: Horticultural crops in Karnataka (lakh hectares)[4]

Crops	2007-08	2008-09	2009-10	Crops	2007-08	2008-09	2009-10
Fruits	2.99	3.15	3.32	Cashew	0.7	0.73	0.76
Coconut	4.60	4.69	4.79	Flowers	0.25	0.26	0.27
Spices	2.46	2.54	2.63	Others	2.37	2.41	2.44
Vegetables	4.27	4.48	4.70				

[1] Department of Planning, Programme Monitoring and Statistics (2011). Economic Survey 2010-11

[2] www.krishiworld.com/html/crop_pattern2.html accessed on February 18, 2012

[3] Department of Planning, Programme Monitoring and Statistics (2011). Economic Survey 2010-11

[4] Department of Planning, Programme Monitoring and Statistics (2011). Economic Survey 2010-11

4.1. Cropping pattern changes

The introduction of high yielding varieties (HYVs) has progressively reduced the cultivated area for traditional varieties in the state. This resulted in the extinction of few local varieties. Traditional varieties of paddy, banana, mango and vegetables with distinct taste and aroma have high nutritional values and disease resistance. Landraces of many crops have provided the genes needed for pest and disease resistance or for the crops to adapt to poor soils, drought and cold temperatures.

BCCI-K (2011) collected data on the production, area under crop and productivity for major crops in the districts of Karnataka and analysed trends. Based on their study, a trend in the cropping pattern in the state emerges as shown at Table 13 and Table 14.

Table 13: Area, production and productivity trends of 5 crops (1955–2008)[1]

Districts[2]	Rice			Maize			*Jowar*			Ragi			Cotton		
	Area	Production	Productivity	Area	Production	Productivity	Area	Production	Productivity	Area	Production	Productivity	Area	Production	Productivity
Bagalkote	↑	↓	↓	↑	↓	↓	↑	↑	↓	↑	↑	↓	↓	↑	↑
Bangalore Urban	↑	↓	↓	↑	↑	↓	-	-	-	↓	↓	↓	-	-	-
Bangalore Rural	↓	↑	↓	↑	↑	↑	-	-	-	↓	↑	↓	-	-	-
Belgaum	↔	↓	↓	↑	↑	↓	↔	↑	↑	↓	↑	↑	↓	↑	↓
Bellary	↑	↓	↓	↑	↑	↓	↓	↑	↑	↑	↓	↓	↑	↓	↓
Bidar	↓	↓	↓	↑	↑	↑	↓	↑	↑	↓	↑	↑	↓	↑	↑
Bijapur	↓	↓	↑	↑	↑	↑	↓	↑	↑	↑	↑	↑	↓	↓	↑
Chamarajanagar	↔	↓	↓	↑	↑	↓	↑	↑	↓	↑	↑	↑	↓	↓	↑
Chikkamagalur	↔	↑	↑	↑	↑	↓	↑	↑	↑	↑	↑	↑	↑	↑	↓
Chitradurga	↓	↑	↔	↑	↑	↑	↔	↑	↑	↓	↑	↑	↓	↑	↑
Davanagere	↑	↓	↔	↑	↑	↑	↔	↑	↑	↓	↑	↑	↓	↑	↑
Dharwad	↑	↓	↓	↑	↓	↑	↑	↑	↑	↓	↑	↑	↓	↑	↑
Gadag	↑	↑	↑	↑	↑	↑	↓	↑	↑	↑	↑	↑	↓	↑	↑
Gulbarga	↔	↑	↑	↑	↑	↑	↓	↑	↑	↑	↑	↑	↑	↑	↑
Hassan	↓	↓	↓	↑	↑	↑	↑	↑	↓	↓	↑	↑	↓	↓	↓
Haveri	↓	↓	↓	↑	↑	↓	↓	↓	↓	↓	↑	↑	↔	↑	↑
Kodagu	↓	↑	↑	↑	↑	↑	↑	↑	↓	↔	↔	↑	↓	↑	↑
Kolar	↓	↑	↑	↑	↑	↑	↓	↓	↓	↓	↓	↑	↓	↓	↓
Koppal	↑	↓	↓	↑	↑	↑	↓	↓	↓	-	-	-	↓	↓	↓
Mandya	↔	↑	↑	↑	↑	↑	↓	↑	↑	↓	↑	↑	↓	↑	↑
Mysore	↑	↑	↑	↓	↑	↑	↓	↓	↑	↓	↑	↑	↑	↑	↔
Raichur	↑	↑	↑	↑	↑	↑	↓	↔	↔	↓	↓	↑	↑	↑	↑
Shimoga	↓	↑	↑	↑	↑	↑	↓	↓	↑	↓	↓	↑	↑	↑	↑
Tumkur	↓	↓	↓	↑	↑	↑	↑	↓	↓	↓	↑	↑	↓	↑	↑
Udupi	↓	↓	↓	↑	↑	↑	-	-	-	-	-	-	-	-	-
Uttara Kannada	↔	↑	↑	↑	↑	↓	↑	↑	↑	↓	↓	↑	↑	↑	↑

[1] BCCI-K (2011). Karnataka Climate Change Action Plan; Final Report

[2] In conformity with the fact that historical data sets are used, the source cited lists only 26 districts. Considering the subsequent creation of 3 districts by dividing existing ones and the addition of Dakshina Kannada, the table should be read as to include Ramanagara under Bangalore Rural, Chikkaballapur under Kolar, and Yadgir under Gulbarga.

Table 14: Area, production and productivity trends of 4 crops (1955–2008)[1]

District[2]	Red *gram*			Groundnut			Sunflower			Sugarcane		
	Area	Production	Productivity	Area	Production	Productivity	Area	Production	Productivity	Area	Production	Productivity
Bagalkote	↑	↓	↑	↓	↑	↓	↓	↑	↑	↓	↑	↓
Bangalore Urban	↑	↓	↓	↓	↓	↓	↑	↓	↓	-	-	-
Bangalore Rural	↔	↔	↑	↑	↓	↑	↑	↓	↓	-	-	-
Belgaum	↓	↓	↔	↓	↓	↑	↑	↔	↔	↑	↓	↓
Bellary	↓	↓	↓	↑	↓	↑	↑	↔	↔	↓	↑	↑
Bidar	↑	↓	↑	↓	↓	↔	↑	↑	↓	↓	↑	↑
Bijapur	↑	↔	↔	↓	↓	↔	↑	↑	↔	↑	↓	↓
Chamarajanagar	↓	↑	↑	↓	↓	↓	↑	↑	↑	↓	↑	↓
Chikkamagalur	↔	↔	↔	↔	↔	↔	↑	↓	↓	↓	↑	↑
Chitradurga	↓	↓	↑	↑	↑	↓	↑	↑	↓	↓	↑	↑
Davanagere	↓	↓	↑	↑	↑	↓	↑	↑	↓	↓	↑	↑
Dharwad	↑	↓	↓	↑	↓	↓	↑	↓	↓	↓	↑	↑
Gadag	↑	↑	↑	↓	↓	↑	↓	↓	↓	↑	↑	↑
Gulbarga	↑	↑	↑	↓	↓	↑	↑	↑	↑	↓	↑	↑
Hassan	↓	↔	↔	↔	↔	↔	↑	↑	↑	↓	↑	↑
Haveri	-	-	-	↓	↓	↓	↓	↑	↑	↓	↑	↑
Kodagu	↑	↑	↑	↓	↔	↑	↑	↑	↑	↓	↑	↑
Kolar	↓	↓	↔	↑	↑	↓	↑	↑	↓	↓	↑	↑
Koppal	↓	↑	↑	↓	↓	↓	↑	↑	↑	↓	↑	↑
Mandya	↓	↔	↔	↔	↔	↑	↑	↑	↑	↑	↑	↑
Mysore	↓	↑	↑	↔	↔	↔	↔	↔	↔	↑	↑	↑
Raichur	↔	↔	↔	↓	↓	↑	↑	↑	↑	↑	↑	↑
Shimoga	↓	↓	↓	↑	↑	↓	↔	↔	↔	↑	↑	↑
Tumkur	↑	↓	↓	↑	↑	↓	↑	↑	↔	-	-	-
Udupi	-	-	-	↓	↑	↑	-	-	-	↓	↓	↓
Uttara Kannada	↔	↔	↑	↑	↑	↑	↓	↓	↓	↓	↑	↑

According to the trend analysis of BCCI-K (2011), the overall production and yield of major crops increased since 2000-01. This trend is also somewhat reflected by the fact that Department of Agriculture received the 2011 national award for the best performance in the increase in production of core cereals.

4.2. Impact of dry spells and flash floods

Droughts affect agricultural production in the state to a great extent. In 2009, rainfed *kharif* crops such as *jowar*, maize, *bajra*, *tur*, green *gram*, black *gram*, groundnut, soybean and sunflower covering about 20.4 lakh hectares in major parts of northern and southern districts were affected by severe stress due to a dry spells lasting about 4-6 weeks between July and August 2009. However, widespread rainfall after the second

[1] BCCI- K (2011). Karnataka Climate Change Action Plan; Final Report

[2] In conformity with the fact that historical data sets are used, the source cited lists only 26 districts. Considering the subsequent creation of 3 districts by dividing existing ones and the addition of Dakshina Kannada, the table should be read as to include Ramanagara under Bangalore Rural, Chikkaballapur under Kolar, and Yadgir under Gulbarga.

fortnight of August and September helped in recovery of rainfed crops to some extent while crops recorded a clear decrease in yield.

On the other hand, Karnataka also witnessed heavy rainfall in 2009 in the coastal region, Malnad districts and major parts of north-interior Karnataka. The most affected districts were Raichur, Koppal, Bellary and Gulbarga. Preliminary estimates indicate the loss of *kharif* crops to be about 19.0 lakh hectares by submergence, deposition of silt, deterioration of grain quality. Similarly, *rabi* crops, about 3.0 lakh hectares sown in the second half of September were completely washed off in Bijapur district.

4.3. Decline of production and agro-biodiversity

Other trends indicate that the agriculture sector has not been performing very satisfactorily, causing distress in rural Karnataka. From 2000 onwards agricultural production has been varying. Reasons for decline are attributed to (1) shrinking land-man ratio, (2) depleting vegetation cover, (3) inadequate and unpredictable water resources, (4) high dependence on rainfall, and (5) increasing production costs.[1]

As Karnataka enjoys rich agricultural practices, the loss of agricultural biodiversity is of serious concern. Karnataka Biodiversity Board (KBB) has identified three hotspots of agro biodiversity namely the Cauvery basin, the coastal region and the leeward Deccan plateau. There are studies that indicate that as much as half of all plant species may disappear considering current trends. As per KBB estimates, approximately 6% of cereal crops, 85% of legume species and 13% of vegetables species are under threat of extinction.[2] It is acknowledged by KBB that the replacement of local varieties by improved or exotic varieties and species is the root cause of the genetic erosion of crops. Given that there is a increasing acceptance of genetically modified crops in the current scenario, it is feared that genetic erosion will expand further. There is a need to manage and conserve precious traditional crop varieties, which could become genetic contributors for drought and disease resistant varieties.

4.4. Projected impact of climate change

Available research points out that agriculture is the most vulnerable sector to climate change. The direct effects of climate include variability in temperature, precipitation, and carbon dioxide concentrations while changes in soil moisture content and increased frequency of pest infections and diseases are indirect affects. Various studies have been conducted to understand the impact of climate change on agriculture. As agriculture in Karnataka is mainly rain dependent, the variation in precipitation will alter the agriculture pattern and production to a significant degree.

Studies conducted so far indicate that any change (increase or decrease) in agricultural production is directly dependent on the scenario to which simulation/projection has been carried out. MoEF (2004)[3] studied the impact of 2010 climate change scenario on yields of rice, wheat and *sorghum* and projected that rice and *sorghum* yield will increase by 1.3-5.8% and 1.0-3.4% respectively in South India. Not only climate change factors but existing socio-economic systems and institutional support also influence the primary productivity in India and hence should be considered in assessing the vulnerability of agriculture to climate change. In order to categorise Karnataka in terms of vulnerability,

[1] EMPRI (2012). State of Environment Report Karnataka 2011

[2] Karnataka Biodiversity Board (2010). Biodiversity of Karnataka: At a Glance

[3] MoEF (2004). India's National Communication (NATCOM) to UNFCCC

O'Brien *et al* (2004)[1] reported that higher resilience to climate change and greater irrigation access make Chitradurga district least vulnerable while the north–eastern part of the state is almost twice as vulnerable to a changing climate due to lesser adaptive capacity. Northern inland Karnataka was also placed in the category of high vulnerability while the eastern parts show moderate vulnerability.

BCCI-K (2011)[2] studied in detail the impact of climate change on the major crops grown in Karnataka. Simulations were done with the InfoCrop model using the respective crop coefficients for each of the ten years from 1991 to 2000. The crops selected for the simulation were maize, *sorghum*, rice, red *gram*, cotton, potato, soybean and wheat. The mean of ten years' yield was taken as baseline. The actual crop yield in each district was compared with the predicted yield and the ratio computed. The rainfall and temperature projections described in section 2.5 Trends and projections were used as input. Apart from this, frequency of occurrence of climatic extreme events such as higher/low rainfall events and high temperature events were also taken in account. Based on the simulation study, the a vulnerability map emerges as presented in Table 15.

Table 15: Crops and districts projected vulnerable to declining productivity[3]

District	Rice (irrigated)	Rice (aerobic)	Maize	*Sorgum*	Red *gram*	Cotton	Potato	Soybean	Ragi	Wheat	Sugarcane
Bagalkote					■						
Bangalore Rural + Ramanagara							■	■			
Belgaum	■	■									
Bellary	■	■			■	■					
Bidar									■		
Bijapur			■								
Chamarajanagar	■										
Chikkamagalur		■	■	■		■	■				
Chitradurga						■		■			
Dakshina Kannada	■	■	■	■	■	■			■		■
Davanagere				■			■				
Dharwad	■					■					
Gadag						■					
Gulbarga + Yadgir		■							■		
Hassan	■			■			■				■
Kodagu	■	■	■		■	■					
Kolar + Chikkaballapur				■		■					
Mandya											■
Raichur	■				■					■	
Shimoga			■	■		■			■	■	
Tumkur			■	■				■			
Udupi			■	■	■						■
Uttara Kannada		■	■	■	■	■			■		■

Legend: ■ vulnerable

[1] O'Brien, K. et al (2004). Mapping vulnerability to multiple stressors: Climate change and globalization in India

[2] BCCI-K (2011). Karnataka Climate Change Action Plan; Final Report

[3] BCCI-K (2011). Karnataka Climate Change Action Plan; Final Report

Table 16: Projected productivity changes for Karnataka for major crops[1]

Crops	Projected net yield change in %	< 10 % increase in productivity and identified to increase in growing area	10% < 25% increase in productivity and identified increase in growing area
Rice	–0.3 (irrigated) –0.9 (rainfed)	Bagalkote, Bangalore Rural (+ Ramanagara), Chitradurga, Davanagere, Haveri, Kolar (+ Chikkaballapur), Tumkur	Bangalore Rural (+ Ramanagara), Dakshina Kannada, Udupi, Uttara Kannada, Raichur, Kodagu
Maize	+1.2	Bidar, Chitradurga, Davanagere, Gadag, Gulbarga (+ Yadgir), Haveri, Kolar, Mandya	Bangalore Rural (+ Ramanagara), Belgaum, Chamarajanagar, Mysore
Sorgum	+2.6	Bagalkote, Belgaum, Haveri, Raichur,	Bangalore Rural (+ Ramanagara), Bellary, Bidar, Chamarajanagar, Chitradurga, Gadag, Gulbarga (+ Yadgir), Kodagu, Mandya
Red *gram*	+1.3	Chamarajanagar, Hassan	Bangalore Rural (+ Ramanagara), Chikkamagalur, Chitradurga (upto 35%), Davanagere, Dharwad, Gadag, Haveri, Kolar, Mandya, Mysore, Shimoga
Cotton	+1.3	Bidar, Davanagere, Haveri	Bangalore Rural (+ Ramanagara), Belgaum, Bijapur, Mandya, Raichur, Tumkur
Potato	–14.0		
Soybean	–2.8		
Ragi	–5.8	Mysore, Hassan, Kolar (+ Chikkaballapur), Chitradurga, Davanagere, Haveri, Gadag	Chikkamagalur
Sugarcane	+2.6	Mandya, Shimoga, Belgaum	

BCCI-K (2011) found that *kharif* crops may witness greater changes in their productivity, spanning a range from a +9.5% gain to -14.4% loss from their base yields. A loss is projected for much of Karnataka's the irrigated rice (-8.2%) while yields in districts not presently growing rice may rise by +6.2%. The yield of rainfed rice may undergo changes between +7.2% (gain) to -13.8% (loss) with large regions losing up to -9.6%. Southwestern Karnataka however may gain as the yield of both irrigated and aerobic rice is projected to increase. Maize and sorghum yields are projected to change from +27.6 % to -19.3 % and +17.2 % to -18.4% respectively from their baseline yield. This is attributed mainly to property of C_4 carbon fixation.[2]

A rise in temperature will provide less opportunity for crop canopies to accumulate dry matter by accelerating the growth rates of the crops. This will result in reduced yield. Projections of MoEF and INCCA (2010) suggest that in the 2035s, higher temperatures and reduced sunshine may limit biomass production and yield as compared to baseline conditions. The estimated 2.1°C rise in mean temperature and a 4.5% increase in mean precipitation would reduce net agricultural productivity in the state by 1.2%. This sectoral and regional analysis for the 2030s also provides projections for possible changes in crop production in the western coastal areas of India.[3]

The simulation model InfoCrop was used to assess the impact of climate change scenarios under a SRES A1B scenario for the 2030s for four cereals (wheat, rice, maize and *sor-*

[1] BCCI-K (2011). Karnataka Climate Change Action Plan; Final Report

[2] BCCI-K (2011). Karnataka Climate Change Action Plan; Final Report

[3] MoEF and INCCA (2010). Climate Change and India: A 4x4 Assessment

ghum), two oilseeds (soybean and mustard), potato and coconut. The study reveals that as in most of the Western Ghats, the monsoon rainfall is likely to increase, the changes in temperature and rainfall would cause direct impacts on the production of *kharif* crops and due to heavy cloud cover cause low radiation. Any further increase in rainfall (more cloud cover) would result in reduced yields in the *kharif* season. Coconut yields are projected to increase by up to 30% in the majority of the coastal region. Increases in the coconut yield could be attributed to projected increases in rainfall (~10%), temperatures and to CO_2 fertilization benefits. However, regions such as south-west Karnataka, parts of Tamil Nadu and parts of Maharashtra may record up to 24% reduction in yield. The simulation also indicates that the productivity of irrigated rice in the Western Ghats region is likely to change by +5 to -11%. However, the yield of irrigated rice in parts of southern Karnataka is projected to increase. In case of rainfed rice, the projected change in yield is in the range of +35 to -35%. Further, climate change is also likely to reduce yields of maize and *sorghum* by up to 50% depending upon the region.

Considering the projected 4.5% increase in mean precipitation and rise in mean temperature predicted for the state, BCCI-K (2011) also estimated that Karnataka could witness a -2.5% decline in net agriculture production with a major reduction in coastal regions. Further, the study observed that state may record a -12.3% loss in food production due to climate change while enhanced CO_2 and temperature may cause significantly higher productivity (up to +35%) in certain districts.

4.5. Fisheries

Fisheries play an important role in food supply and livelihood security of fishermen communities living in coastal areas. The state of Karnataka contains rich fishery resources with a continental shelf of 27,000 km^2, about 320 km of coastline and 5.20 lakh hectares of inland water area. An additional 8,000 hectare of brackish water provides ample opportunities for shrimp farming. The total fishing folk population of the state is 7.67 lakh comprising of 2.76 lakh engaged in marine and 4.91 lakh in inland areas. The fish production of Karnataka was around 2 lakh tons in early 80s, grew to 3 lakh tons in mid 90s, further increased to 3.61 lakh tons in 2008-09 and reached 4.08 lakh tons in 2009-10 contributing about 4.8% of India's total fish production. The marine sector contributes 60% while the remaining 40% come from the inland sector (refer also to section 7.3).[1]

Due to lack of adequate simulation models in the fishery sector, there are no significant studies where impacts of climate change in respect of trends or projections. Hence the analysis and interpretation of past records related to fishing, change in weather and sea surface temperature is used to review the impact of climate change on fisheries.[2] Many tropical fish stocks are already exposed to high temperatures and may see regional extinction or migration towards higher latitudes. It is expected that climate change may induce phonological changes (sense of sound) in fishes, especially species with shorter life spans such as such as plankton and small pelagic fish. There are possibilities that net primary production may change at long time scales of multi-decades.

Tropical fisheries are characterised by several fast growing and multiple spawning species and low levels of spawning continue throughout the year for most of the species with one or two distinct spawning peaks in a year according to Vivekanandan *et al*

[1] Department of Planning, Programme Monitoring and Statistics (2011). Economic Survey 2010-11

[2] MoEF and INCCA (2010). Climate Change and India: A 4x4 Assessment

(2010).[1] Eggs of these species are pelagic and directly exposed to higher temperatures and currents. As temperatures rise, the development duration of eggs decreases resulting in smaller size of larvae states Vidal *et al* (2002). The study by Jackson and Moltschaniwskyj (2001) illustrated that the growth rates of adults would be faster initially up to a certain stage and then would decrease due to higher metabolic costs. It is also stated that the average life span will decrease as a function of increased growth rate and individuals in some marine species will mature at a smaller size. As smaller individuals produce a lesser number of eggs, this will lead a reduction in the capacity to produce abundant offspring (fecundity). This is expected to adversely affect the overall production of fish and the livelihood of the fishing communities.

Protection and conservation of indigenous fish is a priority. As of September 2011, there are seven inland fish sanctuaries in four districts in Karnataka and nine more are in the process of being recognised.[2]

4.6. Animal husbandry

Karnataka has a livestock population of 30.7 million and a poultry population of 42.4 million (refer Table 17). Livestock plays a significant role in the Indian economy and contributes between 15% and 40% of the total income of farm households. Karnataka is ranked at 10th and 3rd in the country in milk and egg production respectively.[3] About 38% of the rural households have livestock and or poultry contributing significantly to their livelihood.

Table 17: Livestock population in Karnataka in thousands[4]

Livestock	1997	2003	2007	1997/2007 change in %
Cattle (total)	10,832	9,538	10,503	-3.03
Crossbred therein	1,293	1,602	2,602	101.3
Indigenous therein	9,539	7,936	7,901	-17.2
Bovine (total)	15,199	13,530	16,830	10.7
Buffalo therein	4,367	3,991	4,327	-0.91
Sheep	8,003	7,256	9,558	19.4
Goat	4,875	4,484	6,153	26.2
Pigs	405	312	280	-30.86

Hallikar, *amrithmahal*, *khillar*, *krishnavalley* and *deoni* are drought purpose cattle breeds indigenous to Karnataka. *Malnad Gidda* is a dwarf cattle breed from the Malnad region. Indigenous cattle breeds have unique genetic structures that helps them adapt to local environments, cope with heat and resist diseases. Indigenous buffalo breeds include *pandharpuri*, *surthi* and *murrah*. As Table 17 shows, the population of indigenous breeds has declined over the last decade. The reasons are being attributed to the cross breeding programme of the state. In response, Government of Karnataka has taken initiatives that are discussed later in this chapter.

[1] Vivekanandan V. et al (2010). Background information on the pre-draft notification; National Fishworker's Forum

[2] Karnataka Biodiversity Board (2011). Comments on the draft Karnataka SAPCC dated September 24, 2011

[3] Government of Karnataka (2010). Draft Karnataka Livestock Development Policy 2010

[4] EMPRI (2012). State of Environment Report Karnataka 2011

Livestock diseases

A changing climate with altered feed resources can adversely affect the immune system of animals leading to more incidences of diseases and lower productivity. Extreme hot and cold climates in particular result in increased occurrence of vector borne diseases (blue tongue in sheep, rift valley fever) by providing favourable breeding conditions for the arthropods, especially in tropical areas.[1]

Livestock and global warming

Ruminants release methane (CH_4) as a part of their natural digestive process. Forage and fodder dependent feeding practices produce more hydrogen in rumen due to bacterial metabolism for eventual production of CH_4. The anaerobic decomposition of organic material in livestock manure also releases CH_4 and nitrous oxide (N_2O). Nitrous oxide is also produced by the microbial transformation of nitrogen in soils and manures and is enhanced in cases when the available nitrogen exceeds plant requirements. The contribution of agriculture to global warming should be treated with as much respect as the impact of climate change on agriculture commands. Greenhouse gases from this sector are predominantly methane (enteric fermentation in ruminants, rice cultivation) and nitrous oxide (livestock manure management). With a livestock population of more than 30 million and paddy as main crop, Karnataka generates significant emissions. These amount to 20.2% of the state's GHG emissions (refer to section 3.6).

Continuous flooding through irrigation or rain is found to induce higher methane emissions. Multiple aeration by contrast reduces methane emissions. Apart from rice cultivation, agriculture contributes to global warming through the release of nitrous oxide (N_2O) from fertilizers. The clearance of forests for cultivation in earlier decades has a lasting adverse impact on the carbon sequestration potential. In addition, overgrazing leads to soil depletion resulting in the release of CO_2 from the soil.

4.7. Vulnerabilities

From studies cited it emerges with clarity that, besides water resources, agriculture and allied sectors will be the most affected by climate change. It is feared that the changing pattern of temperature and precipitation may cause more extreme weather in both magnitude and frequency. Not only would these events affect the availability of water for agriculture and animal husbandry but also reduce disease resistance in crops and animals. This is compounded by an anticipated shift of cropping patterns, the loss of traditional species and increased vulnerability of crops and animals to vector borne diseases. Taken together, these impacts are feared to decrease agricultural productivity, affecting the livelihood of farmers. The projected sea level rise and surface temperature increase will adversely affect coastal communities dependent on coastal agriculture and fisheries.

BCCI-K (2011) attempted to classify sectors on the basis of its exposure to climate:

- **First order:** Sectors whose performance is directly determined by climatic variations, such as agriculture, fisheries, forestry and health;
- **Second order:** Sectors susceptible to climatic conditions while mitigation measures could reduce the influence of climatic variations. This includes mining, construction, cottage industries, education, transport and communication;

[1] EMPRI (2012). State of Environment Report Karnataka 2011

- **Third order:** Sectors relatively independent of climatic variations such as the service sector, industry among others.

BCCI-K (2011) ranked districts based on the size of population involved in a particular order. It was observed that with between 34% and 35% of the population depends on primary sectors while Tumkur, Mandya, Hassan and Haveri are the most vulnerable. By contrast, Udupi, Kodagu, Dakshina Kannada and Bangalore districts are affected least as they have the lowest share of populations dependent on agriculture and associated sectors. The study also proposes a composite vulnerability index based on four dimensions: Demographic and social, occupational, agriculture and climate. According to the index Gulbarga, Raichur and Bijapur were identified as most vulnerable.[1] It does not however emerge as clear what precisely has been assessed under these four dimensions and how.

4.8. Conclusions

Besides water resources, agriculture and allied sectors will be most affected by climate change. More than half of the state's population relies on these sectors for livelihood. Agriculture bears a chronic threat as all required resources will suffer in qualitative and quantitative terms i.e. soil health, water resources and resilience. Many crops, as projected by several researchers, may witness reduced production as well as poor quality. It is also predicted that due to changes in the weather pattern, many regions may become suitable for new crops while others may lose their regular crops. Under this altered scenario, a revision of relevant policies and initiatives is warranted. An extension of crop insurance to new regions and crops is vital. Likewise, the creation of mechanisms to revisit subsidies to encourage certain changes in cropping patterns is an emerging priority.

As detailed in Table 18, BCCI-K (2011) proposes consequently the promotion of certain crops for specific agro-climatic zones in order to harness benefits of climate change and overall strengthening the agriculture resilience in the state.

Table 18: Projected priorities of crops for adaptation and mitigation strategies[2]

Zone	Suggested change in cropping pattern
1. North–eastern transition zone	Area under rainfed maize, *sorghum*, cotton and wheat is proposed to be increased substituting the area under red *gram.*
2. North-eastern dry zone	Area under rainfed maize, *sorghum* and wheat is proposed to be increased, substituting the area under red *gram* and other crops.
3. Northern dry zone	Area under rainfed cotton, wheat and *sorghum* which have shown higher productivity is proposed to be increased in Bijapur district. Maize, *sorghum* and red *gram* can be expanded in Gadag district by reducing cotton area.
4. Central dry zone	Area under *sorghum* can be extended to the entire Bellary district substituting the area under rice. Rice, maize, *sorghum*, red *gram* and ragi area is to be increased by intercropping *sorghum* and pearl millet. Cotton and soy area is proposed to be restricted to irrigated areas.
5. Eastern dry zone	Areas under maize, *sorghum*, red *gram* and cotton area is proposed to be increased by substituting a part of rainfed finger millet in Bangalore district and in parts of Tumkur district. In Kolar district and maize, red *gram* and ragi area can be increased in lieu of *sorghum*. With the projected increase in rainfall, mulberry and vegetable area can be enhanced during *kharif.*

[1] BCCI-K (2011). Karnataka Climate Change Action Plan; Final Report

[2] BCCI-K (2011). Karnataka Climate Change Action Plan; Final Report

Zone	Suggested change in cropping pattern
6. Southern dry zone	Area under rice is proposed to be reduced by expanding maize, *sorghum* and red *gram*. Rice can be increased in Mysore and Mandya district and parts of Hassan district in view of the high yield potential and water availability. Ragi can be continued in the same area. By increasing the cropping intensity under irrigation the area under rice and sugarcane proposed to be increased.
7. Southern transition zone	Area under *kharif sorghum* proposed to be increased in view of their high productivity. Summer rice area is proposed to be diverted to irrigated groundnut.
8. Northern transition zone	Because of the high yield potential, areas under cotton, wheat, *kharif sorghum* and groundnut is to be increased. Green *gram* is to be introduced on large scale as a cash crop in *kharif*. A part of the area under rainfed rice is to be substituted by maize.
9. Hilly zone	Area under red *gram* in Chikkamagalur is to be increased. Rice area in Shimoga can be enhanced. Rice in the upland is to be substituted by finger millet. Green *gram* and black *gram* are to be introduced in rice fallows. Plantation crops are to be increased.
10. Coastal zone	Area under groundnut is to be increased in rice fallows , either based on residual moisture or supplemental irrigation. Black *gram* is proposed as second crop after rice in cases of residual moisture. In view of the sugar factories, area under sugarcane is to be increased to some extent.

4.9. Actions, policies and institutional preparedness

The contribution of agriculture to Karnataka's GSDP has been declining from 43% in 1981 around 17% in 2009 and is stagnating since.[1] Nevertheless, the sector's importance for food security and livelihoods cannot possibly be overstated. For 69 lakh cultivators and 62 lakh agricultural labourers agriculture is livelihood.[2] The economic significance of the sector may not even have declined in actuals but is dwarfed by the tremendous growth of the secondary and tertiary sectors.

The net irrigated area has more than doubled over the last three decades. From 16.8 lakh ha in 1980-81 it reached 39.4 lakh ha in 2008-09. 32% of the cultivable land is irrigated[3] and about 68% rain-fed. 34% of irrigated areas are irrigated by groundwater. The consumption of fertilisers is steadily rising while the cultivatable area is actually showing a marginal decline since 2006. N-P-K fertilisers accounted for 18.3 lakh metric tons in 2009, 20.5 lakh tons in 2010 and may touch 21.4 lakh tons in 2011.[4] The dependence on irrigation and, by implication, on groundwater is rising. The absence of tangible irrigation tariffs constitutes a significant impediment for both the reduction of water requirements and the generation of revenue for water infrastructure. The government is aware that that the increased dependence on irrigation and fertilisers renders agriculture less sustainable, jeopardising the long-term perspective of livelihoods of the great majority of the rural population. There are no measures at hand that can address these concerns on a larger scale quickly and sustainably. These are pressing issues even without climate change being on the horizon. And the threat of climatic variations and greater unpredictability exacerbates the situation drastically. Various policies and programmes initiated by the state and central government are being implemented in Karna-

[1] Department of Planning, Programme Monitoring and Statistics (2011). Economic Survey 2010-11

[2] BCCI-K (2011). Karnataka Climate Change Action Plan; Final Report

[3] Department of Planning, Programme Monitoring and Statistics (2011). Economic Survey 2010-11

[4] Department of Planning, Programme Monitoring and Statistics (2011). Economic Survey 2010-11

taka in order to ensure sustainable agriculture and animal husbandry practices. In the state budget 2011-12, INR 17,857 crore were announced for the development of agriculture and allied sectors.[1] At about the same time, 2011-20 has been declared as 'Irrigation decade' in the state.

Karnataka has a broad and efficient policy framework to achieve sustainability in agriculture and allied sectors. Government of India also supports, financially and technically, the state government through various schemes. The existing framework of and initiatives by the state and union governments provide opportunities to address risks associated with climate change and could reduce vulnerabilities and enhance resilience of this sector and dependent communities.

4.9.1. Karnataka Agriculture Policy[2]

The Karnataka Agriculture Policy in 2006 targets a growth rate of 4.5% per annum to in the agricultural Gross State Domestic Product (GSDP) within a decade. It also aims at:

- Protection and improvement of soil health;
- Conservation of natural resources with emphasis on water and micro-irrigation;
- Timely availability of credit and other inputs to the farmers;
- Integration of post-harvest processing with production process;
- Reduction in the gap between labs-to-land in technology transfer.

4.9.2. Karnataka Agriculture Mission

Karnataka Agriculture Mission was set up for the comprehensive development of agriculture and allied sectors. One objective of the mission is to develop new programmes for agriculture under close involvement of agriculture universities and line departments. The mission also includes streamlining and coordinating the functions of line departments and agriculture related universities to provide technical information and services through a single window. The mission envisages drafting new programmes for sustainable agriculture, conservation of natural resources such as land, water and improving the fertility of soil and water use efficiency, promotion of organic farming, intensification of farmer training in modern agriculture and marketing and to provide infrastructure for seed storage, water harvesting and water use efficiency, processing and value addition.

4.9.3. Programme for increased production of food grains, pulses and oilseeds

In 2009, the High Yielding Varieties Programme (HYVP) covered an area of 46.6 lakh hectare against a target of 53.5 lakh hectare. The Accelerated Maize Development Programme (AMDP) which was initiated in 15 districts in 1990-91, is now extended to all districts under Integrated Scheme for Oilseeds, Pulses, Oil Palm & Maize (ISOPOM). ISOPOM[3] was launched by Government of India in 2004-05 by merging three erstwhile schemes i.e. Oil Palm Development Programme (OPDP), National Pulses Development Project (NPDP) and AMDP. The major objectives of the schemes are enhancing productivity and the efficiency of oilseed production, processing, value addition and product diversification to make the oilseed sector sustainable and competitive, attaining self-reliance in pulses for household nutritional security, crop diversification and sustainability of the production system and enhancing productivity, profitability nutritional

[1] Government of Karnataka (2011). Budget 2011-2012; Part I: Agriculture

[2] Department of Agriculture (2006). Karnataka Agriculture Policy 2006

[3] Department of Agriculture & Cooperation (2010). Integrated scheme of oilseeds, pulses, oilpalm & maize; Circular

quality and diversified uses of maize by harnessing technology advancements. This scheme is being implemented in all 30 districts. Main activities under the scheme are the purchase of breeder seeds, the production of foundation and certified seeds and the distribution of certified seeds, plant protection chemicals, plant protection equipment, biofertilizers, gypsum as nutrient, phosphorus solubilising bacteria (PSB) and block demonstration of Integrated Pest Management (IPM) besides farmers' training and infrastructure development.

4.9.4. National Food Security Mission

The National Food Security Mission (NFSM) was launched in 2007-08 by National Development Council. The mission seeks to increase production of rice, wheat and pulses through area expansion and productivity enhancement in a sustainable manner in identified districts, restoring soil fertility and productivity at farm level and enhancing farm level economy. The NFSM has three components: Rice, wheat and pulses. Under this scheme are seven districts for rice (Belgaum, Shimoga, Uttara Kannada, Dakshina Kannada, Udupi, Hassan and Raichur) and 13 districts for pulses (Bagalkote, Belgaum, Bellary, Bidar, Bijapur, Chitradurga, Dharwad, Gadag, Gulbarga, Koppal, Mysore, Raichur and Tumkur). The state has a vision to achieve an average productivity target of 45 quintals paddy per hectare and seven quintals of pulses per hectare in the NFSM implementing districts during 2009-10 with the financial support of INR 66 crore.[1]

4.9.5. Rashtriya Krishi Vikas Yojana

The National Development Council also launched a special additional central assistance scheme called Rashtriya Krishi Vikas Yojana (RKVY) in 2007 in order to incentivise the development of comprehensive plans for the holistic development of agriculture and allied sectors and increase in public investment. RKVY aims at achieving the goal of reducing yield gaps in important crops and optimising returns to farmers. Under RKVY, an amount of INR 172 crore has been earmarked by the Department of Agriculture for the implementation of (a) revitalizing the agriculture extension system and accelerating agricultural growth in Karnataka, 2) the Karnataka Seed Mission, 3) the Karnataka Farm Mechanization Mission and 4) Bhoo Chetana (which is discussed separately in the following section).[2]

4.9.6. Bhoo Chetana[3]

The government devised two significant interventions at the level of farming practices. Considered as a flagship programme, Department of Agriculture together with the Watershed Development Department launched a dry-land farming support scheme under the name Bhoo Chetana ("Land improvement") in 2009. It aims at increasing the productivity of rain-fed crops by 20% through soil testing based nutrient management for 11 crops in 25 selected dry land districts in a phased manner over four years.[4] The approach also includes GIS based soil mapping and the issue of soil health cards to farmers as well as their capacity building. Significant yield increases were noted in 2009-10 already: Up to 44% for maize, 35-65% for ragi, 32-41% for groundnut and 39% for soybean. In 2010-11 the programme was expanded from 6 to 16 districts, covering about 12

[1] Ministry of Agriculture. National Food Security Mission, www.nfsm.gov.in accessed February 18, 2012

[2] Ministry of Agriculture. Rashtriya Krishi Vikas Yojana, http://rkvy.nic.in accessed February 18, 2012

[3] Department of Planning, Programme Monitoring and Statistics (2010). Economic Survey 2009-10

[4] Maize, groundnut, ragi, soyabean, red *gram*, black gram, greengram, bengalgram, sunflower, jowar and bajra

lakh ha of land, 8.7 lakh farmers in 5,030 villages.[1] While the scheme improves the land for the purpose of farming, what the scheme does not do is *improve* the soil as such. Instead it optimises external supply of nutrients and in doing so prevents the restoration of the natural soil fertility. Nevertheless, the scheme does succeed in building confidence in rain-fed agriculture. In the 2011-12 budget speech a grant of INR 40 crore was announced to extend Bhoo Chetana to all 30 districts of the state.

4.9.7. Insurance schemes

The long needed crop insurance has been introduced in Karnataka in 2000 with the National Agricultural Insurance Scheme (NAIS). It indemnifies farmers against loss of yield from natural calamities for notified crops based on region, season and risk. Being open to all farmers for a decade now it is compulsory for loan-taking farmers. And even though 10% of the premium is subsidised for small and marginal farmers it is yet to find acceptance with the majority of farmers. Of the gross cultivated area (124 lakh ha) about 21 lakh ha (17%) were insured in 2009. In 2007 the central government introduced the Weather Based Crop Insurance Scheme which indemnifies farmers against *anticipated* loss in crop yield due to adverse whether conditions. The higher premium is subsidised down by both the centre and state (50:50), offering the farmer a premium identical to that under NAIS. In response to lessons learnt with this still new instrument, a modified NAIS (or MNAIS) is being implemented since 2010. It fixes the indemnity level at 70% and covers pre-sowing and post harvest risks.[2]

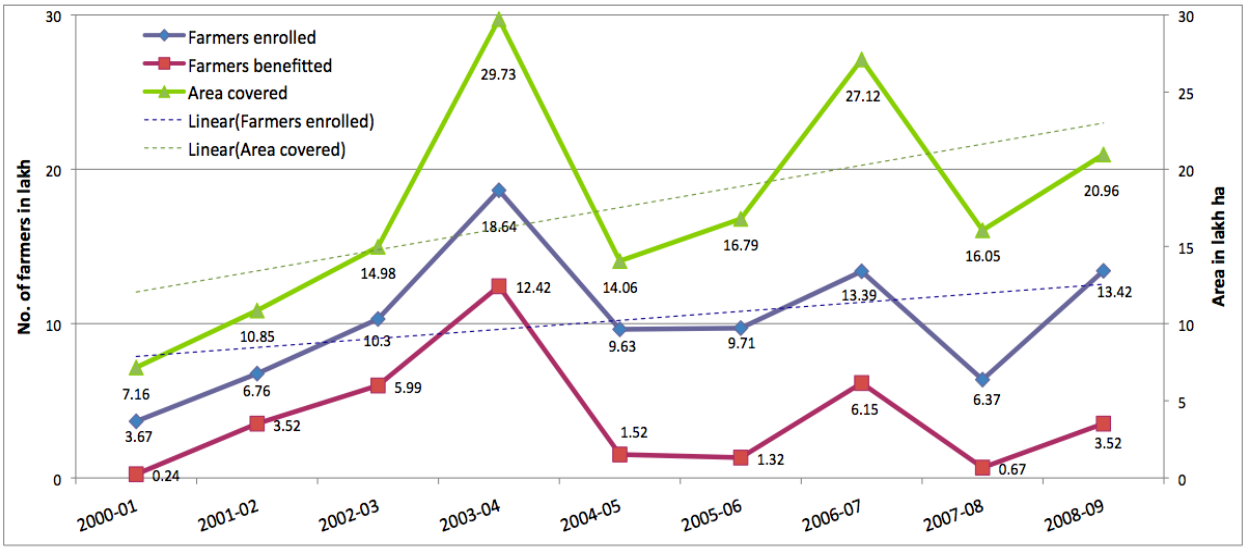

Figure 18: Trends of the coverage under the NAIS crop insurance

4.9.8. Horticulture

The National Horticulture Mission (NHM) was launched by Government of India during the 10th Plan in 2005-06. The mission follows an area-based, regionally differentiated approach for the development of horticultural crops. During the 10th Plan, Government of India provides 100% assistance to the state missions. During the 11th Plan, the assistance is 85% with 15% contribution by the state. The mission pursues area expansion of

[1] Department of Planning, Programme Monitoring and Statistics (2011). Economic Survey 2010-11

[2] Department of Planning, Programme Monitoring and Statistics (2011). Economic Survey 2010-11

spices, cashew and cocoa. It also promotes Integrated Pest Management and subsidises bio-pesticides (50% of the cost up to a maximum of INR 1,000 per hectare).[1]

The possible impact of climate change on seven major horticultural crops[2] has been assessed by the Department of Horticulture.[3] Several possible counter measures to adapt to climatic changes have been suggested, which include:

- Modified crop production practices such as choice of varieties, root stocks, crop season, duration, density and agronomic practices;
- Crop management practices such as pruning, crop architecture, canopy management, crop regulation and crop protection. It is worth noting that the department is implementing a programme under which the crop canopy and biomass is enhanced for perennial and annuals crops;[4]
- Adoption of varieties with greater tolerance to drought and heat;
- Modified irrigation schedules and practices and integrated moisture conservation practices.

Coconut Development Board is providing financial assistance for the development of the coconut industry of the state. The programmes implemented include laying and maintenance of demonstration plots, establishment of organic manure units, distribution of plant protection chemicals, organic manures, chemical and bio-fertilizers for improvement in production of coconut and production of hybrid coconut seedlings.

4.9.9. Watershed development and micro-irrigation

Assisted by World Bank, the Sujala Watershed Development Programme covers five districts, namely Kolar, Tumkur, Chitradurga, Haveri and Dharwad with a budget of INR 557 crore.

A centrally funded schemes on micro irrigation is promoting the use of drip irrigation since 1991-92. The objective is to achieve economical and judicious use of water. State and centre contribute 40% and 35% of the cost respectively while participating farmers contribute 25%. In Bijapur and Kolar districts the subsidy is 100%.[5] The fact that INR 160 crore[6] were committed to this programme in 2010-11 is indicative of a significant scale.

4.9.10. Organic farming

Recognising the threat to soil fertility, the government has also embarked on an initiative promoting organic farming. In 2008 it constituted a committee for a State Level Organic Farming Mission with *progressive* farmers as stakeholders. 174 organic farmer's association were selected through which a total of 53,000 farmers were brought under this programme in the first year. An additional 35,000 farmers were included in the subsequent year. The programme focuses on capacity building and provides financial incen-

[1] Ministry of Agriculture. National Horticulture Mission, www.nhm.nic.in accessed February 18, 2012

[2] Mango, citrus, banana, grape, potato, coconut and cashew

[3] Department of Horticulture (2011). Perspectives of horticulture sector for formulating action plan on climate change; Presentation, March 8, 2011

[4] Department of Horticulture (2011). Consultation held on March 7, 2011

[5] Department of Horticulture. www.horticulture.kar.nic.in, accessed April 07, 2011

[6] Department of Horticulture (2010). Scheme-wise Allocation under Plan during in 2010-2011; Internal document, obtained March 8, 2011

tives. It is implemented virtually across Karnataka (172 of the 176 taluks)[1] on a total of 70,000 ha of land.[2] Organically cultivated land under the programme constitutes about 0.6% of the cultivated area (0.7 of 124 lakh ha). As of March 2012, more than 1 lakh farmers have adopted organic farming and the establishment of a network for marketing of organic produce is reportedly underway.[3] Regretfully, a larger scale expansion of this important programme does not appear to be on the planning horizon as yet.

4.9.11. Fisheries

Government of Karnataka is implementing several programmes in the state to support and reduce the risk associated with fisheries. Under Mathsya Mahila Swavalambana Yojane INR 1,000 lakh were sanctioned to 2,000 fisher-women groups for fish marketing in 2009-10. Other programs taken up in that year include group insurance, housing, support to fishermen co-operatives, assistance for mechanisation of traditional fishing boats and assistance for fish processing and marketing.

INR 194 lakh was spent in 2008-09 to bring 3,900 hectares of inland water spread area under fish culture. Government of India is also funding the construction of fishing harbours, landing centres and the development of inland fisheries. Main schemes include a subsidy on the purchase of seeds, supply of fishery requisites kits and aqua parks.

4.9.12. Animal husbandry

Department of Animal Husbandry is projecting significant livestock vulnerabilities to climate change. It expects the emergence of new diseases, triggered by changes in environmental conditions. The need to conduct in-depths studies to understand likely changes for livestock before they actually occur was emphasised in discussions held with the department. Another concern is productivity, milk yield for example, which is highly dependent on the fodder (both quantity and quality) apart form the climate. Fodder itself is a point in question as its availability might decline with temperatures rising. The increased incidence of floods constitutes a potentially lethal threat for all kinds of livestock. No direct action in respect of climate change was taken by the department as yet. At the same time efforts to preserve native cattle breeds continue. Some 4,000 animals belonging to four major cattle breeds have been reared, supported by INR 307 lakh since commencement of the programme in 2007-08. There is an implied hope that the robustness inherent to native species may also provide for greater adaptation capabilities.[4]

The draft Karnataka Livestock Development Policy 2010 focuses on augmenting farmers' income through an accelerated growth of the livestock sector; aiming at a two-fold increase in livestock production in the next 8-10 years by increasing productivity and the quality of products.[5]

Department of Animal Husbandry has undertaken several initiatives to enhance sustainability and economic viability of animal husbandry. Free health care facilities are provided for animals. In 2009-10 an amount of INR 456 crore was allocated and INR 241

[1] Department of Planning, Programme Monitoring and Statistics (2011). Economic Survey 2010-11

[2] Department of Ecology & Environment (2010). Actions on climate change; Presentation, August 19, 2010

[3] Department of Agriculture (2012). Comments on the Draft State of Environment Report Karnataka 2010 dated March 16, 2012

[4] Department of Animal Husbandry (2011). Consultations held on March 8, 2011

[5] Department of Animal Husbandry (2010). Draft Karnataka Livestock Development Policy 2010

crore spent till end of November 2009. The health of livestock and poultry is monitored through 4,110[1] veterinary institutions. Government also conducted a wide vaccination programme and 262 lakh vaccinations were administered in 2009-10 as of November 2009.

A cattle breeding programme for milch animals and conservation of indigenous breeds (*hallikar*, *amrutmahal*, *khilar* and *deoni* for drought purposes) are pursued through artificial insemination and embryo transfer. Indigenous breeds are developed through selective breeding at livestock farms of Tumkur, Chikkamagalur and Haveri districts. 21 lakh artificial inseminations were conducted in 2009-10. Six sheep breeding farms are functioning under Karnataka Sheep and Wool Development Corporation (KSWDC). A 'mini wool scouring plant' funded by Central Wool Development Board, Jodhpur is being installed at Ranebennur. As part of the Breed Improvement Programme, KSWDC has been implementing a scheme for supply of cross-bred rams at subsidised rates under which 596 cross-bred rams were distributed in 2009-10 as on November 2009. Another 500 cross-bred rams were distributed to farmers in the project areas of Belgaum and Chitradurga. Besides, a Buffalo Breeding and Research Centre in Karnataka, a Livestock and Buffalo Breeding Programme and livestock insurance are understood to be on the anvil.

To mitigate the green fodder deficiency, several programmes are implemented to enhance potability of feed under the Feed and Fodder Development Programme. They concern fodder production, fodder seeds production and training of farmers.

4.10. Missions under the NAPCC

The **National Mission on Sustainable Agriculture** has been released as draft in August 2010. It identifies agriculture as a major sector affected by climate change in India. With a view of increasing resilience of the sector to climate change, the mission aims at four focus areas, namely dry land agriculture, risk management, access to information, and use of biotechnology.

Dry-land agriculture

60% of the net cultivated area in country is categorised as dry land/rain fed. To harness the potential for agricultural growth, the mission emphasises development of drought- and pest-resistant crop varieties, improving soil and water conservation, capacity building of stakeholders dissemination and providing financial support to enable farmers to invest in appropriate technologies.

Karnataka also has one of the largest areas under dry land agriculture. An intervention that enhances productivity will provide distinct advantages to the state.

Risk management

The agriculture sector may witness increased incidents of flood, droughts and other natural hazards. Primary areas to work upon under risk management are (1) strengthening of agricultural and weather insurance mechanisms, (2) development and validation of weather derivative models, (3) creation of web-enabled, regional language services facilitating weather-based insurance schemes, (4) development of GIS and remote-sensing tools for soil resource mapping and land use planning at watershed or a river basin level

[1] This includes 369 Veterinary Hospitals, 1,941 Veterinary Dispensaries, 1,181 Primary Veterinary Centres, 230 artificial insemination centres and 174 mobile veterinary clinics and 215 other institutions

and (5) developing and implementing region-specific contingency plans based on vulnerability and risk scenarios.

Though, Karnataka has a well developed disaster management strategy, the provisions under the NAPCC for the development of regional language based web services and use of GIS and remote sensing could further strengthen the existing disaster management system of the state. Detailed mapping would help identifying hot spots of agro-biodiversity and possible vulnerabilities. The efficient risk management strategy will help farmer communities to adapt better for the changing climate.

Access to information

A well developed information and early warning system will help the agriculture sector to enhance its resistance to combat adverse impacts of climate change. With this, the mission stresses (1) the development of regional databases for soil, weather, genotypes, land-use patterns and water resources, (2) monitoring of glacier and ice-mass, impacts on water resources, soil erosion, and associated impacts on agricultural production in mountainous regions, (3) providing information on off-season crops, aromatic and medicinal plants, greenhouse crops, pasture development, agro-forestry, livestock and agro-processing, and (4) collation and dissemination of block-level data on agro-climatic variables, land-use, and socio-economic features and preparation of state-level agro-climatic atlases.

Application of biotechnology

NAPCC envisages the use of biotechnology to enhance resilience of agriculture in respect of drought proofing, increasing yields and greater pest resistance. The focus areas identified are (1) use of genetic engineering to convert C_3 into C_4 crops to enhance photosynthetic efficiency and productivity at higher CO_2 levels in the atmosphere, (2) development of crops with better water and nitrogen efficiency which may result in reduced emissions of GHGs or greater tolerance to drought, submergence or salinity, and (3) development of nutritional strategies for managing heat stress in dairy animals to prevent nutrient deficiencies leading to low milk yield and productivity.

The mission's objectives are planned to be achieved through ten key interventions, each of which enlists of a set of strategies. The strategies consist of:

1) Improved crop seeds, livestock and fish culture;
2) Water efficiency;
3) Pest management;
4) Improved farm practices;
5) Nutrient management;
6) Agriculture insurance;
7) Credit support;
8) Market mechanisms;
9) Access to information;
10) Livelihood diversification.

Overall, the mission has a sufficiently broad scope and provides both technical and financial support to prepare better for and adapt to a changing climate. In total INR 108,000 crore are earmarked for the period 2011-17.

Karnataka has several indigenous crop varieties that are fairly drought and pest resistant. Their preservation would be an essential step towards adaptation to climate change as these varieties may provide required genes to combat climate change.

4.11. Selected emerging intervention areas

Agriculture in general

- Development and planting of climate-hardy indigenous cultivars tolerant to drought, thermal extremes, salinity and pests, and cultivars that can utilize water and nitrogen efficiently;
- Establishment of a seed storage network for climate-hardy cultivars;
- Promoting pest and disease surveillance to correlate changes in crop-pest indicators with changes in climatic variables;
- Undertake long-term research into climate change impacts on crop growth and yield, pest and weed growth, water availability, soil moisture and organic matter, rate of evaporation etc.;
- Conduct vulnerability and impact assessments, including assessments of vulnerability under a range of plausible future scenarios;
- Development of tissue culture labs to enhance the germ plasm conservation capacity;
- Promote knowledge sharing between organizations;
- Conservation and promote traditional knowledge in plant breeding;
- Development or identification of agro-biodiversity sites and support farmers developing indigenous varieties;
- Identification of agro-heritage sites such as the Varada river basin for flood resistant rice, areas under *togari bele* in Gulbarga, millet growing areas in arid and semi-arid regions, horticulture in Bijapur.

Dry land farming

- Research the carbon sequestration potential of carbon-deficient dry land soils;
- Promotion of dry land agriculture techniques such as low or zero tillage, in-situ soil moisture conservation, raised bed, ridge furrow, mulching etc.;
- Explore possibilities for collaboration with international research institutes to develop and adopt resource-efficient dry land techniques.

Agro forestry

- Promotion of agro-forestry. Explore convergence of ongoing agro-forestry projects with activities under NREGA;
- Spreading awareness among farmers of the benefits of multifunctional agro-forestry, domestication of relevant species.

Animal husbandry

- Breeding of climate-hardy livestock and development of nutritional strategies to prevent heat stress and productivity loss;
- Conducting studies to assess the relationship between climate change and animal health;
- Conversion of wastelands to pasturelands in a phased manner;
- Take learnings from traditional methods of animal feed for obtaining higher production of Tipu Sultan's time (1750-99) into consideration.

5. WATER RESOURCES

5.1. Water balance

Most early civilization settled on water bodies that provided for essential needs. Gradually, these needs grew to include agriculture, transportation and later expanded to production and industries. Karnataka's rapid population growth, the rate of urbanisation and industrialisation place extreme demands on water resources. In addition, industrial effluents and sewage find their way into water bodies, pollute them and degrade their ecosystem and value. Ensuring adequate availability of water in terms of quality as well as quantity is recognised as an effective way of addressing vulnerabilities associated with climate change. Even without climatic changes this is already a challenge in Karnataka. The ever-increasing demand has been adversely affecting water resources and several regions are facing severe scarcity.

As shown in Table 19, the state receives a total of 236 billion m^3 of water every year, 92% from rainfall and 8% from the upper riparian state Maharashtra. 110 billion m^3 of the total are 'lost' through evapo-transpiration from forests and lands, irrigated or otherwise. A similar amount of 109 billion m^3 flows into the Arabian Sea and adjoining states of Andhra Pradesh and Tamil Nadu. A balance of 17.7 million m^3 (about 7.5%) remains from which Karnataka meets its agricultural, industrial and domestic requirements.

Table 19: Water balance of Karnataka under average conditions[1]

Flow	Quantity in million m^3/a	%
A. Input		
Precipitation over Karnataka	218,323	92%
Expected flow from upper riparian's (Maharashtra)	18,159	8%
Total	**236,483**	**100%**
B. Output		
Evapo-transpiration from forests	45,754	20.9%
Evapo-transpiration from non-forest and non-agricultural land	18,955	8.7%
Evapo-transpiration from rainfed agriculture	27,172	12.4%
Evapo-transpiration attributable to irrigated agriculture	19,046	8.7%
Total evapo-transpiration	109,727	50.2%
Water release to Andhra Pradesh	31,407	14.4%
Water release to Tamil Nadu	7,607	3.5%
Water release into Arabian Sea	70,000	32.0%
Total water release	109,014	49.8%
Total output	**218,741**	**92.5%**
C. Excess of input over output	**17,741**	**7.5 %**

[1] Asian Development Bank (2009). Scoping Study for CDTA: Integrated Water Resource Management in Karnataka; TA RSC-C91761 (India)

5.2. Surface water resources

The state has about 6% of country's total surface water which is contributed by seven river basins and their tributaries with a total catchment of 191,773 km^2 (Figure 19). These river basins are Krishna, Cauvery, Godavari, North Pennar, South Pennar, Palar and the west flowing rivers.

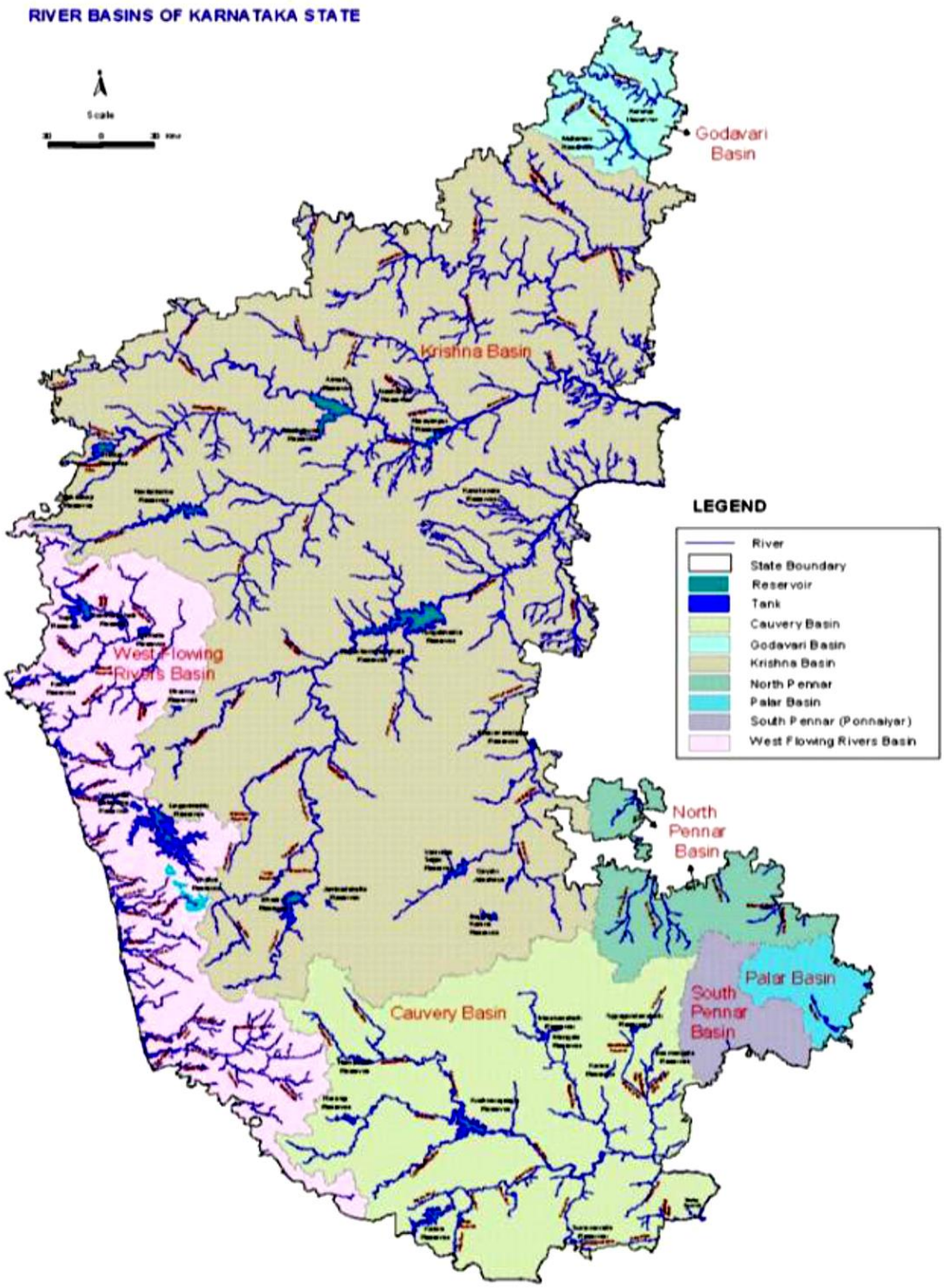

Figure 19: River systems of Karnataka[1]

[1] Raju, K.V. (2009). Water for all in Karnataka: Issues and options; Presentation

Table 20 presents the contribution of surface water from the river basins and economically available water for utilization. Total availability of water from these basins amounts to 7,663 thousand million cubic feet[1] (TMC) per year. Approximately 40% of the surface water is contributed by east flowing rivers while the remaining 60% are from west flowing rivers. Only 3,475 TMC of surface water is economically utilizable. Nearly 58% surface water of the west flowing rivers cannot be utilised due to the topography. Taken together, Karnataka utilises 1,690 TMC (49%) of the available 3,475 TMC of surface water.

Table 20: Estimated yield of water from river basins of Karnataka[2]

River system	Catchment Area km²	%	Economically available (TMC)[3]	%	Utilization (TMC)	%
1. Godavari	4,405	2.3%	49.97	1.4%	22.37	1.3%
2. Krishna	1,13,271	59.1%	969.44	27.9%	1156.00	68.4%
3. Cauvery	34,273	17.8%	425.00	12.2%	408.62	24.2%
4. West Flowing Rivers	26,214	13.7%	1998.83	57.5%	0	0
5. North Pennar 6. South Pennar 7. Palar	13,610	7.1%	32.00	0.9%	103.31	6.1%
Total	**191,773**	**100 %**	**3475.2**	**100%**	**1,690.30**	**100%**

Besides river basins, lakes and tanks store significant amounts of water. There are 36,672 lakes and tanks in the state with an aggregate area of 685,000 ha. The southern plateau contains 60% of these followed by the Malnad region (25 %) while the remaining ones are located on the northern plateau. Karnataka also has 20,152 irrigation tanks, accounting for 10% of the all India value. The irrigation potential of these is 0.65 million hectares. Bangalore alone has presently 201 water bodies, 96 of which are perennial.[4]

5.3. Groundwater resources

Groundwater availability is determined by space, time, rainfall, hydrogeology and other factors. Table 21 illustrates the groundwater settings of the state. Nearly 97% of the area is covered by weathered hard rock aquifers while 3% belong to alluvial, coastal or flood plain deposits.

Table 21: Ground water settings in Karnataka[5]

Type	Sub-type	Share
Weathered hard-rock aquifers	Granite basement complex	90%
	Deccan Trap basalts	7%
Alluvial, coastal and flood plain deposits		2%
Other formations		1%

[1] Thousand million cubic feet (TMC). 1 TMC = 28,316,847,000 m³ = 28.3 million m³

[2] Department of Water Resources (2010)

[3] Thousand million cubic feet (TMC). 1 TMC = 28,316,847,000 m³ = 28.3 million m³

[4] EMPRI (2011). Parisara: Conservation of Water Bodies in Bangalore; Newsletter 23 of the ENVIS Centre Karnataka

[5] EMPRI (2012). State of Environment Report Karnataka 2011

Karnataka experienced a decline in net annual groundwater availability by 3.2% between 2004 and 2009 (refer Table 22). The decline is attributed to extraction beyond amounts replenished. Groundwater sources provide for 45% of irrigation in the state. There are 860,363 irrigation wells (dug-wells, shallow-wells, deep-wells) of which 807,377 or 93.8% are equipped with electric pumps. Groundwater development is at 68% and the remaining irrigation potential has dropped by 4.6% to 618,071 hectare metre[1] (HAM).

Table 22: Groundwater resources of Karnataka[2]

Particulars	Groundwater in HAM[3]	
	2004	2009
Net annual groundwater availability	1,529,660	1,481,015
Existing groundwater draft for irrigation	974,731	900,712
Existing groundwater draft for domestic and industrial supply	96,581	99,975
Existing groundwater draft for all uses	1,071,312	1,000,687
Provision for domestic and industrial requirement supply for 2025	140,693	126,380
Net annual groundwater availability for future irrigation development	647,580	618,071
Stage of groundwater development	70%	68%

Recent studies indicate that as much as 64 watersheds covering 35 of the 176 taluks of the state are over-exploited while 123 watersheds in 70 taluks are still in safe limits. However, the increasing demand of water resources in Karnataka is a serious threat (refer to Table 23).

Table 23: Classification of watersheds in Karnataka (2008-09)[4]

Categorization	Watersheds	Taluks
Safe	123	70
Semi-critical	13	10
Critical	2	3
Over-exploited	64	35
Mixed category	32	58
Total	**234**	**176**

[1] Hectare metre (HAM). 1 HAM = 10,000 m^3

[2] Department of Planning, Programme Monitoring and Statistics (2011). Economic Survey 2010-11

[3] Hectare metre (HAM). 1 HAM = 10,000 m^3

[4] Department of Mines and Geology (2010)

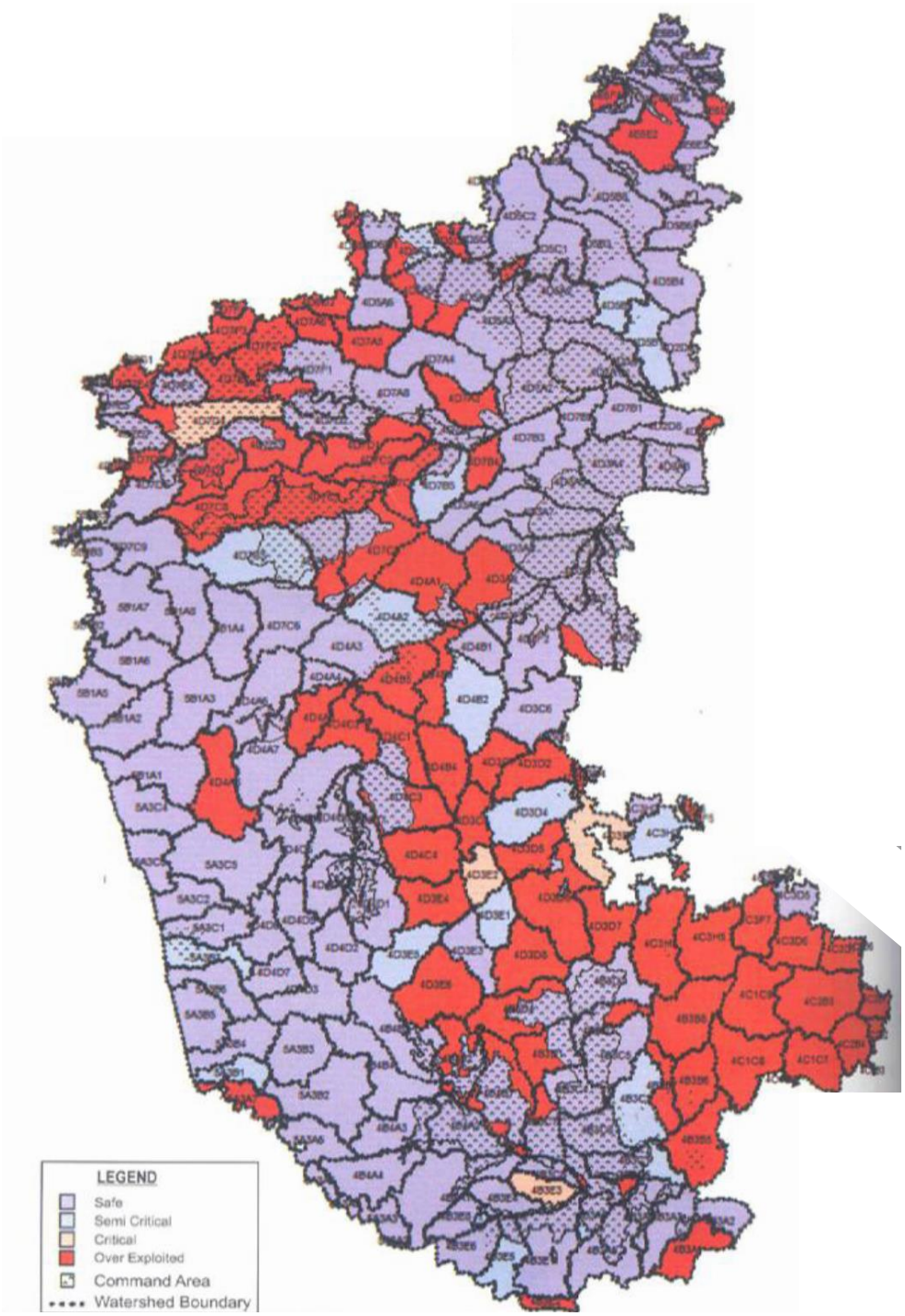

Figure 20: Categorisation of groundwater in Karnataka (2009)[1]

5.4. Demand and pressure

The major demand on water resources emerges from agriculture (irrigation), industries (mainly chemical industries) and the domestic sector (municipal water supply). Though a detailed estimation of water usage is not available, it can be said that ever increasing demand with reference to economic development of the state has caused shortage of water resources in the state.

[1] Department of Mines and Geology (2010)

5.4.1. Agriculture

Agriculture being the largest consumer of water, demands about 84% of utilizable water of the state. It is estimated that the water requirement of agriculture will continue to increase considering the contribution of agriculture in the state's economy. The agriculture sector also suffers from inefficient water management which results into reduced water productivity. As mentioned before, nearly 45% irrigation water of the state is met from groundwater sources. This is prevailing in regions where surface water is limited. Further the advancement in technology, the low cost of extraction and the absence of regulations until 2011 have been responsible for the growing pressure on groundwater resources. A shown in Table 24, several districts including Bangalore, Kolar, Tumkur, and Chitradurga draw more groundwater than is naturally recharged.

Table 24: Groundwater draft development stage (2006)[1]

District	Annual groundwater draft in HAM[2]			Number of bore wells	Stage of groundwater development
	Irrigation	Domestic, industrial	Total		
1. Bagalkote	35,962	3,416	**39,378**	38,189	92%
2. Bangalore Rural incl. Ramanagara	72,223	3,336	**15,559**	46,701	171%
3. Bangalore Urban	31,470	1,557	**33,027**	13,980	197%
4. Belgaum	121,666	8,818	**130,485**	100,318	91%
5. Bellary	23,740	4,182	**27,921**	23,369	44%
6. Bidar	19,826	3,279	**23,105**	26,990	56%
7. Bijapur	31,028	4,617	**35,646**	54,314	65%
8. Chamarajanagar	34,597	2,162	**36,760**	26,007	89%
9. Chikkamagalur	20,087	3,243	**23,330**	24,638	48%
10. Chitradurga	55,844	3,633	**59,477**	50,099	102%
11. Dakshina Kannada	27,623	3,792	**31,415**	41,278	60%
12. Davanagere	42,656	3,176	**45,832**	43,226	77%
13. Dharwad	9,580	1,526	**11,106**	9,433	38%
14. Gadag	19,966	2,136	**22,102**	9,915	94%
15. Gulbarga incl. Yadgir	19,447	5,618	**25,065**	33,653	28%
16. Hassan	31,152	5,709	**36,861**	47,344	71%
17. Haveri	26,247	2,870	**29,117**	24,584	72%
18. Kodagu	6,699	1,547	**8,246**	1,383	29%
19. Kolar incl. Chikkaballapur	110,918	4,405	**115,323**	61,526	195%
20. Koppal	31,400	2,379	**33,779**	28,407	48%
21. Mandya	19,649	4,065	**23,714**	38,828	37%
22. Mysore	19,923	3,915	**23,838**	26,901	58%
23. Raichur	10,102	3,141	**13,243**	11,673	20%
24. Shimoga	23,943	3,198	**27,141**	26,408	32%
25. Tumkur	96,635	5,965	**102,600**	111,718	110%
26. Uttara Kannada	15,212	2,241	**17,452**	27,016	25%
27. Udupi	17,138	2,654	**19,792**	29,804	39%
Total in HAM	**974,731**	**96,581**	**1,071,312**	**977,702**	**70%**
in %	**91%**	**9%**	**100%**		

Legend: Extraction beyond recharge

[1] Central Ground Water Board (2006)

[2] Hectare metre (HAM). 1 HAM = 10,000 m^3

As the breakup of sources of irrigation in Table 25 shows, 34% the demand is met by tube and bore wells while canals contribute 36%. The total irrigation potential created in the state from all the sources is estimated to be 39.4 lakh ha.

Table 25: Sources of irrigation in Karnataka 2008-09[1]

Sources	Area in lakh ha	Share	Sources	Area in lakh ha	Share
Canals	14.02	36%	Tube and bore wells	13.49	34%
Tanks	2.34	6%	Lift irrigation	1.45	4%
Wells	4.58	12%	Other sources	3.55	9%
Total				**39.42**	

5.4.2. Industries

The state has approximately 6.5 lakh industries.[2] 13,125 operating industries[3] are classified as highly polluting (or 'Red') by Karnataka State Pollution Control Board (KSPCB) on account of products and processes affection water resources and/or air. It is estimated that industries consume 47.6 TMC,[4] or 3.6%, of Karnataka's water. This amount is expected to increase to 125 TMC by 2025. The largest water consumers include dying, paper mills, iron ore mining, pharmaceutical and other chemical industries.

A recent survey identified 33 industries that discharge more than 100 kg_{BOD}[5] per day and which are therefore classified as 'grossly polluting'. 85% of these belong to the group of '17 category industries' such as sugar industries, distilleries and paper mills with enormous resource requirements.[6] Untreated or insufficiently treated effluents are discharged into natural water bodies or land. Discharged wastewater contains nutrients, allowing various pathogens to grow, toxins and heavy metals.[7] Depending on the mode of discharge, these effluents contaminate the lands or natural water bodies restricting their use and productivity or may contaminate the groundwater tables.

5.4.3. Domestic demand

With the increasing population and urbanisation of the state, the demand for domestic water is growing at par. There is increasing demand for both surface and groundwater and nearly 4.4% of the state's water demand is for domestic uses. It is estimated that the per capita water requirement in urban areas is 200 litres per capita per day (LPCD) and 150 LPCD in rural areas. This is far above the actual supply.

Rural areas experience poor supply and quality of water. Women and children spend a substantial amount of time lost for productive purposes carrying water. In urban centres 78.4% of households have access to tap water but only 48% of households. Urban centres discharge huge amounts of sewage loaded with nutrients and organics. In view of inadequate wastewater treatment facilities, untreated sewage is discharged in to natural

[1] Department of Planning, Programme Monitoring and Statistics (2011). Economic Survey 2010-11

[2] Karnataka Small-Scale Industries Association (KASSIA), (2008). Consultation held in 2008

[3] EMPRI (2011). Inventorisation of red category industries in Karnataka

[4] Thousand million cubic feet (TMC). 1 TMC = 28,316,847,000 m^3 = 28.3 million m^3

[5] Biological oxygen demand

[6] EMPRI (2011). Inventorisation of red category industries in Karnataka

[7] Department of Mines & Geology (2011). Groundwater Hydrology and Groundwater Quality in and around Bangalore

water bodies or lands. About 2,260 million litres of sewage[1] is generated in Karnataka's urban areas. There collection rate is only 80% according to some estimates and much less of it is treated.

5.5. Projections

India observes floods and droughts every year in some or the other region. National Flood Commission (Rashtriya Barh Ayog) reports that nearly 40 million hectares (mn ha) of area is flood-prone while 51 mn ha are drought prone, constituting 12% and 16% of the geographical respectively. Gupta and Deshpande (2004) projected that the gross per capita water availability in India will decline from about 1,820m^3/year in 2001 to 1,140 m^3/year in 2050 caused by the growing population and increasing demand. Water availability is further expected to decline considering the adverse impacts of climate change. Studies conducted by Gosain *et al* (2004, 2006) suggest that the quantity of surface run-off may vary across the river basins due to climate change in 2050s with a declining trend in quantity. The Mahanadi, Brahmani, Ganga, Godavari and Cauvery basins may observe increased rainfall under the climate change scenario of IPCC IS92a[2] and SRES A2 scenarios.

Agriculture being the largest consumer of water resources is also the largest livelihood provider of the state. The state therefore places high priority on the development of irrigation facilities in order to enhance agricultural production and improve the livelihood of rural communities. The rapid urbanisation of the state also challenges government to ensure safe supply of potable water to its citizen. Recent trends indicate that the water quantity available to meet such demands is depleting over decades. Also the quality of water is severely deteriorated due to discharge of industrial effluents and municipal sewage in natural water bodies. Besides, water supply and use is also not very efficient resulting in wastage of water and reduced water productivity. Table 26 illustrates the projected water demand by in year 2025.

Table 26: Projections for sectoral water demand in Karnataka[3] (in TMC[4])

Sectors	2000		2025	
Household sector	58.15	4.4%	91.62	4.95%
Agriculture sector	1,110.06	84.0%	1,356.00	73.33%
Industrial sector	47.57	3.6%	125.10	6.76%
Power sector	52.86	4.0%	65.19	3.52%
Others	52.86	4.0%	211.44	11.43%
Total	**1,321.44**	**100%**	**1,850.10**	**100.00%**

Unsurprisingly, agriculture will remain the largest consumer of water resources, though its share may observe a minor reduction (84% to 73%) on account of other demands rising faster. Household and industrial demands are expected to roughly double. Overall it is projected that water demand will reach to 1,850 TMC in 2025 against 1,321 TMC in 2000. This will certainly put challenges to existing water resources of the state. Accord-

[1] Assuming an urban population of 37% of Karnataka's 61.1 million and 100 litres of sewage per person and day

[2] One among the global energy scenarios of IPCC's Supplementary Report (1992): Business-as-usual in which policy fails to acknowledge the need to mitigate climate change

[3] Planning Commission (2007). Karnataka Development Report; Academic Foundation, New Delhi

[4] Thousand million cubic feet (TMC). 1 TMC = 28,316,847,000 m^3 = 28.3 million m^3

ing to projections, Karnataka will have a water demand of 1.41 billion cubic metres for domestic and industrial purposes leaving 6.48 billion m^3 for irrigation while the state will reach 70% of groundwater resource development.

Climate change will affect the availability of water and its quality for various needs. IPCC's 4th Assessment Report (2007) suggested that climate change will severely affect both groundwater and surface water supply by changing global hydrological cycles.[1] It states that "*The negative impacts of climate change on freshwater systems outweigh its benefits*". The response to changed hydrological cycles will directly depend on physiographical and hydro-geological characteristics of the catchments.[2] Erratic climate events are highly likely to change evapo-transpiration, rainfall pattern, temperature and extreme events and consequently the available surface water. This may results into increased events of flood in surplus regions and or drought in deficit regions. Further, increased floods may contaminate and pollute safe water bodies, rendering them unfit for domestic uses. Gosain *et al* (2006)[3] suggested that efficiency of the water supply system, resilience and response mechanism to climate change of a region will play decisive role on the extent of impacts of climate change.

Further, Gosain et al (2006) assessed the impact of climate change on the major river basins of India using climate data generated by the HadRM2[4] control scenario (1981-2000) and under a future GHG scenario (2041-60). Table 27 shows how climate change is projected to affect rainfall, evapo-transpiration and availability of water resources in the state.

Table 27: Climate change impacts on rainfall and run-off of major river basins[5]

Basin	Scenario	Rainfall (mm)	Run-off (mm)	Actual evapo-transpiration (mm)
Cauvery	Control	1,309.0	661.2	601.6
	GHG	1,344.0	650.4	646.8
Godavari	Control	1,292.8	622.8	624.1
	GHG	1,368.6	691.5	628.3
Krishna	Control	1,013.0	393.6	585.0
	GHG	954.4	346.9	575.6
Pennar	Control	723.2	148.6	556.7
	GHG	676.2	110.2	551.7

As shown in Table 27, the Krishna basin may record reduced precipitation resulting in severe drought-like situations. On the other hand, the Cauvery basin may experience increased rainfall. Yet contrary to common expectation, this may not lead to an increase of surface run-off. A net decline of 2% is projected because of the enhanced rate of evapo-transpiration (increase by 7%). This conclusion also emerged from BCCI-K (2011) as we shall see in the following. Its study suggests that the northern and central regions of the Cauvery basin would record a decrease in run-off though increases are projected for Bidar and the eastern parts of the basin.

[1] IPCC (2007). 4th Assessment Report; The Physical Science Basis

[2] BCCI-K (2011). Karnataka Climate Change Action Plan; Final Report

[3] Gosain, A.K., Rao, S. and Basuray, D. (2006). Climate change impact assessment on hydrology of Indian river basins, Current Science 90(10), 346-353

[4] High resolution atmospheric model developed by the Hadley Centre of the Met Office, United Kingdom

[5] MoEF (2004). India's National Communication (NATCOM) to UNFCCC

BCCI-K (2011) projects impacts of climate change for the period 2021 to 2050 on the run-off in two major river basins (Cauvery and Krishna). As shown in in section 2.5, the research group used the HadCM3 global climate model and a SRES A1B scenario, investigating precipitation, surface run-off and evapo-transpiration.

Figure 21 to Figure 24 illustrate the change in rainfall projected for the period 2021-50 for the *kharif* and *rabi* seasons in the Krishna and Cauvery basins .

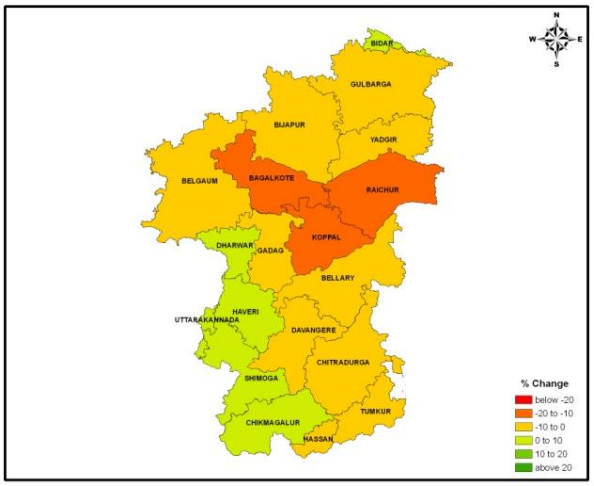

Figure 21: Change in precipitation for 2021-50 for the *kharif* season in the Krishna basin (A1B)[1]

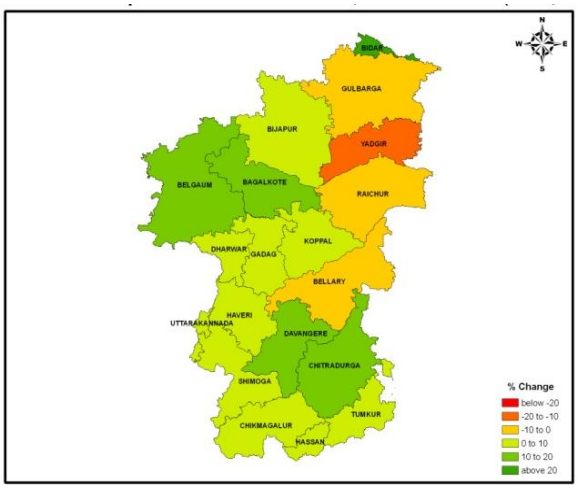

Figure 22: Change in precipitation by 2021-50, for the *rabi* season in the Krishna basin (A1B)[2]

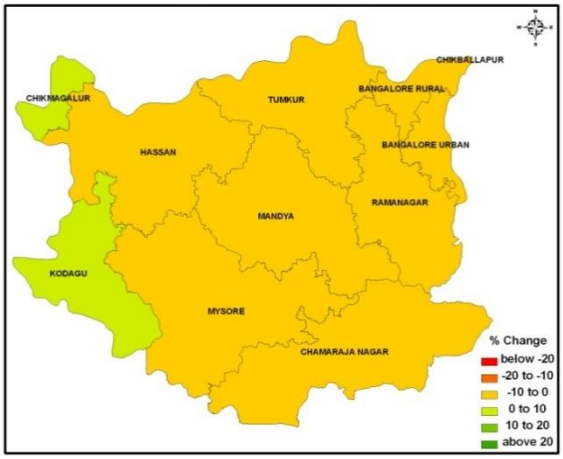

Figure 23: Change in precipitation for 2021-50 for the *kharif* season in the Cauvery basin (A1B)[3]

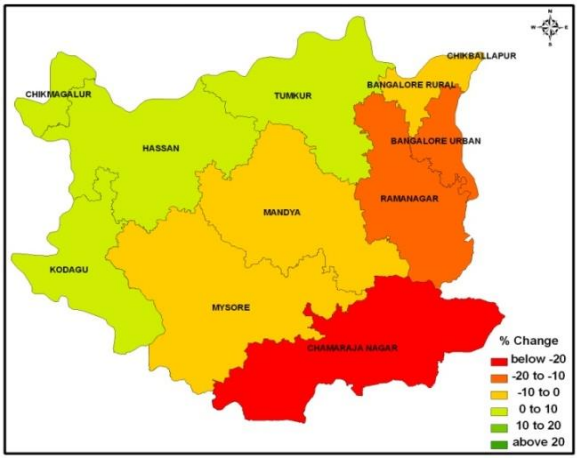

Figure 24: Change in precipitation for 2021-50 for the *rabi* season in the Cauvery basin (A1B)[4]

Around 10% increase in precipitation is project for the southern part of the Krishna basin during the *kharif* season with up to 20% increase in the districts of Shimoga, Chikkamagalur, Haveri, Uttara Kannada and Dharwad. The study also estimated around 10% reduction in rainfall in the north-eastern part of the Krishna basin while Yadgir dis-

[1] BCCI-K (2011). Karnataka Climate Change Action Plan; Final Report

[2] BCCI-K (2011). Karnataka Climate Change Action Plan; Final Report

[3] BCCI-K (2011). Karnataka Climate Change Action Plan; Final Report

[4] BCCI-K (2011). Karnataka Climate Change Action Plan; Final Report

trict may see a decline in rainfall up to 20%. A decline in rainfall up to 10% is projected for all districts in the Cauvery basin during *kharif* with Chikkamagalur and Kodagu experiencing up to 20% decline. Chamarajanagar may record decreased rainfall of -20% and above and Ramanagara and Bangalore Urban between 10-20% during *rabi*.

Figure 25 to Figure 28 illustrate the projected change in run-off under the SRES A1B scenario between 2021 and 2050 for the *kharif* and *rabi* seasons in the Krishna and Cauvery basin as projected by BCCI-K (2011).

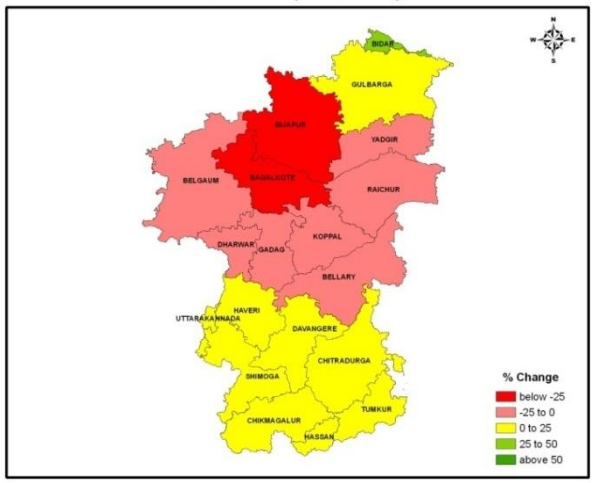

Figure 25: Change in run-off for 2021-50 for the *kharif* season in the Krishna basin (A1B)[1]

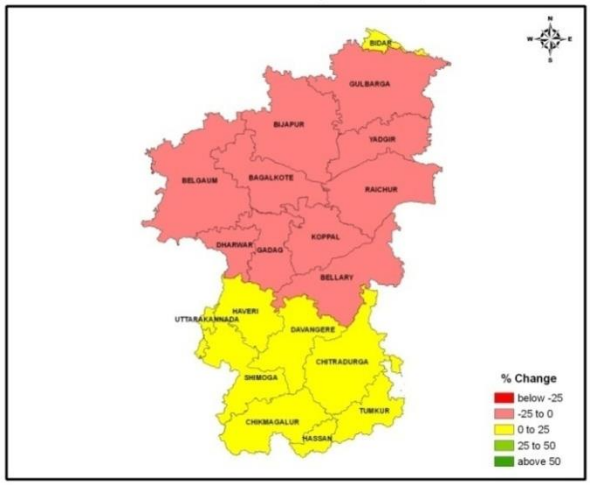

Figure 26: Change in run-off for 2021-50 for the *rabi* season in the Krishna basin (A1B)[2]

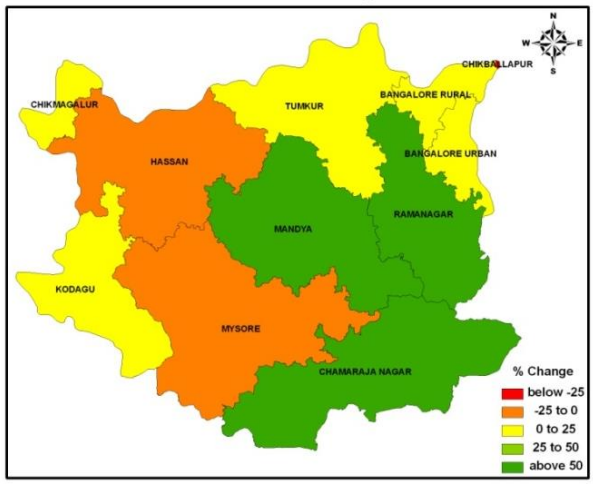

Figure 27: Change in run-off for 2021-50 for the *kharif* season in the Cauvery basin (A1B)[3]

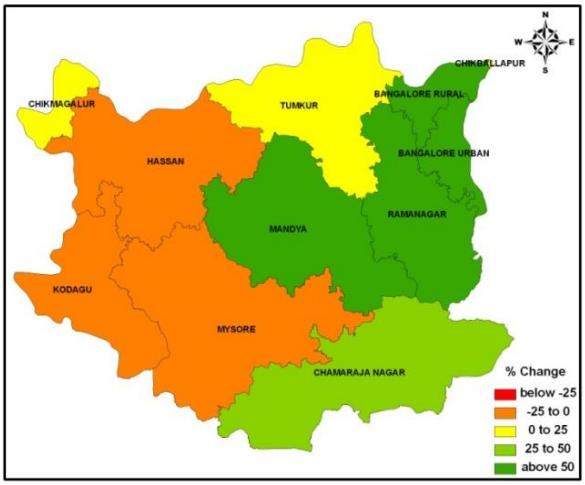

Figure 28: Change in run-off for 2021-50 for the *rabi* season in the Cauvery basin (A1B)[4]

The total run-off is projected to increase by more than 50% in the northern district of Bidar during the *kharif* season and 0-25% in the southern region of the Krishna basin. The study did not predict in any significant increase in run-off in other parts of Krishna basin during the *kharif* season while Bagalkote and Bijapur districts are to witness re-

[1] BCCI-K (2011). Karnataka Climate Change Action Plan; Final Report

[2] BCCI-K (2011). Karnataka Climate Change Action Plan; Final Report

[3] BCCI-K (2011). Karnataka Climate Change Action Plan; Final Report

[4] BCCI-K (2011). Karnataka Climate Change Action Plan; Final Report

duced run-offs. However during the post monsoon *rabi* season, the northern and central region of the Cauvery basin may experience a decrease in run-off except Bidar which may see a higher run-off. Similarly, BCCI-K (2011) projected that the eastern part of the Cauvery basin will see an increase in run-off in both seasons. Districts such as Mandya, Chamarajanagar and Ramanagara have been projected to see 50% more run-off. The study further predicts that, while Chamarajanagar, Mandya, Ramanagara, Bangalore Urban and Bangalore Rural will see increased run-off during the *rabi* season, a decrease in run-off has been projected for Hassan, Mysore and Kodagu districts.

Figure 29 to Figure 32 illustrate the projected change in the evapo-transpiration under SRES A1B scenario for the period 2021-50 for the *kharif* and *rabi* seasons in the Krishna and Cauvery basins as projected by BCCI-K (2011).

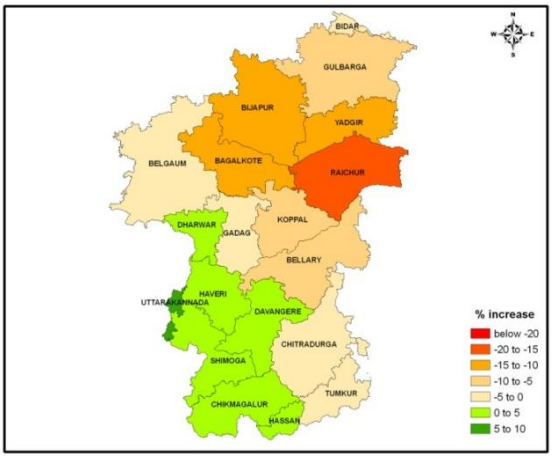

Figure 29: Change in evapo-transpiration for 2021-50 for the *kharif* season in the Krishna basin (A1B)[1]

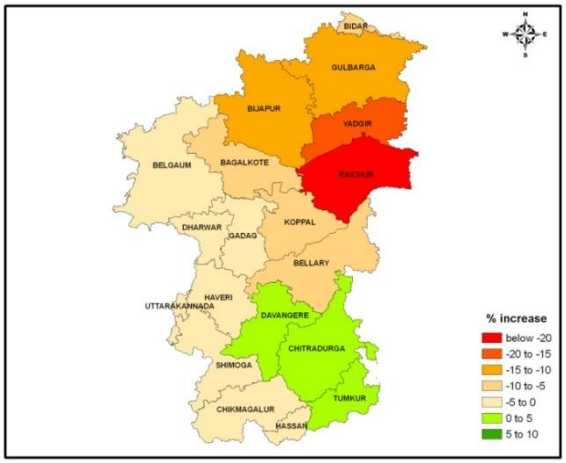

Figure 30: Change in evapo-transpiration by 2021-50, for the *rabi* season in the Krishna basin (A1B)[2]

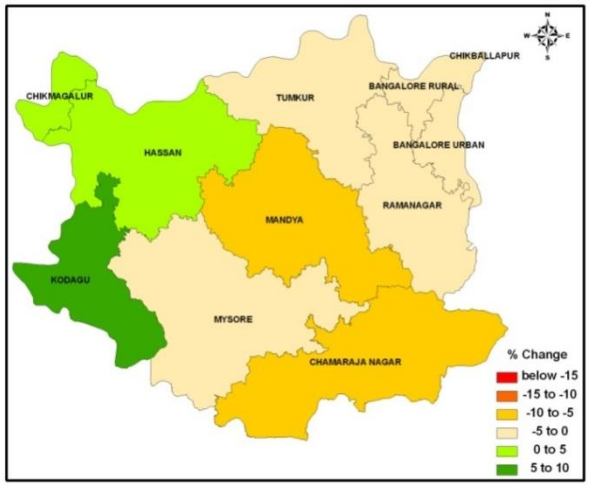

Figure 31: Change in evapo-transpiration for 2021-50 for the *kharif* season in the Cauvery basin (A1B)[3]

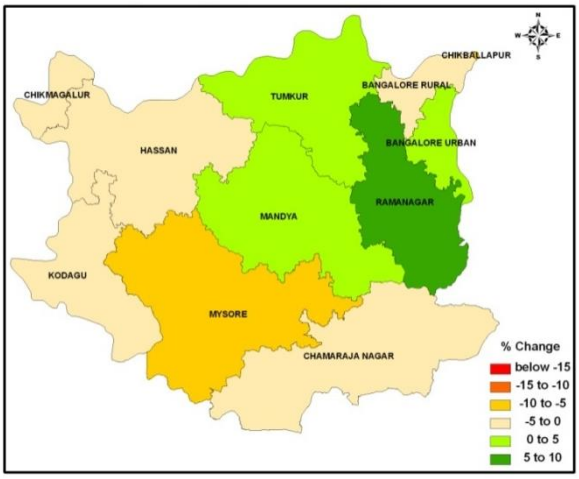

Figure 32: Change in evapo-transpiration for 2021-50 for the *rabi* season in the Cauvery basin (A1B)[4]

[1] BCCI-K (2011). Karnataka Climate Change Action Plan; Final Report

[2] BCCI-K (2011). Karnataka Climate Change Action Plan; Final Report

[3] BCCI-K (2011). Karnataka Climate Change Action Plan; Final Report

[4] BCCI-K (2011). Karnataka Climate Change Action Plan; Final Report

The study projects that the Krishna basin will witness reduced evapo-transpiration in both the *kharif* and *rabi* seasons. A decline is predicted for Raichur for both the *kharif* (up to -20%) and the *rabi* season (above -20%). For the south-western region of the Cauvery basin the study predicts an increase in evapo-transpiration during *kharif* and a reduction during *rabi*. Evapo-transpiration in Chamarajanagar and Mandya districts is projected to decline during *kharif* by -5% to -10%.

Both the Krishna basin with its water intensive paddy and sugarcane and the Cauvery basin with its paddy, sugarcane, ragi, *jowar* and coffee are predicted to experience reduced rain and evapo-transpiration and increased run-off. Considering this, BCCI-K (2011) concludes that it is likely that both basins would further suffer with water stress.

Also MoEF and INCCA (2010)[1] studied the impacts of climate change on India's water resources. It used data of the Indian Institute of Tropical Meteorology (IITM), Pune and processed these with the PRECIS[2] regional climate modelling system for the SRES A1B scenario at a resolution of about 50 km. The study also deployed a hydrologic model known as the Soil and Water Assessment Tool (SWAT). According to the results published, in the 2030s India's west coast will experience a wide variability in precipitation, ranging from +4% in southern Karnataka to -25% in Gujarat (refer to Figure 33). Further, the west coast shows up to 4% reduction in evapo-transpiration for Karnataka (Figure 34). This is attributed to the increased soil moisture storage with increase in rainfall. Karnataka and Kerala are expected to witness higher reduction in evapo-transpiration mainly due to inadequate availability of moisture. In addition, Karnataka is also expected to record about 10% reduced water yield (Figure 35).

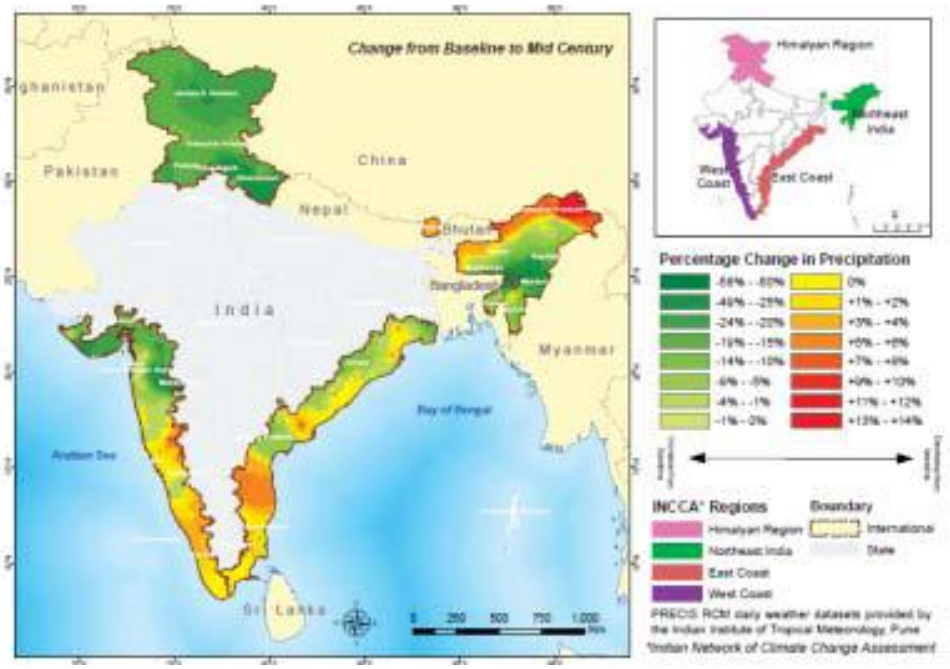

Figure 33: Projected change in precipitation in the 2030s with respect to the 1970s (A1B)[3]

[1] MoEF and INCCA (2010). Climate Change and India: A 4x4 Assessment

[2] Software for regional climate modelling developed by the Hadley Centre, Met Office, United Kingdom

[3] MoEF and INCCA (2010). Climate Change and India: A 4x4 Assessment

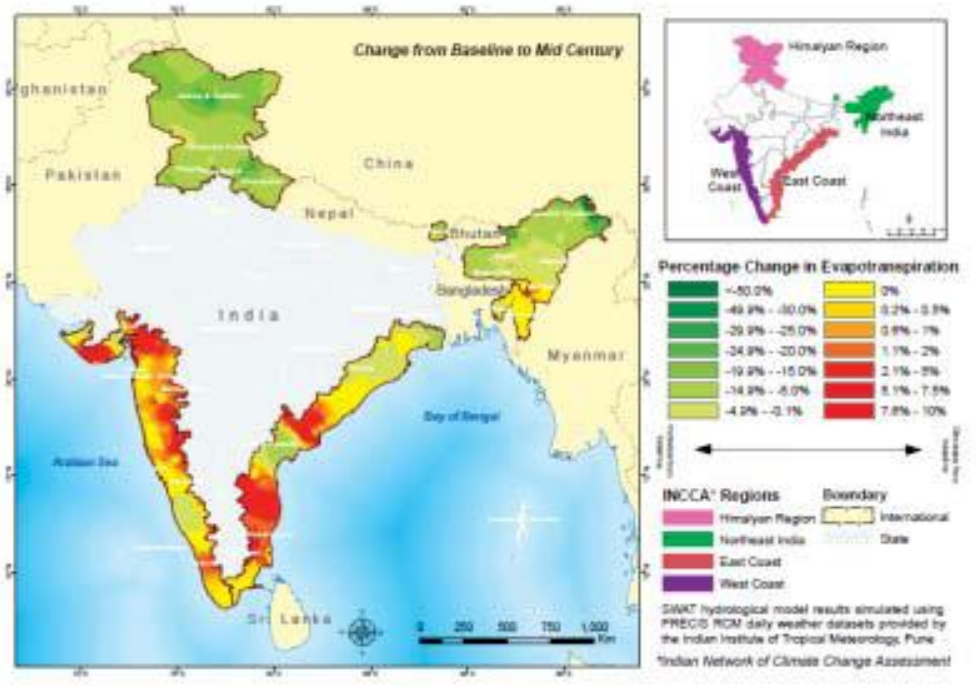

Figure 34: Projected change in evapo-transpiration in the 2030s with respect to the 1970s (A1B)[1]

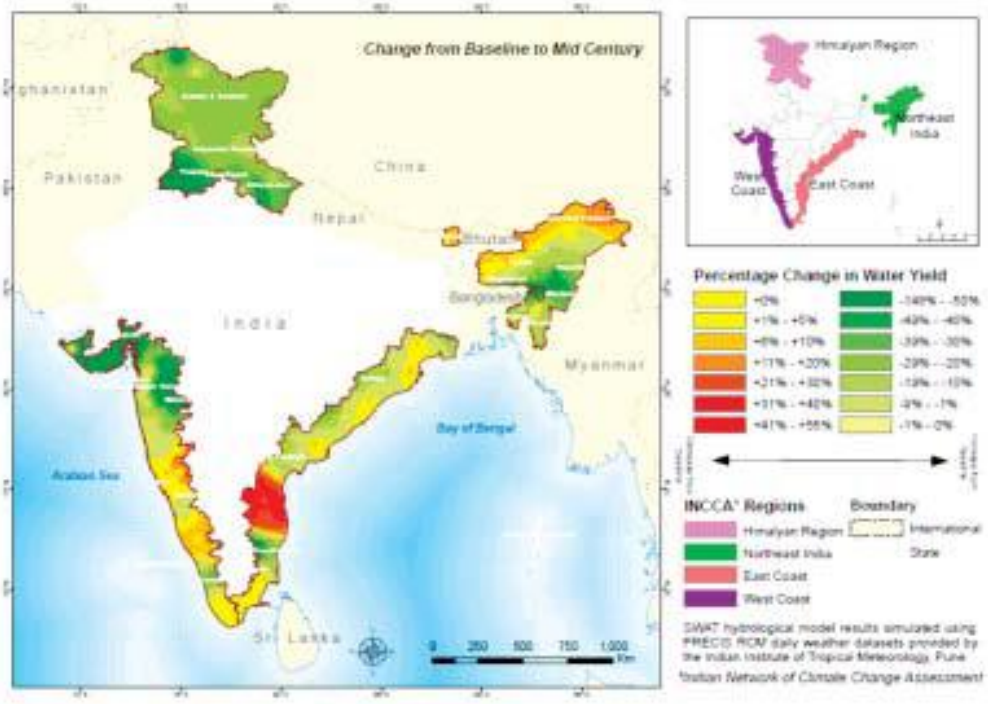

Figure 35: Projected change in water yield in the 2030s with respect to the 1970s (A1B)[2]

[1] MoEF and INCCA (2010). Climate Change and India: A 4x4 Assessment

[2] MoEF and INCCA (2010). Climate Change and India: A 4x4 Assessment

5.6. Actions, policies and institutional preparedness

5.6.1. State Water Policy 2002

The State Water Policy[1] of Karnataka aims at

- Providing drinking water at the rate of 55 LPCD in rural areas, 70 LPCD in towns, and 100 LPCD in city municipal council areas and 135 LPCD in city corporation areas;
- Stepping up irrigation to reach an accumulated 45 lakh hectares under major, medium and minor irrigation projects;
- Improved productivity of irrigated agriculture by involving users in irrigation management;
- Harness the hydropower potential in the state;
- Provide a legislative, administrative and infrastructural environment, which will ensure fair, just and equitable distribution and utilisation of water resources.

5.6.2. Rainwater harvesting

The establishment of Rainwater harvesting (RWH) structure has been made mandatory for certain categories of buildings[2] within the area of Bangalore Water Supply & Sewerage Board (BWSSB) and enforced by BWSSB itself through the Bangalore Water Supply and Sewerage (Amendment) Act 2009. According to unverified press articles, some 25,000 RWH systems have been established in the 58,000 buildings coming under the purview of the Act. While 43% compliance is a noteworthy level of achievement for a time span of merely two years, measures are being considered to enforce compliance in remaining building more rapidly through disconnection of water supply, a proposal of which has been forwarded to the Urban Development Department.[3]

5.6.3. Irrigation

As agriculture is largest water consuming sector, the state of Karnataka has been investing a large share of its budget on major, medium and minor irrigation facilities an amount of INR 2,586 crore was invested on major and medium irrigation and INR 785 crore on minor irrigation structures. The state is also promoting the adoption water efficient technologies such as drip and sprinkler irrigation techniques in order to enhance water productivity and consequently the cost of cultivation. However, only 66,300 ha area in state was under drip irrigation in 2001 (Table 28). Theft of drip irrigation pipes has emerged as an obstacle of noteworthy proportions. The area under sprinkler irrigation has increased from 41,900 ha in 1998 to 125,000 ha in 2005 (Table 29).

Table 28: Area under drip irrigation[4]

	1991-92		1997-98		2000-01	
	Area in ha	Share	Area in ha	Share	Area in ha	Share
Karnataka	11,400	16.2%	40,800	16.6%	66,300	18.0%
India	70,600		246,100		367,700	

[1] Department of Water Resources (2002). State Water Policy 2002 (Karnataka)

[2] New buildings on sites measuring 1,200 ft² and above; existing sites of 2,400 ft² and above

[3] The Hindu, Bangalore edition (April 19, 2011). Watch out, the government may turn off your tap

[4] Agricultural Finance Corporation (1998). Evaluation of Drip Irrigation Systems

Table 29: Area under sprinkler irrigation[1, 2]

	1997-98		2004-05	
	Area in ha	Share	Area in ha	Share
Karnataka	41.9	6.4%	125.0	7.7%
India	658.5		1634.9	

5.6.4. Groundwater protection

Groundwater quality is monitored by the Department of Mines and Geology through network laboratories in all districts of Karnataka. While surface water is not monitored routinely, its quality is assessed in cases of complaints. With financial assistance from World Bank a state-of-the-art Hydrological Information System (HIS) has been established.[3] The department also played a key role in the formulation of the long-anticipated Karnataka Groundwater (Regulation and Control of Development and Management) Act, 2011, which received the Governor's assent in April 2011. Through the constitution of an empowered Groundwater Authority, the Act is a key instrument for curbing indiscriminate exploitation of groundwater. Now permissions have to be obtained for drilling bore wells and drawing water for water-intensive crops in notified areas. The Act also has an impact on the existing 1 lakh existing bore wells, some 50% of which are estimated to be operating. In notified areas, well owners will be obliged to obtain registration certificates for continued use of groundwater which can be refused by the Groundwater Authority if certain conditions are not met.

In consultations it was learnt that close to 56,000 groundwater recharge structures were created by Department for Panchayat Raj and Rural Development in 2009-10, costing INR 530 crore (approx. INR 94,000 each). Another 90,000 structures were proposed for 2010-11 with roughly three times the previous year's budget (INR 1.8 lakh each). Over the last 8 years the department also constructed rooftop rainwater harvesting structures on around 1,000 sites in four districts where fluoride and chlorine content rendered drinking water unfit for consumption.[4] Watershed Development Department (which is allied with the Agriculture Department and not the Water Resources Department) is reported to establish around 6,000 recharge structures per annum from a fund of INR 100 core. With a budget of less than INR 15 crore per annum the Department of Mines and Geology is also said to have constructed 1,200 groundwater recharge structures (approx. INR 1.25 lakh each). A budget of INR 500 crore has been earmarked for groundwater development under the *Jalasiri* Programme for the 3-year period from 2010 to 2012. Recognising the imminent need for groundwater recharge, the Water Resources Department proposes the construction of 200,000 recharge structures per annum for a period of five years with particular focus on over-exploited and critical water sheds.

5.6.5. Water resources management

In order to address knowledge deficits in water management and for providing a platform for the inclusion of stakeholders in decision processes, GoK established the Karnataka Water Resources Authority under chairmanship of the Minister for Water Re-

[1] Indian National Committee on Irrigation and Drainage (1998). Sprinkler Irrigation in India

[2] National Committee on Plasticulture (2005). Applications in Horticulture

[3] Department of Mines & Geology (2011). Consultation held on March 7, 2011

[4] Department of Rural Development and Panchayat Raj (2011). Consultation held on March 9, 2011

sources in 2008.[1] There is however an impression that the authority failed to live up to expectations. In addition a Groundwater Authority will now be established under the Karnataka Groundwater Act 2011.

There is a rapidly growing understanding that water as precious resource that requires protection and professional management. This led to the transformation of the former Irrigation Department into the Water Resources Department. Besides planning, constructing and monitoring irrigation projects, the department develops command areas, collects and analyses hydrological data and, by mandate, is required to conduct research. Subsidiary bodies include the Water Resources Development Organisation (WRDO) and a number of Command Area Development Authorities. In discussion with the authors, the department acknowledged the challenge in the management of water resources while ensuring equitable access, emphasising the need for building conceptual clarity. McKinsey is reportedly developing a strategy for Karnataka on behalf of the Water Resources Department. Considering that the cost of the strategy development is said to be around INR 6 core – fairly high for what is only an assessment – one could assume that it would cover a broad scope of work providing a high degree of spatial detail. However, terms of the assignment were not available for review yet. A first draft of the strategy was anticipated for 2011. The development of water infrastructure is reportedly impeded by the need to ensure technical viability, socio-economic acceptance as well as political consensus. The discussion on tangible tariffs for irrigation water is a case in point here. Their absence is key obstacle in capital-intensive water infrastructure development and it is difficult to envisage building consensus on hugely unpopular pricing.[2]

5.6.6. Sewage management

The fact that only 40% of Bangalore's sewage is being treated has received much public attention. The remainder is known to enter and pollute water bodies.[3] The existing secondary treatment capacity of 721 MLD is only used to a fraction. Likewise it is a paradox truism that only 10% of the available tertiary treatment capacity of 73 MLD is used due to "unavailability of sewage".[4] The board projects that this situation would be resolved by 2014, by which time tertiary treatment is expected to reach 60 MLD.

While the addition of a further 339 MLD of secondary treatment capacity is in the pipeline it is noted that no plan exists for the expansion of tertiary treatment capacity, which could help address the looming water crisis. Tackling sewage and the requisite infrastructure emerges as one of the two key priorities today and the board appears inadequately equipped to deal with this challenge in shorter timeframes. Certain decisions are however encouraging, such as on the provision of dual piping in new layouts. BWSSB plans to provide underground drainage to 7 CMCs and 1 TMC by 2021, covering 230 km^2 appears is commendable if not ambitious. By 2036 the board aims to cover a further 110 villages. The board rightly pointed out that catchment protection is to be taken up and that enormous funding is required for achieving complete coverage with underground drainage.

[1] Government of Karnataka (2008). Government Order WRD 85 MBI 2008 dated September 8, 2008

[2] Department of Water Resources (2011). Consultation held on March 31, 2011

[3] EMPRI (2009). State of Environment Report Bangalore 2008

[4] Bangalore Water Supply & Sewerage Board (BWSSB), (2011). Consultation held on March 7, 2011

5.6.7. Municipal water supply

The second priority of BWSSB is addressing the water supply deficit. Bangalore is receiving only around 800 MLD of its required 1,200 MLD from surface water and the difference is chiefly met by groundwater drawings. The board has been criticised for focussing on augmentation of further water resources (500 MLD from the Cauvery River) while not succeeding in reducing unaccounted-for water (UFW), which stands at 48%.[1] This amount would suffice meeting water requirements altogether and may last for another 5-10 years if one assumes continued rapid growth of Bangalore. It is noted with appreciation that BWSSB has commenced tendering of work addressing unaccounted-for water for around 1 lakh households, a scale greater than that of a pilot project. This leaves hope that UFW will be addressed – and utilised – systematically and thus effectively contribute to reducing water requirements.

5.6.8. National programmes

Bharat Nirman

The Bharat Nirman scheme is a central government initiative focusing on creating rural infrastructure to enhance rural water supply in areas affected by water contamination.[2]

National River Conservation Plan

The National River Conservation Programme (NRCP), initiated 1992-93, identified eight towns of Karnataka for initiation of actions on preventing further pollution (Table 30). Under this scheme, sewage has been diverted from flowing into rivers and sewage treatment plants are established in eight towns, six of which have already been completed. The Karnataka State Pollution Control Board is the nodal agency for implementation schemes under NRCP while work is undertaken by BWSSB and Karnataka Urban Water Supply and Drainage Board respectively.[3]

Table 30: Rivers and towns under National River Conservation Plan

	Town	River	Basin
1.	Nanjangud	Cauvery	Cauvery basin
2.	K.R.N agar	Cauvery	
3.	Srirangapatna	Cauvery	
4.	Kollegal	Cauvery	
5.	Shimoga	Tunga	Krishna basin
6.	Bhadravathi	Bhadra	
7.	Davanagere	Tungabhadra	
8.	Harihar	Tungabhadra	

National Lake Conservation Programme

Government of India provides financial assistance to the state governments to conserve lakes under the National Lake Conservation Programme (NLCP). Activities carried out under this scheme include de-silting, de-weeding, strengthening of bunds, interception and diversion of sewage entering the tanks, fencing and similar work. Conservation

[1] EMPRI (2009). State of Environment Report Bangalore 2008

[2] Government of India (2005). Bharat Nirman: A time-bound plan for rural infrastructure by the Government of India in partnership with State Governments and Panchayat Raj Institutions 2005-09

[3] MoEF. http://moef.nic.in/modules/recent-initiatives/NRCD/table.htm accessed on February 21, 2012

plans for 16 lakes in the state have been approved for the year 2002-03 and development of four lakes has been completed by November 2009.[1]

5.7. Missions under NAPCC

The **National Water Mission** aims for conservation of water minimizing wastage and ensuring equitable distribution across and within states through integrated water resources development and management. With this objective, five goals have been identified and strategies for achieving these have been identified. The five goals are:

- Establishment of a comprehensive water resource database in the public domain;
- Promotion of citizen and state actions for sustainable water consumption;
- Conservation and augmentation (in this order);
- Focused attention on over-exploited areas;
- Increasing the efficiency of water uses by 20%;
- Basin-wise designs for integrated water resources management.

Areas where national and state challenges meet

Water resources are under severe threat in Karnataka. The state is endowed with limited water resources that are stressed and depleting. Sectoral demands are growing rapidly on account of increase in population, urbanisation, rapid industrialisation and rising incomes. Water Resources Department has initiated comprehensive actions on conservation needs, replenishment, supply and the participation of common people in watershed management.

The mission document emerges as recommending a revision of the National Water Policy to address vulnerabilities related to climate change. Going by communications received from departments, the likewise need for a revision of the State Water Policy 2002 does not seem to have been identified yet. The attention on rainwater harvesting and groundwater recharge schemes within the Karnataka State Water Policy is however in line with the NAPCC.

One of the most important goals of the mission is to improve the efficiency of water use by 20%. This objective is to be achieved by ensuring improved efficiency both on the demand and supply side. Consistent water metering and water audits recommended by the mission are a necessity. There is presently no information available on sectoral groundwater consumption for domestic or agricultural uses. Comprehensive studies proposed under the mission will be crucial for identifying water shortage and surplus regions. Basin-wise designs for integrated water resources management will also be beneficial for address Karnataka's water shortage.

5.8. Selected emerging intervention areas

Assessments

- Setting up a real time dynamic database for water resources and development of a Water Resources Information System (WRIS) including mapping of catchments, surveying and assessing land use patterns with emphasis on drainage at district level;
- Conducting a detailed water resources inventory, including annual variations at a micro-watershed scale;

[1] MoEF. http://moef.gov.in/nrcd/NRCD/NRCP1.htm accessed February 21, 2012

- Conducting spatial and temporal assessments of water availability for micro-watersheds and analyse trends using models such as Surface Water Assessment Tool (SWAT);
- Setting up dedicated facilities with advanced computing systems to make predictions for water resources;
- Conducting GIS based aquifer studies for assessing recharge possibilities;
- Conducting assessments on reducing evaporation losses within water storage structures, wastelands, fallow lands, agriculture lands through usage of mulches, canal lining etc.;
- Conducting pilot studies to explore augmentation of water resources from flood water;
- Conducting studies on efficient crop water utilisation and pressure irrigation methods;
- Measurement of flows of major irrigation canals for accounting losses and improving efficiency.

Regulation

- Regulate the use of bore wells;
- Consider a policy on water metering for bulk consumers of groundwater;
- Formulating a legal provision in by-laws of local bodies for water conservation.

Implementation

- Constructing wastewater treatments plants in the entire state for treatment and recycling to reuse in the domestic sector, industries and irrigation;
- Measurement of unaccounted for water (UFW) and its reduction to an acceptable level through leak detection and rehabilitation programmes for water supply;
- Installation of water saving equipment for toilets in public and government buildings, including schools, colleges, hotels etc.;
- Mandatory water audit for all sectors, including the domestic sector, small and large scale industries, along with irrigation projects.

Other areas

- Undertake awareness programmes on the remediation of water losses and educate the masses.

6. FORESTRY, BIODIVERSITY AND WILDLIFE

6.1. Forest cover

Karnataka has 3.83 million hectare of forest area accounting for about 20% of the geographical area. The state has varied forests ranging from evergreen in the Western Ghats to the scrub jungles in the plains. The Western Ghats are among the 25 global biodiversity hotspots and one among the two on the Indian subcontinent.

Reserve forest constitutes 74.9% of the state's forests, protected forest 10.3% and unclassified forest 14.8%. Very dense forest covers 1,777 km^2, accounting for 0.93% of Karnataka's geographical area. Moderately dense forest covers 20,181 km^2 (10.5%), open forest 14,232 km^2 (7.4%) and scrubs 3,167 km^2 (1.7%).[1]

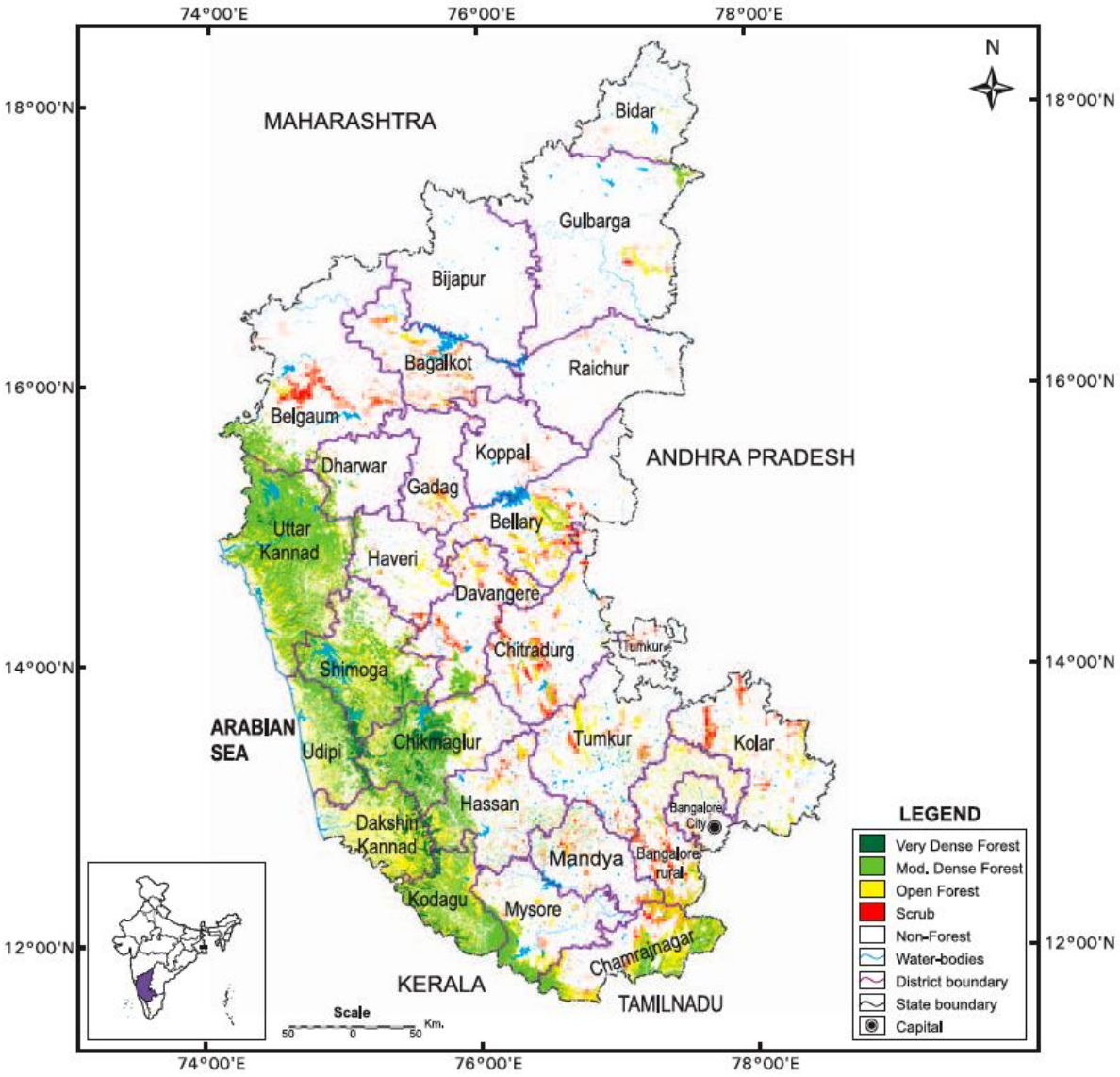

Figure 36: Forest cover of Karnataka[2]

[1] Forest Survey of India (2009). State of Forest Report 2009

[2] Forest Survey of India (2009). State of Forest Report 2009

Karnataka's forest area is marginally declining (-2%). Area under dense forest declined by a significant 16% from 2001 to 2007 (refer Table 31). As dense forest declined, the area under open forest increased.[1] In light of the loss of forest area, CSD (2011) estimated that a carbon removal potential of 0.6 million tons of CO_2 (or 0.36%) out of 17 million was lost between 2003 and 2007.[2]

Table 31: Trends in area under different types of forest in Karnataka (km²)[3]

Forest type	2001	2003	2005	2007	Change 2001-07
Dense forest	26,156	22,461	21,968	21,958	-16%
Open forest	10,835	13,988	14,232	14,232	31%
Scrub forest	3,245	3,141	3,173	3,176	-2%
Total	**40,236**	**39,590**	**39,373**	**39,366**	**-2%**

6.2. Wildlife and sanctuaries

Karnataka's forests are home to 25% of India's elephant and 18% of the tiger population.[4] Wildlife of the state includes 395 tigers, 6,185 elephants, 817 panthers, 2,324 bears, 15,760 wild boar, 25,850 deer, 8,484 bisons and 4,998 sambar deers.

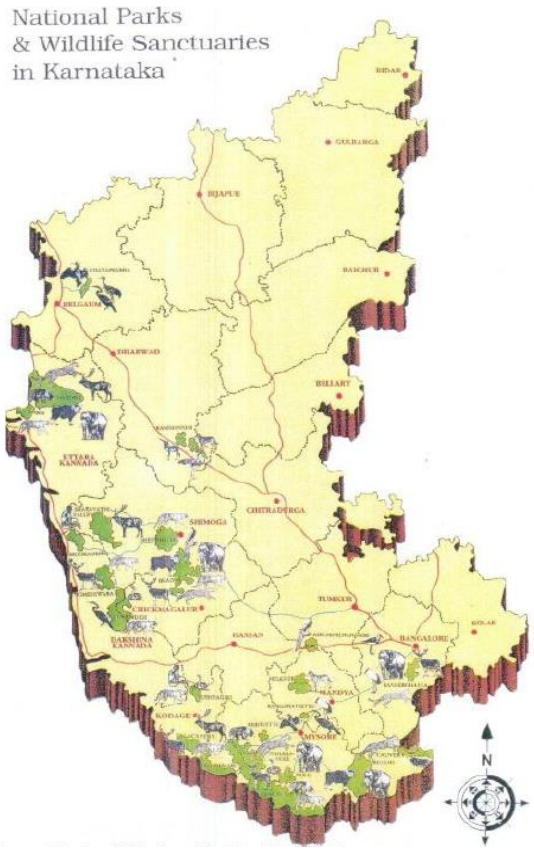

Figure 37: National parks and wildlife sanctuaries in Karnataka

[1] Forest Survey of India (2009). State of Forest Report 2009

[2] Centre for Sustainable Development (CSD), (2011). Karnataka Climate Change Action Plan

[3] BCCI-K (2011). Karnataka Climate Change Action Plan; Final Report

[4] Karnataka Biodiversity Board (2010). Biodiversity of Karnataka: At a Glance

The Niligiri Biosphere Reserve (5,520 km^2) was established in 1986 and the Bandipur and Nagarhole National Parks were included in the reserve later. The state has five national parks and 21 wildlife sanctuaries. Of these, five protected areas are covered by 'Project Tiger'. As of September 2011, seven inland fish sanctuaries have been created in four districts and nine are in the process of being recognised.[1]

6.3. Biodiversity

6.3.1. Coastal zone

Karnataka's coastline extends over 320 kilometres with about 14 coral species, four sponge species, 62 phytoplankton, 78 species of seaweeds, two species of sea grass and 115 zooplanktons. Also, 234 species of molluscs are present out of which three are threatened. About 33 species of shrimps, 103 species of crabs, 5 species of star fish, two species of sea urchins, one species of sea cucumber, 390 marine fish species, three species of sea turtles, four species of whales and four species of dolphins are commonly seen along the coasts. There is a rich coral reef ecosystem surrounding Netrani Island. The coast has 14 species of mangroves belonging to eight families including *Rhizophora mucronata, Avicennia marina, Avicennia officinalis, Bruguiera cylindrica, Rhizophora apiculata, Sonneratia alba among others* (also refer to section 7.2 Coastal biodiversity).[2]

6.3.2. Western Ghats

The Western Ghats include a range of forest types: Tropical evergreen, moist and dry deciduous, high altitude sholas, savannas and scrubs. There are over 4,500 species of flowering plants (38% endemic), 330 butterflies (11% endemic), 156 reptiles (62% endemics), 508 species birds (4% endemics), 150 mammals (12% endemics), 289 fishes (41% endemics) and 135 amphibians (75% endemic) in the Western Ghats. Important endemic tree species of the region include *Dipterocarpus indicus* and *Hopea parivflora*.

Economically important naturally grown species include *Santalam album, Dalbergia latifolia, Tectona grandis* and *Dysoxylum malabaricum*. The indiscriminate harvesting of non-timber forest products (NTFP) such as *Machilus macrantha* and *Ailanthus malabarica (Halmaddi)* has resulted in significant reductions of their population to a level which poses threat of extinction. Shola forests are usually confined to sheltered valleys, hollows and depressions where there is adequate moisture and good drainage. The main tree species growing include *Alseodaphne semecarpifolia, Cryptocarya beddomei.*[3]

6.3.3. Eastern plains

The Deccan plateau forms the eastern plains of Karnataka marked by low or scanty rainfall, high temperature, rocky topography and thorny scrub vegetation. Forests cover only 7% of the area with frequently occurring species such as *Acacia, Hardwikicia, Neem, Santalam albam, Ficus*. The region has 1,421 species of angiosperms belonging to 696 genera under 140 families. 107 species are listed as medicinal plants but due to scarce occurrence many cannot be harvested. There are some endemic species in the region such as *Brachystelma ciliatum, Brachystelma kolarensis* in Kolar district, *Brachystelma elenaduensis* in Tumkur district, *Schizachyrium sudhanshuii* in Raichur district.[4]

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[1] Karnataka Biodiversity Board (2011). Comments on the draft Karnataka SAPCC dated September 24, 2011

[2] Karnataka Biodiversity Board (2010). Biodiversity of Karnataka: At a Glance

[3] Karnataka Biodiversity Board (2010). Biodiversity of Karnataka: At a Glance

[4] Karnataka Biodiversity Board (2010). Biodiversity of Karnataka: At a Glance

6.3.4. Coral reefs

Coral reefs are among the most productive ecosystems in tropical waters. Netrani Island off the coast of Murdeshwar is surrounded by a rich coral reef ecosystem. A biodiversity survey conducted during 2005-06 shows the noteworthy presence of rare and new species. 89 coral associated fishes were recorded in which 27 species and four genera were new findings with respect to the Indian coast. Of the fishes studied, four genera were reported for the first time on the Indian coast. Two species are on the IUCN Red List of Threatened Species. The survey identified 14 coral species, four sponge, 15 bivalves, 48 gastropods and eight nudibranch species. Also small giant clams (*Tridacna maxima*) were found which are protected under the Indian Wildlife Act and appear on the IUCN Red List as 'Lower Risk: Conservation Dependent'. Also, the occurrence of humphead wrasse (*Cheilinus undulatus*) is significant as it has a low recruitment rate, is heavily exploited and is therefore listed in the CITES Appendices. Present threats to the coral ecosystem of Netrani Island are mostly human in origin. As a study revealed, dead corals are lying on the side of the island as a result of habitat degradation.[1]

6.3.5. Threatened and endangered species

Evergreen trees such as *Dipterocarpus bourdilloni, Hopea erosa* and *Hopea jacobi, Croton lawianus* (a small tree) and *Pinnatella limbata* (a moss) are among critically endangered species. Other endangered trees found in Karnataka include *Isonandra stocksii, Kingiodendron pinnatum, Maesa velutina, Myristica magnifica, Rapanea striata* and *Xylosma latifolium*.

Endangered fauna found in Karnataka include the tiger, the Indian elephant, the lion tailed macaque, the turtle and the *dhole* (the Indian wild dog *Cuon alpinus*). It also includes amphibians (*Indirana brachytarsus, Microhyla sholigari, Minervarya sahyadris, Nyctibatrachus aliciae, Nyctibatrachus hussaini, Nyctibatrachus sanctipalustris, Philautus charius, Philautus wynaadensis, Ramanella mormorata* and *Rhacophorus lateralis),* a toad *(Bufo beddomii)* the Kolar leaf-nosed bat *(Hipposideros hypophyllus)* and a mollusc *(Pseudomulleria dalyi).*

Table 32: Species threat in Karnataka[2]

Domain	Total species	Key species under threat
Fishes	300 freshwater species, 405 marine species	A total of 20 fish species have been reported to be on the verge of extinction, which includes *Labeo fimbriatus* (Bloch), *Gonoproktopterus curmuca* (Hamilton – Buchanan), *Puntius carnaticus* (Jerdon) and *Neolissochilus hexagonolepis* (McClelland).
Medicinal plants	1,493 species of 808 genera and 108 families	*Rauvolfia serpentina, Saraco asoca, Gloriosa superba*
Avian biodiversity		The most number of endemic birds in Karnataka is found along the Western Ghats
Orchids	176 species of 49 genera	The hotspots of orchids in Western Ghats of Karnataka are Tadianamol in Kodagu (61 species, 6 endemic), Bababudan in Chickmagalore (41 species, 18 endemic) and Dandeli in Uttara Kannada district (37 species, 23 endemic).
Butterflies	Over 300 species	Some are endangered such as Crimson rose, Danaid Eggfly, *Cramer* and *Appias hippo* nut statistics are not availanle.

[1] Karnataka Biodiversity Board (2010). Biodiversity of Karnataka: At a Glance

[2] Karnataka Biodiversity Board (2010). Biodiversity of Karnataka: At a Glance

6.4. Impact of climate change

6.4.1. On forests

Climate is among the most important determinants of forest growth. It has significant influence on the distribution, structure and ecology of forests. Changes in the climate alter the balance of forest ecosystems. As evidence has shown, carbon dioxide concentrations rose from 280 ppm in 1750 to 379 ppm 2005 (refer to section 3). In response to rising CO_2 levels, IPCC (2007) concludes that nearly all models used predict a "*stimulation of carbon assimilation and sequestration*". The net uptake of CO_2 predicted gives rise to hope that, up to a certain degree, the vegetation's natural response to increased GHG concentrations could be compensatory rather than exacerbating the imbalance.[1]

This aside, a prominent concern is that climatic changes will impact *exiting* vegetation and forests in particular. Investigating this BCCI-K (2011) assessed the impact climate change may have on the state's forests. The research group used HadRM3[2] global climate model and projected changes for the period 2021 to 2050 against a baseline period 1961-90 under a SRES A1B scenario. It found that 38% of forest area is projected to be impacted by climate change by the 2030s.[3] According to the study, the projected climate is not suitable for certain existing forest types and species present. The change in forest distribution under projected climate change impacts is presented in Figure 38 for the 2030s. Mainly forests in the central and northern parts of the Western Ghats are projected to be impacted by climate change.

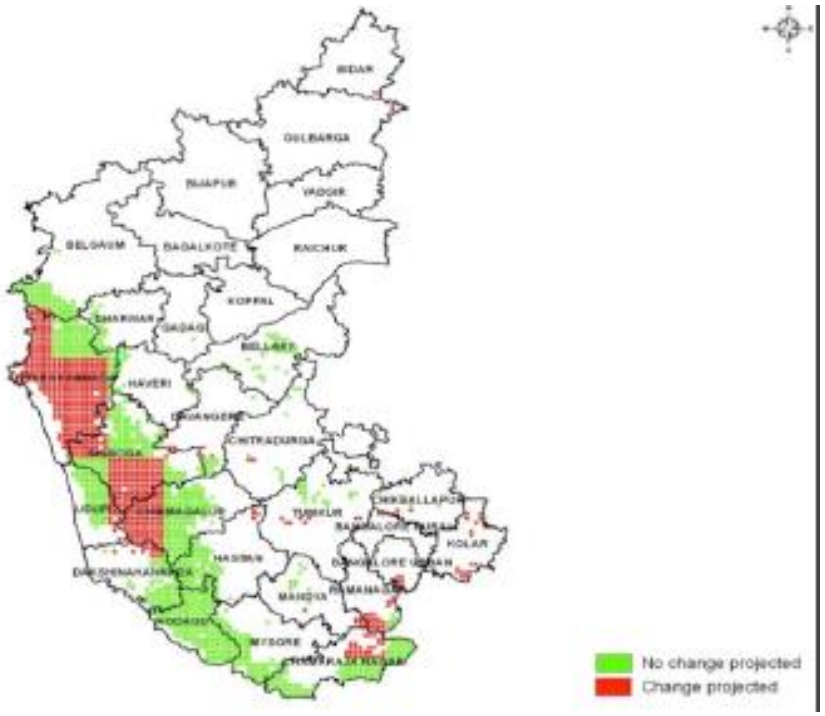

Figure 38: Projected change in forest types for 2021-50 in Karnataka (A1B)[4]

[1] IPCC (2007). 4th Assessment Report; The Physical Science Basis

[2] High resolution atmospheric model developed by the Hadley Centre of the Met Office, United Kingdom

[3] BCCI-K (2011). Karnataka Climate Change Action Plan; Final Report

[4] BCCI-K (2011). Karnataka Climate Change Action Plan; Final Report

6.4.2. On the Western Ghats

In the Western Ghats, MoEF and INCCA (2010) project an increase an in the annual mean temperature between 1.7°C and 1.8°C with respect to the 1970s. Minimum temperatures may rise by 2°C to 4.5°C. By the 2030s, the study finds, mean annual rainfall is likely to vary from 935±185 mm to 1,794±247 mm with a net increase of 6% to 8% with respect to the 1970s. The number of rainy days is likely to decrease along the entire west coast, including the Western Ghats. The intensity of rainfall is likely to increase by 1-2 mm/day.[1]

A climate change study by Ravindranath and Sukumar (1998) investigates two scenarios: Increase in GHG (a) and increase in GHG *and* aerosol concentrations (b). Under scenario (a) a shift in vegetation type along the altitudinal as well as west east gradient is predicted for the Western Ghats. It is projected that wattles (*Acacia sp*.) could invade the grasslands. Longer dry spells may cause an increase in dry season fires, threatening the moist and dry deciduous forests. Under scenario (b), a change in precipitation is projected that could weaken the Indian summer monsoon.[2]

The coastal regions and Western Ghats are moderately vulnerable to climate change. 18 of the 54 forest grids of the Western Ghats region are projected to undergo changes by the 2030s. The net primary productivity (NPP) of the region is projected to increase by 20% on average.[3] It needs mention that the forests of Uttar Kannada, Chikkamagalur and Shimoga districts are projected to be particularly vulnerable to climate change by the 2030s.[4]

6.4.3. On the coastal region

As discussed in the previous section, projections by MoEF and INCCA (2010) indicate also for the coastal region that by the 2030s annual rainfall will vary from 935±185 mm to 1,794±247 mm with respect to 1970s. A net increase of 6% to 8% is expected, ranging from 69 to 109 mm. Though June, July and August show an average increase of 8 mm rainfall in the 2030s, winter rainfall however is projected to decrease on an average by 19 mm in January and February. The period March, April and May also shows a decrease.[5]

In the coastal region 30% of the 96 grids (excluding the Western Ghats) are expected to experience change. The net primary productivity (NPP) in this region is predicted to rise by 31% on average.

6.5. Other threats

Decline in urban green cover: Bangalore previously had a good record on urban forestry. Flowering roadside trees was planted up by the Urban Forest Division. Innumerable trees had to be removed due to widening of roads, construction of bridges and refurbishment of water supply and sewerage.

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[1] MoEF and INCCA (2010). Climate Change and India: A 4x4 Assessment

[2] Planning Commission (2007). Karnataka Development Report; Academic Foundation, New Delhi

[3] MoEF and INCCA (2010). Climate Change and India: A 4x4 Assessment

[4] BCCI-K (2011). Karnataka Climate Change Action Plan; Final Report

[5] MoEF and INCCA (2010). Climate Change and India: A 4x4 Assessment

Mining: Mining is a key sector in Karnataka. Movement of heavy machinery, blasting, power drilling, excavations, benching and dumping of spoils are responsible for destabilising soils, slopes, valleys and water courses. The conditions stipulated for soil and moisture conservation, rehabilitation of mined areas and quick restoration of stabilizing vegetation are often violated. Mines on the ridges and upper slope of hills cause substantial damage to flora and fauna.

Forest encroachments: The loss of forests due to encroachments has a long history. Even before the birth of forest administration, there was a system of shifting cultivation practiced mainly by tribals. With a view to regulate loss of forest cover, certain measures were taken such as *ek sala* (one year lease), periodic lease, clearance of forest strips around cultivated lands for crop protection from wild animals, grants for fruit cultivation, permits for coffee or cardamom cultivation.

Rehabilitation: Large stretches of forestlands were released for rehabilitation of displaced families. Refugees from Tibet who were settled on forest lands near Bylukuppe in Kodagu, Indur in Uttara Kannada and Kollegal in Mysore district are a case in point. Notwithstanding the important purpose served by accommodating diaspora, these settlements contribute to the decimation of forest cover and biodiversity.

Forest degradation: Forest areas lost only quantify the loss. But there is another creeping loss by way of honey-combing, human habitations and unrestricted grazing of livestock. Nearly 150,000 families have settled in encroached forest lands. In addition to their requirements for fuel, fodder, poles, fencing, grazing and green manure, the settlements keep their surroundings cleared for self-protection from fire and wildlife. Fires spreading in forests nevertheless delay natural regeneration and jeopardise the top soil.

Invasive alien species: Exotic species have impacted the biodiversity of various freshwater and terrestrial ecosystems of Karnataka. The spread of exotic fishes like *Tilapia* and, more recently, the African catfish has contributed to an erosion of indigenous fish biota. The weedy water hyacinth is choking many of the wetlands. Large tracts of forests stand invaded by the weedy *Eupatorium.* Some areas have also been converted to monoculture plantations of exotic species such as *Acacia auriculiformis, A. mangium, Eucalyptus* and *Casuarina equisetifolia*. *Parthenium* has come to cover many scrublands and grasslands. The damage is further aggravated by climate change, pollution, fragmentation and loss of habitat.

6.6. Policies and legislative framework

In the following laws and regulations relevant to Karnataka, particularly in relation to biodiversity, forest and wildlife is summarised.

- The **Wildlife (Protection) Act, 1972** provides protection to listed species of flora and fauna and establishes a network of ecologically important protected areas. The Act empowers the central and state governments to declare any area a wildlife sanctuary, national park or closed area. There is a blanket ban on industrial activities in protected areas. It also provides instruments for the implementation of the Act to regulate hunting of wild animals, for protection of specified plants, sanctuaries, national parks and closed areas and restricting trade in wild animals or animal products. The Act prohibits hunting of animals except with prior permission in case an animal threatens human life or property or is disabled or diseased beyond recovery. The near-total prohibition on hunting was made more effective by the Amendment Act 1991.

- The **Forest (Conservation) Act, 1980** was adopted to protect and conserve forests. The Act restricts the powers of the state in respect of de-reservation of forests and use of forestland for non-forest purposes. The clause on 'non-forest purposes' for example also prohibits clearing of forestland for cultivations.
- The **National Forest Policy 1988** aims to ensure environmental stability and the maintenance of an ecological balance which is vital for sustenance of all life forms. The derivation of direct economic benefit is subordinated to this principle aim. It aims at management of forests with the active participation of local communities through what is known as Joint Forest Management (JFM).
- The **Biological Diversity Act, 2002** aims to "*provide for the conservation of biological diversity, sustainable use of its components, and fair and equitable sharing of benefits arising out of the use of biological resources, knowledge*". As per the provision of Act certain areas, which are rich in biodiversity and encompasses unique and representative ecosystems are identified and designated as biosphere reserve to facilitate conservation. All restrictions applicable to protected areas such as national parks and sanctuaries are also applicable to these reserves as well. Also Karnataka Biodiversity Board (KBB) was established in 2003 under this Act and in 2005 the Karnataka Biodiversity Rules were framed.
- The **Scheduled Tribes and Other Traditional Forest Dwellers (Recognition of Forest Rights) Act, 2006** aims at recognising and vesting forest rights and occupations with forest dwelling scheduled tribes and other traditional forest dwellers who depended on forests for generations.
- The **Karnataka Forest Act, 1963** consolidates and amends the law relating to forests and forest produce in the state of Karnataka. The Karnataka Forest Rules were framed in 1969.
- The **Karnataka Preservation of Trees Act, 1976** offers stronger provisions for protection of trees in the state, especially with regard to felling. It also introduces the concept of liability for the preservation of trees. Under this Act, no person shall fell any tree or cause any tree to be felled in any land, whether in his ownership or occupancy or otherwise except with the previous permission of the Tree Officer. The Act further stipulates the constitution of Tree Authorities.
- The **Karnataka Forest Manual** sets out procedures for recognition of reserved forests, constitution of village forests, management of district and private forests, pasturing of cattle and cutting of grass for fodder in forests.[1]
- The **Karnataka Marine Fishing (Regulation) Act, 1986** regulates fishing from fishing vessels along the coastline. The Act prohibits fishing during the monsoon period (June to August) in the state. Also the operation of mechanised fishing vessels is banned in a 10 km radius of the foreshore wile an area of 3,000 km^2 is set apart for traditional fishing to prevent over-exploitation in foreshore waters.
- The **Karnataka Inland Fisheries (Conservation, Development & Regulation) Act 1996** aims to providing for conservation, development and regulation of inland fisheries in the state.
- The **National Bio-fuel Policy** aims at promoting the development and utilization of indigenous biomass for production of bio-fuels. The policy also envisages development of more efficient bio-fuel conversion technology.

[1] Karnataka Forest Department (1976). Karnataka Forest Manual 1976

6.7. Actions and institutional preparedness

6.7.1. Forest management

Karnataka Forest Department (KFD) highlighted the significance of forestry in combating climate change in its 2008 release "Forestry & Climate Change". The document also drew attentions to a predicted shift in forest types in about 70% of India's forest grids by 2085 and outlined the department's future role and response to climate change. It proposes "*development of robust C* [carbon] *sinks and augmenting income of local communities for their sustainable development*" as targets.[1] It calls for massive reforestation of degraded lands and expansion of agro-forestry, linked to the assumption that greater carbon assimilation is feasible and should be achieved.

Some concepts of this initial paper were defined in detail later on and presented in the department's Vision 2020 document released in 2010[2]. It defines a number of specific intervention areas to achieve quantitative and qualitative 'transformations', specifying methods and estimating costs. Although titled as vision document, it contains elements of a work plan, including the following targets and objectives:

- Increase of tree cover in the state to 33% of the geographical area through afforestation, Joint Forestry Planning & Management (JFPM), free distribution of seedlings, soil and moisture conservation, roadside afforestation, maximising bamboo and sandalwood resources and raising of bio-fuel plantations;
- Consolidation and protection of existing forest resources and existing deemed forest;
- Enhancement of forestry resource productivity and carbon assimilation;
- Protection and inventorisation of medicinal plants;
- Promotion of employment generation through forestry;
- Development and implementation of GIS-based forest land management system;
- Curtailing the utilisation of forest land for non-forestry purposes;
- Recruitment and training of forest personnel.

In the process KFD is found to have embarked on a conscious climate change mitigation course by fostering forestry resources as carbon sinks. Though KFD's Vision 2020 is testimony to a forestry approach centred around statutory responsibilities, it also looks at forests in the context of climate change, thus enlarging the significance of the role the department is endowed with. Seedlings were distributed to private landowners for reclamation of lost green cover in the state. In 2010-11 approximately 80,000 ha were planted in Karnataka, including on barren lands. Funds are drawn under different schemes, mostly from the Finance Commission and Compensatory Afforestation Fund Management and Planning Authority (CAMPA). KFD envisages that once additional funds under the National Mission for Green India become available, the scale of activities could be increased. But mission funds are not necessarily expected to add elements entirely to the Karnataka portfolio but rather expand the coverage of scheduled activities. The mission's all India budget of INR 200 crore[3] for 2011-12 was perceived as sobering

[1] Karnataka Forest Department (2008). Forestry & climate change – Vision & Mission Document

[2] Karnataka Forest Department (2010). Vision 2020

[3] Ministry of Finance, Press information Bureau (February 28, 2011). Union Budget 2011-12 Highlights

because the share earmarked for Karnataka would suffice only for planning – which was already accomplished – while major implementation would need to wait larger funds.[1]

As envisaged in its 2008 document, KFD constituted a Project Formulation Group in 2009. Comprising of 19 members initially, the group pursues the integration of climate change into the department's work. The focus is on research input and development of concepts, concrete projects and policy recommendations while assisting other department wings with research and planning. A central aim is the demonstration of strategies for adaption and mitigation. This includes research, a good example for which is the preparation of region specific carbon yield tables, and extends to the development of operating procedures for field activities in view on climate change needs.[2] It should be kept in mind that these actions are voluntary in nature.

Preparatory work resulted in proposals for climate change interventions in collaboration with Indian Institute of Science (IISc). This includes impact and vulnerability modelling for forests, mitigation and adaptation projects as well as long-term monitoring. With institutional support from forestry colleges in Sirsi and Ponnampet, KFD intends to undertake monitoring based research on carbon stocks, biodiversity, forest growth and, in association with Institute for Socio-Economic Change (ISEC), socio-economic aspects related. Mitigation options have been proposed for 0.56 million ha (11%) of the potential area of 5.1 million ha over a 5-year period with focus on forest cover quality, restoration, tree cover increase and agro-forestry. The coverage will be adjusted in accordance with future funding secured through the National Mission for Green India as well as other budgets. However, KFD acknowledges the insufficiency of manpower especially at lower level to execute the implementation of programmes under the mission. To overcome this limitation a special purpose vehicle (SPV) is mooted. Institutional capacity is projected to be expanded further by involving the Directorate of Social Forestry assisted by subject specialists for sociology, economy and capacity building. And for implementation, Village Forest Committees (VFCs) and Eco-Development Committees (EDCs) are envisaged to work in tandem with NGOs and self-help groups (SHG).[3]

The formulation of a new Karnataka Forest Policy was initiated in 2011. It seeks to strengthen operational and administrative capacities within KFD and aims to increase performance in areas of statutory work by notifying operating guidelines. If successful, the new policy could enhance the abilities of the department, particularly for implementation. This could be expected to result in a stronger institutional base, which is important also for taking up climate change related work. Some of its elements however have a direct bearing on the department's climate change agenda. Prominent examples are the identification and promotion of alternative energy options from forest areas and the demarcation and consolidation of forest areas.[4] The policy under preparation is understood to aim at stipulating measures for the protection of forest resources and biodiversity. Major areas are earmarked for plantation of trees including medicinal plants, extending to urban and other non-forest areas, degraded forestlands and roadsides. It is further expected that it would establish guidelines for the protection of natural resources in vicinity of mines and quarries and include provisions for tribals. Supply and

[1] Karnataka Forest Department (2011). Consultation held on March 11, 2011

[2] Karnataka Forest Department (2011). Communication on Project Formulation Group, March 14, 2011

[3] IISc and Karnataka Forest Department (undated). Climate change and forest sector in Karnataka; Impacts, Adaptation and Mitigation; Working paper, received on March 11, 2011

[4] Karnataka Forest Department (2011). Policy areas and issues; Internal draft work plan, received on April 6, 2011

demand side management will be introduced for forest raw material and small forest products. Also the recommendation of creating green belts around industrial areas – which has been emphasised by nearly every study on industrial pollution and which has not found takers – is slated to be included in the policy with clear definition of responsibilities. A vast programme for wildlife, flora and fauna protection and rehabilitations of endangered species will be prescribed and capacity building is expected to be operationalised and incentivised for both KFD personnel and collaborating NGOs.

6.7.2. Conservation of biodiversity

Government of India enacted the Biological Diversity Act 2002 to conserve biological resources, promote sustainable use of these resource and equitable sharing of benefits. Under its purview, Karnataka Biodiversity Board (KBB) was established in 2003 under whose guidance 3,542 Biodiversity Management Committees (BMCs) were established until March 2011. These seek to anchor conservation, sustainable use and documentation of biological diversity at local levels.

The preparation of People's Biodiversity Registers (PBRs) in consultation with Gram Panchayats is a crucial instrument in this pursuit. PBRs aims to build a village level platform for biodiversity information, medicinal properties and usage of certain species. Building on existing local knowledge, PBRs play a vital role in enhancing local capacities for safeguarding and sustainable use of natural resources. 213 of them have been prepared so far and another 25 will be completed in 2012. PBRs were first initiated in the state in 1995 by the Foundation for the Revitalisation of Local Health Traditions (FRLHT). Between 1996 and 1998 the Indian Institute of Science (IISc) coordinated the preparation of PBRs at 52 locations in eight states under the national Biodiversity Conservation Prioritisation Programme.

KBB also initiated the preparation of a bio-diversity atlas. Major efforts are now being directed at establishing dry zone biodiversity conservation sites. Project areas of 100-200 ha have been demarcated in 13 dry districts. According to the concept implemented here, there will be no harvesting in these areas while fire protection, sowing of indigenous species, soil and water conservation are ensured. This paired with a thorough documentation of biodiversity seeks to help in the conservation of dry zone forest species under threat due to their high medicinal value. The project identified 14 rare, endemic or threatened (RET) species. A comprehensive inventory of bio-resources and their commercial use has been developed together with an association of medicine manufacturers. In Karnataka 198 pharmaceuticals and 82 cosmetics industries are reported to use bio-resources.

Other actions taken or funded for biodiversity conservation by KBB include:[1]

- Declaration of three areas as biodiversity heritage sites under the Biological Diversity (Conservation) Act, 2002. These comprise of Nallur Tamarind Grove, and sites at GKVK Campus, Bangalore and Hogrekhan in Chikkamagalur district. Two more sites at Ambargudda in Shimoga district and Netrani Island are under consideration. Also the Kali and Agnashini estuaries have been surveyed to assess their eligibility to be proposed as biodiversity heritage sites;
- Proposal to declare ten tree species as heritage trees under the Biological Diversity (Conservation), Act 2002;

[1] Karnataka Biodiversity Board (2011). Comments on the draft Karnataka SAPCC dated September 24, 2011

- Directing the declaration of seven inland fish sanctuaries under the Karnataka Inland Fisheries Act, 1996. Nine more sanctuaries are in the process of being recognised. Changes in fisheries due to climatic changes remain to be studied;
- Establishment of a herbarium and a botanical museum of Western Ghat species;
- Conducting several studies including (a) an assessment of the ecological carrying capacity of Uttara Kannada district, (b) a survey of sacred groves in coastal Karnataka and the Western Ghats region and (c) a project on floristic diversity, ecological uniqueness and conservation strategies of riparian flora of Netravathi river system in the Western Ghats range of Dakshina Kannada district.

Table 33: Fish sanctuaries in Karnataka[1]

Location	River	Taluk	District
1. Chippalagudda	Tungabadhra	Thirthahalli	Shimoga
2. Hariharapura	Tungabadhra	Koppal	Chikkamagalur
3. Sringeri	Tunga	Sringeri	Chikkamagalur
4. Thodikana	Chandragiri	Sulya	Dakshina Kannada
5. Thingle	Seethanadi	Karkala	Udupi
6. Matturu	Tunga	Shimoga	Shimoga
7. Bacchnayakanagundi	Kllaje	Sulya	Dakshina Kannada

Since 2008 biodiversity conservation in the Western Ghats is also strengthened by Western Ghats Task Force. It holds the mandate to develop policies for sustainable development and formulate recommendations to the Chief Minister. Strengthening of institutions, institutional cooperation and stakeholder involvement are recurring elements in its work. Education and research institutions were approached by the task force with the request to engage in conservation work. Efforts are made to streamline unspecified activities of KFD's Research Wing through consultations, involving the possibility of establishing a research institute promoted by the department. Several short-term studies have been commissioned to improve planning clarity. A 2010 report[2] of the task force presents achievements in this respect:

- Declaration of Bhimagad Reserve Forest in Belgaum district as wildlife sanctuary under the Wildlife (Protection) Act, 1972 through the State Wildlife Board. The same is being pursued also for Chincholi in Gulbarga district and Kappata Gudda in Gadag district;
- Declaration of four biodiversity hotspots as conservation reserves under the Wildlife (Protection) Act, 1972 through the State Wildlife Board. These include Aghanahshini Valley, Bedthi Valley and the Dandeli forest region in Uttara Kannada district and Basur Amrutha Mahal Kaval in Chikkamagalur district. The latter was recommended particularly for its traditional cattle breeds;
- Promotion of participatory agro-forestry practices through a series of workshops in five locations. Action has been initiated in Uttara Kannada to develop minor forest with certain privileges to farmers with landholdings in hilly terrain;
- Commencement of development of a mine reclamation model in Bisgod Reserve Forest in Uttara Kannada with active participation of the local community.

[1] Karnataka Biodiversity Board (2011). Comments on the draft Karnataka SAPCC dated September 24, 2011

[2] Western Ghats Task Force (2010). Major Achievements

6.7.3. Tree planting

Tree planting emerges as an inter-departmental effort with several agencies other than KFD also contributing, albeit within the confines of their respective jurisdictions. KSPCB reports to have encouraged industries to plant 75 lakh saplings over the past two years by making it conditional for granting consent for establishment or operation. A target of 1.5 crore saplings has been set for industrial areas.[1] Public Works Department (PWD) reports to examine the possibility of including cost and other provisions for tree planting in road construction estimates.[2] Compensatory tree planting however appears to be already established practice and prerequisite for obtaining environmental clearances. PWD's Karnataka State Highways Improvement Project for example was accorded consent to fell nearly 11,000 trees for upgrading 650 km of state highway as its proposal included plantations along the entire road length at a rate of 200 trees per km. For every tree felled around ten new ones will be planted.[3] Obligations emerging from environmental management plans are said to be implemented with care and thought, stressing on benefits such as emission reductions through improved riding, carbon sinks created and, without quantification, adoption of social forestry and improvement of roadside ponds.[4]

6.8. Missions under the NAPCC

The **National Mission for Green India** acknowledges that climate change will affect and alter the distribution, type and quality of natural resources and livelihoods of people. The mission acknowledges the influence that the forestry sector has on environmental amelioration through climate mitigation, food security, water security, biodiversity conservation and livelihood security of forest dependent communities. It therefore intends to achieve three overall objectives:

- Enhance carbon sinks in sustainably managed forests and other ecosystems;
- Enhance the resilience and ability of vulnerable species and ecosystems to adapt to the changing climate;
- Enable climate adaptation of forest dependant local communities.

With regard to the functioning of the mission, an Advisory Council chaired by MoEF will provide guidance while a National Steering Committee will direct mission activities. The implementation period is ten years from 2010-11 to 2019-20 with a budget of INR 44,000 crore. Overall targets of the mission include:

- Doubling of the afforestation area and eco-restoration in India in the next ten years, taking the total area to be afforested or eco-restored to 20 million ha;
- Increase GHG removals of India's forests to 6.35% of India's annual GHG emissions by the 2020.

Several programmatic areas with independent budget allocations are outlined:

- Increase forest cover and density of 2 million ha of moderately dense forests (INR 3,000 crore);

[1] Karnataka State Pollution Control Board (KSPCB), (2011). Consultation held on March 8, 2011

[2] Public Works Department (PWD), (2011). Letter dated February 02, 2011

[3] State Level Environmental Impact Assessment Authority (SLEIAA). Letter dated January 29, 2011

[4] Karnataka State Highways Improvement Project (2011). Note on climate change, April 20, 2011

- 4 million ha of degraded forests to be regenerated/afforested and sustainably managed (INR 12,000 crore);
- A total of 2 million ha of scrub/grasslands will be restored and put under sustainable multiple uses (INR 5,000 crore);
- 0.1 million ha of mangroves to be restored/established (INR 500);
- Improving the conservation status of 0.1 million ha of wetlands (NR 600 crore);
- 0.2 million ha of urban/peri-urban forest lands and institutional lands will be brought under tree cover (INR 2,000 crore);
- 1.5 million ha of degraded agricultural and fallow lands will be brought under agro-forestry (INR 7,500 crore);
- 0.10 million ha of corridor areas, critical to wildlife migration will be secured (INR 500 crore);
- Increasing the adoption of improved fire wood stoves with greater efficiency by about 10 million households.

6.9. Selected emerging intervention areas

Forestry and carbon sequestration

- To enhance carbon stock of forests, encroachments must be cleared and there should be no tolerance towards encroachments;
- The Karnataka Preservation of Trees Act should be abolished and access to bio-resources should be managed through Biodiversity Management Committees under the Biological Diversity Act 2002 read with Karnataka Forest Act;
- An electronic database of forestland records and should be created, hosted by Karnataka State Data Centre. In this regard, the ForDIS project of Karnataka Forest Department should be seriously reviewed;
- Strategies for identifying market-linked opportunities for development of robust carbon sinks as well as increasing income for local communities should be developed;
- To ensure the minimization of GHG emissions a standard code of operations should be developed by and for KFD for activities such as planting, soil and water conservation, use of fertilizers and machinery;
- A plan should be developed for planting about 1.5 crore saplings including bio-diesel plants;
- An urban forestry plan should be developed along with city master plans;
- Pursue obtaining carbon credits for forest conservation projects;
- Identification of important buffer areas, corridors and potential areas for afforestation by satellite and ground surveys;
- Satellite based monitoring processes should continues and feedback needs to be better communicated to policy makers;
- Prepare a plan for involvement of local communities through participatory forest management and developing agro-forestry models.

Biodiversity

- Establishment of a geographical indication registry for both plants and animals;
- Establishing germ plasm banks of forest genetic resources at three sites in the state according to the agro-ecological regions. This should also include fauna;

- Declaration of large tracts under as mangrove sanctuaries;
- Special programmes should be developed and implemented for conservation of sacred groves, *devarkadus*, *kans*, *kumki*, *hadi*, *bane* and *betta* lands;
- Plantation models should be defined based on indigenous species suitable to local climatic conditions;
- A comprehensive plan should be made for creating awareness of tourists of the relationship between tourism and biodiversity conservation.

Other conservation aspects

- Ecological rehabilitation of mined areas in Bellary, Chitradurga and Tumkur districts to be completed in time bound manner;
- Create plantations around lakes and in watersheds to prevent soil erosion, evaporation, siltation and water leaching to other areas;
- Visibly demarcate notified forest areas. This would also facilitate the identification of areas where buffers can be created;
- Rehabilitation of displaced people from protected areas.

Research

- Climate change impact research studies with relevance to Karnataka should be conducted, collated and analysed for developing adaptation and mitigation measures;
- Establishing weather monitoring stations at least 100 distinct sites in protected areas and other important habitats of the state.

7. COASTAL ZONE

Karnataka's coast stretches across 320 kilometres therein the districts of Dakshina Kannada (62 km of coastline), Udupi (98 km) and Uttara Kannada (160 km).[1] There are three distinct agro-climatic zones ranging from coastal flatlands in the west with undulating hills and valleys in the middle and high hills in the east. There is a narrow strip of coastal plains with varying width between the hills and the Arabian Sea, the average width being 50 to 80 km. The average height of the hinterland is 70 to 75 metres but in some places it is as high as 150 metres. The abrupt rises at the eastern flanks form the Western Ghats. The northern parts of the Ghats are of lower elevation (450-600 metres) as compared to the southern parts (900 to 1,500 metres).[2] The exploitation of natural resources (fisheries, sand mining etc.) and industries (petrochemical, fertilizers etc.) has put extreme pressures on the coast of the state.

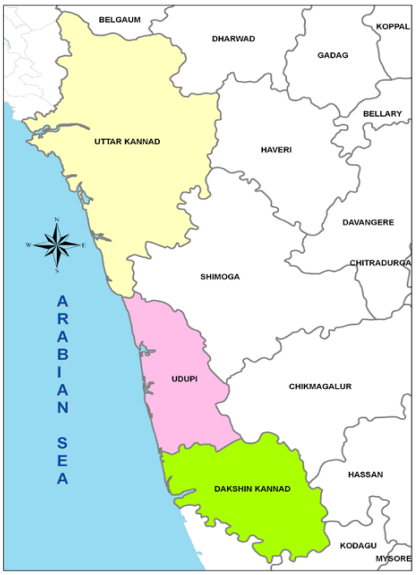

Figure 39: The three coastal districts of Karnataka

7.1. Socioeconomics of the coastal zone

Coastal Karnataka has eight maritime taluks: one in Dakshina Kannada district (Mangalore), two in Udupi district (Udupi and Kundapur) and five in Uttara Kannada district (Bhatkal, Honnavar, Kumta, Ankola and Karwar). The coast has 22 urban agglomerations and 1,044 villages.[3] The area's average population density is 253 persons/km^2 (337 in Dakshina Kannada, 290 in Udupi and 132 in Uttara Kannada).[4]

The area is predominantly agrarian involving about 60% of the workforce. More than 70% of cultivated land is under cereals with rice as the principle crop. Fishing is one of the major sources of livelihood with about one lakh people directly engaged in it and another two lakh in associated work.[5] In addition, industrial activities have also recorded a

[1] Reddy, H.R.V. (2010). Coastal issues and concerned: Challenges for the Research Community; Annamalai University

[2] EMPRI (2012). State of Environment Report Karnataka 2011

[3] Business Line (March 12, 2004)

[4] Census of India. Census Report 2001

[5] Business Line (March 12, 2004)

rapid growth providing direct employment to nearly two lakh people.[1] Similar to problems across the globe, the situation is no different in Karnataka – industrialization, improper land use, unsustainable economic activities and overexploitation of natural resources have adversely affected the coastal environment. Effluents and emissions discharged by large industries and power plants, unregulated tourism and intensive aquaculture have negatively affected the coastal environment. Decline in mangroves and coastal wetlands have eroded its pollutant-filtering capacity.

Table 34: Projected population growth in coastal cities of Karnataka[2]

Town	Population		Area km²
	2011	2016	
Mangalore	415,272	676,788	132.82
Ullaa	49,862	84,864	11.00
Puttur	48,063	63,967	34.00
Udupi	113,039	170,180	65.08
Kundapura	28,595	43,049	15.00
Karwar	62,960	99,564	27.15
Ankola	14,306	26,362	7.42
Bhatkal	58,711	136,420	12.48
Dandeli	31,785	74,651	5.57
Sirsi	53,287	102,842	9.50
Total	**875,880**	**1,478,687**	**320.02**

Table 35: Land use in Karnataka (2001-02)[3]

Land Use	Dakshina Kannada	Udupi	Uttara Kannada
Geographical area (in thousand ha)	477,149,000 ha	356,446, 000 ha	1,024,679000 ha
A. Non-available for cultivation total	**51.8%**	**42.0%**	**84.4%**
Area under forest cover	26.9%	27.9%	79.5%
Land put to non-agriculture use	12.5%	10.8%	3.3%
Barren and uncultivable land	12.4%	3.3%	1.6%
B. Cultivable waste land total	**17.8%**	**25.9%**	**3.0%**
Uncultivable land	6.9%	9.3%	0.7%
Permanent pasture and grazing land	4.1%	3.0%	1.9%
Land user trees and groves	6.8%	13.6%	0.4%
C. Fallow land total	**2.5%**	**3.6%**	**1.9%**
Current fallow land	1.4%	1.2%	0.9%
Other fallow land	1.1%	2.4%	1%
D. Gross cropped area total	**34%**	**36.3%**	**11.6%**
Net sown area	28%	28.5%	10.6%
Area sown more than once	6%	7.8%	1.0%

[1] Reddy, H.R.V. (2010). Coastal issues and concerned: Challenges for the Research Community; Annamalai University

[2] Karnataka Urban Infrastructure Development Corporation (KUIDFC), (2007). Karnataka Urban Development and Coastal Environmental Management Project; Project document

[3] Centre for Multi-Disciplinary Development Research (2008). Natural Resource Accounting in Karnataka: A study of the land & forestry sector (excluding mining)

Table 35 shows the land use pattern of the coastal districts of Karnataka. Uttara Kannada district has the highest percentage (84.4%) of uncultivable land followed by Dakshina Kannada (51.8%). Out of total uncultivable land, around 27% is covered by forest in Udupi and Dakshina Kannada while Uttara Kannada district has land as much as 79.5% of land under forest. Approximately 28% land is cultivated in Udupi and Dakshina Kannada while Uttara Kannada cultivates only 10.6% of land.

7.2. Coastal biodiversity

The state has a rich biodiversity supporting a number of ecological functions in the coastal eco-systems including livelihood opportunities to millions of people. Karnataka's coastline has numerous river mouths, lagoons, bays, creeks, cliffs, sand dunes and long beaches. The shelf off Karnataka has an average width of 80 kilometres and the depth of the shelf break is between 90 and 120 meters. There are 26 estuaries with more than 70,000 ha water spread area and 8,000 ha of brackish water area, making the coastal line of Karnataka very rich in marine, estuarine and riverine biodiversity.[1] The Western Ghats, which run parallel to the coastline, are indeed an integral part of the coast. Fourteen rivers which originate in here run westward and join the Arabian Sea. These rivers carry silt and organic debris from the forested hinterland into the estuarine areas and the coastal sea and contribute greatly to the productivity and diversity of the coastal ecosystems. The tides travel long distances, even 20-30 km interior, through many of these rivers, making the saline aquatic habitat suitable for several marine and estuarine organisms. Important estuaries include Netravati, Gurpur, Mulki, Hangarkatta, Gangolli, Sharavathi, Aghanashini, Gangavali and Kalinadi.[2] The forests of the hinterlands, almost 20 to 30 km interior, were considered during the British period as 'inner coastal zone'.[3] The commercial exploitation of coastal resources is causing irreparable damage to regeneration of coastal vulnerable resources. These are subjected to severe threats due to anthropogenic pressures in the coastal areas over the years. Many anthropogenic activities have led to the loss of biodiversity. There are few islands of the coast such as St. Mary's Island four kilometres off Malpe.

Coastal areas are among the most productive and important habitats of the biosphere, including estuaries, backwaters and coastal wetlands. There are 14 coral species and 4 sponge species found in this region such as *Dendrophyllion* sp. *Turbinana* sp, Goniastrea pectinatu che. Small gaint clams *(Tridacna maxiona)* are protected under the Indian Wildlife Protection Act. There are about 62 phytoplanktons and 78 species of sea weeds *(sangassam ilicifolium)*, two species of sea grass, 115 zooplankton such as *Acartia clausii, Acrocalanus gibber, Euphausia diomedeae, Stylocheiron armatum* are found along the Karnataka coasts apart from 234 species of *Mollusce* out of which three are threatened *(Tridacna maxima, Lambis chiragra* and *placenta).* 33 species of shrimps were first recorded on Karnataka coasts recently. 103 species of crabs, five species of starfish, two species of sea urchins, one species of sea cucumber have been observed along the coasts. 390 marine fish species, three sea turtle species, four whale species and four dolphin species are commonly seen along the coasts.[4]

[1] Karnataka Biodiversity Board (2007). Biodiversity conservation and management in coastal districts of Karnataka

[2] Department of Forest, Ecology & Environment (2004). State of Environment Report Karnataka 2003

[3] Karnataka Biodiversity Board (2007). Biodiversity conservation and management in coastal districts of Karnataka

[4] Karnataka Biodiversity Board (2010). Biodiversity of Karnataka: At a Glance

7.3. Fisheries

The fisheries sector contributes 0.7% of gross GSDP and 3.18% of net GSDP to the state's economy at current prices. The share of fisheries within agriculture sector and in the total is on an increasing trend. Thus fisheries are one of the thrust areas in the development of the state. The coast has 27,000 km^2 of continental shelf area, rich in pelagic fishery resources. The state's share of 'exclusive economic zones' comprises of 87,000 km^2 of coastal waters and open sea with more than 300 varieties of marine fishes. Its resource potential is estimated at annual fish harvest of 4.25 lakh metric tons per year of which 2.25 lakh tons are from inshore areas up to a depth of 70 m and the remaining 2.0 lakh tons from the off shore/deep sea zone. There are 29 fish-landing centres including five minor fishing harbours along the Karnataka coast (also refer to section 4.5).[1]

Marine fish production from Karnataka's coast has witnessed considerable variation. During the last ten years the lowest production of 1.28 lakh metric tons was recorded in 2001-02. In 2009-10 it was 2.49 lakh metric tons and 57,359 metric tons of marine products worth INR 391 crore were exported from the state.[2]

Table 36: Fish production coastal Karnataka[3]

Year	Marine quantity (Mt/a)	Inland quantity (Mt/a)	Total quantity (Mt/a)
1997-98	189,859	120,542	310,401
1998-99	160,627	118,419	279,046
1999-00	165,653	126,646	292,299
2000-01	177,907	127,468	305,375
2001-02	128,416	121,196	249,612
2002-03	180,161	86,262	266,423
2003-04	187,003	70,036	257,039
2004-05	171,227	80,470	251,698
2005-06	176,974	120,599	297,573
2006-07	168,545	123,919	292,464
2007-08	175,566	122,124	297,690
2008-09	218,137	143,717	361,854

7.4. Environmental issues

7.4.1. Coastal erosion and sea level rise

Increasing reports of coastal erosion in the last two decades raised doubts on whether erosion is a recent phenomenon. Dynamic changes have occurred in this fragile boundary between the land and the sea ever since the boundary was formed, but the changes have received public attention only now because of their increased importance and economic impact. It is also possible that increased human interference may have upset the delicate equilibrium established by nature. The primary causes of coastal erosion in any given region are generally wave action, the interception of littoral drift, sea level and river mouth changes and sand mining.[4]

[1] Department of Fisheries (2010). Draft Fisheries Policy of Karnataka

[2] Department of Fisheries (2010). General statistics and fish production

[3] Department of Fisheries (2010). General statistics and fish production

[4] Dattatri, J. (2007). Coastal Erosion an Protection Along Karnataka Coast; Centre for Environmental Law, Education, Research and Advocacy (CEERA); National Law School of India University

About 30% of the area of the coastal zone is subjected to moderate soil erosion and 16% of the area to severe soil erosion. The annual rates of soil erosion vary from 5-15 tons per hectare (t/ha) to 15-40 t/ha in moderate to severe soil erosion areas.[1] The problem is relatively more severe in Dakshina Kannada and Udupi coasts. The erosion becomes severe due to the synchronization of high floods in rivers with strong wave activity during the southwest monsoon. The most affected locations are Kundapur Kodi, Hangarkatta and Bengere. Erosion and bank collapse in the tidal reaches of rivers is also severe and extends at least to about 12 km. This has also been noticed in the Haladi river, Sitanadi near Mabukal and Ullal of Netravathi riverbank.[2] In another study coastal erosion and submergence of land have been reported at Ankola, Bhatkal, Malpe, Mulur, Mangalore, Honnavar, Maravante and Gokarn in Karnataka. About 60 km of beach (19% of the total length of shoreline) is affected by erosion. The problem is more severe in Dakshina Kannada and Udupi coasts where about 28% of the stretch is critical. In Uttara Kannada region about 8% of the coast is subjected to severe erosion.[3, 4] In 2004 MoEF reported that mouths of the small coastal rivers and backwaters at many places are experiencing erosion. Around 41% area of coastline is eroded which includes 6% highly eroded area. Dynamic and migratory shoaling at several locations along the coastline makes it prone to destruction and vulnerable to climate related risks.

Sea-level rise projections along the Indian coastline adhere to the projections of IPCC (2007). There are four major factors related to this: Thermal expansion of the oceans, melting of the mountain glaciers and small ice caps, melting of the Greenland ice sheet and the rapid breakdown of the edge of the Antarctic ice sheet are possible factors for the global sea level rise.[5] Descriptive statistics of the mean sea level are listed in Table 37. In a study on Udupi coast (95 km) erosion was found to be 0.6 km^2/year between 2000 and 2006 and around 46 km is critically eroded. If sea levels rise, 59% of shore of 95 km would be at very high risk, 7% at high, 4% at moderate and 30% low risk. An inundation analysis of Udupi coast shows that 42.2 km^2 and 372 km^2 of the land area will be submerged by flooding at 1 m and 10 m inundation levels respectively.[6]

Table 37: Trend and projection of sea levels at Mangalore[7]

	Trends in mm/a				Standard deviation	Projection by 2100 in mm/100a	
	Minimum	Maximum	Mean	Observed			
Prior 1980	6,963	7,018	24	6,919	27.5	Before 1978	-149
After 1980	7,072	7,141	20	7,028	32.1	After 1978	256

Dependable projections of the impact of climate change or sea level rise on food production or biodiversity loss along west coast particularly Karnataka coast are still in an infancy stage. However, some simulations on possible impacts on prominent crops in coastal districts of India were carried out by MoEF & INCCA (2010) under a SRES A1B

[1] Reddy, H.R.V. (2010). Coastal issues and concerned: Challenges for the Research Community; Annamalai University

[2] Reddy, H.R.V. (2010). Coastal issues and concerned: Challenges for the Research Community; Annamalai University

[3] Das, C.K.L. (2006). Coastal Erosion Management: Recent Initiatives; National Institute of Disaster Management

[4] Department of Forest, Ecology & Environment (2004). State of Environment Report Karnataka 2003

[5] IPCC (2007). 4th Assessment Report; The Physical Science Basis

[6] Dwarakish, G.S. et al (2009). Coastal vulnerability assessment of the future sea level rise in Udupi coastal zone of Karnataka state, west coast of India; Ocean and Coastal management, 52 (9): 467 to 478

[7] Dwijendra, N.D. and Vinod Kumar S. (2005). Analysis of sea level rise and its impact on coastal wetlands of India Proceedings of the 14th Biennial Coastal Zone Conference New Orleans

scenario for the 2030s.[1] Climate change is projected to affect the yields of irrigated rice in some parts of west coast districts. Irrigated rice yields are projected to marginally increase (<5%). Rain-fed rice on the other hand may reduce by up to 20% in west coast districts. Yields of coconut are projected to increase on the west coast of India up to 30% provided the current levels of water will remain available in future as well. This may be due to lower current temperatures along the west coast.

The impact of sea level rise on coastal wetlands of Karnataka was studied in 2005. The results confirm that there is direct relationship between sea level rise and coastal wetland loss. The study projected that, if the current sea level rise since 1978 continues for the next 100 years, 461 km^2 of coastal wetlands could be inundated (refer Table 38).[2]

Table 38: Projected loss of coastal wetlands in different scenarios[3]

Scenario	1	2	3	4	5	Present trend after 100 years
Sea level rise by	10 cm	20 cm	30 cm	40 cm	50 cm	25.6 cm
Wetlands lost	180 km^2	360 km^2	540 km^2	720 km^2	900 km^2	460.8 km^2

7.4.2. Coastal pollution

Fish and fish oil industries at present discharging effluents directly into the sea or backwaters. The solid waste dumping yard of Mangalore has an area of 28.3 hectares, which is poorly managed. It is estimated that about 300 tons per day solid waste is generated in Mangalore of which 200 t/d are collected and landfilled. At Udupi, the solid waste generation is of the order of 8 t/d of which 5 t/d are disposed at unsecured landfills with an area of 6 acres.[4] The near shore and estuarine waters are subjected to pollution due to several reasons such as inadequate sanitary measures in adjacent areas, port activities, effluent discharge from industries, dumping of fish wastes etc. Marine pollution here generally extends up to 5 km and rarely up to 10 kilometres from the shore.[5]

To sum up, in the coastal region the major threat has been littering of the region with biomedical waste, solid waste and the inflow of sewage in urban areas and plastic paired with industrial effluents. Large scale awareness and people participation and penalising violators will help improve the environment. An immediate necessity is the elimination of plastic from the towns.

7.4.3. Salinity

A grave problem of coastal regions is saline water intrusion and the subsequent destruction of large spans of standing agriculture and horticulture crops. The problem is more pronounced on India's east coast and less so on the western coast which Karnataka shares. The problem may remain within safe limits here too provided that groundwater extraction in coastal aquifers does not exacerbate.

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[1] MoEF and INCCA (2010). Climate Change and India: A 4x4 Assessment

[2] Dwijendra, N.D. and Vinod Kumar S. (2005). Analysis of sea level rise and its impact on coastal wetlands of India Proceedings of the 14th Biennial Coastal Zone Conference New Orleans

[3] Dwijendra, N.D. and Vinod Kumar S. (2005). Analysis of sea level rise and its impact on coastal wetlands of India Proceedings of the 14th Biennial Coastal Zone Conference New Orleans

[4] Department of Forest, Ecology & Environment (2004). State of Environment Report Karnataka 2003

[5] Reddy, H.R.V. (2010). Coastal issues and concerned: Challenges for the Research Community, Annamalai University

Nevertheless, instances of saline water intrusion have been recorded on the coast due to sea erosion and tidal influx in the estuary. Coastal alluvial aquifers are highly permeable and are in hydraulic continuity with sea/estuarine water. Therefore, indiscriminate drawings from wells would facilitate the intrusion of saline water. The high level of groundwater exploitation, levelling of sand for agriculture or constructions in the coastal zone accentuate the problem.[1] The intrusion of saline water into groundwater aquifers and the ingression of seawater to rivers/estuaries are adversely affecting the availability of potable water, especially in the dry season. On the riverbank, the main reason for tidal water intrusion is the poor quality of bund constructions causing breaches. To address this problem, Government of Karnataka initiated the construction of sea walls to prevent saltwater entry into the paddy fields. However, the poor quality of the construction destroyed the wall in part and the problem persists.[2]

Table 39: Projected groundwater exploitation in coastal cities of Karnataka[3]

Place	Level of exploitation (%)				Area category
	1998	2002	2007	2012	
Karwar	16	22.6	37	52	white
Kumata	54	60	75	90	dark
Honnavar	45	51	66	81	gray
Bhatakal	52	58	73	89	dark
Ankola	16	22	37	52	white
Kundapur	33	41	60	79	gray
Udupi	45	53	72	90	dark
Mangalore	45	53	66	80	grey

7.4.4. Unsustainable fishing

Commercially important fishes in the sea around Karnataka are soil sardine, mackerel, catfishes, penaeid prawns, sharks, seer fishes, anchoivies, clupiods, squill and squids. Karnataka has a shelf area of 27,000 km^2 of which 8,000 km^2 have a water depth up to 50 m and which are extensively exploited for marine fishing. The state contributes about 10% of the total marine fish landing in the country. There has been substantial increase in the use of trawlers in recent years. In 2004-05, altogether about 5,500 trawl nets and 425 purse-seine nets have been used. On an average, about 82% of the total catch is harvested using purs-seine (27%) and trawl nets (55%).[4, 5] The purse-seine net method targets an identified shoal and the sea bottom is subsequently scooped. Selective scooping exerted tremendous pressures on benthic organisms and their survival as these are thrown overboard and are discarded. One study was estimated that the peak catch over the last 20 years from the state was 0.22 million tons in the year 1996-97 against an estimated maximum sustainable yield of 0.15 million tons. It is no surprise therefore that the per-unit effort and return on investment are declining in Karnataka's marine fishery sector.[6]

[1] EMPRI (2012). State of Environment Report Karnataka 2011

[2] Department of Forest, Ecology & Environment (2004). State of Environment Report Karnataka 2003

[3] Department of Forest, Ecology & Environment (2004). State of Environment Report Karnataka 2003

[4] Reddy, H.R.V. (2010). Coastal issues and concerned: Challenges for the Research Community, Annamalai University

[5] Department of Forest, Ecology & Environment (2004). State of Environment Report Karnataka 2003

[6] Department of Forest, Ecology & Environment (2004). State of Environment Report Karnataka 2003

7.4.5. Encroachment

Notable encroachments are observed in the Mangalore Port, Belekeri Port, Naval Base, Murdeshwar and other places. In addition, dredging in the harbour regions lead to dumping of dredging material on reclaimed land. Encroachments and dredging have been causing erosion at several places that require scientific confirmation. An example is the construction of breakwaters in Baithkol, Karwar and the Binga naval area. Similarly for construction of jetties and wharfs encroachments are made into the sea across the entire coastal region.[1]

7.5. Actions, policies and institutional preparedness

The coastal ecosystems are highly disturbed and very much threatened, encountering problems such as pollution, siltation, erosion, flooding, saltwater intrusion, storm surges due to ever expanding human settlements. Under the Environment (Protection) Act, 1986, the Coastal Regulation Zone Notification was issued in 1991. Under it coastal areas were classified into four categories (CRZ I to IV). Ecologically sensitive areas and areas of extraordinary natural beauty are included under CRZ I where no activity is allowed. Coastal stretches of urban and developed areas are categorized under CRZ II. Areas which do not come under CRZ I and II are included in CRZ III where no construction is permitted up to 200 m from the high tide line. The Lakshadweep, Andaman and Nicobar Islands and small islands are categorized in CRZ IV.

In all CRZ notifications, environmental impact assessment (EIA) has been made mandatory before notification of any CRZ. Karnataka State Coastal Zone Management Authority prepared the state's first Coastal Zone Management Plan, which received MoEF approval in 1996.[2] Areas to be regulated were identified using maps and satellite imagery. The precision of the definition of demarcations however proved insufficient. Mapping with better accuracy was then entrusted to National Hydrographic Office, Dehradun.[3] Karnataka State Coastal Management Authority established a regional office in each of Karnataka's three coastal districts, followed by the constitution of District Coastal Zone Management Committees in 2002. These may be re-constituted now, including representatives of local fishing communities, implying that the committees had fallen defunct. In its March 2011 meeting, Karnataka State Coastal Management Authority defined a range of actions to be taken.[4] These action points are indicative of clarity on priorities and stipulate both timeframes and agencies responsible. They include:

- Curbing unauthorised disposal of untreated effluent from industries and settlements (target April 2013), industrial waste, construction debris and fly ash (April 2012);
- Enforcing the prohibition on mining of sand and rock (March 2011);
- Enforcing a prohibition on ports and harbours in highly eroded areas to be identified;
- Preparation of comprehensive plan for permitting dwelling of traditional coastal communities between 100-200 m in CRZ III in consultation with traditional coastal communities and incorporating measures for disaster management;
- Preparation of a revised Coastal Zone Management Plan under development of requisite maps (April 2013) and obtaining MoEF approval (October 2013);

[1] EMPRI (2012). State of Environment Report Karnataka 2011

[2] Department of Forest, Ecology & Environment (2004). State of Environment Report Karnataka 2003

[3] Department of Ecology & Environment. http://parisara.kar.nic.in/czm.html accessed February 21, 2012

[4] Karnataka State Coastal Zone Management Authority (2011). Proceedings of the meeting, March 14, 2011

- Advising MoEF on the need to amend the notification by including permissibility of certain facilities to safeguard livelihoods.

The Department of Minor Irrigation created an unspecified length of seawalls, inviting at one point criticism on account of improper slopes and formations during an inspection in Dakshin Kannada in 2005.[1] Responsibilities were subsequently transferred to the Department of Ports & Inland Water Transport (under PWD) who has been engaged in the creation of seawalls since 1979.[2] Between 2006 and 2008 department constructed seawalls of 111 km length with a budget of INR 118 crore.[3] During the same period PWD proposed an INR 140 core master plan for permanent sea erosion work to the Central Water Commission. Between 2008 and 2010 also the Western Ghats Task Force joined hands by launching a project for construction of "green walls" to combat erosion through vegetation barriers grown beyond the high tide line in Honnavara, Kundapura and Mangalore Forest Divisions.[4]

7.6. Missions under the NAPCC

Though the NAPCC does not provide a mission on coastal zone management, coastal zone issues are covered under three missions: The National Water Mission, the National Mission for Green India and the National Mission on Strategic Knowledge.

The **National Water Mission** focuses on conservation of water and equitable distribution. Key areas under this mission are development of a wetland inventory, water purification technologies and mapping of catchments and survey of land use patterns with emphasis on conservation of mangroves. The recommended strategy is the establishment of a network for collection of additional necessary data. Data needed includes hydro-meteorological and hydrological data, particularly from coastal regions, coastal and estuarine waters as well as salinity and tidal water levels and changing discharges in estuarine areas. Likewise recommended are the strengthening of the groundwater monitoring network through observation wells and sanctuary wells for coastal aquifer management, data collection on tidal hydraulics, development of a water resources information system and research on impact of climate change on water resources including tidal embankments and sea levels. The mission emphasises the need to establish a regulatory regime to ensure prudent use of wetlands, environmental appraisal of developmental projects on wetlands and strengthening of links with afforestation and wetland conservation programmes. It lays stress on meeting water requirements of coastal cities through appropriate technologies such as low temperature desalination of ocean water. The budget for addressing issues related to impact of climate change on water resources works in the 11th Plan period is INR 28,651 crore.

The **National Mission for Green India** aims at addressing climate change by enhancing carbon sinks in sustainably managed forests and other ecosystems, enhancing the resilience and ability of vulnerable species and ecosystems to adapt to the changing climate, and enabling the adaptation of forest dependant communities in the face of climatic changes. Some of its objectives are closely related to coastal resources, mangroves, wetlands and their protection. The strategy includes the planting of mangroves in places from where their disappearance was noted. Coastal wetlands will receive protection

[1] Coastal Protection & Development Advisory Committee (2005). Minutes of the 8th meeting, June 17, 2005

[2] Department of Forest, Ecology & Environment (2004). State of Environment Report Karnataka 2003

[3] Public Works Department (PWD), (2007, 2008 and 2009). Management Information System, 2007, 2008 and 2009

[4] Western Ghats Task Force (2010). Major Achievements

from encroachments, change of land use, infrastructure development, pollution, growth of invasive species and over-fishing. The mission budget for restoring mangroves and wetlands are INR 500 and 600 crore respectively for the 10-year period.

A limiting constraint at present is the inadequacy of knowledge on the impacts of climate change. The **National Mission on Strategic Knowledge seeks** to address this constraint by establishing research networks and encouraging research on socio-economic impacts of climate change including impact on health, demography, migration patterns and livelihoods of coastal communities.

7.7. Selected emerging intervention areas

Biodiversity

- Beach protection through bio-shielding: The construction of seawalls to end erosion and breakwaters can have adverse consequences. Seawalls and breakwaters should be restricted to areas where they are extremely necessary. Since a healthy beach is the best protection for the coast, beach nourishment, strand vegetation along with selected technological interventions should be promoted;
- Baseline knowledge on flora and fauna: Beaches should be evaluated and appropriate restoration and conservation plans to be implemented where needed. Beach beautification programmes through restoration of natural vegetation can also enhance their tourism potential and benefit the local communities;
- Special protection for turtle breeding areas: Many of the beaches which marine turtles visit to lay eggs should be given special protection and preferably be brought under co-management programmes;
- Beach management to strengthen local economy: Planting of species suitable for beaches with medicinal, food and other value to be promoted and brought under co-management with local communities;
- Nursery of beach plant species: District-wise plant nurseries may be opened up for propagation of key psammophytic plant species, both local and selected introduced ones, after proper evaluation of their economic and ecologic values;
- Best practices: Promoting best practices for conservation and sustainable utilisation of coastal resources.

Policy and institutional arrangements

- Strengthening the delivery and preparedness in disaster prone coastal areas including flood management;
- Construction of seawalls and breakwaters should be subjected to comprehensive environmental impact assessment.

Research interventions

- Flood mapping, flood forecasting, downscaled climate change projections using improved grid resolution modelling;
- Long-term study on the response of coastal ecosystem and biodiversity to climate change;
- Assessment of erosion prone areas with the help of digital elevation models;
- Assessment of risks due to change in precipitation, temperature, humidity etc. on coastal functions and services.

Other interventions

- Beaches to be zero waste areas: Steps should be taken to promote beaches as zero waste areas through awareness programmes, village and town level solid waste management programmes, providing sanitation facilities all along the coast and periodic cleaning of beaches;
- Promoting community education and environmental action plan centres;
- Setting up an integrated coastal zone management training centre;
- Developing a techno-legal regime for construction of disaster resilient housing and infrastructure in the coastal districts;
- Strengthening exiting coastal protection methods in the state.

8. ENERGY

8.1. Introduction

Amid rising energy prices, energy security is a key issue for India. The national energy scenario is undergoing a transformation with severely stressed energy supplies in relation to the increase of energy demand. Further, with scientific evidence clearly correlating the use of fossil fuels to climate change, energy plays a pivotal role in greenhouse gas (GHG) emission mitigation through the National and State Action Plan on Climate Change (NAPCC).

Karnataka is the ninth most populous state of India, with decadal population growth rate of 17.5% per decade. Its Gross State Domestic Product (GSDP) is growing at a 7.0% compounded annual growth rate.[1] The structure of GSDP provides references to the energy demand of a state. Services led growth tends to lead to lower energy intensity growth as compared to a manufacturing sector led growth. For Karnataka, the share of the services and manufacturing sectors are increasing while that of agriculture is declining, leading to lower energy intensity growth. However, the absolute demand for energy in the state will continue to increase as evident from the increase in GSDP to over 57% from services sector, with an annual growth rate of over 8.4%. Also equally perceptible is the growth in manufacturing sector with an annual growth rate of 9.5%.[2] Karnataka faces various challenges with supply constraints coupled with generation of energy through clean sources.

8.2. Energy sources

Coal continues to be a dominant source of primary energy for Karnataka. It meets 52% of the primary energy requirement. The state takes advantage of its ports which facilitate the import of coal. Petroleum products also form a major share of energy sources at 38%. This implies a prominence of fossil fuels in its energy mix of Karnataka, leading to high GHG emissions. However, Karnataka is also provided with significant yet not abundant hydro resources. In 2009-10, hydro resources generated more than 12 billion kWh of electricity. This accounts for 29% of the total electricity supply in Karnataka and 47% of the production of Karnataka Power Corporation Limited (KPCL), the only state owned power company.[3]

Biomass such as firewood, agricultural residues, animal wastes and other forest produce are also important sources of energy for the state, especially in rural areas. Among renewables, wind energy achieved a proud 17% of the state's installed generation capacity. Natural gas is not at the moment a significant source of energy in Karnataka but gas power projects are on the anvil. Gasification of biomass for electricity generation has been demonstrated and is awaiting development of its potential of about 5,000 MW in the state.[4]

[1] Department of Planning, Programme Monitoring and Statistics (2011). Economic Survey 2010-11

[2] EMPRI (2012). State of Environment Report Karnataka 2011

[3] EMPRI (2012). State of Environment Report Karnataka 2011

[4] Biomass Energy for Rural India (2012). Comments on the draft Karnataka SAPCC dated September 20, 2011

8.3. Power generation

Hydro, thermal and wind power account for the majority of electricity generation capacity. The total installed generation capacity in Karnataka is 9,702 MW (refer Table 40) as on November 2010.[1] This does not including central government power plants (approx. 195 MW and captive power generation (approx. 1,000 MW), (refer Table 43).

Table 40: Karnataka's generation capacity in MW (excl. central generating capacity) in 2009-10[2]

	Hydro	Thermal	Wind	Co-generation and biomass	Diesel	Solar	Total
State-owned (KPCL)	3,637	2,220	5	0	108	6	**5,976**
Privately owned	609	709	1,634	774	0	0	**3,726**
Total in MW	**4,246**	**2,929**	**1,639**	**774**	**108**	**6**	**9,702**

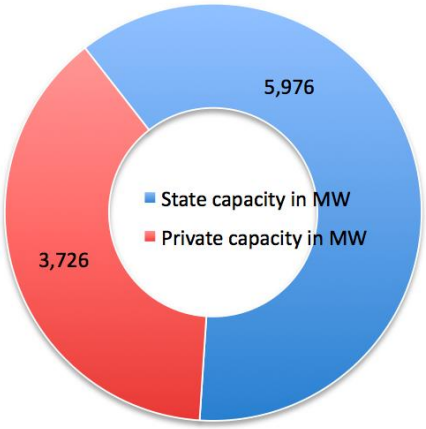

Figure 40: Karnataka power generation capacity by ownership in Nov. 2010[3]

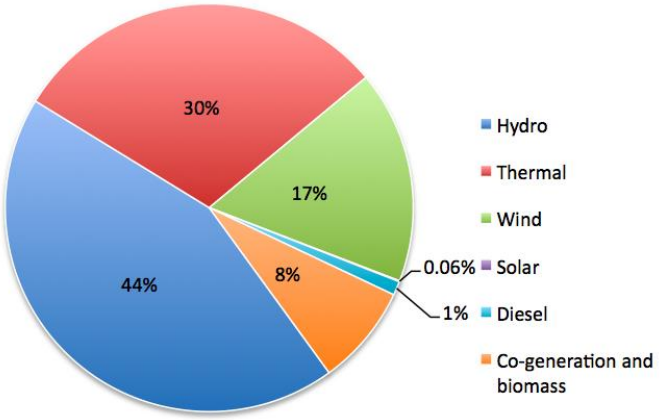

Figure 41: Karnataka power generation capacity by type in Nov. 2010[4]

Between 2001 to 2010, 50.8% of KPCL's energy supply was generated by thermal power plants. Of non-thermal sources, hydro electricity constituted about 29% in the energy mix KPCL's in 2010. However, the generation of hydropower has declined by 18% between 2007 and 2009 (refer Table 41). The primary reason for this decline are changes in rainfall. This situation could worsen with changes in precipitation, leading to a pronounced non-uniform water availability.[5]

Though a significant 17% of the state's generation capacity is constituted by wind power, its contribution to electricity generation is only a third of that. Using estimates of BCCI-K (2011) at Table 43, the actual contribution is estimated to be in the order of 5-6%. This major difference arises from the fact that, unlike conventional power plants, wind mills cannot be operated at their rated capacity for most of the time as actual wind speeds are much lower than the design wind speeds that determine the rating. This discrepancy between generation capacity and low actual generation is generally referred to as ' low plant load factors'.

[1] Department of Planning, Programme Monitoring and Statistics (2011). Economic Survey of Karnataka 2010-11

[2] Department of Planning, Programme Monitoring and Statistics (2011). Economic Survey of Karnataka 2010-11

[3] Department of Planning, Programme Monitoring and Statistics (2011). Economic Survey 2010-11

[4] Department of Planning, Programme Monitoring and Statistics (2011). Economic Survey 2010-11

[5] EMPRI (2012). State of Environment Report Karnataka 2011

Table 41: Electricity supply by source in 2009-10[1]

Source	Type	Units in million kWh/a		Share
State (KPCL)	Hydro	12,249		
	Thermal	13,263		
	Diesel	492	**26,020**	47.1%
	Wind	13		
	Solar	3		
Private (including thermal, diesel, wind)			**5,546**	13.0%
Central			**10,974**	25.8%
Other states			**35**	0.1%
Total in million kWh/a			**42,575**	**100%**

Table 42: Energy consumption in Karnataka for 2010[2]

	Fuel type	Consumption	Energy content (GJ)	% excluding biomass	% including biomass
Coal	Coal (electricity)	11,742,073 Mt/a	206,341,097	22.5%	11.8%
	Coal (non-electricity)	15,281,704 Mt/a	268,542,336	29.3%	15.3%
	Total		**474,883,434**	**51.7%**	**27.1%**
Petroleum/crude processing	Motor gasoline	859,700 Mt/a	38,513,700	4.2%	2.2%
	Diesel	3,438,420 Mt/a	148,997,054	16.2%	8.5%
	Kerosene	468,110 Mt/a	20,480,749	2.2%	1.2%
	Naphtha	209,120 Mt/a	9,412,073	1.0%	0.5%
	LPG	885,020 Mt/a	41,871,181	4.6%	2.4%
	Light Diesel Oil	13,412 Mt/a	581,198	0.1%	0.0%
	Furnace oil/LSHS	734,720 Mt/a	29,530,586	3.2%	1.7%
	Bitumen	301,693 Mt/a	12,125,931	1.3%	0.7%
	Lubes	49,421 Mt/a	1,986,375	0.2%	0.1%
	Aviation turbine fuel (ATF)	364,000 Mt/a	16,306,837	1.8%	0.9%
	Crude processing loss	-	34,177,500	3.7%	2.0%
	Total		**353,983,184**	**38.6%**	**20.2%**
Electricity other than coal thermal		**24,781 mn kWh**	**89,212,176**	**9.7%**	**5.1%**
Biomass		**833,341 mn MJ**	**833,341,401**		**47.6%**
Total excluding biomass			**918,078,794**	**100%**	**52.4%**
including biomass			**1,751,420,195**		**100%**

Transmission and distribution (T&D) losses remain significant in the state albeit a considerable reduction from 38% to 22% was achieved between 1999-2000 and 2009-10. It is expected that losses will be reduced to less than 21% in 2010/11.[3] The government has also taken the initiative to implement the central government's "Restructured Accelerated Power Development and Reform Programme (R-APDRP) with the aim to reduce aggregate technical and commercial losses (AT&C) to 15% in five years.[4]

[1] Department of Planning, Programme Monitoring and Statistics (2011). Economic Survey 2010-11

[2] EMPRI (2012). State of Environment Report Karnataka 2011

[3] Department of Planning, Programme Monitoring and Statistics (2010, 2011). Economic Survey 2009-10; 2010-11

[4] EMPRI (2012). State of Environment Report Karnataka 2011

Table 43: Current and projected installed capacity and power generation[1]

Power generation technology	2010		2020 business-as-usual scenario	
	Installed capacity (MW)	Net generation (billion kWh)	Installed capacity (MW)	Net generation (billion kWh)
Coal sub-critical	3,903	23.59	12,600	81.24
Coal supercritical	-	-	400	2.58
Gas[2]	220	0.84	440	1.87
Diesel	333	1.28	460	1.96
Nuclear (PHWR)	195	0.62	880	5.55
Hydro + small hydro	3,763	11.44	4,200	12.77
Wind	1,448	2.49	2,000	3.43
Biomass + cogeneration	623	2.03	800	2.61
Solar	10	0.02	100	0.16
Captive generation	1,000	2.01	-	-
Total (utility + non-utility)	**11,495**	**44**	**21,880**	**112**

Capacity additions

KPCL is preparing installation of further 7,814 MW of generation capacity in Karnataka, 39% of which are already under construction.[3] Generation capacity would rise to 151% once all projects currently under construction are commissioned and 231% when projects under preparation are completed as well (refer to Table 44). These are estimated to generate around 61 billion kWh per annum as compared to KPCL's 26 billion kWh/a generated in 2009-10. This would take electricity generation of KPCL to an overall 87 billion kWh/a vis-à-vis a demand projection of 80 billion kWh/a in 2016-17.

Table 44: KPCL's upcoming power projects[4]

Power generation projects	Gas	Thermal	Hydro	Wind	Solar	Total
For comparison: **Present capacity**						**5,976**
Under construction						**3,039**
Bellary Thermal Power Station: 2 + 3		600				
Nagjhari powerhouse: Up-gradation			30			
Solar power plants: 3					9	
Yeramarus Thermal Power Station		1,600				
Edlapur Thermal Power Station		800				
Under preparation						**4,775**
Tadadi Combined Cycle Power Plant	2,100					
Bidadi Combined Cycle Power Plant	1,400					
Wind energy projects				500		
Gundia Hydel Scheme			400			
Shivanasamudra seasonal scheme			345			
Ghataprabha project			20			
Munirabad Hydel Power Station			10			
Total upcoming in MW	**3,500**	**3,000**	**805**	**500**	**9**	**7,814**

[1] BCCI-K (2011). Karnataka Climate Change Action Plan; Final Report

[2] This plant is reported to have been decommissioned in 2010.

[3] Department of Planning, Programme Monitoring and Statistics (2011). Economic Survey of Karnataka 2010-11

[4] Department of Planning, Programme Monitoring and Statistics (2011). Economic Survey of Karnataka 2010-11

Upcoming power projects are significant in two respects. Firstly, the scale of capacity additions is extremely significant. Secondly 3,500 MW of gas-based power generation – 45% of the total additions – constitutes a historical shift in terms of energy sources for Karnataka. This shift is enabled by a 993 km-CNG pipeline from Maharashtra[1] expected to commence operation in 2014. On the anvil are two combined cycle gas-based power plants at Tadadi and Bidadi respectively. Land has already been allotted for the 2,100 MW plant at Tadadi and statutory clearances are being obtained. A draft gas purchase agreement for the 1,400 MW plant at Bidadi is under review.[2]

The fact that gas-based power generation accounts for the greatest single technology in upcoming power generation capacity is a welcome mid-term solution. It permits rapid capacity expansion at lower CO_2 emissions while the gradual scaling up of renewables can be promoted. By comparison, coal has larger carbon emissions per unit of electricity apart from the inherent problem with fly ash disposal; hydropower cannot be expanded at scale and nuclear power would need decades until commencement while leavening radioactive waste for future generations to deal with. Gas power costs less and is less CO_2 intensive than coal or oil-based power generation.

8.4. Energy consumption

There are four prime consumers in Karnataka: Irrigation pump sets, domestic lighting and appliances, industries and commercial lighting. These four accounted for about 87% of the total power consumption in the state in 2009-10.[3] Data in Table 45 below is indicative of increasing power consumption in the state.

Table 45: Power consumption in Karnataka[4]

Consumer groups	2008-09		2009-10		
	Consumption in million kWh/a		Consumption in million kWh/a		Average rate paise/kWh[5]
1. Industries (other than IT)	5,693	17.78%	5,932	17.61%	495
2. Irrigation pump sets	11,217	35.03%	11,772	34.94%	102
3. Domestic lighting and appliances	6,710	20.96%	7,360	21.84%	343
4. IT industries and water works	1,519	4.75%	2,366	7.02%	412
5. Public water works and sewage	1,779	5.56%	1,044	3.10%	354
6. Commercial lighting	4,010	12.52%	4,350	12.91%	644
7. Public lighting	493	1.54%	690	2.05%	311
8. Others	599	1.87%	177	0.52%	1,013
Total	**32,020**	**100%**	**33,690**	**100%**	**333**

The consumption of mineral oil products has been increasing rapidly in the state. Figure 42 shows consumption trends over the past seven years, reflecting a substantial increase in particularly aviation turbine fuel (ATF), diesel and petrol. The increases seen here are a proxy for the rising transportation requirements of the state.

[1] MoEF (2011). Letter to GAIL on CRZ clearance dated April 23, 2011

[2] Department of Planning, Programme Monitoring and Statistics (2011). Draft Annual Plan 2011-12

[3] Department of Planning, Programme Monitoring and Statistics (2010, 2011). Economic Survey 2009-10; 2010-11

[4] Department of Planning, Programme Monitoring and Statistics (2010, 2011). Economic Survey 2009-10; 2010-11

[5] Estimate based on the revenue realised

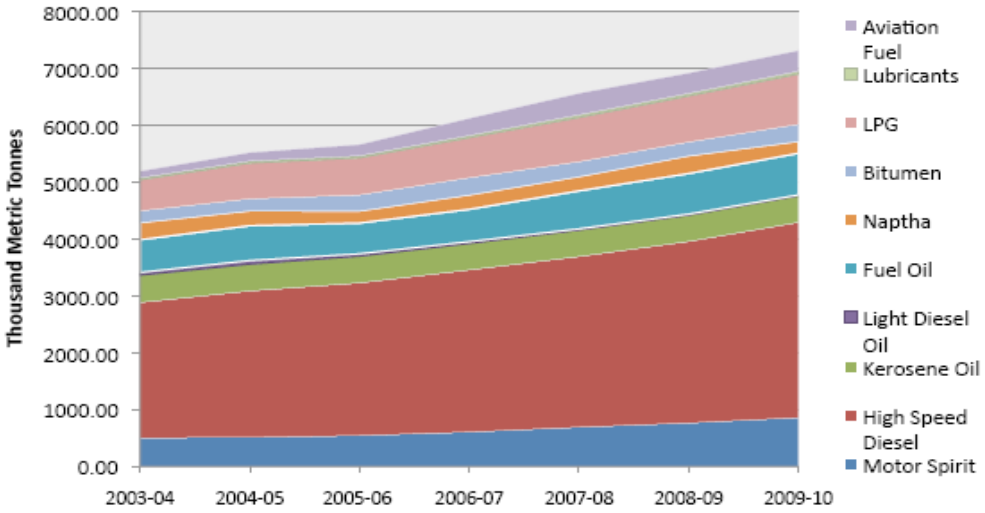

Figure 42: Trends of fossil fuel consumption in Karnataka[1]

8.4.1. Industries

The industrial sector is energy intensive and one of the largest consumers of energy in the state. Cement, iron and steel, aluminium and paper are among the most energy intensive industries. Karnataka ranks seventh in the production of cement in the country with an annual production of 12.1 million tons emitting 7.6 million tons of CO_2 annually. Karnataka is also the third largest steel producer in India with an annual production of 10.7 million tons. These two industries account for 20% of Karnataka's GHG emissions (CO_2-equivalent) and for 90% of the emissions from industrial sector.[2] GHG emissions from the industrial sector are projected to increase from 18 million tons in 2008-09[3] (also refer section 3.5) to 54 million tons in 2020-21.

Probably more than 90% of industries in Karnataka are small-scale. This poses a considerable challenge for enhancing energy efficiency. However, there is hope that energy efficiency will make inroads, especially in view of the Perform Achieve and Trade (PAT) scheme under the National Mission on Enhanced Energy Efficiency that is based on market based mechanism but not yet operational in Karnataka. This mechanism allows trade of energy efficiency certificates in the market.

8.4.2. Transportation

Karnataka has a well-developed transport system which consequently is a large emitter of CO_2. Road, rail, road and air transport depend on fossil hydrocarbon fuel almost entirely, directly or indirectly. LPG does not constitute a significant share yet. Bio-fuels are even smaller in transport and their marginality is highlighted by the absence of official consumption data for Karnataka.[4] Air and road transport are more energy intensive sectors compared to rail and waterways. Within road transport, buses are less energy intensive than individual modes of road transport (refer Table 46).

[1] EMPRI (2012). State of Environment Report Karnataka 2011

[2] BCCI-K (2011). Karnataka Climate Change Action Plan; Final Report

[3] BCCI-K (2011). Karnataka Climate Change Action Plan; Final Report

[4] WISE (2010). Clean Energy Technology Action Plan for Climate Mitigation for Karnataka

There has been a fourfold increase in the vehicular population in Karnataka in less than 20 years. Emissions from the transport sector are estimated to account for 10.4% of Karnataka (also refer section 3.3).[1] Considering the growth rate of the GSDP, the implications for consumption of petroleum call for attention to curb the excessive dependence of fossil fuels.

Table 46: GHG emissions from different modes of transportation[2]

Type of transport	Average occupancy	gram of CO_2-equivalent per passenger-km (full energy cycle)
Car (gasoline)	2.5 pax	130 - 170
Car (diesel)	2.5 pax	85 – 120
Car (natural gas)	2.5 pax	100 - 135
Car (electric)	2.0 pax	30 - 100
Scooter (two stoke)	1.5 pax	60 - 90
Scooter (four stroke)	1.5 pax	40 – 60
Minibus (gasoline)	12.0 pax	50 – 70
Minibus (diesel)	12.0 pax	40 - 60
Bus (natural gas)	40.0 pax	25 – 25
Bus (hydrogen fuel cell)	40.0 pax	15 – 25
Rail transit	75% of capacity	20 - 50

For a discussion of the energy requirements of other sector, please refer to section 3.1.

8.4.3. Demand projections

Karnataka's overall energy intensity is lower than the national average. It has been estimated to be 521 t_{OE}/million USD of GSDP (116 t_{OE}/crore INR[3]).[4] Encouragingly, energy intensity in the state has reduced by 25% since the 1990s, which is attributed to the rapid expansion of the less energy-intensive service sector.[5] Nevertheless, demand for electricity in Karnataka is estimated to grow by 55.8% over the next 6 years from the present 44.7 billion kWh to 80 billion kWh in 2016-17.[6] Karnataka already faces peak load deficits to the tune of 13.2% and obtains a major part of its energy supplies from outside the state.[7] The economic loss of the power shortage over the past six years has been estimated to be INR 21 billion per year on average.[8]

[1] BCCI-K (2011). Karnataka Climate Change Action Plan; Final Report

[2] WISE (2010). Clean Energy Technology Action Plan for Climate Mitigation for Karnataka

[3] Assuming an exchange rate of 45 INR/USD

[4] t_{OE} refers to energy expressed in tonnes of oil equivalent and therefore energy intensity is the quantity of energy consumed in the state of Karnataka to generate products or services of a value of 1 million US dollar

[5] EMPRI (2012). State of Environment Report Karnataka 2011

[6] Central Electricity Authority (2007). Report on the 17th Electric Power Survey of India

[7] Central Electricity Authority (2010). Annual Report 2009-10

[8] EMPRI (2012). State of Environment Report Karnataka 2011

8.5. Actions, policies and institutional preparedness

8.5.1. Institutional anchorage

Karnataka Renewable Energy Development Limited (KREDL) is the nodal agency for promotion for renewable energy and energy efficiency. It passes on subsidies provided by Ministry of New and Renewable Energy (MNRE), Government of India, coordinates with the Bureau of Energy Efficiency (BEE), is responsible for the implementation of the Energy Conservation Act and emerges as the nodal agency for implementation of both the National Solar Mission and the National Mission for Enhances Energy Efficiency in Karnataka.

8.5.2. Karnataka Renewable Energy Policy

Renewable Energy

Renewable energy plays a twin role by tackling climate change while also improving energy access and energy security. It has vast carbon avoidance potential and is a key focus for climate mitigation strategies. Preliminary estimates for renewable energy in India show that the country could avoid 16 million tonnes of carbon every year by the end of the 10th Five-Year Plan. This would increase to about 27 million tonnes of carbon avoidance by the end of the 11th Five-Year Plan.[1]

In view of this potential, KREDL took the lead in preparing the Karnataka Renewable Energy Policy 2009-2014. The policy assesses Karnataka's renewable energy potential as 10,000 MW[2] for solar energy and 18,500 MW[3] for other forms of renewable energy. The presently installed capacity of 2,987 MW constitutes about 10.5% of the combined potential. Further, the government has allotted 13,512 MW to renewable energy power capacity which amounts to nearly half of it.[4]

Highlights of the Karnataka Renewable Energy Policy[5]

- Increase renewable installed capacity from 2,400 MW to 6,600 MW by 2014. This implies increasing the share of renewable energy in the electricity mix from 11.5% to 20% by 2014.
- Saving 7,900 million units of energy (equivalent to 900 MW of installed capacity) over the five-year period through effective measures of energy conservation and energy efficiency.
- Creation of a Green Energy Fund through a cess of INR 0.05 per kWh for commercial and industrial consumers to generate about INR 55 crore annually
- Increase wind power installed capacity from 1,121 MW to 3,500 MW by 2012 (contributing about 8,260 million kWh per annum) and 7,500 MW by 2018 (contributing about 17,700 mn kWh/a).
- Increase installed mini and small hydro capacity from the current 416 MW to 900 MW by 2012 (contributing 2,754 mn kWh/a) and 1,500 MW by 2018 (contributing 4,590 mn kWh/a).
- Increase cogeneration installed capacity in sugar industries from 340 MW to 450 MW by 2012 (contributing about 2,363 mn kWh/a) and 700 MW (contributing about 3,675 mn kWh/a) by 2018.
- Increase biomass installed generation capacity and waste to energy from 81 MW to 400 MW by 2012 (contributing about 2,452 mn kWh/a) and 1,000 MW (contributing about 6,130 mn kWh/a) by 2018.
- Increase grid-connected solar PV and thermal power generation capacity to 200 MW by 2012 (about 290 mn kWh/a) and 1,000 MW by 2018 (about 1450 mn kWh/a).

[1] Karnataka Renewable Energy Development Limited. http://kredl.kar.nic.in, accessed April 14, 2011

[2] Karnataka Renewable Energy Development Limited. Progress of grid connected NCE projects as on 30.11.2010 http://kredl.kar.nic.in/ProgressReport.htm, accessed February 27, 2012

[3] Department of Emergy (2009). Karnataka Renewable Energy Policy 2009-14

[4] Karnataka Renewable Energy Development Limited. Progress of grid connected NCE projects as on 30.11.2010 http://kredl.kar.nic.in/ProgressReport.htm, accessed February 27, 2012

[5] Karnataka Renewable Energy Development Limited. http://kredl.kar.nic.in accessed April 14, 2011

Table 47: Renewable energy targets of the Karnataka Renewable Energy Policy[1]

Source	Potential in MW	Installed capacity in MW	Targeted addition in MW	Targeted annual capacity addition in MW					Cost[2] in crore INR
				2009-10	2010-11	2011-12	2012-13	2013-14	
Wind power	12,950	1,368	1,368	630	680	530	530	599	15,680
Mini and small hydro	3,000	416	416	100	100	150	150	100	2,700
Co-generation in sugar industries	1,500	535	535	56	56	56	56	57	1,120
Biomass and biogas	1,000	81	81	60	60	60	60	60	2,100
Waste to energy	135	--	--	10	10	10	10	10	400
Total	**18,500**	**2,400**	**2,400**	**856**	**906**	**806**	**806**	**826**	**22,000**

Table 48: Progress of grid-connected projects as of November 2010[3]

Sector	Potential available	Projects allotted by government		Projects commissioned	
		Number	MW	Number	MW
Wind	13,236	485	9531	681	1,608
Small hydro	3,000	458	2655	71	617
Cogeneration	1,500	59	1693	31	669
Biomass	950	66	471	12	87
Solar	10,000	21	129	2	6
Total	**28,686**	**1,089**	**13,909**	**797**	**2,987**

Targets are set to nearly triple renewable energy generation capacity within five years, leading to an increase from 2,400 MW in 2009 to 6,600 MW in 2014 at an estimated investment of INR 22,000 core. The policy lays emphasis on a rapid expansion of particularly wind power capacity, an area where Karnataka has lost a point in its leadership position to Gujarat which overtook Karnataka in both installed capacity and annual wind power generation, putting Karnataka on place four after Tamil Nadu, Maharashtra and Gujarat.[4] In 2009 the exploitation of Karnataka's wind potential was estimated to be around 11%.[5]

Also the instruments of the policy evoke optimism. Perhaps most notable among them is the creation of a Green Energy Fund (Akshaya Shakti Nidhi). By levying 0.05 INR/kWh on the supply from of electricity to commercial and industrial consumers, the creation of a INR 55 crore fund is projected to fund implementation of the policy. Being roughly mid-way of the policy's planning horizon, the fund is yet to be created as administrative approvals remain to be obtained. Other instruments of the policy include:[6]

[1] Department of Energy (2009). Karnataka Renewable Energy Policy 2009-14

[2] Investment at current prices

[3] Karnataka Renewable Energy Development Limited. Progress of grid connected NCE projects as on 30.11.2010 http://kredl.kar.nic.in/ProgressReport.htm accessed February 27, 2012

[4] www.windpowerindia.com State-wise unit generation data from wind power projects, accessed April 13, 2011

[5] Department of Energy (2009). Karnataka Renewable Energy Policy 2009-14

[6] Department of Energy (2009). Karnataka Renewable Energy Policy 2009-14

- Large industries with a connected load of 2,000 kVA and above need to produce at least 5% of their electricity requirement through captive power plants using renewable energy sources;
- Solar water heaters will be promoted through a rebate of INR 100 per month in the electricity bills of domestic users;
- 10% of land in Special Economic Zones (SEZs) shall be set apart for KREDL to develop renewable energy projects. In addition, at least one designated renewable energy SEZ will be created in a backward taluk for manufacturing of renewable energy equipment and machinery;
- Under the Solar Karnataka Programme component, grid-connected photovoltaic systems of 5 to 10 kW_P capacity will be set up on up to 25,000 houses until 2014. Remuneration for energy fed into the grid by participating houses will be ceiled at 70% of their respective consumption. The potential is estimated to be 350 million kWh per annum.

Energy efficiency

Though the title suggests otherwise, the Karnataka Renewable Energy Policy also sets a strong emphasis on energy efficiency. It aims at conserving nearly 8,000 million kWh of electricity in the five-year period, equivalent to the avoidance of roughly 900 MW of generation capacity. Interventions to achieve this include energy efficient appliances, energy efficient building designs, which are commonly referred to as demand side management (DSM). Interventions also extend to reducing transmission losses, which is a supply-side measure. Energy audit and adopting energy efficiency measures are prescribed as mandatory for industrial and commercial installations of 600 kVA of contract demand and above.

Table 49: Energy conservation targets of the Karnataka Renewable Energy Policy[1]

Sector	Present energy consumption in million kWh		Conservation targets (25 %) in mn kWh 2009–14	Per annum
Agriculture	10,814	35%	2,703	540
Industries	7,263	24%	1,815	363
Domestic	6,690	21%	1,672	334
Commercial	4,006	14%	1,001	200
Municipal utilities and others	2,841	6%	710	142
Total	**31,614**	**100%**	**7,901**	**1,579**

The policy aims to facilitate the implementation of the Energy Conservation Act 2001, for which KREDL has been notified as designated agency. To implement the act, KREDL is mandated to prepare a Strategic Action Plan[2] so as to:

- Regulate activities for enforcing Energy Conservation Act in the state;
- Foster school and college education, policy promotion and research;
- Disseminate information on energy efficiency;
- Develop energy efficiency/demand side management (DSM) programmes; and
- Develop delivery mechanisms for energy efficiency programmes.

[1] Department of Energy (2009). Karnataka Renewable Energy Policy 2009-14

[2] Department of Energy (2009). Karnataka Renewable Energy Policy 2009-14

Programmes under the policy scheduled for 2011 to 2014

- SME Programme: Energy efficiency improvement in small and medium enterprises.
- Work Bright Programme: Commercial high-efficiency lighting programme (CFLs/LED lamps/solar lighting).
- Motor Renewable Energy Power: High efficiency motor rewinding programme.
- Agricultural Efficiency: Energy efficiency improvement in agriculture by modification and retrofitting, star-rated pumps/solar pumps, non-metallic PVC/polyethylene pipes for suction and delivery, friction free foot valves.
- Bright Streets: Municipal street lighting programme deploying advanced technology (CFLs, LED lamps, solar, on-off timer).
- Green Buildings Programme: Constructing one or two model "Green Buildings" in each district in accordance with the Energy Conservation Building Code. The concept will be made mandatory for corporate buildings and buildings constructed by developers in city corporations by the amendment of building by-laws.
- Municipal Energy Efficiency Programme: Improvement of energy efficiency in municipal water pumping and for effluents.

8.5.3. Karnataka Solar Policy

Besides the Renewable Energy Policy of 2009, which also promotes energy efficiency, Karnataka notified a separate policy for solar energy in 2011. Unlike its multi-pronged sibling, the Karnataka Solar Policy 2011-16[1] focuses singly on scaling up solar power generation by 200 MW in the state until 2016 so as to enable ESCOMs to comply with the compulsion of supplying 0.25% of electricity from solar sources.[2] The capacity of photo-voltaic plants, according to the regulation notified in 2011 must be between 3 and 10 MW while the minimum capacity for solar thermal plants must be no less than 5 MW. KREDL is understood to have already floated tenders for setting up of 80 MW[3] solar projects under this policy.

8.5.4. Renewable Purchase Obligation

Since April 1, 2011 Energy supply companies (ESCOMs) in Karnataka are required to procure and supply a defined share of electricity from renewable sources. For each ESCOM Renewable Purchase Obligations (RPO) between 7.25% and 10.25% were notified by KERC in 2011 (refer Table 50). While for the bulk of the obligation utilities are free to choose any type of renewable tapped, a portion of 0.25% compulsorily mandates solar energy as source.[4] However, ESCOMS are free to meet RPOs specified partly or entirely through Renewable Energy Certificates (REC). This helps tying green power to Karnataka's electricity supply while the necessary capacities are being created. Yet the instrument could also open a back door to circumvention of the solar RPO portion which is particularly vital for promoting large-scale development of solar energy.

This regulation reflects a push of the central government who introduced Renewable Purchase Obligations (RPO) to launch renewables into large-scale deployment so as to achieve a contribution of 15% by 2020.[5] This regulatory move generates an imperative

[1] Department of Energy (2011). Karnataka Solar Policy 2011-16

[2] Karnataka Electricity Regulatory Commission (2011). KERC (Power Procurement from Renewable Sources by Distribution Licensee and Renewable Energy Certificate Framework) Regulations, 2011

[3] Department of Energy (2012). Comments on "Draft State of Environment Report Karnataka 2010"; UO note dated January 6, 2012

[4] Karnataka Electricity Regulatory Commission (2011). KERC (Power Procurement from Renewable Sources by Distribution Licensee and Renewable Energy Certificate Framework) Regulations, 2011

[5] Central Electricity Regulatory Commission (2010). CERC (Terms & Conditions for recognition & issuance of Renewable Energy Certificate for Renewable Energy Generation) Regulations, 2010

that, in terms of solar energy, may achieve greater results in shorter timeframes than the instruments of the National Mission for Solar Energy alone would have.

Table 50: Renewable Purchase Obligations effective as of April 1, 2011[1]

ESCOM	From renewables other than solar	From solar	Total
BESCOM	10%	0.25%	10.25%
MESCOM	10%	0.25%	10.25%
CESC	10%	0.25%	10.25%
HESCOM	7%	0.25%	7.25%
GESCOM	7%	0.25%	7.25%
Hukkeri Society	7%	0.25%	7.25%

8.5.5. Selected actions taken

Solar water heating

In order to facilitate the implementation of the Energy Conservation Act, 2001 Government of Karnataka notified in 2007 the mandatory use of solar water heaters, CFLs, ISI marked motor pump sets and integration of energy efficiency and renewable energy in new buildings.[2] The use of solar water heaters was made mandatory for a wide range of establishments within municipal corporations in the same year. The notification covers hospitals, hotels, canteens, housing complexes and residential buildings with a built-up area of at least 600 ft^2 on sites measuring 1,200 ft^2 and above, all government buildings and even industries with water heating requirements.

ESCOMs were positioned as enforcers by making the installation prerequisite to the provision of electricity connections. Bangalore Electricity Supply Company (BESCOM), which serves the districts of Kolar, Tumkur, Chitradurga and Davanagere besides the Bangalore Metropolitan Region, has gone one step further by providing a tariff rebate of 0.5 INR/kWh[3] for connections with a solar water heating system installed. This incentive believed to have contributed in shaving off a portion of the morning peak load and to have reduced the need for load shedding in this period. As the rebate is ceiled at INR 50 per month and installation, it may fail to excite high income households with high comfort needs while at the same time remaining out of reach for low income sections because of the investment. It appears nevertheless a step in the right direction while its expansion to other ESCOM is highly desirable and preferably monitored to understand the actual impact made.

Solar power generation

The National Solar Mission places primary attention on a massive upscaling of grid-connected solar power generation and the eventual achievement of tariff parity. The challenge is perhaps most pronounced in this segment as the cost of solar photovoltaic systems is precisely the reason for India's slow progress on this path. Looking at large solar thermal collector plants, here turn-key solutions for cost-effective technology do

[1] Karnataka Electricity Regulatory Commission (2011). KERC (Power Procurement from Renewable Sources by Distribution Licensee and Renewable Energy Certificate Framework) Regulations, 2011

[2] Department of Energy (2007). Notification EN 396 NCE 2006 dated November 13, 2007

[3] Bangalore Electricity Supply Company Limited. Conditions applicable to LT installations and billing www.bescom.org/en/services/bescom-policies-tariff-lt.asp accessed February 21, 2012

not exist yet and a massive research and demonstration programme has inevitably to precede commercial large scale deployment.

It is encouraging to note that some inroads were made in the state, though not literally major ones. Karnataka Power Corporation Limited (KPCL) took the lead and commissioned two grid-connected solar power plants of 3 MW_P each in Kolar in Belgaum district[1] in 2009-10. A third unit of the same capacity in Raichur district[2] and 5 MW_P plant in Mandya district[3] – the largest yet in Karnataka – are under development. A total of 21 solar projects with a combined capacity of 129 MW_P were allotted as of November 2010 (refer Table 48). One year later KREDL announced that the allocation of a further 400 MW_P of grid-connected solar power generation capacity would commence shortly.[4]

Energy efficiency

The replacement of incandescent lights, commonly know as bulbs, with compact fluorescent lamps (CFLs) in all government buildings across Karnataka was notified by GoK[5] in 2007 and is understood to have been fully completed. Public Works Department (PWD), responsible for construction and maintenance of government buildings, acted on the 2007 notification. It replaced electric geysers with solar hot water heaters wherever funds permitted (more than 100 government buildings) and proceeded with replacement of incandescent bulbs. Quantitative data on the latter is regretfully not available.[6]

In March 2011, just before the release of the 2011-12 budget, the *Belaku* scheme was announced under which each household could exchange up to four incandescent lamps for CFLs at a subsidised rate of INR 15 per lamp. CFLs are supplied by a single selected supplier. While the scheme has been launched in areas served by Bangalore Electricity Supply Company (BESCOM), its ultimate extension to the entire state was announced. Expected energy savings of the scheme are estimated to be 3,000 million kWh[7] per year, nearly 38% of energy savings targeted with Karnataka Renewable Energy Policy. By December 2011, 3.7 million CFLs were distributed to 1.1 million households in Bangalore Rural and Kolar district.[8]

In view of Karnataka's historic energy supply deficit the *Belaku* scheme is an overdue response to exploiting the energy savings potential of the household sector. It is estimated that in spite of the subsidy, the scheme would also make economic sense because it sets off much needed electricity load Karnataka is unable to supply in the near term. KREDL intends to pull carbon finance through Clean Development Mechanisms (CDM) through tendering into the scheme eventually.[9] The benefits of the scheme seem to address both ecologic and economic concerns while also being in tune with developmental

[1] Karnataka Electricity Regulatory Commission (2010). Discussion paper on determination of tariff for grid connected solar power plants in Karnataka, May 27, 2010

[2] Department of Planning, Programme Monitoring and Statistics (2011). Economic Survey 2010-11

[3] The Hindu, Bangalore edition (February 11, 2011). KPCL to set up 5 MW grid-linked solar plant at Shimsha

[4] The Hindu, Bangalore edition (November 23, 2011). Allocation of 400 MW grid-linked solar projects to start in six months

[5] Department of Energy (2007). Notification EN 396 NCE 2006 dated November 13, 2007

[6] Public Works Department (PWD), (2011). Consultation held on March 10, 2011

[7] The Hindu, Bangalore edition (March 1, 2011)

[8] Department of Energy (2012). Comments on "Draft State of Environment Report Karnataka 2010"; UO note dated January 6, 2012

[9] Karnataka Renewable Energy Development Limited (KREDL), (2011). Consultation held on March 8, 2011

priorities. However, there are concerns related to the fact that adequate CFL disposal and mercury recovery mechanism have not been created anywhere, thus enlarging an already existing problem with the disposal of CFLs and tube lights. Another anxiety is that the subsidy may create a huge low-price market dominated, as is feared, by products whose quality and lifetime may be inferior to branded products. Other and perhaps more reliable products may thus be driven into a nice market while the reputation of CFLs as a whole may decline. The scheme undermines the market forces that have led to the successful introduction of CFLs on its own strengths. If subsidised CFLs begin to fail at larger scale, then they are more likely to be replaced with low cost incandescent bulbs rather than unsubsidised CFLs, a product in which customer confidence may have collectively declined.

Some 30 government buildings in Bangalore have reportedly being energy audited by Karnataka Renewable Energy Development Limited (KREDL). It is aimed to conduct audits for all consumers with a connection load of 110 kVA and above. No defined timeframes have been communicated or set here.[1] Energy efficiency made inroads with two other prominent initiatives. A major energy audit pilot project has been conducted in Mysore. Some 250,000 connections are said to have been audited in this town of inhabited by a population of about 800,000 but it is not documented what energy savings this effort has resulted in. Capacities for providing energy audits and advisory services at the designed scale do not exist yet in Karnataka. KREDL intends to establish an in-house team of certified energy auditors. Options for human resource development were examined and the agency is understood to have embarked on a major capacity building initiative that involves transfers and training of officers from the Department of Energy. Timeframes and targets have either not been communicated or not been established.[2]

8.5.6. Feed-in tariffs

Tariffs for power purchase from renewable energy sources are notified by Karnataka Electricity Regulatory Commission (KERC) in line the KERC (Power Procurement from Renewable Sources by Distribution Licensee) Regulations 2004. Its order effective from 2010 constitutes a substantial increase of tariffs for all four categories for a period of ten years as compared to 2005 (refer to Table 51).

KERC also defined 3.40 INR/kWh as feed-in tariff for grid connected photovoltaic (PV) systems.[3] Regrettable, this incentive is limited to demonstration projects alone while the Commission reserves a decision on commercial plants.[4] Under the policy an identical tariff is extended to grid connected roof top solar PV systems between 5 and 100 kW_P for as long as supplies into the grid do not exceed 70% of consumption. Ministry of New & Renewable Energy (MNRE) is backing the states in incentivising rooftop solar PV connected to the 11 kV grid. While the distribution is obliged to pay the tariff determined by KERC, the utility receives a normative generation based incentive under the National Mission for Solar Energy.[5] For power plants of 1 MW and greater MNRE offers a feed-in tariff of 12 INR/kWh for solar PV and 10 INR/kWh for solar thermal power generation. The scale indicates commitment to the much needed development of large commercial

[1] Karnataka Renewable Energy Development Limited (KREDL), (2011). Consultation held on March 8, 2011

[2] Karnataka Renewable Energy Development Limited (KREDL), (2011). Consultation held on March 8, 2011

[3] Department of Energy (2009). Karnataka Renewable Energy Policy 2009-14

[4] Karnataka Electricity Regulatory Commission (2008). Order on determination of tariff for grid interactive solar power demonstration projects

[5] Ministry of New and Renewable Energy (2009). National Mission for Solar Energy

scale power generation as envisaged by the mission. Generation based tariffs incentives are a precondition for attracting private funds and having market forces support a broad introduction into the market dominated by fossil fuel that cost much less.

Table 51: Notified power purchase tariffs for renewables[1]

Year	Wind in INR/kWh	Mini hydro in INR/kWh	Co-generation in INR/kWh	Biomass in INR/kWh
Order of January 18, 2005				
	3.40 without appreciation	2.80 without appreciation	2.80 with 2% annual appreciation	2.85 with 2% annual appreciation
Revision effective as of January 1, 2010				
Year 1	3.70	3.40	3.59	3.66
Year 2	3.70	3.40	3.63	3.69
Year 3	3.70	3.40	3.67	3.72
Year 4	3.70	3.40	3.72	3.77
Year 5	3.70	3.40	3.77	3.81
Year 6	3.70	3.40	3.83	3.86
Year 7	3.70	3.40	3.90	3.92
Year 8	3.70	3.40	3.97	3.99
Year 9	3.70	3.40	4.05	4.06
Year 10	3.70	3.40	4.14	4.13

Back in 2009 KERC had also notified a quantum for renewable power purchases by ESCOMs in Karnataka. These were fixed at 10% for BESCOM, MESCOM and CESC and 7% for the other ESCOMs. These quanta, which stand superseded by the RPOs discussed in section 8.5.4) were providing an initial framework for purchase of power from renewable sources to help doubling the contribution of renewables by 2014 as envisaged by Karnataka Renewable Energy Policy.[2]

8.5.7. Energy Conservation Building Code

The Energy Conservation Building Code (ECBC) is yet to be legislated at state level. KREDL in its role as key advisor on matters of energy efficiency can be assumed to have a role in this process but timeframe projections were not available. It is feared that state level implementation has not been scheduled. This fact combined with unavailability of publicly declared targets for KREDL's capacity expansion suggests that a broader initiative on the National Mission for Enhanced Energy Efficiency in Karnataka may not be implemented anytime soon. This concern also relates to the concept of Green Rating for Integrated Habitat Assessment (GRIHA), which is incorporated in ECBC.

8.5.8. Biomass development

Keeping in view the need to develop decentralised solutions for energy supply in unserved and underserved rural areas, the project Biomass Energy for Rural India (BERI) was set up jointly by five agencies in 2001[3] with a funding outlay of INR 40 core.[4] The

[1] Karnataka Electricity Regulatory Commission (2009). Order on determination of tariff in respect of renewable sources of energy

[2] Department of Energy (2009). Karnataka Renewable Energy Policy 2009-14

[3] GEF-UNDP, ICEF, Government of India, Government of Karnataka and others

[4] Biomass Energy for Rural India. http://bioenergyindia.kar.nic.in/pro_detail.htm accessed March 5, 2012

project endeavours to demonstrate that small-scale biomass gasification is viable and capable of ensuring rural energy supply while at the same time offering an environmentally sound solution that fosters carbon sequestration. The project seeks to foster the establishment of small gasifiers of 2 MW each at Gram Panchayat level to gradually tap the potential estimated to be 5,000 MW. Charcoal generated in the process of gasification can be ploughed into biomass plantations to increase growth and to ensure a high amount of carbon remains sequestered in the process cycle. The project could achieve electricity generation costs of approximately INR 6 per kWh (excluding administrative cost). While these results are encouraging, impetus on dissemination is needed now.[1]

The Karnataka State Bio-fuel Policy 2009[2] stipulates mandatory bio-fuel use by state departments as a part of a popularisation strategy. It also sets 5% as a target for bio-fuel blending in 2012 – which as of date was not achieved – and 10% by 2017. Karnataka State Bio-fuel Development Board (KSBDB) was established to oversee the implementation of the policy. The state government proposed a budget of INR 500 crore for bio-fuel development in the 11th Five-Year Plan (2007-12). There is a need to build up production of non-edible oilseeds. Lands not suitable for food crops should be considered. Likewise *gomal* lands, C&D class lands, tank foreshores, roadsides, canal sides and degraded forest lands may be considered too, keeping in mind that bio-fuel should not be made to compete with food crops for cultivation land. Progress in the bio-fuel production has been slower than hoped. The reasons are attributable to hesitations in the farming community, which in turn can be linked to the absence of an organised market and uncertainty about the prospects of bio-fuel. It emerges that the promotion of bio-fuel needs more focus on farmers, markets and impediments. Besides other instruments needed for a more effective promotion, the suggestion of setting up decentralised oil mills at Gram Panchayat level is worth considering.[3]

8.5.9. CDM

There is scope for reaping benefits of Clean Development Mechanisms (CDM) in Karnataka, according to KREDL. But until 2008 only 31 renewable energy projects in the state obtained 80.6 million Certified Emission Reductions (CERs).[4]

KREDL is understood to facilitate energy efficiency/conservation projects[5] yet the scope of CDM is far from being exhausted. A key constraint is the extensive approval and certification process, which is not a deterrent for larger project such as wind power but which makes participation for many small and scattered renewables projects unviable. The scope for 'classical' CDM is limited given that, up until now, project sizes are small but there is scope for alternative CDM options. Of particular interest are bundling of projects – which is challenging because of multiple ownerships – and programmatic approaches, which may be most suitable for Karnataka. The viability of these approaches needs to be demonstrated in Karnataka to encourage wider utilisation of these meaningful instruments.

[1] Biomass Energy for Rural India (2012). Comments on the draft Karnataka SAPCC dated September 20, 2011

[2] Department of Rural Development and Panchayat Raj (2009). Karnataka State Bio-fuel Policy 2009

[3] Biomass Energy for Rural India (2012). Comments on the draft Karnataka SAPCC dated September 20, 2011

[4] Department of Energy (2009). Karnataka Renewable Energy Policy 2009-14

[5] Karnataka Renewable Energy Development Limited. http://kredl.kar.nic.in accessed April 14, 2011

8.5.10. GHG inventory

A greenhouse gas emission inventory in line with the IPCC methodology has not been prepared in Karnataka yet. BCCI-K (2011) prepared what is believed to be the first comprehensive assessment for the state. Besides there are some sectoral inventories initiated by Karnataka State Pollution Control Board (KSPCB). The board released an inventory of Bangalore's transport sector in 2008[1] and later on another inventory of the transport sector of selected other districts.[2] The board also intends to prepare a GHG profile for highly polluting industries in Karnataka in 2011-12.[3] This would comprise of 17 categories of industries with highest levels of resources consumption.

8.6. Missions under the NAPCC

The **National Mission for Solar Energy** is a major initiative promoted to achieve an ecologically sustainable growth while addressing India's energy security challenge. Being a tropical country, India has sunshine for long periods and high solar radiation. Thus with conditions being apt, the vast potential of solar energy could be well harnessed through solar thermal and solar photovoltaic projects. The mission also seeks to establish India as a global leader in solar energy by creating a suitable policy framework for its diffusion across the country. Key challenges for achieving the same would include:

- The creation of conditions permitting rapid scale-up of capacity and technological innovation to drive down costs and achieve grid parity. It is recognised that the cost trajectory depends on the scale of global deployment and technology development;
- Off-grid solar applications should be able to meet rural energy needs and to serve populations without access to commercial energy.

Targets were set to ramp up capacity of grid-connected solar power generation to 1,000 MW by 2013 and an additional 3,000 MW by 2017.

The **National Mission for Enhanced Energy Efficiency** seeks to address the challenge of sustaining rapid economic growth while at the same time coping with an energy deficit that has historically been insurmountable. Other challenges include reducing energy intensity with current commercially available technologies.

8.7. Selected emerging intervention areas

Energy efficiency

- Capacity building of municipal bodies and other local bodies for planning and implementation energy efficiency means;
- Creation of the energy conservation fund for energy efficiency and renewable energy measures in the state. The resources shall be generated by a cess on unit energy consumption;
- There is no relevant means to regulate the SME sector. Also, the industrial policy or the investment policy does not consider energy efficiency. Therefore an integrated approach to ensure industrial growth in an efficient manner is needed;

[1] Enzen Global (2008). Greenhouse gas inventory of Karnataka, Series 1: Bangalore City Road Transport Sector

[2] Enzen Global (undated). Greenhouse gas inventory of Karnataka, Series 2: 7 Southern Districts

[3] Karnataka State Pollution Control Board (KSPCB), (2011). Consultation held on March 8, 2011

Renewable energy

- Development of indigenous and cost effective solar technology to enable harnessing full potential and also reach grid parity;
- Fiscal incentives to promote setting up of manufacturing units in the state;
- Creation of a solar centre of excellence which would enable applied research and commercialisation of nascent technologies in case of solar;
- Pioneering and demonstration of successful application of CDM bundling and programmatic approaches for smaller and scattered renewable energy is needed to encourage wider utilisation of these instruments in Karnataka.

Agriculture sector

- Revival of community biogas plants to reduce methane emissions, firewood use for cooking and indoor air pollution.

Biomass

- Gasification of biomass for electricity generation has been demonstrated in Karnataka by the BERI project and now steps are needed to develop the vast potential, estimated to be 5,000 MW in the state. Specific attention should be placed on providing suitable incentives for underserved and unserved Gram Panchayats for developing gasifiers of about 2 MW each;
- A detailed biomass assessment study and forecasting is needed for preparing a biomass promotion strategy. It should consider production, transportation, distribution, regulation and monitoring;
- The promotion of bio-fuel needs more focus on farmers, markets and impediments faced in Karnataka. Besides other instruments for an effective promotion, the suggestion of setting up decentralised oil mills at Gram Panchayat level is worth considering;
- The Karnataka State Bio-fuel Policy 2009 should be amended to include quantified targets and specific incentives for realising them.

Other areas

- Study the impacts of climate change on energy systems. For example, there might be further significant increases in electricity use and peak demand in Karnataka due to future temperature rises. Changes in rainfall and water availability, observed and projected, are also yet to be studied for their impact on hydro power generation;
- A comprehensive GHG emission inventory for Karnataka is needed in order to prioritise mitigation strategies appropriately;
- Launch of a comprehensive programme for promotion of biomass gasification based cooking systems, solar lighting solutions and desalination.

9. URBANISATION

9.1. Urban planning and land use

Due to increasing populations, cities are under immense pressure to meet the growing demands and aspiration of citizens in qualitative and economic terms. Karnataka observed rapid economic growth in the last two decades accompanied by fast urbanization levels. It is India's third most urbanised state with the urban population accounting for 37%[1] of the state's 61.1 million (Provisional Census 2011). Karnataka has 218 urban local bodies (ULBs), comprising of 8 City Corporations, 43 City Municipal Councils (CMCs), 94 Town Municipal Councils (TMCs), 68 Town Panchayats as well as 5 Notified Area Councils (NACs).[2] According to the Provisional 2011 Census, Bangalore Urban is the most populous district in the state with a population of 95.9 lakh and a decadal growth of 46.7% against the state average of 15.7%.[3] The pace of transition and degradation of natural resources is posing a huge challenge for municipal governance.

The rapid growth in the urban population is driven by both push and pull factors. The absence of basic amenities and the lack of employment opportunities in rural areas urge populations out of rural areas and small urban settlements. On the other hand, the presence – or perceived presence – of these in larger urban settlements attracts migration of rural populations into urban areas.[4]

The state has a geographical area of 191,791 km^2 and is home to 27,481 inhabited villages and 270 towns and urban agglomerations. Table 52 provides data on land use in 2008 for the then 29 districts. 3.1 million hectares of land are under forest cover and 12.9 million ha are under cultivation. 69% and 49% of land is agricultural and 12% and 16% is forest area respectively in northern and southern Karnataka. Other lands available are fallow and uncultivated lands. It may be necessary to convert agricultural land for non-agricultural purposes to accommodate the growing population.[5]

With presently about 10 million houses, Karnataka is falling short of about 5 lakh houses. Considering the average decennial growth at 4%, it is estimated that about 1.44 million houses would be required in 2021. Assuming a gross density of 100 persons per hectare, additional land required by 2021 would be 216,535 ha.

To accommodate the growing population, trees and vegetation may need to be cleared for constructions. A reduction in the growing stock would reduce the carbon sequestration potential. There is an increase in the number of buildings due to increased population and migration of people into cities in search of better livelihood. This has led to increase in temperatures due to radiation from buildings and paved roads (heat islands), and inadequate tree cover to counter this rise in temperature. Air circulation is also reduced due to the dense residential development.[6] Green spaces in Karnataka are reducing[7] and there is a perceived lack of adequate lung space in cities.

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[1] BCCI-K (2011). Karnataka Climate Change Action Plan; Final Report

[2] Directorate of Municipal Administration (2011). Presentation on municipal solid waste management on Mar 8, 2011

[3] Directorate of Municipal Administration (2011). Annual Administration Report 2010-11

[4] EMPRI (2009). State of Environment Report Bangalore 2008

[5] EMPRI (2012). State of Environment Report Karnataka 2011

[6] Department of Forest, Ecology & Environment (2004). State of Environment Report Karnataka 2003

[7] Department of Forest, Ecology & Environment (2004). State of Environment Report Karnataka 2003

Table 52: Land utilization district wise 2007-08 in hectare[1]

District		Forest	Area not available for agriculture	Other uncultivated land	Fallow land	Area sown
1.	Bagalkote	81,126	53,642	5,738	50,095	600,414
2.	Bangalore Urban	5,055	116,347	17,616	19,508	60,814
3.	Bangalore Rural	11,322	50,965	20,004	43,376	134,084
4.	Belgaum	190,424	113,710	40,653	166,574	1,051,947
5.	Bellary	97,017	122,100	33,917	96,101	602,438
6.	Bidar	27,707	41,133	44,207	98,491	411,180
7.	Bijapur	1,977	64,906	16,393	90,982	1,060,841
8.	Chamarajanagar	275,610	46,040	35,169	27,019	218,655
9.	Chikkaballapur	49,704	66,235	72,135	45,728	174,212
10.	Chikkamagalur	200,485	70,961	130,839	23,041	325,270
11.	Chitradurga	73,719	76,646	121,672	63,229	484,550
12.	Dakshina Kannada	128,476	122,853	82,409	13,012	158,179
13.	Davanagere	89,918	59,496	33,018	25,394	422,634
14.	Dharwad	35,235	25,732	6,418	41,450	528,521
15.	Gadag	32,614	22,109	3,865	22,396	558,533
16.	Gulbarga incl. Yadgir	69,089	131,107	51,257	200,985	1,444,923
17.	Hassan	58,775	109,046	54,042	71,084	440,719
18.	Haveri	47,454	37,480	17,334	17,645	429,658
19.	Kodagu	134,597	54,971	47,354	6,501	179,229
20.	Kolar	20,620	74,547	52,824	54,114	179,355
21.	Koppal	29,451	55,497	17,453	68,440	508,052
22.	Mandya	24,765	82,425	83,386	73,723	283,928
23.	Mysore	62,851	112,840	83,587	75,798	579,739
24.	Raichur	18,167	40,647	44,208	15,270	722,518
25.	Ramanagara	69,946	50,564	29,790	46,683	163,595
26.	Shimoga	276,855	101,765	206,638	41,637	256,163
27.	Tumkur	45,177	151,780	160,128	99,477	664,314
28.	Udupi	100,102	50,857	94,489	10,122	122,943
29.	Uttara Kannada	813,595	50,656	28,116	17,620	125,263
	Total in ha	**3,071,833**	**2,157,057**	**1,634,659**	**1,625,495**	**12,892,671**

9.2. Transport

The transport sector is both a prerequisite for and a driver of development. As of March 2009, Karnataka has 8.3 million registered vehicles, the majority of which are motorcycles.[2] The vehicular population has increased by an alarming 70% in merely six years. As Table 53 indicates, the increase of cars, lorries and buses is almost equally pronounced while motorcycles grew at a lower pace.

[1] Directorate of Economics and Statistics (2009). Karnataka at a Glance 2008-09

[2] EMPRI (2012). State of Environment Report Karnataka 2011

Table 53: Growth of motor vehicles in Karnataka (in thousands)[1]

Vehicle type	2003	Share	2009	Share	Change
Motorcycles	3,556.74	73.0%	5,914.00	71.3%	66.3%
Cars	537.47	11.0%	1,018.00	12.3%	89.4%
Auto rickshaws	188.59	3.9%	276.00	3.3%	46.4%
Buses	80.8	1.7%	142.00	1.7%	75.7%
Lorries	161.12	3.3%	302.00	3.6%	87.4%
Others	351.04	7.2%	638.00	7.7%	81.8%
Total	**4,875.76**	**100.0%**	**8,290.00**	**100.0%**	**70.0%**

Table 54: Breakup of motor vehicles (in thousands)[2]

Items	2007-08	2008-09	2009-10	2010-11 (up to Dec 2010)
Motorcycles	5,269	5,914	6,242	6,665
Cars	774	910	973	1,115
Jeeps	45	46	46	47
Auto rickshaws	249	276	288	293
Buses	68	77	80	91
Motor cabs	58	62	72	69
KSRTC buses	19	18.2	18.7	20.8
Private buses	7	8	9	17
Goods carriages	254	302	310	418
Tractors	210	230	238	240
Trailers	200	216	221	226
Others	164	180	321	205
Total	**7,317**	**8,239**	**8,819**	**9,407**

The higher density of vehicles in urban areas coupled with insufficient road space drastically reduces the average speed on the roads. Reduction in speed increases travel times and leads to increased consumption of fuel and emission of carbon dioxide, hydrocarbons and oxides of nitrogen.[3] The daily consumption of petrol and diesel in the state is INR 31 lakh litres and INR 81 lakh litres respectively.[4]

9.2.1. Road network

Karnataka has a road network of 2.2 lakh kilometres, consisting of national highways, state highways, major district roads, municipal roads and other village roads. The aggregate road length increased by almost 66% between 2003 and 2009.[5] 70% of traffic is carried by national highways in Karnataka. However, during the last six years even though national highways increased by 254 km, its share of total road length of the state has declined from 2.8% to 1.8%. In the same period the share of state highways in-

[1] EMPRI (2012). State of Environment Report Karnataka 2011

[2] Department of Planning, Programme Monitoring and Statistics (2010 and 2011). Economic Survey 2009-10 and 2010-11

[3] EMPRI (2012). State of Environment Report Karnataka 2011

[4] Business Standard (June 18, 2008). Karnataka - Petrol prices may come down

[5] EMPRI (2012). State of Environment Report Karnataka 2011

creased from 7.3% to 9.5% which is a welcome development. Though it appears that most of the bottlenecks of the state highways system have been addressed in the last six years, the number of trips and the per capita trip rate have also increased substantially.[1] On many of Bangalore's thoroughfares, the volume-capacity (V/C) ratio in is exceeding recommended limits.[2]

Table 55: Road infrastructure in Karnataka (2009)[3]

Road type	2003		2009	
	Length (km)	Share	Length (km)	Share
National highways	3,728	2.8%	3,982	1.8%
State highways	9,829	7.3%	20,905	9.5%
Major district roads	28,247	21.1%	47,836	21.8%
Village roads	92,258	68.8%	147,212	66.9%
Total	**134,062**	**100.0%**	**219,935**	**100.0%**

9.2.2. Impact on air quality

The transport sector, especially road transport, contributes significantly to air pollution. Vehicular air pollution depends on a wide array of factors: The age and type of vehicle, the fuel composition, engine maintenance, the load carried, elevations, driver behaviour and congestions. Petrol engines emit more carbon monoxide and hydrocarbons while diesel engines emit more particulate matter, oxides of sulphur and nitrogen. Carbon monoxide is the single biggest pollutant emitted by automobiles. Of greatest concern however is particulate matter whose concentrations have risen above prescribed limits in all of Bangalore's monitoring stations since 2006-07.[4]

9.3. Waste management

9.3.1. Solid waste generation

Solid waste can be harmful to human health and ecosystems. Improperly disposed solid waste, a common sight in cities, also spoils the aesthetics of a living environment. The quantity of municipal solid waste generated varies greatly across municipalities. It ranges from 0.57 tons per day (TPD) in a small town and 140 TPD in Belgaum City Corporation to 3,500 TPD in Bangalore.[5] The total quantity of municipal solid waste generation from 218 urban local bodies in Karnataka is close to 9,000 tons per day.

Table 57 presents the details of the solid waste generated by selected ULBs. Unsurprisingly, city corporations generate the greatest amount of solid waste. Considering a waste generation growth rate of 6%, the projected municipal solid waste for the year 2020 would be 14,550 TPD. Even if the landfillable volume is reduced to through composting and incineration to minimum, still 20% of it will have to be landfilled.[6]

[1] EMPRI (2012). State of Environment Report Karnataka 2011

[2] EMPRI (2012). State of Environment Report Karnataka 2011

[3] EMPRI (2012). State of Environment Report Karnataka 2011

[4] EMPRI (2012). State of Environment Report Karnataka 2011

[5] EMPRI (2012). State of Environment Report Karnataka 2011

[6] EMPRI (2012). State of Environment Report Karnataka 2011

Table 56: Waste generation and collection as on 2008-09[1]

Type of urban local body	Quantity of waste generated (t/d)	Quantity of waste collected (t/d)	Collection efficiency average in %
City Corporations	4,650	3,720	80
City Municipal Councils	2,179	1,591	73
Town Municipal Councils	1,244	933	75
Town Panchayats	752	534	71
Total	**8,825**	**6,778**	**75**

Table 57: Municipal solid waste generation of selected urban local bodies[2]

Urban local body	Population (2009)	MSW generated total (t/d)	MSW generated total (g/d/capita)
1. Baavakalyana	68,935	26	377
2. Bhadravathi	160,662	51.68	322
3. Bidar	210,000	50	238
4. Bijapur	285,000	109	382
5. Channapatna	70,287	24	341
6. Chintamani	65,493	23.5	359
7. Chitradurga	125,000	44	352
8. Dandeli	53,287	19	357
9. Doddaballapur	85,000	38	447
10. Gadag-Betgeri	172,291	70	406
11. Gangavati	105,000	30	286
12. Gokak	76,832	25.5	332
13. Harihar	87,048	25	287
14. Haveri	55,913	17	304
15. Karwar	62,973	20	318
16. Kolar	130,052	60	461
17. Koppal	61,759	25	405
18. Madikeri	32,296	14	433
19. Mandya	156,000	54.6	350
20. Nippani	58,061	18.09	312
21. Raichur	245,030	90	367
22. Ramanagara	100,000	40	400
23. Ranebennur	89,618	29	324
24. Sagara	58,000	18	310
25. Shahabad	50,285	7.8	155
26. Shimoga	274,105	94.1	343
27. Sindhanoor	65,001	25	385
28. Sira	61,310	21.5	351
29. Sirsi	59,000	30	508
30. Tiptur	57,196	25	437
31. Tumkur	327,851	114	348
32. Udupi	131,803	58	440

[1] EMPRI (2012). State of Environment Report Karnataka 2011

[2] EMPRI (2012). State of Environment Report Karnataka 2011

9.3.2. Waste transportation

Records from Directorate of Municipal Administration reveal that nearly 91% of the waste collected in the state is transported to disposal sites for further treatment and final disposal. This includes organic and inorganic waste. Several modes of transportation are used to transfer waste from the collection points to the disposal site depending on the road conditions, the quantity of waste collected and also the financial viability. Table 58 provides the details of the modes of transportation involved in waste transportation in the state.

Table 58: Modes of waste transportation employed in ULBs (2004)[1]

Type of urban local body	Number of lorries	Number of mini lorries	Number of tractors	Number of modes
City Corporations	43	11	55	5
City Municipal Corporations	28	25	170	20
Town Municipal Corporations	1	14	129	12
Town Panchayats	5	4	99	25

As expected, in major cities, a larger number of lorries are employed for transportation of waste whereas in Town Panchayats it is transported mostly with tractors. With the increase in population, the generation of municipal solid waste also increases. The increase in the number of vehicles is directly proportional to the consumption of fuel and increased air pollution.

9.3.3. Indiscriminate burning of waste

In Karnataka, no engineered landfill with a total waste recycling system exists. Most of the collected waste is disposed on lands in the outskirts of the city. It is also burnt either on roadside heaps or at dumpsites to reduce the waste volume and sometimes to recover recyclable materials. Indiscriminate open burning of waste significantly contributes to urban air pollution as mixed waste contains tires, aluminium foils and domestic hazardous waste emitting toxic fumes.[2] Because of the moisture of waste and the limited heat generated, open air burning almost always leads to incomplete combustions and produces more carbon monoxide than controlled burning.

Illegal disposal of waste is a serious problem with ecological long-term impacts. Unscientific disposal of wastes, for prolonged duration results in land degradation and groundwater pollution through leachate percolation. A study on Bangalore cited in 2003 states that 600 tons of municipal solid waste is daily dumped illegally in and around the city.[3] During the monsoon stagnant water could cause soil contamination. Due to lack of knowledge on waste minimization and the benefits of recycling, the chain of the recycling process is not complete and often results in illegal burning or dumping.[4]

[1] EMPRI (2012). State of Environment Report Karnataka 2011

[2] Department of Forest, Ecology & Environment (2004). State of Environment Report Karnataka 2003

[3] Department of Forest, Ecology & Environment (2004). State of Environment Report Karnataka 2003

[4] Department of Forest, Ecology & Environment (2004). State of Environment Report Karnataka 2003

9.4. Actions, policies and institutional preparedness

9.4.1. Regional imbalances

Rapid urbanisation of the Bangalore region continues to be driven in part by regional imbalances, some of which can be traced back to the formation of Karnataka state in 1956. The Dr. Nanjundappa Committee report identified imbalances in opportunities, development and education in 2002.[1] Government of Karnataka continues to implement several important recommendations of it such as the Special Development Plan for backward taluks and the progress is monitored.[2] Addressing regional imbalances also forms an element of the Karnataka Industrial Policy 2009-14, which aims at attracting an investment of INR 300,000 crore and employment of 10 lakh. Incentives provided to industries in backward taluks are consistently higher. In the long run, this could be a capable instrument for shifting the industrial development focus into rural areas. Very appropriately, environmental incentives of the policy are not linked to location.[3]

9.4.2. Urban planning and land use

The needs of urban planning and development are in custody of the Urban Development Department. Three directorates are under its umbrella with specific roles: Directorate for Town & Country Planning, Directorate of Municipal Administration (DMA) and the Directorate of Urban Land Transport (DULT). The Urban Development Department also provides anchorage to urban development authorities across the state and, in respect of Bangalore, Bangalore Development Authority (BDA) and Bangalore Metropolitan Region Development Authority (BMRDA).[4] DMA in turn coordinates with all urban local bodies (ULBs).[5] Through its line agencies the department is a key facilitator of environmental practices with a certain bearing on mitigatory aspects of climate change. This includes planning of urban areas, preparation of the blueprints for creation of parks and lung spaces and implementation of waste management.

The Karnataka Town and Country Planning Act, 1961 originally provided for a three-tier system of urban planning. It stipulated the preparation of Outline Development Plans which broadly indicated zoning of land and proposed zoning regulations. Based on this a Comprehensive Development Plan was prepared and fleshed out with details such as complete street patterns, improvements of existing roads, reservation of areas for public purposes such as parks, playgrounds and other recreational uses, public buildings and areas for housing. Lastly town planning schemes were prepared to implement the Comprehensive Development Plan. This process was time consuming. According to experience, it required nearly 20 years.[6] In 2004 an amendment to the act was passed that defines a revised approach. It prescribes the preparation of Master Plans by planning authorities. Added to this, there is a provision for Interim Master Plans pending preparation of the Master Plan for regulating land use and road allocation. Further a time up to one year is permitted for the preparation of Master Plans. Another important feature is the mandatory revision of the Master Plan every ten years.

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[1] Nanjundappa, D.M. et al (2002). Report of the High Power Committee for Redressal of Regional Imbalances in Karnataka; Dr. D. M. Nanjundappa Committee

[2] Department of Planning, Programme Monitoring and Statistics (2011). Economic Survey 2010-11

[3] Department of Industries & Commerce (2009). Karnataka Industrial Policy 2009-14

[4] Directorate of Urban Land Transport (DULT), (2011). Consultation held on March 9, 2011

[5] Directorate of Municipal Administration (2011). Presentation on municipal solid waste management, Mar 8, 2011

[6] Department of Forest, Ecology & Environment (2004). State of Environment Report Karnataka 2003

Structure Plans are the underlying planning instrument which integrate policy decisions. The Directorate of Town & Country Planning prepares them and, in case of Bangalore, BMRDA. Development zones are demarcated in it from areas where a conservatory approach is taken to preserve the natural character or agricultural utilisation. Zonal Regulations form an accompanying instrument, ensuring that policies adopted in Structure Plans will be integrated into subsequent Master Plans as well. Approval for the latter rests with respective ULBs. While planning institutions, mechanisms and capacities appear prima face adequate for environmental planning, bottlenecks exist in the implementation of Master Plans. Fund shortages – which are not uncommon at ULB level – can delay or completely thwart the acquisition of land for some purposes, especially when these, as in the case of parks, create no revenue. After a delay of five years, Master Plans expire and the obligation on part of the ULB for development of these components lapses. In these cases the respective owner of the land in question is re-entitled to its use for any purpose desired and the well-intended regulation eventually fails.[1]

The prescribed use of solar water heaters and rainwater harvesting systems are two prominent examples where policy decisions were made mandatory through first Structure Plans and then Master Plans. While the integration into plans is not an implementation or enforcement arrangement by itself, it sets clear goals for ULBs and places the subject prominently on the radar of authorities. The greater success in these two cases probably owes to the fact that required funding is not to be footed by ULBs. That and the not unimportant fact that ULBs are at liberty to define appropriate mechanisms for realising these goals. In Bangalore for example, BMRDA introduced a refundable security deposit of 2% of the project cost for construction of solar water heaters. The agency also makes tree plantations prerequisite for approval of development plans. However, no quantitative data has been published regarding achievements of these interventions.[2]

9.4.3. Housing

Rajiv Gandhi Rural Housing Corporation Limited (RGRHC) caters to the housing needs of economically weaker sections of the society. Housing for some 20 lakh people were created by the corporation so far, 75% of which in rural areas. All schools constructed by the RGRHC are said to be equipped with rainwater harvesting. Cement-bound mud blocks are promoted al low-energy alternative in about 2-3% of housing projects in urban areas. Decentralised wastewater treatments systems (DEWATS) for sewage were installed for four layouts comprising of around 4,000 houses. In contrast to conventional treatment plants, DEWATS operate without electricity. For the latter initiative the corporation received support from the Bremen Overseas Research & Development Association (BORDA), Germany. RGRHC's commitment to implementing key elements for sustainable housing in line with the spirit of the National Mission for Sustainable Habitat is commendable, especially in view of the corporation's limited financial flexibility.[3]

Karnataka Housing Board (KHB) constructs houses for subsequent purchase, 10-15% of which is reserved for economically weaker sections. As self-financing organisation, cost recovery is essential and funding for new projects is secured chiefly through loans. More than 300 housing schemes[4] have been established in this way in Karnataka since 1960,

[1] Directorate for Town & Country Planning (2011). Consultation held on March 11, 2011

[2] Bangalore Metropolitan Region Development Authority (BMRDA), (2011). Consultation held on March 9, 2011

[3] Rajiv Gandhi Rural Housing Corporation Limited (RGRHC), (2011). Consultation held on March 10, 2011

[4] Department of Housing (2011). Letter dated February 17, 2011

creating around 2 lakh houses in 176 different taluks for an unknown number of beneficiaries. It operates several schemes with different target groups, budgets and levels of convenience. The board asserts that parks are developed in 10% of the area reserved for this purpose. In these, rainwater is harvested for groundwater recharge and septic tanks are provided in each of the schemes. Since 2010, also solar water heaters are included for each building. A pilot project with 20 solar streetlights has also been commissioned in Bangalore in 2011, its scale limited only by the funding available.[1] The systematic integration of these elements are both laudable and essential because the state has to take a lead in adopting sustainable practices.

Even Karnataka Slum Clearance Board – which was renamed as Karnataka Slum Development Board in 2010 – intends to follow suit by adopting rainwater harvesting, DEWATS and solar lighting at some scale. The board has not only been renamed but also reoriented. Today it is mandated to provide essential amenities, create hygienic living conditions and ensure access to safe drinking water for 2,251 notified slums.[2] The emphasis is clearly on development and the board has proposed the inclusion of rainwater harvesting, DEWATS and solar lighting for the Rajiv Awas Yojana programme, a forthcoming 5-year scheme. The crux is additional funding and the board is already reeling under deficits as the state is said to contribute less than the stipulated 20%. Nevertheless, a pilot project with nine solar streetlights has been implemented in Laggere, Bangalore and a second one at Sadarmanagala, Bangalore is said to be commissioned shortly.[3]

It is noteworthy that Rajiv Gandhi Rural Housing Corporation Limited (RGRHC) is actively pursuing fly ash utilisation. Five thermal power plants and a paper mill have allotted land to the corporation for the making of building blocks in proximity to their premises. The agency considers itself to be the largest user of fly ash in Karnataka.[4] Fly ash is also utilised by Public Works Department, (PWD) although quantities were not reported. In 2002 it notified as mandatory the use of fly ash for certain building and road constructions within 100 km from thermal power plants and PWD is believed to be implementing the same.[5] It noted with concern however that unspecified amounts of fly ash are dumped on the coast, action on which is being initiated.[6]

The National Building Code of India 2005 provides guidelines for building constructions across the country. It serves as a model code for adoption, containing administrative regulations, development control rules and general building requirements. Further, the Ministry of Power's Bureau of Energy Efficiency (BEE) has also developed the Energy Conservation Building Code (ECBC) 2006. The purpose of this code is to provide minimum requirements for the energy-efficient design and construction of buildings. Mandatory for commercial buildings and complexes, codes for residential structures are only voluntary.[7] As discussed in section 8.5.7, the code is yet to be notified in Karnataka.

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1 Karnataka Housing Board (KHB), (2011). Consultation held on March 10, 2011

2 Karnataka Slum Development Board (2011). Consultation held on March 10, 2011

3 Department of Housing (2011). Letter dated February 17, 2011

4 Rajiv Gandhi Rural Housing Corporation Limited (RGRHC), (2011). Consultation held on March 10, 2011

5 Public Works Department (PWD), (2002). Notice PWD 345 CRM 200 on Fly ash utilisation dated December 2, 2002

6 Karnataka State Coastal Zone Management Authority (2011). Proceedings of the meeting, March 14, 2011

7 Sustainable Habitat. A TERI Initiative for Sustainable Development; www.sustainable-buildings.org accessed on February 22, 2012

9.4.4. Transport

To integrate transportation needs better into urban planning, Directorate of Urban Land Transport (DULT) was established under the Urban Development Department in 2007. Its focus is set on improving the utility and acceptance of public transport and to create and improve infrastructure for pedestrians and bicycles. DULT's mandate was initially limited to seven CMCs, expanding gradually to all urban settlements with a population of over one lakh.[1] The directorate deserves credit for preparing transportation plans for six towns and comprehensive mobility plans for four other towns. It pioneered the concept of a rapid bus transit systems in Karnataka which has since been introduced in Bangalore, Mysore and Hubli-Dharwad. Bangalore Metro is expected to achieve full-scale operation by 2014. DULT is working on a bus feeder concept to widen the geographic reach of the Metro. Equipped with a budget of INR 178 crore, DULT has roped in additional funding through a State Level Urban Fund with an initial corpus of INR 60 core to fund feasibility and transport studies, build capacities of ULBs and even for implementation of projects. The promotion of pedestrian infrastructure and establishment of dedicated cycle lanes is overseen by a Taskforce for Non-motorized Transport on the initiative of DULT. Feasibility studies for five cycle lanes for the Jayanagar area in south Bangalore have been forwarded to Bangalore Bruhat Mahanagar Palike (BBMP) for implementation. Traffic-free pedestrian zones, one in Gandhi Bazaar and another in Commercial Street have been proposed as well. It is worth noting that non-motorised modes of transport that were hitherto excluded from transportation concepts altogether are being reconsidered and promoted now. The narrow, uneven and obstacle-laden pavements exemplify best the priority given to pedestrians so far. If successful, DULTs proposals will create urban spaces through which a part of the city is being returned to its citizens, providing spaces for rediscoveries of qualities of life lost decades ago. Street Design Guidelines are currently under preparation by the directorate were expected to be presented around December 2011. They aim to establish concepts and standards for the design of junctions, the width of pavements and a road hierarchy.[2][3]

The National Bio-fuel Policy prepared by Ministry of New and Renewable Energy (MNRE) has proposed a 20% substitution of diesel by bio-diesel to be achieved in the year 2017.[4] The policy deals with two classes of renewable bio-fuels namely bio-diesel and bio-ethanol. Government recognizes the importance of bio-fuels as extremely critical to sustainable energy security and environment protection with creation of employment and further economic growth. Bangalore Metropolitan Transport Corporation (BMTC) has introduced the usage of bio-fuel in part of its fleet.

In view the need of building research capacity for transportation and urban planning, Department of Transport created a dedicated body in 2009. Pooling in a corpus of about INR 30 crore from stakeholder departments, it established the Centre for infrastructure, Sustainable Transport and Urban Planning (CiSTUP) in 2009, hosted by Indian Institute of Science (IISc).[5]

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[1] Bangalore, Mysore, Mangalore, Hubli-Dharwad, Belgaum, Gulbarga and Bellary

[2] Directorate of Urban Land Transport (DULT), (2011). Response to EMPRI questionnaire, March 5, 2011

[3] Directorate of Urban Land Transport (DULT), (2011). Consultation held on March 9, 2011

[4] WISE (2010). Clean Energy Technology Action Plan for Climate Mitigation for Karnataka

[5] Government of Karnataka and IISc (2009). Memorandum of Understanding for establishment Centre of infrastructure and Sustainable Transportation and Urban Planning (CiSTUP) dated January 2, 2009

Department of Transport also initiated action to improve air quality in Bangalore. In 2001 it achieved passing of a Government Order prohibiting commercial vehicles older than 15 years. Implementation of this order has however proven difficult if not impossible. And while the order was not withdrawn, it is not acted upon in a way that is apparent.[1] Equipping petrol-engined auto rickshaws with LPG conversion kits is made attractive through a subsidy offered. In March 2011 around 90% of Bangalore's auto rickshaws were believed to have been converted. It also offers INR 10,000 as reward replacement of every two-stroke auto rickshaw with a four-stroke one. Raising the subsidy to INR 20,000 is under review. A catch however is that the two-stroke vehicle replaced is not scrapped but can – and should – be re-registered elsewhere, proof of which has to be submitted for availing the subsidy. Across Karnataka the department has licensed 460 emission test centres, 260 (57%) of which are in Bangalore alone. Nearly half of those in Bangalore have their test results automatically transmitted to a central database. While this network is currently being expanded it is unclear what exactly is being done with the data collected. It appears that sulphur dioxide and nitrous oxides are well in check as most of the time while suspended particulate matter (SPM) is reason for concern.[2] Ironically, SPM, which has its source in two-stroke and diesel engines apart from ordinary dust, is not covered by emission tests because the substance is not covered by the Central Motor Vehicle Act. This points at a possible opportunity for intervention. However, SPM testing would possibly require testing under load (not idle speed) for which test centres are not equipped. While a CNG pipeline is currently being build it is uncertain whether the fuel is expected to enter the vehicle market, especially in view of the fact that LPG has already made significant inroads and modifications required for conversion from LPG to CNG may cost another INR 2,000 on top of whatever conversion expenses were incurred for the switch to LPG.[3]

9.4.5. Waste management

Considerable effort is being made by DMA to implement waste management in all 218 ULBs. An 8-months education and communication programme for waste segregation was conducted back in 2005-06 in three phases. With the help of selected NGOs the programme is said to have covered 43 towns, 23 CMCs, 66 TMCs and 81 other ULBs. Apart from shorter-term break-throughs, particularly in coastal urban areas, segregation has not caught on substantially. Constrains are attributable not only to lack of awareness but also the absence of people participation paired with unavailability of decentralised waste handling centres, as pointed out by an NGO during a Lok Adalat hearing in 2010.[4] DMA holds that efforts are being renewed and it is suggested tentatively that Mysore could emerge as the first town to implement segregation successfully. Highest priority is attached to achieving compliance with legal provisions on municipal solid waste. 213 of the 218 ULBs have so far prepared a solid waste management plan. Land for the establishment of the necessary waste management facilities has been acquired by 183 ULBs (84%). In some cases the acquisition process is tied to court proceedings and here timeframes for completion are not under control. It has been reported that door-to-door waste collection has been achieved in 79 ULBs so far with the involvement of more than 1,000 self-help groups. DMA appears optimistic that legal compliance in municipal solid

[1] Taskforce for Control of Air Pollution In Bangalore (2010). Minutes of the 18th meeting held December 14, 2010

[2] EMPRI (2009). State of Environment Report Bangalore 2008

[3] Department of Transport (2011). Consultation held on March 8, 2011

[4] Solid Waste Management Round Table (2010). Presentation at Lok Adalat hearing, Bangalore, October 23, 2010

waste management will be achieved by all ULBs in 2012-13.[1] A Policy on Integrated Solid Waste Management was adopted by the state in 2004. Its main objective is to develop and implement scientific and sustainable methods for management of solid waste with specific reference to collection, segregation, storage, transportation, treatment and disposal in urban local bodies as per the provisions of Municipal Solid Waste Management Rules 2000.[2] Under the Jawaharlal Nehru National Urban Renewal Mission (JNNURM), BBMP is developing engineered sanitary landfills with private participation at Kannahalli and Mavallipura under a build operate-transfer concession framework. A waste-to-energy plant is also being developed by the private developer.[3]

In state-run health care establishments there is an appreciable level of knowledge on environmental requirements and commitment to achieve compliance with legislation. The attention is on management of biomedical waste (BMW) and capacity building, aspects where the department is known to cope. Deficiencies in treatment and disposal of liquid waste have received significant public attention in 2010 with KSPCB issuing closure orders to some. Department of Health and Family Welfare operates 19 district hospitals and 2,586 other health care facilities, the great majority of which are Primary Health Centres (PHCs). Preference is given to tie-ups with centralised BMW collection systems. This however is possible only if inclusion of a given health care facility is economically feasible in view of small quantities generated and distances from collection routes. This has been achieved in 76% of district hospitals and 41% of taluk hospitals but only to 15% in Community Health Centres (CHCs). As PHC are often remote and inaccessible, deep burial practices are adopted in absence of better alternatives. Deep burial constitutes a greater risk for contact with or exposure to infectious materials.[4]

The establishment of liquid waste treatment plants in health care establishments has significantly advanced. At district hospital and PHC level 53% of compliance has been achieved. Success at taluk level hospitals is somewhat lower (38%) and significantly lower at CHCs (15%). Department of Health and Family Welfare projected that remaining facilities would achieve compliance within 2011. The BMW management drive is accompanied by capacity building measures. 106 trainers were inducted through a training of trainers (ToT) until March 2011. It is planned to train a total of 5,028 staff across all 2,603 facilities within March 2012. Success permitting, this would result into two trained staff for each facility on average. NGOs were assigned key roles in training activities. Also EMPRI has embarked on supporting this area with a larger scale training programmes at district level since 2011.

Table 59: Bio-medical waste management in state-run health care facilities[5]

Facilities	Total	BMW collection system		BMW deep burial		Liquid waste treatment	
District hospitals	17	13	(76%)			9	(53%)
Taluk hospitals	146	60	(41%)			55	(38%)
Community Health Centres	182	27	(15%)			27	(15%)
Primary Health Centres	2,258			1,114	(49%)	1,205	(53%)

[1] Directorate of Municipal Administration. Presentation on municipal solid waste management, March 8, 2011

[2] EMPRI (2012). State of Environment Report Karnataka 2011

[3] EMPRI (2009). State of Environment Report Bangalore 2008

[4] Department of Health and Family Welfare (2011). Letter on biomedical waste management, dated March 3, 2011

[5] Department of Health and Family Welfare (2011). Consultation held on March 10, 2011

9.5. Missions under the NAPCC

The **National Mission on Sustainable Habitat** under the NAPCC states that in order to reduce risks of climate change, urban development in the country should target the promotion of energy efficiency in residential and commercial sectors, the management of municipal solid waste and the promotion of urban public transport.

An increase in the demand for transportation services for both passengers and freight is inevitable, given economic growth and increase of population. Key actions identified in the mission are setting up of demonstration units for recycling of vehicles, especially two wheelers, which require new techniques. The mission also focuses on combustion research and advancement of engine design. Providing tax benefits and investment support for recovery of materials from scrap vehicles is also envisaged as encouraging incentive to the recyclers.

The mission carries a budget of INR 53,761 crore to implement identified actions. In this INR 30,032 crore is earmarked for water supply, INR 17,061 crore for wastewater management, INR 6,163 crore for solid waste management, INR 207 crore for enhancing energy efficiency and INR 298 crore for urban transport.

9.6. Selected emerging intervention areas

Housing

In the building sector the key challenge lies in reducing energy demand for lighting and cooling. Besides energy saving appliances, green building concepts are of increasing importance. They extend to passive cooling and lighting as well as low-energy construction materials considering life cycle emissions.

- Develop guidelines for less energy intensive buildings that use rainwater harvesting, solar heating, energy conservation, water conservation, preferably in line with the GRIHA rating system which is important especially for arid climate conditions;
- Provide incentives for the construction of buildings compliant with developed guidelines;
- Integrate passive cooling into Structure Plans;
- Customise the Energy Conservation Building Code (ECBC) to suite climate conditions of the state and notify the code in Karnataka;
- Research and demonstration of innovative building techniques for increasing the benefits of solar energy, water management and passive cooling;
- Training on green building practices to be provided to personnel of municipalities;
- Once notified, conduct massive awareness drives on ECBC and green buildings concepts in the building sector.

Transport

In the transport sector, key priorities include the reduction of demand[1] and to bring about a shift from road to rail, from individual to public transport and from motorised to non-motorised transport.

- Conduct studies to identify relevant tools and policy options to integrate land use and transport planning;

[1] Though desirable from an environment point of view, this is virtually impossible to achieve in a developing society

- Provide training on tools for travel demand modelling, spatial planning etc. such as TransCad and GIS;
- Conceptualise tools such as accessibility index, walkability index and integrate them into transport planning and mobility concepts;
- Put in place education and social marketing – behaviour change campaigns – to educate and pursue citizens to use public transport. Introduce incentives such as off-peak discount and corporate discount on fares;
- Improve public transport dependability, timeliness, comfort and frequency and conceptualise the integration of a door-to-door concept;
- Mandate the possession of a valid PUC (Pollution Under Control) certificate at renewal of insurance, transfer in ownership etc. to ensure enforcement;
- Revise the existing PUC (Pollution Under Control) guidelines to consider specific conditions depending on the vehicle and engine type and age (two-, three- and four-wheelers; petrol, diesel, LPG);
- Increase the registration costs for new motor vehicles with low milage;
- Carry out a congestion and transport mobility study in urban agglomerations for developing better solutions for traffic and travel demand management;
- Research in identifying barriers that exist in using hybrid/electric vehicles.

Waste

- Implement an integrated municipal solid waste management programme across ULBs including a door-to-door collection and segregation. This needs to be accompanied by awareness and behavioural campaigns on cleanliness and hygiene, instructions for segregation at household level;
- Inventorisation of bio-medical waste and e-waste to inform policy and programmes in that context;
- Establish common bio-medical waste treatment facilities;
- Develop state-of-the-art end-of-life waste management and gas-to-energy systems;
- Conduct research on the life-cycle assessment of critical materials in order to understand the material inputs, energy inputs and environmental releases associated with the manufacture, use, transport and disposal of a given material to suggest strategies to reduce energy input and adverse impacts on the environment;
- Conduct research on the current status and contribution of the informal recycling sector to solid waste management in order to understand their role and inform policy. Integrate handlers and recyclers progressively into the mainstream.

10. HUMAN HEALTH

10.1. Indicators

Genetic resistance of individuals and environmental quality generally determines the health of a community. Any kind of deterioration in environmental quality affects health of the community, either by providing suitable conditions to vector borne diseases or by jeopardising food insecurity or by inducing disorders. Pollution in air, water and soil finds their way into the human body through inhalation, ingestion or dermal contact. Besides, public health depends on availability of food, safe drinking water, decent housing, protection against disasters, a reasonable income and good social and community relations.[1]

Karnataka has shown a steady progress in ensuring health services to its citizen since independence. Table 60 captures the status of health indicators in the state as well as target set for 2020 by government.

Table 60: Health indicators in Karnataka (2005-06)[2]

Indicator	Current level	National figure	Goal for 2020
Crude birth rate (2007)	19.9	23.1	
Crude death rate	7.3	7.4	
Infant mortality rate	47	55	10
Maternal mortality rate	228	254	50
Under 5 mortality	54.7	65.6	15
Total fertility rate	2.08	2.7	1.8
Child sex ratio	949	914	975
Women in reproductive age (15-49year) with anaemia	50%		15%
Births assisted by appropriate health personnel	7.13%		100%
Anaemia in children (6-35 month)	82.7%		25%
Child vaccination	55%		100%

Though important indicators such as mortality, birth and death rates are better in Karnataka compared to India, the state needs to make efforts to perform at par with the best performing states. Moderately high infant mortality, maternal mortality, malnutrition among children and women, high incidence of childhood diseases, inadequacies in water supply and sanitation, and poor socio-economic status of women along with social discrimination are important concerns in the state. 70% of children in the age group 6-59 months and 60.4% pregnant women were anaemic in the state in 2005-06. About 35-39% children below 5 years of age are underweight. Inadequate availability and poor quality of water, unsafe sanitation practices and lack of awareness on personal hygiene and primary health care are some of the key factors responsible for widespread health risks associated with consumption of pathogen infested drinking water in rural of Karnataka.[3]

[1] WHO (2003). Social determinants of health: The solid facts

[2] Department of Planning, Programme Monitoring and Statistics (2010, 2011). Economic Survey 2009-10; 2010-11

[3] Ministry of Health & Family Welfare (2008). National Family Health Survey 3, Karnataka 2005-06

10.2. Impact of climate change on health

Climate change presents risks for human health. Projected increases in temperature may increase the frequency of heat waves and thermal stress leading to heat cramps, dehydration, influenza, cardio-vascular and respiratory diseases.

Flood or drought by contrast would affect the primary sector and reduce crop productivity. This in turn could reduce food availability resulting in malnutrition or inadequate nutrition as well as nutrition related diseases. While on one hand, malnutrition would reduce resistance to infections by weakening hosts' immune response, infectious diseases decrease the nutrient absorption capacity resulting in nutrition deficits. Several studies have established a link between deficiencies in micronutrients (vitamin A, zinc, iron etc.) and significant incidents of malaria morbidity and mortality. Heavy rain as projected in certain areas would adversely affect cash crop production such as coffee and tea, causing soil erosion and increasingly limit employment in the sector with negative implications on livelihoods.[1] Floods could directly contaminate drinking water and cause outbursts of water borne diseases such as diarrhoea.

Warming trends will favour the spread of vector borne diseases (malaria, kala azar, dengue) into new areas by shortening the development duration of vectors (mainly mosquitoes). Bhattacharya *et al* (2006)[2] pointed out that the malaria transmission window with respect to temperature lies between 15°C and 40°C while the period for completing a life cycle varies with the prevalence of a particular temperature range of and humidity. Martens *et al* (1995) found that with a rise in temperatures the rate of blood meal digestion in mosquitoes increases. This in turn accelerates the ovarian development and reduces the duration of the gonotrophic cycle, leading to higher frequency of feeding on hosts and consequent enhanced probability of transmission.[3] For Karnataka though the transmission window for malaria is already 10-12 months in a year and a further increase is impossible (refer Figure 43).

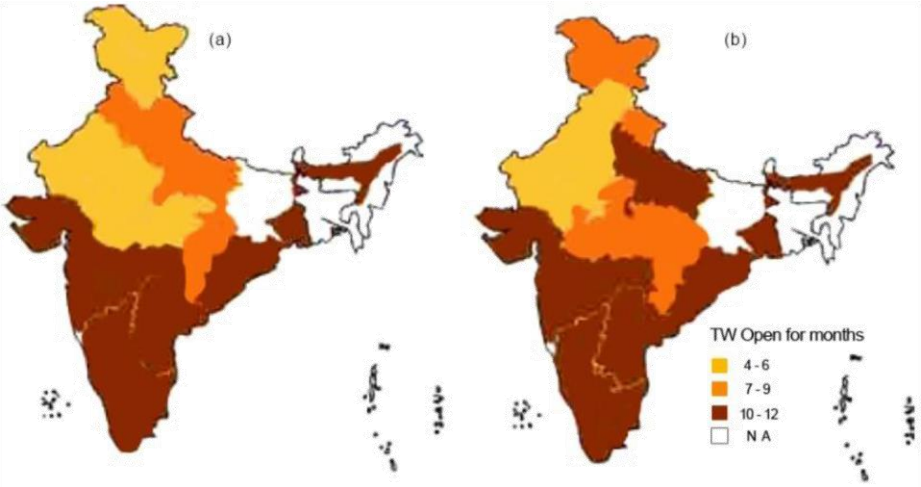

Figure 43: Malaria transmission window (a) Base year 2000 (b) Projection under climate change scenario in the 2050s[4]

[1] MoEF and INCCA (2010). Climate Change and India: A 4x4 Assessment

[2] Bhattacharya, S. et al (2006). Climate change and malaria in India, Current Science

[3] Martens W.J.M., Jetten T.H. et al (1995). Climate change and vector-borne diseases: A global modeling perspective, Global Environmental Change

[4] MoEF and INCCA (2010). Climate Change and India: A 4x4 Assessment

Table 61: Health vulnerabilities vis-à-vis climate change[1]

Health concern	Vulnerability due to climate change
Temperature related morbidity	▪ Heat and cold related illnesses ▪ Cardio-vascular illnesses
Vector borne diseases	▪ Changed pattern of diseases ▪ Malaria, filaria, kala azar, Japanese encephalitis, and dengue caused by bacteria, viruses and other pathogens carried by mosquitoes, ticks, and other vectors
Health effects of extreme weather	▪ Diarrhoea, cholera and poisoning caused by biological and chemical contaminants in the water (even today about 70% of the epidemic emergencies in India are water-borne). ▪ Damaged public health infrastructure due to cyclones/floods ▪ Injuries and illnesses ▪ Social and mental health stress due to disasters and displacement
Health effects due to insecurity in food production	▪ Malnutrition and hunger, especially in children

10.3. Actions, policies and institutional preparedness

10.3.1. Preparedness and facilities

IPCC (2007) anticipates that climate change will increase both vulnerabilities and risks for human health. Discussions with the Department of Health and Family Welfare suggest that no long-term strategy has been prepared yet in this respect. Programmes implemented by the department are focusing on existing priorities.[2]

Karnataka's institutional network provides health services in urban and rural areas through 19 district hospitals, 10 other hospitals, 29 autonomous and teaching hospitals, 325 Community Health Centres, 2,193 Primary Health Centres and 8,143 sub centres.[3] A total of 974 PHCs in Gulbarga, Bidar, Raichur, Koppal, Bijapur and Bagalkot have been upgraded to provide around the clock access to essential obstetric care and newborn care.

10.3.2. National Vector-Borne Disease Control programme

National Vector-Borne Disease Control Programme (NVBDCP) is the umbrella programme initiated by Government of India for vector borne diseases (VBDs) such as malaria, dengue and chikungunya. Specific programmes and guidelines have been established for different diseases, detailing prevention, detection and case management.[4]

10.3.3. Karnataka Health System Development & Reform Project

Karnataka Health System Development & Reform Project was launched in 2007 with support from World Bank at a budget of INR 898 crore. The project aims to increase utilization of curative and preventive diseases and enhance public health services, particu-

[1] MoEF (2004). India's National Communication (NATCOM) to UNFCCC

[2] Department of Health and Family Welfare (2011). Consultation held on March 10, 2011

[3] Department of Planning, Programme Monitoring and Statistics (2011). Economic Survey 2010-11

[4] Ministry of Health & Family Welfare. National Vector-Borne Disease Control Programme; www.nvbdcp.gov.in accessed February 22, 2012

larly in backward areas and among vulnerable groups to accelerate the achievement of health related Millennium Development Goals (MDGs).[1]

10.3.4. National Rural Health Mission

The National Rural Health Mission (NRHM) is implemented since 205. It aims at providing accessible, affordable, acceptable and accountable health care through a functional public health system. The main objectives are:[2]

- At least 50% reduction in infant mortality rate and maternal mortality ratio in seven years;
- Enable universal access to public health services for women's health, child health, water, hygiene, sanitation and nutrition;
- Prevention and control of communicable and non-communicable diseases, including locally endemic diseases;
- Access to integrated comprehensive primary healthcare;
- Ensuring stabilisation of the population as well as gender and demographic balance;
- Increasing community ownership by vesting responsibility;
- Appointment of Accredited Social Health Activists (ASHA) to facilitate access to health services.

Since its inception, the state has also constituted a State Health Mission for policy and institutional reforms to enable an effective implementation in Karnataka, state level planning and monitoring. To ensure programme implementation, also District Health and Family Welfare Societies have been formed in all districts.

10.3.5. Thayi Bhagya

The 'Thayi Bhagya' scheme envisages a basket of interventions funded by Government of India under the National Rural Health Mission (NRHM) and Government of Karnataka. The interventions include:[3]

- Janani Suraksha Yojana (Safe delivery): Reduction in maternal mortality and infant mortality rate, increasing institutional deliveries among families below the poverty line (BPL) and those belonging to Scheduled Casts/Scheduled Tribes (SC/ST). This scheme ensures maternity services (three antenatal check-ups), referral transport, and cash assistance;
- Prasuthi Ariake Yojana: Provides financial support for nutritious diet and incentives to seek antenatal check-ups. The scheme was introduced initially in 7 districts and has been expanded to all districts;
- Aarogya Kavaacha: An ambulance service for emergency cases such as delivery, accident etc. free of cost within 30 minutes (commenced in 2009-10);
- Arogya Sanjeevini: Provides free health facilities to SC/ST families living below the poverty line (BPL), (commenced in 2009-10).

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[1] Department of Health & Family Welfare. Karnataka Health System Development & Reform Project; http://stg2.kar.nic.in/healthnew/KSHRDP/PrOD.aspx accessed February 22, 2012

[2] Ministry of Health & Family Welfare. http://mohfw.nic.in/NRHM.htm accessed February 22, 2012

[3] Department of Planning, Programme Monitoring and Statistics (2010, 2011). Economic Survey 2009-10; 2010-11

10.3.6. Safe drinking water

The Department for Panchayat Raj and Rural Development constructed rooftop rainwater harvesting structures on around 1,000 sites in four districts over the past 8 years where fluoride and chlorine content rendered drinking water unfit for consumption.[1]

10.4. Missions under the NAPCC

Though NAPCC does not provide a specific mission on health, it anticipates the threat to human health which climate change poses. The NAPCC umbrella document therefore envisages not only the need of enhanced public health care services but also research to assess cases of diseases relating to or triggered by climate change. Identified focus areas include:

- Study on regional patterns of diseases with correlation to climate data;
- Development of a high-resolution health impact model at the state level;
- GIS mapping of access routes to health facilities in areas prone to climatic extremes;
- Prioritisation of areas based on epidemiological data and the extent of vulnerability to climate change;
- Studies on the response of disease vectors to climate change; and
- Enhanced service provision of primary, secondary, and tertiary health care facilities.

Karnataka offers fair health care services to its citizen but in the absence of regional level health impact studies it is difficult for the state to devise strategies to reduce climate change related health risks.

10.5. Selected emerging intervention areas

Data management

- Improve the quality of data, periodicity of collection and the extent of coverage in existing systems of surveillance such as under the Integrated Disease Surveillance Programme, National Surveillance Programme for Communicable Diseases and National Vector Borne Disease Control Programme;
- Maintain a digital health database at fine spatial and temporal scales for both communicable and non-communicable diseases;
- Periodic analysis of data to identify trends, trigger events and regular feedback to state surveillance units;
- Establish specific guidelines for quality control in respect of the data collected and reported. Provide adequate training to health personnel to handle data.

Diagnosis

- Provide adequate training to Auxiliary Nurse Midwifes (ANMs) and other medical personnel responsible for identifying symptoms and reporting cases;
- Up-gradation and strengthening of laboratories for case diagnosis.

Research

- Study the regional pattern of climate-sensitive diseases and disease outbreaks such as malaria, dengue, chikungunya, water borne diseases, heat stress etc. to analyze trends in incidence and prevalence;

[1] Department of Rural Development and Panchayat Raj (2011). Consultation held on March 9, 2011

- Assess regional vulnerability (spatially and temporally) with respect to changes in the climate to identify areas, population groups and diseases that may be impacted more significantly;
- Procure, develop and or customize health impact models to assess potential impacts;
- Identify trigger events (climatic and non-climatic) that influence infection-transmission-spread of climate sensitive diseases;
- Validate predictive modelling results with qualitative and quantitative assessments.

Other areas

- Prioritise water scarce regions to ensure supply of potable drinking water and adequate sanitation facilities in both rural and urban areas as envisaged by the State Water Policy;
- Strengthen the health component of the Karnataka Disaster Management Plan released in 2010 in respect of management of casualties, mental health, environmental health, reproductive health, provision of emergency shelter, sanitation, food and water as well as disease surveillance;
- Promote health insurance, especially for the weaker sections of society;
- Promote health education and awareness with respect to climate risks through schools and community based organisations (CBOs).

11. ACTION PLAN

11.1. Actions already underway[1]

Agriculture and allied sectors

- Provision of crop insurance under the National Agricultural Insurance Scheme and (NAIS) and Weather Based Crop Insurance Scheme (WBCIS);
- *Bhoo Chetana* (Land improvement) programme;
- Promotion of organic farming;
- *Sookshma Neeravari* (Micro irrigation) scheme;
- Implementation of the *Rashtriya Krishi Vikas Yojana* (National Agriculture Development Scheme);
- Implementation of the *Rashtriya Krishi Bima Yojana* (National Agricultural Insurance) programme;
- Implementation of the *Mathsya Mahila Swavalambana Yojane (Financial support for fisherwoman)* scheme;
- Incentives for fish farming, construction of fish markets and *Mathsyashraya* (housing for fisher folk) programme;
- Implementation of the *Suvarna Gramodhya (Village development)* scheme;
- Implementation of the *Suvarna Bhoomi (Land prosperity)* scheme;
- Implementation of the *Shramashakti (Skill development)* scheme for skills improvement of artisans and traditional workers;
- Allocation of a separate agriculture budget of INR 17,000 crore for 2011-12;
- Implementation of the National Horticulture Mission.

Water resources

- Mandatory use of rainwater harvesting in residential and commercial buildings in certain areas;
- Enactment of the Karnataka Groundwater (Regulation and Control of Development and Management) Bill, 2011 for better protection of groundwater resources;
- Watershed development and construction of groundwater recharge structures by several departments;
- Launch of the *Jalasiri (*Water recharge) programme;
- Installation of a permanent water storage scheme of 7.5 million litre ground level reservoir at Ramamurthinagar (foundation completed);
- Mandatory dual piping in new layouts for use of treated water;
- *Bharat Nirman* Policy (Rural India development), a flagship programme under Mahatma Gandhi National Rural Employment Guarantee Act for creation of rural infrastructure to enhance rural water supply in areas affected by water contamination;
- State Water Policy 2002;
- National lake and river conservation;

[1] Unless indicated otherwise, based on consultation with departments of Government of Karnataka between March 7 to 11, 2011, submissions by departments to EMPRI and published advertisements of Government of Karnataka in the Times of India

- Initiation of the construction of a sea wall to prevent salt-water entry into paddy fields. However, poor quality of construction destroys the wall and the problem persists.[1]

Forestry and biodiversity

- Approximately 80,000 ha of plantation by Karnataka Forest Department in 2010-11
- Development of carbon sinks and potential;
- Protection of forests, enhancement of resources productivity and growing of medicinal plan;
- Establishment of the Western Ghats Task Force.

Energy

- Mandatory use of solar water heaters, CFLs, ISI marked motor pump sets and integration of energy efficiency and renewable energy in new buildings;
- Incentivisation of installation of solar water heater by BESCOM through tariff discounts;
- Tariffs for power purchase from renewable energy sources;
- Decision of creating a Green Energy Fund (Akshaya Shakti Nidhi) to generate financial resources within the state to implement its policy;
- *Belaku* (Light) scheme to replace up to four incandescent bulbs with CFLs at a subsidised rates per household;
- Decision to introduce a Green Energy Cess of INR 0.05 per kWh on commercial and industrial consumers to generate about INR 55 crore annually through the Karnataka Renewable Energy Policy 2009-14;
- Decision to reserve 10 % of land in SEZ's for development of renewable energy;
- Solar Karnataka Programme for 25,000 solar rooftops of 5 to 10 kW with net metering;
- *Nirantara Jyothi Scheme* providing 24 hours of quality power supply to rural households and fixed hours of supply to irrigation pump sets in 126 taluks in two phases with a total of INR 2,213 crore;[2]
- Establishment of Karnataka State Bio-fuel Development Board (KSBDA) for bio-fuel energy development;
- Inauguration of three grid-connected photovoltaic power plants with a combined capacity;
- Work on the Dhabol-Bangalore CNG pipeline is in progress and joint venture agreement signed to pursue natural gas deployment in Karnataka.

Urbanisation

- Development of lung spaces;
- Waste management across urban local bodies;
- Planning of dedicated cycle lanes and traffic-free pedestrian-only zones in Bangalore;
- Promotion of replacement of 2-stroke auto rickshaws with a 4-stroke ones;

[1] Department of Forest, Ecology & Environment (2004). State of Environment Report Karnataka 2003

[2] Department of Energy (2012). Comments on "Draft State of Environment Report Karnataka 2010"; UO note dated January 6, 2012

- Establishment of decentralised wastewater treatments systems (DEWATS);
- Commissioning of solar streetlights in Bangalore;
- Implementation of the *Rajiv Awas Yojana* (Housing scheme) and establishment of 1,300 permanent houses for slum dwellers;
- Development of traffic and transit management centre at Yeshwanthpur;
- Proposal of high speed rail connecting Bangalore International Airport;
- Formation of a 'green police' guarding prominent tourist locations.

Health

- Systematic enforcement of proper disposal of bio-medical waste;
- Rooftop rainwater harvesting structures providing drinking water for areas contaminated with chlorine and fluorine;
- Implementation of the National Vector-Borne Disease Control Programme (NVBDCP);
- Implementation of the Karnataka Health System Development & Reform Project;
- Implementation of *the Janani Suraksha Yojana* (Maternal care scheme) and *Prasuthi Ariake Yojana* (Pregnant woman care) schemes under the umbrella of the *Thayi Bhagya* (Maternal health care) programme;
- Free emergency care services to the rural people under the *Arogya Kavacha* (Health care) scheme;
- Free heart surgery for 2,000 very poor patients under the *Hrudaya Sanjeevini* (Heart care) scheme so far. Another INR 5 crore have been allotted in 2011-12;
- Improving access of quality medical care for treatment for serious illnesses for below poverty-line (BPL) citizens under the *Vajpayee Arogya Shree* (Health care scheme named after Mr. Vajpayee) scheme.

Other interventions

- Release of Karnataka's first Disaster Management Plan in 2010;
- Monitoring of natural disasters through the Karnataka State Natural Disaster Monitoring Centre (KSNDMC);
- Enhancement of whether monitoring through expansion of capabilities of Karnataka State Natural Disaster Monitoring Centre (KSNDMC).

11.2. Actions required

Legend: ■ Priority action and entry point (refer section 11.3)

Challenges to be met	Action: **Implementation**	Action: **Data management**	Action: **R&D**	Action: **Policy intervention**
1a. Agriculture				
1. Agriculture consumes a significant portion of energy, causing a roughly proportionate emission of GHGs emissions from energy alone.	1. Ensure voltage stability as prerequisite for enhancing energy efficiency of pumps and other machinery, possibly in conjunction with the Nirantara Jyothi Scheme. 2. Preparation of irrigation charts to enhance irrigation efficiency and reduce power consumption. 3. Promotion of renewable energy in farms, especially biogas, which reduces methane emissions and solar photovoltaic for IP sets.	1. Data on the seasonal peak power consumption pattern. 2. Data on the number of Power consuming machineries at farms.	1. Identifying intervention areas for improving energy efficiency at farm levels, especially in view of irrigation charts and the need to aid stabilising voltage through demand side management, possibly in conjunction with the Nirantara Jyothi Scheme. 2. Cost benefits analysis in order to assess the extra financial burden to the government.	■ Re-structuring the power tariffs in the agricultural sector to disincentivise avoidable electricity consumption. The same volume of subsidies may be shifted to things such as investment in more efficient plant and machinery (refer to section "Energy" in this matrix, point 2 and action 1). 2. Incentives and subsidies for promotion of renewable energy at farm level.
2. Subsidies supporting farming lack mechanisms for shifting cropping patterns in line with projected climatic shifts across agro-climatic zones.		1. Preparation of an inventory of cropping patterns and changes in the same with respect to agro-climatic zones of the state.	1. Studies on adaptation and mitigation measures in agriculture sector of the state.	■ Establishment of a state level policy body to develop suitable mechanisms for encouraging cropping shifts through re-distribution of existing subsidies (refer to action 2). 2. Re-assess the state agriculture policy and provision for subsidies and incentives to grow climate hardy crops.

Legend: ■ Priority action and entry point (refer section 11.3)

Challenges to be met	Action: **Implementation**	Action: **Data management**	Action: **R&D**	Action: **Policy intervention**
3. The current level of knowledge on the spatial dimension, time scale and magnitude of climatic changes is too limited to make predictions for cropping pattern with the necessary certainty.	1. Web based services to provide all weather related information through a single window, preferable trough Karnataka State Natural Disaster Monitoring Centre.		1. Research studies on the regional level prediction on the likely impact of climate change on cropping pattern. 2. Development of weather derivative models.	1. Re-evaluating all agriculture related policies and programmes in order to integrate climate change issues.
4. Widespread absence of scientific dry-land farming practices.	■ Creation of model farms and villages, establishment of fodder banks under use of instruments provided by National Mission on Sustainable Agriculture (refer to action 3).		1. Developing suitable drought and pest resistant crop varieties under use of instruments provided by National Mission on Sustainable Agriculture.	
5. Significant untapped minimisation potential in the application of synthetic agrochemicals (pesticides, fertilizers).	1. Promotion of Integrated Pest Management (IPM) and Integrated Nutrient Management (INM) to reduce chemical consumption. 2. Government of Karnataka is already promoting organic farming (Bhoo Chetana), IPM and INM through specific schemes. The coverage of these needs to be extended.	1. Block wise data on the agro-chemical usage at farm level. 2. Pest and disease surveillance.	1. Research on the nutrient requirement of soils, agro-climatic zones wise. 2. Research on the spread of pests and climate change linkages. 3. Soil resource mapping using GIS and remote sensing.	1. Provision for incentives/subsidies on the organic farming, integrated pest management (IPM) and integrated nutrient management (INM).

Legend: ■ Priority action and entry point (refer section 11.3)

Challenges to be met	Action: **Implementation**	Action: **Data management**	Action: **R&D**	Action: **Policy intervention**
6. Significant untapped potential for enhancing irrigation efficiency especially in northern Karnataka. The expansion of micro irrigation is also hampered by security concerns of theft of distribution pipes.	1. Promote pressurised micro irrigation techniques at larger scales. 2. Create awareness through the demonstration of efficient irrigation technologies.	1. Identify available land for possible micro irrigation practices district wise.		■ Eradication of the market for stolen pipes through redistribution of existing subsidies on micro irrigation so as to bring farmer's net cost of distribution pipes below the black market prices (refer to action 4).
7. Agro-biodiversity is jeopardised. Indigenous resilient varieties of crops like maize, rice, sorghum require interventions to safeguard their preservation.	■ Preservation of indigenous varieties of crops through creation of a market for such products. The network of state agencies including HOPCOMS could help market these as specialities for a higher price (refer to action 5).	1. Preparation of a comprehensive inventory of agro-biodiversity of the state in regular intervals. For this the ongoing preparation of People's Biodiversity Registers is establishing a solid fundament.		1. Creation of a policy framework to create viable markets for indigenous species. 2. Development of agro-biodiversity parks.
8. Livelihoods of farmers who are already vulnerable may be exposed further.	1. Crop insurance schemes, particularly Weather Based Crop Insurance needs to be expanded through adequate packaging to cover a greater share of farmers.		1. Research on specific livelihood risks and possible solutions considering the local contexts.	

Legend: ■ Priority action and entry point (refer section 11.3)

Challenges to be met	Action: **Implementation**	Action: **Data management**	Action: **R&D**	Action: **Policy intervention**
1b. Horticulture				
9. Significant unutilised portions of degraded land/arid land are unsuitable for agriculture but suitable for horticulture, especially in northern Karnataka.	1. Promotion of development of pastureland. 2. Promotion of drought resilient trees for arid areas. 3. Create awareness through massive tree plantation campaigns in arid/semi arid regions.	1. Comprehensive block-wise data on the type, area and problems of degraded lands.	1. Research focusing on the local solution to reclaim degraded lands. 2. Development of drought and pest resistant crop varieties. 3. Research into highly productive crop varieties.	
10. Necessary food processing facilities and marketing mechanisms supporting horticultural produce from degraded/arid lands do not exist at required scale.	1. Development of larger scale food processing parks.			
11. Horticultural biodiversity is jeopardised. Indigenous resilient varieties such as mango and jackfruit require interventions to safeguard their preservation.	■ Preservation of indigenous varieties of crops through creation of a market for such products. The network of state agencies including HOPCOMS could help market these as specialities for a higher price (refer to action 6).	1. Preparation of comprehensive inventory of agro-climatic zones based agro-biodiversity in regular intervals. For this the ongoing preparation of People's Biodiversity Registers is establishing a solid fundament.		1. Creation of a policy framework to create viable markets for indigenous species.

Legend: ■ Priority action and entry point (refer section 11.3)

Challenges to be met	Action: **Implementation**	Action: **Data management**	Action: **R&D**	Action: **Policy intervention**
1c. Animal Husbandry				
12. Reducing GHGs emissions from ruminants is unfeasible at scale unless livestock holdings are discouraged. The resulting destabilisation of livelihoods would be greatly undesirable.	1. Promotion of renewable energy at farm level, especially biogas, which also reduces methane emissions (refer to section "Agriculture" in this matrix, point 3).		1. Research on improving cattle productivity in order to reduce GHG emissions by reducing the necessity to maintain the current large cattle population.	
13. Lack of mechanisms, initiative and incentives for systematically enhancing livestock resistance to vector borne diseases and increasing heat/cold stresses as may be expected from changes in the climate.	1. Systematic vaccination of livestock at larger scale.	1. Prepare district a wise inventory of livestock mortality and morbidity and attributed causes.	1. Studies on animal health and the climate change link. 2. Develop nutritional strategies to improve coping with heat and water stress. 3. Studies on the spread of pests vis-à-vis climate trends and projections.	■ Government of India to conceptualise and formulate a livestock insurance policy with premiums taking into account vaccination records and suitability of a breed for a given region price (refer to action 7).
14. Lack of mechanisms, initiative and incentives for preserving indigenous climate tolerant breeds of cattle (amrithmahal, hallikar, khillar) and buffalo (pandharpuri, surthi).	■ Indigenous breeds are being developed through selective breeding in livestock farms located in Tumkur, Chickmagalur and Haveri. This needs to be extended (refer to action 8). 2. Improve coordination between Departments of Animal Husbandry & Veterinary Services, veterinary institutes and farmers.	1. Maintaining data on the number of indigenous breeds and trends observed.	1. Improve the knowledge on coping abilities (resilience) of indigenous breeds to climate stresses on a comparative basis.	

Legend: ■ Priority action and entry point (refer section 11.3)

Challenges to be met	Action: **Implementation**	Action: **Data management**	Action: **R&D**	Action: **Policy intervention**
2. Water resources				
1. Over-extraction of groundwater resources, especially in 35 over-exploited and 3 critical taluks.	■ Enforcement of regulation measures in place under the newly enacted Groundwater Act (refer to action 9). 2. Groundwater monitoring for quality and quantity at block level. 3. Expand the promotion of groundwater recharges beyond present levels.	1. Prepare and update an inventory of sectoral use of groundwater.	1. Groundwater resource mapping using GIS tools. 2. Spatial and temporal assessment of micro-watershed based water availability using models such as the Soil and Water Assessment Tool (SWAT). 3. GIS-based study of geo-hydrology.	■ Establishment of a state level policy body to review the possibility of prohibiting the use of groundwater for non-drinking and non-emergency uses. Should in conclusion groundwater use be approved for agricultural uses than a water price should be introduced as incentive for water saving (refer to action 10).
2. The vast potential for collection of rainwater for productive use, groundwater recharge and temporary storage in water bodies in order to reduce the irrigation dependency on groundwater (at present it is 45%) remains to be utilised.	1. Extend the BWSSB rule on rainwater harvesting to other urban local bodies. 2. Promote multiple use water services in drought/flood prone areas. 3. Demonstrate best practices at pilot scale.		1. Prediction of actual water availability and trends in the state using high resolution climates impacts studies at block level.	■ Introduction of a groundwater cess from which a groundwater fund would be created. The groundwater fund would finance groundwater recharge schemes proposed by private and public project proponents (refer to action 11). ■ Devise an incentive in form of a capital investment subsidy for rainwater harvesting structures (also refer to section "Urbanisation" in this matrix, point 3 and action 12).

Legend: ■ Priority action and entry point (refer section 11.3)

Challenges to be met	Action: **Implementation**	Action: **Data management**	Action: **R&D**	Action: **Policy intervention**
3. Urban water supply is dramatically inefficient (48% UFW in Bangalore). The quantity grows in actuals with the increasing supply. This jeopardises water security and increases the dependence on groundwater.	*Actions for addressing this issue may be defined in forthcoming editions of the Karnataka SAPCC.*			
4. Reuse of treated water in industries and urban local bodies (ULBs) has been unable to make significant in roads.	■ Integrated water resources management to commence in public buildings to set examples and inspire confidence (refer to action 13). 2. Create awareness in order to enhance social acceptability of treated water.		1. Conduct socio-economic studies to understand the social acceptability of treated water. 2. Assess the potential volume of treated water that can be reused and application areas.	1. Formulation of a state Water Reuse Policy to make further dual piping in new layouts and preferential usage of treated water for watering parks in existing layouts.
5. Low priced irrigation water is a substantial impediment for investment in water infrastructure and sustainable resource utilisation and management.				■ Water Resources Department to lead a cost benefits analysis in order to assess the financial burden of irrigation water and to formulate a pricing policy rationalising irrigation in view of long-term sustainability and the need for adequate finance (refer to action 14).

Legend: ■ Priority action and entry point (refer section 11.3)

Challenges to be met	Action: **Implementation**	Action: **Data management**	Action: **R&D**	Action: **Policy intervention**
6. A minimum flow of rivers in the dry season is not being maintained, leading to excessive concentrations of pollutants.			1. Estimate a safe minimum water flow for maintenance of ecosystems.	
3. Forestry, biodiversity and wildlife				
1. Long-term carbon capture strategies would require a currently not envisaged return to timber as building material from mature and sustainably managed forests and plantations.	1. Raising of forest plantations in non-forest land unfit for agriculture. 2. Raising of farm forestry plantations by encouraging farmers.	1. Monitoring of carbon stocks through collaboration of Karnataka Forest Department with Indian Institute of Science (IISc) and other universities.	1. Devise strategies to identify market-linked opportunities for development of robust carbon sinks as well as increasing income for local communities.	1. Develop a sustainable timber harvest plan along with reforestation schemes and revenue plantations. 2. Develop a policy to protect existing forest stocks as carbon sinks through stronger conservation and community participation.
2. Biodiversity hotspots such as the Western Ghats are insufficiently protected.	1. Rigid protection from biotic and abiotic interferences.	1. Comprehensive documentation of the status of flora and fauna. 2. Monitoring and documentation of biotic a abiotic interferences.	■ Estimate the carrying capacity of the Western Ghats for settlements, agriculture, roads and mines (refer to action 15). 2. Establish monitoring mechanisms for biodiversity including the wildlife population to detect changes and needs for responses early.	

Legend: ■ Priority action and entry point (refer section 11.3)

Challenges to be met	Action: **Implementation**	Action: **Data management**	Action: **R&D**	Action: **Policy intervention**
3. Forest degradation due to unplanned extraction of firewood, fodder, NTFP, green manure etc.	1. Undertake reforestation/ afforestation in degraded areas. 2. Rigid protection of forest through strengthening personnel and infrastructure.	1. Systematic recording of unplanned extraction of fuel wood, fodder, non-timber forest products (NTFP), green manure etc.		1. Enhance the capacity of communities to manage and store firewood and fodder under ambient conditions. Provide institutional credit and create alternative market-based market options. 2. Devise schemes for providing alternative sources of energy for forest fringe households to prevent firewood collections in forests.
4. Invasion of alien species (*Tilapia* sp, *Eupatorium* sp etc.).	1. Implement education/outreach activities that are targeted to ensure public support for rapid response measures. 2. Establish a coordinated public monitoring network to detect and report invasive alien species.	1. Develop and maintain a database containing information on the control and management of invasive alien species that is easily accessible to public.	■ Scientific research on eradication, containment and control methods and technologies for priority invasive alien species (refer to action 16).	1. A surveillance policy covering inspection and interception is essential to verify authorized introductions, detect illegal introductions, and detect unintentional introductions through key commodities, pathways, and vectors, as is the capacity to implement the strategy.
5. Encroachment of forests by human settlements, agriculture, coffee plantations and mines.	■ Remove encroachments within a timeframe of 5 years (refer to action 17).	A database to be established and maintained tracking encroachments, evictions and reforestation measures.		

Legend: ■ Priority action and entry point (refer section 11.3)

Challenges to be met	Action: **Implementation**	Action: **Data management**	Action: **R&D**	Action: **Policy intervention**
6. Vast tracts of forest fall victim to forest fires every year. Both fire prevention and emergency response appear inadequate to tackle the challenge.	1. Incentive-based community participation in fire prevention. 2. A strategy for fire forecasting, prevention and fighting to be implemented.		1. Research on adopting modern technology to locate and forecast fires. Fire risk zones prioritisation and monitoring based on satellite imageries.	
7. Gradual loss of green cover in urban areas.	1. Implement an urban biodiversity education programme for schools and the public at large.	1. Biodiversity inventories of specific areas within cities should be documented.		1. Urban forestry plan should be developed along with city master plans with the additional objective of strengthening emotional bonds between trees and citizens.
4. Coastal Zone Management				
1. Coastal pollution due to industries, aquaculture, port activities and sand mining has the potential to upset the fragile coastal ecological balance.	■ Promoting of treatment plants at point source and CETPs for clusters of small industries (refer to action 18). 2. Strengthen the implementation arrangement for the Coastal Regulation Zone. 2. Strict follow-up on environmental impact assessments. 3. Promoting and restoring mangrove/ wetlands vegetation along the coastal belt.	1. Data on type and amount of hazardous chemicals released by sector. 2. Data on area under mangrove ecosystem and temporal change in the same.	1. Research on the implementation of advance treatment technology to reduce pollutants entering the sea. 2. Conduct research into the scope, options and viability for turning conventional into organic aquaculture.	

Legend: ■ Priority action and entry point (refer section 11.3)

Challenges to be met	Action: **Implementation**	Action: **Data management**	Action: **R&D**	Action: **Policy intervention**
2. In portions of the coastline the scale of marine fishing is ecologically unsustainable, leading to substantial seasonal fish population decimations. Dependent communities have in a number of cases moved on to shell collection and sand mining for the sake of livelihood while labour cost along the coast is high.			1. Conducting a socio-economic impact study due to change in ecological conditions and impact on livelihood.	1. Re-assessing the state fishery policy and provision for subsidies and incentives to sustainable fishing. 2. Forming of a committee to develop an action plan for sustainable fishing in coastal districts. 3. Formulate policies to provide alternative livelihood options especially during the fish breeding seasons by utilising synergies with funding under NREGA.
3. Very limited research publications are available that investigate the link between climate change and behavioural responses of fish and other marine biodiversity.		1. Development of a marine resources information system. 3.Promoting web based services to provide information on coastal climate and resources.	1. Research on regional level predictions of likely impact of climate change on coastal fisheries and ecosystems. 2. Review of options for establishment of a network for collection of additional data: Hydro-meteorological and hydrological data from the coastal region, coastal and estuarine water, salinity and tidal water levels and the changing discharges in both directions in estuarine areas.	

Legend: ■ Priority action and entry point (refer section 11.3)

Challenges to be met	Action: **Implementation**	Action: **Data management**	Action: **R&D**	Action: **Policy intervention**
4. No systematic mapping of Karnataka's 320 km coastline has been undertaken to project the possible impact of the anticipated sea level rise and determine protection measures and timeframes.		1. Reassessment and mapping of coastal resources. Concerned departments and research institutes to store and publish data related to sea level, sea erosion, flood, river flow and change in biodiversity etc. 2. Establishment of a sea level monitoring station under the aegis of the National Institute of Oceanography. 3. Establishment/ strengthening of a groundwater monitoring network with observation wells, sanctuary wells for coastal aquifers.	1. Research on flood forecasting, downscaled climate change projections with improved grid resolution. 2. Research on impact of sea level rise on groundwater salinity including hydrochemical and solute transport modelling. 3. Research into marine biogeochemistry and influence on GHG sources and sinks. 4. Establishment of an inventory of wetlands, mapping of vegetation cover, silting, encroachment, conservation of mangrove areas conservation, afforestation, hydrological and hydro-meteorological data, salinity, well observation, sea level rise, sediment transport in the river etc. 5. Mapping of encroachments, change of land use, infrastructure development, pollution, growth of invasive species and over-fishing.	

Legend: ■ Priority action and entry point (refer section 11.3)

Challenges to be met	Action: **Implementation**	Action: **Data management**	Action: **R&D**	Action: **Policy intervention**
5. Bengere, a coastal settlement near Mangalore locked between the sea and river, is completely unprotected. A natural disaster such as a tsunami or typhoon could wipe out its population.	*Actions for addressing this issue may be defined in forthcoming editions of the Karnataka SAPCC.*			
6. The mangrove ecosystem and coral reefs are insufficiently protected.	1. Expand existing mangrove cover across the coast.		1. Establish a mangrove study centre, which will take up research on mangroves and associated biodiversity vis-à-vis climate change. 2. Monitor the relationship between changes in mangrove species under changing climate patterns.	■ Formulate an action plan for replanting of mangrove in lands where they have disappeared. To be taken up in conjunction with protection of mangroves, patches of biodiversity rich habitats in the coastal, riverine and deltaic belt (refer action 19)
5. Energy				
1. The power deficit is likely to remain unaddressed in the short and mid term, leading to load shedding and a continuation of large investments into secondary energy infrastructure such DG sets and UPSs which increase the burden on the environment through air pollution, noise levels and disposal of lead acid batteries.	1. Electricity demand for the next 15 years should be forecasted along with anticipated supply from state owned plants, the contribution from central schemes and private producers to determine the scale of the required capacity. The emphasis on gas based power generation should be retained to the extend gas supply permits.	1. Aggregate data on load shedding and to develop a procedure to allocate it judiciously across the sectoral customers to reduce dependence on secondary sources.		

Legend: ■ Priority action and entry point (refer section 11.3)

Challenges to be met	Action: **Implementation**	Action: **Data management**	Action: **R&D**	Action: **Policy intervention**
	2. In the meantime, load shedding to follow a structured plan notified 1 week in advance for all categories, but keeping especially industries' need to predict in mind.			
2. Free electricity to farmers is a substantial impediment for garnering the investment necessary to addressing the demand-supply gap and for improving voltage stability necessary for many energy efficient applications.				Constitution of a committee to review the options for disincentivising energy consumption by farmers by shifting existing subsidies, for instance to capital goods (refer to section "Agriculture" in this matrix, point 1)
3. High transmission and distribution losses of currently 22%.	1. Reduce T&D losses through improvement of sub stations, modernised automation and instrumentation. 2. Minimise the theft of electricity.	1. Computation of T&D losses by Aggregate Technical & Commercial (AT&C) losses to capture the difference between billing and collection of power under the Restructured Accelerated Power Development and Reform Programme (R-APDRP).		1. Establish a policy for improving metering efficiency, proper energy accounting and auditing and improved billing and collection efficiency.

Legend: ■ Priority action and entry point (refer section 11.3)

Challenges to be met	Action: **Implementation**	Action: **Data management**	Action: **R&D**	Action: **Policy intervention**
4. Energy efficiency failed to make substantial inroads. Energy audit still has low visibility, the necessary professional capacities remain to be created at scale, the Energy Conservation Building Code (ECBC) is yet to be notified at state level, the concept of Green Rating for Integrated Habitat Assessment (GRIHA) is also not in force as it is a part of ECBC. Altogether, the Market Transformation for Energy Efficiency (MTEE) under the NAPCC are not on the horizon in Karnataka yet.	■ Stabilise the grid supply voltage in a systematic and time bound manner so that appliances achieve their design efficiently and lifetime. This requires scheduled load planning/shedding until the demand-supply gap is closed (refer to action 20). ■ KREDL to strategise covering all establishments with a connected load of 500 kVA and above with energy audit in a time bound manner with priority on industries. This may entail capacity building on part of KREDL (refer to action 21). 3. Perform, Achieve and Trade (PAT) mechanism to mandate specific energy consumption targets for large industries and trade of savings beyond the target	1. Collection of data for trend analysis in electricity demand before/after incorporation of energy efficient measures.	1. Conduct market surveys to evaluate the penetration potential of energy efficient appliances in the domestic sector. 2. Carry out studies to assess the scope of energy saving at farm level through voltage stabilisation and more efficient appliances (electric motors, agricultural pump sets etc.), possibly in conjunction with the Nirantara Jyothi Scheme. 3. Assess the impact of the *Belaku* scheme in terms of power savings, CFL lifetime and consumer confidence over a period of at least 2 years.	■ The Energy Conservation Building Code (ECBC) to be notified at state level within 2011 (refer to action 22). ■ KREDL to develop strategies for Market Transformation for Energy Efficiency (MTEE) under the National Mission for Enhanced Energy Efficiency (refer to action 23). 3. Devise strategies and polices for demand side management (DSM) interventions beyond the *Belaku* scheme.

Legend: ■ Priority action and entry point (refer section 11.3)

Challenges to be met	Action: **Implementation**	Action: **Data management**	Action: **R&D**	Action: **Policy intervention**
5. The estimated potential of renewables has till date been harnessed to 11.5%. Large-scale pilots projects are not on the horizon yet, apart from KPCL's demonstration plants of 3-5 MW capacity.	■ Rapid scaling up of activities to implement the Renewable Energy Policy through time-bound targets wherever instruments of the National Mission for Solar Energy provide for the requisite resources (refer to action 24). 2. Promote renewable energy at decentralised level. 3. Proactive implementation of the special incentive package policy to promote photovoltaics manufacturing plants. 4. Capacity building on use of solar and biomass energy for domestic purposes at decentralised level and successful demonstration of these technologies.	1. Tracking the success rate and performance of implementation of renewable energy projects.	1. Research interventions to tap biogenic gas generated from methanogenic organisms in marshes, bogs, landfills and shallow sediments.	■ Review the barriers that have resulted into Karnataka losing its leading role in wind energy and the slow pace of expanding solar energy power generation and determination of instruments through which renewable deployment can be progressively accelerated with specific attention to private sector investments, PPP and time-bound targets (refer to action 25). 2. Promote the utilisation of Renewable Energy Certificates (REC) to enabling market mechanisms. 3. Review gaps in the present financing of renewables and identify means for infusion of capital.
6. Except from traditional firewood use, the use of bio-fuels failed to make substantial inroads at scale.	1. Foster the wider implementation of decentralised biomass gasification at underserved and unserved Gram Panchayats as demonstrated by BERI.		■ R&D to focus on piloting viable options for subsequent larger-scale deployment of bio-fuels as substitutes for fossil fuel for diesel and petrol engines (vehicles and DG sets); (refer to action 26).	1. Subject to successful piloting (refer to adjacent cell) the Karnataka Bio-fuel Policy should be amended to include quantified targets and specific incentives for realising them.

Legend: ■ Priority action and entry point (refer section 11.3)

Challenges to be met	Action: **Implementation**	Action: **Data management**	Action: **R&D**	Action: **Policy intervention**
7. The use of improved cooking stoves (*chulas*) is too limited for its potential of reducing wood consumption while reducing indoor air pollution and safeguarding human health, especially of women who spend considerable time indoors.	1. Expansion of deployment of improved *chulas* by leveraging public-private partnership for dissemination.		1. Conduct a larger field survey of indoor air pollution in respect of traditional and improved stoves under real-life conditions across Karnataka and identify reasons impeding further deployment of improved stoves.	■ Action plan for the development and deployment of improved *chulas* to the most vulnerable section of society under the National Biomass Cookstoves Initiatives (NBCI); (refer to action 27).
6. Urbanisation				
1. The magnitude of present migration from rural areas to urban results from inadequacies in health, education, housing and employment in tier 2 and 3 cities.	1. Improve the quality and accessibility of health care, education, housing and employment in tier 2 and 3 cities.			1. Create employment opportunities for the rural populations especially in seasons of non-cultivation by furthering the incentives provided by the Karnataka Industrial Policy, which encourages industries in tier 2 and 3 cities.
2. Strom water drains are unable to deal with water from moderately heavy rainfalls while climate change may lead to greater precipitation in shorter intervals than previously encountered.	1. Encouraging rainwater harvesting in cities similar to BWSSB Rules. 2. Create awareness about rainwater harvesting among citizens through Residents' Welfare Associations (RWAs) with the help of NGOs. 3. Cleaning of existing drainages prior to monsoon.	1. Data on potential for rainwater harvesting and artificial recharge possibility	1. Develop a better rainfall run-off model in the urban context to improve on the empirical system still followed for sizing of storm water drains.	1. Revision of design guidelines for storm water drains to reduce flooding risk from presently 60% to zero.

Legend: ■ Priority action and entry point (refer section 11.3)

Challenges to be met	Action: **Implementation**	Action: **Data management**	Action: **R&D**	Action: **Policy intervention**
	4. Ensure sewage does not enter storm water drains.			
3. Much remains to be done to manage municipal solid waste in line with good practices and legislative requirements.	1. Emphasis on achieving a fair degree of segregation of waste at source so as to maximise reuse and recycling options. 2. Promoting awareness among citizens on the 4 R's in association with Residents' Welfare Associations (RWAs).		■ Assessment of impediments in proper management of municipal waste at the level of urban local bodies (ULBs); (refer to action 28). 2. Using GIS/ remote sensing techniques for tracking disposal of waste. 3. Targeted exploration of new and economically viable recycling options.	1. Providing incentives for organisations and adult rag pickers collecting recyclable waste by considering support prices to stimulate recycling. 2. Devising means of introducing buy-back mechanisms at state level.
4. Large untapped energy potential from solid waste (135 MW) that could be an interim solution until better composting is realised.	1. Provision for collection of wet waste form restaurants and apartments.		1. R&D on techniques and methods to generate energy from waste.	1. Policies incentivising waste co-processing in power plants to address health issues besides energy generation.
5. Considerable inadequacy in sewage collection, treatment and reuse of treated water.	*Actions for addressing this issue may be defined in forthcoming editions of the Karnataka SAPCC.*			
6. Absence of a planning perspective capable of envisaging decades as necessary for rail-bound public transport in cities and public transport in emerging cities.	1. Initiation of long-term planning processes which are followed through to their implementation and logical conclusion.			

Legend: ■ Priority action and entry point (refer section 11.3)

Challenges to be met	Action: **Implementation**	Action: **Data management**	Action: **R&D**	Action: **Policy intervention**
7. Basic needs of the urban poor in respect of water, sanitation, electricity unmet for many.	1. Ensure continuation of the work of Karnataka Slum Development Board in ensuring access to safe water and sanitation in slums.			
8. Difficult to change behavioural patterns result in road humps that increase fuel consumption, air pollution and noise apart from being undesirable for commuters	*Actions for addressing this issue may be defined in forthcoming editions of the Karnataka SAPCC.*			
9. Gradual loss of green cover in urban areas.	1. Encouraging plantation of suitable species. 2. Implementation of the Parks Act.	1. Maintain data on annual tree plantations and removals.		
7. Health				
1. Absence of a health status inventory	1. Enhancing disease monitoring and surveillance, especially in respect of malaria.	1. Maintenance of data related to mortality and morbidity at district/block level.		
2. The relationship between human health and climate change (vector borne disease, heat stress etc.) is not well established in published literature.		1. Development of a database on the cases of vector borne diseases and transmission.	1. Conduct region wise research on diseases related to water availability and quality. 2. Procure, develop and customize high-resolution health impact models in collaboration with national and international agencies to exchange knowledge.	

Legend: ■ Priority action and entry point (refer section 11.3)

Challenges to be met	Action: **Implementation**	Action: **Data management**	Action: **R&D**	Action: **Policy intervention**
			3. Studies on climate change linked parasite activities and impact on human health.	
3. Most vulnerable regions of the state in the context of health remain to be identified.			1. Conduct research on the trend of vector borne diseases and identify vulnerable regions under use of GIS mapping.	
4. Drinking water quality is often compromised.	1. Water utilities need to institutionalise rigorous quality assurance to ensure meeting of drinking water standards at consumer end.			
8. Other intervention areas				
1. The current level of knowledge on the spatial dimension, time scale and magnitude of climatic changes is extremely limited. An accurate and quantitative in-depth understanding of probable climate change impacts emerges as critical need. In its absence the framing of long-term policy and appropriate adaptive measures remains severely impeded.			■ Conduct extensive research on the spatial dimension, time scale and magnitude of climatic changes impacts so as to be able to make more accurate predictions about likely impacts of climate change in Karnataka (refer to action 29).	

Legend: ■ Priority action and entry point (refer section 11.3)

Challenges to be met	Action: **Implementation**	Action: **Data management**	Action: **R&D**	Action: **Policy intervention**
2. There is no mechanism for sharing information on adaptation pilots, practices and experiences made across India. This being a very new field, the absence of systematic communication might lead to a situation where each state reinvents wheels starting from zero while the opportunities to build on each others' experience are foregone.		■ Government of India to lead the systematic documentation and evaluation of adaptation practices in the country. Karnataka should designate a state nodal agency to provide relevant information on behalf of Karnataka and provide experiences made elsewhere (refer to action 30).		
3. This present Action Plan is based on current understanding and published research, the underlying knowledge of which is subject to rapid evolvement. Without a regular review and updation, this Action Plan is bound to loose its relevance within a span of years.			■ Establish a systematic review process for new scientific findings, new modelling results and changes in policy, legislation and incentives, leading to an updation Karnataka State Action Plan on Climate Change every 2 to 5 years (refer to action 31).	

11.3. Priority actions and entry points

11.3.1. Restructuring agricultural power traffis

Sector: Agriculture	*Type:* Policy intervention	*No.:* 1
Issues being addressed:	Agriculture consumes a significant portion of energy, causing a roughly proportionate emission of GHGs emissions. As agriculture sector is one of the major sources of income to large section of Indian population, the power tariff in agriculture sector has been on lower side to support the agricultural activities. This has led to unproductive use of electricity resulting in more demand at incentivise rates. Thus, it is imperative to re-structure the power tariffs in the agricultural sector to disincentivise avoidable electricity consumption. The same volume of subsidies may be shifted to other priority areas such as investment in more efficient plant, machinery, and agri-product distribution systems.	
Implementation arrangement:	▪ Due to subsidised electricity in agriculture sector, the energy sector incurs financial loss shouldered by GoK. However, with the restructured power tariffs, the revenue thus earned could be invested to promote renewable energy at farm levels. ▪ Such restructuring of power tariffs may be initiated with a dialogue between all the relevant stakeholders including big and marginal farmers to identify the challenges and develop a framework with time line. ▪ This may be followed by establishment of a committee with the representation from key implementers and stakeholders to draw up a policy aiming at gradually increasing power tariffs in the agriculture sector and promotion of renewable energy. ▪ The framework may include a full section on development of renewable energy, creating awareness and incentives to promote renewable energy. ▪ The restructured power tariff may be on incremental basis i.e. lesser rate for lesser consumption. This will also attract farmers to consume the electricity only in case of need. ▪ If required, department of agriculture and energy may jointly establish a Knowledge Cell to provide all necessary information (technical and financial) on restructured power tariffs to farmers. ▪ Some of the revenues earned may be diverted to the promotion of crops which require less water and power. ▪ There should also be a mechanism to get the borewells/tubewells registered with water resources department prior to electricity connection for agricultural activities. Help from Water resources department may be sought in this case. This will also help monitoring the operation of tubewells/borewells. ▪ An effective mechanism to monitor the progress on renewable energy development and electricity consumption should be developed.	
Key implementer:	Department of Energy	
Stakeholders:	Department of Agriculture Department of Water Resources Panchayat Raj institutions	

Capacity building needs:	There could be a series of capacity building programmes for 1. State level programmes for district level officers from relevant departments 2. District level programme for farmers and Panachayati raj institutions 3. District level programmes for taluk level officers from relevant departments 4. Additionally, a session on power restructuring may be integrated into all regular training programmes being conducted by relevant departments at various levels.
Timeframe:	Short term (1 – 2 years). The committee can be set up immediately.
Funding:	No significant funding requirement envisaged.

11.3.2. Establishing a State Level Policy body for devising cropping shifts

Sector: Agriculture	*Type:* Policy intervention	*No.:* 2
Issues being addressed:	Subsidies supporting farming lack mechanisms for shifting cropping patterns in line with projected climatic shifts across agro-climatic zones. Shifting cropping patterns may be a potential strategy to adapt to climate change and combat the impacts of same. As temperature and rainfall change with climate change, the agri-climatic features of a particular zone might become favourable for a new crop or may adversely affect the survival of existing crop. Under such scenario, shifting cropping pattern would help in sustaining agricultural activities. Establishment of a state level policy body to develop suitable mechanisms for encouraging cropping shifts through re-distribution of existing subsidies so that climate hardy and resistant crops may be promoted to combat the adverse impacts of climate change.
Implementation arrangement:	Department of Agriculture to establish the state level policy body with the representation from stakeholders. The body would aim to formulate plans to: ▪ Maintainenance and interpretation of historical data on and gradual changes in climate and cropping pattern. This will enhance the understanding on the drivers of change in cropping pattern (environmental, financial or other) and may be used as fundamental principles to formulate policies on change in cropping pattern. ▪ Crop and region wise redistribution ofexisting subsidies to promote cropping patternsin line with climate most suitable for them; ▪ Arrive at consensus among farmer's organizations through awareness creation and building their capacity for changed cropping pattern through workshops, training programmes, field visitsetc; ▪ Pilot scale execution may be demonstrated in different agro climatic zones to assess the feasibility and obstacles. Such pilot scale study would also help in identifying any unforeseen obstacle and find solution. Such field demonstration may be promoted as case study of successful implementation of policy. ▪ Devise an adequate and effective financing mechanism to sustain such shifts for a longer term. ▪ Review such policies periodically in order to assess the international/national advancements in the field of climate change and related predictions/projections. This is required to update and keep improving any mechanisms related to shifting cropping pattern. ▪ Further, Change in cropping patterns should be able to meet the nutrient demands of local communities otherwise any long distance transportation of agri-products to meet local demands may further adversely affect the climate change. ▪ The policy should also give due consideration to the agro-biodiversity of the state, its conservation and propagation.
Key implementer:	Department of Agriculture
Stakeholders:	Agriculture Universities Indian Council of Agriculture Research (ICAR) Department of Water Resources Food Corporation of India (FCI) – Regional

	Farmers' organizations NGOs Regional rural banks Cooperative banks
Capacity building needs:	Enhance farmers' capacities to understand risks of climate change on current crops and advantages on the alternative crops being promoted. Such capacity building programme may be conducted at district level with the sessions on climate change, its impact and need to shift the cropping pattern. The capacity building programme may also include intrastate/interstate field visits to well-equip the farmers on the implementation of shift cropping pattern.
Timeframe:	Mid to long term (2 – 10 years). The policy body should submit a plan within a period of two years
Funding:	INR 65,000 crore of the total of INR 108,000 core under the NAPCC Mission for Sustainable Agriculture are earmarked for technology, products and practices. This includes advisories for different climatic zones as identified under the key intervention "Access to information". The crop sector, with which the scope of this action can be best identified, carries a budget allocation of INR 3,000 crore of the INR 65,000 crore earmarked for the entire component.

11.3.3. Promotion of Dry land farming

Sector: Agriculture	*Type:* Implementation	*No.:* 3
Issues being addressed:	There is a widespread absence of scientific dry-land farming practices impeding the further expansion of this method. Successful models are needed to inspire expansion. Fodder banks are vital for livestock keeping in such areas. Creation of model farms and villages, establishment of fodder banks under use of instruments provided by National Mission on Sustainable Agriculture. The dry land farming could become a successful technique to address the issue of water scarcity, fodder un-availability especially in northern Karnataka region and would also offer a reliable source of income to rural communities, largely dependent on agriculture for their income. Thus, promotion of dry land farming in Karnataka has been identified as one of the entry points needing immediate action. .
Implementation arrangement:	Department of Agriculture and Horticulture may jointly initiate action: ▪ Identifying dry land regions, transit regions and regions where dry spells have increased in duration and frequency where agriculture is increasingly vulnerable. ▪ Selecting farms and/or villages as development models for dry land farming. During the pilot phase of about 2 years, these will receive continuous advisory and material support; ▪ Engaging agriculture research institutions to continuously develop improved methods and crops for dry land farming. ▪ Promoting and demonstrating above mentioned pilot studies as successful case studies to make these attractive to farmers. ▪ A suitable financial assistance scheme may be devised to offer certain but limited subsidies, and also to develop a mechanism of agri-product distribution. ▪ Promotion of the establishment of fodder banks in consultation with farmer groups. This includes the identification of suitable ownership models; ▪ Assess training needs of various stakeholders through discussions and workshops. ▪ Explore possible convergence with on-going programmes such as-BhooChetana (soil revitalization) and the National Horticulture Mission. National Horticulture Mission provides technical as well as financial assistance to promote specific horticulture crops. ▪ Additionally, technical support may be also sought from National Mission on Sustainable Agriculture.
Key implementer:	Department of Agriculture Department of Horticulture
Stakeholders:	Agriculture universities/Horticultural universities Indian Council of Agriculture Research (ICAR) Research and academic institutes Local NGOs Panchayat Raj institutions
Capacity building needs:	A capacity building programme in line with training needs identified above should include both government personnel and farmercommunities. Such capacity building programme may also include intrastate/interstate field vis-

	its. The experts from different regions may be invited to share their experiences. Training programmes may also be conducted for KVKs and district level officers.
Timeframe:	Short term (Should be initiated immediately)
Funding:	INR 6,500 crore of the total of INR 108,000 crores under the NAPCC Mission for Sustainable Agriculture is earmarked for research and development. This includes dry land agriculture and the establishment of model farms explicitly (together INR 1,000 crores).

11.3.4. Rendering theft of sprinkler pipes unviable

Sector: Agriculture	*Type:* Policy intervention	*No.:* 4
Issues being addressed:	Significant untapped potential for enhancing irrigation efficiency especially in northern Karnataka. The expansion of micro-irrigation is also hampered by security concerns of theft of distribution pipes. Eradication of the market for stolen pipes through re-distribution of existing subsidies on micro irrigation so as to bring farmer's net cost of distribution of pipes below the black market cost.	
Implementation arrangement:	Re-distribute existing subsidies on micro-irrigation so that the supply of pipes, which are often subjected to theft, fetch a resale value below farmers' subsidised procurement price. This would render theft unattractive. ▪ Requires coordination with governments of neighbouring states. ▪ Stricter regulations to make such theft cases seldom. Such regulations may be discussed and finalised in consultation with other relevant departments.	
Key implementer:	Department of Agriculture Department of Horticulture	
Stakeholders:	Department of Water Resources Watershed Department Local NGOs	
Capacity building needs:	Propagate micro-irrigation through creating farmers' awareness at Taluk and Gram Panchayat levels on benefits of micro-irrigation, available financial assistance and governments supporting programmes. Local NGOs may play important role in such awareness creation programmes.	
Timeframe:	Short term (1 – 2 years)	
Funding:	INR 20,630 and INR 49,600 crores have been allotted under NAPCC National Water Mission for Policy and Institutional Framework and Efficient Use of Water for Various Purposes respectively. INR 65,000 crores of the totals of INR 108,000 crores under the NAPCC Mission for Sustainable Agriculture are earmarked for technology, products and practices. This includes the promotion of efficient water use (INR 37,500 crore) including sprinkler systems explicitly.	

11.3.5. Creation of a market for indigenous agricultural crops

Sector: Agriculture	*Type:* Implementation	*No.:* 5
Issues being addressed:	Agro-biodiversity is jeopardised. Indigenous resilient varieties of crops like maize, rice, *sorghum* require interventions to safeguard their conservation. These indigenous varieties need attention not only to conserve gene pool but also to combat climate change impacts. Conservation of indigenous varieties of crops through creation of a market for such products. The network of state agencies including HOPCOMS could help to market these as specialities for a higher price. In addition research institutes may be engaged in conservation of such varieties.	
Implementation arrangement:	To begin with, the Department of Agriculture would be required to; ▪ Prepare an inventory of indigenous varieties of agricultural crops which were abundant but are currently under threat. The inventory should also be based on kind of crops like oil, cereal or pulses. ▪ Appoint a nodal agency (agriculture universities or research institutes) to developappropriatemarket-linked conservationconcepts. The required technical assistance, if required, may be provided by ICAR, or foreign research institutes through signing a MoU. ▪ Devise an intelligent, consumer centric marketing initiative for products from such varieties of crops. ▪ Effective mechanisms (electronic as well print) to promote the use of products from such varieties of crops with the help of panchayats, and co-operative banks. ▪ Draw up an incentive plan to promote such productswhich could include a minimum support price to build farmer confidence. The budget for such incentive may be pooled from existing mechanisms. ▪ A possibility for public - private partnership may be looked in close consultation with planning department of the state. ▪ Assistance from central government may be sought after submitting a detailed proposal for review.	
Key implementer:	Department of Agriculture	
Stakeholders:	Agriculture universities Research institutes Indian Council of Agricultural Research (ICAR) Co-operative banks and societies	
Capacity building needs:	Training programmes for farmers on benefits of conserving indigenous varieties. Department of Agriculture may conduct such training programme at block and Gram Panchayat level through KrishiVigyan Kendra/ Agriculture Extension.	
Timeframe:	Mid term (2 – 5 years)	
Funding:	INR 14,500 crores of the total of INR 108,000 crores under the NAPCC Mission for Sustainable Agriculture is earmarked for infrastructure. This includes the improvement of markets (INR 3,000 crores) and marketing (INR2,000 crores) explicitly.	

11.3.6. Creation of a market for indigenous horticultural crops

Sector: Horticulture	*Type:* Implementation	*No.:* 6
Issues being addressed:	Horticultural biodiversity is jeopardised. Indigenous resilient varieties of crops such as mango and jackfruit require interventions to safeguard their conservation. These indigenous varieties need attention not only to conserve gene pool but also to combat climate change impacts. Conservation of indigenous varieties of crops through creation of a market for such products. The network of state agencies including HOPCOMS could help to market these as specialities for a higher price. In addition, research institutes may be engaged in conservation of such varieties.	
Implementation arrangement:	At outset, Department of Horticulture would be required to: ▪ Prepare an inventory of indigenous varieties of horticultural crops which were abundant but which were under threat now. The inventory should also be based on kind of crop like medicinal plant, fruit, vegetables etc. ▪ Appoint a nodal agency (horticulture universities or research institutes) to develop appropriate market-linked conservation concepts. The required technical assistance, if required, may be provided by ICAR, or foreign research institutes through signing a MoU. ▪ Effective mechanisms (electronic as well print) to promote the use of products from such varieties with the help of panchayats, and co-operative banks. ▪ Devise an intelligent, consumer centric marketing initiative for products from such varieties; ▪ Draw up an incentive plan to promote such products which could includea minimum support price to build farmer's confidence. The budget for such incentive may be pooled from existing mechanisms. ▪ Possibilities for Public private partnership may be explored in close consultation with planning department. ▪ Regions in close proximities to urban centres generally grow such horticultural crops in view of ready market in town, cities. Actions to conserve and propagate indigenous horticultural crops may be initiated in such regions.	
Key implementer:	Department of Horticulture	
Stakeholders:	Horticulture/Agriculture universities Research institutes Indian Council of Agricultural Research (ICAR) Co-operative banks and societies	
Capacity building needs:	Training programmes for farmers on benefits of conserving indigenous varieties. Department of Horticulture may conduct such training programme at block and Gram Panchayat level through KrishiVigyan Kendra/ Agriculture Extension. Such training programmes may be conducted periodically at taluk/district level for farmers and may be integrated as sessions in existing training schedules of in-line departments.	
Timeframe:	Mid term (2 – 5 years)	

Funding:	INR 14,500 crores of the total of INR 108,000 crores under the NAPCC Mission for Sustainable Agriculture is earmarked for infrastructure. This includes the improvement of markets (INR 3,000 crores) and marketing (INR 2,000 crores) explicitly.

11.3.7. Formulation of a livestock insurance policy

Sector: Animal Husbandry	*Type:* Policy intervention	*No.:* 7
Issues being addressed:	Lack of mechanisms, initiatives and incentives for systematically enhancing resistance of livestock to vector borne diseases and increasing heat/cold stresses as may be expected from changes in the climate. Central Government to conceptualise and formulate a livestock insurance policy with premiums taking into account vaccination records and suitability of a breed for a given region. Opportunities to conserve indigenous breeds which are adapted to extreme climate or have potential to adapt, may also be explored in such insurance policy.	
Implementation arrangement:	▪ Prepare detailed livestock inventory including region-wise breeds, existing resistance, level of vaccination and threat due to climate change. This would help in identifying the target (priority) breeds. Also historical data on adaptation of indigenous breeds may be collected, analysed to draw conclusion on their resistance erratic against climatic events. ▪ Formulate a plan to execute large-scale vaccination. This will also include awareness of livestock owners. This may be achieved through organizing vaccination camps at taluk level with prior promotion and awareness creation. ▪ Submission of a proposal for an insurance toCentral Government for financial as well as technical assistance. ▪ Centre of excellence in this field may be established in existing Veterinary Research Institutes. ▪ There should also be a mechanismto periodically review the progress and identify any emerging gaps. ▪ A nodal cell within animal husbandry department may be constituted having members from department, research institutes, panchayat etc.	
Key implementer:	Department of Animal Husbandry and Veterinary Services	
Stakeholders:	State Veterinary Research Institutes Indian Veterinary Research Institute (IVRI) Panchayat Raj institutions Local NGOs	
Capacity building needs:	Training for administrators on assessment of resistance and threats emerging from climate change. Training for livestock owners on: ▪ Risks associated with climate changes; ▪ Benefits of vaccination; ▪ Promotion of livestock insurance.	
Timeframe:	Mid term (2 – 5 years)	
Funding:	INR 6,500 crores of the total of INR 108,000 crores under the NAPCC Mission for Sustainable Agriculture is earmarked for research and development. This includes risk management (INR 1,000 crores) explicitly. The development of a new generation of insurance products including livestock insurance is explicitly mentioned in the key intervention area “Agriculture insurance”.	

11.3.8. Expansion of breeding of indigenous cattle breeds

Sector: Animal Husbandry	*Type:* Implementation	*No.:* 8
Issues being addressed:	Lack of sufficient mechanisms, initiative and incentives for conserving indigenous climate tolerant breeds of cattle (amrithmahal, hallikar, khillar) and buffalo (pandharpuri, surthi). These breed hold promise to survive successfully against erratic climatic events. Thus breeding of these breeds should be one of the top priorities of the state in order to combat climate change. Indigenous breeds are being developed by selective breeding in livestock farms located in Tumkur, Chikkamagalur and Haveri. This needs to be extended.
Implementation arrangement:	▪ Department of Animal Husbandry may approve new livestock farms in other districts to promote the conservation of indigenous breeds. This may be based on the geographical division of the state. Further depending upon the need, new breeds may also be included in conservation plan. ▪ As and when required, research collaboration with international institutes may be solicited. This will bring international expertise at local level. ▪ To devise a mechanism to monitor the success of the programme and need to include/exclude any cattle breed.
Key implementer:	Department of Animal Husbandry
Stakeholders:	Karnataka Animal Husbandry and Veterinary Science universities Veterinary research institutes Indian Veterinary Research Institute (IVRI) Panchayat Raj institutions Local NGOs
Capacity building needs:	Capacity building of veterinary doctors and scientists as mentioned above.
Timeframe:	Mid to long term (3 – 7 years)
Funding:	Funding sources to be identified. Although the NAPCC Mission for Sustainable Agriculture provides a diversified budget of INR 108,000 crores for the period 2011-2017, the scope of this action is not covered. Nevertheless, the conservation of indigenous livestock species is an explicit goal of a the key intervention area "Improved crop seeds, livestock and fish cultures" yet the funding allotted here is aimed at screening and cataloguing of indigenous plant and animal gene pools.

11.3.9. Enforcement of Karnataka Groundwater Act

Sector: Water Resources	*Type:* Policy intervention	*No.:* 9
Issues being addressed:	Over-extraction of groundwater resources, especially in 35 overexploited and 3 critical taluks.Groundwater has been indiscriminately used in the state with the extraction levels exceeding 100 per cent in many regions. Ground water continues to be one of the major sources of water supply in many rural and urban areas. In the agriculture sector, surface irrigation sources and traditionally used tanks have lost the cadence of irrigation potentiality due tovarious reasons and there has been a shift on the development of groundwater based irrigation that has also led a way for intensive multi season agriculture. Thus, the ground water withdrawal is far in excess of recharge leading to declining water levels and increasing pumping costs. Enforcement of the newly enacted Karnataka Groundwater Act 2011 is vital for protection of groundwater resources as it considers necessary to bring a general legislation to control the indiscriminate exploitation of ground water especially in the notified areas of the state.
Implementation arrangement:	▪ Initiation of statutory functioning of the Groundwater Authority to be constituted under the Groundwater Act. ▪ A monitoring mechanism should be devised to evaluate the effectiveness of the implementation and identify emerging challenges which may need inclusion/exclusion of certain clauses and rules. ▪ Any revenue earned through fine/penalty should be directed towards the groundwater recharge.
Key implementer:	Department of Water Resources
Stakeholders:	Department of Mines & Geology Department of Agriculture/Horticulture Department Water supply boards ULBs Panchayat Raj institutions
Capacity building needs:	Training of relevant officials may be conducted on the Act and its implementation i.e. clause, rules, actions, penalty, prohibited activities etc. A nodal officer/cell at state level may be appointed for 1st year to resolve and address issues emerged at field level in implementation.
Timeframe:	Short term (1 – 2 years)
Funding:	INR 7,805 crore has been allotted for groundwater management under the NAPCC National Water Mission.

11.3.10. Creation of Policy body for restricting groundwater use

Sector: Water Resources	*Type:* Policy intervention	*No.:* 10
Issues being addressed:	Groundwater resources are subjected to over-extraction, especially in 35 overexploited and 3 critical taluks. Unplanned and excessive extraction of groundwater may lead to the *no*-watersituation in near future. To avoid such situation, there should be adequate mechanism to restrict groundwater use and also promote groundwater recharging. As a Groundwater Authority will be established under the Groundwater Act, 2011, guidelines and policies need to be framed for granting permissions for groundwater used. No suitable body has been constituted to assume these functions. Establishment of a state level policy body is required to review the possibility of prohibiting the use of groundwater for non-drinking and non-emergency uses.
Implementation arrangement:	Government of Karnataka to set up a policy body to review the existing scenario and prepare a plan to impose restrictions on groundwater. The plan will include ▪ Restriction on groundwater use in overexploited and critical taluks for all uses except drinking purposes; ▪ Fixing the diameter of pipes to draw groundwater for drinking water uses in line with CGWB rules. ▪ Provision for mandatory groundwater recharge by water supply boards and other agencies (townships of PSUs, industries) extracting groundwater for large scale drinking purposes; ▪ Arriving at a groundwater tariff for the non-drinking purposes for agriculture and linked to agricultural power tariffs as discussed in point no. 1. ▪ All industries withdrawing ground water for industrial operations should mandatorily recharge the groundwater. There should be mechanism to ensure their partnership in watershed management. ▪ Promotion of artificial groundwater recharge through provision of a rebate on water tariffs to groundwater recharging entities (farmers, industries etc.). The policy body would provide suitable guidelines and policy input to Government of Karnataka and specifically the yet to be established Groundwater Authority.
Key implementer:	Department of Water Resources
Stakeholders:	Central Ground Water Board (CGWB) Department of Mines & Geology Department of Agriculture Department of Rural Development &Panchayat Raj ULBs Water supply and sewerage boards Panchayat Raj institutions
Capacity building	Training and awareness programmes for large consumers (industries, farm-

needs:	ers) on the importance of groundwater, introduction to water use efficiency and conservation, government's support for groundwater recharge including rebate and incentives. Local NGOs may be important partners. Numbers and contents of these training programmes may be finalised in close consultation with relevant departments and stakeholders.
Timeframe:	Short term (1 – 3 years)
Funding:	INR 7,805 crores has been allotted for groundwater management under the NAPCC National Water Mission.

11.3.11. Introduction of a groundwater cess

Sector: Water Resources	*Type:* Policy intervention	*No.:* 11
Issues being addressed:	Introduction of a groundwater cess from which a groundwater fund would be created. Levying cess on groundwater extraction will not only address the problem of overuse and scarcity of ground water but also supports the creation of the groundwater fund that would finance groundwater recharge schemes within the state proposed by private and public project proponents. Currently, there is no proper database of the groundwater users that is necessary to measure, control or monitor groundwater usage. If carefully planned,the proposed cess will help regulate unscrupulous extraction of groundwater since the state's groundwater resources have been already extracted to exhaustion in many regions.
Implementation arrangement:	▪ A cess may be finalised based on the stage of groundwater development in particular region. It should vary for different volume brackets (incremental in nature); ▪ A rebate may also be provided to the entities practising groundwater recharge/rainwater harvesting ▪ Cess remitted may be utilised for the promotion and implementation of groundwater recharge. ▪ Apart from cess, government may also make groundwater recharge mandatory to large consumers of groundwater.
Key implementer:	Department of Water Resources
Stakeholders:	Central Ground Water Board (CGWB) Department of Mines & Geology Department of Agriculture Department of Rural Development &Panchayat Raj ULBs Water supply boards Panchayat Raj institutions
Capacity building needs:	Since water has been treated as a private resource the cess on groundwater will need to be accompanied with large scale media campaigns and necessary capacity building activities. A nodal agency may be appointed to develop adequate capacity building strategies in this regard.
Timeframe:	Short term (1 – 2 years)
Funding:	No significant funding requirement envisaged.

11.3.12. Introduction of capital subsidy for RWH structures

Sector: Water Resources	*Type:* Policy intervention	*No.:* 12
Issues being addressed:	The vast potential for collection of rainwater for productive use, groundwater recharge and temporary storage in water bodies in order to reduce the irrigation dependency on groundwater (at present it is 45%) remains to be utilised.As rainwater is in pure form, collected rainwater may be utilised for many productive uses with a light treatment. The state of Karnataka with sufficient rainfall in most of the region except northern part has distinct advantage and opportunity to harvest rains to reduce pressure on ever depleting ground water resources. The Karnataka government in February 2009 announced that buildings, constructed in Bangalore city will have to compulsorily adopt rain water harvesting facility. Residential sites, which exceed an area of 2400 sqft (40 x 60 ft), need to create rain harvesting facility according to the new law. However, the rainwater harvesting is yet to gain momentum in terms of actual implementation and use. Devise an incentive in the form of a capital investment subsidy for rainwater harvesting (RWH) structures.
Implementation arrangement:	Formulation of a state level body with representation from all stakeholders to: ▪ Review the existing pressure on groundwater region wise; ▪ Design agro climatic zone wise incentive plans including subsidies on material (pipes, roof materials, filters etc.); ▪ Funding could be met through the groundwater cess (refer action 11 above). ▪ The subsidies should be designed on differential basis i.e different for different uses like agriculture, industries, domestic etc. ▪ All the municipalities in the state may be advised to develop their own strategies to promote rainwater harvesting. The technical assistance mat be provided by state. ▪ A Rainwater harvesting cell may be dedicated to address frequently raised queries. Similarly municipalities may also have such cells. ▪ Adequate monitoring and evaluation of this initiative should be done periodically.
Key implementer:	Bangalore Water Supply and Sewerage Board
Stakeholders:	Department of Town Planning Public Works Department ULBs Water supply and sewerage boards Panchayat Raj institutions
Capacity building needs:	At outset, simple guidelines to construct rainwater harvesting infrastructure and its operation and maintenance may be prepared. Mass media campaigns on the water scarcity and the need for rainwater harvesting needs to be carried out. Electronic and print media may be used to promote the rainwater harvesting, its advantages and available subsidies. To promote rainwater harvesting in the in urban municipal areas, it is also necessary to have dialogues with industries and corporate organisations.

Timeframe:	Short term (1 – 3 years)
Funding:	INR 7,805 crore has been allotted for groundwater management under the NAPCC National Water Mission.

11.3.13. Integrated water resources management in public buildings

Sector: Water Resources	*Type:* Implementation	*No.:* 13
Issues being addressed:	There is growing need to manage water judiciously to address the ever increasing demand supply gap on account of unprecedented demand for water with limited availability. Re-use of treated water in industries and urban local bodies had failed to make significant achievements in near past. Wastewater generated in various industrial operations carry loads of toxic pollutants which is discharged into river, arable lands etc. This water if treated effectively may be re-used thus reducing the wastage of this precious resource and avoiding environmental deterioration. The adoption of a long term strategy for integrated water resources management in public buildings will set an example to emulate by private building owners.
Implementation arrangement:	▪ Department of Urban Development to make re-use of treated wastewater mandatory in public buildings; ▪ A rebate on water tariffs in case of recycling and reuse of treated waste water may be introduced as incentive; ▪ Water tariffs may be restructured taking into account not only the inflow of water but also wastewater generated.
Key implementer:	Department of Urban Development
Stakeholders:	Department of Town Planning Public Works Department ULBs Water supply and sewerage boards
Capacity building needs:	A Nodal Agency may be appointed to develop guidelines on Integrated Water Resource Management. Capacity building programmes need to be conducted for industries and public sector institutions to recognise the growing problems and proactively seek best management solutions in the sector.
Timeframe:	Short to mid-term (2 – 5 years)
Funding:	INR 47,059 crores has been allotted under City Development National Mission on Sustainable Habitat towards sewage treatment, reuse, recycle of wastewater and rain water harvesting and INR 25 croresfor capacity building for RWH and reuse recycle waste water. Substantial financial commitments are also available under NAPCC National Water Mission.

11.3.14. Revision of pricing policy for irrigation water

Sector: Water Resources	*Type:* Policy intervention	*No.:* 14
Issues being addressed:	Low priced irrigation water is a substantial impediment for investment in water infrastructure and sustainable resource utilisation and management. Water charges recovered from farmers form only a fraction of water productivity and the actual O&M cots. Thus, Water Resources Department to lead a cost benefits analysis in order to assess the financial burden of irrigation water and to formulate a pricing policy rationalising irrigation in view of efficiency, cost effectiveness and long-term sustainability and the need for adequate finance.	
Implementation arrangement:	Government may constitute a committee to assess: ▪ Financial implications of current irrigation water schemes for farmers and tax payers; ▪ Carry out cost benefit analysis to arrive at suitable water tariff structure to provide for the operation and maintenance of watersheds and distribution infrastructure; ▪ Develop consensus among stakeholders on water tariffs.	
Key implementer:	Department of Water Resources	
Stakeholders:	Department of Agriculture Academic and research institutes Panchayat Raj institutions Farmers' communities Department of Revenue	
Capacity building needs:	With the help of local NGOs, awareness programmes for farmers' to demonstrate the need of water tariffs may be conducted at block and Gram Panchayat levels. Participatory capacity building programmes for farmers need to be effectively planned.	
Timeframe:	Mid term (3 – 5 years)	
Funding:	No significant funding requirement envisaged.	

11.3.15. Estimation of the ecological carrying capacity of the Western Ghats

Sector: Forestry and Biodiversity	*Type:* R&D	*No.:* 15
Issues being addressed:	Carrying capacity is defined as the maximum numberofactivities - like domestic, agriculture, transport,industries- that can be done continuously over a period of timewithout affectingthe existing quality of life (existingtraditional practices, access to resources, etc.), biodiversity, ecological systems like coastal systems, forests etc. The carrying capacity study of Western Ghats will help to understand the limits on the availability ofresources and their usage. The Western Ghats is a global biodiversity hotspot, but scientific research shows that biodiversity is not well conserved in the region's vast terrain and forest tracts. Some of the major problems in the Western Ghats are habitat loss and fragmentation, forest degradation, unplanned tourism and changing land use, human-elephant conflict, timber and wildlife poaching/ trade and inclusion of invasive alien species and forest fires.
Implementation arrangement:	A Nodal Agency (group of expert institutes) may be appointed to: ▪ Study the existing development pressures on the Western Ghats; ▪ Devise a methodology to assess the overall carrying capacity in respect of anthropogenic pressures including but not limited to settlements, agriculture, roads and other construction, industries and mines; ▪ Develop high resolution maps for monitoring the status of the Western Ghats; ▪ Formulate recommendations on restrictions or prohibition of further development activities; ▪ The study could provide a blue print that may be worth replicating or adapting for other biodiversity hot spots. The study will result in the development of an integrated ecological carrying capacity framework for Western Ghats. This will cover valuation of ecosystem services and goods that will help the decision makers in terms of sustainable use and planning of developmental activities through proper zoning with minimal impact on critical biological systems. The work should be an open ended one with inbuilt provision for integration of new data and findings in the future.
Key implementer:	Karnataka Forest Department
Stakeholders:	Karnataka Biodiversity Board Western Ghats Task Force Department of Mining and Geology Research institutes
Capacity building needs:	Orientation, training and exposure visit programmes should be conducted for capacity building of farmers, implementing officers, agencies, and local self -government members (Panchayat).
Timeframe:	Short to midterm (2 – 5 years)
Funding:	Funding sources to be identified; Consider purview of the NAPCC Mission for Green India and budgetary provisions hereunder.

11.3.16. Control and eradication of invasive alien species

Sector: Forestry and Biodiversity	*Type:* R&D	*No.:* 16
Issues being addressed:	Biological invasion by alien species is recognised as one of the major threats tonative species and ecosystems. Introduction of new species into a habitat causes serious consequences to the existing flora and fauna. IUCN has identified introduction of invasive as one of the possible reasons for the population decline of native organisms.Currently, there is insufficient information about invasive alien plants; their distribution, rate of spread and adaptability to new environments. The introduction of the African catfish (*Clariasgariepinus*), a carnivorous fish has caused serious damage to the indigenous fauna in the lakes and rivers of Karnataka.Weeds like *Eupatorium*, *Lantana* and *Parthenium* have invaded large areas. *Eucalyptus* plantations in the Ranibennur Blackbuck sanctuary have affected the population of the rare Great Indian Bustard.[1] An opening up of the forest canopy in the humid areas has resulted in the invasion of the exotic weed*Eupatorium*. An increase in *Eupatorium* is one of the causes for the spread of Kyasanur Forest disease among people since it supports tick population which act as vectors for this disease.
Implementation arrangement:	Scientific methods for eradication, containment and control methods and technologies for invasive species.Karnataka Forest Department may initiate partnership with institutes of repute so as to: ▪ Inventorise alien species and assess the extent of invasion region wise; ▪ Assess the impact of such invasion on ecosystems; ▪ Develop scientific methods and/or evaluate existing methods to control invasive species; ▪ Demonstrate successful control or containment techniques and implementation at large scale; ▪ Close and periodical monitoring of control programmes.
Key implementer:	Karnataka Forest Department
Stakeholders:	Karnataka Biodiversity Board Research and academic institutes Department of Agriculture
Capacity building needs:	Training of government officials and staff must be conducted: • To make them aware of contemporary issues (pest risk analysis and identification of pests of quarantine importance); • To effectively manage and handle alien species in an area; and • To ensure the effective implementation of the above.
Timeframe:	Midterm (2 – 5 years)
Funding:	Government of India has launched a centrally sponsored scheme called "Intensification of Forest Management", under which there is a new component called Control and Eradication of Invasive Alien Species, from which funding can be obtained from the MoEF, GoI.

[1] http://ces.iisc.ernet.in/envis/sdev/CES_ETR/etr16.pdf

11.3.17. Eviction of forest encroachments

Sector: Forestry and Biodiversity	*Type:* Implementation	*No.:* 17
Issues being addressed:	About 60.2% of the population of Karnataka is engaged inagricultural and allied activities. The per capitaland of the state is 2.13 ha, whereas in the Western Ghats,the average holding is 0.22 ha. Since the proportion ofmarginal and small land holdings is very high in the state, pressure on forest land is immense.Encroachment of forest land in the state is for human settlements, agriculture, coffee plantations and mines. Encroachment of forestland and diversion of forestlandfor non-forestry purposes have together caused fragmentation offorest ecosystem, loss of habitat, disturbance to wildanimals, loss of endemic species, etc.[1] About 84,799 hectares of forest area is said to be under encroachment, causing fragmentation andreduction in the forest area.[2]	
Implementation arrangement:	▪ Inventorisation of encroachment by location, extent and type (agriculture, mining, settlements) needs to be done. The objective of the inventorisation exercise is to find out the encroachment pattern by the individuals or group of individuals in the forests of Karnataka, and to gather information about the causes of encroachment. It is very important to understand the socio-economic pattern of the encroachers as well as the encroachment pattern (duration of illegal occupation, rate of encroachment, etc.). ▪ Map and estimate recent status and types of forest encroachment using Remote Sensing data. ▪ Removal of encroachments through enforcement of existing legislation under provision of the necessary protection of personnel involved; ▪ List of encroachers may be widely circulated and advertised to generate further awareness on the stringent actions. ▪ For eviction of encroachers, the Forest Department, JFM committees and Self Help Groups should work together.	
Key implementer:	Karnataka Forest Department	
Stakeholders:	Revenue Department, Village Forest Committees, Self Help Groups	
Capacity building needs:	Equip the Forest Department and its frontline personnel with proper understanding of the relevant legislations addressing socio-economic challenges in performing their duties to evict the encroachments.	
Timeframe:	Short to mid term (1 – 5 years)	
Funding:	Funds available under Karnataka Forest Development Fund and 13th Finance Commission may be utilized.	

[1] http://www.parisara.kar.nic.in/PDF/Forest.pdf

[2] http://www.karnatakaforest.gov.in/English/aboutus/note.pdf

11.3.18. Promotion of effluent treatment plants

Sector: Coastal Zone	*Type:* Implementation	*No.:* 18
Issues being addressed:	The population pressure is expected to increase further due to urbanization and industrial development all along the Karnataka coast. The pollution level in inland surface water increasing during post monsoon and pre monsoon periods. The concentration of direct or indirect disposal of effluents and municipal drains to estuaries, rivers or near shore waters causing water pollution. Further, the haphazard dumping of fish waters near fish landing centres, processing of fish catch and the large number of ice factories also causing water pollution. Improper solid waste disposal and inadequate treatment of sewage contributing to the water pollution in urban areas. Similarly beach and river sand mining also contributing to the problem which leads to decline in fragile coastal ecological balance. Considering above major problem with respect to water pollution in coastal region it very essential to promote treatment plants at point source/ CETPs for small industries.
Implementation arrangement:	Karnataka State Pollution Control Board (KSPCB) to: ▪ Update the inventory of industries located in the coastal zone and the status of water discharge and treatment facilities; ▪ Undertake a needs assessment and a and feasibility analysis of CETPs in the coastal zone; ▪ Define a suitable ownership model (private player, association, KSPCB or PPP) and develop technical and financial plan to setup a CETP in the region; ▪ Enforce existing rules and regulation in stricter manner and monitor compliance closely; ▪ Devise options for limiting the sanction of new industries in vulnerable coastal hotspot.
Key implementer:	Karnataka State Pollution Control Board
Stakeholders:	Karnataka State Coastal Zone Management Authority Department of Water Resources Research institutes
Capacity building needs:	It is very essential to build capacity and create awareness among industrialist, regulators, developers, consultants, NGOs, students and academics to understand wastewater treatment process, technologies, affordable treatment optionsand threat from discharging untreated effluent.
Timeframe:	Short term (1 – 2 years)
Funding:	Fee collected from the project proposals/industries, etc, may be utilized.

11.3.19. Conservation and development of Mangroves

Sector: Coastal Zone	*Type:* Policy intervention	*No.:* 19
Issues being addressed:	The coastal zone in Karnataka contains habitats and ecosystems, such as, estuaries, mangroves and coral reefs is entailed with a galaxy of resources, which have definite role in the maintenance of the ecological balance and economic vitality of the coastal region. The diversity and distribution of mangroves along the Karnataka coast indicates the sensitivity to various environmental changes. Further increasing anthropogenic pressures, in the form of conversion of habitats or pollution, are mainly responsible for the decline in species level diversity of mangroves and core reef along the coast. To overcome above problem it is very essential to formulate an action plan for replanting of mangrove in the area where they have disappeared. Also taken up in conjunction with protection of mangroves, patches of biodiversity rich habitats in the coastal, riverine and deltaic belt.
Implementation arrangement:	Karnataka State Coastal Zone Management Authority to: ▪ Develop a viable concept for replanting in terms of extent, timeframe, implementation, monitoring etc. in consultation with a competent research institute; ▪ Ensuring local communities' participation to protect mangroves; ▪ Promotion of awareness on the importance of mangrove ecosystems; ▪ Removal of encroachments posing a threat to mangrove ecosystems; ▪ Re-plantation plan to rejuvenate the mangrove ecosystem.
Key implementer:	Karnataka ForestDepartment
Stakeholders:	Karnataka State Coastal Zone Management Authority Karnataka Biodiversity Board Department of Agriculture Panchayat Raj institutions Local NGOs
Capacity building needs:	It is essential to impart knowledge on mangrove protection to different groups of coastal population. The awareness /user-interaction should be conducted in different regions during different times of the year. Further, skill training programme on mangrove nursery and using of Information and communication tools improves the desired level of awareness.
Timeframe:	Short to mid term (2 – 5 years)
Funding:	Mission on NAPCC National Mission for Green India allocates INR 500 crore to regenerate 0.1 million ha of mangrove ecosystem.

11.3.20. Stabilization of the grid supply voltage

Sector: Energy	*Type:* Implementation	*No.:* 20
Issues being addressed:	• Energy efficiency failed to make substantial inroads. • Energy audit still has low visibility; the necessary professional capacities remain to be created at scale. • The Energy Conservation Building Code (ECBC) is yet to be notified at state level, the concept of Green Rating for Integrated Habitat Assessment (GRIHA) is also not in force as it is a part of ECBC. • The Market Transformation for Energy Efficiency (MTEE) under the NAPCC is not on the horizon in Karnataka yet. • Stabilisation of the grid supply voltage in a systematic and time bound manner is required so that appliances achieve their design efficiently and lifetime. This requires scheduled load planning/shedding until the demand-supply gap is closed.	
Implementation arrangement:	Enhance energy efficiency with technological interventions and adoption of best practices: ▪ Development of an automated load shedding system; ▪ Reduction in the overloading of existing lines and substation equipment. ▪ Grid connection of power pooling arrangements by developing Public private partnerships. ▪ Adapting how the transmission system is operated, using both new and traditional "balancing services" of demand and supply bought from the market by National Grid. ▪ Focus on energy efficiency investments in industry by the energy data reporting and bench-marking practices. ▪ The smart grid initiative for demand side management and integration of renewable resources.	
Key implementer:	Electricity supply companies (ESCOMs)	
Stakeholders:	Department of Energy Karnataka Electricity Regulatory Commission (KERC) Rajiv Gandhi Grameen Vidyutikaran Yojana	
Capacity building needs:	• Planning and co-ordination of the state power grid with the central electricity authority, southern regional electricity board, power generating companies and with the distribution and retail supply licensees. • Trainings, networking and exchange of experiences for professionals across the states and nations to learn from their success stories. •	
Timeframe:	Short to mid term (1 – 3 years)	
Funding:	INR 485 crores plus additional anticipated private contributions of INR 14,000 crores to the NAPCC National Mission for Enhanced Energy Efficiency.	

11.3.21. Making Energy Audits mandatory

Sector: Energy	*Type:* Implementation	*No.:* 21
Issues being addressed:	• Energy efficiency failed to make substantial inroads. • Energy audit still has low visibility, the necessary professional capacities remain to be created at scale, the Energy Conservation Building Code (ECBC) is yet to be notified at state level, the concept of Green Rating for Integrated Habitat Assessment (GRIHA) is also not in force as it is a part of ECBC. Altogether, the Market Transformation for Energy Efficiency (MTEE) under the NAPCC is not on the horizon in Karnataka yet. • KREDL to strategize covering all establishments with a connected load of 500 kVA and above in a time bound manner with energy audit with priority on industries. • This entails the capacity building of the KREDL.
Implementation arrangement:	• To be defined by KREDL based on experiences made so far and strategies envisaged. • To encourage energy audit in industrial, institutional, commercial and government buildings, the state government has to initiate schemes to bear the energy audit cost as financial assistance.
Key implementer:	Karnataka Renewable Energy Development Limited (KREDL)
Stakeholders:	Department of Energy Bureau of Energy Efficiency (BEE) Electricity supply companies (ESCOMs)
Capacity building needs:	• Improve and increase the local capacities and skills on energy auditing and to increase contribution towards energy efficiency. • Development of software's to calculate energy saved, profitability achieved by audits.
Timeframe:	Short to mid term (1 – 3 years)
Funding:	Funding sources to be identified; Consider purview of Mission for Enhanced Energy Efficiency and budgetary provisions hereunder.

11.3.22. Notification of the Energy Conservation Building Code (ECBC)

Sector: Energy	*Type:* Policy intervention	*No.:* 22
Issues being addressed:	• Energy efficiency failed to make substantial inroads. • Energy audit still has low visibility; the necessary professional capacities remain to be created at scale. • The Energy Conservation Building Code (ECBC) is yet to be notified at state level, the concept of Green Rating for Integrated Habitat Assessment (GRIHA) is also not in force as it is a part of ECBC. • The Market Transformation for Energy Efficiency (MTEE) under the NAPCC is not on the horizon in Karnataka yet. • The Energy Conservation Building Code (ECBC) to be notified at state level within 2011.	
Implementation arrangement:	▪ Notification of the Energy Conservation Building Code (ECBC); ▪ Strategizing viable promotions strategies considering delivery mechanism for energy efficiency programmes, a framework for coordination between various government entities and awareness creation. ▪ Development of energy conservation handbooks for commercial buildings and residential apartments ▪ Constitution of a state level technical committee to recommend amendments in the building bye-laws.	
Key implementer:	Karnataka Renewable Energy Development Limited (KREDL)	
Stakeholders:	Department of Energy Department of Town Planning	
Capacity building needs:	• Capacity building of the institutions that support energy efficiency at state level, like the State Designated Agencies (SDAs), Urban Development Department (UDD), Public Works Department (PWD), Urban Local Bodies (ULBs). • Workshop for promoting ECBC for creating awareness architects, engineers, builders and other stake holders.	
Timeframe:	Short to mid term (1 – 3 years)	
Funding:	No significant funding requirement envisaged for the notification.	

11.3.23. Implement NAPCC's Market Transformation for Energy Efficiency

Sector: Energy	*Type:* Policy intervention	*No.:* 23

Issues being addressed:

- Energy efficiency failed to make substantial inroads. Energy audit still has low visibility, the necessary professional capacities remain to be created at scale, the Energy Conservation Building Code (ECBC) is yet to be notified at state level, the concept of Green Rating for Integrated Habitat Assessment (GRIHA) is also not in force as it is a part of ECBC.
- Altogether, the Market Transformation for Energy Efficiency (MTEE) under the NAPCCare not on the horizon in Karnataka yet.
- KREDL to develop strategies for Market Transformation for Energy Efficiency (MTEE) under the National Mission for Enhanced Energy Efficiency
- Create institutional capacity for creating a market/platform for sale of carbon credits;
- Offer fiscal incentives for adoption of energy-efficient equipment and appliances under the National Mission for Enhanced Energy Efficiency;
- Introducing CDM into energy-efficiency.
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Implementation arrangement:

- Preparation of a ranking of carbon emission abatement costs for different mitigation options specific to Karnataka (as was done for India) in order to inform decision processes to overcome cost bias and to initiate market transformation towards their preferential adoption;

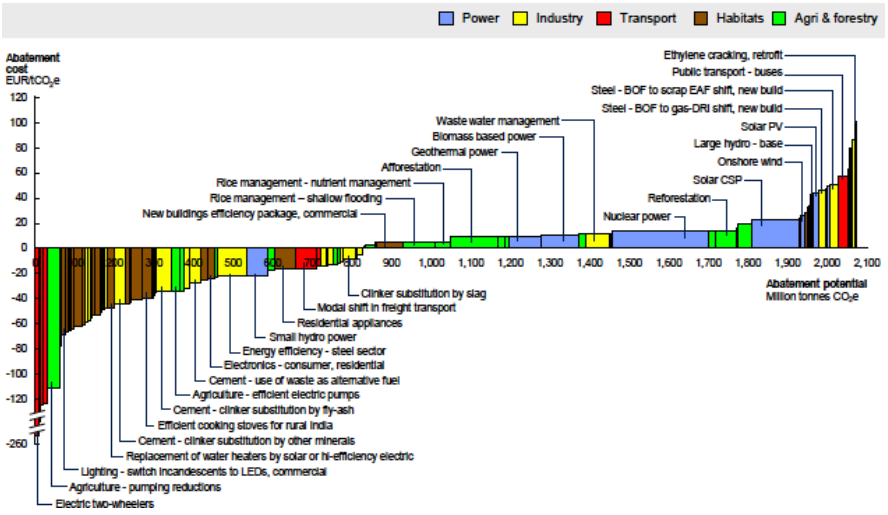

Figure 44: Emission abatement costs for India in 2030[1]

- Conduct an in-depth assessment of leveraging carbon finance including CDM for single/bundled projects, programmatic approaches, voluntary emission reductions for energy efficiency projects. Identify barriers and most viable options followed by the development of a Karnataka guide to carbon finance. The most viable options should be piloted and demonstrated to encourage wider participation and utilisation of the useful instruments (also refer action 24 below).
- Mandating specific energy consumption reductions in the large energy- using industries, including a system for companies to trade energy-savings certificates.

[1] McKinsey & Company, Inc (2009). Environmental and Energy Sustainability: An Approach for India

Sector: Energy	*Type:* Policy intervention	*No.:* 23
	▪ Reducing market barriers to support the adoption of cost-effective, energy-efficient and clean energy products in a sustainable manner. ▪ Energy conservation in buildings and municipalities through performance contracting by ESCOs;	
Key implementer:	Karnataka Renewable Energy Development Limited (KREDL) Private parties	
Stakeholders:	Department of Energy Department of Commerce and Industries Bureau of Energy Efficiency (BEE)	
Capacity building needs:	• Creating awareness on the use of incentives, including reduced taxes on energy-efficient appliances. • Financing for public–private partnerships for demand-side management programmes that reduce energy consumption in the municipal, buildings and agricultural sectors. • Consumer education, loans/rebates and promotional activities (e.g. labeling) help expand market share of energy efficient appliances.	
Timeframe:	Short to mid term (1 – 3 years)	
Funding:	Funding sources to be identified; Consider purview of Mission for Enhanced Energy Efficiency and budgetary provisions hereunder.	

11.3.24. Scale-up renewables' contribution

Sector: Energy	*Type:* Implementation	*No.:* 24
Issues being addressed:	• Among the states in India, Karnataka has one of the highest potentials for renewable energy. The renewable energy potential in the state is estimated at about 19 GW, primarily from wind, small hydro, co-generation and bio-mass sectors. Currently renewable sources are contributing to around 22% of the installed capacity implying a large potential remaining to be tapped. Large-scale solar power pilot projects are not on the horizon, except KPCL's three demonstration plants of 3-5 MW capacity each. • Project financing for renewable energy thorough the creation of green energy fund. • Establishment of renewable energy economic zones. • Rapid scaling up of activities to implement the Renewable Energy Policy through time-bound targets wherever instruments of the National Solar Mission provide for the requisite resources.
Implementation arrangement:	▪ Conduct an in-depth assessment of barriers impeding the deployment of different renewable energy technologies; ▪ Strategize how these barriers can effectively be overcome for every technology. Define policy interventions where necessary to address barriers; ▪ Pursue negotiations with private developers and financing institutions to invest, particularly in large scale projects to drive down the cost with specific focus on large solar power plants; ▪ Removal of implementation barriers of renewables and biomass based generation with regulatory incentives for its promotion; ▪ Create platform for domestic solar industry followed by effective mechanism for certification and rating of manufacturers of solar applications; ▪ Conduct an in-depth assessment of leveraging carbon finance including CDM for single/bundled projects, programmatic approaches, voluntary emission reductions for renewables projects. Identify barriers and most viable options followed by the development of a Karnataka guide to carbon finance. The most viable options should be piloted and demonstrated to encourage wider participation and utilisation of the useful instruments (also refer action 23 above).
Key implementer:	Department of Energy and Karnataka Renewable Energy Development Limited (KREDL)
Stakeholders:	Wind energy developers and Investors and other line departments like forest and revenue etc, for diversion of land and KPTCL and other utilities like BESCOM, CHESCOM, MESCOM, HESCOM and GESCOM and also Panchayat raj institutions and ULBs.
Capacity building needs:	• Most feasible energy generation source to meet long-term energy needs • To set-up an environment for solar technology penetration to serve populations without access to commercial energy. • Expanding the renewable market by scaling up of renewable energy solutions • To demonstrate the economic, social, and environmental viability of

	low carbon development pathways. • Commission work to actively identify weaknesses in current grid infrastructure and consider the attributes of renewable energy in future infrastructure developments
Timeframe:	Mid term (5 – 7 years)
Funding:	INR 12,000-15,000 crores under the NAPCC National Mission for Enhanced Energy Efficiency.

11.3.25. Remove barriers in wind energy development

Sector: Energy	*Type:* Policy intervention	*No.:* 25
Issues being addressed:	• Karnataka is one of the wind-rich state in India and has a potential of around 13 GW. Currently, only a capacity of around 2 GW has been installed harnessing only about 15% of the estimated potential. This is not an encouraging development considering a significantly high wind potential in the state and developments experienced in other wind-rich states. • Review the barriers that have resulted in Karnataka losing its leading role in wind energy development and its current slow pace of development. Evolve appropriate policy changes and tariff frame work to encourage the investment in wind energy development in the state.	
Implementation arrangement:	▪ Create a platform to attract industries, PPP and project developers to invest in research, domestic manufacturing and development of wind energy generation; ▪ State government to involve regulators, power utilities and local citizens to formulate effective policy and framework; ▪ Support up-gradation of technologies and manufacturing capacities through soft loans to achieve higher efficiencies and cost reductions.	
Key implementer:	Department of Energy and Karnataka Renewable Energy Development Limited (KREDL)	
Stakeholders:	Wind energy developers and Investors and other line departments like forest and revenue etc, for diversion of land and KPTCL and other utilities like BESCOM, CHESCOM, MESCOM, HESCOM and GESCOM.	
Capacity building needs:	• Build comprehensive energy strategies and policies, with generation targets for particular technology; long-term success could then be ensured by combining these with implementation review and enforcement plans. • Development of "one-stop shops" or regulatory focal points for private developers who, in turn, could align with regulators through the formation of renewable energy associations.	
Timeframe:	1 to 3 years	
Funding:	No funding required as wind power projects are implemented through private wind energy developers and individual power producers.	

11.3.26. Pilot large-scale bio-fuel substitution in the transport sector

Sector: Energy	*Type:* R&D	*No.:* 26
Issues being addressed:	▪ R&D to focus on piloting viable options for a sustainable larger-scale development of bio-fuel as a substitute for fossil fuels like diesel and petrol for use in vehicles and DG sets.	
Implementation arrangement:	▪ Setting up of a high level research council to guide the overall technology development strategy; ▪ Identify most prospective options that offer benefits to farmers. ▪ Pursue demonstration projects until technology dissemination can rely on market forces.	
Key implementer:	Karnataka State Bio-fuel Board	
Stakeholders:	Department of Transport and its corporations Indian Renewable Energy Development Agency (IREDA) Karnataka Renewable Energy Development Limited (KREDL) Department of Commerce and Industries	
Capacity building needs:	• To transform bio-diesel from a niche player in the transport sector into one that can dominate the mainstream market, which, will require that governments and manufacturing industry work closely together to lay the right foundations. • A set of enabling conditions (finance and innovation) have to be in place. State government, Panchayat raj institutions, the financial sector and multilateral development banks have to work hand in hand.	
Timeframe:	Short to mid term (1 – 3 years)	
Funding:	Funds available under MGNREGA and other ongoing schemes of the Bio-fuel Board may be utilized.	

11.3.27. Enhanced supply of improved chulas

Sector: Energy	*Type:* Policy implementation	*No.:* 27
Issues being addressed:	▪ The use of improved cooking stoves (chulas) is too limited considering its vast potential of not only reducing wood consumption but also reducing indoor air pollution and safeguarding human health, especially of women who spend considerable time. ▪ Action plan for the development and supply of improved *chulas* to the most vulnerable sections of society under National Biomass Cook stoves Initiatives (NBCI).	
Implementation arrangement:	▪ Setting up of state-of-the art testing, certification and monitoring facilities and strengthening R&D programmes in key institutions to enhance technical capacity; ▪ Leveraging Public Private Partnership to explore the range of technologies available for deployment, biomass processing and delivery models.	
Key implementer:	District, Taluk and Village level Panchayat raj institutions	
Stakeholders:	Department of Rural Development and Panchayat Raj and other line departments	
Capacity building needs:	▪ To enhance the availability of clean and efficient energy for the energy deficient and poorer sections of the society in the state; ▪ To achieve quality of energy services from cooking stoves comparable to that from other clean energy sources such as LPG.	
Timeframe:	Mid term (3 – 5 years)	
Funding:	Funds available under various ongoing state sector, central sector and centrally sponsored schemes may be used.	

11.3.28. Assessment of MSW management impediments

Sector: Urbanisation	*Type:* R&D	*No.:* 28
Issues being addressed:	Much remains to be done in the management of municipal solid waste by incorporating good practices and making it in consonance with the legislative requirements. Assessment of impediments in proper management of municipal waste at the level of urban local bodies (ULBs) is not only an urgent need but also a challenging task.	
Implementation arrangement:	▪ Conduct a ULB-wide assessment of impediments in proper management of municipal waste; ▪ A state level committee to review and monitor the progress made by the ULBs on municipal waste may be set up. A premier and a reputed institute in this field may be co-opted as a member for such committee. ▪ Include an assessment plan prepared by the ULBs on solid waste management in the KSAPCC ▪ Identification of options for addressing constraints; ▪ Demonstration with hand-holding supports to the selected few ULBs in implementation and operation of solid waste management with emphasis on both management and technical aspects (segregation, collection, waste recovery, pre disposal treatment and disposal).	
Key implementer:	Department of Urban Development Directorate of Municipal Administration	
Stakeholders:	Research institutes ULBs Karnataka State Pollution Control Board	
Capacity building needs:	▪ Conducting awareness training programmes to the citizens on the importance of segregation and management of solid waste; ▪ Capacity building of personnel on efficient and integrated management of solid waste; ▪ Use of information, education and communication to achieve a desired level of awareness.	
Timeframe:	Short to mid term (1 – 5 years)	
Funding:	Under NAPCC National Mission on Sustainable Habitat the following funds have been earmarked: ▪ INR 90 crores for capacity building; ▪ INR 6,073 crores for Urban Solid Waste Management; ▪ INR 40 crores on Solid Waste Management (complimentary action).	

11.3.29. Regional research on climate change

Sector: Other interventions	*Type:* R&D	*No.:* 29
Issues being addressed:	The current level of knowledge on the spatial dimension, time scale and magnitude of climatic changes is extremely limited. An accurate and quantitative in-depth understanding of probable climate change impacts emerges as critical need. In its absence, the framing of long-term policies and evolving appropriate adaptive as well as mitigative measures remains severely impeded. Conduct extensive research on the spatial dimension, time scale and magnitude of climatic change impacts to make more accurate predictions of likely impacts of climate change and possible options of adaptation and mitigation in the state of Karnataka.	
Implementation arrangement:	▪ Develop a centre of excellence for climate change and establish a regional climate monitoring network to conduct all the relevant research interventions. The results of such studies may help in enhanced understanding of climate change processes specific to Karnataka state; ▪ Improving the spatial resolution of present climate models in order to capture the changes in various sectors (Agriculture and allied sectors, Water Resources, Forestry, Biodiversity and Wildlife, Coastal Zone, Energy, Urbanisation, Human Health etc.); ▪ Partnership with research and academic institutes, within and outside the state to bridge the knowledge gaps.	
Key implementer:	Department of Ecology & Environment	
Stakeholders:	Academic and Research institutes Karnataka State Natural Disaster Monitoring Centre Indian Meteorological Department (IMD) Department of Agriculture Department of Water Resources Karnataka Biodiversity Board Karnataka Forest Department Department of Urban Development Department of Health & Family Welfare	
Capacity building needs:	Capacity building of department personnel by conducting training workshops and visiting centres of excellence in climate change across the state and/or abroad.	
Timeframe:	Short term (1 – 3 years)	
Funding:	Funding can be obtained from the National Mission on Strategic Knowledge for climate change.	

11.3.30. Documentation of adaptation practices

Sector: Other interventions	*Type:* Data management	*No.:* 30
Issues being addressed:	There is no mechanism for sharing information on adaptation pilots, practices and experiences made across India. This being a very new field, the absence of systematic communication might lead to a situation where each state reinvents wheels starting from zero while opportunities to build on each others' experience are foregone. Government of India to lead the systematic documentation and evaluation of adaptation practices in the country. Karnataka should designate a state Nodal Agency to provide relevant information on behalf of Karnataka and to compile the experiences made elsewhere in the country.	
Implementation arrangement:	Nodal Agency to be appointed	
Key implementer:	Department of Ecology & Environment	
Stakeholders:	Academic and Research institutes Department of Panchyat Raj and Rural Development Karnataka Forest Department Department of Agriculture Department of Horticulture Department of Water Resources Karnataka Biodiversity Board Local NGOs	
Capacity building needs:	Dissemination of information at state and district levels through publications and trainings.	
Timeframe:	Short to mid term (1 – 5 years)	
Funding:	Funding can be obtained from the National Mission on Strategic Knowledge for climate change.	

11.3.31. SAPCC updation process

Sector: Other interventions	*Type:* R&D	*No.:* 31
Issues being addressed:	This present Action Plan is based on current understanding and published research. The underlying knowledge of which is subject to rapid evolvement, without a regular review and updation, this Action Plan is bound to loose its relevance within a span of couple of years. Establish a systematic review process for compilation of new scientific findings, new modelling results and changes in policy, legislation and incentives, leading to an up to date of Karnataka State Action Plan on Climate Change once in every 2 to 5 years.	
Implementation arrangement:	▪ Nodal Agency to be appointed ▪ Nodal Agency to systematically keep itself abreast of the latest developments in the field of Climate change including policies, technologies, adaptation, mitigation, international negotiation etc.; ▪ Nodal Agency to develop a comprehensive annual report for circulation to all relevant stakeholders to draw their immediate attention on any urgent issues; ▪ Once in every 2 to 5 years, the Nodal Agency to submit an up to date of report along with its recommendations to revise the action plan, circulate it to all stakeholders, to conduct a consultation workshop to present its recommendations on revision of action plan.	
Key implementer:	Department of Ecology & Environment	
Stakeholders:	Academic and Research institutes Department of Panchyat Raj and Rural Development Karnataka Forest Department Department of Agriculture Department of Horticulture Department of Water Resources Karnataka Biodiversity Board Local NGOs	
Capacity building needs:	The officers of the line departments especially involved in planning and implementation of the programmes need to be given training regarding the impacts of climate change including the options for adaptation and mitigation.	
Timeframe:	Long term (5 – 20 years)	
Funding:	Funding can be obtained from the National Mission on Strategic Knowledge for climate change.	

11.4. Indicative budget for implementation of KSAPCC

The Expert Committee of the Ministry of Environment and Forests (MoEF), GoI had reviewed the action plan on September 18, 2012 and suggested to the state Government to furnish an estimate of the incremental budget requirement for implementation of the KSAPCC. In pursuance of this, the Coordination Committee for Climate Change under the chairmanship of the Development Commissioner, GoK in its meeting held on October 9, 2012 resolved that the line departments concerned should prepare and furnish the necessary budget estimates pertaining to their departments against each actionable point in the format designed by the EMPRI. Accordingly, EMPRI had designed a format for providing the budget estimation for period of five (5) years and circulated the format to the departments/agencies concerned through DO letter dated November 16, 2012 requesting them to furnish the budget estimation for actionable points.

The budget estimates received from the eighteen (18) line departments have been compiled against actionable points for a period of 5 years. These actionable points have further been re-classified into four (4) categories based on the nature and kind of the actionable point. The four categories are; (i) Implementable action points, (ii) Data management action points, (iii) Research & Development action points and (iv) Policy Intervention action points. Further, the action plan also identified 31 priority actionable points covering various sectors. The details of the abstract of the budget requirement for a period of 5 years are given below for all the actionable points and also for priority actionable points:

	Category	No. of actionable points	Budget in Lakh Rupees*	No. of priority actionable points	Budget in Lakh Rupees*
1.	Implementable action points	71	410243	11	53983
2.	Data management action points	35	79797	1	-
3.	Research & Development action points	59	104772	6	5104
4.	Policy intervention action points	41	102377	13	30025
5.	Actions are yet to be defined	4		-	-
	Total actionable points	**210**	**697189**	**31**	**89112**

* *Amount indicated does not include the budget requirement for all the actionable points because some departments have not furnished their budget requirement for all the actionable points pertaining to them, instead provided budget for some of the actionable points.*

Methodology followed for compilation of budget estimates and an abstract of budget estimation are given in Annex 4. The details of actionable point-wise budget estimates for actionable points and also for 31 priority actionable points have been enclosed as Annex 4.1.

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ANNEX 1: CONSULTATIONS HELD

1. Bangalore Water Supply and Sewerage Board	Date: March 7, 2011
Represented by:	**Mr. Ramaswamy,** Chief Engineer (Projects) **Mr. Narahari,** Executive Engineer, Waste Water Management
Points noted:	▪ By 2012 plans to add 500 MLD surface water supply Cauvery (JICA funded) ▪ By 2014 utilise current STP capacity of 721 MLD and 73 MLD tertiary treatments (current utilisation only 10%). ▪ Replacement of all old connection ▪ By 2021 7 CMCs and 1 TMC to be UGD covered 230 km^2 ▪ By 2036 110 villages to be covered ▪ Also intend to add 339 MLD of STP capacity on top of the existing ▪ Estimates Bangalore water supply to be 900 MLD and 200 MLD from bore wells. ▪ Plans to augment another 500 MLD from Cauvery ▪ From 2010 all new BDA/private layouts including hospitals to have a 40ft road with dual piping ▪ Have tendered addressing unaccounted for water for 1 lakh households (roughly 33% of BWSSB area) ▪ 73 MLD tertiary treatment (10% utilization today, because demand much less and also less sewage). Use for toilet and gardening including industry. 60 MLD will be utilized by end of 2014. No plans for adding more tertiary capacity as of now. But plan is there to convert treated water will be blended with the fresh water. ▪ Operation of private STPs monitored by KSPCB ▪ Of the INR 5,972 crore required for the 2014 plan only 1,686 are available as of now ▪ Funding for dual piping to be recovered from BDA ▪ Catchments protection area is urgently required ▪ Funding is required for 100% network, sewage treatment etc (UGD system WB loan, replacement and rehabilitation of Cauvery water out of 243 km)
2. Department of Mines and Geology	Date: March 7, 2011
Represented by:	**Mr. D.R. Veeranna**, Additional Director (Mineral)
Points noted:	▪ Groundwater policy formulated and tabled in assembly; expecting legislation in this session. ▪ Better management for groundwater including for permission at district level for new bore wells. Penalty would be that other agencies (load, electricity, water) would not provide services ▪ Not clear if policy would have any impact on 1 lakh existing bore wells but

	some 50% of existing may not be operative. ▪ Department monitors groundwater quality through network lab in all district (state own laboratories). Pizometric fluctuation data of every month from networked (grid pattern) bore wells, open wells are analysed. ▪ Lakes are monitored if problems are reported about surface water quality. ▪ The entire work comes under Hydrology Projects created with World Bank assistance (Hydrological Information System).
3. Department of Agriculture	Date: March 7, 2011
Represented by:	**Prof. M.B. Rajagowda**, Professor of Agro-meteorology
Points noted:	▪ Establishment of national network for climate change on agriculture, through ICAR ▪ Bhoo Chetna scheme is for nutrient management promoting efficient fertilizer use depending on soil needs. After testing the sites, with assessment of the deficiency level fertilizers recommended. ▪ Chairman of all district are identifying vulnerable area where organic farming can be generated and utilize. Department is planning for large scale expansion programme on organic farming. ▪ Upland paddy developed hybrid of its kind are promoted in the areas of Tumkur, Mandya, Hassan etc ▪ Agriculture Policy Karnataka, 2006 framed ▪ After modelling study only action plan for agriculture can be provided.
4. Department of Horticulture	Date: March 7, 2011
Represented by:	**Dr D.L. Maheswar**, Additional Director **Mr. G.N. Venkatarama Rao**, Senior Assistant Director for Planning
Points noted:	▪ In 2003-04 drought caused INR 1,771 crore damage on coconut and plantation crops ▪ Crop canopy and bio-mass enhancement through Crop Area Expansion plans; perennials and annuals ▪ Rejuvenation and rehabilitation of plantations ▪ Location specific seeds production and multiplication ▪ Introduction & import of elite genotypes & cultivars ▪ Large scale tissue culture based plant propagation ▪ Eco-friendly composting for Mushrooms production ▪ Conservation & Promotion of Bio-diversity horticultural plantations ▪ Promotion of intercrops and cropping systems

5. Department of Animal Husbandry	Date: March 8, 2011
Represented by:	**Dr. Kulkarni,** Joint Director (Extension and Training)
Points noted:	▪ 542 villages in Krishna basin; 600 animal lost officially (only sheep and chicken washed away but not accounted). ▪ Cloud bursts (North Karnataka twice in last 40 years) ▪ Blue tongue diseases (live animal can be imported, bulls from USA, Australia). ▪ New diseases are expected due to change of environmental condition for which study is required and compare with other country. ▪ Fodder availability will go down with the change of temperature in semi-arid region, arid region. Expected big increase of sheep population. Increment of sheep population was 5 % in last 25 years, buffalo bovine population increased only 1%. Pigs and poultry are more tolerant, to climate change. Caprines (goats) can be intensified population stagnant. At Karnataka some areas going to be arid region where sheep (Animal Science Series, vol 2,) can survive. ▪ Malnad region likely to face soil health problems. ▪ 42% area is vulnerable (semi arid sections). ▪ 47 taluks are drought prone. ▪ Since 2008-09 one-month fodder can be protected during flood process. ▪ Need base shelter for animals & fodder already provided and ongoing- capacity of shelter needs to be enhanced (presently 20-30%), lack of initiatives delaying the process. ▪ Study should start immediately; lack of understanding the requirement and importance of subject, lack of funding for study. ▪ Species of productivity changes study is priority. ▪ Change of species with low plane of nutrients, local new breed and 307 lakhs has been spend on preserving conserving and developing cattle breed since 2007-08

6. Department of Fisheries	Date: March 8, 2011
Represented by:	**Mr. Gangadhara V. Maddikery,** Joint Director of Fisheries (Marine)
Points noted:	▪ Vision 2020 (draft) is available ▪ Actions are identified but funding is not available. ▪ 1400 technical and non-technical workers in department. ▪ 120 among 176 offices are in taluks are fisheries graduate ▪ Impacts study on Indian fisheries especially Karnataka is mostly required.

7. Department of Energy	Date: March 8, 2011
Represented by:	**Dr. Raju,** General Manager, KREDL **Mr. B.R. Nagaraja,** Chief Engineer (Gas, Solar, and Wind),
Points noted:	▪ Natural gas supply for use of domestic and power sectors in North Karnataka supposed to be commissioned in 2012 with the help of GAIL natural gas pipeline. ▪ 1400 capacity of gas power plant suppose to come by GAIL (under negotiation) support. After wards natural gas will enter fuel sector. Cost of generation is high. ▪ 1072 MW capacity thermal power plant at Raichur and 1000 MW at Bellary ▪ 3 MW solar power plants at Kolar is operational from November, 2009 with support of KPCL and MNRE

8. Karnataka Renewable Energy Development Limited (KREDL)	Date: March 8, 2011
Represented by:	**Dr. Raju**, General Manager
Points noted:	▪ Associated activities like fixing energy conservation building code with involvement of PWD, municipality, Town planning etc. basis on GoI guidelines under the ECBC schemes will be adapted at state level. A draft of which has already been prepared. ▪ Energy audit (110 kVA consumer consumption) for all consumers will be done but not in any stipulated time frame. Already 30 GoK building audited. This year all Bangalore government building will be audited. ▪ Two major activity PAT (designated consumer targeted, BESE enlisted around 32 out of 700 consumers in Karnataka; mostly industry) ▪ Awareness generation among major industry for PAT ▪ Establishment of benchmark for certain percentage of conservation at state level then implementation ▪ Energy Conservation Act 2001 is not popular so still is no enforcement. Effective steps taken for that: 1) first create awareness to make the act familiar. Familiarity of the acts started irrespective of designated consumers by NGOs, Other organisation in Zilla Panchayat and District level etc. and 2) implementation of MTEEE within as time frame. KREDL has the onus but not implantation part. ▪ Creation of another wing headed by superintended engineers. Empanelment of energy auditor and hiring of accredited energy auditor for MTEEE work. In Mysore city (pilot project) two and half lakh connection is already ▪ From 2007 solar water heater is mandatory for all government buildings and institutions. Department should find source to provide solar unit with KREDL support via media. ▪ Targets set for 25% conservation for all sectors as per Renewable Energy Policy ▪ 100% achievement use of CFL in Government building. ▪ GoI supports subsidy (small hydro, wind power etc) and GoK will support energy efficiency subsidy. ▪ GRIHA is not implemented yet.

- State Level Renewable Energy Policy is expected to receive cabinet approval.
- Belaku scheme gets budget from Yojana and project cost will be recovered by carbon benefit. Option 1: One way investor mode-tender basis, organisation will spend the entire money, Up to 4 incandescent lamps subsidised per household and organisation will claim the credit (KREDL will be facilitator), Option 2: KREDL will invest money.

9. Karnataka State Pollution Control Board Date: March 8, 2011

Represented by: **Mr. M.D.N. Simha,** Chief Environment Officer

Points noted:

- For transport sector of Bangalore GHG inventory already exists 2009-10
- Recycling and reuse of water in all cases those who come under consent process enforcing in non-sewage area as well as sewage area also. Compliance level is not known and work will be assigned for some agency.
- For greening of open space 75 lakh trees planted since 2009. The target is 1.5 crore saplings will confined to the industrial areas.
- GHG emission quantification can commence.
- Data of energy consumption is not available with KSPCB.
- Methodology contradictions exist for GHG emission profiling.

10. Department of Transport Date: March 8, 2011

Represented by: **Mr. Basavaraj,** Deputy Secretary
Mr. Hemantha Kumar, Joint Commissioner

Points noted:

- Expected plan that CNG vehicle may start in Bangalore from April 2015
- Plan for phase out two-stroke engined vehicles: Enhancement of present subsidy for replacement has been proposed Finance Department.
- Transport Department has started initiative and restrain issuing fitness certificate /emission certificates. Retrofit of any parts is not possible for 15 years old vehicles. After 1 year every 6 months emission testing is compulsory.
- INR 2,000 is require to convert from LPG mode to (propene:butane = 60:40 for vehicle) to CNG
- From 2005 onwards replacements of two strokes vehicles with four-stroke ones was carrying out in the Bangalore Metropolitan Region and from 2009 onwards replacement was taking place for entire Karnataka.
- Require a mobility plan with some flexibility.
- Motor vehicle inspector has done the testing study but more people require for work out. Exclusive pollution inspector to check the status regularly will be appointed.
- SPM is not under central motor vehicles act. Manufacturer should have a performance centre in every state in everywhere.
- Department is interested having a integrated plan for vehicle standard, operation of vehicle and proper infrastructure for vehicle movement in all transport sectors.

11. Directorate of Municipal Administration	Date: March 8, 2011
Represented by:	**Mr. Nagesh Kumar G.N.,** Environmental Engineer **Mr. H.P. Nayak,** Executive Engineer
Points noted:	▪ Development and modernisation of slaughterhouses; MoU IDD through KIPDC company. In 43 CMCs land is not available; Inspection report o ULB approval from govt to release the fees to ULB. Roughly 2014 anticipated to be operational. ▪ Presently it is on the 2nd (strengthen ULB) stage of MoU. 1st was inception and survey. ▪ Waste segregation: from 2005-06 information, community programme has been developed for source segregation. 8 months successful competition of source segregation work. In coastal areas source segregation has started from 2005-06. Mysore is likely to be first one where segregation has the infrastructure of maintain segregating source at household level and ULB level (city corporation website in Mysore). ▪ DMA (engineer section of DMA) has initiated energy audit (empanelment of energy auditor) for ULBs in entire state started in 2009. Expected reduction of energy consumption 20-30%. ▪ Allotment of land for landfill has started in 2004-05. Six to seven areas will be problematic due to some legal constraints. ▪ Completion of land allotment to ULB is expected by 2011 ▪ Large waste generator stage-wise: 1st phase 14 ULBs, 2nd phase 15 ULBs
12. Bangalore Metropolitan Region Development Authority	Date: March 9, 2011
Represented by:	**Mr. Mahendra,** Addl. Director of Town Planning
Points noted:	▪ Master plan (available in website also) for urban development that include massive tree plantation. ▪ Before getting approval of the developmental plan tree plantation mandatory and also existence of the plantation will be assessed ▪ Solar water heater and lighting installation is mandatory with security deposit to BMRDA/BDA of 2% money of total project cost. Successful implementation will return the deposited money. ▪ 74th amendment of constitution Metropolitan Planning Committee will be established. ▪ BMRDA has prepared a structural plan which includes a policy cut out rather a framework which has to be followed by every planning authority. In case of Bangalore BDA prepares this master plan and other planning agency for non-BDA areas. Final approval of projects is done by urban planning. Rural areas not declared as local planning scale so Rural Development cannot work without consent of BMRDA.

13. Department of Rural Development and Panchayat Raj	Date: March 9, 2011
Represented by:	**Mr. Prabhakar Chimney,** Chief Engineer
Points noted:	▪ Vision 2020 document of department available ▪ Roof top water harvesting structure (in 4 districts), specially where drinking water is not safe from contaminants such as fluorine, chloride. ▪ Drought proofing: RWH, sprinkler irrigation (GW based on pump sets and bore wells). Divert the canal water to small MI tanks to use in drinking water domestically. ▪ Flood control initiatives: Nalla creation, MI tanks ▪ Flood relief area with shelter (river side) has been created to keep people away from flood prone areas. Scheme is partly funded by NREGA. Material, labour and administrative cost has been done by fund from GoK. Expected completion of the work by 2011. ▪ 1 lakhs /house to be shifted from the flood affected areas. Around 80 flood affected villages identified as of now. ▪ Alternative land for forest department to compensate the forest area.

14. Directorate of Urban Land Transport	Date: March 9, 2011
Represented by:	**Mr. Shailender Singh,** Special Officer
Points noted:	▪ Urban Land Transport Act as a facilitator, task manager, policy adviser not as an implementing agency. ▪ Not all roads can be widened. ▪ National Urban Transport Plan 2006 released. Probation for infrastructure for pedestrian walking already exists. In-house studies have been done for improving pedestrian facilities. ▪ Feasibility studies: 5 studies for a cycle friendly Jayanagar (BBMP implement as pilot scale). Cycle oriented study in state (Bhagyalaxsmi scheme, free cycle for school going girls) lends impetus to improve cycling infrastructure. ▪ Madiwala lake: Joggers track established, dedicated cycle lane proposed. ▪ Pedestrian zone including a parking plan proposed at Gandhi Bazar and one more location in Bangalore ▪ Sidewalk should be clear and should have some 2 m for pedestrian safety on a certain grade of road. ▪ For old roads widening should incorporate sidewalk, dedicated public transport road. ▪ Urban street design guidelines standards are under preparation. Three major components 1. Road hierarchy, 2. Junction design, 3. Pedestrian infrastructure and cycling facilities (in some part) are proposed. ▪ Non-motorized task force looking for two aspects cyclist and pedestrians. ▪ Service level benchmark for air pollution (document is available).

15. Rajiv Gandhi Rural Housing Cooperation (RGRHC)	Date: March 10, 2011
Represented by:	**Mr. Hanumanthaiah,** Under Secretary to Government **Mr. N.S. Mahadeva Prasad,** General Manager (Prog. Implementation) **Mr. Vasudev,** General Manager (Technical)
Points noted:	▪ RWH as model project: selected 20 houses in each of the 176 taluks for demonstration. Construction of RWH in schools mandatory. ▪ 20 lakhs RGRHC facilitate the programme. 25% urban area under RGRHC and 75% rural areas under RHRHC. Urban areas implementation done by GoK through agencies ▪ Fly ash: Around all thermal powers stations in Karnataka 2-3 acres of land were provided to make fly-ash blocks: 4 government power plants and 1 private paper mills. In Raichur RTPC, 7-8 tons of fly-ash generated. RGRHC is largest user of fly ash produced by power plants. Alternative cement and sand blocks use fly ash. Fine fly ash used by RGRHC but rest is disposed. ▪ Decentralize water treatment plant in association with BORDA (provide technology and budget) and CDD. DEWATS implemented in 4 layouts say 4000 houses out of 20 lakhs (2 in Bangalore, 2 outside). DEWATS do not require power/machinery and cost less than conventional STPs. ▪ Kaushalya skills development training programme. ▪ 2-3% mud blocks in urban areas.

16. Department of Health	Date: March 10, 2011
Represented by:	**Dr. Bandiegeri,** Joint Director **Dr. Ravishankar,** Consultant
Points noted:	▪ Nine districts established liquid waste management (LWM). Notice received from KSPCB to comply with norms. Expected completion of work by end of 2011 at primary health centres (PHC), Taluks, community health centres (CHC), Hospitals also. ▪ Out of 2258 PHC, 1114 deep burial well established for solid waste part of bio-medical waste (BMW), and 1205 for LWM completed. For PHC common treatment plant (CTP) is preferred, if accessible otherwise deep burial is recommended. Anticipated time to achieve the target of 100% for all district hospitals, PHC and Taluks. Deep burial is for PHC if CTP is not accessed. ▪ Common treatment facility will be established for all major hospitals before the end of 2010 financial year. 60 out of 146 taluks established SWM whereas 55 LWM will be completed by (anticipated) March 2011. ▪ 27 of 182 CHC has been completed for MSW and LWM establishment (anticipated rest of the CHC will be completed by March 2011) ▪ 106 members TOT completed, proposed to train 5028 medical trainer by March 2012 at taluks. Training is already started from 2010. NGO's are working for training. ▪ Regular Monitoring of the maintenance is also going by Health and Family Welfare Department (H&FW) as well as by KSPCB.

17. Department of Housing	Date: March 10, 2011
Represented by:	**Mr. T. Bisse Gowda,** Chief Engineer **Mr. Hanumanthaiah,** Under Secretary to Government
Points noted:	▪ Layout have 10% area reserved for parks, plantation ▪ 200 to 300 layouts in Karnataka, 1960 started 10-15 layouts are in dist level/taluks level (urban focus). 80% of all 176 taluks have already layout done. Every scheme of development is reserve for 10-15% of total site for economically low people at ownership level. ▪ Roughly 3 lakh homes have already constructed more than 2 lakh houses. ▪ RWH is constructed in a layout normally in a park and pond depending on terrain. Rainwater use for percolation collecting by percolation ponds. Sewage treatment plant (STP) water is mainly used for gardening. For smaller layouts septic tanks is constructed whereas in bigger layout STP is constructed.

18. Karnataka Slum Development Board	Date: March 10, 2011
Represented by:	**Mr. K. Guruuraja Rao,** Joint Director **Mr. Hanumanthaiah,** Under Secretary to Government
Points noted:	▪ From 1973 slum clearance board identifying and notifying slums. Since 2010 change from slum clearance to slum development. 2722 slums are identified as of date, out of which 2251 are notified. ▪ Since 2007-08 under Jawaharlal Nehru National Urban Renewal Mission (JNNURM) at pilot scale basis in Bangalore 310 slums are notified and declared but works undertaken in 58 slums and in Mysore 103 notified out of which 71 slums implemented BSU. JNNURM 4000 scheme will be closed by March 2012. ▪ Basic amenities like infrastructure of water, sanitation, electricity is provided to slum people. Also include decentralised wastewater treatment (DEWAT), RWH. Solar street light have been proposed under (Rajiv Awas Yojana) through GoK as next five year programme.

19. Public Works Department	Date: March 10, 2011
Represented by:	**Mr. K.B. Kulkarni,** Deputy Secretary **Dr. H.R. Shantarajan,** Superintendent Engineer (Design)
Points noted:	▪ 2007 circular directing replacement of electric geyser and incandescent lamps with solar water heaters and CFL respectively if funds available (only Govt owned building) under the Energy Conservation Act, 2001. BEE started in 2005 and selected 20 building for replacement of incandescent bulb by CFL and installation of solar water heater. ▪ Maintenance of work is carried out only by PWD for Pre-university colleges (PUC), composite buildings and government departments up to taluk level excluding zilla panchayat. ▪ In a phase wise manner replacement will take place but for new building it is mandatory to use CFL and solar water heater.

20. Department of Revenue	Date: March 10, 2011
Represented by:	**Mr. Desai,** Deputy Secretary **Dr. V. S. Prakash,** Director Karnataka State Natural Disaster Monitoring Centre **Mr. V. S. Gaekowad,** Consultant
Points noted:	▪ Disaster management plan of 2009 came on March 2010. Disaster Management Plan is updated by annually. ▪ The plan of 2010 will be available in mid of 2011. ▪ Plan earmarks INR 4 crore/a to Karnataka for capacity building for 5 yrs (2010-2015). Department is preparing a work plan for capacity building programme strengthening the institutes. ▪ INR 160 crore allocated to SDRF (75% GoI and 25% state). ▪ National Disaster Responsive Fund (NDRF) – State will expend first later central will provide the support. ▪ Repay, Restoration is available for immediate damage infrastructure ▪ Control room to operate immediate disaster / emergency measure ▪ Empowered committee will follow ▪ Karnataka State Disaster Management Authority, District Disaster Management Authority having control room, District Disaster Management Plan, risk assessment for the district, multi hazard mapping, resource inventory for the district level which was established in 2006. ▪ Risk reduction is part of developmental activity as and where require incident command system (type of disaster responsible by dept, rather role of each dept.), DDMP provide a network through different department. ▪ GoI provided vulnerable map-flood and drought map separately by GoK since the issue is regional. ▪ Chemical disaster include in commerce industry, labour department, every unit disaster management plan at industry. ▪ For each natural disaster a separate standard operating procedure (SOP) is developed: Flood, drought, earthquake, forest fire, land slide, cyclone. Development commenced in 2008, finalisation anticipated for 2011. ▪ SOP will be revised considering climate change and it will emphasize on the design. Entire structural design for heavy rainfall in the prone zone along with the PWD including drains (normally 50% capacity is there for all infrastructure) with best-fit situation can be proposed. Government support is required to achieve the capacity. ▪ Redefining of vulnerability map and redefining the risk associated in a state is a big job to integrate the climate change. ▪ State plan is more or large generic in nature but district plans are more specific in nature. ▪ Action plan will contain risk reduction plan and risk transfer (e.g., property management) plan using instrument to control extreme event.

21. Department of Tourism	Date: March 10, 2011
Represented by:	**Mr. K.S. Shivalangappa,** Deputy Director
Points noted:	▪ Recently developed 40-50 buildings with RWH as per the Government Order from 2009. ▪ Solar water heaters are available almost all old as well as new tourism sites. ▪ Location specific use of local material. e.g. red colour laterite stone for constructions in coastal areas. ▪ Following tourism guidelines Tourism Department gives the approval of new set up. In approval process they emphasize on and recommend RWH and solar water heater but not legislated. Private entrepreneurs only get the consent if they have RWH, water recycling facility, KSPCB clearance for the tourism infrastructure. ▪ Some eco properties have restricted facilities e.g. no television. ▪ KSTDC (165 properties) and Jungle Lodges (12 properties) evenly adopt eco friendly measures.

22. Department of Primary and Secondary Education	Date: March 11, 2011
Represented by:	**Dr. Rajannna,** Deputy Secretary **Mr. Srinivas Murthy,** E-governance
Points noted:	▪ Disaster management: Following national construction code for safety; going to take up all possible safety measure as per national building code of India in Karnataka; across aided and unaided schools. Mandate use of fire extinguisher (5 kg to be installed) some school is already started, inflammable material not to be disposed, some emergency task force (with local health officers) for contagious diseases like chickungunya, dengue, malaria etc. ▪ Capacity building among student community, dedicated chapter for environmental pollution in general. ▪ Shifting of flood effected schools; under flood relief (INR 131 crore from Education Dept. contribution also from GoI and donors); 297 villages having school shifted to higher area; ongoing process/phased wise (30-40% completed). Anticipated completion of all constructions by 2012. ▪ Roughly 26,644 primary schools, 30896 higher, 3535 PU; 80 lakh students at schools and 10 lakh at PUs. ▪ Promoting segregation of waste and cleaning (mainly done by Panchayat Raj). Kitchen garden developed, compost garden waste for prepare mid day meal scheme; this dept implementing agency sometimes through NGO; 65.14 lakhs student (aided and unaided schools) under this scheme (2011-12), class 1-10 students are counted. Free mid day meal started since 2008.

23. Karnataka Forest Department	Date: March 11, 2011
Represented by:	▪ **Mr. Dipak Sharmah, IFS,** Additional Principal Chief Conservator of Forests ▪ **Mr. Jagmohan Sharma, IFS,** Conservator of Forest (Project Formulation and Planning) ▪ **Mrs. Sashwati Mishra, IFS,** Deputy Conservator of Forest
Points noted:	▪ Within the framework with the National Policy, KFD develops a strategy conforming with national policy incorporating climate change. ▪ Programme proposed for plantation of 80 thousand extra saplings but this is unlikely covered by the budget declared for 2011. Without the mission document ~80 thousands/annum (2010-11) planting is going on in Karnataka including on barren land. ▪ Several works before this mission formulated which are going on in different scale like, firm forestry, restoring land, etc. This mission will extend the provision of money under a new heading of Green Mission. ▪ Seedlings are given from now Forest Department along with money (will start 2011) for nurturing those plants. ▪ Funding (Finance and CAMPA) source available from other source. Green mission funding will be spend/depending on the provision of research activities component. Else Finance commission and CAMPA will be used. ▪ Project formulation group (PFG) has been formulated, trainings, requirement for climate change including research projects (IISc and forest ecologist), monitoring of plots at different altitude change will be observed. Then will identify at what extent works need to be done. ▪ Only the figure of mitigation document may change with the alignment of Green India Mission. ▪ Adaptation: Department has some information about vulnerability, carbon pool, carbon sequestration potential of forest and outcome is available in a model base result.

24. Department of Industries and Commerce	Date: March 11, 2011
Represented by:	**Mr. Gurunath S. Kulkarni,** Director (Technical Cell**)**
Points noted:	▪ Pursuing development of industries in the less industrialised areas. ▪ Promoting zero discharge, RWH and recycling in approved industry projects of INR 50 crore and above (State High-Level committee approved). Developmental activities associated with industry are expected to help maintain the greenery and ecology in the area. ▪ Cleaner Production Centre to be proposed. ▪ Department hesitant to commit on establishment of an industry registry, as proposed by State of Environment Report Bangalore 2008. The department is keen to maintain its image as facilitator, not regulator.

25. Department of Town and Country Planning	Date: March 11, 2011
Represented by:	**Mr. H.B. Mukunda,** Director
Points noted:	▪ Karnataka Town and Country Planning Act (KTCP) exist since 1961. According to that planning authority constituted in Bangalore ▪ Outline development plan (also structure plan): City improvement boards constituted for development work; ULBs to ensure maintenance. ▪ Enforcement of provisions of the master plan often fails at the implementation level at ULBs. ULBs have to acquire lands for civic amenities (parks and playgrounds) within 5 years. After that the Master Plan expires and if land was not acquired, the present owner can use it for any purpose. ▪ Zonal regulation to be incorporated into Master Plan as well Structure Plan. Zoning regulation (also has strong hold on BBMP) is the starting point for prescribing deployment of solar water heaters. KTCP Act amended any important regulation can be implemented under zonal regulation without revising master plan in anytime. ▪ ULB should take care of the monitoring the implementation part and KREDL has to decide the technical specification of how much RWH and structures and energy conservation is permissible.

26. Department of Water Resources	Date: March 31, 2011
Represented by:	**Mr. D. Satya Murthy,** Principal Secretary
Points noted:	▪ 'Vision 2020' document is under preparation, work given McKinsey (INR 6 crore project) ▪ Department is interested to adopt water conservation strategies, enhancement of efficiency of water usage in various sector and optimum utilization capacity of the state. ▪ Water allocation to every sector and pricing for water usage is still unclear. ▪ State government is the only funding agency to provide the fund for its work. ▪ Dept. is interested to adopt appropriate technology that are economically viable and socially acceptable and politically consensual.

27. Coordination Committee constituted for preparation of the Karnataka State Action Plan on Climate Change	Date: September 21, 2011

Members:

- **Additional Chief Secretary & Development Commissioner**, Government of Karnataka
- **Additional Chief Secretary**, Department of Energy
- **Principal Secretary**, Forest, Ecology and Environment Department
- **Secretary (Ecology and Environment)**, Department of Forest Ecology and Environment
- **Principal Secretary**, Housing Development Department
- **Principal Secretary**, Department of Tourism
- **Principal Secretary**, Department of Revenue
- **Principal Secretary**, Department of Animal Husbandry & Fisheries
- **Principal Secretary**, Department of Transport
- **Principal Secretary**, Public Works Department (PWD)
- **Principal Secretary**, Department of Water Resources
- **Principal Secretary**, Department of Rural Development and Panchayat Raj
- **Principal Secretary**, Department of Urban Development
- **Principal Secretary**, Department of Health & Family Welfare
- **Member Secretary**, Karnataka State Pollution Control Board
- **Representative**, Development Alternatives, New Delhi
- **Representative,** Ministry of Environment and Ecology Forest (MoEF), Government of India
- **Director**, Department of Town and Country Planning
- **Professor**, Department of Civil Engineering, University Visvesvaraya College of Engineering, Bangalore University
- **Director General**, Environmental Management and Policy Research Institute

Invitees:

- **Principal Secretary**, Department of Planning, Programme Monitoring and Statistics
- **Principal Secretary**, Department of Horticulture
- **Managing Director**, Karnataka Renewable Energy Development Ltd.
- **Principal Secretary**, Department of Commerce & Industries (Mines)
- **Principal Secretary**, Department of Higher Education
- **Principal Secretary**, Department of Agriculture Department
- **Secretary (Forest)**, Department of Forest Ecology and Environment
- **Secretary**, Department of Primary and Secondary Education
- **Member Secretary**, Karnataka Biodiversity Board
- **Additional Principal Chief Conservator of Forests and Project Coordinator**, Biodiesel Energy for Rural India (BERI) Project
- **Director**, Indian Meteorology Department, Bangalore
- **Chief Executive Officer**, Lake Development Authority
- **Director**, Karnataka State Natural Disaster Monitoring Centre, Bangalore
- **Director**, Centre for Sustainable Development, Bangalore

	▪ **Director**, Institute of Social & Economic Change, Bangalore ▪ **Senior Advisor & Director**, The Energy Research Institute (TERI), Southern Regional Centre ▪ **Professor**, Centre for Ecological Sciences, Indian Institute of Science, Bangalore
Points noted:	▪ Refer to Proceedings of the 3rd meeting of the Coordination Committee on Climate Change held on September 21, 2011 at 3.30 PM in Room No. 313, Vidhana Soudha, Bangalore regarding the draft "Karnataka State Action Plan on Climate Change (SAPCC)".
28. Indian Meteorological Department, Bangalore	Date: November 03, 2011
Represented by:	**Mr. B. Puttana**, Director
Points noted:	▪ IMD does not agree with BCCI-K (2011) conclusion that rainfall in Karnataka is decreasing. The period considered by BCCI-K is too short. Based on long-term data series annual rainfall has been found to have increased. ▪ IMD Pune will shortly publish a revised edition of "Climate of Karnataka" last published in 1984

ANNEX 2: GOVERNMENT ORDER FEE 181 ENV 2007

PROCEEDINGS OF THE GOVERNMENT OF KARNATAKA

Sub: Constitution of Co-ordination Committee for ensuring effective steps to combat climate change reg.

Preamble :

'Climate change' is a major global issue for this century. Patterns of production and consumption in nation and societies that has prospered have drawn on technology fuelled by energy source that emit Green house gases, resulting in global warming and climate change at accelerated and unpredictable degrees than what the natural revolutionary changes may have resulted. It had implication for food production, water supply, health and energy.

Building the capacity for societies to adapt to climate change is a key challenge for all communities and government. As a part of responding to the challenge that is reducing emission of these green house gases to a level that will not result in dangerous climate change – governments, multilateral institution, scientists, civil society, NGOs, business and others have to take measures and global regional, national, state and grass root levels.

An effective road map for development is to adopt a sustainable pathway by shifting to environmentally sustainable technologies that is promotion of energy efficiency, renewable energy, increase in green cover, protection and conservation of forest areas, soil and water conservation, protection of watersheds and catchment areas, recharge of ground water, promotion of Organic cultivation, crop selection and scientific irrigation besides the efficient use of surface and ground water, rain water harvesting, waste water treatment, re-cycling and re-use, adoption of green technology energy efficiency technologies, scientific management of solid waste, recycling waste to energy, mandatory blending of petroleum fuel with Bio-fuels, introduction of CNG in commercial vehicles improvements of mass transport system, road network, grade separator, policy on phasing out of old vehicles are the issues to be carried forward in sustainable development.

Owing to the importance and the gravity of the issue, Government of India has come out with 'National Action Plan on Climate Change' which was formally launched by the Hon'ble Prime Minister at New Delhi on 30-06-2008.

The action plan is the result of extensive discussions and meticulous ground-work among Government agencies, scientific institutions and

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independent experts over the past year. In the National Action Plan the following eight key National Missions have been proposed and these are:

1. National Solar Mission
2. National Mission for Enhanced Energy Efficiency
3. National Mission on Sustainable Habitat
4. National Water Mission
5. National Mission for Sustaining the Himalayan Ecosystem
6. National Mission for a "Green India"
7. National Mission for Sustainable Agriculture
8. National Mission on Strategic Knowledge for Climate Change

The mission need to be further elaborated refined and for this inputs, ideas and suggestions from a wide variety of sources are to be considered.

The Government of India have also drawn the action plans arising from the National Action Plan on Climate Change assigning the objectives to all concerned Ministries / agencies or groups which are involved therein.

Now to take this process forward in a focussed way, it is essential than a Co-ordination committee is to be constituted at State Level involving the Principal Secretaries/ Secretaries of the respective departments for completing the Action Plan. The issues are to be discussed thread bear and recommendations there on are to be vetted through necessary policy decisions / circulars / Government directions / orders for achieving the stipulated objectives.

In view of this, it is felt necessary to constitute a Co-ordination Committee under the chairmanship of the Addl. Chief Secretary to Government and Development Commissioner. Hence the order:

GOVERNMENT ORDER NO. FEE 181 ENV 2007, BANGALORE DATED 20-06-2009

After careful consideration the Government are pleased to constitute a Co-ordination Committee to oversee and coordinate the issues spelt out in the preamble related to 'Climate Change' under the Chair person ship of

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Additional Chief Secretary to Government and the Development Commissioner. The Co-ordination Committee shall constitute the following members:

1.	The Additional Chief Secretary to Government and Development Commissioner	- Chairperson
2.	The Principal Secretary to Government, Forest, Ecology & Environment Dept.	- Member
3.	The Principal Secretary to Government, Urban Development Dept.	- Member
4.	The Principal Secretary to Government, Energy Dept.	- Member
5.	The Principal Secretary to Government, Health & Family Welfare Dept.	- Member
6.	The Principal Secretary to Government, Transport Dept.	- Member
7.	The Principal Secretary to Government, Public Works Dept.	- Member
8.	The Principal Secretary to Government, Water Resources Dept.	- Member
9.	The Principal Secretary to Government, Housing Department	- Member
10.	The Secretary to Government, Tourism Dept.	- Member
11.	The Principal Secretary to Government, Revenue Department	- Member
12.	The Principal Secretary to Government, Animal Husbandry and Fisheries Dept.	- Member
13.	The Secretary to Government (Ecology and Environment), Forest, Environment and Ecology Dept.	- Member
14.	The Secretary to Government (Forest), Forest, Ecology and Environment Dept.	- Member
15.	Director, Town Planning Dept.	- Member
16.	The Member Secretary, Karnataka State Pollution Control Board	- Member
17.	Representative from the Development Alternatives, B-32, Tara Crescent, Qutab Institutional Area, New Delhi 110 016.	- Member
18.	Representative, Ministry of Environment and Forests, Government of India	- Member

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19.	Shri. B.S. Nagendra Prakash, Professor, Department of Civil Engineering UVCE, Bangalore University, Jnanabharathi Campus, Bangalore-56	- Member
20.	The Director General, Environmental Management and Policy Research Institute, Bangalore	- Member Secretary

The Committee shall meet at least once in three months and decide the road map on 'Climate Change' and monitor the actions initiated by the respective departments and ensure enforcement of strategy/guidelines stipulated by the Committee.

By order and in the name of the
Government of Karnataka

Sd/-
(N.R. JAGANMATHA)
Under Secretary to Government
Forest, Environment and Ecology Dept.

To,

The Compiler, Karnataka Gazette, Bangalore for publication in the next issue of the Gazette and to supply 200 copies to this Department.

Copy to:

1) The Additional Secretary, Government of India, Ministry of Environment and Forest, Paryavaran Bhavan, C.G.O. Complex, Lodhi Road, New Delhi – 110 003.
2) The Statistical Advisor, Ministry of Environment and Forests, Government of India, Paryavaran Bhavan, C.G.O. Complex, Lodhi Road, New Delhi-110 003.
3) The P.S to Principal Secretary to Government, Forest, Ecology and Environment Department.
4) All Principal Secretaries to Government.
5) All Secretaries to Government.
6) All Members of the Committee.
7) S.G. File / Spare copies.

ANNEX 3: PROCEEDINGS OF THE MEETING HELD ON NOV. 25, 2009

Proceedings of the meeting held under the Chairmanship of the Principal Secretary to Government & Development Commissioner on 25.11.2009 at 11.30 AM regarding 'Preparation of State Action Plan on climate change'

The Chairman welcomed the members. Principal Secretary Department of Forest, Ecology & Environment made the opening remark with an introduction to the subject and stated that based on the letter written by the Union Ministry for Environment, addressed to the Honourable Chief Minister of Karnataka, there was an immediate need to take stock of the present status of climate change and its ensuing trend in Karnataka and to prepare State Level Action Plan on climate change.

Special Secretary, Department of Ecology & Environment, Government of Karnataka made an elaborate power point presentation on the National Action Plan released by the Hon'ble Prime Minister of India in June, 2008 and highlighted eight key missions of the Action Plan and present scenario and future implication on the country as a whole. After detailed deliberations and discussion, it was resolved that Environmental Management & Policy Research Institute, Bangalore should take up the task of consolidating all relevant information from different Departments of the State, best practices being followed, mission & vision of respective department and mitigatory measures being adopted in combating climate change inclusive of contribution to reduced emission and then to prepare the status report on the climate change and action plan for the State of Karnataka. It was also decided that the Principal Secretary, Agriculture, Horticulture & Education Department shall also be included as members of the Co-ordination Committee. Once the draft action plan on climate change is prepared by the EMPRI, then it shall be placed before the Co-ordination Committee for discussion and approval. Director General, EMPRI may entrust this work to a consultant of repute and oversee that state plan on climate change is prepared expediously. The Director General of EMPRI agreed for the same.

The meeting ended with vote of thanks to the chair

Sd/-

(Subir Hari Singh)
Principal Secretary to Government
and Development Commissioner

Sd/-

(B.MANOHAR)
Under Secretary to Government,
Forest, Ecology and Environment Department

INDICATIVE BUDGET ESTIMATES FOR A PERIOD OF 5 YEARS FOR IMPLEMENTATION OF KSAPCC

Government of Karnataka (GoK) entrusted EMPRI to prepare the Karnataka State Action Plan on Climate Change (KSAPCC). The report was prepared and submitted to GoK on April 12, 2012. The KSAPCC was approved by Government of Karnataka (GoK) on March 31, 2012 and subsequently submitted to the Ministry of Environment and Forests (MoEF), Government of India (GoI). The Expert Committee of MoEF had reviewed the action plan and suggested to the state Government to furnish an estimate of the incremental budget requirement for implementation the KSAPCC along with the details for the entry point activities indicated in the action plan.

In pursuance of this, the Coordination Committee for Climate Change under the chairmanship of the Development Commissioner, GoK in its meeting held on October 9, 2012 resolved that the line departments concerned should prepare and furnish the necessary budget estimates pertaining to their departments against each actionable point in the format designed by the EMPRI. The details of departments that have furnished budget details vis-a-vis the departments that have not furnished the budget details are as below:

A.	**List of departments that have furnished the budget in old format**
1.	Department of Ecology and Environment
2.	Karnataka Biodiversity Board
3.	Karnataka Electricity Regulatory Commission
4.	Karnataka State Bio Fuel Development Board
5.	Urban Development Department, GoK
6.	Karnataka State Natural Disaster Monitoring Centre (KSNDMC)
7.	Agriculture Department, GoK
8.	Department of Energy, GoK (Have received it from all the ESCOMs)
9.	Karnataka Renewable Energy Department (KREDL)
10.	Department of Mines and Geology, GoK
11.	Town Planning Department, GoK
12.	Directorate of Health and Family Welfare, Bangalore
13.	Horticulture Department, GoK (Submitted in revised format also)
14.	Fisheries Department, GoK (Submitted in revised format also)
15.	Karnataka Forest Department, GoK
16.	Animal Husbandry & Veterinary Services
17.	Directorate of Municipal Administration, GoK
18.	Karnataka Slum Development Board
B.	**List of departments that have not responded at all**
1.	Water Resources Department, GoK
2.	Department of Rural Development and Panchayat Raj, GoK

C.	List of departments that do not require incremental budget
1.	Karnataka State Pollution Control Board
2.	Watershed Development Department, GoK
3.	Commerce & Industries Department (Mines), GoK

The budget component received from the line departments are compiled and incorporated into the report as Annex 4. Further, the 210 actionable components are segregated into category wise namely, implementable action points, data management action points, research & development action points and policy intervention points. A brief summary of category wise budget estimation is depicted in the table below:

	Category	No of action points	Budget in Rs.
1.	Implementable action points	71	410243 Lakhs
2.	Data management action points	35	79797 Lakhs
3.	Research & Development action points	59	104772 Lakhs
4.	Policy intervention action points	41	102377 Lakhs
5.	Actions are yet to be defined	4	
	Total actionable points	**210**	**697189Lakhs**

Out of 210 actionable points 31 are tagged as priority action points or entry points. Among these 11 are implementable, 1 data management, 6 research and development and 13 are policy intervention priority action points. Total budget requirement for 15 priority action points is Rs. 89112 Lakhs whereas 16 of them fall under either policy scheme or concerned departments has not indicated any budget for the particular activity.

The detail of the budget estimates against each activity in the designed format is presented in Annex 4.1.

ESTIMATION OF INDICATIVE BUDGET FOR A PERIOD OF 5 YEARS BASED ON THE INFORMATION PROVIDED BY VARIOUS DEPARTMENTS

Action	*State coordinator*	*Collaborator*	*5-year budget*
	1a. Agriculture		
Challenge 1. Agriculture consumes a significant portion of energy, causing a roughly proportionate emission of GHGs emissions from energy alone.			
1. Ensure voltage stability as prerequisite for enhancing energy efficiency of pumps and other machinery, possibly in conjunction with the Nirantara Jyothi Scheme.	Karnataka Electricity Regulatory Commission (KERC)	Electricity supply companies (ESCOMs)	Rs. 54995 Lakhs
2. Preparation of irrigation charts to enhance irrigation efficiency and reduce power consumption.	Dept. of Water Resources		**
3. Promotion of renewable energy in farms, especially biogas, which reduces methane emissions and solar photovoltaic for IP sets.	Karnataka Renewable Energy Development Limited (KREDL)	KREDL can facilitate the private entrepreneurs who come forward to implement the scheme with the coordination of RDPR and Revenue Department.	
4. Data on the seasonal peak power consumption pattern.	Electricity supply companies (ESCOMs)		Rs. 1126 Lakhs.
5. Data on the number of power consuming machineries at farms.	Electricity supply companies (ESCOMs)		Rs. 672 Lakhs.
6. Identifying intervention areas for improviding energy efficiency at farm levels, especially in view of irrigation charts and the need to aid stabilising voltage through demand side management, possibly in conjunction with the Nirantara Jyothi Scheme.	Karnataka Renewable Energy Development Limited (KREDL)		Rs. 375 Lakhs.
7. Cost benefits analysis in order to assess the extra financial burden to the government.	Karnataka Electricity Regulatory Commission (KERC)		Rs. 26400 Lakhs.
8. **Priority Action1**: Re-structuring the power tariffs in the agricultural sector to disincentivise avoidable electricity consumption. The same volume of subsidies may be shifted to things such as investment in more efficient plant and machinery (refer related action at section "Energy" in this matrix, and explanation at SAPCC, page 165).	Dept. of Energy		*
9. Incentives and subsidies for promotion of renewable energy at farm level.	Karnataka Renewable Energy Development Limited (KREDL)		Rs. 25000 Lakhs.

Action	State coordinator	Collaborator	5-year budget
Challenge 2. Subsidies supporting farming lack mechanisms for shifting cropping patterns in line with projected climatic shifts across agro-climatic zones.			
10. Preparation of an inventory of cropping patterns and changes in the same with respect to agro-climatic zones of the state.	Dept. of Agriculture		Rs. 130 Lakhs.
11. Studies on adaptation and mitigation measures in agriculture sector of the state.	Agriculture universities		Rs. 2000 Lakhs.
12. **Priority Action2**: Establishment of a state level policy body to develop suitable mechanisms for encouraging cropping shifts through re-distribution of existing subsidies (refer explanation at SAPCC, pages 167).	Dept. of Agriculture		*
13. Re-assess the state agriculture policy and provision for subsidies and incentives to grow climate hardy crops.	Dept. of Agriculture		Rs. 2500 Lakhs.
Challenge 3. The current level of knowledge on the spatial dimension, time scale and magnitude of climatic changes is too limited to make predictions for cropping pattern with the necessary certainty.			
14. Web based services to provide all weather related information through a single window, preferable trough Karnataka State Natural Disaster Monitoring Centre.	Karnataka State Natural Disaster Monitoring Centre		Rs. 17625 Lakhs.
15. Research studies on the regional level prediction on the likely impact of climate change on cropping pattern.	Dept. of Agriculture	Academic and research institutes	Rs. 3270 Lakhs.
16. Development of weather derivative models.	Academic and research institutes		Rs. 1091 Lakhs.
17. Re-evaluating all agriculture related policies and programmes in order to integrate climate change issues.	Dept. of Agriculture		Rs. 250 Lakhs.
Challenge 4. Widespread absence of scientific dry-land farming practices.			
18. **Priority Action3**: Creation of model farms and villages, establishment of fodder banks under use of instruments provided by National Mission on Sustainable Agriculture (refer explanation at SAPCC, pages 169).	Dept. of Agriculture	Dept. of Horticulture	**
19. Developing suitable drought and pest resistant crop varieties under use of instruments provided by National Mission on Sustainable Agriculture.	Agriculture universities		**
Challenge 5. Significant untapped minimisation potential in the application of synthetic agro-chemicals (pesticides, fertilizers).			
20. Promotion of Integrated Pest Management (IPM) and Integrated Nutrient Management (INM) to reduce chemical consumption.	Dept. of Agriculture		Rs. 4000 Lakhs.

Action	State coordinator	Collaborator	5-year budget
21. Government of Karnataka is already promoting organic farming (Bhoo Chetana), IPM and INM through specific schemes. The coverage of these needs to be extended.	Dept. of Agriculture		Rs. 1000 Lakhs.
22. Block wise data on the agro-chemical usage at farm level.	Dept. of Agriculture		Rs. 1700 Lakhs.
23. Pest and disease surveillance.	Dept. of Agriculture		Rs. 19 Lakhs.
24. Research on the nutrient requirement of soils, agro-climatic zones wise.	Agriculture universities		Rs. 1780 Lakhs.
25. Research on the spread of pests and climate change linkages.	Agriculture universities		Rs. 1350 Lakhs.
26. Soil resource mapping using GIS and remote sensing.	Agriculture universities		Rs. 7323 Lakhs.
27. Provision for incentives/subsidies on the organic farming, integrated pest management (IPM) and integrated nutrient management (INM).	Dept. of Agriculture		Rs. 6000 Lakhs.
Challenge 6. Significant untapped potential for enhancing irrigation efficiency especially in northern Karnataka. The expansion of micro irrigation is also hampered by security concerns of theft of distribution pipes.			
28. Promote pressurised micro irrigation techniques at larger scales.	Dept. of Agriculture Dept. of Horticulture	Dept. of Water Resources	Rs. 15000 Lakhs.
29. Create awareness through the demonstration of efficient irrigation technologies.	Dept. of Agriculture		Rs. 10000 Lakhs.
30. Identify available land for possible micro irrigation practices district wise.	Dept. of Agriculture		Rs. 180 Lakhs.
31. **Priority Action4**: Eradication of the market for stolen pipes through redistribution of existing subsidies on micro irrigation so as to bring farmer's net cost of distribution pipes below the black market prices (refer explanation at SAPCC, pages 171).	Dept. of Agriculture	Dept. of Horticulture	*
Challenge 7. Agro-biodiversity is jeopardised. Indigenous resilient varieties of crops like maize, rice, sorghum require interventions to safeguard their preservation.			
32. **Priority Action5**: Preservation of indigenous varieties of crops through creation of a market for such products. The network of state agencies including HOPCOMS could help market these as specialities for a higher price (refer explanation at SAPCC, pages 172).	Dept. of Agriculture		Rs. 1000 Lakhs.

Action	State coordinator	Collaborator	5-year budget
33. Preparation of a comprehensive inventory of agro-biodiversity of the state in regular intervals. For this the ongoing preparation of People's Biodiversity Registers is establishing a solid fundament.	Dept. of Agriculture	Agriculture universities	Rs. 1985 Lakhs.
34. Creation of a policy framework to create viable markets for indigenous species.	Dept. of Agriculture		Rs. 200 Lakhs.
35. Development of agro-biodiversity parks.	Dept. of Agriculture		Rs. 2500 Lakhs.
Challenge 8. Livelihoods of farmers who are already vulnerable may be exposed further.			
36. Crop insurance schemes, particularly Weather Based Crop Insurance needs to be expanded through adequate packaging to cover a greater share of farmers.	Dept. of Agriculture		Rs. 12000 Lakhs.
37. Research on specific livelihood risks and possible solutions considering the local contexts.	Dept. of Agriculture	Agriculture universities	Rs. 21000 Lakhs.
		Sub-total for Agriculture	**Rs. 222471**
1b. Horticulture			
Challenge 9. Significant unutilised portions of degraded land/arid land are unsuitable for agriculture but suitable for horticulture, especially in northern Karnataka.			
38. Promotion of development of pastureland.	Dept. of Horticulture		Rs. 18935 Lakhs.
39. Promotion of drought resilient trees for arid areas.	Dept. of Horticulture		Rs. 11167 Lakhs.
40. Create awareness through massive tree plantation campaigns in arid/semi arid regions.	Dept. of Horticulture		Rs. 7768 Lakhs.
41. Comprehensive block-wise data on the type, area and problems of degraded lands.	Dept. of Horticulture		Rs. 7768 Lakhs
42. Research focusing on the local solution to reclaim degraded lands.	Dept. of Agriculture	Agriculture universities	Rs. 1250 Lakhs
43. Development of drought and pest resistant crop varieties.	Dept. of Agriculture	Agriculture universities	Rs. 663 Lakhs
44. Research into highly productive crop varieties.	Dept. of Agriculture	Agriculture universities	Rs. 1450 Lakhs
Challenge 10. Necessary food processing facilities and marketing mechanisms supporting horticultural produce from degraded/arid lands do not exist at required scale.			
45. Development of larger scale food processing parks.	Dept. of Horticulture		Rs. 10559 Lakhs
Challenge 11. Horticultural biodiversity is jeopardised. Indigenous resilient varieties such as mango and jackfruit require interventions to safeguard their preservation.			

Action	State coordinator	Collaborator	5-year budget
46. **Priority Action 6**: Preservation of indigenous varieties of crops through creation of a market for such products. The network of state agencies including HOPCOMS could help market these as specialities for a higher price (refer explanation at SAPCC, pages 173).	Dept. of Horticulture		Rs. 7768 Lakhs
47. Preparation of comprehensive inventory of agro-climatic zones based agro-biodiversity in regular intervals. For this the ongoing preparation of People's Biodiversity Registers is establishing a solid fundament.	Agriculture universities		**
48. Creation of a policy framework to create viable markets for indigenous species.	Dept. of Horticulture		Rs. 5584 Lakhs
		Sub-total for Horticulture	**Rs. 72912 Lakhs**
1c. Animal Husbandry			
Challenge 12. Reducing GHGs emissions from ruminants is unfeasible at scale unless livestock holdings are discouraged. The resulting destabilisation of livelihoods would be greatly undesirable.			
49. Promotion of renewable energy at farm level, especially biogas, which also reduces methane emissions (refer to section "Agriculture" in this matrix, point 3).	Karnataka Renewable Energy Development Limited (KREDL)	KREDL can facilitate the private entrepreneurs who come forward to implement the scheme with the coordination of RDPR and Revenue Department.	
50. Research on improving cattle productivity in order to reduce GHG emissions by reducing the necessity to maintain the current large cattle population.	Dept. of Animal Husbandry & Veterinary Services		**
Challenge 13. Lack of mechanisms, initiative and incentives for systematically enhancing livestock resistance to vector borne diseases and increasing heat/cold stresses as may be expected from changes in the climate.			
51. Systematic vaccination of livestock at larger scale.	Dept. of Animal Husbandry & Veterinary Services		**
52. Prepare district a wise inventory of livestock mortality and morbidity and attributed causes.	Dept. of Animal Husbandry & Veterinary Services	Veterinary research institutes	Rs. 200 Lakhs
53. Studies on animal health and the climate change link.	Dept. of Animal Husbandry & Veterinary Services	Veterinary research institutes	**
54. Develop nutritional strategies to improve coping with heat and water stress.	Dept. of Animal Husbandry & Veterinary Services	Veterinary research institutes	**
55. Studies on the spread of pests vis-à-vis climate trends and projections.	Dept. of Animal Husbandry & Veterinary Services	Veterinary research institutes	**

Action	State coordinator	Collaborator	5-year budget
56. **Priority Action7**: Government of India to conceptualise and formulate a livestock insurance policy with premiums taking into account vaccination records and suitability of a breed for a given region price (refer explanation at SAPCC, pages 175).	Dept. of Animal Husbandry		*
Challenge 14. Lack of mechanisms, initiative and incentives for preserving indigenous climate tolerant breeds of cattle (amrithmahal, hallikar, khillar) and buffalo (pandharpuri, surthi).			
57. **Priority Action8**: Indigenous breeds are being developed through selective breeding in livestock farms located in Tumkur, Chickmagalur and Haveri. This needs to be extended (refer explanation at SAPCC, pages 176).	Dept. of Animal Husbandry		**
58. Improve coordination between Dept.s of Animal Husbandry & Veterinary Services, veterinary institutes and farmers.	Dept. of Animal Husbandry & Veterinary Services		**
59. Maintaining data on the number of indigenous breeds and trends observed.	Dept. of Animal Husbandry & Veterinary Services		Rs. 150 Lakhs
60. Improve the knowledge on coping abilities (resilience) of indigenous breeds to climate stresses on a comparative basis.	Dept. of Animal Husbandry & Veterinary Services	Veterinary research institutes	*
		Sub-total for Animal Husbandry	**Rs. 350 Lakhs**
		Total for Agriculture and Allied Sector	**Rs. 295383 Lakh**
2. Water resources			
Challenge 1. Over-extraction of ground-water resources, especially in 35 over-exploited and 3 critical taluks.			
61. **Priority Action9**: Enforcement of regulation measures in place under the newly enacted Groundwater Act (refer explanation at SAPCC, pages 177).	Dept. of Water Resources		‡
62. Groundwater monitoring for quality and quantity at block level.	Dept. of Mines & Geology		**
63. Expand the promotion of groundwater recharges beyond present levels.	Dept. of Water Resources		‡
64. Prepare and update an inventory of sectoral use of groundwater.	Dept. of Water Resources		‡
65. Groundwater resource mapping using GIS tools.	Dept. of Water Resources		‡
66. Spatial and temporal assessment of micro-watershed based water availability using models such as the Soil and Water Assessment Tool (SWAT).	Watershed Dept.		***
67. GIS-based study of geo-hydrology.	Dept. of Water Resources		‡

	Action	State coordinator	Collaborator	5-year budget
68.	**Priority Action10**: Establishment of a state level policy body to review the possibility of prohibiting the use of groundwater for non-drinking and non-emergency uses. Should in conclusion groundwater use be approved for agricultural uses than a water price should be introduced as incentive for water saving (refer explanation at SAPCC, pages 178).	Dept. of Water Resources		*
	Challenge 2. The vast potential for collection of rainwater for productive use, groundwater recharge and temporary storage in water bodies in order to reduce the irrigation dependency on groundwater (at present it is 45%) remains to be utilised.			
69.	Extend the BWSSB rules on rainwater harvesting to other urban local bodies.	Dept. of Urban Development	Urban local bodies	Rs. 2130 Lakhs
70.	Promote multiple use water services in drought/flood prone areas.	Dept. of Watershed Development Dept. of Agriculture		***
71.	Demonstrate best practices at pilot scale.	Dept. of Watershed Development Dept. of Agriculture		***
72.	Prediction of actual water availability and trends in the state using high resolution climates impacts studies at block level.	Dept. of Water Resources		‡
73.	**Priority Action11**: Introduction of a groundwater cess from which a groundwater fund would be created. The groundwater fund would finance groundwater recharge schemes proposed by private and public project proponents (refer explanation at SAPCC, pages 180).	Dept. of Water Resources		*
74.	**Priority Action12**: Devise an incentive in form of a capital investment subsidy for rainwater harvesting structures (refer three related actions at section "Urbanisation" in this matrix and explanation at SAPCC, pages 181).	Dept. of Water Resources		*
	Challenge 3. Urban water supply is dramatically inefficient (48% UFW in Bangalore). The quantity grows in actuals with the increasing supply. This jeopardises water security and increases the dependence on groundwater.			
75.	➔*Actions for addressing this issue may be proposed.*	*Opinion of the house is solicited*		
	Challenge 4. Reuse of treated water in industries and urban local bodies (ULBs) has been unable to make significant in roads.			

Action	State coordinator	Collaborator	5-year budget
76. **Priority Action13**: Integrated water resources management to commence in public buildings to set examples and inspire confidence (refer explanation at SAPCC, pages 183).	Dept. of Urban Development		Rs. 5545 Lakhs
77. Create awareness in order to enhance social acceptability of treated water.	Water supply and sewerage boards		Rs. 500 Lakhs
78. Conduct socio-economic studies to understand the social acceptability of treated water.	Water supply and sewerage boards		Rs. 100 Lakhs
79. Assess the potential volume of treated water that can be reused and application areas.	Water supply and sewerage boards		Rs. 50 Lakhs
80. Formulation of a state Water Reuse Policy to make further dual piping in new layouts and preferential usage of treated water for watering parks in existing layouts.	Dept. of Water Resources		*
Challenge 5. Low priced irrigation water is a substantial impediment for investment in water infrastructure and sustainable resource utilisation and management.			
81. **Priority Action14**: Water Resources Dept. to lead a cost benefits analysis in order to assess the financial burden of irrigation water and to formulate a pricing policy rationalising irrigation in view of long-term sustainability and the need for adequate finance (refer explanation at SAPCC, pages 184).	Dept. of Water Resources		*
Challenge 6. A minimum flow of rivers in the dry season is not being maintained, leading to excessive concentrations of pollutants.			
82. Estimate a safe minimum water flow for maintenance of ecosystems.	Dept. of Water Resources	Academic and research institutes	‡
		Total for Water Resources	**Rs. 8325 Lakhs**
3. Forestry, biodiversity and wildlife			
Challenge 1. Long-term carbon capture strategies would require a currently not envisaged return to timber as building material from mature and sustainably managed forests and plantations.			
83. Raising of forest plantations in non-forest land unfit for agriculture.	Karnataka Forest Dept.	Dept. of Agriculture Dept. of Horticulture	Rs. 6105 Lakhs
84. Raising of farm forestry plantations by encouraging farmers.	Dept. of Agriculture	Karnataka Forest Dept.	Rs. 7605 Lakhs
85. Monitoring of carbon stocks through collaboration of Karnataka Forest Dept. with Indian Institute of Science (IISc) and other universities.	Karnataka Forest Dept.	Indian Institute of Science (IISc)	Rs. 122 Lakhs

Action	State coordinator	Collaborator	5-year budget
86. Devise strategies to identify market-linked opportunities for development of robust carbon sinks as well as increasing income for local communities.	Karnataka Forest Dept.		Rs. 305 Lakhs
87. Develop a sustainable timber harvest plan along with reforestation schemes and revenue plantations.	Karnataka Forest Dept.		Rs. 4884 Lakhs
88. Develop a policy to protect existing forest stocks as carbon sinks through stronger conservation and community participation.	Karnataka Forest Dept.		Rs. 611 Lakhs
Challenge 2. Biodiversity hotspots such as the Western Ghats are insufficiently protected.			
89. Rigid protection from biotic and abiotic interferences.	Karnataka Forest Dept.		Rs. 9768 Lakhs
90. Comprehensive documentation of the status of flora and fauna.	Karnataka Biodiversity Board		Rs. 75 Lakhs
91. Monitoring and documentation of biotic a abiotic interferences.	Karnataka Biodiversity Board		Rs. 4000 Lakhs
92. **Priority Action15**: Estimate the carrying capacity of the Western Ghats for settlements, agriculture, roads and mines (refer explanation at SAPCC, pages 185).	Karnataka Forest Dept.	Karnataka Biodiversity Board	Rs. 92 Lakhs
93. Establish monitoring mechanisms for biodiversity including the wildlife population to detect changes and needs for responses early.	Karnataka Biodiversity Board	Academic and research institutes	**Summed up in 91**
Challenge 3. Forest degradation due to unplanned extraction of firewood, fodder, NTFP, green manure etc.			
94. Undertake reforestation/ afforestation in degraded areas.	Karnataka Forest Dept.		Rs. 30526 Lakhs
95. Rigid protection of forest through strengthening personnel and infrastructure.	Karnataka Forest Dept.		Rs. 1832 Lakhs
96. Systematic recording of unplanned extraction of fuel wood, fodder, non-timber forest products (NTFP), green manure etc.	Karnataka Forest Dept.		Rs. 153 Lakhs
97. Enhance the capacity of communities to manage and store firewood and fodder under ambient conditions. Provide institutional credit and create alternative market-based market options.	Karnataka Forest Dept.		Rs. 92 Lakhs
98. Devise schemes for providing alternative sources of energy for forest fringe households to prevent firewood collections in forests.	Karnataka Renewable Energy Development Limited (KREDL)		Rs. 14884 Lakhs

Action	State coordinator	Collaborator	5-year budget
Challenge 4. Invasion of alien species (*Tilapia* sp, *Eupatorium* sp etc.).			
99. Implement education/outreach activities that are targeted to ensure public support for rapid response measures.	Karnataka Biodiversity Board		**Summed up in 91**
100. Establish a coordinated public monitoring network to detect and report invasive alien species.	Karnataka Biodiversity Board		**Summed up in 91**
101. Develop and maintain a database containing information on the control and management of invasive alien species that is easily accessible to public.	Karnataka Biodiversity Board		
102. **Priority Action16**: Scientific research on eradication, containment and control methods and technologies for priority invasive alien species (refer explanation at SAPCC, pages 186).	Karnataka Forest Dept.		Rs. 1832 Lakhs
103. A surveillance policy covering inspection and interception is essential to verify authorized introductions, detect illegal introductions, and detect unintentional introductions through key commodities, pathways, and vectors, as is the capacity to implement the strategy.	Karnataka Biodiversity Board		**Summed up in 91**
Challenge 5. Encroachment of forests by human settlements, agriculture, coffee plantations and mines.			
104. **Priority Action17**: Remove encroachments within a timeframe of 5 years (refer explanation at SAPCC, pages 187).	Karnataka Forest Dept.		Rs. 24420 Lakhs
105. A database to be established and maintained tracking encroachments, evictions and reforestation measures.	Karnataka Forest Dept.		Rs. 92 Lakhs
Challenge 6. Vast tracts of forest fall victim to forest fires every year. Both fire prevention and emergency response appear inadequate to tackle the challenge.			
106. Incentive-based community participation in fire prevention.	Karnataka Forest Dept.		Rs. 611 Lakhs
107. A strategy for fire forecasting, prevention and fighting to be implemented.	Karnataka Forest Dept.		Rs. 153 Lakhs
108. Research on adopting modern technology to locate and forecast fires. Fire risk zones prioritisation and monitoring based on satellite imageries.	Karnataka Forest Dept.		Rs. 153 Lakhs
Challenge 7. Gradual loss of green cover in urban areas.			
109. Implement an urban biodiversity education programme for schools and the public at large.	Karnataka Biodiversity Board		Rs. 153 Lakhs
110. Biodiversity inventories of specific areas within cities should be documented.	Karnataka Biodiversity Board		Rs. 208 Lakhs

Action	State coordinator	Collaborator	5-year budget
111. Urban forestry plan should be developed along with city master plans with the additional objective of strengthening emotional bonds between trees and citizens.	Dept. of Town & Country Planning		Rs. 8547 Lakhs
Total for Forestry, Biodiversity and Wildlife			**RS. 117,223 Lakhs**
4. Coastal Zone Management			
Challenge 1. Coastal pollution due to industries, aquaculture, port activities and sand mining has the potential to upset the fragile coastal ecological balance.			
112. **Priority Action18**: Promoting of treatment plants at point source and CETPs for clusters of small industries (refer explanation at SAPCC, pages 188).	Karnataka State Pollution Control Board		***
113. Strengthen the implementation arrangement for the Coastal Regulation Zone.	Dept. of Ecology & Environment	Deputy Commissioners of Dakshina Kannada, Udupi and Uttara Kannada districts	Rs. 940 Lakhs
114. Strict follow-up on environmental impact assessments.	Karnataka State Coastal Zone Management Authority		Rs. 928 Lakhs
115. Promoting and restoring mangrove/ wetlands vegetation along the coastal belt.	Karnataka Forest Dept.	Karnataka Biodiversity Board	**
116. Data on type and amount of hazardous chemicals released by sector.	Karnataka State Pollution Control Board		***
117. Data on area under mangrove ecosystem and temporal change in the same.	Karnataka Forest Dept.	Academic and research institutes	**
118. Research on the implementation of advance treatment technology to reduce pollutants entering the sea.	Karnataka State Pollution Control Board		***
119. Conduct research into the scope, options and viability for turning conventional into organic aquaculture.	Dept. of Fisheries	Academic and research institutes	Rs. 70 Lakhs
Challenge 2. In portions of the coastline the scale of marine fishing is ecologically unsustainable, leading to substantial seasonal fish population decimations. Dependent communities have in a number of cases moved on to shell collection and sand mining for the sake of livelihood while labour cost along the coast is high.			
120. Conducting a socio-economic impact study due to change in ecological conditions and impact on livelihood.	Dept. of Fisheries	Academic and research institutes	Rs. 90 Lakhs
121. Re-assessing the state fishery policy and provision for subsidies and incentives to sustainable fishing.	Dept. of Fisheries		Rs. 20 Lakhs
122. Forming of a committee to develop an action plan for sustainable fishing in coastal districts.	Dept. of Fisheries		Rs. 10 Lakhs

Action		State coordinator	Collaborator	5-year budget
123.	Formulate policies to provide alternative livelihood options especially during the fish breeding seasons by utilising synergies with funding under NREGA.	Dept. of Fisheries		*
	Challenge 3. Very limited research publications are available that investigate the link between climate change and behavioural responses of fish and other marine biodiversity.			
124.	Development of a marine resources information system.	Dept. of Fisheries	Academic and research institutes	Rs. 120 Lakhs
125.	Promoting web based services to provide information on coastal climate and resources.	Dept. of Fisheries	Academic and research institutes	Rs. 90 Lakhs
126.	Research on regional level predictions of likely impact of climate change on coastal fisheries and ecosystems.	Dept. of Fisheries	Academic and research institutes	Rs. 60 Lakhs
127.	Review of options for establishment of a network for collection of additional data: Hydro-meteorological and hydrological data from the coastal region, coastal and estuarine water, salinity and tidal water levels and the changing discharges in both directions in estuarine areas.	Dept. of Water Resources		‡
	Challenge 4. No systematic mapping of Karnataka's 320 km coastline has been undertaken to project the possible impact of the anticipated sea level rise and determine protection measures and timeframes.			
128.	Reassessment and mapping of coastal resources. Concerned departments and research institutes to store and publish data related to sea level, sea erosion, flood, river flow and change in biodiversity etc.	Dept. of Ecology & Environment	Academic and research institutes	Rs. 150 Lakhs
129.	Establishment of a sea level monitoring station under the aegis of the National Institute of Oceanography.	Dept. of Ecology & Environment	National Institute of Oceanography	Rs. 200 Lakhs
130.	Establishment/ strengthening of a groundwater monitoring network with observation wells, sanctuary wells for coastal aquifers.	Dept. of Mines & Geology	Central Ground Water Board (CGWB)	Rs. 2390 Lakhs
131.	Research on flood forecasting, downscaled climate change projections with improved grid resolution.	Dept. of Water Resources	Academic and research institutes	‡
132.	Research on impact of sea level rise on groundwater salinity including hydrochemical and solute transport modelling.	Dept. of Water Resources	Academic and research institutes	‡
133.	Research into marine biogeochemistry and influence on GHG sources and sinks.	Dept. of Ecology & Environment	Academic and research institutes	Rs. 111 Lakhs

Action	State coordinator	Collaborator	5-year budget
134. Establishment of an inventory of wetlands, mapping of vegetation cover, silting, encroachment, conservation of mangrove areas conservation, afforestation, hydrological and hydrometeorological data, salinity, well observation, sea level rise, sediment transport in the river etc.	Dept. of Ecology & Environment	Academic and research institutes	**
135. Mapping of encroachments, change of land use, infrastructure development, pollution, growth of invasive species and over-fishing.	Dept. of Ecology & Environment	Academic and research institutes	Rs. 337 Lakhs
Challenge 5.*Bengeres*, coastal settlements locked between the sea and river, are completely unprotected. A natural disaster such as a tsunami or typhoon could wipe out its population.			
136. ➔*Actions for addressing this issue may be proposed.*	*Opinion of the house is solicited*		
Challenge 6. The mangrove ecosystem and coral reefs are insufficiently protected.			
137. Expand existing mangrove cover across the coast.	Karnataka Forest Dept.		**
138. Establish a mangrove study centre, which will take up research on mangroves and associated biodiversity vis-à-vis climate change.	Karnataka Forest Dept.	Academic and research institutes	**
139. Monitor the relationship between changes in mangrove species under changing climate patterns.	Karnataka Forest Dept.	Academic and research institutes	**
140. **Priority Action19**: Formulate an action plan for replanting of mangrove in lands where they have disappeared. To be taken up in conjunction with protection of mangroves, patches of biodiversity rich habitats in the coastal, riverine and deltaic belt (refer explanation at SAPCC, pages 189).	Karnataka Forest Dept.		*
		Total for Coastal Zone	**Rs. 5516 Lakhs**
5. Energy			
Challenge 1. The power deficit is likely to remain unaddressed in the short and mid term, leading to load shedding and a continuation of large investments into secondary energy infrastructure such DG sets and UPSs which increase the burden on the environment through air pollution, noise levels and disposal of lead acid batteries.			
141. Electricity demand for the next 15 years should be forecasted along with anticipated supply from state owned plants, the contribution from central schemes and private producers to determine the scale of the required capacity. The emphasis on gas based power generation should be retained to the extend gas supply permits.	Dept. of Energy	Karnataka Power Corporation Limited (KPCL)	**

Action	State coordinator	Collaborator	5-year budget
142. Load shedding to follow a structured plan notified 1 week in advance for all categories, with special preferences to industries sector.	Karnataka Electricity Regulatory Commission (KERC)	Electricity supply companies (ESCOMs)	Rs. 47542 Lakhs
143. Aggregate data on load shedding and to develop a procedure to allocate it judiciously across the sectoral customers to reduce dependence on secondary sources.	Karnataka Electricity Regulatory Commission (KERC)	Electricity supply companies (ESCOMs)	Rs. 53910 Lakhs
Challenge 2. Free electricity to farmers is a substantial impediment for garnering the investment necessary to addressing the demand-supply gap and for improving voltage stability necessary for many energy efficient applications.			
144. Constitution of a committee to review the options for dis-incentivising energy consumption by farmers by shifting existing subsidies, for instance to capital goods (refer related action at section "Agriculture" in this matrix).	Dept. of Energy	Dept. of Agriculture	*
Challenge 3. High transmission and distribution losses of currently 22%.			
145. Reduce T&D losses through improvement of sub stations, modernised automation and instrumentation.	Dept. of Energy	Karnataka Power Transmission Corporation Limited (KPTCL) Electricity supply companies (ESCOMs)	Rs. 11500 Lakhs
146. Minimise the theft of electricity.	Electricity supply companies (ESCOMs)		Rs. 14000 Lakhs
147. Computation of T&D losses by Aggregate Technical & Commercial (AT&C) losses to capture the difference between billing and collection of power under the Restructured Accelerated Power Development and Reform Programme (R-APDRP).	Dept. of Energy	Karnataka Power Transmission Corporation Limited (KPTCL) Electricity supply companies (ESCOMs)	Rs. 3400 Lakhs
148. Establish a policy for improving metering efficiency, proper energy accounting and auditing and improved billing and collection efficiency.	Dept. of Energy	Electricity supply companies (ESCOMs)	Rs. 1200 Lakhs
Challenge 4. Energy efficiency failed to make substantial inroads. Energy audit still has low visibility, the necessary professional capacities remain to be created at scale, the Energy Conservation Building Code (ECBC) is yet to be notified at state level, the concept of Green Rating for Integrated Habitat Assessment (GRIHA) is also not in force as it is a part of ECBC. Altogether, the Market Transformation for Energy Efficiency (MTEE) under the NAPCC are not on the horizon in Karnataka yet.			

Action	State coordinator	Collaborator	5-year budget
149. **Priority Action20**: Stabilise the grid supply voltage in a systematic and time bound manner so that appliances achieve their design efficiently and lifetime. This requires scheduled load planning/shedding until the demand-supply gap is closed (refer explanation at SAPCC, pages 190).	Karnataka Electricity Regulatory Commission (KERC)	Electricity supply companies (ESCOMs)	Rs. 15200 Lakhs
150. **Priority Action21**: KREDL to strategise covering all establishments with a connected load of 500 kVA and above with energy audit in a time bound manner with priority on industries. This may entail capacity building on part of KREDL (refer explanation at SAPCC, pages 191).	Karnataka Renewable Energy Development Limited (KREDL)		Rs. 50 Lakhs
151. Perform, Achieve and Trade (PAT) mechanism to mandate specific energy consumption targets for large industries and trade of savings beyond the target	Electricity supply companies (ESCOMs)		**
152. Collection of data for trend analysis in electricity demand before/after incorporation of energy efficient measures.	Karnataka Renewable Energy Development Limited (KREDL)	Academic and research institutes	Rs. 25 Lakhs
153. Conduct market surveys to evaluate the penetration potential of energy efficient appliances in the domestic sector.	Karnataka Renewable Energy Development Limited (KREDL)	Academic and research institutes	Rs. 25 Lakhs
154. Carry out studies to assess the scope of energy saving at farm level through voltage stabilisation and more efficient appliances (electric motors, agricultural pump sets etc.), possibly in conjunction with the Nirantara Jyothi Scheme.	Karnataka Renewable Energy Development Limited (KREDL)	Academic and research institutes	Rs. 375 Lakhs
155. Assess the impact of the *Belaku* scheme in terms of power savings, CFL lifetime and consumer confidence over a period of at least 2 years.	Karnataka Renewable Energy Development Limited (KREDL)	Academic and research institutes	Rs. 25000 Lakhs
156. **Priority Action22**: The Energy Conservation Building Code (ECBC) to be notified at state level (refer explanation at SAPCC, pages 192).	Karnataka Renewable Energy Development Limited (KREDL)		*
157. **Priority Action23**: KREDL to develop strategies for Market Transformation for Energy Efficiency (MTEE) under the National Mission for Enhanced Energy Efficiency (refer explanation at SAPCC, pages 193).	Karnataka Renewable Energy Development Limited (KREDL) Private parties		Rs. 25 Lakhs

Action	State coordinator	Collaborator	5-year budget
158. Devise strategies and polices for demand side management (DSM) interventions beyond the *Belaku* scheme.	Karnataka Renewable Energy Development Limited (KREDL)	Academic and research institutes	*
Challenge 5. The estimated potential of renewables has till date been harnessed to 11.5%. Large-scale pilots projects are not on the horizon yet, apart from KPCL's demonstration plants of 3-5 MW capacity.			
159. **Priority Action24**: Rapid scaling up of activities to implement the Renewable Energy Policy through time-bound targets wherever instruments of the National Mission for Solar Energy provide for the requisite resources (refer explanation of explanation at SAPCC, pages 195).	Karnataka Renewable Energy Development Limited (KREDL)		**
160. Promote renewable energy at decentralised level.	Karnataka Renewable Energy Development Limited (KREDL)		**
161. Proactive implementation of the special incentive package policy to promote photovoltaics manufacturing plants.	Dept. of Industries & Commerce		***
162. Capacity building on use of solar and biomass energy for domestic purposes at decentralised level and successful demonstration of these technologies.	Karnataka Renewable Energy Development Limited (KREDL)	Academic and research institutes	KREDL can facilitate the private entrepreneurs who come forward to implement the scheme with the coordination of RDPR and Revenue Department.
163. Tracking the success rate and performance of implementation of renewable energy projects.	Karnataka Renewable Energy Development Limited (KREDL)	Academic and research institutes	**
164. Research interventions to tap biogenic gas generated from methanogenic organisms in marshes, bogs, landfills and shallow sediments.	Karnataka Renewable Energy Development Limited (KREDL)	Academic and research institutes	With the prior approval of MNRE the programme can be implemented.
165. **Priority Action25**: Review the barriers that have resulted into Karnataka losing its leading role in wind energy and the slow pace of expanding solar energy power generation and determination of instruments through which renewable deployment can be progressively accelerated with specific attention to private sector investments, PPP and time-bound targets (refer explanation of explanation at SAPCC, pages 197).	Karnataka Renewable Energy Development Limited (KREDL)		Rs. 30000 Lakhs

Action	State coordinator	Collaborator	5-year budget
166. Promote the utilisation of Renewable Energy Certificates (REC) to enabling market mechanisms.	Karnataka Renewable Energy Development Limited (KREDL)	Private parties	**
167. Review gaps in the present financing of renewables and identify means for infusion of capital.	Karnataka Renewable Energy Development Limited (KREDL)	Academic and research institutes	*
Challenge 6. Except from traditional firewood use, the use of bio-fuels failed to make substantial inroads at scale.			
168. Foster the wider implementation of decentralised biomass gasification at underserved and unserved Gram Panchayats as demonstrated by BERI.	Karnataka Renewable Energy Development Limited (KREDL)	Zilla Panchayats	KREDL is only the facilitating agency, not implementing any projects in the State. RDPR and Revenue Dept. can take up this scheme to root level with existing BERI.
169. **Priority Action26**: R&D to focus on piloting viable options for subsequent larger-scale deployment of bio-fuels as substitutes for fossil fuel for diesel and petrol engines (vehicles and DG sets); (refer explanation of explanation at SAPCC, pages 198).	Karnataka State Bio-fuel Board		Rs. 780 Lakhs
170. Subject to successful piloting (refer above) the Karnataka Bio-fuel Policy should be amended to include quantified targets and specific incentives for realising them.	Karnataka State Bio-fuel Board		*
Challenge 7. The use of improved cooking stoves (*chulas*) is too limited for its potential of reducing wood consumption while reducing indoor air pollution and safeguarding human health, especially of women who spend considerable time indoors.			
171. Expansion of deployment of improved *chulas* by leveraging public-private partnership for dissemination.	Dept. of Rural Development & Panchayat Raj	Gram panchayats	‡
172. Conduct a larger field survey of indoor air pollution in respect of traditional and improved stoves under real-life conditions across Karnataka and identify reasons impeding further deployment of improved stoves.	Dept. of Rural Development & Panchayat Raj	Academic and research institutes	‡
173. **Priority Action27**: Action plan for the development and deployment of improved *chulas* to the most vulnerable section of society under the National Biomass Cookstoves Initiatives (NBCI); (refer explanation of explanation at SAPCC, pages 199).	Dept. of Rural Development & Panchayat Raj	Zilla Panchayats Gram Panchayats	‡
		Total for Energy	**Rs. 203032**

Action	State coordinator	Collaborator	5-year budget
6. Urbanisation			
Challenge 1. The magnitude of present migration from rural areas to urban results from inadequacies in health, education, housing and employment in tier 2 and 3 cities.			
174. Improve the quality and accessibility of health care, education, housing and employment in tier 2 and 3 cities.	Deputy Commissioners of districts with tier 2 and 3 cities	Various departments	‡
175. Create employment opportunities for the rural populations especially in seasons of non-cultivation by furthering the incentives provided by the Karnataka Industrial Policy, which encourages industries in tier 2 and 3 cities.	Deputy Commissioners of districts with tier 2 and 3 cities	Zilla Panchayats	‡
Challenge 2. Strom water drains are unable to deal with water from moderately heavy rainfalls while climate change may lead to greater precipitation in shorter intervals than previously encountered.			
176. Encouraging rainwater harvesting in cities similar to BWSSB Rules (refer related action at section "Water resources").	Dept. of Water Resources		‡
177. Create awareness about rainwater harvesting among citizens through Residents' Welfare Associations (RWAs) with the help of NGOs (refer related action at section "Water resources").	Dept. of Water Resources		‡
178. Cleaning of existing drainages prior to monsoon.	Dept. of Urban Development (through DMA)	Urban local bodies	Rs. 3128 Lakhs
179. Ensure sewage does not enter storm water drains.	Dept. of Urban Development (through DMA)	Water supply and sewerage boards	Rs. 2200 Lakhs
180. Data on potential for rainwater harvesting and artificial recharge possibility (refer related action at section "Water resources").	Dept. of Water Resources		‡
181. Develop a better rainfall run-off model in the urban context to improve on the empirical system still followed for sizing of storm water drains.	Dept. of Urban Development (through DMA)	Academic and research institutes	Rs. 100 Lakhs
182. Revision of design guidelines for storm water drains to reduce flooding risk from presently 60% to zero.	Dept. of Urban Development (through DMA)	Academic and research institutes	Rs. 50 Lakhs
Challenge 3. Much remains to be done to manage municipal solid waste in line with good practices and legislative requirements.			
183. Emphasis on achieving a fair degree of segregation of waste at source so as to maximise reuse and recycling options.	Dept. of Urban Development (through DMA)	Urban local bodies (ULBs)	Rs. 25400 Lakhs
184. Promoting awareness among citizens on the 4 R's in association with Residents' Welfare Associations (RWAs).	Dept. of Urban Development (through DMA)		Rs. 10000 Lakhs

Action	State coordinator	Collaborator	5-year budget
185. **Priority Action28**: Assessment of impediments in proper management of municipal waste at the level of urban local bodies (ULBs); (refer explanation at SAPCC, pages 200).	Dept. of Urban Development		Rs. 2100 Lakhs
186. Using GIS/ remote sensing techniques for tracking disposal of waste.	Dept. of Urban Development (through DMA)	Urban local bodies (ULBs)	Rs. 580 Lakhs
187. Targeted exploration of new and economically viable recycling options.	Dept. of Urban Development	Academic and research institutes	Rs. 100 Lakhs
188. Providing incentives for organisations and adult rag pickers collecting recyclable waste by considering support prices to stimulate recycling.	Dept. of Urban Development (through DMA)		**
189. Devising means of introducing buy-back mechanisms at state level.	Dept. of Urban Development (through DMA)		Rs. 20 Lakhs
Challenge 4. Large untapped energy potential from solid waste (135 MW) that could be an interim solution until better composting is realised.			
190. Provision for collection of wet waste form restaurants and apartments.	Dept. of Urban Development (through DMA)	Urban local bodies (ULBs)	Rs. 1000 Lakhs
191. R&D on techniques and methods to generate energy from waste.	Dept. of Urban Development	Academic and research institutes	Rs. 4000 Lakhs
192. Policies incentivising waste co-processing in power plants to address health issues besides energy generation.	Dept. of Urban Development	Urban local bodies (ULBs)	**
Challenge 5. Considerable inadequacy in sewage collection, treatment and reuse of treated water.			
193. ➔*Actions for addressing this issue may be proposed.*	*Opinion of the house is solicited*		
Challenge 6. Absence of a planning perspective capable of envisaging decades as necessary for rail-bound public transport in cities and public transport in emerging cities.			
194. Initiation of long-term planning processes which are followed through to their implementation and logical conclusion.	Dept. of Urban Development		‡
Challenge 7. Basic needs of the urban poor in respect of water, sanitation, electricity unmet for many.			
195. Ensure continuation of the work of Karnataka Slum Development Board in ensuring access to safe water and sanitation in slums.	Karnataka Slum Development Board		8400 Lakhs
Challenge 8. Difficult to change behavioural patterns result in road humps that increase fuel consumption, air pollution and noise apart from being undesirable for commuters.			
196. ➔*Actions for addressing this issue may be proposed.*	*Opinion of the house is solicited*		

Action	State coordinator	Collaborator	5-year budget
Challenge 9. Gradual loss of green cover in urban areas.			
197. Encouraging plantation of suitable species.	Dept. of Urban Development	Urban local bodies Karnataka Forest Dept.	Rs. 2500 Lakhs
198. Implementation of the Parks Act.	Dept. of Urban Development	Urban local bodies Karnataka Forest Dept.	Rs. 2500 Lakhs
199. Maintain data on annual tree plantations and removals.	Dept. of Urban Development	Urban local bodies Karnataka Forest Dept.	Rs. 532 Lakhs
		Total for Urbanization	**Rs. 62610 Lakhs**
7. Health			
Challenge 1. Absence of a health status inventory			
200. Enhancing disease monitoring and surveillance, especially in respect of malaria.	Dept. of Health and Family Welfare	Research institutes	Rs. 250 Lakhs
201. Maintenance of data related to mortality and morbidity at district/block level.	Dept. of Health and Family Welfare	Research institutes	**
Challenge 2. The relationship between human health and climate change (vector borne disease, heat stress etc.) is not well established in published literature.			
202. Development of a database on the cases of vector borne diseases and transmission.	Dept. of Health and Family Welfare		Rs. 400 Lakhs
203. Conduct region wise research on diseases related to water availability and quality.	Dept. of Health and Family Welfare	Academic and research institutes	**
204. Procure, develop and customize high-resolution health impact models in collaboration with national and international agencies to exchange knowledge.	Dept. of Health and Family Welfare	Academic and research institutes	Rs. 20 Lakhs
205. Studies on climate change linked parasite activities and impact on human health.	Dept. of Health and Family Welfare	Academic and research institutes	**
Challenge 3. Most vulnerable regions of the state in the context of health remain to be identified.			
206. Conduct research on the trend of vector borne diseases and identify vulnerable regions under use of GIS mapping.	Dept. of Health and Family Welfare	Academic and research institutes	Rs. 240 Lakhs
Challenge 4. Drinking water quality is often compromised.			
207. Water utilities need to institutionalise rigorous quality assurance to ensure meeting of drinking water standards at consumer end.	Dept. of Urban Development	Water supply and sewerage boards Urban local bodies	Rs. 3540 Lakhs
		Total for Health	**Rs. 4450 Lakhs**

	Action	State coordinator	Collaborator	5-year budget
	8. Other intervention areas			
	Challenge 1. The current level of knowledge on the spatial dimension, time scale and magnitude of climatic changes is extremely limited. An accurate and quantitative in-depth understanding of probable climate change impacts emerges as critical need. In its absence the framing of long-term policy and appropriate adaptive measures remains severely impeded.			
208.	**Priority Action29**: Conduct extensive research on the spatial dimension, time scale and magnitude of climatic changes impacts so as to be able to make more accurate predictions about likely impacts of climate change in Karnataka (refer explanation at SAPCC, pages 201).	Dept. of Ecology & Environment (through EMPRI)	Academic and research institutes	Rs. 200 lakhs
	Challenge 2. There is no mechanism for sharing information on adaptation pilots, practices and experiences made across India. This being a very new field, the absence of systematic communication might lead to a situation where each state reinvents wheels starting from zero while the opportunities to build on each others' experience are foregone.			
209.	**Priority Action30**: Government of India to lead the systematic documentation and evaluation of adaptation practices in the country. Karnataka should designate a state nodal agency to provide relevant information on behalf of Karnataka and provide experiences made elsewhere (refer explanation at SAPCC, pages 202).	Dept. of Ecology & Environment (through EMPRI)	Ministry of Environment & Forests (MoEF)	Rs. 50 Lakhs
	Challenge 3. This present Action Plan is based on current understanding and published research, the underlying knowledge of which is subject to rapid evolvement. Without a regular review and updation, this Action Plan is bound to lose its relevance within a span of years.			
210.	**Priority Action31**: Establish a systematic review process for new scientific findings, new modelling results and changes in policy, legislation and incentives, leading to an updation Karnataka State Action Plan on Climate Change every 2 to 5 years (refer explanation at SAPCC, pages 203).	Dept. of Ecology & Environment (through EMPRI)	Academic and research institutes	Rs. 50 Lakks
			Total for other intervention areas	**Rs. 300 Lakks**
			Grand total	**Rs. 697189 Lakhs**

*** Departments concerned not indicated budget presumably it is a policy actionable points**

**** Departments concerned not indicated budget for the particular action point**

***** Karnataka State Pollution Control Board, Department of Commerce and Industries and Watershed Development Department indicated that they do not require any budget for the actionable points pertaining to them**

‡ Water Resource Department, Department of Rural Development and Panchayat Raj did not respond at all.

<End of list >

AN ABSTRACT OF SECTOR-WISE INDICATIVE BUDGET ESTIMATE FOR A PERIOD OF 5 YEARS'

Actionable points	Sector	Budget in lakh rupees
Agriculture		
Implementable action points	11	115620
Data management action points	7	5812
R and D action points	10	64589
Policy intervention action points	9	36450
Total	**37**	**222471**
Priority action points	5	1000
Horticulture		
Implementable action points	5	56197
Data management action points	2	7768
R and D action points	3	3363
Policy intervention action points	1	5584
Total	**11**	**72912**
Priority action points	1	7768
Animal Husbandry		
Implementable action points	4	0
Data management action points	2	350
R and D action points	5	0
Policy intervention action points	1	0
Total	**12**	**350**
Priority action points	2	0
Water resources		
Implementable action points	8	8175
Data management action points	1	0
R and D action points	7	150
Policy intervention action points	5	0
Total	**21**	**8325**
Priority action points	5	0
Forestry, Biodiversity and Wildlife		
Implementable action points	11	81173
Data management action points	7	4650
R and D action points	5	2382
Policy intervention action points	6	29018
Total	**29**	**117223**
Priority action points	3	26344

Actionable points	Sector	Budget in lakh rupees
Coastal Zone Management		
Implementable action points	5	1868
Data management action points	7	2950
R and D action points	12	668
Policy intervention action points	4	30
Total	**28**	**5516**
Priority action points	2	0
Energy		
Implementable action points	13	88292
Data management action points	4	57335
R and D action points	6	33060
Policy intervention action points	10	31225
Total	**33**	**203032**
Priority action points	8	45275
Urbanisation		
Implementable action points	12	55128
Data management action points	2	532
R and D action points	5	0
Policy intervention action points	5	70
Total	**24**	**62610**
Priority action points	1	0
Health		
Implementable action points	2	3540
Data management action points	2	400
R and D action points	4	260
Policy intervention action points	0	0
Total	**8**	**4450**
Priority action points	0	0
Other Intervention		
Implementable action points	0	0
Data management action points	1	50
R and D action points	2	250
Policy intervention action points	0	0
Total	**3**	**300**
Priority action points	3	0
Grand total	**206***	**697189**

*Action points for four (4) challenges are yet to define.