Rajasthan State Action Plan on Climate Change

Government of Rajasthan

The preparation of the action plan has been facilitated by TERI

Supported by GIZ

Disclaimer:

This report has undergone review by various government departments of the Government of Rajasthan and other stakeholders residing therein. Detailed discussions with concerned departments were conducted and besides a review of the strategies and proposed interventions, some departments also quantified the information by providing outlays of physical and financial targets. In some cases based on the information provided by the departments, the financial estimates for proposed actions under each sector have been estimated using certain assumptions.

Foreword

Climate change is the greatest global challenge facing us today which through a multitude of impacts poses a risk to our ecology, economy and society. Observation shows that changes being experienced in the climate of Rajasthan are over and above the natural climate variability prevailing in the region. Studies have shown that Rajasthan falls within areas of greatest climate sensitivity, maximum vulnerability and lowest adaptive capacity. Already, water resources in the State are scarce and have a highly uneven distribution both temporally and spatially. The State also has the highest probability of drought occurrence in the country. A threat such as climate change thus calls for timely and coherent policy response and action that will help reduce vulnerability and build resilience of the State to likely climate impacts.

I am pleased to know that the various departments of the Government of Rajasthan, with the help of a multi-disciplinary team of experts from TERI and support from GIZ have drafted the Rajasthan Action Plan on Climate Change.

I hope that the priorities identified under the Climate Change Action Plan will lead to sound implementation of strategies that will help to address the challenge of climate change in the State and ensure a future of sustainable development.

Preface

Statement

The priorities identified under the RAPCC are in coherence with the overall development perspective of the State and was developed by adopting an inclusive and collaborative process with extensive consultations with various departments of the Government of Rajasthan and other stakeholders. The RAPCC has been envisioned in concurrence with the guiding principles of the Rajasthan Environment Policy, 2010; Rajasthan Environment Mission, 2010; and the Climate Change Agenda for Rajasthan (2010-2014). The vision of Rajasthan Action Plan on Climate Change (RAPCC) is "to achieve sustainable development by reducing vulnerability to climate change impacts and enhancing resilience of ecological, economic and social systems in Rajasthan".

Acknowledgments

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List of Abbreviations

ACZ	Agro Climatic Zone
AFPRI	Arid Forest Research Institute
AFPRI	Arid Forest Research Institute
ANM	Auxiliary Nurse Midwife
ARS	Agricultural Research Stations
ASHA	Accredited Social Health Activist
AYUSH	Ayurveda, Yoga & Naturopathy, Unani, Siddha and Homoeopathy
BPL	Below Poverty Line
CAZRI	Central Arid Zone Research Institute
CBDR	Common but Differentiated Responsibility
CCAR	Climate Change Agenda for Rajasthan
CBOs	Community-based organizations
CDM	Clean Development Mechanism
CHC	Community Health Centre
CSP	Concentrating Solar Power
DLHS	District Level Health Survey
DMRC	Desert Medical Research Centre
DMRC	Desert Medical Research Centre
ET	Evapo-transpiration
GCM	Global Climate Models
GHG	Greenhouse Gases
HDI	Human Development Index
HDR	Human Development Report
ICDS	Integrated Child Development Services
ICT	information and communication technology
IDSP	Integrated Disease Surveillance Program
IGNP	Indira Gandhi Nahar Paroiyogna
IMD	India Meteorological Department
IMR	Infant Mortality Rate
IMSD	Integrated Mission for Sustainable Development
INCCA	Indian Network on Climate Change Assessment
IPCC	Intergovernmental Panel on Climate Change
IPD	In-Patient Department

KVK	Krishi Vigyan Kendras
MMR	Maternal Mortality Ratio
MoEF	Ministry of Environment and Forests
NAPCC	National Action Plan on Climate Change
NGOs	Non-governmental organizations
NRHM	National Rural Health Mission
NVBDCP	National Vector-Borne Disease Control Program
OPD	Out-Patient Department
PRIs	Panchayati Raj Institutions
RAPCC	Rajasthan State Action Plan on Climate Change
RCH	Reproductive and Child Health
RCM	Regional Climate Models
RGNDWM	Rajeev Gandhi National Drinking Water Mission
RHSDP	Rajasthan Health Sector Development Project
RSPCB	Rajasthan State Pollution Control Board
RRSC	Regional Remote Sensing Centre
RUIDP	Rajasthan Urban Sector Development Investment Program
SAPCC	State Action Plan on Climate Change
SRS	Sample Registration System
SWH	Solar Water Heating
SWRPD	State Water Resources Planning Department
UIDSSMT	Urban Infrastructure Development Scheme for Small and Medium Towns
UIG	Urban Infrastructure and Governance
ULW	unaccounted for water loss
UNFCCC	United Nations Framework Convention on Climate Change
VBDs	Vector Borne Diseases
VWSC	Village Water and Sanitation Committee
WRIS	water resources information system

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PART A

STRATEGIC APPROACH FOR THE PREPARATION OF RAPCC

Chapter 1 Introduction

1.1 India's National Action Plan on Climate Change (NAPCC)

Climate change is a global challenge with diverse implications at the national and sub-national levels, through impacts on various sectors such as agriculture, water resources, forestry & biodiversity, human health, energy and infrastructure. Such diverse impacts require a range of strategies to be deployed for an effective response and for better preparedness towards climate change. In 2008, a National Action Plan on Climate Change (NAPCC) for India was released by the Honourable Prime Minister. In view of the criticality of addressing the challenges posed by climate change along with the imperatives of poverty alleviation and economic growth for India, the NAPCC 'identifies measures that promote development objectives while also yielding co-benefits for addressing climate change effectively'. The focus of NAPCC is to improve the understanding of climate science, adaptation, mitigation, energy efficiency and natural resource management & conservation. The NAPCC, further sets eight priority missions to respond to climate change; these include National Missions on Solar Energy, Enhanced Energy Efficiency, Sustainable Habitats, Water, Sustaining the Himalayan Ecosystem, Greening India, Sustainable Agriculture and Strategic Knowledge for Climate Change, covering a range of response strategies.

1.2 Contextualising the Need for State Level Actions

There is a need to achieve synergy between national priorities and state-specific strategies, given that in many cases the actions being discussed are State subjects and have to be implemented in the States. While adaptation by its very nature is localized in action, mitigation actions taken at the state level can tap on the opportunities that the State can benefit from or follow a co-benefits approach simultaneously buttressing national mitigation efforts. In this context, it becomes crucial to prepare State level action plans on climate change in order to address current and future climate risks and tap on potential opportunities through a diverse set of response strategies. The first step towards preparation of a detailed State Action Plan on Climate Change (SAPCC) is to identify state-specific risks & impacts and opportunities in the context of climate change. Thereafter, prioritize areas for research & policy action in response to identified current & future vulnerabilities and projected impacts of climate change. Effective policy design could be laid by juxtaposing identified strategies with national priorities and Missions.

While the NAPCC provides a roadmap that can guide states to prioritize a set of strategies for the state, the Ministry of Environment and Forests (MoEF), has also developed a common framework that can facilitate the States to prepare their State Action Plans in line with the broad objectives of the NAPCC, and it includes the following steps:

- ***Conduct scientific assessment*** of climate observations and projections, sectoral impacts and vulnerabilities, and prepare an inventory of greenhouse emissions in the state in order to identify vulnerable regions, sectors and communities for targeted adaptation and mitigation action.
- ***Identify Adaptation/Mitigation options*** based on the Missions identified under the NAPCC, consideration of ongoing programmes and projects in the state, and

identification of additional strategies that may not be covered directly under the eight national Missions.

- ***Prioritize Adaptation/Mitigation options*** by taking into account the national policies, sectoral strategies under the national Missions and state level priorities, through multi-stakeholder consultations and interactions.
- ***Identify financial needs and sources*** to implement selected Adaptation/Mitigation options (MoEF 2010).

Table 1.1 presents guiding principles for the preparation of the SAPCCs as per the MoEF framework.

Table 1.1 Guiding Principles for Preparation of the SAPCCs (MoEF 2010).

Guiding Principles for Preparation of the SAPCC
• Implementing inclusive and sustainable development strategy that protects the 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 improve knowledge about appropriate responses
• Assessing impact of climate change on existing vulnerabilities, and Identifying and enhancing risk management tools for addressing climate change
• Setting out options and evaluating and ranking them according to criteria (cost-effectiveness, cost-benefit, feasibility, ease of implementation, "no-regrets", robust to different scenarios, incremental vs transformative change etc)
• Identifying and implementing state-planned and community-based voluntary/autonomous adaptation
• Building broader stakeholder engagement to maximize perspectives and involvement in implementation
• Addressing state-specific priority issues, whilst also creating appropriate enabling environment for implementation of NAPCC at state level
• Considering governance and institutional contexts and ensuring appropriate Institutional arrangements and building capacities, keeping in view the coordination, inter-departmental consultations, stakeholder involvement, and integration with regular planning and budgetary processes
• Estimating additional resource requirements and exploring existing and new & additional carbon finance potential
• Linking up with national policies and programmes for consistency and to identify financial or policy support that may be available

Though it is understood that the climate is changing, the nature of risks that are likely to emerge in the future is uncertain and the scale of impacts may vary from that being witnessed currently. The state-of-the-art scientific knowledge and in-depth impacts & vulnerability assessment and emission profiling faces a number of challenges in terms of expertise, institutional capacities and resource availability to conduct these exercises. Also, changes in the State's development path over time may have an impact on the degree of

resilience to the risks of climate change. Hence, the SAPCC needs to be a dynamic document that should follow a regular interactive and iterative process to reflect new knowledge and developments at the national, state and local levels.

For the realization of these actions at the State level, it is imperative for identified actions to be coherent with national priorities and the State's own development plans. Therefore, SAPCC could build on the existing policies of the State by taking into consideration the ongoing programmes and schemes being implemented at the state level and may consider new strategies in the light of climate change.

1.3 Rajasthan Environment Mission and Climate Change Agenda

Preparation of the Climate Change Agenda for Rajasthan (CCAR) was an important beginning given towards addressing climate risks that Rajasthan is the largest state in the country and that there are unique vulnerabilities associated with the state in terms of exposure to climatic extremes and varying capabilities to be able to respond to the likely risks, and opportunities that can be tapped on like harnessing solar energy. Rajasthan released a State Environment Policy (SEP) in 2010 identifying the key environmental challenges that the state must address to ensure continued sustainable development and economic growth that is equitable. The **Rajasthan Environment Mission** was constituted to bring into focus the high priority issues emerging from the SEP and CCAR, and mobilize government and non-government stakeholders to address these issues. Within the State Environment Mission, some sectors have been identified as being critical in terms of the climate change impacts on them. These include sectors such as human health, agriculture and animal husbandry, enhanced energy efficiency including solar energy, and strategic knowledge for climate change. Under the Rajasthan Environment Mission, the CCAR listed a set of state priorities for policy and action with respect to adaptation and mitigation for the time-period 2010-2014. The CCAR was guided by following principles:

- National Priorities highlighted in NAPCC;
- State-specific climate -related risks and opportunities; and
- Consultations with stakeholders (sectoral experts and officials from Rajasthan State Government departments, non-government, research institutions & academia).

State-specific missions for Rajasthan were developed highlighting research gaps and needs along with relevant policy measures, in light of the state's vulnerabilities and capacities. For each task force, certain research and development needs as well as supporting policy and regulatory measures were identified. Based on the guiding principles, the CCAR identified a list of strategies under the following seven state level Task Forces constituted under the concerned Principal Secretary/ Secretary of the Department:

1. Water Resources
2. Agriculture and Animal Husbandry
3. Forestry and Biodiversity
4. Human Health
5. Enhanced Energy Efficiency and Solar Energy

6. Urban Governance and Sustainable Habitats
7. Strategic Knowledge for Climate Change

A set of state priorities for policy, research and implementation with respect to adaptation and mitigation for the time-period 2010-2014 had been identified in the CCAR.

1.4 Rajasthan Action Plan on Climate Change (RAPCC)

The RAPCC builds on the key areas as identified under the CCAR by prioritizing urgent areas of action in a phased and time-bound manner and is in coherence with the Rajasthan State Environment Policy and Environment Mission. While the RAPCC primarily focuses on risk reduction and adaptation measures, it also looks into the co-benefits offered by specific strategies in the form of mitigation.

1.5 Task Force Constitution

To begin with, the State Government established a 'Climate Change and CDM Cell' in the Rajasthan State Pollution Control Board (RSPCB) to act as a nodal agency for dealing with all issues related with Climate Change in the State. The Cell had been constituted in April 2010 and had been involved in the drafting of the CCAR. A Steering Committee has been formed, headed by the Chief Secretary and Principal Secretaries of various Key Departments as Members to monitor the implementation of various actions proposed under the Rajasthan Environment Mission. The same task forces may be engaged in the implementation of the RAPCC. A brief description of the constituted task forces is provided below;

The State of Rajasthan has constituted a team to review the implementation of the Environment Mission. The composition of the Environment Mission includes the;

Chairperson: Chief Minister

Convener: Principal Secretary Environment

Members: Ministers of the under-mentioned departments, Chief Secretary, Principal Secretaries and Secretaries in-charge of the of the under mentioned departments

1. Environment
2. Forests
3. Mines and Petroleum
4. Industries
5. Water Resources
6. Command Area Development
7. Agriculture
8. Urban Governance
9. Transport
10. Energy, renewable energy
11. Science and Technology
12. Plan
13. Finance
14. Policy Planning

The Steering Committee is chaired by the Chief Secretary, headed by the Principal Secretary Environment and members from each designated department mentioned above. The Steering Committee includes participation from the non-governmental bodies. Role is to

review the implementation of each of the missions. For the implementation of the Environment Policy, Rajasthan Environment Mission and Climate Change Agenda task forces have been constituted for different sectors viz.,

1. Industry
2. Water
3. Forestry and Bio-diversity
4. Urban Governance and sustainable Habitat
5. Enhanced energy efficiency including solar energy
6. Strategic Knowledge for Climate Change

These Task forces have been developed under the chairmanship of respective principal secretaries/ secretaries, and concerned departments. Task forces for the sectors of agriculture and health are still to be constituted and are in discussion. Role of the task forces has been identified to develop concrete proposals for implementation of the various actions as indicated in the Mission document.

Chapter 2 RAPCC Vision and Approach

2.1 RAPCC Vision

"The vision of RAPCC is to achieve sustainable development by reducing vulnerability to climate change impacts and enhancing resilience of ecological, economic and social systems in Rajasthan".

2.2 Approach

Figure 2.1 suggests the broad methodological approach that was undertaken for the development of the RAPCC. The RAPCC largely dwells on the scientific know-how, experience of experts on the various response measures and the use of traditional knowledge systems as they apply in strengthening the cause for adaptation. The RAPCC has been developed in view of observed trends and future projections of climate variability and change while simultaneously considering current and future trajectories of socio-economic development in the State, conducted through detailed literature review and considering the existing scientific knowledge base. These climatic and non-climatic drivers define the current and future impacts and vulnerability profile of the populations, which also help in reconfirming the focus areas (identified as seven task forces) identified in the CCAR.

In light of these specific impacts and vulnerabilities, the strategic plan of action in these sectors has been put forth primarily by consulting experts and through consultations with the various government departments in the state. These consultations were conducted as interviews, focused group discussions and stakeholder workshops. For operationalization of the Plan, effort to put specific time-bound targets (physical and/or financial) along with identification of climate strategies or actions including research & development, technology needs, support from existing or new policy measures and institutional arrangements have been considered. This will however, be identified primarily by the government departments. The RAPCC has been prepared building on the adaptation priorities and mitigation co-benefits in the state while considering relevant ongoing policies and programmes in Rajasthan. The preparation of the RAPCC hence can be divided into four stages, as indicated in the MoEF framework:

Stage I: Assessment: Stage I focuses on developing a state profile highlighting the socio-economic and demographic trends and projections, observed climate data and projections, sectoral risks and impacts to climate variability and change and missions profile of the state through a review of scientific literature and policy documents and consideration of stakeholder perspectives (State government departments, non-governmental organizations (NGOs), community-based organizations (CBOs), research institutes etc.). To understand the state-of-the-art in terms of scientific research on adaptation issues in Rajasthan, a workshop was organized by the Rajasthan State Pollution Control Board (RSPCB) from 24-25 February 2011, on 'Science-Based Policy Options for Climate Change Adaptation in Rajasthan'. The focus of the workshop was adaptation given that climate change is already occurring and early actions are required to respond effectively. The workshop was also intended to identify opportunities for synergistic interaction among various stakeholders and provide recommendations for the development of the SAPCC. Key findings that emerged during the

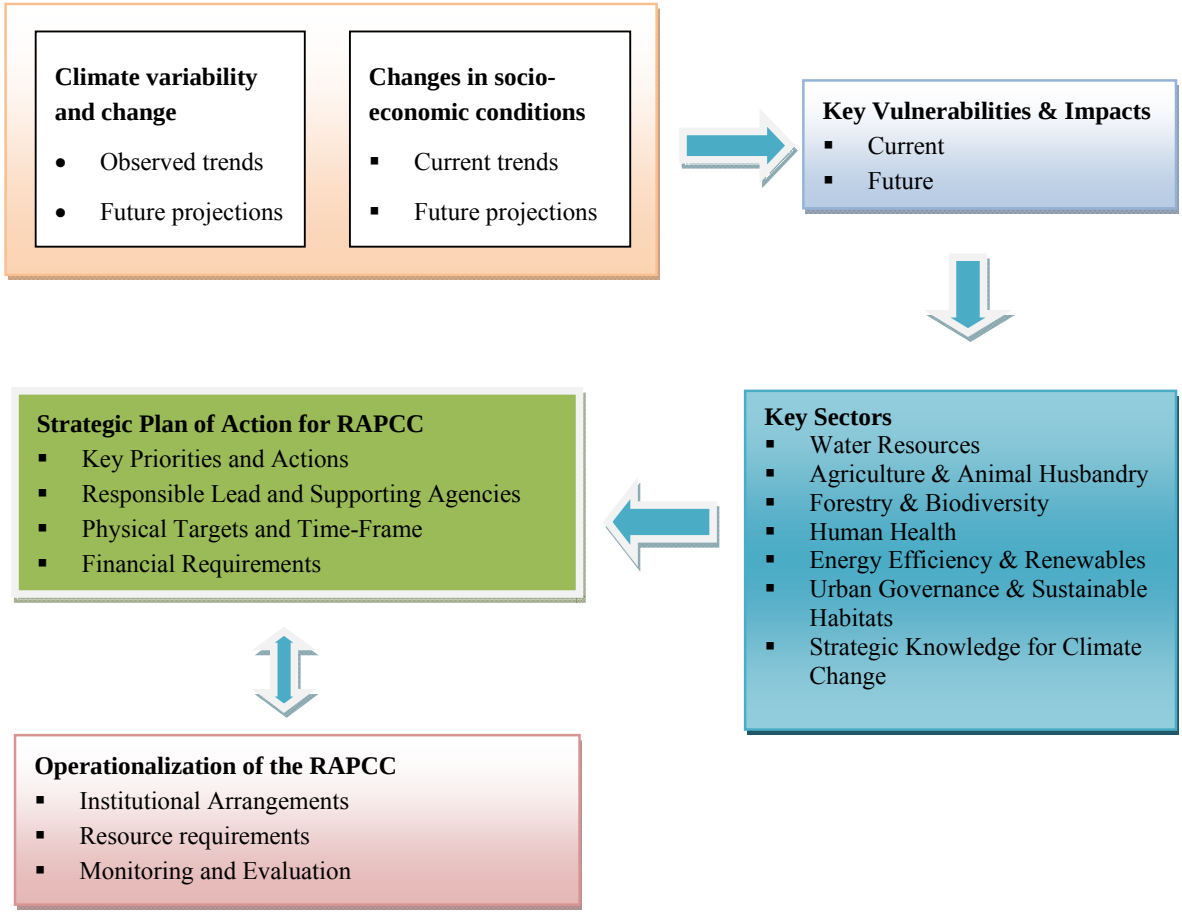
discussions in this workshop have been used to support the scientific basis for suggested action in various sectors as part of the Rajasthan SAPCC.

Stage II: Identification and priority setting: This stage focuses on identifying a set of adaptation needs and mitigation opportunities for Rajasthan, to deal with likely risks and impacts of climate variability and change.

Stage III: Implementation Plan: This stage focuses on setting targets, estimating the additional resource requirement, identifying capacity needs and institutional arrangements for implementation of these strategies, in consultation with the State Government departments.

Stage IV: Monitoring and Evaluation Plan: This stage focuses on developing a set of criteria and process to conduct periodic monitoring and evaluation (M&E) of the implementation and success of identified adaptation and mitigation strategies. Periodic M&E is essential to ensure that the strategies are being implemented properly, to certify that they are still considering and adequate to address the changing nature of climate risk and developmental patterns in the state, and to identify the need to modify the current design and implementation plan of these strategies, including introduction of new elements.

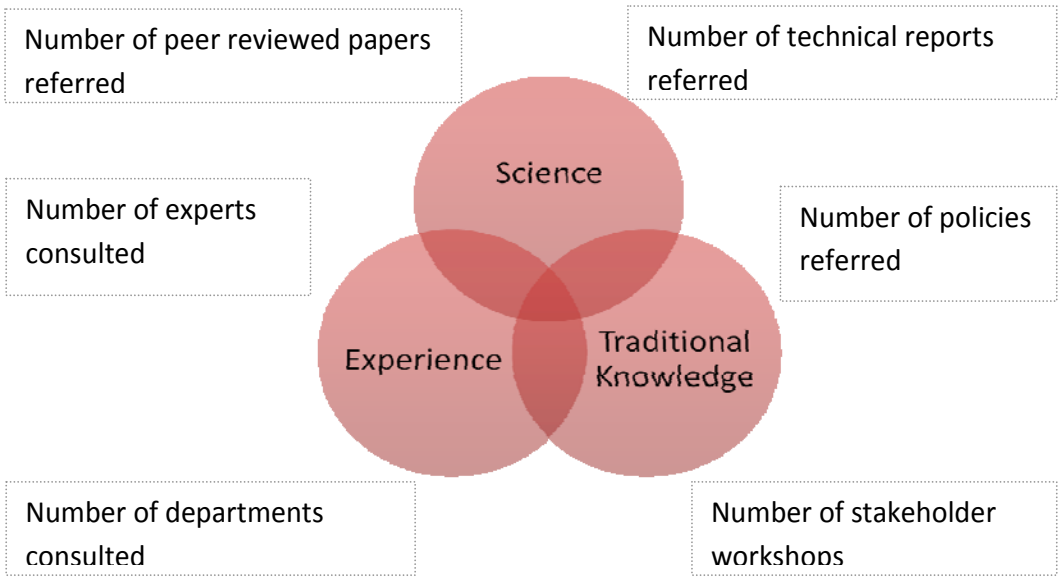
Figure 2.1: Rajasthan Action Plan on Climate Change: Approach



The RAPCC identifies action points/strategies in the context of climate change. These action points or strategies have been developed on the basis of existing scientific knowledge, rich

experience available in the form of existing work done in the state and the vast traditional knowledge that grounds the state. Figure 2.2 illustrates the interface for synthesizing scientific knowledge, experiential knowledge and traditional knowledge through review of vast amount of literature and synthesis of views from stakeholder consultations held for the development of the RAPCC.

Figure 2.2: Literature consulted and stakeholder engagement in the process of finalising the RAPCC



PART B

Rajasthan: Profile

Chapter 3 Rajasthan: Socio-economic Profile

3.1 State Overview

The State of Rajasthan is situated in the western part of India, which faces severe water scarcity, poor rainfall, and is classified as arid/semi-arid region. Administratively, the State comprises of 33 districts, 39753 inhabited villages, 249 Panchayat Samities and 9168 Gram Panchayats. Geographically, deserts in the State constitute a large share of landmass. The forest cover of the State contributes 4.19% to the national forest cover (Table 3.1). There are three major rivers flowing through Rajasthan, the Chambal, Tapi and Luni. The state is severely deficient in the most important resource, that is, water. With 10.4 percent of the country's area and 5.5 percent of its population, Rajasthan has only about 1 % of the country's water resources. On the basis of climatic conditions and agricultural practices, Rajasthan has been divided into 10 agro-climatic zones ranging from arid western to flood prone eastern. Rajasthan is the largest state of India, comprising 10.4 % of the country's total area. Nearly 76 % of the state's population resides in rural regions. Rajasthan produces 5.49% of the nation's total food grains production and 21.31 % of its oil seeds. The state has 49 million livestock—mainly cows, buffaloes, and goats—comprising 10.13 % of the country's livestock population.

Table 3.1 An overview of Rajasthan[1]

Sl No.	Indicators	Rajasthan	% of India
1	Area	3,42,000 sq. km.	10.4
2	Population	56.5 million	5.49
3	Rural population	43.2 million	5.8
4	Total forest cover	32,627 sq. km.	4.19
5	Gross cropped area	2,16,99,000 hectare	11.25
6	Net sown area	1,68,36000 hectare	11.87
7	Net irrigated area	62,94,000 hectare	10.46
8	Livestock	49 million	10.13
9	Food grain production	1,14,45,000 tonnes	5.49
10	Oilseed production	59,64,000 tonnes	21.31
11	Rainfall	57.5 cm (annual average)	

3.2 Rajasthan: Demographic Profile

The total population of the state is about 56.5 million. The population density of the state is 165 per sq. km. (compared to the country's average of 313 sq. Km) and it varies from as low as 13 per sq. km. in Jaisalmer district to as high as 471 per sq. km. in Jaipur. The decadal growth rate recorded during the previous decade at 28.41% is higher than the national level of 21.5 %. Over 76% of the population resides in rural areas. The number of females per 1000 males (sex ratio) in Rajasthan was 921 in 2001 and had shown an increase as compared to that in 1991 at 910. The future demographic projections (Table 3.2) suggest a further increase

[1] STATISTICAL ABSTRACT, RAJASTHAN, 2009. DIRECTORATE OF ECONOMICS AND STATISTICS, GOVERNMENT OF RAJASTHAN, JAIPUR, PP NO. 1–23.

of more than 100 per cent in total population of Rajasthan, suggesting increased population pressure in the State. Average life expectancy in the state is 62.0 years.

Table 3.2: Rajasthan: Population projections

S.No	State/District	2001	2021	2051
1.	Rajasthan	54940	82080	114180
2.	Ganganagar	3294	4980	7051
3.	Bikaner	1679	3091	5860
4.	Churu	1962	3036	4435
5.	Jhunjhunun	2008	3096	4497
6.	Alwar	2919	4514	6585
7.	Bharatpur	2040	2980	3990
8.	Dholpur	933	1383	1895
9.	Sawai Madhopur	2438	3600	4900
10.	Jaipur	6300	10696	17789
11.	Sikar	2393	3846	5874
12.	Ajmer	2014	2604	2866
13.	Tonk	1177	1634	2002
14.	Jaisalmer	474	852	1536
15	Jodhpur	2697	4026	5481
16.	Najaur	2739	4245	6099
17.	Pali	1680	2039	2023
18.	Barmer	1784	2618	3453
19.	Jalor	1401	2000	2530
20.	Sirohi	765	992	1088
21	Bhilwara	1877	2471	2767
22.	Udaipur	3431	4588	5249
23.	Chittaurgarh	1730	2225	2390
24.	Dungarpur	1084	1577	2038
25.	Banswara	1458	2196	2988
26.	Bundi	938	1317	1611
27.	Kota	2597	4001	5575
28.	Jhalawar	1128	1474	1606

3.3 Rajasthan: Economic Profile

Rajasthan's economy is predominantly agricultural and rural with fluctuations in the growth rate of the NSDP (Net State Domestic Product) because of the uncertainties in agriculture as it is almost entirely dependent on rainfall. The trend growth rate of the GSDP during decades ending 1991 and 2001 is estimated at 6.5 per cent and 6.1 per cent respectively. In spite of a marginal decrease to 5.1 per cent during 2000-06 the aggregate growth is still higher than the all India average putting Rajasthan among the three best performing states. The per capita growth in GSDP has been modest as the population growth at about 2.5 per cent per annum in the state has been the highest among the major states in India. The per capita average income of the state stands at 12003 rupees with Dungarpur, Barmer and Dholpur districts as the least per capita income. The year-wise estimates of the Gross/Net State Domestic Product (GSDP/NSDP) and Per Capita Income (PCI) since year 2005 at constant prices are provided in Table 3.3. Rapid reductions in poverty trends have been observed in the past three decades with poverty rates falling from an estimated fifty plus

percent in the 1970s to a mere 15.4% during 1999-2000. On the other hand, a rising trend in urban poverty levels has been observed.

Table 3.3: Estimates of the Gross/Net State Domestic Product (GSDP/NSDP) and Per Capita Income (PCI) 2005-2010 at constant prices2

Year	Constant (1999-2000) Prices (Rs Crore)		
	GSDP	NSDP	Per Capita Income (PCI) (Rs)
2005-06	110293	97277	15736
2006-07	124339	110039	17480
2007-08 P	135654	120267	18769
2008-09 Q	144568	128496	19708
2009-10 A	148200	131331	19806
P- Provisional; Q- Quick; A- Advance			

3.4 Rajasthan: Development Profile

Education, health, nutrition, family welfare, sanitation, water supply, roads etc are the basic social infrastructure that the population of a state requires. Although progress has been achieved in each aspect of social development, Rajasthan still lags behind in some of these indicators. Most of the districts in Rajasthan have low Human Development Index (HDI) values with Ganganagar (0.656), Hanumangarh (0.644), Kota (0.613), and Jaipur (0.607) being amongst the districts with high HDI value. Districts with HDI values less than or equal to 0.5 include Dungarpur (0.456), Barmer (0.461), Banswara (0.472), and Jalore (0.500). Budgetary allocations show that Power, Social & Community Services and Irrigation have the highest budgetary allocation in the 11th five year plan for the State. The major head-wise approved outlay for the 11th Five Year Plan (2007-2012) is as given in Table 3.4

Table 3.4: Major head-wise approved outlay for the 11th Five Year Plan (2007-2012) for Rajasthan

Development Sector	% share of Total Approved Outlay for 2007-2012
Agriculture and Allied Services	3.16
Rural Development	5.99
Special Area Programms	2.45
Irrigation and Flood Control	10.18
Power	35.70
Industry and Minerals	1.34
Transport	6.53
Scientific Services	0.04
Social and Community Services	27.49
Economic Service	1.02
General Services	6.10
Total	**100.0**

2 ECONOMIC REVIEW 2009-10, DIRECTORATE OF ECONOMICS & STATISTICS, GOVERNMENT OF RAJASTHAN

Most of the population lives in the rural areas and is highly dependent on agriculture and livestock rearing for their livelihood with more than 50 % of the total population as cultivators in the region. Agriculture is mostly dependent on rainfall which is scanty and mostly irregular. Development and availability of agricultural technology suitable for the state's agro climates, along with both the public and private investment in irrigation and a suitable price environment for the diversified crops helped improve agricultural performance during the 1980s and 1990s. As much as 62,94,000 hectare of land is irrigated in the state, which is 10.45% of the net irrigated area of India and 38% of net sown area of the state of Rajasthan. The state has a variety of soils that support cultivation of a diverse range of crops such as wheat, rapeseed, mustard, soy bean, millet, maize and cotton. A comparison of statistics from year 2007-08 to 2009-2101 indicate a decline in both *rabi* and *kharif* foodgrain production. People have also adopted alternate livelihoods since agriculture yields little in the face of repeated droughts. These include mixed cropping, animal husbandry, multiple occupations within a household and short term out-migration.

Also, there exists large number of female population employed in household handicraft industry. Cement, auto and auto components, IT, ceramics, mining, tourism, textile, agro-based industry, gems and jewellery, marble etc are the major industries present in the State. The State government is making large scale efforts to promote and facilitate industrial growth in the State. During the year 2009-10, RIICO has developed Special Industrial Parks, Theme Parks, 8 growth centres and mini centres in the State. Khadi and Village industries also play an important role in the economy of the State especially supporting rural livelihood. Rajasthan is also endowed with ample mineral resources. Energy is an important issue for the State government. The installed capacity as on December 2009 in the State was around 7716 MW. Rajasthan has around 5,585 km of National Highways, 11,758 km of State Highways and 7,673 km of major district roads. The road density in the state has increased from 54.6 km per 100 sq. km in 2008-09 to 54.9 km per 100 sq. km in 2009-2010. Under various schemes such as the Missing Link project and the Central Road Fund, new roads are being constructed to link all villages in the state.

As per the 2001 Census, Rajasthan recorded a literacy rate of 60.4 percent as compared to 38.6 percent in the year 1991, registering a net increase of 21.8 percent during the decade 1991-2001. The subsequent figures for male and female literacy rates are 75.7 and 43.9 percent respectively. As a result, the gap between literacy rates in the state when compared to the national aggregate has reduced from being 14 percent in the year 1991 to 4 percent in 2001. The drop-out rate in elementary education in the year 2004-05 was 65.34. Between 1993 and 2002, the primary Gross Enrolment Ratio (GER) increased from 89 percent to 97 percent, slightly above the national average of 95 percent, which increased to 120 percent in 2004. 33.13 Girls GER in primary education grew from 56 percent to 92 percent between 1993 and 2002 and are only one percent lower than the national average. The State Government is endeavouring to achieve the objective of total literacy through various programmes/schemes such as Sarva Shiksha Abhiyan, District Primary Education Programme, and Continuing Literacy Programme. Amongst the various districts, literacy is highest in Kota district.

From the health care perspective, the total number of hospitals has seen a decline from a total of 215 hospitals in 2003-04 to 126 in 2007-08. On the other hand, a number of community health centres in the range of 337-349 have come up in recent years which were lacking before 2005-06. This seems to reflect a favourable trend of increasing availability of local medical support in the state. However, such positive trends have been slow in case of

health indicators. Life expectancy has only marginally improved from 59.1 years during 1991-95 to 60.8 during 1997-2001. Broadly, northern and eastern districts of the state show little improvement in IMR and/or life expectancy at birth. The aggregate IMR declines from 85 in 1995 to 80 in 2001 and further to 67 in 2004. The rural IMR has declined from 90 in 1995 to 74 in 2004 while urban IMR observes a sharper decline from 62 in 1995 to 42 in 2004. One third of the women in 2005-06 are estimated to have lower than the normal Body Mass Index (BMI). More than half of the ever married women between 15 and 49 years are estimated to be anaemic while 80 percent of the children between 6 and 35 months are anaemic. Forty-four percent of children under three years of age are found to be under weight.

3.5 Summary

Given the wide variations in geography, natural resources, social structure, livelihoods patterns, infrastructure development and cultural beliefs within the State, it is important to take into account the local context while planning response strategies for a multi faceted threat such as climate change.

Chapter 4 Rajasthan: Climate Profile

4.1 Introduction

Since the beginning of industrial revolution human activities have led to unprecedented changes in the chemical composition of Earth's atmosphere. There is now credible evidence that shows that such changes carry significant potential to influence Earth's climate (Houghton et al., 2001), however owing to complex interactions within the climate system it is difficult to differentiate the characteristics of climate change associated with natural and anthropogenic forcings. From a pre-industrial value of about 280 ppm, the global atmospheric concentration of carbon dioxide (a greenhouse gas; GHG) has increased to 379 ppm in 2005. Similarly, concentrations of other potent GHGs like methane and nitrous oxide have also increased considerably on a global scale. According to the IPCC 4th assessment report (IPCC, 2007), 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 greenhouse gas concentrations. The AR4 concludes that discernible human influences have now extended to other aspects of climate, including ocean warming, continental-average temperatures, temperature extremes and wind patterns. Projected scenarios have also indicated rise in global mean temperatures in the range of 1.1 to 6.4^{o}C by 2100 (IPCC, 2007). The analysis from global instrumental records of over one and half century have revealed that that earth has warmed by 0.74 (0.56 to 0.92)^{o} C during the last 100 years, with 12 of the last 13 years being the warmest. According to IPCC AR4, the rise in temperature by the end of the century with respect to 1980-1999 levels would range from 0.6^{o}C to 4.0^{o}C.

4.2 Observed Climate trends Over Indian region

The annual mean temperature for the period 1901-2007 over India has shown a significant warming trend of 0.51^{o}C per 100 year (Kothawale et al., 2010). In the recent period of 1971-2007 accelerated warming have been observed, which has mainly been contributed by the warming in winter and post-monsoon seasons, which have increased by 0.80^{o}C and 0.82^{o}C in the last hundred years respectively. The all India maximum temperatures also have shown an increase trend in temperature by 0.71^{o}C per 100 year (Figure 4.1a). The all India minimum temperature also shows an increase in temperature by 0.27^{o}C per 100 years during the period 1901-2007 (Figure 4.1b). It has been found out that some of the metropolitan cities in India have recorded significant increase in minimum temperature during winter (Dhorde et al., 2009). For India as whole and in particular homogenous regions of East coast, West Coast and Indian peninsula show a significant increasing trend in frequency of hot days as well as decreasing trends in frequency of cold days during the pre-monsoon season over the period 1970-2005 (Kothawale et al., 2005).

It has been showed that during the last four decades the monsoon rainfall has been trend less (Partha Sarthy, 1984), particularly on all India Scale but trends in regional monsoon rainfall in the past century have been brought out (Kumar *et al.*, 1994). Trend analysis of 1-day extreme rainfall series based on the period 1951-2007, show that the extreme rainfall amounts are increasing at many places over India. State of Rajasthan also shows pockets of increasing trend in extreme rainfall during this period (Figure 4.2). An overall increase in extreme rainfall events and their intensities during the period 1901-2000 have also been observed (Partha Sarthy, 1984). The state of Rajasthan shows warming trends for maximum temperatures and a cooling trend for minimum temperatures.

Figure 4.1a & 4.1b: Spatial patterns of linear trends of (a) maximum and (b) minimum temperature Key: Red- warming trend at 5%; Blue- Cooling trend at 5%; Green- cooling trend; yellow- warming

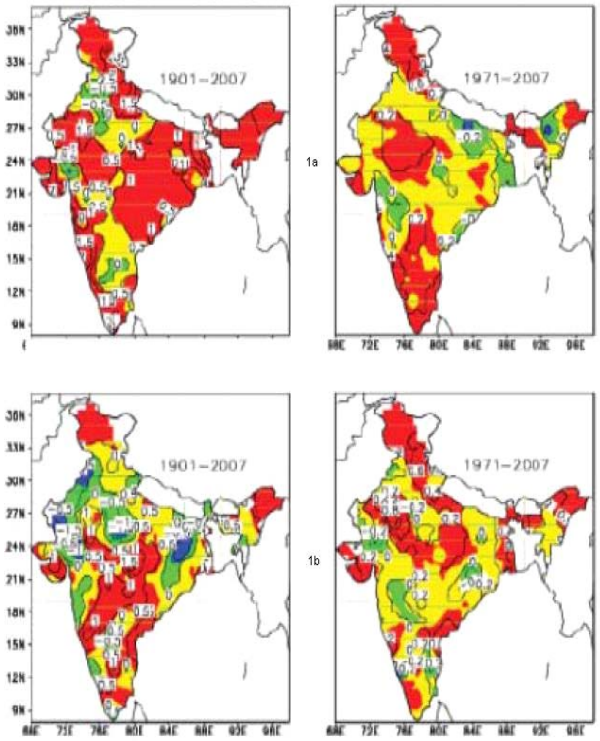
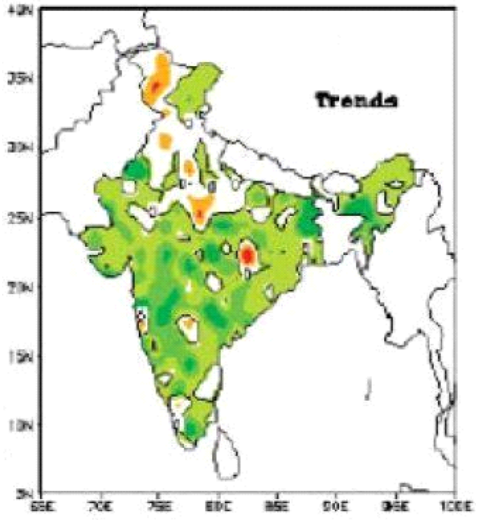


Figure 4.2: Trends in annual extreme rainfall. Dark green color indicates increasing trends and red denotes decreasing trends



4.2.1 Data and model projections used

The high resolution (1°X1° lat/long) IMD gridded data and station data from observatories has been utilized in most of the variability studies over Indian as well as Rajasthan region. The all India model projections for future climate stated in this chapter are generated by

PRECIS (Providing Regional Climates for Impact Studies, a high-resolution modelling system developed by the Hadley Centre, UK). The runs were made at 50X50 km resolution for various IPCC SRES scenarios.

SRES scenarios

A2 scenarios are of a more divided and independently operating world having self-reliant nations with continuously increasing population and regionally oriented economic development. A2 is characterized by slower and more fragmented technological changes and improvements to per capita income.

B2 scenarios are of an ecologically friendly divided world with slower rate of increasing population than in A2. Under this scenario the emphasis are on local rather than global solutions to economic, social and environmental stability with intermediate levels of economic development. B2 is characterized by less rapid and more fragmented technological change than in A1 and B1 (IPCC, 2000)[1].

4.3 Climate variability over Rajasthan

4.3.1 Baseline Observations

4.3.1.1 Rainfall

The average rainfall of Rajasthan is 574 mm compared to the all-India average of 1,100mm and a significant variation is seen across different regions. In the western Rajasthan, the average annual rainfall ranges from less than 100 mm in north-western part of Jaisalmer (lowest in the state) to over 400 mm in Sikar, Jhunjhunu, Pali region and along the western periphery of the Aravali range. In the eastern region, the rainfall ranges from 550 mm in Ajmer to 1020 mm in Jhalawar. In plains, Banswara (92.0cm) and Jhalawar (95cm) districts receive the maximum annual rain. The highest rainfall (1638 mm) is received at Mount Abu (Sirohi district) in the southwest region of the state. The annual spatially averaged rainfall is highly variable and it is most erratic in the western region with frequent dry spells, punctuated occasionally by heavy downpour in some years associated with the passing low pressure systems over the region (Rathore, 2004) (Draft: Disaster Risk Reduction, SAARC Disaster Management Centre, 2008). The number of rainy days during the South west monsoon period from June end to mid-September over Rajasthan varies from 10 in Jaisalmer to 40 in Jhalawar and to 48 in Mount Abu. The number of rainfall days during the rest of the year in different parts of Rajasthan range from 2.1 cm at Jaisalmer to 7.2 cm at Jaipur, distributed over 2.5 to 6 rainy days (Khan, 1988). During the rainfall deficit year of 2002, the state received just 220.4mm rainfall up to September, against the normal of 518.6mm in the overall monsoon. During this year, the monsoon was worst for Rajasthan in last 17 years as the state recorded a minimum of 220.4mm rainfall against the normal of 533mm. The maximum average rainfall of 726mm was recorded in 1996 and minimum 291.6mm was recorded in 1987 prior to 2002 (Goel and Singh, 2006).

4.3.1.2 Temperature

A gradual decreasing trend in mean annual temperature for the region of northwest India has been observed (Pant and Hingane, 1988). The maximum contribution to this decrease is

during the southwest monsoon (-0.52°C/100 years). An assessment on extreme weather events over India for the last 100 years has been done by De et al. (2005). Table 4.2 gives the frequencies of the occurrence of cold waves and hot waves in Rajasthan for different time periods. After Jammu and Kashmir, Rajasthan is the second state where maximum number of cold waves has occurred (De *et al*., 2005). On the other side, Alwar in Rajasthan (East) holds the record for the highest maximum temperature of 50.6°C (123°F) on 10 May 1956.

Table 4.2 Frequencies of the occurrence of cold waves and hot waves in Rajasthan for different periods

Rajasthan		
Period	Cold waves	Heat waves
1901-10	11	
1911-67	124	43
1968-77	7	1
1978-99	53	7
1901-99	195	51

Source :
1901-10: Annual Summary
1911-67: Bedekar FMU
1968- 77: Disastrous Weather Events Reports . Annual
1978 -99: WMO Bulletin October 2000, 49, 4, pp. 340 – 348

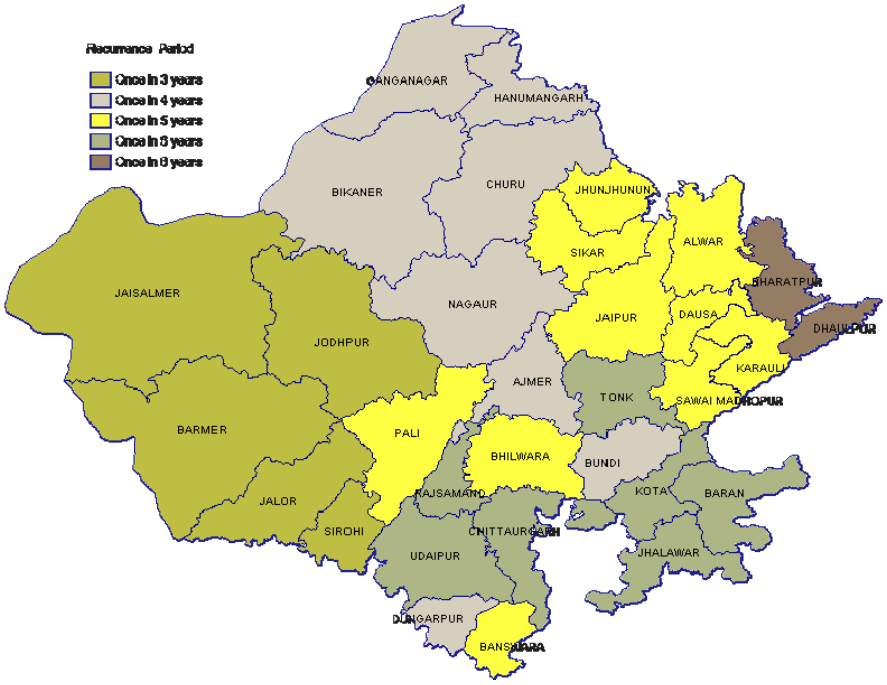
4.3.1.3 Extreme Events

Droughts

The perspective towards drought needs strengthening as its association as a phenomenon of arid and semi-arid areas is changing because even areas with high average rainfall often face acute water scarcity, for e.g., acute drinking water shortage in Cherrapunji and drought in Orissa (Rathore, 2004). For Rajasthan, there have been 48 drought years of varied intensity in the period 1901-2002, which means that the chance of occurrence of a meteorological drought in the state is 47% (Table 4.1) (Rathore, 2004). The state has the maximum probability of occurrence of droughts in India (RPCB, 2010). A detailed analysis has revealed that in only 9 out of these years none of the districts in the state were affected by droughts. This figure is even less at the village level. The number of severe and very severe drought years is larger in the western and southern districts of Rajasthan even though the southern region receives high average rainfall. Ray and Shewale et al (2001) estimated the percentage area in India affected by moderate and severe drought and found (based on data analysis of a 124 year time-period, 1875- 1998) that the probability of occurrence of droughts was maximum in West Rajasthan. The probability of moderate drought in Rajasthan was found to vary between 17- 24%, and between 2-14% in case of severe drought. During the year 2002 when about 29% of the total area of the country was affected by drought, the seasonal rainfall departure (%) for west Rajasthan and east Rajasthan were -71 and -60 respectively. Based on historical data the frequency of occurrence of droughts in the state varies district wise. The recurrence period (year) of once in 3 years is seen for the districts Barmer, Jaisalmer, Jalore, Jodhpur and Sirohi. For the recurrence period of once in 4 years is seen for

the districts Ajmer, Bikaner, Bundi, Dungarpur, Sriganganagar, Nagaur, Hanumangarh and Churu. For districts Alwar, Banswara, Bhilwara, Jaipur Jhunjhunu, Pali, Sawai Madhopur, Sikar, Dausa and Karauli the frequency of droughts are once in 5 years where as for Chittorgarh, Jhalawar, Kota, Udaipur, Tonk, Rajsamand and Baran the frequency is once every 6 years. The least drought occurring frequency of once every 8 years is seen for the districts Bharatpur and Dholpur. Figure 4.3 presents the above information. These conditions may however deteriorate in terms of severity of droughts in a projected climatic scenario with enhanced greenhouse gas conditions.

Figure 4.3: Map of Rajasthan showing drought frequency for different districts; Source: Disaster Management & Relief Department, Government of Rajasthan



District	Number of years with droughts of different intensity				% of all drought years in the period
	Very Severe	Severe	Moderate	Light	
Western Region	**12**	**12**	**11**	**11**	**45.0**
Barmer	4	15	17	11	46.0
Jaisalmer	6	12	13	17	48.0
Bikaner	8	12	16	10	46.0
Sri Ganganagar	9	9	12	18	47.5
Churu	8	11	8	17	43.1
Nagaur	2	17	15	15	48.5
Jodhpur	5	16	16	18	53.9
Pali	7	12	19	14	52.0
Jalore	7	13	13	20	48.1
NE Region	**12**	**8**	**11**	**16**	**46.0**
Sikar	5	20	11	14	49.5
Jhunjhunu	9	15	12	12	47.0
Alwar	7	16	10	15	47.0
Jaipur	10	11	16	9	45.5
Ajmer	6	16	21	13	45.5
Tonk	9	11	10	15	45.9
Swai Madhopur	8	8	14	21	50.0
Bharatpur	9	13	11	12	44.5
Southern Region	**10**	**12**	**9**	**12**	**42.1**
Bhilwara	3	9	10	14	40.0
Chittorgarh	10	12	9	13	44.0
Udaipur	10	14	14	6	43.5
Sirohi	5	17	10	21	53.0
Banswara	11	14	13	9	44.7
Dungarpur	9	16	10	5	49.5
Bundi	7	16	13	11	44.7
Kota	8	16	11	11	45.5
Jhalawar	8	13	14	8	43.8
All Rajasthan	**10**	**10**	**15**	**13**	**47.0**

Table 4.1 District wise frequency and intensity of droughts in Rajasthan during 1901-2002. (Rathore, 2004) (Based on district wise annual rainfall data)

Barring the districts of Banswara and Dungapur, all of the districts in Rajasthan come under high damage rise zone owing to high velocity winds. This is depicted in Figure 4.4. In July 1981, Rajasthan received abnormally heavy rain that caused flooding in Jaipur, Tonk, Nagaur and Sawai Madhopur. In July 1943, 50 inches of rain in one day was recorded on the hills of Mewar and Merwara. In August 2006, the usually drought prone Barmer district was hit by flash floods. Many people (about 1200) died in this flood. All these floods have resulted in unprecedented loss of lives and property. Apart from flooding from rainfall, river water flooding in Rajasthan has also caused havoc in past years. On 25th Aug, 1982 Dholpur in Rajasthan witnessed severe floods owing to river Chambal where the water level deviation was 14.21m over the danger level (DL) mark. The location map of flood prone areas for Rajasthan is seen in Figure 4.5.

Figure 4.4: Map of Rajasthan showing wind damage risk zones. Blue: high risk green: moderate risk (Disaster Management & Relief Department, Government of Rajasthan)

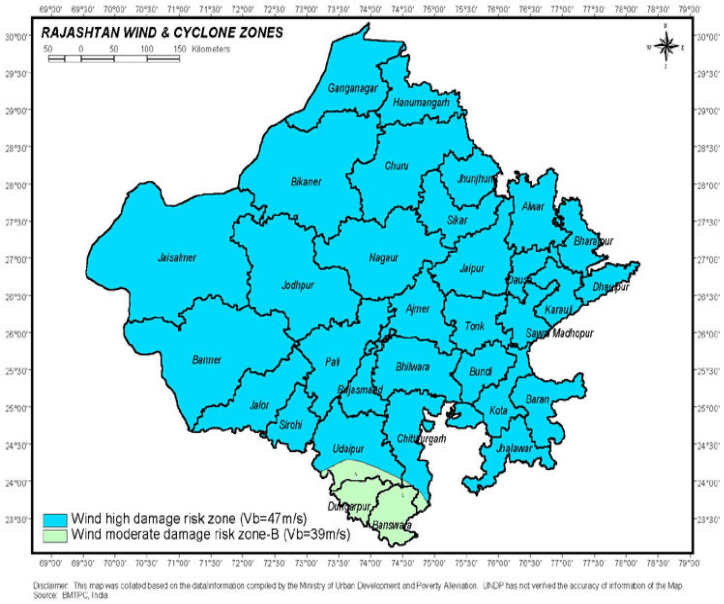
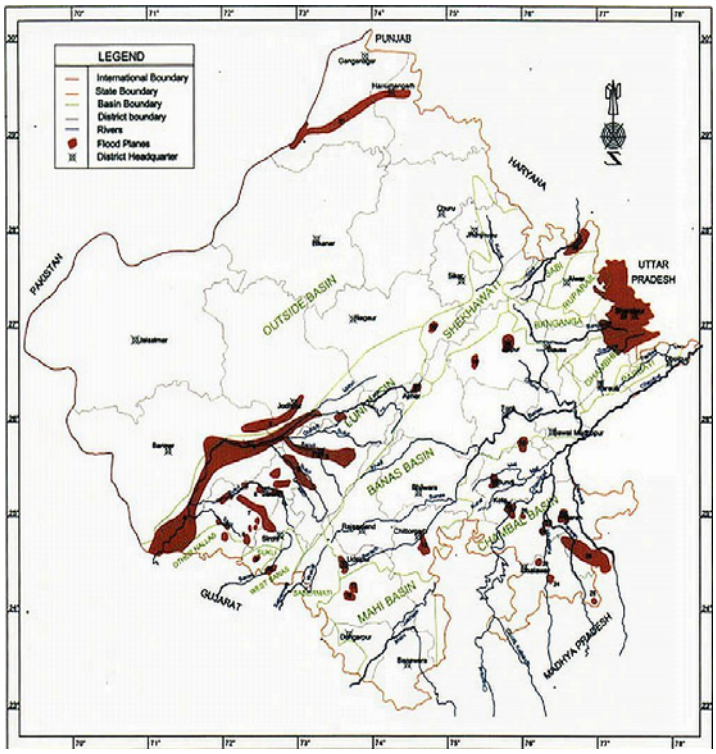


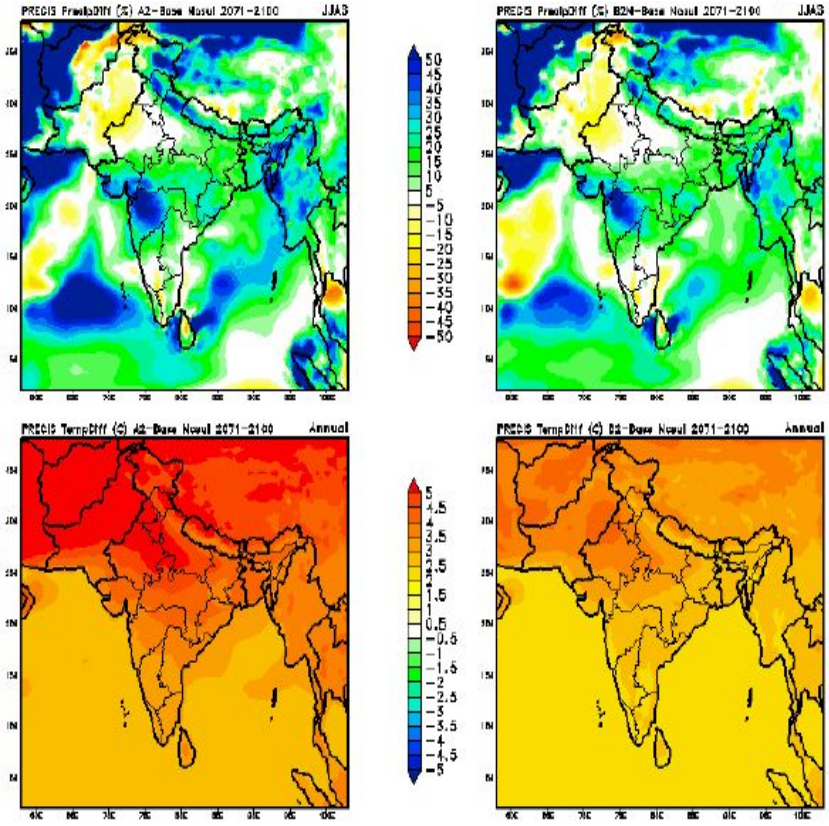
Figure 4.5: Map of Rajasthan showing locations of flood prone areas (Disaster Management & Relief Department, Government of Rajasthan)



4.3.2 Model Projections

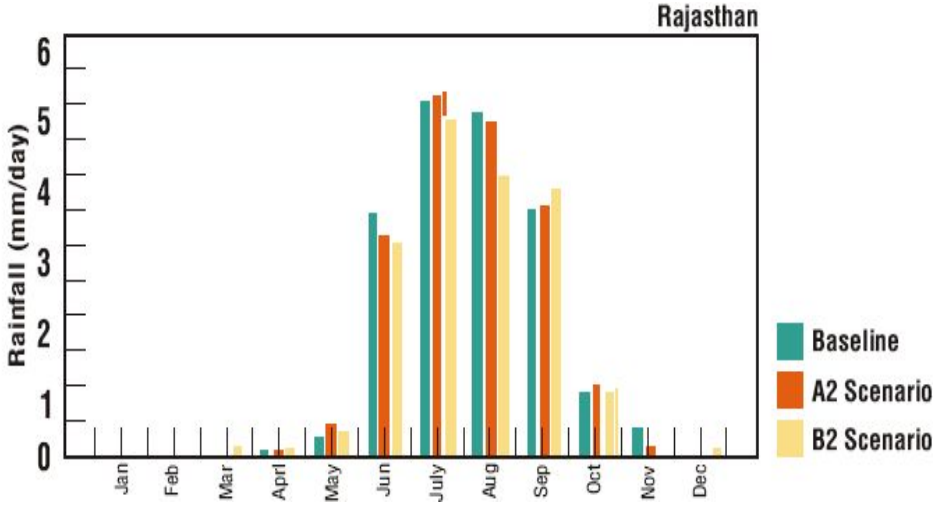
High resolution climate change scenarios for India, generated by PRECIS indicate a rise in annual mean surface air temperature for all parts of India. Temperatures are likely to rise by 2-5^{0}C and 2.5-4^{0}C in A2 and B2 IPCC SRES emission scenarios by the end of 21st century (2071-2100), with warming more pronounced over the northern parts of India. The warming is also expected to be relatively greater in winter and post-monsoon seasons than in the summer monsoon season. Spatial pattern of rainfall change estimates a 20% rise in all India summer monsoon rainfall for the future in both A2 and B2 scenarios as compared to present (SDC V&A Program, 2009). (Figure 4.6)

Figure 4.6: Projected changes in summer monsoon rainfall (upper panel) and surface air temperature (lower panel) for A2 and B2 scenarios for 2071-2100 (Kumar et al. (2006)).



The model projections for mean annual surface air temperature in Rajasthan indicates an increase by 2-4^{0}C for the 2071-2100 period. Mean annual rainfall is predicted to decrease slightly, whereas the extreme rainfall is expected to increase in frequency and intensity. Maximum 1-day rainfall is expected to increase by 20mm, and maximum 5-day rainfall by 30mm in the period 2071-2100 (SDC V&A Program, 2009). An overview of the projected changes in the annual rainfall cycle is shown in Figure 4.7.

Figure 4.7: Baseline and future (2071-2100) projections of mean annual cycles of precipitation for Rajasthan, as simulated by PRECIS (Kumar et al., 2006)



Regional Climate Modeling projections for Rajasthan using the A1B SRES scenario conducted for near-term of 2021-2050 project an increase in temperature by about 2-2.5^{o}C. The average rise in temperature in Rajasthan projected by 2035 is in the range of 1.8^{o} to 2.1^{o}c and maximum rise in temperature is projected for South Eastern part of the Rajasthan. These model runs indicate that minimum temperature rise will be much more than maximum temperature rise in Rajasthan. The model runs do not indicate any significant change in precipitation (Gopalakrishnan et al 2011).

Figure 4.8a District-wise projected increase in average temperature for Rajasthan in 2035 (Gopalakrishnan et al 2011)

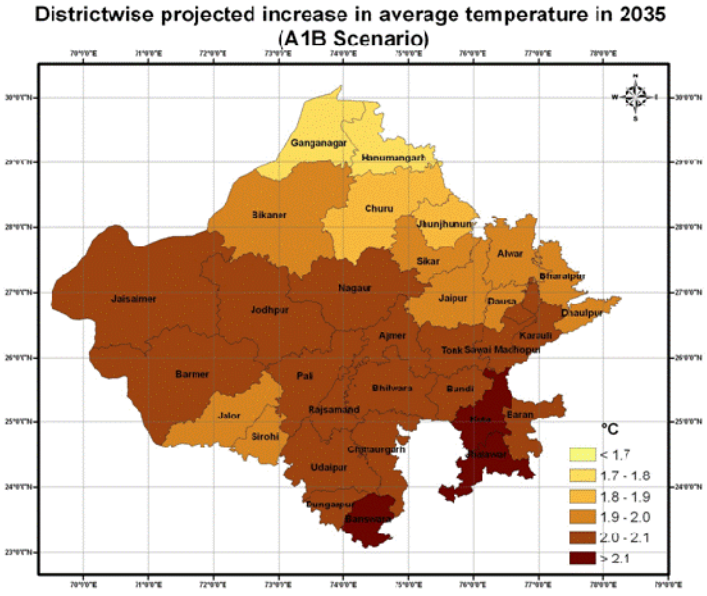


Figure 4.8b: District-wise projected increase in minimum temperature for Rajasthan in 2035 (Gopalakrishnan et al 2011)

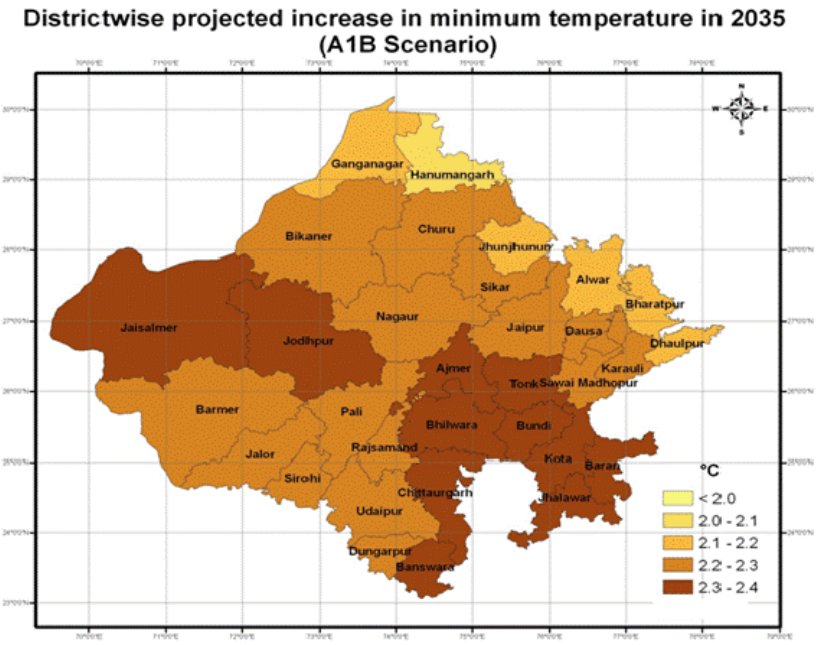


Figure 4.8c: District-wise projected increase in maximum temperature for Rajasthan in 2035 (Gopalakrishnan et al 2011)

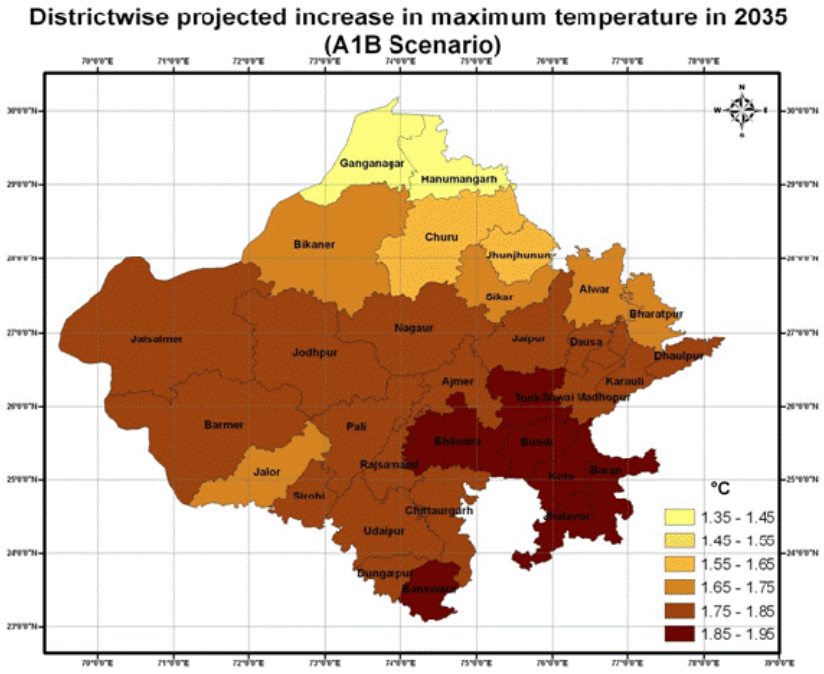
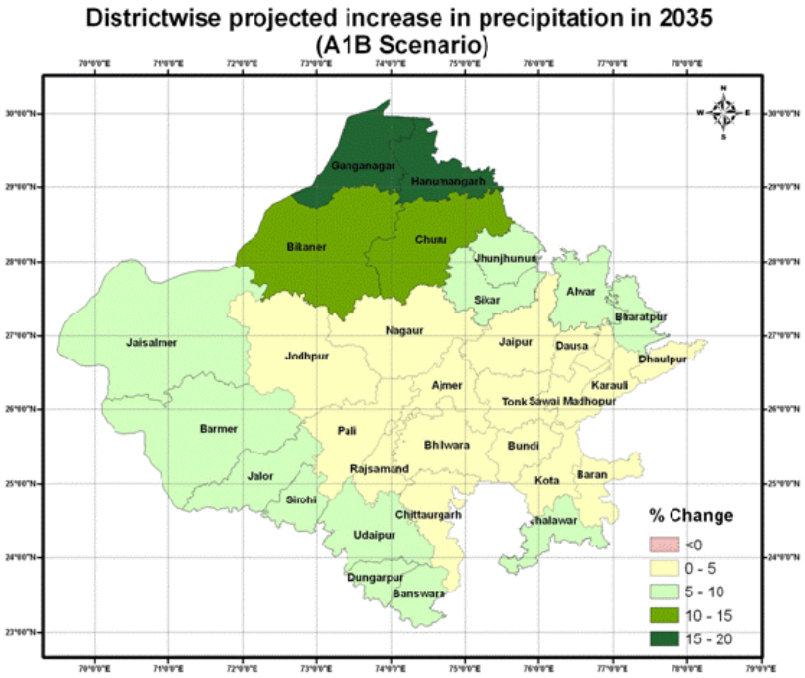


Figure 4.9: District-wise projected increase in precipitation for Rajasthan in 2035 (Gopalakrishnan et al 2011)



4.4 Summary

4.4.1 Rainfall Variation

Historical data for the state shows that in Western Rajasthan the average rainfall ranges from less than 100mm to over 400 mm whereas in Eastern Rajasthan the rainfall ranges from 220mm to 1020 mm. In plains districts of Banswara and Jhalawar and in the Southwest region, Mount Abu in Sirohi district receives the highest rainfall.

High variability is associated with the annual averaged rainfall spatially and is the most erratic in the western region with frequent dry spells, with occasionally heavy downpour.

The regional model estimates the mean annual rainfall to decrease slightly, but the extreme rainfall is expected to increase in frequency and intensity. 2071-2100 projections show an increase of 20mm for maximum 1-day rainfall and 30 mm for maximum 5-day rainfall.

4.4.2 Extreme Climate: Droughts and Floods

Observational records show that for over 100 years that the probability of occurrence of severe and very severe droughts is high over the Western Rajasthan region. Inspite of receiving high average rainfall the Southern districts of Rajasthan have also experienced large number of severe droughts in the past.

Many places in Rajasthan have witnessed flash floods due to heavy rainfall events. Floods in July 1981 in Jaipur, Tonk, Nagaur and in 2006 over Barmer are few examples. All these floods have resulted in unprecedented loss of lives and property.

Due to heavy rain downpour, flooding in rivers have been also observed over the state. Dholpur flood in Aug., 1982 is an example of flooding due to river Chambal.

4.4.3 Temperature Variation

The historical data (past 100 years) analysis for extreme weather events indicates Rajasthan to be the second state after Jammu and Kashmir where maximum number of cold waves has occurred.

A gradual decreasing trend in mean annual temperature for North West region over India has been observed during the southwest monsoon season in the past.

High resolution regional model projections for 2071-2100 have predicted an increase in annual mean surface temperature for all parts of India with an increase of 2-4^{o}C for the state of Rajasthan.

4.5 Future Studies

There are not many hazard risk mapping and climate modeling analysis studies available for Rajasthan. A further in-depth detailed study for extreme climate especially in terms of rainfall, temperature and wind extremes by the use of dynamic high resolution regional climate modeling is advised. Detailed ground-truthing has to be undertaken to study the effect of these extreme weather events at settlement level. While presenting any modeling output study a proper peer review should be carried out and uncertainty in data and model outputs should be reported. For validating the modeling outputs, high number of observations network is imperative and the data gaps associated with these should be addressed.

Chapter 5: Rajasthan: Mitigation Opportunities

5.1 Introduction

Global GHG emissions have grown since pre-industrial times, with an increase of 70% between 1970 and 2004 (IPCC, 2007). The largest growth in global GHG emissions in this period has come from the energy sector (an increase of 145%) while growth in direct emissions from transport in this period was 120%, industry 65% and Land Use Land Use Change and Forestry (LULUCF) 40%. Owing to the increasing emission trends and its implication on the future climate change, international community in its global response formulated the United Nations Framework on Climate Change (UNFCCC) and its Kyoto Protocol. The UNFCCC aims 'to stabilize of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system' and asks developed country to take the lead in combating climate change and sets emissions reduction targets for the developed countries. However, developing countries have no obligations given their developmental priorities and on the basis of the principle of Common but Differentiated Responsibility (CBDR). UNFCCC under its Kyoto Protocol provides for flexibility mechanism such as Clean Development Mechanism (CDM) to assist developed countries in achieving compliance with their emission reduction commitments and also assist developing countries in achieving sustainable development through technology transfer & finance. Therefore, mitigation actions taken at the state level can tap on these opportunities or follow a co-benefits approach, which builds on realizing synergies, at the same time buttressing national mitigation efforts.

5.2 India's Emission Profile

The net GHG emissions from India, that is emissions with Land Use Land Use Change and Forestry (LULUCF), in 2007 were 1727.71 million tons of CO_2 equivalent (eq) of which GHG emissions from Energy, Industry, Agriculture, and Waste sectors constituted 58%, 22%, 17% and 3% of the net CO_2 eq emissions respectively (INCCA Report, 2010). The energy sector emitted 1100.06 million tons of CO_2 eq due to fossil fuel combustion in electricity generation, transport, commercial/Institutional establishments, agriculture/fisheries, and energy intensive industries such as petroleum refining and manufacturing of solid fuels, including biomass use in residential sector. The agriculture sector emitted 334.41 million tons of CO_2 eq in 2007. Estimates of GHG emissions from the agriculture sector arise from enteric fermentation in livestock, manure management, rice paddy cultivation, and agricultural soils and on field burning of crop residue. The waste sector emissions were 57.73 million tons of CO_2 eq from municipal solid waste management, domestic waste water and industrial waste water management. The estimates from LULUCF sector include emission by sources and or removal by sinks from changes in forest land, crop land, grassland, and settlements. Wetlands have not been considered due to paucity of data. The LULUCF sector in 2007 was a net sink. It sequestered 177.03 million tons of CO_2. However, India's per capita CO_2 eq emissions including LULUCF are only 1.5 tons per capita in 2007. Given the low per capita emissions and India's developmental priorities, it is important for the State to follow

high development pathways without restricting its economic growth. However, the sector wise emissions profiling would help identify opportunities where in mitigation could be a significant co-benefit.

5.3 Rajasthan's Emissions Profile

Aggregate Greenhouse gas (GHG) emissions from the anthropogenic activities in Rajasthan in 1990 amounted to 18.6 million tons of the CO_2, 827.9 thousand tons of the CH_4, and 6.6 thousand tons of N_2O. In terms of CO_2 equivalent, emissions amount to 38.0 million tons[3]. According to similar estimates aggregate emissions from the anthropogenic activities in Rajasthan in 1995 amounted to 27.0 million tons of the CO_2, 1044 thousand tons of CH_4, 10.5 thousand tons of N_2O. In terms of CO_2 equivalent, emissions in 1995 amount to 52.2 million tons[4]. Rajasthan ranked 10th with 3.7 % of India's emissions in 1990 and ranked 9th with 4.2 % of India's emissions in 1995. On the sectoral basis, emissions were estimated from the energy sector, agriculture sector, industrial processes, waste disposal activities and from land-use, land-use change and forestry sector. Key districts with high emissions in 1990 include Ganganagar, Jaipur, Ajmer, Jodhpur, Nagaur, Udaipur, Chittaurgarh and Kota (Total emissions in the district in was greater that 1.5 million tons CO_2 equivalent). In 1995, Alwar, Sawai Madhopur and Bhilwara were also added in this category. Table 5.1 summarizes district wise emissions for these two years. These estimates were made in the context of the first national communication to the UNFCCC[5]. The only other estimates or updated information on the GHG emissions is for the year 2007 as part of the INCCA publication, India's greenhouse gas emissions 2007[6]. These estimates suggest that there is about 3% increase (CAGR) in 2007 as compared to 1994[7]. However, the study does not give state-wise estimates therefore similar estimates for Rajasthan are not available. **Some of the recent trends in activities that contribute to the GHG emissions are discussed in the following section with a view to identify opportunities which could enable the State to benefit from the existing international mechanisms such as CDM.**

Table 5.1 Emissions inventory for districts of Rajasthan for 1990 and 1995 (Ibid)

	District	CO_2	CO_2	CH_4	CH_4	N_2O	N_2O	NOx	NOx	SO_2	SO_2	CO_2 (Eq)	CO_2 (Eq)
	Year	1990	1995	1990	1995	1990	1995	1990	1995	1990	1995	1990	1995
	Unit	(MT)	(MT)	(Tons)	(Tons)	(Tons)	(Tons)	(Tons)	(Tons)	(Tons)	(Tons)	(MT)	(MT)
1	Ganganagar	0.81	0.65	46.9	63.4	0.63	1.36	6.3	7.1	7	4.1	2.03	2.43
2	Bikaner	0.33	0.38	27.1	35.1	0.09	0.09	2.5	3.6	2	2.3	0.93	1.16
3	Churu	0.26	0.22	26.5	37.5	0.13	0.12	2.2	2.5	1.7	1.5	0.86	1.06
4	Jhunjhunun	0.31	0.28	21.2	27.9	0.15	0.19	2.4	2.8	16.5	23.3	0.81	0.93
5	Alwar	0.41	0.5	34.5	43.7	0.34	0.54	3.9	5	3.1	4.5	1.26	1.61
6	Bharatpur	0.29	0.27	26.7	32.9	0.26	0.46	2.5	3	2	1.8	0.93	1.12
7	Dholpur	0.07	0.1	12.8	15.2	0.15	0.18	0.8	1.2	0.6	0.7	0.39	0.48

3 A.Garg P.R Shukla, (2002) Emission Inventory of India

4 Ibid

5 Ibid

6 INCCA (2007)

7 INCCA (2007)

	District	CO_2	CO_2	CH_4	CH_4	N_2O	N_2O	NOx	NOx	SO_2	SO_2	CO_2 (Eq)	CO_2 (Eq)
8	Sawai Madhopur	0.31	0.29	37.1	47.1	0.41	0.64	3.2	3.7	2.2	2	1.26	1.5
9	Jaipur	1.59	1.97	72.9	92.4	0.37	0.69	11.9	17.2	9.4	11.6	3.28	4.17
10	Sikar	0.3	0.29	29	36.1	0.16	0.26	2.7	3.1	2	1.8	0.96	1.14
11	Ajmer	1.26	1.63	30	40.3	0.15	0.23	4.8	7.1	5.5	7	1.94	2.57
12	Tonk	0.16	0.17	23	26.7	0.13	0.25	1.5	1.9	1.1	1.1	0.68	0.82
13	Jaisalmer	0.08	0.1	10.7	16.9	0.1	0.03	0.8	1.1	0.5	0.7	0.34	0.48
14	Jodhpur	0.81	0.98	32.9	44.9	0.24	0.32	6.3	8.4	5.5	6.9	1.57	2.04
15	Nagaur	1.01	1.17	38.1	47.3	0.21	0.39	4.4	5.2	4.4	4.8	1.9	2.31
16	Pali	0.32	0.44	29.4	36	0.23	0.38	2.7	4.4	2.3	3	1.01	1.33
17	Barmer	0.2	0.23	23	35.5	0.13	0.11	2.1	2.9	1.4	1.6	0.72	1.03
18	Jalor	0.22	0.33	19.8	24.3	0.15	0.28	2.3	3.8	1.5	2.2	0.68	0.94
19	Sirohi	0.66	0.87	10.4	12.4	0.09	0.18	2.1	3.6	2.5	3.5	0.9	1.19
20	Bhilwara	0.29	0.34	39.6	47.3	0.28	0.39	2.7	3.8	6.9	7.2	1.22	1.47
21	Udaipur	1.03	1.12	59.7	70	0.3	0.43	6.3	9.1	22.5	23.7	2.42	2.75
22	Chittaurgarh	3.24	4.44	38.5	43.2	0.54	0.58	6.4	9.3	11.3	15.1	4.22	5.55
23	Dungarpur	0.1	0.09	22	24.3	0.12	0.13	1.2	1.4	0.7	0.6	0.6	0.65
24	Banswara	0.14	0.13	28.6	30.9	0.34	0.4	1.8	2	1.1	1	0.85	0.91
25	Bundi	0.41	0.5	20.7	23.5	0.28	0.44	1.8	2.3	1.7	2	0.94	1.14
26	Kota	3.83	9.34	42.6	62.8	0.48	0.85	13	23.9	24.7	44	4.88	10.95
27	Jhalawar	0.14	0.14	23.6	26.8	0.18	0.35	1.3	1.8	1	0.9	0.69	0.83

5.3.1 Energy sector overview

The emissions from the energy sector largely are on account of combustion of fossil fuels and constitutes the major sources of emissions in all other sectors. There are three major sources of energy in Rajasthan i.e., (i) firewood or dung cakes in rural areas for cooking, heating, lighting; and in small scale industries (ii) electricity in several sectors i.e., domestic, industrial, agriculture, transport, and others (iii) petroleum products in transport sector; in captive power plants and domestic both in rural and urban areas (Kerosene and LPG).[8] The following section elaborates on recent trends in the state in electricity generation, transportation, commercial, residential, agriculture; fugitive emissions from coal and oil.

5.3.1.1 Electricity generation

The total installed capacity for electricity generation in Rajasthan is 7716.63 MW (as on December 2009)[9] . Of the installed capacity around 52.97 % is thermal, 19.14 % is hydel, 8.61 % is gas, 6.08% is atomic and approximately 13.19 % is renewable (wind and biomass). The main sources of power generation for the state are Kota and Suratgarh thermal projects, Dolpur Gas thermal projects, Mahi hydel, Wind farms, Biomass, Captive power plants, Bhakra, Vyas, Chambal, Satpura Interstate Partnership Projects. Besides this, the state also gets power from Rajasthan Atomic Power projects, Singroli, Rihand, Dadri, Anta, Auriya, Dadri gas plants, Unchahar thermal and Tanakpur, Salal, Chamera and Uri hydel projects from the central sector. Though the installed capacity has approximately doubled from 2000-01 in 2009-10, there exist supply deficit by around 20 %. According to the 17th Electric Power Survey Report, by the end of XII Plan (2016-17), the state will have an electricity demand of

8 State Of Environment Report For Rajasthan, (2007)

9 Economic review of Rajasthan, (2009-2010)

around 11400 MW[10]. Low energy efficiency is a major concern in the State. This is generally related with the inefficient devices, technologies, components, improper instrumentation, poor maintenance etc. Low efficiency results in more consumption of fuel resources[11]. Further, with the increase in temperatures, it is expected that there would be an increase in the electricity demands including the peak demand in Rajasthan. To meet continuously growing power demands of the state, the Rajasthan Power Generation Company has identified new power plants in the State with coal as a major option to enhance power availability in the State. At present, captive power plants (mostly diesel based), are used in the industries for dedicated power supply of around 500 MW[12]. Additionally, the state is now looking at renewable sources of energy such as Solar and Biomass. Rajasthan Renewable Energy Corporation Ltd (RREC) is the nodal agency for development of energy from renewable energy sources in the state as well as the state designated agency for promoting energy efficiency and energy conservation. The renewable energy projects could also be scaled up using mechanisms like CDM thereby also addressing energy security concerns.

5.3.1.2 Transport

Due to rapid economic growth, increase in tourism activities, and developmental growth in the state, there is an increased demand in the transportation services. Private vehicles have grown at a rapid pace in the state. The total number of vehicles registered in the state increased about six times from 1051343 in 1990 to 6993548 in 2009[13]. These vehicles mainly consume non-renewable fossil fuels, and are a major contributor of green house gases, particularly CO_2 emission. The total commercial energy consumption in the transport sector is estimated to be huge and includes fuels such as diesel, petrol, CNG, LPG etc. In India, transport sector emits an estimated 258.10 Tg of CO_2, of which 94.5% was contributed by road transport (2003–2004)[14]. Among all the states and Union Territories, Rajasthan contributes 15.17 Tg which is 6.22% of the India's emissions from the road sector. Growing private vehicles and lack of good public transport has led to increased emissions from the sector. The State has already initiated efforts like the Rail Metro system in Jaipur and the city buses in major towns, which could be supported by international mechanisms.

5.3.1.3 Residential/ commercial and agricultural/fisheries

Energy used in residential sector is primarily used for cooking, lighting, heating and household appliances. For cooking, LPG is the primary source in the urban areas while in rural areas biomass fuels such as fuel wood, crop residues, and animal dung continues to be the dominant fuel. In the commercial sector, key activities include lighting, cooking, space heating/cooling, pumping, running of equipments and appliances. Sources of energy

10 http://www.powermin.nic.in/generation/pdf/17th%20EPS.pdf

11 State Environment Policy, 2007

12 Interview with Dr. K L Jain

13 Statistical abstract, 2010

14 Emissions from India's transport sector: Statewise synthesis, T.V. Ramachandra , Shwetmala Atmospheric Environment xxx (2009) 1–8

include grid based electricity, LPG, kerosene, diesel, charcoal and fuel wood. Commercial and institutional sector also sees extensive use of captive power generation across the country due to frequent power shortages in various seasons. These power generation units generally run on diesel.

5.3.2 Industry

The industrial sector includes emissions from fossil fuel combustion and the emissions related to various processes to manufacture industrial goods. The share of industry in the GSDP at constant 1999-2000 price was about 30%. The annual growth of the overall index of industrial production (IIP), a measure of the absolute level and percentage growth of industrial production, has shown a steady increasing trend between 2005 and 2010. The important industries of the state include cement, mineral based industries, steel rerolling, textile dyeing and printing, brick and lime kilns and chemical. The industrial growth in the state is dominated by small scale industries. The industrial statistics reveal that while the numbers of large and medium scale industrial units have more or less remained same (378 units in 2001 and 384 units in 2006-07), small scale units have increased from 221,045 in 2001-02 to 320000 in 2008-09. As per data compiled by RIICO for the registered industrial units, only 10% of them are located in notified industrial areas, the rest are set up in non-notified areas lacking the necessary industrial infrastructure, making it difficult for the regulatory agencies to monitor them for their performance[15]. It is highly likely that these clusters would be using obsolete technology options due to unavailability of funds and low profit margins. There is however, lack of data on the emissions from the respective sectors and industrial clusters. The state government has been making persistent efforts for rapid industrialization of the state. During the year 2009-10, RIICO has developed Special Industrial Parks, Theme Parks, 8 growth centers and mini growth centers. Besides this, several special economic zones are being developed. Since the state is coming up with new clusters and growth centers which are essential for the progress of the state, it is important that proper planning is done in terms of landscape planning, utilization of renewable energy applications as applicable and energy efficient technologies amongst other.

5.3.3 Agriculture and Livestock

India's agriculture sector emitted 334.41 million tons of CO_2 equivalents, of which enteric fermentation constituted 63% and 21% of emissions, were from rice cultivation, crop soils 13% and remaining 2.7% is attributed to livestock manure management and burning of crop residue. The agriculture sector contributes 27% to Rajasthan's GSDP and is critical to the economy of the state. The contribution of animal husbandry to the GSDP is about 9.16%. More than 80% of the rural families keep livestock in their household to supplement their income and nutritional requirements. The GHG emissions from the agriculture sector are mainly in the form of CH_4. These are due to enteric fermentation and from rice paddy cultivation. N_2O is also emitted from this sector and is mainly from the agricultural fields due to application of fertilizers. Livestock is a major source of methane emission from agriculture. Rajasthan possesses the India's second largest livestock population of 49136

15 State of Environment Report, Rajasthan, 2010

thousand (10.13%), with a high degree of diversity in its composition. The total methane emission from Indian livestock, which includes enteric fermentation and manure management, was 11.75 Tg in 2003. Enteric fermentation accounts for 10.65 Tg (~91%) of methane emissions compared to 1.09 Tg (~9%) by manure management. Dairy buffalo and indigenous dairy cattle together contribute 60% of the total methane emission. Rajasthan contributed 9.1% of India's total livestock emissions (Chabbra et al 2009). The spatial analysis in GIS has identified a few districts like Udaipur and Jaipur, with total methane emission above 0.05 Tg (Chhabbra et al 2009). With a livestock population of 49.14 million in Rajasthan, emissions from enteric fermentation accounts to .98 (Tg) and manure management accounts to .09 (Tg). According to other estimates the contribution of the state is 8.68% to India's total[16]. India emitted 3.3 million tons of CH_4 in 2007 from 4 3.63 million hectare of rice cultivation. There are no state wise estimates of emissions from rice cultivation as emissions are function of the crop duration, water regimes and organic soil amendments. However, rice cultivation in Rajasthan is only approximately 1 % of the total area under cultivation. One of the factors responsible for emissions from agricultural soils is the human induced net N addition in the soil caused due to synthetic or organic fertilizers, deposited manure, crop residues and sewage sludge. Since, agriculture in Rajasthan is likely to face challenges due to increased production demand, use of fertilizers will increase. Apart from this other sources includes field burning of agriculture crop residue which is common in certain areas. However, there are no firm estimates of emissions from these sources.

In the agricultural sector, there exists a high potential for reducing these methane emission from livestock. Some of the options include improved nutrition and feeding method for large ruminants, replacement of roughages with concentrates and a change in composition of concentrates, modification in feeding like alkali/ammonia treatment of low digestibility straws, supplementation with molasses, urea nutrient blocks, defaunation through mineral/protein supplementation. If the modified feed intake results in less acetate and more propionate from rumen fermentation, it results in increase in the productivity of the animals as well as reduction of methane. However, as livestock is seen as a complimentary livelihood for poor farmers, the nutrient feed to should be cost effective. Research and development would be required for the same and also subsidies through local bodies/extension schemes would be needed. Better manure management and methane recovery techniques to generate energy could be used. Either manure can be kept under aerobic condition by turning the manure regularly to reduce emissions or methane can be used for energy generation or flaring. Revival of community Biogas plants could be a potential activity as besides mitigating emissions, it also supplies energy and manure. This further reduces emissions and local pollutants through substituting firewood for cooking, kerosene for lighting and cooking and chemical fertilizers. A study calculates mitigation potential of a family size biogas plant was 9.7 t CO_2 equiv. year−1. Same study estimates potential of 39189 thousand tons of CO_2 equivalent in Rajasthan with a potential of 4040 thousand biogas plants. Revival of the biogas plants is important for energy access especially in rural areas and will have other ancillary benefits like less indoor pollution, better sanitation, less exploitation of resources as fuel wood amongst others.

16 Current science, vol. 91, no. 10, 25 November 2006 1341

5.3.4 Land Use, Land Use Change and Forestry

As indicated in the previous section, land use land use change and forestry is a net sink as reported in the INCCA Report on GHG Emissions from India in 2007. While there are no net emissions from this sector, there are many opportunities that can be tapped in the forestry sector to sequester carbon. Under the Kyoto Protocol, there has been provision to use the Clean Development Mechanism and there is potential to use this mechanism to gain credits from the forestry sector. Also credits could be aimed at through the REDD plus mechanism.

5.3.5 Waste

About 6600 MT of municipal solid waste is generated per day in the state and dumped in low depressions[17]. The main greenhouse gases emitted from waste management is CH_4. It is produced and released into the atmosphere as a by-product of the anaerobic decomposition of solid waste, where-by methanogenic bacteria break down organic matter in the waste. Similarly, wastewater becomes a source of CH_4 when treated or disposed anaerobically. It can also be a source of nitrous oxide (N_2O) emissions as well due to protein content in domestically generated waste water. The greenhouse gases and their source categories include municipal solid waste disposal, domestic waste water disposal, and industrial waste water disposal. There are no estimates of emissions from this sector at the state level. Some of the options to reduce emissions from this sector include securing landfills, composting plants, and supporting waste to energy projects. These projects could be successfully implemented through making use of existing support mechanism. Capacity building of local bodies and municipalities for this purpose however is key.

5.3.6 Tourism

The state of Rajasthan is a major tourist destination in India promoting culture and nature based tourism through forts, architectural and heritage sites, temples, festivals, fairs and cultural events, wild life safaris, nature parks and forests, mountains etc. The state attracts around 25% of the total international tourists coming to India, and about 5% of the total domestic tourists, which in terms of numbers for 2008, was over 298 lakhs. The tourism though big source of revenue have been a reason for increased pressure on resources and especially energy. Measure to make the tourism low carbon should be promoted inevitably. Provision for offsetting the emissions of tourists by way of increased urban plantation could be promoted. The urban plantations would not only sequester carbon but also make the landscape more attractive.

5.4 Future Emissions

There are no estimates or studies for future emissions currently available for the state of Rajasthan. However, given that about 70 % of population is rural where energy access is still a challenge **it is imperative for the state to emphasise more on programs with an objective to consider co-benefits of such programs and tap international mechanisms for financial support.**

17 State of Environment Report, Rajasthan, 2010

5.5 Future Studies

There exists a need for GHG inventorisation and developing a GHG management plan in the state. An inventory of GHG estimations for the state of Rajasthan will serve as an important tool to assess key areas where the intervention is required and potential policies aimed at GHG mitigation. Further, spatial and sectoral analysis will identify hotspot areas or districts and hence facilitate decision making as to what gases to mitigate, how much mitigation is cost-effective for each gas, where mitigation actions should be located, when to mitigate and how to mitigate. It would also serve as benchmark for comparing the evolution of developmental strategies across regions and sectors. Further to the GHG estimations, future emissions scenarios for Rajasthan could be predicted using an optimization energy environment modeling framework. This will facilitate in long-term planning in identifying technological and policy choices today that would result in sustainable low carbon high growth development in Rajasthan. This will help avoiding the issue of stranded assets since the technology and investments in many sectors have long life span. However, it may be noted that mitigation beyond the optimum level may require fuel substitution or technology choices that are very expensive and hence an additional burden.

The GHG inventorisation process could further be extended to indicate levels of local pollutant emissions. This will facilitate understanding of the key areas where impacts of local pollutants are immediate on health for example. This would guide the Rajasthan Pollution Control Board to plan measures and generate other co-benefits. Integration of GHG management plan with existing plans and policies, targeting relevant sectors such as control of local pollution, energy & infrastructure planning, urban development and industrial development will be required to make the Plan consistent with Rajasthan's sustainable development and industrial policies.

PART C

KEY SECTORS

Chapter 6: Water Resources

6.1 Background

Climate change poses uncertainties to the supply and management of water resources. According to the IPCC (2007) "*Many semi-arid and arid areas are particularly exposed to the impacts of climate change and are projected to suffer a decrease of water resources (high confidence)*". Increase in temperatures can affect the hydrological cycle by directly increasing evaporation of available surface water and vegetation transpiration. These changes can consequently influence precipitation amounts, timings and intensity and indirectly impact the flux and storage of water in surface and subsurface reservoirs (i.e., lakes, soil moisture, and groundwater). Climate change can impact surface water resources directly through changes in the major long-term climate variables such as air temperature, precipitation, and evapo-transpiration. The relationship between the changing climate variables and groundwater is more complicated. Greater variability in rainfall could result in frequent and prolonged periods of high or low groundwater levels, and saline intrusion in aquifers (Singh and Kumar, 2010). The direct effect of climate change on groundwater resources depends upon the change in the volume and distribution of groundwater recharge.

Rajasthan covers 10.5 percent of the country's geographical area but shares only 1.16 percent of its water resources. It is the driest state with nearly 70 percent (2/3rd) of the area classified as arid and semi arid region. Rajasthan has always been a water deficit area. The average rainfall is 531 mm against national average of 1200 mm while desert areas have an average of 380 mm (State Water Policy, 2010). The rivers of the state are rain-fed and there is no perennial river in the state except Chambal. Water resources in the state are not only scarce but have a highly uneven distribution both in time and space with most of the available water resources been confined to south and south-eastern part of the State. The rainfall occurs only during two months of monsoon and the rainy days are very limited.

6.2 Current vulnerabilities

6.2.1 Limited Surface Water Resources

Surface water resources in the state are in a precarious situation. Except in canal command area in the north, surface water potential is very low in the central, western and southern parts of the state (CAZRI, 2009). Although the whole of Rajasthan is categorized as water-scarce (having per capita water availability below 1000 m3 year-1 Narain *et al.*, 2006), the condition in western Rajasthan is more critical. The west-central part of western Rajasthan is devoid of any drainage network and has scanty surface water resources, which adds to the problem. Additionally, replenishment of these water resources is also very poor due to low and erratic rainfall. Also, due to high atmospheric temperature and low humidity, a large part of the rainwater is lost as evapo-transpiration.

Total surface water available in the state is 21.71 BCM, out of which 16.05 BCM is economically utilizable. The state has so far harnessed 11.84 BCM which is 72% of economically utilizable portion (State Water Policy, 2010). Further there exists a huge deficit between the available water and demand. Per capita annual availability of water is about .000780 BCM against minimum requirement of .001 BCM. According to the International standards set up by IWS, availability of water below .001 BCM indicates water scarcity. The deficit between demand and supply is 8 BCM at present and likely to increase to 9 BCM by

2015 (State Water Policy, 2010). It is anticipated that the water availability would fall below .00045 BCM by 2050 against a national average of .001 BCM by the year 2050. Demand of water for irrigation is high and irrigation presently uses 83 per cent of total water resources of the state. With an increase in population along with water demand for non-agriculture purposes, the share of water for agriculture is set to reduce to 70 per cent by 2050 (ID&R, 2005). Correspondingly non-agricultural water demand which was 3.28 BCM in 1997 is expected to reach 5.05 BCM in 2015 and 8.07 BCM in 2045 (Water Resource Vision, 2045, GoR). This means the state will slip from scarcity to an absolute scarcity zone. The impacts of climate change will further impinge on this critical situation and act as an additional stressor.

Increased demand of water for various purposes has led to adverse effects on surface water resources like lakes in the state. The human settlements and public effluent sources are the chief factors for the degradation of lakes, particularly the urban lakes in Rajasthan (SEP, 2010) and have resulted in converting all urban lakes into hyper eutrophic state. For example, Udaipur is dependent on its lake system, which is directly, or indirectly the life source of the city in terms of surface water resources, tourism, and the ecosystem at large. Udaipur has most of its lakes in danger of irreparable degeneration (SEP, 2010). Water resources in Udaipur city are polluted due to disposal of sewage directly into surface drains or surface water bodies. There are two major sources of water pollution in the state: sewage water and industrial effluents. None of the towns in the State, except Jaipur have sewage collection, treatment and disposal system (SEP, 2010). CPCB has identified highly polluting industries in Rajasthan which includes textile, cement, distilleries, fertilizer, pharmaceuticals, and thermal power plants. Industrial water pollution in the state is found in Kota, Alwar, Udaipur, Jodhpur, Pali, Balotra, Sanganer, Bhilwara, Jhotwara and Bagru.

Another major issue regarding the use of surface water resources in the state is that of water logging which is prominent in canal command areas like those of IGNP (Indira Gandhi Nahar Paroiyogna). More than 60% of canal command area has sandy soils with poor water holding capacity (CAZRI, 2009). Nearly 50% of additional water applied in form of irrigation goes as deep percolation and joins groundwater. The problem of water logging has become more evident in recent years. The mean rate of water table rise varies from 1.1 m per year in Stage-I of IGNP to 0.81 to 0.85m per year in Ghaggar plain and Bhakra command, respectively, and 0.64 m per year in Gang canal command area (CAZRI, 2009). On the basis of annual rise in water table, it has been found that an area of 1456 km^2 has already turned critical (water table within 6 m of land surface) (CAZRI, 2009). However, a far more serious water logging problem could be encountered in Stage-II of IGNP in the future, owing to an underground hard substratum of gypsum within 10m depth. In about 34% area (1205 km^2) of the gross command area of 3544 km^2, water collected in low lying areas does not seep down (Rahmani and Soni, 1997). Due to capillary action, the water comes to the surface with dissolved salts and evaporates, leaving the salt behind, thus making the land saline. With research studies indicating that state surface water resources will get more limited in the future due to impacts of climate change, there is a need to manage and use the surface water resources more effectively and optimise the use of water rather than it being lost due to water logging.

6.2.2 Over-exploited Ground Water Resources

The surface water resources of the state are insufficient and the entire state is principally dependent on groundwater for its water needs (Rathore, 2006). A dominantly sandy terrain

and disorganized drainage network (drainage density is as low as 0.3 km km^{-2}), and recurring droughts constantly exert pressure on already meagre groundwater resources. The stage of groundwater development has exceeded 100% in Barmer, Jalore, Jhunjhunu, Jodhpur, Nagaur, and Sikar districts (CAZRI, 2009). The number of safe blocks has been significantly reduced because of scanty rainfall and over exploitation of groundwater resources mainly for irrigation purposes.

Nearly 90 percent of the drinking water and 60 percent of the water required in the agriculture sector is extracted from ground water reservoirs (GOR, 2009). This heavy withdrawal has led to over exploitation and critical condition of ground water tables. Nearly 80 percent of ground water is now witnessing depletion (State Water Policy 2010). Mall et al. (2006) highlight that scanty and irregular rainfall conditions have resulted in poor recharge to groundwater as compared to its extraction. In Western Rajasthan due to increased overdraft of groundwater from all the potential regions recharge to the aquifer during normal rainfall periods is inadequate, especially because of the sporadic rainfall distribution patterns and the terrain characteristics, with a major portion of the precipitation being lost as runoff or through evaporation (Rathore, 2005).

The stage of ground water exploitation which was 35 percent in 1984 has reached a level of 138% in 2008 (State Water Policy, 2010). Also out of the 237 blocks only 30 are in safe category and the number of over-exploited blocks has increased from 140 to 164 from 2004 to 2008 (Table 6.1). According to the latest NASA satellite data the ground water levels in northern states of India including Rajasthan have been declining at the rate of 33 cm per year over the past decade (SDC, 2009).

Category	1984	1988	1998	2001	2004	2008
Over-Exploited (>100%)	12	44	41	86	140	164
Critical (90 to 100%)	11	18	26	80	50	34
Semi Critical (70 to 90%)	10	42	34	21	14	8
Safe (<70%)	203	122	135	49	32	30

Table 6.1: Ground Water Status of Blocks[18], *Source: State Water Policy, 2010*

Table 6.2 highlights that almost in each river basin the groundwater table is categorized as over exploited, except Mahi, West Banas and Sabarmati basins where it is in critical/semi-critical stage.

Basin	Potential zone (sq. km.)	Net annual availability	Gross for irrigation	Gross for domestic/industrial use	Gross for all use	Allocation for dom./ind l use as on 2025	Net GW available for irrigation	Stage of GW development, %	Category
Shekhawati	9495.20	503.8462	972.1902	111.5795	1083.7697	243.4481	-468.1225	215.1	Over exploited
Ruparail	942.30	347.3004	418.6182	55.2695	473.8877	72.2153	-143.533	136.45	Over

18 Draft Annual Plan (2011-2012), Department of Water Resources. Online. Available at : http://www.planning.rajasthan.gov.in/Annual%20plan_1112/chapters/pdf/chap_12.pdf. Accessed on 27th February 2011, Government of Rajasthan

									exploited
Banganga	6593.35	605.8966	813.9884	90.2855	904.2739	143.8773	-351.969	149.25	Over exploited
Gambhir	3615.57	349.2411	409.1767	46.7283	455.9051	73.2904	-133.2261	130.54	Over exploited
Parwati	4879.94	153.5688	186.1281	18.0913	204.2194	28.6049	-79.2555	132.98	Over exploited
Sabi	400.48	426.1719	644.216	43.9114	688.1274	64.2581	-282.3022	161.47	Over exploited
Banas	41089.68	2290.853	2814.7422	389.1081	3203.8503	794.9698	-1318.859	139.85	Over exploited
Chambal	27751.94	1921.567	1966.2914	135.399	2101.6905	280.2566	-324.9812	109.37	Over exploited
Mahi	12062.20	528.3994	439.3851	36.8787	476.2732	109.7902	-20.777	90.14	Critical
Sabarmati	1056.57	80.4701	65.7375	4.8663	70.6038	20.8108	-3.7772	87.74	Semi critical
Luni	24547.64	1039.594	1567.0464	119.0169	1686.0633	234.9463	-762.3988	162.18	Over exploited
West Banas	1186.74	75.5004	64.8149	3.4235	68.2385	6.7468	3.9385	90.38	Critical
Sukli	867.20	47.8323	53.0038	0.9764	53.9801	2.0709	-3.9517	112.85	Over exploited
Other Nala	1749.51	100.4201	249.778	8.8426	258.6206	15.7973	-165.1552	257.54	Over exploited
Outside	80329.77	2063.497	2317.3663	463.1662	2780.5325	688.9201	-942.7896	134.75	Over exploited

Table 6.2: Basin wise availability of groundwater, *Source:* SWRPD, Govt, Of Rajasthan

Future projections of ground water utilization by CAZRI (2009) present a grave situation for the arid regions of the state. The stage of groundwater development is likely to reach 189.1, 221.4 and 259.1% in the year 2015, 2020 and 2025, respectively.

Projection	**Year**			
	2010	2015	2020	2025
Utilizable groundwater recharge (mcm)	3519	3519	3519	3519
Net ground water utilized (mcm)	5685.43	6655.22	7790.42	9119.25
Balance groundwater (mcm)	-2166.43	-3136.22	-4271.42	-5600.26
Groundwater development stage (%)	161.56	189.12	221.38	259.14

Table 6.3: Projected ground water scenario for arid Rajasthan, Source: CAZRI, 2009

6.2.3 Deteriorating Water Quality

The quality of ground water has also progressively deteriorated. Over-extraction of ground water has brought adverse changes in the geochemistry of water. Natural contaminates such as fluoride, nitrate, and chloride salts are increasing in concentration in ground water

making it unfit for drinking and posing risk to health[19]. Rajasthan accounts for 51 percent of fluoride and 42 percent of saline affected areas in the country (Reddy 2010) (Table 6.4). More than 75% of the villages and habitations are affected by poor quality water, affecting 20 million people in the state. Based on the WHO guidelines for drinking-water quality, about 56% of the water sources are un-potable (GOR, 2005)[20]. Climate change will further increase ground water extraction due to less availability of surface water and rising demand which could further deteriorate ground water quality and have serious effects on health of people.

High levels of	Villages/Habitations affected	Names districts
Salinity	21,190	Churu, Bharatpur, Barmer, Jhunjhunu, Nagaur and Ajmer
Fluoride	11,909	Jaipur, Tonk, Nagaur, Ajmer, Bhilwara, Sirohi and Pali.
Nitrate	20,659	Jaipur, Nagaur, Barmer, Udaipur, Jodhpur, Churu, Alwar and Tonk.

Table 6.4: Districts affected by salinity, high fluoride and nitrate in ground water

6.2.4 Low Water Use Efficiency

Water use efficiency is very low in the state and unaccounted for water loss (ULW) is very high. As mentioned earlier about 83 per cent of the water is used for irrigation and of this, 65 per cent is surface water; losses in surface water irrigation are much higher as compared to those in ground water irrigation (SEP, 2010). Thus, about two-thirds of the water used for irrigation is affected by inefficiency. High cost of service, low cost recovery and low level of expenditure on O&M reduce the water use efficiency. Also, the water rates do not convey a sense of scarcity among the stakeholders, thereby leading to increase in water losses and thus inefficiency (SEP, 2010).

6.2.5 Weak Sectoral Policies

Sectoral policies like subsidies for irrigation (power, pumps) and other inputs in agriculture sector indirectly have adverse impact on water resources. The environmental cost arising out of wasteful water use practices are not internalised. The farmers at the head end region of irrigation projects tend to over irrigate and also shift their cropping patterns towards water intensive crops, exerting pressure on limited water resources of the state. The demand for increase in agricultural production has led to increased use of chemical /inorganic fertilizers, pesticides, high yielding varieties and mechanization of agriculture. The use of chemical fertilizers has been steadily increasing. This has lead to water pollution and causing water quality problems having repercussions for human health (SEP, 2010).

19 Draft Document, State Rural Drinking Water & Sanitation Policy, Government of Rajasthan, August , 2005

20 Sector Policy for Drinking Water and Sanitation, 2005. Online. Available at: http://rajwater.gov.in/sprdws.pdf. Accessed: 12th February, 2011. Department of Water Resources, government of Rajasthan

6.2.6 Recurrent Droughts

The state of Rajasthan has the maximum probability of occurrence of drought in India, with recurring droughts in 3–4 years in a cycle of 5 years (Mall et al., 2006) and this condition may deteriorate in terms of severity of droughts in Rajasthan (RPCB, GoR, 2010). It can be inferred from Figure 1 that except Churu, all districts observe drought once in a minimum of five year. Sinha Ray et al (2001) using rainfall data from 1875 to 1998, have estimated the percentage area of the country affected by moderate and severe drought, thereby highlighting that in the 124 years time period considered, the probability of occurrence of drought has been found to be maximum for West Rajasthan. Further the probability of moderate drought varies from 17 to 24%, whereas the probabilities of severe drought varies from 2 –14% (Gore et al., 2010). Climate is projected to increase drought occurrence in the state which would impact not only water resources but also have a cascading effect on other dependent sectors. For pastoralists and agro-pastoralists whose livelihoods and food security depend on livestock, drought conditions can cause malnutrition or disease in livestock because of insufficient fodder and deterioration in pastoral lands.

6.3 Likely Impacts of Climate Change

As highlighted above the present water resources of Rajasthan are not enough to cater to the needs of the population, including agriculture and non- agriculture demands and climate change will act as an additional stressor. Rajasthan is likely to experience water shortage due to an overall reduction in rainfall (RPCB, GoR, 2010). According to preliminary assessments as part of India's first national communication (GoI, 2004) and a study on hydrologic modeling of the river basins (Gosain et al. 2006), it can be inferred that under the considered GHG scenarios, severity of droughts in some parts of the country would increase along with an enhanced intensity of floods in other parts of the country, however there would be a general overall reduction in the quantity of the available runoff. Further the study brings forth that Luni along with the west-flowing rivers of Kutch and Saurastra which occupy about 60 per cent of the area of Rajasthan shall face acute water stress conditions, also the river basins of Mahi and Sabarmati are likely to experience constant water scarcities and shortage (GoI 2004).

Changes in the climate will have an adverse effect on hydrological cycle. Changes in evapo-transpiration (ET) - a major component of hydrological cycle will affect crop water requirement and future planning and management of water resources. According to, Kumar et al. 2006, even though a 20% rise in all-India summer monsoon rainfall is projected, in Rajasthan the overall rainfall is projected to decrease, and evapo-transpiration to increase, due to climate change. Evaporation accounts for over two third of water losses from surface water bodies in hot arid regions. Increase in evapo-transpiration (ET) for the state of Rajasthan has been identified as one of the key impacts on water resources due to climate change (Mall et al., 2006). The normal average annual evapo- transpiration of Rajasthan is estimated as 1701 mm (CAZRI, 2009). Goyal *et al* highlight that sensitivity of evapo-transpiration to global warming for arid regions of Rajasthan is projected to increase by 14.8% with increase in temperature. A small increase of 1% in temperature (0.42°C based on normal maximum temperature of Rajasthan) from baseline could result in an increase in evapo-transpiration by 15 millimeter (mm), resulting into additional water requirement of 34.275 million cubic meter (mcm) for Jodhpur district alone and 313.12 mcm for entire arid zone of Rajasthan (Goyal *et al*., 2004).

Total available utilizable groundwater for Rajasthan is 11159 mcm and the increase of 1% in temperature will put additional stress of 6.43% to 20.16% on existing groundwater resources and will reduce the number of safe districts from 6 to 3. An increase in temperature by 2-3% from normal (i.e. 0.82-1.24^{o}C) will leave only 1 district in the category of 'safe' zone. The remaining 31 districts will be mostly in the category of 'overexploited'.

The satellite data of Rajasthan shows a total wetland area of 3450 Km^2 which includes 1239 Km^2 ha as natural and 2210 Km^2 as man-made. Increase in evaporation due to climate change will cause additional annual water loss of 40.4, 80.7 and 121 mcm for 1, 2 and 3% increase in temperature, respectively (CAZRI, 2009). Thus increased water demand due to increased evapo-transpiration can put tremendous pressure on existing overstressed water resources of this region (Goyal, 2004).

4 Policy Framework

WATER RESOURCES			
Policy / Programme	**Intent / Purpose**	**Strategy to be adopted to meet the objectives**	**Implementing departments**
State Water Policy, 2010	To adopt a multi sectoral and integrated approach to water resources planning, development and management on sustainable basis taking river basin/sub basin as the unit. This shall be done by treating surface and sub-surface water with a unitary approach	The policy intends to function from the new perspective of Integrated Water Resources Management, which is holistic and includes a bottom up approach. It addresses issues related to : Water supply and development, Integrated Water Resource Management, Irrigation, Water resources infrastructure, Water conservation, Water quality, Environmental management, Water pricing, Legal enablement, Capacity building, Research, Monitoring and evaluation of water policy and action plans	Rajasthan State water Resource Planning Department, (RSWRP)
IRRIGATION PROJECTS: Narmada Project	To utilize 0.5 MAF of Narmada water allocated to Rajasthan. This water will be available to Rajasthan from Sardar Sarowar Project, under construction in Gujarat.	Would provide irrigation in 2.46 lac ha by adopting improved method of irrigation i.e. sprinkler irrigation system which is mandatory in this project. This project would provide drinking water facility to 1107 villages & 2 towns.	Water Resources Department
Mahi Project	Mahi Bajaj Sagar is an interstate project between the States of Gujrat & Rajasthan for the development of irrigation & power generation. This project would provide irrigation in 80 thousand ha. land		Water Resources Department
Bisalpur Project	Bisalpur project is a irrigation cum drinking water supply project. The		Water Resources Department

WATER RESOURCES			
	dam is constructed across river Banas near village Bisalpur in district Tonk to provide irrigation facility in an area of 81.8 thousand ha. and to provide drinking water to Jaipur, Ajmer, Beawar, Kishangarh, Nasirabad & other enroute villages		
Water Harvesting Structures	About 48000 structures have been identified in the state for consideration of the scarce rainy water and augmentation of traditional water resources	Construction of sub-surface barriers/sub surface dykes etc. in the "overexploited" & "critical" category blocks. • Construction of Roof Top Rainwater Harvesting Structures in all government & semi government buildings in urban areas and prominent buildings in rural areas. • Storm Rain Water Harvesting along roads pavements in the prominent cities of the state. • Recharge of wells in the fields of farmers by diverting the field water received from monsoon rainfall. • Strengthening & monitoring network by replacing shallow wells by deep piezometeres. • Increasing frequency of water level monitoring, ensuring availability of realistic data. Post irrigation monitoring be done in addition to existing pre & post monsoon monitoring to enable correct assessment of ground water draft from the aquifers. • Mass Awareness Programme by publication and distribution of booklets/pamphlets regarding the water conditions in the concerned village	
Minor	The objective of the project is to		

WATER RESOURCES			
Irrigation Improvement Scheme	restore about 4.6 lac ha. CCA and to increase about 0.64 lac ha. CCA of 1198 MI tanks by reducing water losses in conveyance system		
Ground Water Dept	The scarce ground water resources in the state are depleting at an alarming rate. Out of 237 blocks, 140 blocks have been come under "over-exploited" category and 50 blocks under "critical" category. This scenario envisages an urgent need to replenish the ground water resources. As such, it is proposed to take up artificial ground water recharge activities on a mass scale for sustainable management of ground water resources in the state	Construction of sub-surface barriers/sub surface dykes etc. in the "overexploited" & "critical" category blocks. • Construction of Roof Top Rainwater Harvesting Structures in all government & semi government buildings in urban areas and prominent buildings in rural areas. • Storm Rain Water Harvesting along roads pavements in the prominent cities of the state. • Recharge of wells in the fields of farmers by diverting the field water received from mansoon rainfall. • Strengthening & monitoring network by replacing shallow wells by deep piezometeres. • Increasing frequency of water level monitoring, ensuring availability of realistic data. Post irrigation monitoring be done in addition to existing pre & post mansoon monitoring to enable correct assessment of ground water draft from the aquifers. • Mass Awareness Programme by publication and distribution of booklets/pamphlets regarding the water conditions in the concerned villages.	Ground Water Department
Indira Gandhi Nahar Program	The main priority is to provide drinking water in the command areas besides irrigation.	Use of Sprinkler Irrigation for reduction in water losses. •Introduction of Participatory Management through formation of Water User Associations.	Indira Gandhi Nahar Dept

		•Encouraging to adopt crops requiring less water. • Provision for upgradation & renovation of main canal & distribution system. • Enhancing water tariff for irrigation, drinking & industrial use so that O&M cost is recovered.	
Rajasthan Farmers Participation in Management of Irrigation System Act 2000	The objects of the Farmers' Organisation shall be to promote and secure distribution of water among its users, adequate maintenance of the irrigation system, efficient and economical utilisation of water to optimize agricultural production, to protect the environment, and to ensure ecological balance by involving the farmers, including a sense of ownership of the irrigation system in accordance with the water budget and the operational plan. -	RFPMIS has been passed for implementing participatory irrigation management and 506 Water User Associations have been constituted The act provides for the delineation of water users' area and territorial constituencies. The Project Authority may, by notification delineate every command area under each of the irrigation systems on a hydraulic basis which may be administratively viable and declare it to be a water users area for the purpose of this Act. Every water users' area shall be divided into territorial constituencies which shall not be less than four but not more than ten, as may be prescribed. The Water Users' Association shall perform the following functions namely: •to prepare and implement a warabandi schedule for each irrigation season, consistent with the operational plan, based upon the entitlement, area, soil and cropping pattern; •to prepare a plan for the maintenance, extension, improvements, renovation and modernisation of irrigation system in the area of its operation and carry out such works of both distributary system and field drains in its area of operation with the funds of the	Irrigation Department

WATER RESOURCES		
	association from time to time; •to regulate the use of water among the various outlets under its area of operation according to the warabandi schedule of the system; •to promote economy in the use of water allocated; •to prepare demand and collect water charges; •to maintain a register of land owners as published by the revenue department; •to prepare and maintain an inventory of the irrigation system within the area of operation; •to monitor flow of water for irrigation; •to resolve the disputes, if any, between its Members and water users in its area of operation	

WATER RESOURCES			
Rajasthan Water Sector Restructuring Project	Rajasthan Water Sector Restructuring Project (RWSRP) having the following objectives: • To improve surface irrigation systems performance, efficiency and strengthening agricultural support services in selected schemes through increased involvement of uses. • To strengthen capacity for strategic planning and Environmentally Sustainable Development and Management of surface and ground water resources in Rajasthan.	• Farmers Organisation- Formation of farmers organization in accordance of "Farmers Participation in Irrigation Management Act, 2000" • Participatory Rehabilitation Works - To structurally rehabilitate 91 identified irrigation schemes (8 major, 37 medium and 46 minor) covering a CCA of 6.19 lac ha. to their original design level and some modernization • Water Resources Research Fund - To find out solutions to water management problems certain research activities are proposed to be taken up with the help of National & International level consultants/Institutions. • Management Information System - It is proposed to Computerize all the water resources development related departments such as Irrigation, IGNP, CAD & Ground Water and to develop a integrated management information system, to increase efficiency of information dissemination to help in rapid decision making	RSWRP
Jal Chetana Abhiyaan	To successfully create awareness towards water scarcity and to educate people for water conservation.	• Roof top rain water harvesting structure for all urban buildings constructed on 300 sq. mt. or bigger plot has already been made mandatory. • Roof top rain water harvesting structures are required to be encouraged for even smaller size of plots.	

WATER RESOURCES			
Water Resource Vision 2045	Water Resource Vision 2045 has been prepared to highlight the short term (upto 2015) and long term (upto-2045) thrust areas and action plan which are pre-requisites for successful implementation of the State Water Policy and Plan	• the surface water utilization has to be increased by 60% from present utilization of about 10 BCM, • distribution system efficiency has to be increased to 74% from present estimated efficiency of 54%, • Average on-farm irrigation efficiency has to be significantly increased to about 70% from present estimated efficiency of below 27 %.	Water Resources Department
Bharat Nirman Program	Bharat Nirman Programme is a flagship Programme to upgrade rural infrastructure in a time-bound manner With respect to water resources: ▪ To create additional irrigation potential ▪ Every habitation to have a safe source of drinking water	Additional irrigation potential of 9.72 lacs hectare area is to be created in Rajasthan during 2005-09 under the Bharat Nirman Programme.	Water Resources Department

6.5 Summary

- Rajasthan is a water deficit state. It is the driest state with nearly 70 percent of the area classified as arid and semi arid region. The average rainfall is 531 mm against national average of 1200 mm while desert areas have an average of 380 mm.
- Surface water resources in the state are limited and in a precarious situation. The rivers of the state are rain-fed and there is no perennial river in the state except Chambal. Total surface water available in the state is 21.71 BCM, out of which 16.05 BCM is economically utilizable. The state has so far harnessed 11.84 BCM which indicates that surface water resources will become particularly limited in the future.
- Per capita annual availability of water is about .000780 BCM against minimum requirement of .001 BCM. It is anticipated that the water availability would fall below .00045 BCM by 2050 against a national average of .001 BCM by the year 2050. According to the International standards set up by IWS, availability of water below .001 BCM indicates water scarcity.
- The deficit between demand and supply is 8 BCM at present and likely to increase to 9 BCM by 2015. Non-agricultural water demand which was 3.28 BCM in 1997 is expected to reach 5.05 BCM in 2015 and 8.07 BCM in 2045, implying that the state will slip from scarcity to an absolute scarcity zone.
- Demand for irrigation is high using 83 percent of the total water resources. With a rising demand for water for both agriculture and non-agriculture purposes the share of water for agriculture is set to reduce to 70 per cent by 2050. This will have serious implications for agriculture in the state.
- High dependency on ground water has resulted in its over -exploitation, with nearly 80 percent of ground water witnessing depletion. The stage of ground water exploitation which was 35 percent in 1984 has reached a level of 138% in 2008. Out of the 237 blocks only 30 are in safe category.
- Scanty and irregular rainfall conditions have resulted in poor recharge to groundwater. Climate projections indicate further decrease in rainfall in the future which will further limit the recharge of ground water resources.
- Over-extraction of ground water has brought adverse changes in the geochemistry of water. Rajasthan accounts for 51 percent of fluoride and 42 percent of saline affected areas in the country. Based on the WHO guidelines for drinking-water quality, about 56% of the water sources in Rajasthan are un-potable. Climate change will further increase ground water extraction due to less availability of surface water and rising demand which could further deteriorate ground water quality and have serious implications for health of people.
- Water use efficiency is very low in the state and unaccounted for water loss (ULW) is very high. About two-thirds of the water used for irrigation is affected by inefficiency. Losses in surface water irrigation are much higher as compared to those in ground water irrigation.
- Water rates in the state do not convey a sense of scarcity among the stakeholders, thereby leading to increase in water losses and water use inefficiency
- The state has the maximum probability of occurrence of drought in India, with recurring droughts in 3–4 years in a cycle of 5 years. Climate change is projected to

increase drought occurrence in the state which would impact not only water resources but also have a cascading effect on other dependent sectors and associated livelihoods.

- Climate change will lead to acute water stress conditions for river Luni along with the west-flowing rivers of Kutch and Saurastra which occupy about 60 per cent of the area of Rajasthan
- Increase in temperature will lead to increased evapo-transpiration in the state. A 1% increase in temperature from baseline data could result in an increase in evapo-transpiration by 15 millimeter (mm), resulting into additional water requirement 313.12 mcm for entire arid zone of Rajasthan.

6.6 Strategies for State Mission on Water Resources

The following section presents the key strategies for the state mission on water resources. The state water policy (2010) and its consequent action plan for implementation have been referred to while preparing these strategies in order to ensure synergies and convergence of actions.

Key Strategy 1: Groundwater management with focus on over exploited areas

Action 1:

Comprehensive assessment of ground water resources including groundwater levels, yield, recharge potential, etc .up to block/mandal/ taluka level; and entering the data collected in the water resources information system (WRIS) of the state. This would enable effective planning and management of the fast depleting ground water resources of the state

Action 2:

Evaluation of ground water recharge potential by conducting GIS based aquifer studies and assessing the feasibility and viability of groundwater recharging by rain water harvesting or artificial recharging (by constructing check basins, percolation ponds, artificial recharge through dug wells structures etc.) with particular focus on critical and over-exploited regions (Ajmer, Alwar, Dausa, Jaipur, Jalore, Jhunjhunu, Jodhpur, Nagaur, Pali, Rajasmand, Sikar, Sawai Madhopur). After the evaluation, an implementation plan should be developed which would focus on constructing rain water harvesting or artificial recharge structures in different ground water stressed regions. This should be followed by a post evaluation exercise of these initiatives to assess the impacts on groundwater table at watershed level. Also, there should be a mechanism of incentivising users for taking self-initiatives for recharging ground water.

Action 3:

Conducting ground water exploration studies to decipher the potential of deeper fresh water aquifers, up to 1000/1500m, which would operate as a water bank of water stressed regions. This would be used only in period of extreme events like droughts or other extreme needs and not for addressing regular water demands.

Action 4:

In order to better plan and manage ground water resources under a climate change scenario there should be a regulation on drilling borewell for groundwater extraction along with a policy on mandatory ground water metering for bulk consumers (this can be initiated by establishing a District Metering Area--DMA) in domestic, industrial and agricultural sectors to give prominence to the issue of groundwater decline, conservation and sustainability, especially in critical and over-exploited regions. This could be facilitated by setting up a Ground water Regulatory Authority in the state. This would help enhance water use efficiency in the State.

Action 5:

Building capacity by Mass Awareness Programme by publication and distribution of booklets/pamphlets regarding the ground water situation in the concerned villages and enhance the understanding of groundwater as a finite resource and the imperative of reaching sustainability of extraction before aquifer is exhausted.

Action 6:

Setting up research facilities for ground water assessment and flow modeling, with respect to changes in the climatic variables. This would be complimented with installation of piezometers and automation of ground water level measurement to facilitate assessments. Further, training human resources to best use the modeling facilities and use the consequent outputs for informed decision making.

Agency (ies)	Name
Lead	Ground Water Resources Department (GWD)
Supportive	State Water Resources Planning Department (SWRPD) Community based Organizations (CBOs) Panchayati Raj Institutions (PRIs) Regional Remote Sensing Centre : RRSC / ISRO, Jodhpur Irrigation Department Agriculture Department

Key Strategy 2: Enhancing preparedness for drought monitoring, drought mitigation and development of early warning system

Action 1:

The state of Rajasthan is known for its traditional water harvesting practices like khadins, tankas, bawris, johads, village pond, nadis, baoris, kundis, naada, paar system etc. However there is a need to further mainstream these practices and renovating these traditional water storage structures as they are important source of water during droughts and have a strong significance in the lives and livelihoods of drought prone regions.

Action 2:

Conducting feasibility studies for in-situ water and soil moisture conservation practices like contour furrowing, contour bunding, vegetative barriers, and percolation ponds/trenches in drought prone areas to reduce evaporation losses from soil. Evaporation accounts for more than two thirds of water losses from surface water bodies in hot arid regions. In order to reduce evaporation losses from water bodies adopting a number of measures like reducing surface area by increasing storage depth; storing the water in a compartmentalized reservoir and pumping the water from one compartment to another as the water is used, so that there are some full compartments and some empty, instead of a single shallow sheet when the reservoir is partly used; planting shelter-belts of suitable tree species around water bodies or by artificially shading of water surfaces etc. can be adopted.

Action 3:

Developing an integrated drought monitoring systems which includes climate, water, soil parameters and socio-economic indicators to fully characterize the spatial extent and potential impact of drought situation enabling proper planning of adaptation strategies for the state. This should be complimented with designing effective delivery systems for disseminating the information from early warning systems for droughts at district level for timely planning and management of water resources in drought-prone regions.

Action 4:

Developing a drought management policy for the state which would integrate risks from increased frequency of droughts and have elements like pre-positioning of relief resources to ensure timely response for drought vulnerable populations; allocating of irrigation water on a volumetric basis, with a focus on generating a contingency quota for withdrawal during droughts; actively engaging communities in management and use of water resources and action on restoring the traditional rain water harvesting structures in the state.

Action 5:

Educating farmers about matching land-use systems with water availability by adopting water efficient practices and low water requiring crops for agriculture

Agency (ies)	Name
Lead	Water Resources Department, Disaster Management & Relief Department
Supporting	Irrigation Department Ground water Department PRRD Regional Remote Sensing Centre : RRSC / ISRO, Jodhpur Community Based Organisations (CBOs PRIs

Key Strategy 3: Enhancing Water Conservation Measures

Action 1:

Mass construction of roof top rain water harvesting structures in urban areas. Initially the target can be all public buildings, commercial complexes, then progressively moving on to private houses/complexes in urban areas, villages and habitations. This would be complimented with revival of traditional rain water harvesting structures in rural areas.

Action 2:

Conducting pilot studies to explore augmentation of water resources by transferring the surplus flood water into utilizable water from flood prone districts like Ganganagar, Hanumangarh, Bharatpur, Alwar, Dholpur, Dausa and Jaipur. Harvesting and conservation of floodwater can be used for rejuvenating the depleted aquifers by adopting artificial recharge techniques.

Action 3:

Promoting waste water recycle and reuse in all sectors and creating a knowledge bank linking level of treatment and water quality for each reuse category like domestic usage, industrial usage, horticultural usage, beneficial surface discharge (e.g. for irrigation) and recharge of groundwater. This could be further complimented by providing incentives for industries and commercial establishments for reducing water consumption through wastewater recycling.

Action 4:

Public awareness campaign to encourage rain water harvesting in rural and urban areas along with capacity building of farmers to adopt scientific water management practices through education and training on improved farm practices, such as through the use of sprinkler and drip irrigation systems.

Agency (ies)	Name
Lead	Water Resources Department
Support	Irrigation Department
	RPCB
	RIICO
	PHED
	PRRD
	UDH
	LSG
	PRIs

<u>Key Strategy 4: Improving Water Use Efficiency</u>

Action 1:

Conducting studies on efficient crop water application and utilization by promoting *water saving* techniques like pressure irrigation methods (a) drip (for horticulture purposes, mango, fruit orchards etc.) / (b) sprinkler irrigation (for wheat, gram, barley, pulses etc.). Other

kinds of water saving techniques which can be explored are *life saving irrigation* techniques like diggi construction, water storage tanks; construction of farm ponds and drip cotton demonstration to *supplement irrigation*.

Action 2:

Measurement of UfW (Unaccounted for Water) and its reduction to an acceptable level. This could be supported by developing a long term and short term policy plan for measurement and reduction of UfW.

Action 3:

Conducting feasibility studies for assessing the effectiveness of technologies (conjunctive use, sub-surface drainage system) in managing water logging in areas such as the Chambal command and IGNP command areas. This would assist in reducing the losses incurred in the irrigation command areas and use of irrigation water more effectively.

Action 4:

Mandatory water audit for all sectors including domestic, small and large scale industries, along with auditing irrigation projects; also identification of the drawbacks from water audits and planning of remedial measures to be implemented. This also needs to be supported by training of concerned authorities for conducting water audits, benchmarking of water supply system and irrigation system.

Action 5:

There is a need for rationalizing water pricing for domestic, industrial and irrigation water usage by introducing IBT(Increasing Block Tariff) Water tariff should account for full cost of O&M (operation and maintenance).

Action 6:

Building awareness among all stakeholders on regular monitoring & maintenance of RWH structures, existing water conservation measures, building codes and bye-laws for water conservation; including training of area *sabhas* & Self-Help Groups (SHGs) at the community level, Block Development Officers and village workers; building awareness on water-saving techniques through multi-media, school curricula and technical assistance. Provisions have already been made in the building bye-laws of the state with respect to the wastewater treatment and its recycling for use in gardening and flushing in plots of 5000 sq. Metre and above along with panel clauses.

Agency(ies)	Department
Lead	Water Resources Department
Supporting	RIICO, Irrigation Department, Rajasthan Pollution Control Board, PWD, CGWB, Urban Local Bodies (ULBs), Agriculture Department

Key Strategy 5: Developing a comprehensive water database for assessment of impacts of climate change on water resources

Action 1:

Setting up a real time dynamic database for water resources in the state along with the development of a web enabled water resources information system (WRIS). It should include in addition to climate and hydrologic data monitoring; mapping of catchments, surveying and assessing land use patterns with emphasis on drainage at micro-basin level using GIS and Remote Sensing techniques in order to facilitate climate and water research.

Action 2:

Review of availability and scale (spatial and temporal scale) of hydrological data like surface/ groundwater resource, irrigation canal flow, etc. and identification of additional data requirement for climate change and water research in collaboration with research organisations. This should be complimented with an annual spatial and temporal assessment of macro/micro watershed-wise water availability including an inventorisation of potential and actual water resources and annual variations at micro-watershed level.

Action 3:

Review of network of automatic weather stations and rain gauge stations and establish additional stations with respect to better network for evaporation data and rainfall data collection network through automated sensors

Action 4:

Setting up dedicated facilities with advanced computing systems and customize information on impacts of climate change for regional water basins/sub basins/watersheds. Also technical capacity building should be directed towards GIS-database-website development, GIS-applications in context of water resources planning and management, computer modelling (of groundwater, surface water and basin hydrology by procurement of tools like Soil and Water Assessment Tool (SWAT), Integrated Land and Water Information System (ILWIS), ERDAS etc.). Updation of state of the resource and the impacts can be closely monitored over a regular interval of 5 years or so.

Action 5:

Conducting training programs for government officials to facilitate the understanding of the impacts of climate change on water resources and familiarize them with modelling outputs and its significance for decision making

Agency(ies)	Name
Lead	State Water Resources Planning Department
Support	Water Resources Department, Ground Water Department Regional Remote Sensing Centre : RRSC / ISRO, Jodhpur Irrigation Department Agriculture Department Watershed and Soil Conservation Department

Key Priorities and Actions identified for Water Resources Sector

Key Strategy	Action	Time-frame (ST, MT, LT)[21]	Physical Target/ Scope	Financial Requirement
1	Groundwater management with focused attention on over exploited areas			
	Comprehensive assessment of ground water resources including groundwater levels, yield, recharge potential, etc .up to block/mandal/taluka level; and entering the data collected in water resources information system (WRIS) of the state	ST	Groundwater assessment of all districts/ 249 blocks will be carried out and the relevant data will be incorporated in WRIS	5 lakhs
	Evaluation of ground water recharge potential by conducting GIS based aquifer studies and assessing the feasibility and viability of groundwater recharging by rain water harvesting or artificial recharging with particular focus on critical and over-exploited regions	ST	Aquifer mapping and benchmarking has been awarded to M/S Rolta India Limited. Based on these studies further consultancy will be awarded for evaluation of groundwater recharge potential in critical and over exploited areas of Jaipur, Sikar and Pali districts	815 lakhs (EC funded-State Partnership Program)
	Conducting ground water exploration studies to decipher the potential of deeper fresh water aquifers, up to 1000/1500m, which would operate as a water bank for water stressed regions. This would be used only in period of extreme events like droughts or other extreme needs and not for addressing regular water demands for various purposes.	ST	Groundwater exploration studies based on geophysical survey to decipher the deeper freshwater aquifer upto 1000/1500 m will be taken in the districts of Jaisalmer, Barmer and Jodhpur	5 lakhs

[21] ST: Short Term (2012-2017), MT: Mid-term (2017-2022), LT: Long-term (2022 and beyond)

Key Strategy	Action	Time-frame (ST, MT, LT)[21]	Physical Target/ Scope	Financial Requirement
	Setting up a Ground water Regulatory Authority in the state, regulation on drilling borewell for groundwater use along with a policy on mandatory ground water metering for bulk consumers	ST	The setting up of a Groundwater Regulation Authority in the state is under consideration. The provision of metering for bulk consumers has been incorporated in the State Water Policy.	
	Building capacity by Mass Awareness Programme by publication and distribution of booklets/pamphlets regarding the ground water situation in the concerned villages and enhance the understanding of groundwater as a finite resource and the imperative of reaching sustainability of extraction before aquifer is exhausted.	ST	Following activities will be taken up for awareness building w.r.t the specified action: ▪ State level workshops ▪ Training and exposure visits ▪ Preparation of booklets	5 lakhs 15 lakhs 7 lakhs (EC-SPP funded)
	Setting up research facilities for ground water assessment and flow modeling, with respect to changes in the climatic variables. This would be complimented with installation of piezometers and automation of ground water level measurement to facilitate assessments. Further, training human resources to best use the modeling facilities and use the consequent outputs for informed decision making.	ST	Following activities will be taken up w.r.t enhancing the research facilities: ▪ Support institutional restructuring ▪ Innovative experimentation for improved water harvesting ▪ Upgradation of laboratories ▪ Computerization of WRIS for online data flow management	5 lakhs 25 lakhs 50 lakhs 10 lakhs

Key Strategy	Action	Time-frame (ST, MT, LT)[21]	Physical Target/ Scope	Financial Requirement
			▪ Construction of piezometers	100 lakhs (EC-SPP funded)
2	Enhancing preparedness for drought monitoring, drought mitigation and development of early warning system			
	Mainstream and carry out mass drive for renovating traditional water storage structures	ST	Under EC-SPP programme traditional water storage bodies will be reinstalled and maintained by implementation of IWRM plans at GP level for which training programme in selected districts is in progress	
	Conducting feasibility studies for in-situ water and soil moisture conservation practices like contour furrowing, contour bunding, vegetative barriers, and percolation ponds/trenches in drought prone areas to reduce evaporation losses from soil	ST	The work is being carried out by soil conservation department and is in progress. The studies for in-situ moisture conservation are carried out by Soil Conservation department regularly	
	Developing an integrated drought monitoring systems which includes climate, water, soil parameters and socio-economic indicators to fully characterize the spatial extent and potential impact of drought situation enabling proper planning of adaptation strategies for the state. This should be complimented with designing effective delivery systems for disseminating the information from early warning systems for droughts at district level for timely planning and management of water resources in drought-prone regions.	ST	Targets to be discussed with Panchayati Raj and Rural Development departments*	

Key Strategy	Action	Time-frame (ST, MT, LT)[21]	Physical Target/ Scope	Financial Requirement
	Developing a drought management and mitigation policy for the state which would integrate climate change concerns like increased frequency of drought events and have elements like pre-positioning of relief resources to ensure timely response for drought vulnerable populations; allocating of irrigation water on a volumetric basis, with a focus on generating a contingency quota for withdrawal during droughts; actively engaging communities in management and use of water resources; action on restoring the traditional rain water harvesting structures in the state.	ST	A data Centre is being established under EC-SPP. A data bank for rainfall for last 100 years has already been developed and present on the departmental website.	
	Educating farmers about matching land-use systems with water availability by adopting water efficient practices, low water requiring crops for agriculture	ST	Mass awareness during kharif and Rabi growing seasons will be organized by Agriculture department	
3	Enhancing Water Conservation Measures			
	Mass construction of roof top rain water harvesting structures in urban areas. Initially the target can be all public buildings, commercial complexes, then progressively moving on to private houses/complexes in urban areas, villages and habitations. This would be complimented with revival of traditional rain water harvesting structures in rural areas.	ST	Government is giving incentives for rooftop rainwater harvesting in urban areas. The booklet for the structures has been developed under EC-SPP.	
	Conducting pilot studies to explore augmentation of water resources by transferring the surplus flood water into utilizable water from flood prone districts like Ganganagar, Hanumangarh, Bharatpur, Alwar, Dholpur, Dausa and Jaipur. Harvesting and conservation of floodwater can be used for rejuvenating the depleted aquifers by adopting artificial	ST	A study on basin planning is under progress	

Key Strategy	Action	Time-frame (ST, MT, LT)[21]	Physical Target/ Scope	Financial Requirement
	recharge techniques.			
	Promoting waste water recycle and reuse in all sectors and creating a knowledge bank linking level of treatment and water quality for each reuse category like domestic usage, industrial usage, other horticultural usage, beneficial surface discharge (e.g. for irrigation) and recharge of groundwater. This could be further complimented by providing incentives for industries and commercial establishments for reducing water consumption through wastewater recycling.	ST	A study regarding recycling of water for irrigation use has been referred to Rajasthan Agriculture University and Agriculture Research Station.	
	Public awareness campaign to encourage rain water harvesting in rural and urban areas along with capacity building of farmers to adopt scientific water management practices through education and training on improved farm practices, such as through the use of sprinkler and drip irrigation systems.	ST	This work will be carried out through Communication and Capacity Development Unit, Government of Rajasthan	
4	Improving Water Use Efficiency			
	Conducting studies on efficient crop water application and utilization by promoting water saving techniques like pressure irrigation methods (a) drip (for horticulture purposes, mango, fruit orchards etc.) / (b) sprinkler irrigation (for wheat, gram, barley, pulses etc.). Other kinds of water saving techniques which can be explored are life saving irrigation techniques like diggi construction, water storage tanks; construction of farm ponds and drip cotton demonstration to supplement irrigation.	ST	Drip and sprinkler irrigation have been adopted in the command areas of Narmada Canal and IGNP. In IGNP it is being implemented in selected command coming under lift schemes. More than 7 lakh hectares are being irrigated.	
	Measurement of UfW (Unaccounted for Water) and its reduction to an acceptable level. This could be supported by developing a long term and short term policy plan for	ST	Flow measurement data are being collected through SCADA	

Key Strategy	Action	Time-frame (ST, MT, LT)[21]	Physical Target/ Scope	Financial Requirement
	measurement and reduction of UfW.			
	Conducting feasibility studies for assessing the effectiveness of technologies (conjunctive use, sub-surface drainage system) in managing water logging in areas such as the Chambal command and IGNP command areas. This would assist in reducing the losses incurred in the irrigation command areas and use of irrigation water more effectively.	ST	Conjunctive use initially taken in Narmada Canal project will be done for IGNP and Chambal command area	
	Mandatory water audit for all sectors including domestic, small and large scale industries, along with auditing irrigation projects; also identification of the drawbacks from water audits and planning of remedial measures to be implemented. This also needs to be supported by training of concerned authorities for conducting water audits, benchmarking of water supply system and irrigation system	ST	Implementation of pilot project on water audit is being carried out by ACE, WR, Jaipur	
	Rationalizing water pricing for domestic, industrial and irrigation water usage by introducing IBT(Increasing Block Tariff) Water tariff should account for full cost of O&M (operation and maintenance).	ST	This has already being included in the State Water Policy	
	Building awareness among all stakeholders on regular monitoring & maintenance of RWH structures, existing water conservation measures, building codes and bye-laws for water conservation; including training of area sabhas & Self-Help Groups (SHGs) at the community level, Block Development Officers and village workers; building awareness on water-saving techniques through multi-media, school curricula and technical assistance.	ST	The work is in progress in 11 districts under EC-SPP through CCDU/ NGOs	

Key Strategy	Action	Time-frame (ST, MT, LT)[21]	Physical Target/ Scope	Financial Requirement
5	Developing a comprehensive water database for assessment of impacts of climate change on water resources			
	Setting up a real time dynamic database for water resources in the state along with the development of a web enabled water resources information system (WRIS). It should include in addition to climate and hydrologic data monitoring; mapping of catchments, surveying and assessing land use patterns with emphasis on drainage at micro-basin level using GIS and Remote Sensing techniques in order to facilitate climate and water research	ST	Related work is in progress	
	Review of availability and scale (spatial and temporal scale) of hydrological data like surface/ groundwater resource, irrigation canal flow, etc. and identification of additional data requirement for climate change and water research in collaboration with research organisations. This should be complimented with an annual spatial and temporal assessment of macro/micro watershed-wise water availability including an inventorisation of potential and actual water resources and annual variations at micro-watershed level.	ST	Overall study of water resources planning for all basins/ sub-basin of Rajasthan is being done by M/S Tahal.	
	Review of network of automatic weather stations and rain gauge stations and establish additional stations with respect to better network for evaporation data and rainfall data collection network through automated sensors	ST	Computerization of data is in progress under RWSRP and establishment of data bank is under SWRPD State-wise/ met sub division wise/ state wise rainfall data of last 50 years on different temporal scales	

Key Strategy	Action	Time-frame (ST, MT, LT)[21]	Physical Target/ Scope	Financial Requirement
			is available with IMD	
	Setting up dedicated facilities with advanced computing systems and customize information on impacts of climate change for regional water basins/sub basins/watersheds. Also technical capacity building should be directed towards GIS-database-website development, GIS-applications in context of water resources planning and management, computer modelling (of groundwater, surface water and basin hydrology by procurement of tools like Soil and Water Assessment Tool (SWAT), Integrated Land and Water Information System (ILWIS), ERDAS etc.).	MT	Work will be taken after getting basin wise planning data	
	Conducting training programs for government officials to facilitate the understanding of impacts of climate change on water resources and familiarize them with modelling outputs and its significance for decision making	ST	Training programme will be carried out by IMTI, Kota for officers and stakeholders	

Chapter 7: Agriculture and Animal Husbandry

7.1 Background

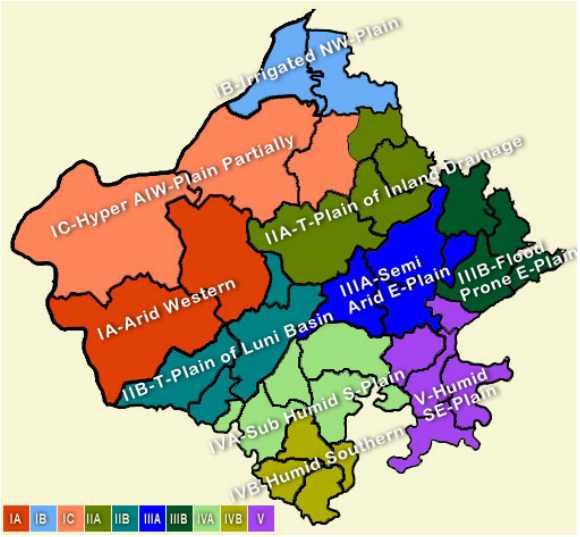
Climate change challenges the path of sustainability in the agriculture sector. Through its direct and indirect impacts - on crop yields, pests and diseases, land and water resources - climate change is expected to affect agriculture through multiple pathways, thereby having an effect on livelihoods and the overall food security situation in the State.

Inter-annual, intra-seasonal, monthly and daily distribution of climate variables (primarily temperature, precipitation and humidity) play a fundamental role in most of the physical, physiological, chemical and biological processes that drive productivity in agriculture, livestock, forestry and fisheries. Any change in climatic determinants can not only lead to adverse impacts on food security and nutrition but also essentially affect well being of the population deriving livelihood and income from the sector. Agriculture and allied sectors therefore exhibit high sensitivity to climate stresses.

Crucial factors characteristic of Rajasthan like scanty rainfall, high air and soil temperature, frequent droughts and water scarce conditions in addition to the impacts of climate change and low adaptive capacity make agriculture a high risk activity in the state.

7.2 Current vulnerabilities

On the basis of climatic factors like temperature, rainfall, humidity, wind velocity and agricultural produce, Rajasthan has been divided into ten agro climatic zones.



Source: http://www.rajasthankrishi.gov.in/Departments/Agriculture/main.asp?p=map3.htm#

1. IA-Arid Western Plain
2. IB- Irrigated North Western Plain
3. IC- Hyper arid irrigated western plain partially
4. IIA- transitional Plain of Inland drainage
5. IIB- Transitional plain of Luni basin

6. IIIA- Semi Arid Eastern Plain
7. IIIB- Flood Prone Eastern Plain
8. IVA- Sub Humid Southern Plain
9. IVB-Humid Southern
10. V-Humid Southern Eastern Plain

Though a number of states or regions in India face drought, three factors place Rajasthan in a more precarious situation:

- The frequency of droughts (four out of every five years)
- Extremely low and erratic rainfall1
- Very limited surface water sources, resulting in greater dependence on groundwater resources.

Apart from the water scarcity issues in the state, the resource base for successful agriculture is also not adequate in most places. The soil organic content stands at 70.08 tonnes per hectare, which is one of the lowest amongst all Indian states (RPCB, 2010). It also ranks among the states where proportion of land undergoing degradation is highest (Ajai et al, 2009). Studies show Rajasthan as part of the group that are major foodgrain-producing states according to the level of groundwater development and suggest that groundwater is overexploited to the tune of 109-145% (Sharma, 2009). Inspite of having the highest share of land area among all other Indian states, the state is not as agriculturally productive as most of the state falls under the semi-arid agro-climatic zones. Moreover, more than 5.017 million hectare of land is cultivable wasteland. The yield of food grains in the State is only 803 kg per hectare and is the lowest for any state in India (Kakade et al., 2003). About three years out of five, severe droughts occur in the State, particularly in the west, which also has large areas of light sandy and/or salt-affected soils and high wind velocities. In rain fed areas, the low water availability and erratic rainfall place severe constraints on the introduction of improved, sustainable production systems. Droughts are ubiquitous to Rajasthan, with erratic rainfall and extreme temperatures being common features in many areas (Kakade et al., 2003).

Several studies expound on the seriousness of recurring droughts in the region. They also examine the long term impacts of droughts on people's assets, livestock in particular and recognize that despite being a single occurrence, the effects are far reaching and deep. In Rajasthan, such frequent drought events continuously impact local livelihoods. The present relief programmes but only provides temporary solution to the problems which is far from adequate (Sivakumar and Kerbart, 2004). Nutritional assessments post the 2002-03 droughts indicated very high prevalence of severe under-weight (28.3%) and wasting (4.7%) amongst under five children (Kumar and Bhawani, 2005).

A study of the impacts of droughts in Shergarh tehsil in western Rajasthan from 1899-1976 revealed that out of the 78 years studied, 43 were mild drought years where 50% of the crops reached maturity, 19 were drought years where 25% of the crops reached maturity and 8 were severe drought years where no crops matured. Analysis of land use changes revealed a positive correlation between the intensity of drought and the extent of the area damaged. Mean annual yield of kharif crops decreased from 90-100 percent in a drought year and 30-

66 percent in a moderately deficit year. Livestock losses ranged from 17 percent for goats to 50 percent for cattle during drought years (Bharara, 1980). Villages in Western Rajasthan have also experienced decline in area and deterioration in quality of common property resources over three decades. Disruption in traditional management of resources caused farmers to adjust to shrinking common property resources by reducing herd size, by changing its composition, and by relying more on private resources to rear animals.

Mechanization of agriculture – Use of tractors has reduced the traditional shallow ploughing tools such as durfan. The traditional system encouraged minimum tillage with low energy that caused least damage to the soil structure. The system also made sowing of small acerage possible within shorter time span especially in the context of arid region. The mechanized and deep ploughing is adversely affecting soil structure and increasing wind erosion hazards. Similarly, use of weedicides, hand operated weeders do not allow the use of weeds as mulching material for moisture conservation (Narain and Kar 2005).

Traditional farming systems – Birani badi, the traditional system of cultivating watermelons and cucurbits in smaller areas with limited water in summer in Bikaner region is practiced by Mali community. The system allows to evade the effects of drought and generate income up to Rs. 10,000/- per ha (Narain and Kar 2005). Similarly, there could be crop specific systems in vogue which could be considered as important decentralized mechanisms for coping with the impacts of the drought and complimentarily address livelihoods and food security.

Storage of food grain and seed bank – The traditional structures such as Kinara to store grains, the earthen structures such as Kothi have been used. Other systems such as Kiradi,the conical bin, onion storage in gunny bags under thatching are also followed (Narain and Kar 2005).

Fodder bank – Excess fodder of pearl millet, wheat, barley, etc. is stored in structures called Karai or Pachave for adverse years. It provides an important coping mechanism for securing livestock during drought (Narain and Kar 2005).

Domesticated breeds of animals – Traditional coping system has relied heavily on drought-hardy and well-adapted breeds of animals like Tharparkar, Rathi, Kankrej, Malvi and Nagauri cows, Marwari, Magra, Chokla Nali, Malpura and Sonadi sheep, and Marwari, Jakharana and Sirohi goats (Narain and Kar 2005).

Diversified agriculture – To avoid crop failure, mixed cropping is traditionally practiced in kharif season using pearl millet, moth bean, mung bean, clusterbean, sesame and vegetable crops. The cash crops like isabgol, cumin, spices and condiments are also used. Medicinal and aromatic plants are utilized for generating cash income. Multipurpose trees are grown on cropland to provide fodder, prevent erosion, fuel, etc.

Nomadism – The migration of pastoral nomads during defined periods as well as during the time of scarcity of fodder, feed, water has been a traditional phenomenon and it is used as a mitigation strategy against the drought. The process also allowed sale of milk, cattle, ghee wool, mutton as one of the mean of subsistence. But the shrinking grazing areas are forcing people to take up sedentary way of life. The border districts of Barmer, Jaisalmer and Bikaner are home to the pastoral nomads of the state. The non-pastoral traditional nomads such as artisans and tribes like Nats, Kalbeliyas migrate in search of work (Narain and Kar 2005).

Pasture / Grazing lands – Every village in western Rajasthan has a traditional Gauchar land used for grazing of animals. But owing to the management tragedy of common lands like Gauchar the grazing resources have been reduced substantially and it has impacted the pastoral livelihoods (Narain and Kar 2005).

Agroforestry – The traditional agroforestry practice involving species such as *Prosopis cineraria*, *Tecomella undulata* and *Salvadora oleoides* has been an important life support system during drought. The agroforestry provided fodder, fuel, tumber, fruits, seeds, pods, and non-timber forest produce such as gum, etc. Intensive agriculture has reduced the agroforestry practice (Narain and Kar 2005).

These changes have reduced the comparative advantage of livestock farming in the arid region. Since the shrinkage of common property resources is largely a result of the transfer of submarginal lands from grazing to cropping, resource degradation has also accelerated (Jodha, 1985). Rajasthan has livestock population of about 49.1 million and ranks among the top three states having the highest livestock population. It also is one of the highest methane emmiters contributing almost 9.1% to the total methane emissions of the country (Chhabra et al., 2009). Studies show an increase in the population of buffaloes 1998 onwards. Although they significantly contribute to the improvement of dairy farmers' economy, unsatisfactory nutritional status and lack of knowledge of balanced feeding and lack of proper marketing facilities for animal products like goat and camel milk, meat and wool in addition to scarcity of fodder are aspects that may lead to an unsustainable future (Rohilla et al., 2004). The contribution of the agriculture sector to the SGDP has sunk from 64% in 1970/71 to around 60% in 1988/89 to 27% in the current time frame. The major agricultural land use is rainfed cropping with pearl millet being the main cereal crop along with kharif legumes (clusterbean, moth bean, mung bean). Bajra, millet grown on un-irrigated land, is planted on the greatest acreage followed by wheat and oilseeds like rapeseed and mustard [22]; Approximately 50% of the land is used for agriculture. Sugarcane and cotton are the major cash crops.

It is interesting to note that lack of water and green fodder has not resulted in reduction in livestock activities in the State primarily because they constitute as alternative forms of livelihood support. On the other hand, with the rural communities increasingly opting for dairy activities, the number of cattle and buffaloes has increased. A 17.84% rise in livestock was observed between 2003 and 2007 (Rajasthan State Livestock Development Policy, 2009). This was attributed to increasing population and growing demand for milk. Goat farming is quite predominant in the project area. It was also noted that dairy activities sustain agriculture by providing dung as organic manure to enrich the soil. Table 7.1 shows the rise in animal population in Rajasthan over the past 20 years.

Table 7.1: Growth in animal population in Rajasthan (in million)

Item	1951	1961	1972	1983	1992	1997	2003	2007
Cattle	10.782	13.136	12.47	13.504	11.666	12.141	10.854	12.410
Buffalo	3.045	4.019	4.592	6.043	7.745	9.77	10.414	11.542

22 Agricultural Statistics, Rajasthan. Directorate of Economics and Statistics, Rajasthan. Yojana Bhawan, Jaipur.

Item	1951	1961	1972	1983	1992	1997	2003	2007
Sheep	5.387	7.36	8.556	13.431	12.491	14.585	10.054	11.283
Goat	5.562	8.052	12.162	15.48	15.285	16.971	16.809	21.881
Camel	0.341	0.57	0.745	0.756	0.746	0.669	0.498	0.430
Other	0.399	0.372	0.353	0.436	0.482	0.519	0.507	0.353
Total	**25.516**	**33.509**	**38.878**	**49.65**	**48.415**	**54.655**	**49.136**	**57.899**

It is apparent from the Table 7.1 that the number of buffalo, goat and sheep has grown significantly in the past 50 years. Steep rise in goat and sheep numbers may be attributed to the poor availability of fodder to sustain buffalo/cattle.

Given the fragility of the resource base in much of Rajasthan, agriculture is a high risk activity. Agricultural development has already led to environmental and social problems. These include: crop production on lands unsuitable for agriculture; declining groundwater tables (except in the canal irrigated areas); increasing salinity of groundwater; large pockets of waterlogging and salinity buildup in the command areas of major irrigation projects; and a tendency towards indiscriminate use of agro-chemicals in irrigated areas.

7.3 Likely impacts of climate change

Changes in climatic variables, crucial for agricultural growth, such as temperature and precipitation, increased incidence of droughts and intensification of water- scarce conditions can adversely impact state agricultural production and productivity owing to changes in the hydrological cycle, changes in plant physiology, soil properties (including nutrient availability), and rate of evapo-transpiration, pest dynamics and rate of weed proliferation. Changes in precipitation patterns can also increase the likelihood of short-run crop failures and production declines. High human and livestock pressures, reducing the plant cover through over grazing and fuelwood collection, expansion of croplands to marginal areas without assured water supply and deep ploughing of sandy terrain with tractors, even along sand dunes, have enlarged and accentuated.

Rajasthan only has 1% of India's total water resources. The average annual rainfall is 58 cm, varying from 15 cm in the dry, hot west to about 90 cm in the east, and 90% of the rainfall is during the monsoon season (July - September). In addition to the spatial variation in rainfall, there is great variability from year to year. Eastern Rajasthan falls in the semi-arid, 500–1000mm annual rainfall zone and is intensively cultivated for pearl-millet/sorghum/ kharif pulses/maize– wheat/barley/mustard/rabi pulses. Agriculture in Rajasthan is likely to face several challenges in the light of increasing competition for resources such as water, land and energy, from nonagricultural sectors, along with increasing food demand due to the rising population, increased use of fertilizers due to increased production demand and increased water withdrawals for irrigation from canals, wells and tube wells.

Climate change poses formidable challenges to the animal husbandry sector as well. Though the vulnerability of farm animals to climate change varies with their genetic composition, type and breed, life stage and nutritional status, studies unambiguously indicate that the performance of farm animals is sensitive to the climate. Heat stress in dairy animals is likely

to impact their productive and reproductive performance. Reduction in feed and fodder availability due to changes in the climate can also affect livestock productivity. During droughts, livestock play a larger role in supporting the income and sustaining the rural population. However, under conditions of declining water and fodder availability, the contribution of this sector to household incomes of farming communities declines drastically.

The contribution of the agriculture sector to the SGDP has sunk from 64% in 1970/71 to around 60% in 1988/89 to 27% in the current time frame.The contribution of animal husbandry to the state GDP is about 9.16%. Rajasthan ranks second highest in milk production in the country (amounting to nearly 17 lakh kg per day). Current annual loss in milk production due to heat stress in Rajasthan is 98.65, 40.55 and 29.74 liters per animal per year in crossbred cows, local cows and buffaloes respectively (Upadhyay et al., 2009). More than 80% of the rural families in Rajasthan keep livestock in their households. This sector is a source of self employment to majority of the households in rural and urban Rajasthan and supplements their income and nutritional requirements. About 35% of the income of small and marginal farmers in the state is derived from animal husbandry, with this share being as high as 50% in the arid regions. Lack of proper feed and fodder and poor market linkages however, affect productivity in this sector. This sector has a high potential to create employment in rural areas with lesser investments as compared to other sectors.

It is projected in a range of studies that climate change will lead to a decrease in crop and animal produce especially in tropical countries like India, aggravating the risk of hunger, malnutrition and poverty, as the availability of food and opportunities for livelihood across sectors get affected. On the other hand, the changes in palate, changes in demand and corresponding changes in crop prices. The harvest prices of foodgrains, pulses, vegetables and spices have constantly been on the rise whereas those for fibres like cotton and sanhemp have gone down. Though it is suggested that in some areas, changes in rainfall and temperature may increase the crop growth potential, in most cases, changing patterns of temperatures, precipitation, extreme events will make it more difficult to grow traditional, culturally acceptable, staple crops. More research is required on the beneficial effects of increased CO_2 must be considered in light of the accompanying changes in air temperature, moisture availability, survival and distribution of pest populations, frequency and intensity of inter- and intra-seasonal droughts, soil organic matter transformations, soil erosion, decline in arable areas due to desertification, socio-economic implications on farming systems etc.

Agriculture is a sector that requires constant adaptation in order to maintain yields. In Rajasthan, changes are consciously being made in attempts to maintain agricultural productivity. During the last three decades the net sown area in arid Rajasthan has increased by 36% while current and long fallows have declined by 29 and 41%, respectively. The net irrigated area has also increased by 140% (Ram and Kolarkar, 1993). In the drought-prone Tonk district, where communities have learnt to cope, Successive droughts over wider geographic areas, combined with other stresses are now threatening to overwhelm coping capacity in ways that might become the norm with climate change. In response to these more frequent extreme events, the local non-governmental organizations in Tonk have introduced adaptation strategies that build on existing knowledge and expertise about water, agriculture and livestock management for better preparedness towards the impacts of climate change. Strategies such as growing new crops such as vegetables, fodder and higher value medicinal crops for commercial sale; use of environmentally sound fertilisers (vermiculture); improved storage for fodder and food grains; and improved water

conservation and harvesting techniques through bunding of fields, construction of *anicuts* and digging and deepening of ponds and wells have been introduced (Chatterjee et al., 2005). Participative water management projects as practiced in Bhipur village promote adaptation strategies such as growing crops with low water requirements and more sustainable farming practices allow farmers to continue their activities despite climate risks (Akermann et al, 2009)

A study conducted in Naga-Ki-Dhani village in Jaipur district, Rajasthan showed that the optimum crop plans to stabilize farm income and employment during drought years should involve the use of improved varieties of crops developed specifically for water scarcity conditions which would then increase farm income. Since little irrigation water is available during drought years, the study also concluded that credit availability to farmers would be crucial (Gupta and Verma, 1993). Jat et al. (2003) predict that mid-season drought is likely in 31st-34th week and terminal drought in the 35th week in the Udaipur region and also reveals that off-season tillage and primary tillage may be started from 24th week and sowing of crop from 26th week to improve yields. Several authors have also urged the utilization of little known indigenous crop varieties in times of acute crisis (Bhandari, 1974). Evaluation of semi-cultivated landraces of mateera (*Citrullus lanatus*), kachari (*Cucumis callosus*), snap melon (*Cucumis melo*) in the north-western parts of Rajasthan showed feasibility for cultivation in the arid regions as they would contribute not only to economic but also nutritional potential (Pareek et al, 1999). Action plans for watershed management that were initiated as early as 1986-87 in Jhanwar village in Jodhpur revealed that farmers have keen and sustained interest adoption of improved dryland farming technologies, including sustainable land use systems. An overall increase in productivity 0f 25-30% was achieved in the region through creation of farm ponds and its recycling in agro-horticulture (Ziziphus *mauritiana*), diversified production of fruit fuel and fodder, development of pastures in community grazing lands for increased forage production and adoption of various physical and biological land treatments to reduce soil erosion and increase ground water recharge (Bhati et al., 1997). Yield–temperature response curves show that there is a decrease in grain yield of wheat in Rajasthan at the rate of 2.49 quintals per hectare per degree rise in seasonal temperature, 0.92 quintals per hectare decrease in yield of mustard (Kalra et al., 2008). In parallel, cultivars of wheat such as Raj3965 showed an increase in productivity of 36% and 29% in the case of an increase of 1^{o}C in the maximum temperature and 1.5 ^{o}C in minimum temperature and a with a doubling of carbon dioxide concentration and a 2^{o}C in the maximum temperature and 2.5 ^{o}C in minimum temperature combined with a doubling of CO_2 concentrations, respectively, under rainfed conditions in Jaipur (Attri and Rathore, 2003; Mall et al., 2006. On the other hand studies have also shown the perceived risks associated with the use of new cultivars under variable climatic conditions. In the case improved cultivars of pearl millet, it was observed that they were not adopted primarily because of poor grain yield as well as poor straw yield in years with low rainfall. Such observations emphasize that if new crop cultivars are introduced to replace traditional varieties, prior steps should be undertaken to evaluate and ascertain their performance under limited resource availability conditions, like low rainfall, that is characteristic of the state (Kelley et al., 1996). Vom Brocke et al., (2003) conclude that introgression of modern varieties of pearl millets leads to populations with a broader adaptation ability in comparison to pure landraces or modern varieties alone but only under conditions of regular introgression combined with mass panicle selection. With such a system, pure landraces also show higher grain yields even under low rainfall and outline the potential of farmers' seed management as an integral part of participatory breeding programs.

There are several instances of traditional practices that help in conservation of resources for example the khejri tree is valued for its moisture-retaining properties, and it is not axed even

if it comes between the constructions (Kala and Sharma, 2010). It also worshipped by Bishnois in orans (Mukhopadhyay, 2008) which leads to an increase in profile moisture and also increases the survival and growth of *Prosopis cineraria* (Gupta and Sharma, 1998 and Gupta et al., 1999). An investigation was carried out in an *Entisol* at farmers' field in Jaipur district, Rajasthan, India during 2002–2004 to evaluate the effect of traditionally grown trees on soil biological characteristics. Traditionally grown trees in farm lands like *Prosopis cineraria* (L.), *Dalbergia sissoo* (Roxb.) ex DC, *Acacia leucophloea* (Roxb.) and *Acacia nilotica* (L.) Del. having a canopy diameter of 8 m. contribute significantly to improvement in soil biological activity in terms of microbial biomass C, N and P, dehydrogenase and alkaline phosphatase activity under different tree based agroforestry systems. Amongst trees, *P. cineraria* based system is reported to bring maximum improvement in soil biological activity (Yadav et al., 2010). Systematic efforts need to be made to improve the existing land races of indigenous vegetables which are hardy, drought resistant that have short duration, grow well and have good nutritive and medicinal value with resistance to biotic and abiotic stresses, like kachari (*Cucumis melo* var. *agrestis*), snap melon (*Cucumis melo* var. *momordica* Duthie and Fuller), spine gourd (*Momordica dioica* Roxb. ex Wild.), bitter melon (*M balsamina* L.) and hill colocynth [*Cucumis hardwickii* (Royle) Gabaev, These varities are currently grown in southern Rajasthan by tribals for income generation (Maurya et al., 2007).

The productivity of the traditional Khadin system of runoff farming, followed in Jaisalmer district in western Rajasthan which lies in 100-200 mm rainfall, remains low. Higher productivity on sustainable basis fro the Khadin system can be ensured through designing of new khadins with provision of spillway, recycling of excess stored water for either growing of crops in down reaches or for life saving irrigation in upper reaches and adjoining land, conservation measures to ensure availability of soil moisture to crops over a period of their duration, standardization of fertilizer requirement of different crops and adoption of multi-production systems such as agroforestry, fisheries, etc. There is a need to generate data on productivity in relation to rainfall, catchment area, ponding depth, status of conserved moisture, and soil fertility for different crops over a period of time for low, normal and above-normal monsoon for prediction of crop productivities. Research on development of short-duration varieties whose water requirement matches with the availability of conserved moisture in khadins should also be promoted. Cultivation of multipurpose woody perennials like *Acacia nilotica* (Linn.) Del sub sp. indica, *Prosopis cineraria* (Linn.) Druice, *Zizyphus mauritiana* Lamk. etc., and fruit bearing plant species such as *Cordia myxa* Linn. and *Phoenix dactylifera* Linn. for enhancing productivity from khadin cultivation should also be emphasized (Prasad et al., 2004).

Post the 2002-03 drought in Rajasthan, intensive public education campaigns have been carried out in Baran district with the help of local tribal 'sahariya' community to promote improved child caring practices and referral of malnourished children with complication to hospitals. Dissemination of facts regarding malnutrition and remedial measures and other activities routed through the Nutrition care centers helped reduce malnourishment in children from 66.7% to 59.6% in six months (Kumar and Bhawani, 2005).

7.4 Emissions

The agriculture sector contributes 27% to Rajasthan's GSDP and is critical to the economy of the state. The contribution of animal husbandry to the GSDP is about 9.16%. More than 80% of the rural families keep livestock in their household that supplements their income and nutritional requirements. The GHG emissions from the agriculture sector are emitted mainly in the form of CH_4. These are due to enteric fermentation and from rice paddy cultivation.

N_2O is also emitted from this sector and is mainly from the agricultural fields due to application of fertilizers. Livestock is a major anthropogenic source of methane emission from agriculture. Rajasthan possesses the India's second largest livestock population of 49136 thousand (10.13%), with a high degree of diversity in its composition. The total methane emission from Indian livestock, which includes enteric fermentation and manure management, was 11.75 Tg in 2003. Enteric fermentation accounts for 10.65 Tg (~91%) compared to 1.09 Tg (~9%) by manure management. Dairy buffalo and indigenous dairy cattle together contribute 60% of the total methane emission. Rajasthan contributed 9.1% of India's total livestock emissions. The spatial analysis in GIS has identified a few districts like Udaipur, Jaipur (Rajasthan), with total methane emission above 0.05 Tg (Manjunath et al 2009). With a livestock population of 49.14 million in Rajasthan, emissions from enteric fermentation accounts to .98 (Tg) and manure management accounts to .09 (Tg). According to other estimates the contribution of the state is 8.68% in India's total[23]. India emitted 3.3 million tons of CH_4 in 2007 from 4 3.63 million hectare of rice cultivation. In Rajasthan only 107758 hectare of total area which is 1.03% of the total area under cultivation. There are no state wise estimates of emissions from rice cultivation as emissions are function of the crop duration, water regimes and organic soil amendments. However, rice cultivation in Rajasthan is only approximately 1 % of the total area under cultivation. One of the factors responsible for emissions from agricultural soils is the human induced net N addition in the soil caused due to synthetic or organic fertilizers, deposited manure, crop residues and sewage sludge. Since, agriculture in Rajasthan is likely to face challenges due to increased production demand, use of fertilizers will increase. Apart from this other sources includes field burning of agriculture crop residue which is common in certain areas. However, there are no firm estimates of emissions from these sources.

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7.5 Policy Framework

Ongoing Initiatives/Government programmes	Key objectives/Goals	Components/Strategies/Activities Linkages
National Seed Project (at Bikaner, RAU and MPUAT, Udaipur)	• To produce breeder and TFL seeds used for certified seed production by Government agencies for the benefit of farmers.	• Research • Such projects can be directed for the production of drought resistant seeds for better yield.
Extension programmes of RAU	• Dissemination of technologies	• Dissemination of technologies through programmes like village adoption, development of model technology units at KVK's, Knowledge centres in villages etc. • Can be tailored to Climate change awareness needs by dissemination of information on off-season crops, aromatic, medicinal and greenhouse crops, promotion of agro-forestry etc. that would support the economy in climate-stressed conditions.
Retail Outlets	Ensuring greater availability of improved seeds to farmers	Retail outlets for certified seeds in remote areas. Higher probability of better yields is ensured by greater availability of improved seeds to farmers.
Buffer Stock of Certified Seed by RSSC	• Increasing production and productivity by ensuring timely availability of good quality seeds	• Buffer stock of certified seeds • Addresses availability of seeds at the correct planting dates to ensure maximum possible yield.
Seed Testing Laboratories	• To ensure quality seed distribution	• Testing seed samples • Ensuring that the seed varieties that are developed address the appropriate targets and to assess the impacts on other sectors.
GOT, Hybridity Test Farms & DNA Finger Printing Laboratory		
Quality Control Laboratory & Soil Testing Lab		

Ongoing Initiatives/Government programmes	Key objectives/Goals	Components/Strategies/Activities Linkages
Pesticides Residue, Pesticide Testing & Phytosanitary Laboratory		
Popularization of Package of Practices (PoPs) upto the farmer level.		Massive campaign before crop season at village level for promoting Organizing trainings Village level POP cards Village level soil health cards etc. Enhancing dissemination and sharing of information.
Establishment of seed processing plants in the private sector	To increase the seed replacement rate (SRR)	Provision of incentives to the private sectors for the establishment of seed processing units Allows for maximizing crop productivity
Distribution of maximum possible seeds by RSSC (Rajasthan State seed corporation)	To support additional availability of Kharif seeds	Allows for maximizing crop productivity
Block-Wise Soil Fertility Mapping for		• Could feed into the construction of State level agro-climatic atlases.
ISOPOM (Centrally Sponsored Scheme)	• 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. • Enhancing productivity, profitability nutritional quality and diversified uses of maize by harnessing potential of technology.	• Purchase of breeder seed • Production of foundation seed & certified seed • Distribution of certified seed, block demonstration • IPM • Plant protection chemical • Plant Protection Equipments • Bio-fertilizers, gypsum as nutrient, • Piped water conveyance • Farmers training and infrastructure development etc. • The rate of assistance available in this scheme is 50% for most of the activities.
ICDP-Cotton Mini Mission-II of	• To boost the production of cotton in terms of	• Certified seed availability, IPM on FFS pattern, plant

Ongoing Initiatives/Government programmes	Key objectives/Goals	Components/Strategies/Activities Linkages
Technology Mission on Cotton (Intensive Cotton Development Programme).	quality and quantity. • This scheme is implemented in 16 cotton growing district of the State Viz: Sriganganagar, Hanumangarh, Bikaner, Pali, Banswar, Bhilwara, Ajmer, Alwar, Jodhpur, Jalore, Jhunjhunu, Nagaur, Sirohi, S.Madhopur, Rajsamand and Chittor.	protection equipments, HRD activities, information support, staff & contingencies etc.
Demonstration on Organic Farming and Vermiculture		• Demonstration of relevant technologies at the farm level makes the farmers more equipped to deal with changes in climate in a sustainable manner.
Vermi compost technique promotion	• Higher nutrients that farm yard manure – provides other micronutrients and helps in enhancing the organic matter content	• Provision of earthworms to cultivators • training and demonstrations • Promotion of relevant techniques popularizes and ensures broader reach and application
Agriculture information	• Advertisement, documentation and publicity of Agriculture Information & Agriculture Technology	• Exhibitions (State / National Level Exhibitions / Expos), Use of Electronic and Print Media i.e. Doordarshan (Navankur), AIR (Kheti Ri Bantan) sponsored programmes, information dissemination through News Papers etc. • Demonstration exercises for the farming community for preparedness to tackle imminent changes.
Adoption of Village		Organize trainings in the adopted villages and seasonal demonstrations on specific technology that needs to be popularized as per need of the area. For maximizing productivity and yield of crops.
Need Based Extension	• Putting in place Kisan Salahkaar Samitis who would help in advising farmer	• The samiti discusses the village plan of kisan mandal with the department of agriculture. And forward the plans for funds • Persons well-qualified to suggest appropriate long term as well as short term adaptation strategies/techniques.

Ongoing Initiatives/Government programmes	Key objectives/Goals	Components/Strategies/Activities Linkages
Inter & Intra State Exposure Visit of Farmers	• To resolve the widening gap between technology evolved and adopted at the farm level.	• To introduce and institutionalize system of providing direct interface between farmers and scientists on problems and constraints faced in agriculture and communicating relevant technological advances in the field to the farming community • Awareness creation; increases access to information and allows farmers to draw from others' experiences.
Communication & Mobility of Field Staff	• For effective monitoring	For effective implementation of agriculture development activities and to facilitate better mobility of field functionaries Allows for swifter detection of untoward events like forest fires. and curbing of damage caused as mobility of field functionaries would ensure immediate action.
Organization of Camps (Krishi Yojana Aapke Dwar)	• Better delivery of extension services	• Providing incentives to farmers under various schemes. • Ensuring transparency in the delivery of services by organizing camps at the panchayat level per gram and some special orientation and review camps • Augmentation of crop production through better delivery of extension services.
Agricultural technological Intensive/ Employment training		
Assistance to NGOs	• In order to be able to implement all kinds of agriculture development programmes	• To undertake agriculture development programmes from state plan funds or to bear administrative cost of NGOs for implementation of ongoing CSSs /State Plan programmes.
Crop Insurance under NAIS		• As payment of bank service charges on deposited premium, premium subsidy for small and marginal farmers • Strengthens agricultural insurance mechanisms which provide an impetus to farmers to more easily accept

Ongoing Initiatives/Government programmes	Key objectives/Goals	Components/Strategies/Activities Linkages
		and apply relevant technological changes.
Weather based crop insurance schemes (WBCIS)	• To increase insurance to weather changes.	• Insures farmers against climate related weather changes.
Distribution of agricultural implements/PP machinery	• For popularization of improved and energy efficient farm machinery	• Differential subsidy and implement testing by third parties • Energy efficiency in the agricultural realm.
Subsidy on pipe line	• Subsidy on water saving devices	• Water resource conservation with respect to irrigation.
Land stock improvement Reclamation of saline and alkaline soil	• Reclamation of saline and alkaline soils and to render them more suitable for agricultural purposes.	• 25% subsidy provided to all farmers for reclamation of saline and alkaline sols • Increases land area suitable for supporting the growth of agricultural or horticultural crops, depending on the fertility and the suitability of the soil.
Innovative programmes	• To meet the requirements of research and extension for specific farming situations	• Contractual researches that permit the taking up any new schemes or programme that are not covered under any of the ongoing schemes or programmes. • This is relevant in case the funds are used for schemes/programmes that address climate relevant issues.
Shifting from flood irrigation to drip irrigation	• Water Conservation and increase in efficiency of water use.	• Distribution of drip irrigation implements
Gramsat	• For facilitating training and extension activities in the various state departments	• Connectivity till the panchayat samiti level • Information dissemination and capacity building for coping with climate stresses.
Rashtriya Krishi Vikas Yojana (RKYV)	• To incentivize the states so as to increase public investment in Agriculture & allied sectors. • To provide flexibility and autonomy to states in the process of planning & executing Agriculture & allied sector schemes. • To ensure the preparation of agriculture	• Promotion of storage bins for grains to popularize scientific storage • Promotion of popularization of village level soil health cards and village level package of practices • Strengthening of soil fertilizer, pesticides and residue testing laboratorial in state • Strenghtening and modernization of laboratories of

Ongoing Initiatives/Government programmes	Key objectives/Goals	Components/Strategies/Activities Linkages
	plans for the districts and the states based on agro-climatic conditions, availability of technology and natural resources. • To ensure that the local needs / crops / priorities are better reflected in the agricultural plans of the states. • To achieve the goal of reducing the yield gaps in important crops, through focused interventions. • To maximize returns to the farmers in Agriculture and allied sectors. • To bring about quantifiable changes in the production and productivity of various components of Agriculture and allied sectors by addressing them in a holistic manner.	Rajasthan • Jal Hauz (Water Tank) in district in district Bikaner • Farm Pond (for efficient water utilization) • Project of seed replacement rate (SRR) • Non conventional energy (solar power) for efficient use of water through drip diggi • Action research for refinement of package of practices for productivity enhancement of crops in different agro-ecological situations • Project proposal on development of laboratory for multiplication of bio-pesticides as a component of IPM for sustainability • Enhancement of productivity and quality of Mandarin in Sub-Humid Tropics of Rajasthan • Collaborative project for balanced use of fertilizers and enhanced accessibility of fertilizers and sustainable agriculture • Diggies/plastic lined diggis in canal command areas • Popularization of biopesticides • Infrastructure development and hi-tech agriculture at newly established Adaptive Trial Centre of DOA at Abusar, district Jhunjhunu. • Strengthening and modernizing the agriculture training infrastructure at State Institute of Agriculture Management (SIAM), Durgapur, Jaipur • Special projects for enhancement of productivity • Community managed small scale land and water resources development for the agriculture and allied development for the rural and the poor farm families in Banswara district

Ongoing Initiatives/Government programmes	Key objectives/Goals	Components/Strategies/Activities Linkages
National Horticulture Mission (15% state share)	• Increasing area, production and productivity	• Diversification of agriculture for sustainability.
	• Establishment of fruit orchards	• Plantations of NHM as well as non-NHM crops to be taken up in the identified districts • For promotion of diversification of agriculture for sustainability
	• Vegetable Demonstration	• Propagation of production technologies for horticultural crops through demonstration of vegetables and high value crops
	• Weather Insurance	• Insurance cover to horticultural crops against aberrant weather conditions through assistance to farmers on premium amount of insurance policy
	• Reducing post harvest losses through Post Harvest Management (PHM)	• Setting up pack houses and processing units and packing material etc.
	• Differential subsidy for establishment of Green House	• For growing off-season vegetables, seedlings and other horticultural crops
	• Implementation of innovative need based schemes	• Assistance to farmers
	• Research and Development	• To enhance productivity level of different horticultural crops • Better PHM • Need based research work
	• Setting of vermi compost units	• Promoting cultivation of organic produce
	• Dry land horticulture on Farmer's field	• Collection of rainwater by diverting the flow from part of field
	• Demonstration of medicinal and aromatic crops	• Create awareness among farmers about other crops
	• Publicity and Media support	• Organization of farmers fairs, seminar,

Ongoing Initiatives/Government programmes	Key objectives/Goals	Components/Strategies/Activities Linkages
		workshops, printing of literature, running and maintenance of computers
	• Assistance on P.P. measures	• Plant protection measures for horticultural plants
Rajasthan State Warehouse Corporation	• Construct godowns and warehouses for scientific storage of agricultural produce, fertilizers, seeds and other notified commodities	
Drought Prone Areas Programme	• To provide capacity for resilience to droughts	• Undertaking watershed projects
Desert Development Programme	• To improve resilience to droughts	• Drought proofing, • Development of watersheds etc. (check) • Improves resilience to droughts.
Integrated Wasteland Development Programme (IWDP)	• Development of wastelands	• Centrally sponsored scheme (central: state expenditure. Rs. 5500:500 per hectare) • Restoration of wastelands so that can become more suitable for agricultural/horticultural purposes.
Macro Management of Agriculture	• ICDP Wheat • ICDP Coarse Cereals • Sugarcane based cropping system • Balanced & Integrated use of Fertilizers • Agriculture Mechanization • Reclamation & development of Alkali Soils	• Popularization of certified seeds • IPM • INM • Agriculture Mechanization • Extension • Training & Information Support activities • Soil Reclamation • Infrastructure Support etc. • The rate of assistance available under this scheme is 25%.
National Food Security Mission (NFSM)	• Increasing production of Wheat, Rice and Pulses in a sustainable manner in identified districts.	• Demonstration of improved packages of practices • Distribution of certified seed for increase in SRR • Integrated nutrient management, integrated pest

Ongoing Initiatives/Government programmes	Key objectives/Goals	Components/Strategies/Activities Linkages
	• Restoring soil fertility • Creating employment opportunities • Enhancing farm level profitability.	management • Mechanization • soil amelioration • farmers field school based training

7.6 Summary

Being one of the most climate sensitive states with one of the lowest adaptive capacity makes immediate action on climate change crucial for the state of Rajasthan. Characteristically high temperatures, extremely scanty and erratic rainfall and very high frequency of extreme events like droughts make agriculture a high risk activity in the state. Limited sources of surface water and declining groundwater levels due to over exploitation and injudicious use of groundwater resources further weaken the already fragile resource base for agriculture. Most of the state falls in the semi arid region and the soil is characteristically low in carbon content and alkaline in most areas. In addition, widespread land degradation also poses a persistent challenge. The problem of salinity has also seeped to the groundwater with groundwater becoming more saline. Major irrigation projects are experiencing problems of water logging and salinity buildup in large pockets. There is also a tendency towards indiscriminate use of agricultural chemicals in irrigated areas.

Climate change is likely to further exacerbate the already strained conditions for agriculture in Rajasthan. Recent studies have further predicted that due to climate change there may be significant increase in the desert area over India in the next 100 years with potentially disproportionate impact of global warming on coupled human and natural systems. Manifestations of a changing climate are being observed as the duration of seasons change. It is observed that summers are expanding and the winters are shrinking. Temperatures in early March have been on the rise which makes the cultivation of wheat more challenging. Decreasing productivity of crops and livestock animals is also being observed. Decline in pasture lands and lesser milch cows and buffaloes are being experienced. As a result of all these changes, the real income as also declined.

7.7 Climate actions and strategies

For these strategies, some broad financial estimates have been worked out. The feedback received from the departments on financial targets has also been incorporated.

Key Strategy 1: Enhancing productivity of crops and livestock

Action 1: Development of climate-hardy cultivars which are tolerant to droughts, thermal extremes, alkalinity and pests, and cultivars that are less water consumptive. Research is being conducted in different agro-climatic zones through 7 Agricultural Research Stations (ARS) and 6 Agricultural Research Sub-stations. The Agricultural Research Stations conduct research through All India Coordinated Research Projects financed by ICAR on 75:25% basis[24]. Research outputs in the form of specific varieties of crops that are suited to specific ACZs should be accordingly field tested. For example planting of improved varieties of Bajra RHB -121 variety that has medium tolerance towards drought; Raj-171 for dry fodder and grain in areas that experience normal to scanty rainfall or Raj Bajra chari-2 would be suitable for alkaline areas[25]. Research work is being done by State Agricultural Universities on the development of cultivars tolerant to drought, thermal extremes, alkalinity and pests and diseases. The Department of Agriculture has also been providing financial support and technical feedback for the same.

24http://www.planning.rajasthan.gov.in/Tenth%20Plan/Chapter/PDF/chap7-agri.pdf

25 http://news.oneindia.in/2006/06/19/six-improved-varieties-of-bajra-in-rajasthan-1150715201.html

Action 2: Breeding of climate-hardy livestock and development of nutritional strategies to prevent heat stress and productivity loss. Dairying of goats and other small ruminants should be promoted through provision of incentives as goat dairying is affected to a lesser degree than cattle dairying during droughts, particularly in land that is affected by salinity and wind erosion. (Patil, N.V. et al) or alternatively rearing of other small ruminants like sheep, except in districts like Hanumangarh and Sriganganagar where production of larger ruminants is dominant. Indigenous varieties with heat resistance capacities could be identified and promoted to minimise related losses in milk production.

Action 3: Emphasis should be on increasing and improving quality of produce of coarse cereals like bajra that are traditionally suited to the region and on promoting coarse cereal based farming systems. Programmes like Macro management of Agriculture and National Food Security Mission that have a wide scope are currently operational in the state. The Macro management of Agriculture has a component dedicated to coarse cereals. Financial support and incentives for conducting field demonstrations to enable technology adoption and deployment at the farm level should also be given.

Agency (ies)	Name
Lead	Department of Environment
Supporting	Water resources department Department of Irrigation Department of Forestry Department of Agriculture & Animal Husbandry Department of Rural Development State Agricultural Universities

Key Strategy 2: Restoration and development of wastelands

Action 1: The state has nearly 1.194 million hectares as wastelands. With a taproot that can extend more than 100 feet deep and an extensive root mass, khejari helps stabilize the sandy desert soil and shifting sand dunes. It can serve as a windbreak, protecting farms from strong desert winds, and its wood is excellent for firewood and charcoal. Khejari is an important feed species that is nutritious and highly suitable as dry fodder, readily eaten by camels, cattle, sheep and goats, and forms a major feed requirement of desert livestock. The leaves are of high nutritive value. Feeding of the leaves during winter when no other green fodder is generally available in rain-fed areas is thus profitable. The pods are also used as fodder for livestock. The tree is a light demander and the older plants are drought resistant and are able to withstand the hottest winds and the driest season, and remain alive when other plants would succumb. Trees like Khejri and su-babool can be grown on a large scale in 1.194 million hectares of wastelands in the state in a phased manner.

Financial requirements:

Unit cost of plantation per hectare (including maintenance/protection costs) = 6916.39 crores/1775000 hectares = 0.0039 crores/hectare

First phase of plantation spanning three years and covering 0.3582 million hectares would cost = **Rs. 0.00139 Crores**

Action 2: Almost one million hectare area is composed of alkaline soil*26*. Under the tenth plan a token of 0.05 Lakhs was provided for reclamation of alkaline soils spread over in the districts over in districts of Bhilwara, Chittor, Alwar, Bikaner, Pali, Nagaur, Bharatpur, Ajmer, Jaipur, Sikar, Dholpur & Jalore. A pilot study should be undertaken to assess the benefits and suitability of the approaches undertaken so far in these districts for the reclamation of alkaline soil.

Financial requirements:

Total alkaline area: 1000,000 hectares approx.

Unit cost of reclamation of alkaline soils = Rs. 11000 (As prescribed under the 'Reclamation of alkaline soils' component under the Macro Management of Agriculture Programme of the GoI)

Pilot study for assessment = **5 lakhs**

Total area to be covered under the pilot project for reclamation in selected districts in first 3 years = 2000 hectares

Total cost for reclamation of soils (pilot project in selected districts) = **2.2 Crores**

Total Financial requirement = 2.2 + 0.05 = **2.25 Crores**

Key Strategy 3: Research and assessment of specific climatic risks to agriculture

Action 1: At present the state has seven automated weather stations situated at Bharatpur, Bikaner, Hanumangarh, Jaipur, Jaisalmer, JhunJunu and Jodhpur districts. Based on its climatic features and agricultural specifics, the state is divided into ten agro climatic zones. An increase in the number of automated weather stations, ensuring that at least one lies with the boundaries of each of the ten agro climatic zones, should be sought. Infrastructure development for advance forecasting of the climatic parameters at the district level should be undertaken to provide timely information on rainfall delays and other important climatic information to farmers to be processed by district agriculture KVKs for use in agro advisory services. The option of incentivising dissemination of information on current market prices, climatic parameters improved animal feeding technology modules through use of mobile phone should be explored.

Financial estimates:

Cost of setting up of one automated weather station. = 10 lakhs approx.

Weather stations to be set up in at least three more regions; ACZs: IIIB- Flood prone eastern plain, IVA- Sub Humid Southern plain, IVB- Humid Southern

Total requirement = 10 * 3 = 30 lakhs

Action 2: Rajasthan Agriculture University in Bikaner and CAZRI in Jodhpur are the important research institutes conducting research on various aspects of crop production and management. The Rajasthan Agriculture University, Bikaner looks after Agriculture

26 http://www.planning.rajasthan.gov.in/Tenth%20Plan/Chapter/PDF/chap7-agri.pdf

Extension, Education and Research and to carry out production - oriented agriculture research programmes, rural mass education, adoption and propagation of new technologies in the State in the field of Agriculture including Animal Husbandry and allied services. Another Agricultural University in Udaipur established in 1999-2000 focuses on Agriculture Education and Research more effectively in southern and eastern zones of the State. Research is being conducted in different agro-climatic zones through its 7 Agricultural Research Stations (ARS) and 6 Agricultural Research Sub-stations. In the light of climate change impacts, rigorous data generation for conduction of vulnerability assessments using crop growth models should be undertaken.

Financial estimates:

Allotment for project for data generation at the field level = Rs. 50,000 each. p.a.

Project period = 3 years

Total number of regions for field studies to be conducted in = number of districts = 33

Total requirement = (50,000*3)*33 = Rs. 49.5 Lakhs

Key Strategy 4: Promotion and management of multifunctional agroforestry systems

Action 1: Traditional agroforestry practice involving species such as *Prosopis cineraria, Tecomella undulata* and *Salvadora oleoides* have contributed towards enhancing drought resilience in the state. Multifunctional agroforestry systems provide fodder, fuel, timber, fruits, seeds, pods, as well as non-timber forest produce such as gum, apart from soil quality enhancement, livelihood support and mitigation co-benefits. A pilot project to assess suitability of specific tree species to regions in combination with crop species before going for large scale agroforestry practices should be undertaken.

Agency (ies)	Name
Lead	Department of Agriculture Department of Environment Department of Forests
Supporting	Public-private partnerships

Key Strategy 5: Promotion of Horticulture

Action 1: At present Favorable climate for production of Seed spices, Ber, Mandarin, Kinnow, Pomegranate, Aonla and Bael. At present surplus is available in Spices, Onion, Pea and Cucurbits although there is limited availability of quality planting material. Poor post-harvest management couples with acute shortage of water continue to pose challenges to the sector. In spite of the existing challenges, ample scope in expansion of area exists for horticultural crops like oranges in Jhalawar and kinu and amla in Ganganagar and Hanumangarh, Guava in Sawai Madhopur and Bundi, Cumin in Jalore, Barmer and Jhalawar. Potential to increase production and export of seed spices also exists. Vast potential of medicinal and aromatic plants also exists.

Financial estimates:

Area for expansion in select districts

- Oranges in Jhalawar over 15000 ha
- Kinnows in Sri Ganganagar and Hanumangarh over 2000 ha
- Amla in Jaipur, Ajmer and Alwar over 15000 ha
- Ber in Jodhpur and Bikaner over 2000 ha
- Guava in Sawai Madhopur and Bundi over 1800 ha

Unit cost for establishment of new gardens (as per National Horticulture Mission norms) = Rs. 30,000 per hectare

Therefore, total financial requirement = (15000 + 2000 + 15000 + 2000 + 1800) * 30,000 = **Rs. 107.4 Crores**

Keeping the target of the first phase (3 years) to cover 10, 740 hectares, total financial requirement would be = **Rs. 32.2 Crores**

Action 2: The National Horticultural Mission programmes are being implemented in the state. Based on agro climatic zones, identified villages in selected districts should receive training and demonstrations on the growing of suitable horticultural crops that are proposed for expansion in the area. For such activities, a cluster of villages should be selected in a potential district of the State.

Financial estimates:

Assuming the requirement of one demonstration per 0.4 ha of land based on the demonstration criteria under the National Food Security Mission.

Total area to be covered for demonstrations = 10, 740 heactares

Total number of demonstrations to be conducted in the three year time frame = 10,740/0.4 = 26850

Per unit cost of demonstrations = Rs. 2000

Total financial requirement = **Rs. 5.37 Crores**

Key Priorities and Actions identified for the Agriculture Sector

Key Strategy	Action	Time-frame (ST, MT, LT)[27]	Physical Target	Financial Requirement
1	Enhancing productivity of crops and livestock			
	Development of climate-hardy cultivars which are tolerant to droughts, thermal extremes, alkalinity, pests, and cultivars which are less water consumptive.	LT research Research study 'Action research on adaptation strategy for mitigating the adverse impact of climate change for enhancing crop production in ACZ- IIIa' under Innovative Programme has been awarded to ARS, Durgapur (Jaipur) Study on Development/ identification of stress tolerant varieties of pulses to elevate productivity in Rajasthan has been awarded to MPUAT, Udaipur under RKVY	Research work Research studies from 2010-2015	25 lakhs 18.25 lakhs for five years 24 lakhs
	Breeding of climate-hardy livestock and development of nutritional strategies to prevent heat stress and productivity loss; Dairying of goats and other small ruminants should be promoted; Indigenous varieties with heat resistance capacities could be identified and promoted to minimize related losses in milk production.	Extension and development activity The nondescript climate hardy bovine population may be upgraded by artificial insemination or by procurement of elite bulls of indigenous breeds to prevent the productivity loss. The Animal husbandry department has the Livestock Policy 2010 and the Livestock Breeding Policy for breed improvement programme in the state.	Elite bull programme (400 bulls) Establishment of buffalo farms (50 buffalo)	80 lakhs 90 lakhs

[27] ST: Short Term (2012-2017), MT: Mid-term (2017-2022), LT: Long-term (2022 and beyond)

Key Strategy	Action	Time-frame (ST, MT, LT)[27]	Physical Target	Financial Requirement
			Establishment of elite indigenous cattle breeding farms of Gir, Kankrej, Rathi and Tharparker (400 cattle- 100 for each breed)	786 lakhs
		Extension and development activity Additionally, regarding development of nutritional strategies a Fodder Action Plan has been prepared under which demonstration camps regarding use of urea mollasis for fodder enrichment are being carried out.		
	Increasing and improving quality of produce of coarse cereals like *bajra* that are traditionally suited to the region and on promoting coarse cereal based farming systems. Financial support and incentives for conducting field demonstrations to enable technology adoption and deployment at the farm level should also be given	Demonstration on coarse cereal/ oilseeds/ pulses based cropping systems like bajra, maize and jowar are being taken in the state during Kharif 2011 under RADP and INSIMP sub-schemes of RKVY.	Maize 15000 ha Jowar 37000ha Bajra 1.94 lakhs ha	Maize 750 lakhs Jowar 1058 lakhs Bajra 5480.5 lakhs
2	Restoration and development of wastelands			
	Promote plantations of trees like Khejri and su-babool that can be grown on a large scale	Action by Department of Forests		

Key Strategy	Action	Time-frame (ST, MT, LT)[27]	Physical Target	Financial Requirement
	in 1.194 million hectares of wastelands in the state in a phased manner*[28]			
	A pilot study should be undertaken to assess the benefits and suitability of the approaches undertaken so far in these districts for the reclamation of alkaline soil.	For the reclamation of problematic soils, demonstrations are being taken up in which gypsum is applied followed by green manuring with dhaincha in the affected fields.	8000 ha	304 lakhs
3	Research and assessment of specific climatic risks to agriculture			
	An increase in the number of automated weather stations, ensuring at least one within the boundaries of each of the ten agro-climatic zones. Infrastructure development for advance forecasting of the climatic parameters at the district level should be undertaken to provide timely information on rainfall delays and other important climatic information to farmers by agriculture KVKs for use in agro advisory services. The option of incentivising dissemination of information on current market prices, climatic parameters improved animal feeding technology modules through use of mobile phone should be explored.	495 Automated Weather Conditions (405 by NCMLC, 39 by IMD and 51 by ISRO) have been established in the State. The data recorded/ collected from these stations are being used for crop insurance and weather forecasting. The number of AWS are being increased through IMD. Project on CUG mobile facility for extension services is sanctioned under RKVY. This shall be helpful to communicate latest agricultural information to the farmers through the extension units.	250 lakhs 6000 field functionaries of Agriculture Department	Funding by ISRO 66 lakhs
	Rigorous data generation for conduction of vulnerability assessments using crop growth models should be undertaken	There is a well-established network of statistics in the department that is collecting all relevant data at the block level and is being used in preparing the crop plans, find out constraints and their solutions.	NA	NA

*Further inputs to be provided by the Department of Forests

Key Strategy	Action	Time-frame (ST, MT, LT)[27]	Physical Target	Financial Requirement
4	Promotion and management of multifunctional agro-forestry systems			
	A pilot project to assess suitability of specific tree species to regions in combination with crop species before going for large scale agro-forestry practices should be undertaken	A project has been given in 2010-11 to MPUAT, Udaipur to undertake study on establishment of silvi-pastoral model in semi-arid regions of Rajasthan under RKVY.	Research work	26.65 lakhs
5	Promotion of Horticulture			
	Explore potential to expand area under cultivation of horticultural crops, seed spices, medicinal and aromatic plants	State Government through the Department of Horticulture encouraging farmers for growing horticultural plants in the state. The funds/ assistance for this purpose is being provided through NHM, NMMP and RKVY.	Fruit plants 11350 ha Spices 4000 ha Medicinal plants 486 ha	Fruit plants 1649.91 lakhs Spices 289.5 lakhs
	Based on agro climatic zones, identified villages in selected districts should receive training and demonstrations on the growing of suitable horticultural crops that are proposed for expansion in the area. For such activities, a cluster of villages should be selected in a potential district of the State.	Training camps and intra/ inter- state exposure visits are being organized for the farmers to train them about growing of suitable horticultural crops. Farmers from different districts are sent for training at different locations based upon suitability.	6850 farmers	98.2 lakhs

Chapter 8: Human Health

8.1 Background

Rajasthan in the last few years has shown progress in terms of health status and outcomes but much still remains to be done to bring the health of the State in the mainstream of national averages. Operational integration in policy and programme between various vertical programmes within the health sector, and between health and other related sectors such as drinking water, sanitation, and nutrition has been limited, resulting in a lack of holistic approaches to health. Table 8.1 gives glimpse of some of the key health indicators along with Eleventh Five Year Plan targets for the State. Table 8.2 indicates the status of health infrastructure in the state as on March 2010.

Table 8.1: Comparative health indicators of India & Rajasthan

S.No	Indicators	India	Rajasthan	XI Plan Targets for Rajasthan
1.	Crude Birth Rate (SRS 2008)	22.8	27.5	21.00
2.	Crude Death Rate (SRS 2008)	7.4	6.8	7.0
3.	Infant Mortality Rate (SRS 2008)	53	63	32
4.	Maternal Mortality Ratio (SRS 2004-2006)	254	388	148
5.	Total Fertility Rate (SRS 2008)	2.6	3.3	2.1
6.	Couple Protection Rate (Any method)	54.0 (DLHS-III)	57.0 (DLHS-III)	65.0

Source: State Annual Plan (2011-2012), Planning Department, Rajasthan[29]

The Eleventh Five Year Plan approach emphasizes the development of good health care infrastructure and providing quality health care services to the people. Simultaneously, the State Government is focusing on technology-based solutions, like telemedicine, emergency ambulance care, and free IPD and OPD health care for BPL families through a number of innovative schemes. The State has identified its goals in tune with National Health Policy, Millennium Development Goals and the basic strategy of National Rural Health Mission guided by issues of equity, gender imbalances, access and availability, quality, decentralization, institutional strengthening and capacity development[30]. The following goals have been fixed for the state under the Eleventh Five Year Plan:

- Reduction in Infant Mortality Rate (IMR) & Maternal Mortality Ratio (MMR)

29 State Health Annual Plan (2011-2012), Planning Department, Government of Rajasthan. Available at: http://www.planning.rajasthan.gov.in/Annual%20plan_1112/chapters/pdf/chap_18.pdf Last accessed 25 February 2011

30 Health Sector Reforms Workshop, 19 June 2008. Compiled and Developed by SIHFW. Available at http://www.mohfw.nic.in/NRHM/Documents/HSR_Rajasthan.pdf Last accessed 15 February 2011

- Reduce fertility to replacement levels for population stabilization
- Arresting gender imbalance
- Restructuring of health care delivery system
- Human resource development and capacity building
- Integration of AYUSH into mainstream of health care delivery
- Consolidation & sustaining achievement of the Tenth Five Year Plan
- Decrease Burden of Diseases and promote healthy life style

Table 8.2: Health Infrastructure in Rajasthan (as on 31.03.2010)

Source: State Annual Plan (2011-2012), Planning Department, Rajasthan[31]

S.No	Particulars	Numbers
1.	Hospitals (including Medical College Hospitals)	127
2.	Community Health Centres (Rural)	368
3.	Primary Health Centres (Rural)	1504
4.	Primary Health Centres (Urban)	37
5.	Health Sub Centres	11487
6.	Dispensaries	199
7.	Mother & Child Welfare Centres	118
8.	Aid-Post (Urban)	13
Total Health Institutions		13853
9.	Number of beds (including 11024 beds of attached hospitals under Medical Colleges)	44608
10.	Served Area per Institution (in km)	25
11.	Served Population per Institution	4079
12.	Served Population per bed	1267

High IMR, MMR, malnutrition among children and women, high incidence of childhood diseases, child marriage, declining sex ratio of girls under six years, low female literacy in comparison to national average, inadequacies in water supply and sanitation, poor health and poor socio economic status of women along with social discrimination, are all already a cause of concern for population health in the State. Thus, when looked at in the light of existing vulnerabilities, changes in climate variables and associated impacts on natural and socio-economic systems are expected to pose additional stress on human health and new challenges for the health sector of Rajasthan. However, a clear understanding of the existing health care environment in the community is essential to probe the suitability of any new intervention such as those envisaged under the Rajasthan Action Plan on Climate Change.

8.2 Current vulnerabilities

Apart from exposure to the climate stress, a wide range factors play a crucial role in determining the vulnerability of the population in terms of their sensitivity and coping capacity. The most vulnerable are often those that are most exposed to hazard, or those that

31 State Health Annual Plan (2011-2012), Planning Department, Government of Rajasthan. Available at: http://www.planning.rajasthan.gov.in/Annual%20plan_1112/chapters/pdf/chap_18.pdf Last accessed 25 February 2011

are most sensitive to the impacts due to changes in climatic patterns and/or those who have limited resources to cope or adapt to climatic shocks and stresses. Various factors contribute to the high vulnerability of Rajasthan's health sector to potential climate change impacts:

8.2.1 High population growth rate

Rajasthan recorded a decadal population growth rate of 28.41 percent during 1991-2001, the highest in the county. As per the 11th Five Year Plan document for the State, the high rate of population growth can be mostly attributed to the high growth potential inbuilt in the existing age structure. About 47 percent female population is within the reproductive age and around 40 percent is below the age of 15 years. Another reason is the low age at marriage particularly in the rural areas. Although the rate of population growth has declined but it still has to enter the stage of rapid fertility transition. High growth rates together with high poverty levels can increase the pressure on natural and socio-economic resources in turn contribute significantly to high sensitivity to climate change impacts. The state has also recorded high urban population growth rate. According to 2001 census, there has been a large scale migration of population from rural areas and smaller towns to bigger towns and cities of the state. By the end of Eleventh Plan, urban population of Rajasthan is projected to be 25.28% of its total population and number of urban settlements, which was 222 in 2001 is projected to go up to 230. Rapid urbanization will increase the demand and put tremendous strain on urban resources, services and infrastructure including the urban health care systems.

8.2.2 Poor health status of population, especially women and children

A major determinant of high vulnerability of population to climate change risks is the poor health status especially that of women and children in the State. Though the IMR has reduced from 80 (SRS-2001) to 63 per 1000 (SRS-2008), it is still higher in comparison to the national average of 53. As per NFHS-3, 53% women in the State are found to be suffering from anemia of which 2% are severely anemic. On the other hand prevalence of anemia among children accounts for 80% of whom 10% are severely anemic. Anemia among women & children is one of the major causes of high IMR & MMR. It has detrimental effects on the health of women and children and also results in an increased risk of premature delivery and low birth weight. High malnutrition rates are another reason for concern in the State. Though it has shown some improvement over the years, malnutrition has reportedly come down to 44% among children 0-3 years of age (NFHS-3) from 51% (NFHS-2), it is still very high from the desired level[32]. Gender bias and disparity on account of sex and caste play a dominant role in the society and has a significant implication on health access and health seeking behavior of the population. Low literacy rate, particularly among women create barrier to health awareness and use of the available health services and schemes. Literacy level, especially for girls, is among the lowest in the country in Rajasthan.

32 State Health Annual Plan (2011-2012), Planning Department, Government of Rajasthan. Available at: http://www.planning.rajasthan.gov.in/Annual%20plan_1112/chapters/pdf/chap_18.pdf Last accessed 25 February 2011

8.2.3 Poor health status of tribals and other backward classes

Review of past performance of health services in the State indicates that the tribal districts of Rajasthan had remained continuously deprived of access to modern specialized services of experts[33]. Habitations are particularly scattered in desert and tribal hilly areas. According to study conducted by Nagda (2004) on health of tribals in the State, infant and child mortality is higher in the tribes' than rest of the population in the State. The major causes of infant and child mortality in tribes were acute respiratory infections, diarrhea and anemia. The medical facilities in the tribal areas are still rudimentary. There is no proper link road between the tribal villages and health centers. Tribals are economically backward with no provision for free medicine and treatment except for some diseases like malaria, polio, diarrhea, tuberculosis etc. The "Sanjivani Programme" was launched to provide services of specialists to these areas through outreach camps. Under the 11th Five Year Plan, public-private and public-civil society partnerships to provide efficient, timely and reasonably priced diagnostic services to the patients is to be promoted. For improving the level of literacy, nutrition and health condition, adequate infrastructure facilities are needed. For uplifting economic status of tribes, new job avenues based on agriculture, forest, forest productions must be established in tribal areas.

8.2.4 Prevalence of climate-sensitive diseases

Incidences of Vector Borne Diseases are widespread in the State. VBDs are probably the most sensitive to changes in climate parameters. Malaria is a major health problem in Rajasthan especially in the North Western desert part of the State. Recently, there has been a resurgence of malaria in several parts of India, and the Thar Desert in north-western India, is currently suffering from the impact of repeated annual epidemics. Some studies have linked the recent malaria epidemics in the Thar Desert with the progression of canal-irrigation work, particularly with the massive Indira Gandhi Nahar Pariyojana (IGNP). When entomological and parasitological investigations were carried out on malaria vectors and disease prevalence in two sets of villages, the first set belonging to the highly irrigated Indira Gandhi Nahar Pariyojana (IGNP) command-area villages, and the other to the truly desertic non-command (unirrigated) area villages, malaria prevalence, as determined through sustained fever surveys, was higher in the IGNP villages than that of in the unirrigated villages. Another finding was the high proportion of Plasmodium falciparum (76.6%) in the former villages as compared to the latter (16.6%) . The major ecological changes associated with irrigation in the Thar Desert are understood to be playing an important role in accentuating the transmission of malaria. Dengue fever and Chickungunya (and more recently Swine Flu) are the other major VBDs in the State. In a 2001 study by Bohra & Andrianasolo, association between dengue risk and select socio-cultural factors was investigated in a dengue endemic area of Jalore in Rajasthan. A number of socio-cultural variables such as on human dwellings, occupational patterns, awareness and knowledge about dengue, mosquito protection practices, sanitation and waste disposal management, cultural practices regarding storage of water containers and health care were considered and found to be significantly correlated for the sample studied. It was observed that storing of

33 Approach to 11th Five Year Plan (2007-2012), Planning Department, Government of Rajasthan. Available at http://www.planning.rajasthan.gov.in/fyp.htm Last accessed 24 February 2011

water in houses due to inadequate water supplies in summer months created conditions conducive to the breeding of Aedes aegypti mosquitoes and led to more pronounced vector presence in the vicinity.

Inadequate availability of water, poor water quality at source, ill-maintained water lines, unsafe sanitation practices and lack of awareness about good sanitation practices, personal hygiene and primary health care are some of the key factors responsible for the common and widespread health risks associated with consumption of pathogen infested drinking water in rural habitations of Rajasthan. In fact both 'tanka' and 'beri', the well-like structures made for storing drinking water by the rural communities in the Thar Desert have been found to be breeding habitats for Anopheles stephensi, the confirmed malaria vector in desert regions . Adverse geographic and climatic conditions-such as persistent drought and lack of water resources force a section of population to be on perpetual migration from one place to another. Desert districts of Western Rajasthan are the worst affected by occurrences of droughts. A study conducted by Desert Medicine Research Centre in the drought affected areas of Western Rajasthan, assessing illnesses and nutritional status among children below five years of age showed that inadequate intake of daily food lead to respiratory, gastroenterological and calorie and protein deficiency amongst a large proportion of children.

8.3 Likely impacts of climate change

Climate change is expected to adversely impact human health by increasing the risk of exposure to vector, water- and food-borne diseases, aggravating malnutrition and increasing injuries and deaths from extreme rainfall events and thermal stresses. However, a number of non-climate factors such as population growth and demographic change, access to clean water, adequate nutrition and sanitation facilities, improvements in health care, and disease prevention and control programs have tremendous influence on either reducing or aggravating these climate induced impacts. However, very few studies have been carried out in the Indian context to study the impacts that climatic changes may have on population health. However more recently interest in this field is increasing and more evidence is being generated.

Preliminary assessments carried out for India's first National Communication to UNFCCC show that under the IS92a scenario, the severity of droughts and intensity of floods in various parts of India is likely to increase. A general reduction in the quantity of available runoff under the IS92a scenario, for period 2041 to 2060, is to be expected which would affect the water availability in many a river basins of the country. River basins like Sabarmati and Luni may experience acute water scarcity along with basins of Mahi, Pennar and Tapi which are likely to experience constant water scarcity and shortage. Further the study brings forth that Luni along with the west-flowing rivers of Kutch and Saurastra which occupy about 60 per cent of the area of Rajasthan shall face acute water stress conditions. Decline in water availability in the State which will affect water resources, agriculture and other dependent sectors can have serious implications on health outcomes such as water-borne and nutrition related diseases amongst others. The state of Rajasthan already has the maximum probability of occurrence of drought in India. With the projected changes, the condition may deteriorate in terms of severity of droughts. Even though a 20% rise in all- India summer monsoon rainfall is projected, in Rajasthan overall rainfall is projected to decrease, and evapo-transpiration to increase. Even a marginal increase in evapo-transpiration due to

global warming will have a larger impact on resource-poor, fragile arid zone ecosystem of Rajasthan having serious implications on population health in terms of increase in water borne diseases such as diarrhoea and cholera (Singh et al 2010).

Water availability is also fundamental to food security. Thus, impacts on water sector can be expected to have a cascading effect on food production thereby affecting food security and nutritional status of the population. Other than this, climate change may impact food production itself as has been projected in a range of simulation studies for various crops (Mall et a; 2006). A study conducted by O'Brien et al (2003) assessed that the areas with high to very high climate sensitivity for agriculture are located in the semiarid regions of the country, including major parts of Rajasthan. Climate change can also be expected to reinforce the association between malnutrition and some infectious diseases (Caulfied et al 2004). While malnutrition can increase susceptibility to infections by inducing alterations in hosts' immune function, infectious diseases adversely affect nutritional status by reducing an individual's capacity for food intake and nutrient absorption (Brown 2003). Some global studies (Caulfied et al 2004) show that deficiencies in Vitamin A, zinc, iron and other micronutrients are responsible for a substantial proportion of malaria morbidity and mortality as these nutrients are vital for building natural resistance against malarial infection. A reciprocal relationship has also been postulated between diarrhea and malnutrition in children, with diarrhea leading to nutrient loss and malnutrition predisposing diarrhea.

There has also been an increasing literature base investigating the influence of climate change on vector production and transmission of Vector-borne diseases. In a study by Bhattacharya et al, (2006) a set of transmission windows, in terms of different temperature and humidity ranges were developed for the malarial parasite, typical to Indian conditions, by analyzing the present climate trends and corresponding malaria incidences. It was observed that though the broad transmission window for malaria in terms of temperature is between 15°C and 40°C, the number of days required for a parasite to complete its life cycle varies according to the number of days a particular range of temperature persists provided the relative humidity remains conducive. Using these transmission window criteria, the most malarious regions in India were identified, both under baseline and greenhouse gas scenarios. The studies report that while some states will continue facing risk of malaria under climate change, while other states may see a reduction in length of transmission season. On the other hand, some regions, today not exposed, are expected to come under threat of malaria in the future due to climate change. It was also found that rainfall during October, over Gujarat, Maharashtra, Rajasthan, Madhya Pradesh, Karnataka and Andhra Pradesh is positively correlated with malaria incidences in following year in these areas (with correlation coefficient, 0.52). This is because the rainfall in October in the previous year creates favorable conditions for a good vegetation growth and hence retention of optimum humidity conditions required for breeding of the mosquitoes in the subsequent year.

In the recent INCCA report (GoI 2010) a district-wise map of India was generated to show the distribution of different categories of transmission windows under baseline and by the year 2030s (**Figure 8.1**). In the region, above the Vindhyas and below the Himalayan region, extending from Rajasthan in the west to West Bengal in the east, the transmission windows are open for 7-9 months in the baseline scenario and continue to do so in the 2030's with increase in temperature, except in the north-western parts of Rajasthan where the windows tend to open only for 4-6 months in the 2030's. These findings are nevertheless subject to a number of uncertainties related mainly to the presence of various environmental and socio-

economic factors, other than climate, which influence the transmission of the disease. As per Garg et al (2009) transmission windows in Rajasthan are likely to increase by 3–5 months.

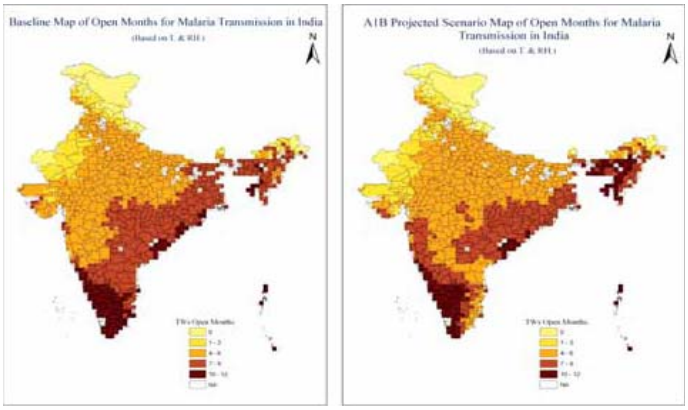


Figure 8.1 Transmission Window of malaria based on minimum required Temperature and RH – (Left) Baseline (1960-1990) and (Right) projection for 2030s (Source: GoI, 2010)

The projected increase in frequency and intensity of extreme temperatures may also have direct impacts on human health in terms thermal stresses, such as cardio-vascular and respiratory diseases, heat exhaustion, heat cramps, dehydration and many others. A recent study (Akhtar 2010) on El Nino related health hazards in India argued that global warming has resulted in increased heat wave conditions in India and accordingly resulting in increased deaths due to heat wave conditions in different parts of the country, particularly in the north-western, south, and south-eastern regions. Analysis of data for Bikaner and Jodhpur of Thar Desert showed that summer monsoon rainfall decreased steadily by more than 45% since 1957. The heat wave occurrence and malaria outbreak in western Rajasthan suggest the role of El Niño in health hazards. The current El Niño has also been considered very strong resulting in widespread drought conditions in India.

8.4 Policy Review

Ongoing Government Programs/ Initiatives	Key Objectives/Goals	Salient components/strategies/activities	Implementing agencies in the State (Nodal and supporting)
National Rural Health Mission (NRHM)	Reduction in Infant Mortality Rate and Maternal Mortality Ratio by at least 50% from existing levels in next seven years; Universalize 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 population stabilization, gender and demographic balance; Revitalize local health traditions and mainstream AYUSH; Promotion of healthy life styles	▪ Increasing Community ownership by vesting responsibility with PRIs ▪ Decentralized village and district level health planning and management ▪ Appointment of Accredited Social Health Activist (ASHA) to facilitate access to health services ▪ Strengthening the public health service delivery infrastructure, particularly at village, primary and secondary levels ▪ Mainstreaming AYUSH ▪ Improved management capacity to organize health systems and services in public health ▪ Emphasizing evidence based planning and implementation through improved capacity and infrastructure ▪ Promoting the non-profit sector to increase social participation and community empowerment, promoting healthy behaviors, and improving intersectional convergence	Nodal agency is the Department of Medical, Health & Family Welfare. Mechanisms in place for coordination with AYUSH, Department of Women and Child Development, and State Public Health and Engineering Department

Ongoing Government Programs/ Initiatives	Key Objectives/Goals	Salient components/strategies/activities	Implementing agencies in the State (Nodal and supporting)
National Vector-Borne Disease Control Program (NVBDCP)	Umbrella programme for all the Vector Borne Diseases (VBDs) in the State, like Malaria, Dengue Chikungunya	▪ Specific program and technical guidelines established for different VBDs (prevention, detection and case management) ▪ Monitoring of implementation through regular reporting	Nodal agency is the Department of Medical, Health & Family Welfare.
Rajasthan Health Sector Development Project (RHSDP)	Strengthen all secondary levels hospitals so that in each block one hospital with 24 hour emergency can be established; Improving quality of health services provided by hospitals; Imparting training to working staff for modernization; Ensuring adequate availability of hospital supplies (medicines/ equipments); Effective disposal of hospital waste	▪ Implemented in all the 33 districts of the State with the financial assistance from the World Bank. ▪ 28 district hospitals, 23 sub divisional hospitals, 113 CHCs located at sub divisional head quarters, 72 other CHCs and 2 block PHCs have been identified for renovation/extension and providing additional facilities ▪ Up-gradation of the healthcare waste management system ▪ Supporting interventions to improve access to healthcare among disadvantaged populations, especially the tribal population and households below the poverty line ▪ Purchase of furniture in hospitals ▪ Supply of medicines to secondary hospitals ▪ Training and workshop: • Essential training of doctors and paramedical staff • Preparation of training modules	Nodal agency is the Department of Medical, Health & Family Welfare

Ongoing Government Programs/ Initiatives	Key Objectives/Goals	Salient components/strategies/activities	Implementing agencies in the State (Nodal and supporting)
		• Organize workshops at division level Implementation of IEC activities	
National Surveillance Programme for Communicable Diseases	Capacity building at the state and district for early identification of outbreaks of communicable diseases and Appropriate and timely response to the outbreaks of communicable diseases	▪ Surveillance system is strengthened through training of medical and paramedical personnel ▪ Dissemination of technical information and guidelines ▪ Up gradation of laboratories ▪ Modernization of communicable and data processing systems ▪ IEC activities to promote community participation in the prevention and control of outbreaks ▪ A district is envisaged as the basic unit within which the reports received, data cleaned, analyzed and monitored continuously. A District Epidemiological Cell, with computer facilities and adequate personnel are established for this purpose	Nodal agency is the Department of Medical, Health & Family Welfare
Integrated Disease Surveillance Project (IDSP)	Establish a decentralised system of disease surveillance for timely and effective public health action; and improve the efficiency of disease surveillance for use in health planning,	▪ Integrating and decentralization of surveillance activities ▪ Strengthening of public health laboratories ▪ Human Resource Development – Training of State Surveillance Officers, District Surveillance Officers, Rapid Response Team, other medical and paramedical staff ▪ Use of Information Technology for	Nodal agency is the Department of Medical, Health & Family Welfare

Ongoing Government Programs/ Initiatives	Key Objectives/Goals	Salient components/strategies/activities	Implementing agencies in the State (Nodal and supporting)
	management and evaluating control strategies	collection, collation, compilation, analysis and dissemination of data	
Reproductive and Child Health (RCH) Program	Reduce IMR and MMR and improve the quality and coverage of reproductive and child health services	▪ Family Planning ▪ Child survival and safe motherhood ▪ Client approach to health care ▪ Prevention and management of RTI/ STD/ AIDS ▪ Adolescent reproductive health ▪ Modified management information sub system ▪ IEC and counselling ▪ Community Needs Assessment approach ▪ High quality training at all levels ▪ District sub projects under local capacity enhancement ▪ Enhanced community participation through *panchayats*, women groups and NGOs ▪ Referral system	Nodal agency is the Department of Medical, Health & Family Welfare
Integrated Child Development Services (ICDS) Scheme	Improve the nutritional status of children in age group 0-6; lay the foundation for proper psychological, physical and social development; reduce child mortality, morbidity, malnutrition	▪ Being implemented in all 33 districts of the State ▪ Supplementary nutrition services ▪ Immunisation ▪ Health check ups ▪ Referral services ▪ Nutrition and health education and awareness campaigns	Nodal agency is the Department for Women and Child Development

Ongoing Government Programs/ Initiatives	Key Objectives/Goals	Salient components/strategies/activities	Implementing agencies in the State (Nodal and supporting)
	and school dropout; achieve effective co-ordination between various departments to promote child and women development; promoting child nutrition and health education amongst mothers	▪ Pre-school education ▪ Special services for pregnant women	
Integrated Management of Newborn & Childhood Illness (IMNCI)	Reduce infant and child mortality rates	▪ Care of new born, young infants (under 2 months) and infants (2 months to 5 years) ▪ Management of diarrhoea, acute respiratory infections (pneumonia) malaria, measles, acute ear infection, malnutrition and anaemia. ▪ Recognition of illness and at risk conditions and management/referral ▪ Prevention and management of Iron and Vitamin A deficiency. ▪ Counselling on feeding for all children below 2 years ▪ Counselling on feeding for malnourished children between 2 to 5 years. ▪ Immunization ▪ IEC campaigns for awareness generation ▪ Training for medical officers and front-line functionaries including ANMs and Anganwadi Workers (AWWs)	Nodal agency is the Department for Women and Child Development

Ongoing Government Programs/ Initiatives	Key Objectives/Goals	Salient components/strategies/activities	Implementing agencies in the State (Nodal and supporting)
Total Sanitation Campaign	Improving the general quality of life in the rural areas; accelerating sanitation coverage in rural areas; generating felt need through awareness creation and health education; covering schools in rural areas with sanitation facilities; encouraging suitable cost effective and appropriate technologies; bringing about a reduction in the incidence of water and sanitation related diseases	▪ Information, Education and Communication (IEC) are the important components of the programme ▪ Sanitary mart to provide materials and guidance needed for constructing different types of latrines, technologically and financially suitable to the areas and other sanitary facilities ▪ Construction of Individual Household Latrines ▪ Village Sanitary Complex for women ▪ School Sanitation	Public Health Engineering Department is the nodal agency. With co-operation from Department of Rural Development, Panchayati Raj, Education, Health and Family Welfare, Women & Child Development, CCDU (Communication and Capacity Development Unit)
National Rural Water Quality Monitoring and Surveillance Program	Decentralization of water quality monitoring and surveillance of all rural drinking water sources; Institutionalization of community participation and involvement of PRIs for water quality monitoring and surveillance; Generation of awareness among the rural masses about the water quality issues and the	▪ Identification of State level Referral Institute ▪ Taking up State and Region specific IEC activities involving PRIs, Co- operatives, Women Groups, SHGs, NGOs ▪ Training to be imparted to district, block and *Gram Panchayat* level functionaries. ▪ The district laboratories are expected to test at least 30 % of the water samples tested by GPs and compulsorily where possibility of contamination is reported by the community (VWSC/GPs). ▪ Identification / Registration of safe drinking water sources in all rural habitations (Gram	Communication and Capacity Development Unit, Water and Sanitation Support Organization is the nodal implementing agency

Ongoing Government Programs/ Initiatives	Key Objectives/Goals	Salient components/strategies/activities	Implementing agencies in the State (Nodal and supporting)
	problems related to water borne diseases; Building capacity of Panchayats to own the field test kit and take up full O&M responsibility for water quality monitoring of all drinking water sources in their respective PRI area	Panchayat wise) ▪ Sanitary inspections of drinking water sources should be done at least once in a year initially, there after as situation demands. ▪ 100 % testing of all sources at village level by grassroots level workers from VWSC/GP	
Swa Jal Dhara Scheme	Aims at providing community-based rural drinking water supply	▪ Demand-driven and community participation approach ▪ *Panchayats*/communities to plan, implement, operate, maintain and manage all drinking water schemes ▪ Partial capital cost sharing by the communities upfront in cash ▪ Full ownership of drinking water assets with *Gram Panchayats* ▪ Full Operation and Maintenance by the users/ *Panchayats*.	Communication and Capacity Development Unit, Water and Sanitation Support Organization is the nodal implementing agency
Panna Dhai Jeevan Amrit Yojana (Jan Shree Bima Yojana)	Provide more financial assistance and insurance to BPL families	▪ Provide free life insurance coverage to head of BPL families, with the premium being borne by the Government depending on the kind of disability to the head of the family	Social Justice and Empowerment Department is the nodal agency
Mobile Surgical Units (MSU)	Provide free of cost medical facilities to rural	▪ Organizing health camps for weaker sections of the society in remote rural areas	Nodal agency is the Department of Medical,

Ongoing Government Programs/ Initiatives	Key Objectives/Goals	Salient components/strategies/activities	Implementing agencies in the State (Nodal and supporting)
	masses in remote areas	▪ 500 bedded mobile hospital established at Jaipur and 100 bedded units at Jodhpur and Udaipur are working under the MSU ▪ Four new MSUs have also been opened at remaining Divisional Headquarters namely at Ajmer, Bharatpur, Bikaner, and Kota in the year 2007-08	Health & Family Welfare
Mukhya Mantri BPL Jeevan Raksha Kosh	Provide free of cost health care to BPL families	▪ Implemented in all the districts of the State ▪ Direct funding to Medicare Relief Societies of Public Health Institutions and covers all 35 lakh BPL families ▪ Completely free OPD & IPD care provided to BPL families of the State including medicines and/or implants needed for the treatment as well as the follow up treatment through government hospitals	Nodal agency is the Department of Medical, Health & Family Welfare
Sanjivani Scheme	Organise health camps at selected Community Health Centres (CHCs) and provide specialist services	▪ Consultation services to patients ▪ Provide knowledge about national programs/schemes ▪ Immunisation ▪ Provide knowledge on HIV/AIDS ▪ Follow ups of referral cases and tracking ▪ Provision of free medicines to BPL families	Nodal agency is the Department of Medical, Health & Family Welfare
Balika Samridhi Yojana (BSY)	Change negative family and community attitudes towards the girl child at birth and towards her	▪ A grant amount of Rs. 500 is deposited in the name of the girl child born on or after 15.8.97 in BPL families ▪ The benefit of BSY will be restricted to two	Department of Local Self Government is the nodal agency

Ongoing Government Programs/ Initiatives	Key Objectives/Goals	Salient components/strategies/activities	Implementing agencies in the State (Nodal and supporting)
	mother; improve enrolment and retention of girl children in schools; raise the age at marriage of girls; assist the girl to undertake income generating activities	girl children in each household irrespective of the total number of children in the house ▪ Since inception of the scheme around 17010 girls have been benefited	
Policy to Promote Private Investment in Health Care Facilities-2006	▪ Promote private sector investment in medical & heath care institutions, medical & dental colleges and support units like diagnostic centers, blood banks and paramedical training institutes. ▪ Ensure delivery of quality health care with reasonable costs ▪ Promote development of Centers of Excellence for medical care. ▪ Promote Rajasthan as a medical tourism destination ▪ Develop complementary and alternative medicine	▪ Identifying the available land for health care facilities ▪ Maintaining a land bank exclusively for health care institutions ▪ Promoting suitable institutions as medical tourism destinations ▪ Facilitating the investment through speedy disposal within given time frame and through financial incentives ▪ Laying down of minimum standards through a committee on standards to help in Certification / Accreditation ▪ Offering paid consultancy/services related to hospital planning and operations	Nodal agency is the Department of Medical Education

Ongoing Government Programs/ Initiatives	Key Objectives/Goals	Salient components/strategies/activities	Implementing agencies in the State (Nodal and supporting)
	centers ▪ Develop super specialty health care institutions ▪ Develop standards for infrastructure and operations ▪ Create a regulatory body with supportive role		
Shahari Jan Sahabhagi Yojana (SJSY)	Development and extension of work in urban areas as well as awareness creation	▪ Public Awareness will be generated through organizing camps, seminars, workshops, regarding beautification of city/ward, sanitation, public health, vaccination, door to door waste collection, environment improvement through plantation and maintenance of plants and preparation of plan for ward development ▪ Development / extension of works like construction of building for government schools, hospitals, veterinary hospitals, library, community centers, *balbadi bhawan, rein basera,* construction of *nallis*, bridge, community toilets, hand pumps, drinking water scheme etc	Department of Local Self Government
Integrated Housing & Slum Development Programme (IHSDP)	Holistic slum development with a healthy and enabling urban environment by providing	▪ All the cities (except those covered under JNNURM) are covered under IHSDP. ▪ The components for assistance include slum	Department of Local Self Government

Ongoing Government Programs/ Initiatives	Key Objectives/Goals	Salient components/strategies/activities	Implementing agencies in the State (Nodal and supporting)
	adequate shelter and basic infrastructure facilities to the slum dwellers of the identified urban areas	improvement/upgradation/relocation projects/new constructions of houses and infrastructure facilities like water supply sewerage	
Urban Infrastructure Development Scheme for Small and Medium Towns (UIDSSMT)	Provide basic infrastructure facilities in the small and medium towns	▪ Applicable to all cities/towns except cities/towns covered under JNNURM ▪ The sharing of funds is in the ratio of 80:10 between Centre and State and balance 10% amount raised by nodal/implementing agencies from the financial institution ▪ Till now 38 projects have been sanctioned under this scheme	Rajasthan Urban Infrastructure Development and Finance Corporation (RUIFDCO) is the nodal agency for implementing this scheme
Jawaharlal Nehru Urban Renewable Mission (JNNURM) *Sub-Mission I: Urban Infrastructure and Governance* *Sub-Mission II: Basic Services to Urban Poor*	Mission aim is to encourage reforms and fast track planned development of identified cities. Focus is to be on efficiency in urban infrastructure and service delivery mechanisms, community participation, and accountability of ULBs/ Parastatal agencies towards citizens	▪ Main thrust of the Sub-Mission-I is on infrastructure projects relating to water supply and sanitation, sewerage, solid waste management, road network, urban transport and redevelopment of old city areas with a view to upgrading infrastructure therein, shifting industrial and commercial establishments to conforming areas ▪ Main thrust of the Sub-Mission-II is on integrated development of slums through projects for providing shelter, basic services and other related civic amenities with a view to providing utilities to the urban poor	Department of Local Self Government

8.5 Summary

Rajasthan in the last few years has shown progress in terms of health status and outcomes but much still remains to be done to bring the health of the State in the mainstream of national averages. High IMR, MMR, malnutrition among children and women, high incidence of childhood diseases, declining sex ratio of girls, low female literacy in comparison to national average, inadequacies in drinking water supply and sanitation, poor health and poor socio-economic status of women along with social discrimination, are all already a cause of concern for population health in the State. The State's demographic trend is another factor hampering progress achieved under the various health programs. The State also shows a high rate of urbanization (with the urban population of Rajasthan projected to be 25.28% of the total population by end of the Eleventh Plan period) increasing pressure on urban infrastructure including that on health care, water and sanitation. Inadequate availability of water, poor water quality at source, ill-maintained water lines, and lack of awareness about good sanitation practices, personal hygiene and primary health care are some of the key factors responsible for the common and widespread health risks associated with consumption of pathogen infested drinking water in rural habitations of Rajasthan. Incidences of VBDs are also widespread in the State. VBDs are probably the most sensitive to changes in climate parameters. Malaria is a major health problem in Rajasthan especially in the North Western desert part of the State. Dengue fever and Chickungunya (and more recently Swine Flu) are the other major VBDs in the State. Operational integration in policy and programme between various vertical programmes within the health sector, and between health and other related sectors such as drinking water, sanitation, and nutrition has also been limited, resulting in a lack of holistic approaches to health.

Potential impacts of climate change can thus be expected to become an additional stressor for Rajasthan's heath sector which may increase the risk of exposure to vector, water- and food-borne diseases, aggravate malnutrition and increase mortality and morbidity associated with changes in intensity and frequency of extreme events. As indicated in the high resolution climate change scenarios for the Indian region, an increase in the mean annual surface air temperature and a decrease in the mean annual rainfall can be expected over the Rajasthan region in the future. Extreme rainfall events are also expected to increase in frequency and intensity. Maximum 1-day rainfall is expected to increase by 20mm, and maximum 5-day rainfall by 30mm in the period 2071-2100. Even in the current scenario the water resources in the State are not enough to cater to the needs of the drinking, agriculture and non- agriculture demands. Climate change will thus act as an additional stress on the precarious water resource condition of the state and would further aggravate its vulnerability. Increased drought conditions can also severely affect agricultural and pastoral livelihoods and increase vulnerability and risks for farmers, pastoralists and people depending on such climate sensitive livelihoods. These in turn will have a cascading effect on the health scenario of the state. With changes in agricultural production, an impact on nutrition related health deficiencies can be expected. Similarly increase in temperatures can result in higher incidences of heat stress related morbidity and mortality in the State.

However detailed vulnerability and impact assessments for the state of Rajasthan with respect to impacts of climate change on health aspects are still missing. Thus in the light of projected changes in climate, future trends in socio-economic scenarios, existing vulnerabilities in the health sector and gaps in policy and research scenario, the following priorities are identified as the key adaptation area under the State Mission for Human Health for the state of Rajasthan:

- **Key Strategy I:** Research-based prioritization of vulnerable regions/ population groups for targeted interventions
- **Key Strategy II:** Improve disease monitoring & surveillance system to enhance response capacity
- **Key Strategy III:** Mainstreaming climate concerns into policy responses and interventions in the health sector
- **Key Strategy IV**: Enhancing primary, secondary & tertiary health care to cope with potential climate risks and additional health impacts of climate change

8.6 Climate actions and strategies

Key Strategy 1: Research-based prioritization of vulnerable regions and population groups for targeted health interventions

To better understand the implications of changes in climate parameters on different aspects of human health, it is essential to undertake research that can help identify and prioritise the most vulnerable regions & population groups and thereby target the direct and indirect causal pathways that pose the risk to population health. Since research focussing on "climate change impacts on human health" specifically for the state of Rajasthan is almost non-existent, the first priority area identified here focuses on building an enabling environment as well as developing capacity of the state to undertake research in this field. This will also help to identify trigger events (climatic and non-climatic) that influence infection-transmission-spread of climate-sensitive diseases. Findings from such assessments will also contribute to informed decision and policy making in the State. The key activities under this priority area are as follows:

Action 1: Source high resolution meteorological data (observed and projections) for the State for linking with epidemiological studies
[Approximate cost estimate: 70 lakhs for procurement]

Action 2: Study the regional pattern of climate-sensitive diseases & disease outbreaks such as malaria, dengue, chickungunya, water borne diseases and heat stress etc. by undertaking regular analysis of data at district level to identify changing trends and providing regular feedback to state surveillance units. This activity should be linked to ongoing programs such as Integrated Disease Surveillance Project which are already collecting data on both communicable and non-communicable diseases and also undertaking trend analysis for certain diseases.

Action 3: Carry out vulnerability assessments to identify areas, population groups and diseases that may be impacted more significantly by projected changes in climate parameters (both spatial & temporal vulnerability). Promote interdisciplinary research since human health is a cross cutting issue and has links with a number of sectors such as agriculture, water supply, sanitation, literacy, livelihoods etc.

Action 4: Procure/develop/customize health impact models to assess potential impact followed by validation of modeling results with qualitative & quantitative assessments

[Approximate cost estimate for Action 2, 3, & 4: Approx 5 crore per annum assuming that State would be funding multiple R&D projects]

Action 5: Facilitate scientific/technical training to health sector staff for example, the epidemiologists, to carry out research in vulnerability and impact assessments by facilitating hands on training in the use of retrospective and forecasting/predictive techniques, models and software as well as RS and GIS tools for spatial analysis
[Approximate cost estimate: 1.0 crore per annum assuming that budgetary allocation for training under IDSP program is 1.04 crores p.a in 2009-2010]

Institutional needs

Agency (ies)	Name
Lead	Department of Medical Health and Family Welfare
Supporting	Desert Medicine Research Institute, Jodhpur and other Organisations undertaking research on human health and climate change
	State Institute of Health and Family Welfare
	Department of Medical Education
	State Meteorological Department (stations)
	State Remote Sensing Application Centre

Key Strategy 2: Improving the disease monitoring & surveillance system to enhance response capacity

There is need to increase the efficacy of disease surveillance in the State as the lack of good quality and high resolution data makes it difficult to generate precise knowledge on current and changing disease incidence rates which in turn makes it difficult to comment on the determinants of change. Such data would also help in validating predictive models as well as provide for baseline scenarios. Ultimately, better assessment and monitoring can allow for better prevention and control of health risks from changing climate. The key activities proposed under this priority are as follows:

Action 1: Develop and maintain a decentralized digital health database at fine spatial and temporal scales for climate-sensitive diseases such as vector-borne diseases, water borne diseases, heat stress, nutrition related disorders, direct and indirect health effects from extreme events (injury, death, psychological health problems etc).

Action 2: Develop mechanism for efficient co-ordination with state health laboratories and Rapid Response Teams to improve response time. Where needed, upgrade and strengthen laboratories for case diagnosis and reporting

Action 3: Issue specific guidelines for quality control of data collected and reported; regular evaluation through submission of monitoring reports to the state surveillance units. Improve the quality of data, periodicity of collection and the extent of coverage in existing systems of surveillance such as those under the Integrated Disease Surveillance Program, National Surveillance Program for Communicable Diseases and National Vector Borne Disease Control Program in order to efficiently utilize the infrastructure as well as institutional set up already created for these programs.

Action 4: Proper training to ANMs/other medical workers responsible for identifying the symptoms and reporting cases. Also provide training to staff handling the information flow including the data managers, data entry operators, epidemiologists, microbiologist and health workers. This should be supported with infrastructure provision such as computer hardware and software, internet connectivity and human resources

[Approximate cost estimate for Activity 1-4: 2.5 crores per annum assuming that budgetary allocation for IDSP program in 2008-2009 is 2.58 crors]

Institutional needs

Agency (ies)	Name
Lead	Department of Medical Health and Family Welfare
Supporting	State Institute of Health and Family Welfare
	Department of Medical Education
	State Meteorological Department (stations)
	Private health institutions to contribute to health database

Key Strategy 3: Mainstreaming climate concerns into policy responses and interventions in the health sector

Since climate change is an emerging threat and is a multi-dimensional issue, it is essential to mainstream climate change risk in the policy and planning process in the State. This will facilitate the implementation of the priorities that have been identified under the Climate Change Action Plan. The main action within this priority area is as follows:

Action 1: Sensitize policy makers and health practitioners on the risks posed by climate change, appropriate adaptation actions and need for mainstreaming through IEC activities such as seminars, workshops, trainings, disseminating related scientific literature.

Action 2: Integrate the concerns on health impacts of climate change in the health policy followed by the State. This should be based on sound scientific literature and assessments on both impacts as well as the suitable adaptation options.

[Approximate cost estimate: 1.5 crores for 5 years]

Key Strategy 4: Enhancing primary, secondary & tertiary health care to cope with potential climate risks and additional health impacts of climate change

Under a future climate change scenario, expansion and improvements in water, sanitation, nutritional programs and most importantly health care facilities, must be prioritized so that health care is accessible to every segment of the population. An improvement in public

health infrastructure which includes public health training, emergency response, and disease prevention and control programs is indispensable. This could be targeted at climate sensitive diseases (such as vector borne diseases, water & food borne diseases, health impacts of climate extremes) which are likely to get impacted by climate change. The key actions under this priority area are as follows:

Action 1: Undertake feasibility studies for establishment of tele-health [34] and video-conferencing facility especially in remote areas, such as in the tribal and desert districts, in order to connect patients in remote sites with a central health facility. The feasibility can be explored by utilizing existing infrastructure provided by cellular operators in respective regions and an up-gradation of infrastructure (software, telecommunication and other hardware) in the health facility. Required training can be provided to health centre staff on operating the facility and demonstration to users. Evaluation of the project can help to explore suitability for up-scaling or replication in other sites. Guidance on planning and implementation of tele-medicine networks can be sought from the Department of Information Technology, Government of India which has issued a document on "Recommended Guidelines & Standards for Practice of Telemedicine in India".

Action 2: Strengthen the disaster management plan specifically for the health sector - for management of injury, casualty, mental health, reproductive health, provision of emergency shelter, sanitation, food, water, medicines and management of communicable diseases (through constant surveillance and response). This should include preparation of specific emergency health support plans for different climate hazards such as heat waves, floods and droughts. Long term support plan can be drawn in case of specifically identified vulnerable groups for example, the tribal populations and the rural poor. Guidelines for assessment of risk of epidemics in affected area should be developed and in case risk is detected then guidelines for controlling the outbreak and issuing warning and instructions to the public is needed.

Action 3: Facilitate and incentivise private sector investment in medical and health care institutions, medical colleges, dental colleges, and other support units such as diagnostic centres, blood banks and paramedical training institutes. The "State Policy to Promote Private Investment, 2006" has already been issued to promote private sector participation in the health sector of Rajasthan.

Action 4: Promote health education and awareness in public with respect to climate risks and adaptation measures through ASHA workers, Self Help Groups, Schools and CBOs. This will require developing intensive Information, Education and Communication activities or linking to IEC components in existing projects such as in the Rajasthan Health Sector Development Project.

Institutional needs:

Agency (ies)	Name

[34] Tele-health is a system for health-care delivery where physicians examine distant patients using telecommunication technologies. With a view to providing specialist consultancy to people residing in rural areas, a tele-medicine project has been set up in collaboration with ISRO to link medical colleges to district hospitals. Under the project block CHCs will be connected with district hospitals in phase-II.

Agency (ies)	Name
Lead	Department of Medical, Health and Family Welfare
Supporting	Disaster Management and Relief Department
	Telemedicine Service Providers
	State Meteorological Department (stations)
	Departments of Medical Education
	Department of Women and Child Empowerment
	Public Health and Engineering Department
	Communication and Capacity Development Unit
	Department of Rural Development
	Urban Local Bodies and *Panchayati Raj* Institutions
	Private medical institutions
	Community Based Organizations
	Desert Medicine Research Centre, Jodhpur

Estimated cost to be provided as inputs from departments

Key Priorities and Actions identified for Health Sector

Key Strategy	Action	Time-frame (ST, MT, LT)[35]	Physical Target/ Scope	Financial Requirement
1	Research-based prioritization of vulnerable regions/ population groups for targeted interventions			
	Source high resolution meteorological data (observed and projections) for the State for linking with epidemiological studies	2012-17	34 districts	68 lakh
	Study the regional pattern of climate-sensitive diseases & disease outbreaks such as malaria, dengue, chickungunya, water borne diseases and heat stress	2012-17	34 districts	68 lakh
	Carry out vulnerability assessments to identify areas, population groups and diseases that may be impacted more significantly	2012-17	34 districts	68 lakh/year
	Procure/develop/customize health impact models to assess potential impact followed by validation of modeling results with qualitative & quantitative assessments	2012-17	34 districts	34 lakh/year
	Facilitate scientific/technical training to health sector staff for example, the epidemiologists, to carry out research in vulnerability and impact assessments	2012-17	34 epidemiologists, 9 entomologists, 34 Deputy CMHO	68 lakh
2	Improve disease monitoring & surveillance system to enhance response capacity			
	Develop and maintain a decentralized digital health database at fine spatial and temporal scales for climate-sensitive diseases	2012-17	34 districts	40 lakh/year

[35] ST: Short Term (2012-2017), MT: Mid-term (2017-2022), LT: Long-term (2022 and beyond)

Key Strategy	Action	Time-frame (ST, MT, LT)[35]	Physical Target/ Scope	Financial Requirement
	Develop mechanism for efficient co-ordination with state health laboratories and Rapid Response Teams to improve response time. Where needed, upgrade and strengthen laboratories for case diagnosis and reporting	2012-17	1 state lab, 7 medical college labs, 34 district labs	2.5 crore
	Issue specific guidelines for quality control of data collected and reported; regular evaluation through submission of monitoring reports to the state surveillance units	2012-17	34 districts	17 lakh/year
	Proper training to ANMs/other medical workers responsible for identifying the symptoms and reporting cases. Also provide training to staff handling the information flow including the data managers, data entry operators, epidemiologists, microbiologist and health workers. To be supported with infrastructure provision such as computer hardware and software, internet connectivity and human resources	2012-17	Training of microbiologists, 34 epidemiologists, 9 entomologists, ANMSs, MIs, MPWs and ASHA	50 lakh/year
3	Mainstreaming climate concerns into policy responses and interventions in the health sector			
	Sensitize policy makers and health practitioners on the risks posed by climate change, appropriate adaptation actions and need for mainstreaming through IEC activities such as seminars, workshops, trainings, disseminating related scientific literature	2012-17	IEC activities at state HQ districts	2 crore/year
	Integrate the concerns on health impacts of climate change in the health policy followed by the State. This should be based on sound scientific literature and assessments on both impacts as well as the suitable adaptation options.	2012-17	34 districts	68 lakh
4	Enhancing primary, secondary & tertiary health care to cope with potential climate risks and additional health impacts of climate change			

Key Strategy	Action	Time-frame (ST, MT, LT)[35]	Physical Target/ Scope	Financial Requirement
	Undertake feasibility studies for establishment of tele-health and video-conferencing facility especially in remote areas, such as in the tribal and desert districts, in order to connect patients in remote sites with a central health facility	2012-17	Tele-health in 19 districts, video-conferencing in 19 districts	38 lakh/year
	Strengthen the disaster management plan specifically for the health sector	2012-17	34 districts	3.4 crore/year
	Facilitate and incentivize private sector investment in medical and health care institutions, medical colleges, dental colleges, and other support units such as diagnostic centers, blood banks and paramedical training institutes	2012-17	34 districts	68 lakhs/ year
	Promote health education and awareness in public with respect to climate risks and adaptation measures through ASHA, SHGs, Schools and CBOs using IEC	2012-17	ASHA, SHG schools	50 lakhs/ year

Chapter 9: Forest and Biodiversity

9.1 Background

Forests of Rajasthan are dominated by dry deciduous type and are concentrated in the Aravalli and Vindhyan hill systems in the east and grasslands in the west (GoR 2007). The forest cover in the State is 16,036 km2, which is 4.69% of the State's geographic (FSI 2009). Historically, forests in the state have been used by the erstwhile Maharajas as their hunting reserves and for meeting subsistence needs of communities living within or neighbouring forests.

The forests, deserts and wetlands of the State house a wide array of flora and fauna, some of which are specific to the region. It is home to about 3000 known species of flora and fauna and, a large number of undocumented insects, butterflies and micro-organisms. A majority of the native plants in the state are known for their economic importance and are being used by local communities. Many of these species have evolved over the years to survive in the harsh climatic condition specific to the region.

Many species of flora and fauna are rare and endangered in the State. Many plant and animal species are endemic to the Thar Desert and the Aravallis which are one of the worlds oldest hill ranges. It is estimated that 100 species of plants (including 61 of desert region) are threatened in view of their conservation status. All the 19 endemic species are threatened, and so are all the 35 wild relatives of cultivated plants. There are 23 species of plants that are endemic to the state.

9.2 Current vulnerabilities

Protected Areas and Biodiversity outside PAs

The state has two national parks (NP), 25 wildlife (WL) sanctuaries and two Conservation Reserves created under the provisions of the Wildlife (Protection) Act, 1972. There are also two critical wildlife habitats. There is evidence in some regions of the world to show that climate change has resulted in population declines in long-distance migratory birds. Rajasthan, on account of several ancient lakes, has been a wintering-ground for many species of birds. Rajasthan's tourism economy is greatly dependent on the protected area tourism. In addition to climate change, habitat fragmentation has long history in Rajasthan. Patch area and isolation are important factors affecting the occupancy of many species (Singh et al 2010). These would affect the ecologically 'specialist' species i.e. the species which would require a specific niche for survival. The habitats of the ecologically sensitive species of desert and dryland forest ecosystems would require a special attention for management and conservation. There will be requirement of identifying as well as creating new habitats, buffers for the habitats as well as corridors for sustaining the ecologically sensitive biodiversity.

Desertification and land degradation

Desertification is defined as land degradation in the arid, semi-arid and dry sub-humid areas, resulting from various factors including climate variations and human activities (UNCCD, 1995). It is a slow and less perceptible process that gradually leads to the decline of production potentials of the land and affects the socio-economic fabric of the people who make a living from those lands (Kar, Moharana and Singh, 2007).In Rajasthan 67% of area is

affected due to desertification / and land degradation where the wind erosion (44.2%) is the maximum contributor followed by water (11.2%), vegetal degradation (6.25%) and salinization (1.07%) (ISRO, 2007).

Types of land degradation and desertification

Wind erosion – Sand dunes and other sandy landforms in Thar desert are most vulnerable to wirnd erosion especially in the western part of the State. High human pressures along with the historical dry climates also contribute to the localized wind erosion or soil reactivation. The mechanized deep ploughing and increase in the net sown area are accelerating the Aeolian processes (Kar, Moharana and Singh, 2007).

Water erosion – Parts of Aravalli hill ranges, eastern margin of Thar desert is experiencing accelerated rill and gully erosion.

Water logging and salinity – Excess irrigation and wrong drainage planning have caused water logging and salinity build up in canal command areas of Ganganagar and Hanumangarh districts.

It is predicted in studies that due to climate change there may be significant increase in the desert area over India in next 100 years with potentially disproportionate impact of global warming on coupled human and natural systems and thus there could be reactivation of sand dune systems in future (Singh et al 2010). Over 30 schemes addressing the halting of desertification have been active for past few decades. Such efforts have successfully attempted the fixation of dunes using *Acacia tortilis*. In addition, the areas covered by these plantations have not been able to cover the vast expanse of sands fully. Paucity of multiple-layers of vegetation is now resulting in dune reactivation due to biotic and natural causes. Reactivation of sand drift exposes roots that cause tree uprooting at many places, and threatens the agricultural production due to moving sands. The process not only endangers the ecosystems but also the livelihoods of the local communities dependent on these ecosystems. There have been excellent results of plantations of indigenous species such as *Calligonum polygonoides* and *Cenchrus ciliaris* combination to provide best yields of fodder and fuelwood in combination with *Cassia angustifolia* to control sand drift (Singh et al 2010).

Traditional ecological knowledge

The situations of drought are not new to the state of Rajasthan and the local communities have traditionally shown the methods of resilience to differentiate and tackle according to the various kinds of droughts according to the intensities such as *Kal, Akal and Trikal*. Thus the traditional knowledge of the local communities form an important asset for identifying the adaptation options in the context of Rajasthan. Following are some of the known examples of the traditional knowledge and practices of the local communities in the state.

Local communities of the state have traditional knowledge on ethno botanical and ethno medicinal use of plants and animals for treating ailments example the Saharia tribe have traditional knowledge on use of different animals (both domesticated and protected species like peacock, hard shelled turtle, and sambhar) and animal-derived products as medicines to treat human ailments.

Fodder bank – Excess fodder of pearl millet, wheat, barley, etc. is stored in structures called *Karai* or *Pachave* for adverse years. It provides an important coping mechanism for securing livestock during drought (Narain and Singh 2005).

Nomadism – The migration of pastoral nomads during defined periods as well as during the time of scarcity of fodder, feed, water has been a traditional phenomenon and it is used as a mitigation strategy against the drought. The process also allowed sale of milk, cattle, ghee wool, mutton as one of the mean of subsistence. But the shrinking grazing areas are forcing people to take up sedentary way of life. The border districts of Barmer, Jaisalmer and Bikaner are home to the pastoral nomads of the state. The non-pastoral traditional nomads such as artisans and tribes like Nats, Kalbeliyas migrate in search of work (Narain and Singh 2005).

Pasture / Grazing lands – Every village in western Rajasthan has a traditional *Gauchar* land used for grazing of animals. But the management tragedy of common lands like *Gauchar* the grazing resources have been reduced substantially and it has impacted the pastoral livelihoods (Narain and Singh 2005).

***Orans* / sacred woodlands, groves –** The traditional sacred conservation practices such as *Oran*s (sacred woodlands) in the western Rajasthan and sacred groves in Aravalis have been supporting important biodiversity (Pandey 1998). The systems like *oran* has acted as emergency reserve especially for animals during drought (Gokhale et al 1998). *Oran*s and *gauchar* togetherly occupy 62158 ha area in Jodhpur district (Narain and Singh 2005). Along with Bishnoi community society at large in the western Rajasthan has been responsible for maintaining *oran*s. Some of the well known *oran*s include those at *Ramdevara*, *Biratra ki aan* near Barmer and so on (Gokhale et al 1998).

Agroforestry – The traditional agroforestry practice involving species such as *Prosopis cineraria, Tecomella undulata* and *Salvadora oleoides* has been an important life support system during drought. The agroforestry provided fodder, fuel, tumber, fruits, seeds, pods, and non-timber forest produce such as gum, etc. The intensive agriculture has reduced the agroforestry practice (Narain and Singh 2005).

But the traditional knowledge system has not been able to sustain in the larger context of the modern development paradigm. Nevertheless, the traditional systems have huge potential to offer in terms of developing the options for adaptations to tackle the future impacts due to climate change as is seen from the examples given above in the context of various resources and practices. Hence, to conserve and make use of the traditional knowledge and the practices there is a need of extensive documentation linked up with the research and development for exploring adaptation options to tackle the climate change.

Urban green areas

The growing rate of urbanisation suggests about 50% of the world is surviving in the cities having hardly 3% of the geographical area. The provisioning services as defined by the Millennium Ecosystem Assessment are also applicable in the context of the urban population especially urban poors. At the same time the urban forest areas provide an excellent opportunity of mitigation benefits along with the additional benefits of aesthetic value addition to the urban landscapes. World Health Organisation suggests ensuring atleast 9 square meter green open space per city dweller (Singh et al 2010).

9.2.1 Future impacts

The issues identified as the vulnerability would have aggravating impacts as the current projections of the impacts of the climate change suggests the increase in the aridity of the existing dry lands and sub0humid lands. Hence the water dependent and the higher and extreme temperature sensitive species diversity and habitats would face danger of reduction in size or population or even face extinction.

The projected changes in temperature and precipitation under climate change scenarios poses additional risks to structure and functions of the forest ecosystems that are already exposed to multiple stresses. Literature is replete with global assessments that have demonstrated the adverse nature of impacts on forests under climate change scenarios. At the national level, Ravindranath and Sukumur (1998), through the use of predictive models under climate change scenario with a general increase in temperature and rainfall observed a potential increased productivity. They also reported that drier forest types could be transformed into moister types. Further Ravindranath et al (2006) employed a BIOME 4 vegetation response model and concluded through their assessment of HadRM3 climate scenario under the A2 and B2 scenario that 77 % of the observed grids could experience shifts in forest types. The forest type shifts for the north western region in India was observed towards drier forest type.

The agro-pastoralists of the state are seen as one of the most vulnerable community but at the same time historically highly resilient group. The nomadic lifestyle to survive in the sparse and scarce natural resources of desert provides huge potential for adaptation against the adverse impacts. The studies (Robbins 1998) suggest that there has been increase in the pastoralism in the *Marwar* region of the state. And probably this might suggest as an impact of the climate change.

9.3 Mitigation Potential

The Mission on Afforestation identifies 13 specific districts for the afforestation purpose. The Forest and Environment policies also mention about the programmes to develop the grazing lands and conserve the *oran,* the traditional sacred woodlands. These provisions provide the scope of undertaking Afforestation / Reforestation CDM possibilities and the REDD+ especially in the context of *orans* and the Sustainable Forest Management Mechanisms.

9.4 Policy Review

Policies	Key objectives and goals	Strategies/ components
State Forest Policy 2010	To protect, conserve and develop natural forests with the participation of the local communities The objectives of the policy address the livelihoods of the forest dependent communities and importance of value addition and processing of non timber forest produce.	**Area under forest –** To achieve the target additional 45000 sq. km area owned by Government, communities and private persons will be brought under afforestation and pasture development. **Forest protection and conservation –** JFM may be used to persuade the encroachers of the forest land, curb forest fires, control illegal grazing. Mining in the forest areas should be discouraged by all means. Adequate infrastructural support and intensified patrolling and interdepartmental co-ordination to reduce poaching and other forest offenses. **Afforestation on Government land, Community land and Private land –** Identification of revenue waste land, vacant institutional land, linear patches along roads, railway tracks for plantation of multi-purpose species will be taken up. **Demand and supply of Forest Produce –** Large scale plantations will be raised outside forests to provide wood produce. **Enhancement of productivity –** Selection of Candidate Plus Trees (CPTs), establishment of Seedling seed orchard, modern hi tech nurseries, use of Quality Planting **Checking land degradation –** Integrated watershed approach, treatment of catchments, reclamation of water logged areas along Indira Gandhi Canal is proposed with suitable tree species. **Combating desertification –**Shelter belt plantations, block plantations of various silvipastoral models and sand dune stabilization programmes and plantations in desert areas with indigenous xerophytic microphyllus species have been emphasized.

Policies	Key objectives and goals	Strategies/ components
		Wildlife and biodiversity conservation – It is targeted to have minimum 5% of the geographical area of the state as protected / conservation area. Inventory of biodiversity, measures of in-situ and ex-situ conservation, rationalization of boundaries of Protected Areas have been suggested for strengthening the wildlife and biodiversity conservation in the state. **Orans / Dev van –** District wise database and demarcation on cadastral maps of such areas is proposed. These patches will be declared as deemed forest as per the Forest (Conservation) Act, 1980. Local committee will be fully empowered for the management of these areas.
		Financial Provisions – Enhancement of sectoral allocation in the state, soft loans, efforts for more central funds, institutional financing such as NABARD, etc., NREGA, CAMPA funds, and special funds to be sought for wildlife conservation and forest protection have been suggested. Corporate investment in JFM plantations, donations from Wildlife tourists and other sources for developing biodiversity resources in the state and sponsorships from various sources have been proposed. .
State Environment Policy 2010		The strategies are mainly oriented at efficient management of protected areas by – Relocation of villages inside protected areas with appropriate package. Conferring heritable but non-transferable rights to the relocated communities to provide defined ecotourism services. Scientific Management Plans with short and long term strategies for improving biomass productivity, habitat improvement, sustainable tourism and meeting the livelihoods of the local communities. Site-specific, people friendly eco-development programmes in fringe areas of Pas Effective use of Community Reserves and Conservation Reserve provisions Strengthening of the existing PA system by

Policies	Key objectives and goals	Strategies/ components
		covering unrepresented ecosystems. Desertification and land degradation Scientific assessment of desertification: Integrated approach for implementation of the schemes to combat the desertification Participatory sand dune stabilization programme shall be encouraged to involve the private land under sand dunes. Biodiversity outside PAs The strategies are summarised as follows – Proper research to be undertaken before introduction of exotic species. Promote use of traditional crop varieties. Technically sound programmes for eradication of invasive species. Legal recognition to the traditional entitlement of the local communities under PESA (Panchayat Extension to Scheduled Areas) Ex-situ conservation of genetic resources in form of gene banks. Cultivating bamboo with the help of JFMCs. **Traditional ecological knowledge and domesticated biodiversity** Focus on indigenous domesticated animal diversity for developing the improved breeds having adaptive abilities in deserts. Research on traditional crop varieties shall be promoted so as to understand their adaptation potential against climate change. Traditional knowledge associated with domesticated breeds of animals and traditional cultivars shall be documented in order to

Policies	Key objectives and goals	Strategies/ components
		facilitate grant of IPRs for traditional knowledge Documentation and demarcation of orans – traditional conservation practices of the local communities. The traditional techniques of seed banks, fodder bank, grain bank shall be effectively used for decentralized storage of resources for disaster management. Organic-farming agriculture technologies shall be promoted with proper incentives
State climate change agenda (2010)		***Climate Change Agenda for Rajasthan (2010)*** The Climate Change Agenda for the state includes the prioritised issues of forestry and biodiversity as follows – **Increasing the forest cover and density** Forest demarcation to facilitate the understanding of likely shifts in forest types under a future climate Forest development and protection for increasing and maintaining the green cover Explore mitigation potential of community-forest projects to obtain carbon credits for forest conservation **Mission on Afforestation** Promotion of agro-forestry in order to buttress livelihoods of forest-dependent communities R & D in Monitoring of shifts in forest types and documenting traditional knowledge for adaptation

Ongoing programmes

Management of Protected Areas

Given below are some of the initiatives taken by the state for management of protected areas:

Setting up of ecodevelopment committees, which is an offshoot of the JFM movement in the state. These committees were set up under the externally aided projects- IDA-GEF assisted India Ecodevelopment Project, implemented in the Ranthambhor Tiger Reserve. This is a step forward in participatory management approach, however the extent and nature of community participation needs a re look. Ecodevelopment approach is yet to be adopted in the remaining protected areas.

As a response to crisis of vanishing tiger population in the country Project Tiger was launched 1972. There are two Project Tiger reserves in the Sate, namely, Sariska (sanctuary) and Ranthambhor (national park).

The Tiger Task Force was constituted by the Government of India in 2005 in response to the tiger disappearance debacle from Sariska in Rajasthan. The Task Force was mandated to study and review the reasons for the disappearance of the Tigers and also come up with recommendations.

Forestry and Biodiversity programmes

State Biodiversity Strategy & Action Plan

The State of Rajasthan has prepared its Biodiversity Strategy & Action within the national framework of National Biodiversity Strategy and Action Plan. With the passage of the Biodiversity Act 2002, a State Board of Biodiversity has been under process.

Cataloguing Plant Genetic Resources

The regional office of the National Bureau of Plant Genetic Resources at Jodhpur is tasked to catalogue plant genetic resources for documentation and research for crop improvement programmes for the development of agriculture in arid and semi-arid regions in particular.

Joint Forest Management

In recognition of the importance of peoples' participation in protection of forests, the Government of Rajasthan had initiated the Joint Forest Management (JFM) programme on degraded, barren, and community lands in 1991. As of 31.3.07 there are over 4691 Joint Forest Management Committees (JFMC[36]) managing 769895.70 ha of forest area (GoR 2008)[37]. In this partnership communities are allowed usufruct rights from the forests in lieu of protection. The JFMC also take up village development works as agreed in general body meetings of the village.

Rajasthan Forestry and Bio-diversity Project

The objectives of the JBIC sponsored project is to restore ecological status of the Aravallis, conserve biodiversity, check desertification, improve moisture regime and protect infrastructure in the desert areas. It is implemented in 18 districts of the state, between the years 2003-04 to 2009-10.

36 Elected executive body responsible for day to day administration

37 1025 and 614 JFMC were set up under Aravalli Afforestation and Forestry Development Project respectively

Table 9.1 Brief on externally aided projects

Project Title	Objectives	Spread	Project period	Cost	Sponsor
Aravalli Afforestation Project	To check desertification and to restore the ecological status of the Aravallis; to meet the fuelwood, tree fodder, grass, timber, fruit and minor forest products; to check soil erosion ; to provide employment to the rural / tribal population; to improve the habitat for the animal population in the wild life sanctuaries.	10 districts of Rajasthan viz. Alwar, Sikar, Jhunjhunu, Nagaur, Jaipur (Including Dausa) Pali, Sirohi, Udaipur, Chittorgarh and Bansware.	1992-97	Rs. 176.69 crores (8095 million Yen).	Overseas Economic Cooperation Fund of Japan (*OECF*).
Rajasthan forestry project	To check desertification and to restore the ecological status; to meet the fuel wood, small timber and minor forest products requirements of the forest population on sustained basis; to provide gainful employment to the rural poor; to check soil erosion; to improve the living environment of the area by stabilizing the active sand dunes and taking up plantations in open spaces in urban areas; to conserve 'gene-pool' and improve the bio-diversity of flora and fauna.	15 districts of the state, namely Jaipur, Dausa, Sawai Madhopur, Karauli, Bharatpur, Dholpur, Kota, Tonk, Dungarpur, Rajsamand, Bundi, Jhalawar, Baran, Ajmer and Bhilwara.	1995-96 to 1999-00	Rs. 139.18 crores (4219 Yen)	OECF, Japan
Afforestation and pasture Dev. Along Indira Gandhi Canal	To improve productivity by increasing production of firewood and fodder and to conserve the infrastructure and the land through planting trees to protect canals, roadways, and farmland, etc., in the desert region of western Rajasthan State, and thereby contribute to the alleviation of poverty in the region.	Bikaner and Jaiselme districts	1990-91 to 1999-00	Rs. 107.50 crores (7869 Yen)	OECF, Japan

Schemes/actions proposed under the Annual Plan 2009-10 of the Planning Department, Government of Rajasthan

A new scheme of "**Van Mitra**" is proposed to be introduced in 2009-10. These Van Mitra or extension workers would facilitate/motivate the JFMCs, Panchayats and local people regarding Forest & Wildlife Protection and Environmental Conservation.

Consolidation, Demarcation & Settlement

The programme aims to demarcate the forest boundaries with the objective to prevent encroachments and boundary disputes

Improvise Working Plan

To boost and revive the dwindling importance of working plans, it is proposed that the Working Plan offices are proposed to be equipped with computer hardware & software, printers, UPS facilities, etc. along with operators on contract.

Reforestation of Degraded Forests

Under this initiative, degraded areas are to be enclosed and in-situ soil & moisture conservation structure are proposed to be made to give a boost to natural regeneration.

Desertification and Land degradation

India is having large number of centrally sponsored schemes for combating desertification (GoI 2007). The State of Rajasthan is also beneficiary of most of the schemes as mentioned below:

Ministry of Environment and Forests

1. National Afforestation Programme (NAP)
2. Grant in Aid for Greening India
3. Externally Assisted Forestry Projects

Ministry of Agriculture

1. Soil Conservation for Enhancing the Productivity of Degraded Lands in the Catchments of River Valley Project & Flood Prone River
2. Reclamation of Alkali Soils (RAS)
3. Strengthening of State Land Use Board (SLUB)
4. All India Soil and Land Use Survey (AIS & LUS) Organisation
5. Soil Conservation Training Centre, Damodar Valley Corporation, Jharkhand
6. National Land Use and Conservation Board (NLCB)
7. Watershed Development Project for Shifting Cultivation Area (WDPSCA)

Externally Aided Projects

1. Indo-German Bilateral Project on Watershed Management
2. Sodic Land Reclamation Project (World Bank assisted)
3. Indira Gandhi Nahar (Canal) Project (IGNP) (Japan Bank For International Cooperation assisted)

Ministry of Rural Development

1. Drought Prone Areas Programme (DPAP)
2. Desert Development Programme (DDP)
3. Integrated Watershed Development Programme (IWDP)

Other Relevant Schemes

1. Sampoorna Grameen Rojgar Yojana, NREGP for poverty alleviation and rural

2. Employment with focus on horticulture and watershed development.
3. Reclamation of mined areas, saline and alkaline areas, and waterlogged areas.
4. Desertification Status Mapping using satellite data has been taken up by Space Application Centre (SAC) of ISRO.
5. SAC/ISRO in collaboration with other national/state organisations has carried out programmes which are required for combating desertification and mitigating the effect of drought.
6. The National Remote Sensing Agency (NRSA) with the cooperation of other agencies of the Department of Space (DoS) has taken up the national programmes for mapping long term drought mitigation.
7. Special Central Assistance to Tribal Sub Plan (SCA to TSP) - initiatives to improve the productivity of lands owned by scheduled tribes (STs).
8. The Swarn Jayanti Gram Swarojgar Yojana (SGSY) for the rural areas
9. In Swarn Jayanti Rojgar Yojana (SJRY) for the urban areas two special schemes, the Urban Self Employment Programme (USEP) and the Urban Wage Employment Programme (UWEP) will address approximately 6 million people who will be direct beneficiaries.
10. To improve the sustainable living in urban areas Jawaharlal Nehru National Urban Renewal Mission (JNNURM) has been launched.
11. UNDP GEF Small Grants Programme (SGP)
12. Role of Private Sector as Corporate Social Responsibility

9.5 Summary

As identified in the section on the current vulnerabilities the biodiversity inside the PAs (sensitive habitats and species) and outside PAs (corridors, buffer areas, etc.) form an important component for management, monitoring and conservation of the natural heritage for the state of Rajasthan. There is a need to have specific programme which would identify the sites of intervention by recognizing the ecologically sensitive habitats and species, connecting corridors for the conservation of the wild biodiversity in the state.

A policy response, long-term financial support to implement a strategy for enhancing the biodiversity, productivity and livelihoods through sequential restoration of vegetation in stabilized and reactivated dunes is required to tackle the reactivation threat of the sand dunes due to the process of desertification.

As the predominant wind direction in Rajasthan is South West to North East, the tendency for desertification has been more in that direction. Indeed, there is clear evidence that the Thar Desert is expanding in an eastward as well as northeast direction. Thus, from the climate-proofing perspective, creating plantation strips and shelterbelts perpendicular to the predominant wind direction in areas spread from Ramgarh to the foothills of Mount Abu is likely to help in climate change mitigation and livelihoods improvement (Singh et al 2010).

The provisions of documentation of traditional knowledge such as People's Biodiverity Registers by working along with the local communities, CBOs, NGOs would play an important role in not only conserving the traditional knowledge but also to explore its use value for the purpose of adaptation to tackle the climate change. The use of traditional knowledge in promoting agro-forestry, identifying the important conservation habitats outside PAs would serve a valuable contribution.

In a nutshell the main priorities of the state can be identified as follows -

Strategy Area 1: Afforestation / Reforestation for maximizing mitigation potential of the forests

Massive efforts for tree planting and restoration of forests in Rajasthan are required in order to encourage carbon sequestration and climate change mitigation. This action would be supplemented by the proposed afforestation on large scale under the newly launched 'Harit Rajasthan' programme with major assistance flowing from the Japanese aided 'Rajasthan Forestry and Biodiversity Project Phase II' commencing in 2011-12.

Strategy Area 2: Sequential restoration of dunes in Thar desert

There is a need to enhance biodiversity through enrichment of stabilized or reactivating dunes with indigenous species that were not possible to grow or failed to grow initially in moving dunes. Such sequential restoration is expected to enhance productivity and initiate succession towards indigenous species that will further yield livelihoods, goods and services to local people. Support to desert afforestation thus needs to be strengthened.

Strategy Area 3: Conservation of Biodiversity and traditional knowledge

Habitat fragmentation and isolation have been important factors affecting the occupancy of many species. Thus providing an intervening corridor is an important conservation strategy for continued species survival. Improving corridor quality may lead to higher conservation returns than manipulating the size and configuration of present wildlife sanctuaries in Rajasthan.

9.6 Climate actions and strategies

Key Strategy 1: Afforestation/Reforestation measures promoting adaptation and carbon sequestration

Targets (physical)	a) Forest demarcation and afforestation – 1775000 ha
	b) In areas outside forest - 3575000 ha
Targets (financial)	a) In forest areas - Rs 7000 crores
	b) In areas outside forest – 35000 crores

Action 1: Network of Mega-shelter belts- As the predominant wind direction in Rajasthan in South West to North East, the tendency for desertification has been more in that direction (Singh et al, 2010). There is now evidence that the Thar Desert is expanding in an eastward as well as northeast direction (Goswami, P. and K.V. Ramesh, 2008). Thus, planting strips and shelter belts perpendicular to the predominant wind direction in areas spread from Ramgarh to the foothills of Mount Abu will climate proof the region. Further, avenue plantations along the major roads, particularly running in north and south, could also strengthen the overall shelterbelt network. This could further reduce the cost in road maintenance due to reduced extremes of alternate heating and cooling of the road surface. Other co-benefits of the shelterbelts include moderation of local micro-climate, interception of particulate matter and dust-storms, pollutant removal. Also, owing to the sequestration potential of these mega-shelter belts, the plantation activities could benefit from the international mechanisms such as CDM.

Action 2: Promote Urban Forestry- Multifunctional landscapes could be enhanced to strengthen the network of urban green spaces, sequential restoration of existing urban forests and developing them into a multifunctional ecosystem. Some of the interventions required to enable this could include integrating urban forest planning into regular master plans and urban development projects; a road entry fee to be used for generating the resources to manage urban green spaces sustainability. Increasing green space and plantations in the urban areas will enhance build urban resilience and human well-being.

Action 3: Management of Dryland Forests and Agroforestry- Agroforestry as a traditional landuse adaptation strategy in Rajasthan supports livelihoods improvement through simultaneous production of food, fodder and firewood thereby increasing the resilience of the communities. Such interventions also have benefits like biodiversity conservation, yield of goods and services to society, augmentation of the carbon storage in agro ecosystems, enhancing the fertility of soils, and providing social and economic well-being to people. Thus, to promote well-being of the society, management of multifunctional traditional agroforestry systems of Rajasthan need to be strengthened by innovations in domestication of useful species and crafting market regimes for the products derived from agroforestry systems. This could be further enhanced by synergising it with other programs such as MNREGA.

Short-term measures – a) Survey, demarcation & notification of forest areas facilitating identification of areas where buffers and megashelter belts can be created. b) Identification of land available under various categories for plantation in Aravalis, mainly 13 districts

having major forests of the state. c) Detailed state land use map of forested and non-forested areas c) The plantation models based on the indigenous species suitable to local climatic conditions should be defined. d) Operationalisation of Hi-tech nurseries for the supply of quality planting material for dryland agro-forestry. e) Prepare a plan for involvement of local communities through Participatory Forest Management and for developing dryland agro-forestry models

Medium-term measures – a) Data collection on the range & density of common and rare species. b) Monitoring and beating of mortality issues are addressed. c) The infrastructure created for plantation is enhanced and used to its available potential. d) Fire prevention, protection and management systems are ensured for better survival of the plantations and megashelter belts. e) Urban forestry to be promoted in major urban centres f) Obtain carbon credits for forest conservation g) Promote livelihood support to forest / grazing dependent communities h) Promote dryland agro / farm forestry by incentives in private lands through extension, distribution of improved seedlings, rationalization of felling & transit regulations on fodder species i) Market linkages and value chain for agro-forestry plantations are established

Long-term measures – a) Monitoring plan for the plantation sites in place. b) Alternative livelihoods are created for livelihood activities of the local communities responsible for degradation and deforestation of the forest areas.

R & D needs - a) Identification of important buffer areas, corridors and potential areas for afforestation by satellite and ground surveys. b) Integrated approach for working with other line departments where the land could be suitable for the afforestation purpose outside the jurisdiction of the forest department. c) Development of agro forestry models focusing on the fodder species. d) Developing models for Urban forestry with ecosystem service perspective

Policy support - 1) Rajasthan State Forest Policy 2010. 2) Rajasthan State Environment Policy 2010 and 3) Rajasthan State Mission on Afforestation under State Environment Mission.

Institutional arrangements - State Forest Department, State Remote Sensing Agency, Forest Survey of India, Central Arid Zone Research Institute, Arid Forest Research Institute

Lead agency: Name & Role

State Forest Department – a) To provide technical support for recognizing the suitable areas by having ground truthing of the satellite data b) Take up actual afforestation activities on ground c) Protection and management of the area under afforestation

Supporting agency (ies) : Name & Role

State Remote Sensing Agency - Identify suitable areas for afforestation at a scale suggested by forest department logistically important for actual implementation

Panchayati Raj Institutions and Eco-task force (ETF)- To take up actual afforestation activities on ground; protection and management of the area under afforestation.

Capacity building needs - a) Interpreting the satellite imageries in the field for ground truthing in the field for the staff of the State Forest Department b) Developing the plan of intervention as per the requirements of the areas identified for the purpose of afforestation c) Strengthening community based organizations such as Joint Forest Management Committees

Key Strategy 2: Sequential Restoration of Dunes in Thar Desert (Singh et al 2010)

It is predicted in studies that due to climate change there may be significant increase in the desert area over India in next 100 years (Goswami & Ramesh, 2008) with potentially disproportionate impact of global warming on coupled human and natural systems. Indeed, reactivation is likely to intensify further as global warming may force remobilization of desert dune systems in future (Thomas et al, 2005). Reactivated sand drift mediated by climate change and anthropogenic activities may threaten the sustainability of agriculture, infrastructure and land resources in Rajasthan. These challenges call for re-examination and reformulation of strategies for management of arid forests and dune vegetation. Thar Desert in India is characterized by low and erratic rainfall, high air and soil temperature, intense solar radiation and high wind velocity. Context-specific interactions of these factors not only give rise to frequent drought and famines, they also make local livelihoods highly vulnerable.

Desert Development Programme (DDP) and Combating Desertification Programme (CDP) have been implemented over decades to address desertification control, protection to infrastructure, and improvement in green cover and local economy.

It is argued that sequential restoration is expected to enhance productivity, and initiate succession towards indigenous species that will further yield livelihoods goods and services to local people. Sequential restoration of sand dunes would be an ideal adaptive management system capable of developing dynamic and resilient natural resource management system that can withstand stresses of climate change and anthropogenic effects in Thar Desert. Low and erratic rainfall, monsoon variability, high air temperature, intense solar radiation, high wind velocities are the main feature of any desert ecosystem. Random recurrence of drought and famines make local livelihoods highly vulnerable. Absence of multiple-layers of vegetation in sand dunes is resulting in dune reactivation due to biotic and natural causes. Reactivation is threatening the infrastructure that was sheltered earlier by treated sand dunes. Dense plantations enhance biodiversity and land productivity, and also protect vital infrastructure against sand filling. Sequential restoration of sand dunes is a gradual approach to restoration. Restoration is not a once-off event, but rather a long-term commitment for shaping landscapes and ecosystems for human welfare and provides an opportunity to combine restoration and regeneration with sustainable rural livelihoods and participation (Pandey 2011).

These programmes have achieved the desired result of sand dune fixation, yet the resultant vegetation consists of only planted *Acacia tortilis* trees. In addition, the areas covered by these plantations have not been able to cover the vast expanse of sands fully. Paucity of multiple-layers of vegetation is now resulting in dune reactivation due to biotic and natural causes. Reactivation of sand drift exposes roots that cause tree uprooting at many places, and threatens the agricultural production due to moving sands. By way of example, indigenous species *Calligonum polygonoides* provides 7.15 t ha-1 biomass at the age of 50 months, *Prosopis julliflora* provides 7.00 t ha-1 biomass after 50 months, and *Acacia tortilis* provides 5.24 t ha-1 biomass after 50 months (Singh et al, 2002). Indeed, *Calligonum polygonoides* and *Cenchrus ciliaris* combination provides best yields of fodder and fuelwood, whereas combination with *Cassia angustifolia* was the best to control sand drift. A minimum of 4200 - 4600 kg C/km2/year of soil organic carbon is likely being sequestered in soils under the plantations in arid region (Singh et al, 2007). Thus, as a policy response, long-term financial support to implement a strategy for enhancing the biodiversity, productivity and livelihoods through sequential restoration of vegetation in stabilized and reactivated dunes is required (Pandey, 2007). Historically, sand dune stabilization was an emergency and the

rapid tree-cover developed through DDP and CDP has served the desired purpose (i.e., sand dune fixation, soil enrichment etc.), but could stabilize only limited areas. Owing to the green cover created through these interventions, soil properties and moisture regimes have improved. It is required to enhance biodiversity through enrichment of stabilized or reactivating dunes with indigenous species that were not possible to grow—or failed to grow—initially in moving dunes. Such sequential restoration is expected to enhance productivity, and initiate succession towards indigenous species that will further yield livelihoods goods and services to local people. Support for desert afforestation, thus needs to be strengthened.

Measures: As a support mechanism it is required standardized methodology based on a sound and unbiased assessment framework shall be developed for the assessment of the desertification is developed along with plan of implementation, sites to be identified for sand dune stabilization and a participatory sand dune stabilization programme is launched by involving local communities and have an integrated approach is developed for implementation of state and centrally sponsored schemes for tackling desertification. Monitoring and tackling likely shifts in forest types, species and especially desert ecosystem and sand dunes. Area of intervention for sand dune stabilization is monitored using satellite imageries. Developing participatory models of sand dune stabilization with the help local communities are developed by focusing livelihood protection.

Key Strategy 3: Conservation of Biodiversity and Traditional knowledge

Action 1: Monitoring and tackling likely shifts in forest types, species and especially desert ecosystem

Targets (physical) – 1) Establishing weather monitoring data loggers at atleast 100 distinct sites in protected areas and other important habitats of the state.

2) Establishing Germ plasm collection banks of forest genetic resources at 3 sites in the state according to the agro-ecological regions. 3) Monitoring desertification and sequential restoration of sand dunes.

Targets (financial) – Rs. 45 crores + more than 30 centrally sponsored schemes to tackle desertification

Short-term measures – 1) Identification of sites for both the targets 2) Identification of suitable data loggers 3) Prioritisation of species for monitoring including animal taxa and lower plants and for germ plasm collection of mainly plant species 4) Data collection and organization from loggers is established with regular intervals

Medium-term measures – 1) Professionals are trained to handle data and analyse it with the help of experts for interpretation 2) Highlights of the results from the data analysis are periodically presented to the government and also communicated to wider scientific audience at national and international levels 3) Maintenance and wear and tear of the data loggers is looked after

Long-term measures – a) Satellite based monitoring process continues and feed back is communicated to the policy makers for further actions.

R & D needs – 1) Prioritisation of species for monitoring including animal taxa and lower plants and for germ plasm collection 2) Developing database management system linking the monitoring sites with the satellite information on GIS platform

Policy support - 1) Rajasthan State Forest Policy 2010. 2) Rajasthan State Environment Policy 2010

Institutional arrangements - State Biodiversity Board, State Forest Department, State Remote Sensing Agency, Forest Survey of India, National Biodiversity Authority, Arid Forest Research Institute, Wildlife Institute of India

Lead agency : Name & Role

State Biodiversity Board – a) To provide technical support for undertaking the work on the ground with the help of concerned departments. b) Act as co-ordinator / facilitator for monitoring of the biodiversity in the state

Supporting agency (ies) : Name & Role

State Forest Department – a) To provide technical support for recognizing the suitable areas by having ground truthing of the satellite data b) Develop the Germ plasm banks in collaboration with the State Biodiversity Board. c) Develop sand dune stabilization programme.

State Remote Sensing Agency – a) Provide technical support for linking relevant satellite information for monitoring of the biodiversity

Forest Survey of India - a) Provide technical support for linking relevant satellite information for monitoring of the forests and other ecosystems

National Biodiversity Authority – a) Guidance for prioritizing species for monitoring

Wildlife Institute of India – a) Guidance for prioritizing species for monitoring

Capacity building needs - a) Training of personnel of the State Biodiversity Board, State Forest Department for interpreting the satellite imageries in the field for ground truthing in the field b) Training of personnel for handling data loggers, data download, and database management along with basic techniques and tools of data analysis

Action 2: Integrating traditional knowledge in adaptation strategies

Targets (physical) Undertake People's Biodiversity Register (PBR) documentation exercise at about 1000 sites (including towns, municipalities and villages spread in 249 blocks) in the state.

Targets (financial) Rs 30 crores

Short-term measures – 1) Identification of sites for PBR documentation in a phase-wise manner 2) Development of formats and database system 3) Training of trainers 4) Identification of facilitating CBOs / NGOs for documenting PBRs

Medium-term measures – 1) Conduct periodic consultations of the trainers, CBOs, NGOs, local communities involved in the PBR documentation process 2) Organise the data collected in a centralized computer based database information system in local language 3) Analyse the data periodically in the context of the use value of traditional knowledge documentation for tackling the impacts of climate change on plant and animal health, productivity of agriculture and animal husbandry, biodiversity conservation, fodder species, etc. 4) Explore the potential of traditional knowledge as local level disaster management mechanism for decentralized and faster responses especially for agriculture and animal husbandry sectors.

Long-term measures – a) Wider dissemination of the outcome from PBR documentation exercise to tackle the impacts of the climate change

R & D needs – 1) Development of the structure, formats of data collection for conducting the PBR 2) Explore the potential of traditional knowledge as local level disaster management mechanism for decentralized and faster responses especially for agriculture and animal husbandry sectors.

Policy support - 1) Rajasthan State Forest Policy 2010. 2) Rajasthan State Environment Policy 2010

Institutional arrangements - State Biodiversity Board, State Forest Department, State Remote Sensing Agency, Forest Survey of India, Central Arid Zone Research Institute, Arid Forest Research Institute, National Biodiversity Authority

Lead agency : Name & Role

State Biodiversity Board – a) To provide technical and logistical support for undertaking the work on the ground for documenting PBRs.

Supporting agency (ies) : Name & Role

State Forest Department – a) To provide technical support for recognizing the suitable areas, information about forests and species as per the formats of the PBR

State Remote Sensing Agency – a) Provide technical support for linking relevant satellite information for documenting the biodiversity and associated traditional knowledge

Forest Survey of India - a) Provide technical support for linking relevant satellite information on the forests and other ecosystems of Rajasthan

National Biodiversity Authority – a) Overall guidance on PBR to link with the Indian Biodiversity Information System

Central Arid Zone Research Institute – a) Develop the disaster management tools and models using the traditional knowledge for agricultural and animal husbandry for wider dissemination and use

Arid Forest Research Institute – a) Develop the disaster management tools and models using the traditional knowledge for tackling fodder availability from various plant species, etc.

Capacity building needs - a) Training of personnel of the State Biodiversity Board, State Forest Department, CBOs, NGOs, colleges, schools, any other institution involved in the documentation of PBRs b) Developing the computer based database management system c) Communicating the findings of the analysis of PBRs

Key Priorities and Actions identified for Forest and Biodiversity Sector

Key Strategy	Action	Time-frame (ST, MT, LT)[38]	Physical Target/ Scope	Financial Requirement
1	Afforestation/ Reforestation measures for promoting adaptation and carbon sequestration			
	Network of Mega-shelter belts*		▪ Forest demarcation and afforestation – 1775000 ha ▪ In areas outside forest- 3575000 ha	▪ In forest areas - Rs 7000 crores ▪ In areas outside forest – 35000 crores
	Promote Urban Forestry			
	Management of Dryland Forests and Agroforestry	▪ Survey, demarcation & notification of forest areas facilitating identification of areas where buffers and megashelter belts can be created. ▪ Identification of land available under various categories for plantation in Aravalis, mainly 13 districts having major forests of the state. ▪ Detailed state land use map of forested and non-forested areas and plantation models based on the indigenous species suitable to local climatic conditions should be defined ▪ Operationalisation of Hi-tech nurseries for the supply of quality planting material for dryland agro-forestry ▪ Prepare a plan for involvement of local communities through Participatory Forest Management and for developing dryland agro-forestry models Medium-term measures ▪ Data collection on the range & density of common and rare species. ▪ Monitoring and beating of mortality issues are addressed.		

[38] ST: Short Term (2012-2017), MT: Mid-term (2017-2022), LT: Long-term (2022 and beyond)
*Targets for these strategies are to be provided as inputs by the State Forest Department

Key Strategy	Action	Time-frame (ST, MT, LT)[38]	Physical Target/ Scope	Financial Requirement
		▪ The infrastructure created for plantation is enhanced and used to its available potential. ▪ Fire prevention, protection and management systems are ensured for better survival of the plantations and megashelter belts. ▪ Urban forestry to be promoted in major urban centres ▪ Obtain carbon credits for forest conservation ▪ Promote livelihood support to forest / grazing dependent communities ▪ Promote dryland agro / farm forestry by incentives in private lands through extension, distribution of improved seedlings, rationalization of felling & transit regulations on fodder species ▪ Market linkages and value chain for agro-forestry plantations are established Long-term measures ▪ Monitoring plan for the plantation sites in place. ▪ Alternative livelihoods are created for livelihood activities of the local communities responsible for degradation and deforestation of the forest areas.		
2	Sequential Restoration of Dunes in Thar Desert*			
	Sequential Restoration of Dunes in Thar Desert			
3	Conservation of Biodiversity and Traditional knowledge			
	Monitoring and tackling likely shifts in forest types, species and	Short-term measures ▪ Identification of sites for both the targets	▪ Establishing weather monitoring data loggers	Rs. 45 crores + more than 30 centrally

Key Strategy	Action	Time-frame (ST, MT, LT)[38]	Physical Target/ Scope	Financial Requirement
	especially desert ecosystem and sand dunes	▪ Identification of suitable data loggers ▪ Prioritization of species for monitoring including animal taxa and lower plants and for germ plasm collection of mainly plant species ▪ Data collection and organization from loggers is established with regular intervals Medium-term measures ▪ Professionals are trained to handle data and analyse it with the help of experts for interpretation ▪ Highlights of the results from the data analysis are periodically presented to the government and also communicated to wider scientific audience at national and international levels ▪ Maintenance and wear and tear of the data loggers is looked after Long-term measures Satellite based monitoring process continues and feedback is communicated to the policy makers for further actions.	at atleast 100 distinct sites in protected areas and other important habitats of the state. ▪ Establishing Germ plasm collection banks of forest genetic resources at 3 sites in the state according to the agro-ecological regions. ▪ Monitoring desertification and sequential restoration of sand dunes.	sponsored schemes to tackle desertification
	Integrating traditional knowledge in adaptation strategies	Short-term measures ▪ Identification of sites for PBR documentation in a phase-wise manner ▪ Development of formats and database system ▪ Training of trainers ▪ Identification of facilitating CBOs / NGOs for documenting PBRs Medium-term measures ▪ Conduct periodic consultations of the trainers, CBOs, NGOs, local communities involved in the	Undertake People's Biodiversity Register (PBR) documentation exercise at about 1000 sites (including towns, municipalities and villages spread in 249 blocks) in the state.	30 crores

Key Strategy	Action	Time-frame (ST, MT, LT)[38]	Physical Target/ Scope	Financial Requirement
		PBR documentation process ▪ Organise the data collected in a centralized computer based database information system in local language ▪ Analyse the data periodically in the context of the use value of traditional knowledge documentation for tackling the impacts of climate change on plant and animal health, productivity of agriculture and animal husbandry, biodiversity conservation, fodder species, etc. ▪ Explore the potential of traditional knowledge as local level disaster management mechanism for decentralized and faster responses especially for agriculture and animal husbandry sectors. Long-term measures Wider dissemination of the outcome from PBR documentation exercise to tackle the impacts of the climate change		

Chapter 10: Enhanced Energy Efficiency and Renewable Energy

10.1 Background

The total installed capacity for electricity generation in Rajasthan is 7716.63 MW (Economic Survey of India, 2009). Of the total installed capacity around 52.97 % is thermal, 19.14 % is hydel, 8.61 % is gas, 6.08% is atomic and approximately 13.19 % is renewable (wind and biomass). Though the installed capacity have approximately doubled from 2000-01 in 2009-10, there exist supply deficit by around 20 %. Also, with increase in industrial development and increased socio-economic growth in the State, the demand is expected to rise further. According to the 17th Electric Power Survey Report, by the end of XII Plan (2016-17), the state is projected to have an electricity demand of around 11400 MW[39]. Meeting the increased demand is a huge challenge faced by the state. There might be further significant increases in electricity use and peak demand in Rajasthan due to temperature rise in future, widening the supply deficit further.

To meet continuously growing power demands of the state, the Rajasthan Power Generation Company has identified new power plants in the State with coal as a major option to enhance power availability in the State. At present, captive power plants (mostly diesel based), are used in the industries for dedicated power supply of around 500 MW. Additionally, the state is now looking at renewable sources of energy such as Solar and Biomass since there exists huge opportunity for the state of Rajasthan to exploit its renewable energy potential. For instance, the State receives maximum solar radiation intensity in India with the least average rainfall (hence number of overcast days in a year) as compared to the rest of the country and hence it's best suited for solar power generation (Sukhatme and Nayak 1997). It also has land available in abundance. Therefore, Rajasthan is likely to emerge as the preferred destination for setting up installed capacity, which may eventually exceed 100,000 MW. In order to promote solar energy in the state the Rajasthan the government under it's 'Policy for promoting Generation of Electricity through Non-Conventional Energy Sources, 2004' has taken initiatives which includes giving incentives viz. exemption from electricity duty, special incentives for industries, single window clearance., allotment of land on concessional rates etc. Also, the government has prepared a draft Solar Policy, which is very ambitious and exhaustive in terms of laid activities and plans. Also, given the surplus biomass available in Rajasthan, the state has a huge potential for electricity generation through biomass. About 1275 MW electrical power can be generated through biomass gasifier based power generation plant by using surplus biomass available in Rajasthan. Such initiatives can result in huge co-benefits for the state; about 1656 tonnes of CO_2 can be saved annually by installation of 1 MW biomass gasifier based power plant (Panwar and Rathore 2009).

Besides, increasing its energy security through harnessing renewable energy potential, the government has taken some important measures on the demand side management and energy efficiency in different sectors. However, one of the many challenges that the state faces is that of low energy efficiency. The MSME clusters in the state use either diesel or furnace oil or use woody biomass in an inefficient manner.

39 http://www.powermin.nic.in/generation/pdf/17th%20EPS.pdf

Some of the activities include promoting the use of Compact Fluorescent Lamps (CFLs) for street and domestic lighting; energy efficiency pump sets; providing tariff concession on solar water heaters; minimizing distribution losses; using new and efficient technologies like super critical boiler technology and integrated gasification combined cycle for thermal power projects. With such a progressive beginning there is a need to strengthen the ongoing programs and policies which would not only address the developmental objectives of the state but also climate change mitigation.

Further, rural energy access is key to sustainable development and growth of the State as about 76 % of the total population is in rural areas with about 20% of the villages still un-electrified[40]. Further some of the districts are sparsely populated where in cost of setting transmission lines and evacuation is high and hence a challenge for the region. Therefore, decentralised renewable energy options could be used. Also, nearly 65% of the households in the state use fuel wood for there daily subsistence needs which is inefficient and contributes to carbon emissions.

10.2 Mitigation Opportunities

10.2.1 Renewable Energy Potential

Rajasthan has meager resources of coal and petroleum but is richly endowed with renewable energy sources such as wind energy, solar energy, and biomass.

Wind: The Rajasthan state has wind energy potential of 4858 MW, which is around 10% of India's wind energy potential.[41] At present, the state has harnessed only 850 MW of wind energy. Some of the potential sites identified in the State Wind Policy (2003) on the basis of average wind speed, wind density profile and power potential per square meter include Devgarh in Chittorgarh district, Harshnath in Sikar district, Jaiselmer in Jaisalmer district, Khodal in Barmer district, Mohangarh at Jaiselmer disctrict, and Phalodi in Jodhpur district. The State should encourage wind assessment studies in additional locations to identify other potential sites to be able to harness the wind energy potential in the State.

Hydro: Given the water scarce situation, small hydro (upto 25 MW) has only 57.17 MW[42] potential out of which 23.85 MW has already been installed.

Solar: Rajasthan is bestowed with significant amount of solar energy potential and the recent interests shown by the developers & investors in addition to the ambitious Solar Policy, Rajasthan is poised to be a leader in the sector. Also, the state transmission utility has developed strong transmission system at Barmer, Jaisalmer, Merta, Jodhupur, Bikaner and Ratangarh along with strong transmission line and sub-station network in desert area. This has led to suitable transmission system to evacuate solar power in the desert area, where the potential of solar energy is maximum. The state can further tap resources and leverage from the Jawaharlal Nehru National Solar Mission.

40 Note on power sector, December 2009. Government of Rajasthan

41 http://www.mnre.gov.in/wpp.htm

42 http://www.mnre.gov.in/

The arid parts of Rajasthan receive average maximum solar radiation of about 7.5 kWh/m^2 in summers and minimum of about 4.6 kW h/m^2 in winters. In most parts of India, clear sunny weather is experienced 250–300 days a year (Purohit and Michaelowa, 2008). The annual global radiation varies from 1600 to 2200kWh/m^2 and the highest annual global radiation (Z2400 kWh/m^2) is received in Rajasthan and northern Gujarat (Purohit and Garud, 2007). Thar Desert of Rajasthan receives around 2200–2400kWh/m^2 annual direct normal incidences. According to Purohit and Purohit, locations blessed with annual direct solar radiation more than 1800kWh/m^2 are best recommended for installation of concentrating solar power (CSP) systems (Purohit and Purohit 2010). Further, the authors suggests districts of Jaisalmer, Bikaner, Barmer, Kota, Jodhpur, Udaipur, Jaipur in Rajasthan as preferred locations for CSP systems.

Besides this, one of the most widespread uses of solar thermal technology is solar water heating (SWH). Theoretical annual CO_2 emissions reduction potential of solar water heating systems in Rajasthan through annual electricity saved amounting to 1.3 (TWh) results is 1.0 million carbon equivalents (Purohit and Michealowa 2008). SWHs find wide application in large establishments such as hostels, hotels, hospitals, small scale industries such as textile, paper, food processing, etc. These applications are also useful for domestic water heating particularly simple domestic systems. Provision has been made in the building bye-laws of the state for Solar water heating in buildings such as hospitals and nursing homes, hotels, guesthouses, dak bungalows, lodges, government guest houses, hostels, community centres and other public utility buildings, along with panel clauses.

Besides, there is also potential for using renewable energy option for autonomous desalination systems and withdrawal pumps as supply of portable water in Rajasthan without any energy input is almost impossible. Even if freshwater is readily accessible under the ground level, energy is required to pump the freshwater from its source. Freshwater drawn from the groundwater source requires 0.14–0.24 kWh/m3 (0.5–0.9 kJ/kg) for a pumping head of 120– 200 ft. Further, treatment of surface waters to potable quality requires 0.36 kWh/m3 (1.3 kJ/kg) to produce freshwater. The author further estimates energy requirements for different desalination processes and associated green house gas emissions (Gude et al 2010). Some of the options as discussed by E. Mathioulakis et al, 2007 include PV or wind-powered reverse osmosis, electrodialysis or vapour compression; or Solar thermal or geothermal energy and distillation processes. Further solar still can be economically used to provide portable water to remote areas of the state (Khanna, Rathore and Sharma).

Solar photovoltaic technology for the purposes of decentralized electricity generation in remote areas, RREC is already installing SPV Domestic lighting system, street lighting system and solar pump sets.

Biomass: As for biomass energy, the main source of biomass energy in the state of Rajasthan is mustard husk and *Julie Flora*. Biomass totaling to 72 MW have already be installed as on December 2009[43] and few are for captive generation. Many of the MSME clusters in the state use either diesel or furnace oil or use woody biomass in an inefficient manner and also

43 Economic review, 2009-10, Government of Rajasthan

nearly 65% of the households in the state use fuelwood that is inefficient and contributes to carbon emissions.[44] A study (Panwar and Rathore 2009) conducted on production of surplus agricultural biomass from all the major crops grown in Rajasthan which categorizes biomass in two classes i.e., as essential class and non-essential class of which biomass residues consumed as fodder, thatching and fencing materials and other socially significant nature are grouped under the essential class and the remaining under non-essential class. Currently, non-essential class biomass is being burnt by the farmer itself in the field[45] leading to emissions; this could however be used for energy generation purposes. The main type of agricultural biomass in Rajasthan from crop production includes straw from rice, soya bean; stalk from castor, cotton, moog, moth, sesame, mustard; and shell from gaur, groundnut. On an average 1 kg biomass with reasonable moisture content per unit of power generation (per kW) is needed in the biomass gasifier based power plant (Mukhopadhyay 2004). Thus annually 7200 tones of biomass are required to run the 1 MW capacity power plants round the clock for 300 days. It is estimated that about 1275 MW power could be generate through biomass gasifier based power generation plant through surplus biomass available in Rajasthan leading to savings of around 2 million tonnes of CO_2.

Biogas: Rajasthan possesses the India's second largest livestock population of 49136 thousand (10.13%), with a high degree of diversity in its composition. Revival of community Biogas plants could be a potential activity as besides mitigating emissions, it also supplies energy and manure. This further reduces emissions and local pollutants through substituting firewood for cooking, kerosene for lighting and cooking and chemical fertilizers. A study (Pathak et al 2005) calculates mitigation potential of a family size biogas plant was 9.7 t CO_2 equiv. year−1. Same study estimates potential of 39189 thousand tons of CO_2 equivalent in Rajasthan with a potential of 4040 thousand biogas plants. This could be used as energy option in rural areas as access to energy in rural areas is still a challenge for Rajasthan with about 20% of the villages still un-electrified[46]. Further from above it is clear that state has immense potential for renewable energy particularly solar, wind and biomass. Also, these applications could be used at decentralised levels. In addition, benefits of carbon credits under Clean Development Mechanism (CDM) under the Kyoto Protocol further improve the financial feasibility of the renewable energy applications.

10.2.2 Energy Efficiency

Low energy efficiency is one of the challenges faced by the state. In order to improve energy efficiency and address these concerns, Rajasthan Renewable Energy Corporation (RREC) has, under the guidelines of Bureau of Energy Efficiency (BEE), been conducting a survey of government buildings for energy efficiency, energy auditing, energy conservation measures for designated consumers, installing solar water heating systems in private establishments, etc.

44 Economic review, 2009-10, Government of Rajasthan

45 Interview with Mr. Patni RRECL

46 Note on power sector, December 2009. Government of Rajasthan

Agriculture: According to the survey, the annual electricity sale to agriculture sector is 8.14 BU with major energy consumption in energizing agriculture pumps with energy efficiency varying from 25-35 % as compared to the efficiency levels of 50-52 % of BEE star labeled agricultural pump sets. Further, it is estimated that by replacement of existing pumps the achievable saving potential is 30-40% and sectoral saving potential works out to be 2.442 BU per year.

Commercial buildings and public works: Also, there are 131 commercial buildings in the state accounting for annual energy consumption of 361 MU (with over 500 kW connected load) which works out to about 23.5% of the sectoral consumption with energy saving potential varying from 20-30 % and accounting to be 72 MU. Further, the annual electricity sale to public lighting and public water works and sewage is 1.31 BU. For 169 major municipalities, 5 municipal corporations and 15 municipal councils considered, annual electricity consumption for street lighting is 188 MU and annual consumption for water & sewage pumping is 1.21 BU. The total consumption is 1398 BU. The energy savings potential for street lighting in municipalities and corporations is assessed to be 25% and works out to 47 MU per year, while the energy savings potential for water works and sewage in municipalities and corporations is assessed to be 20% and works out to 242 MU per year.

Industries: The annual electricity sale to the industry sector in Rajasthan is 12.12 BU and works out to 42% of the total electricity sold. While the larger industries segment is covered for energy efficiency under the mandates of EC Act as designated consumers, SME segment is being addressed for energy efficiency through cluster based initiatives by BEE. The electrical energy saving potential in industry sector varies from 7-10%. The energy savings potential for the sector is assessed to be 0.849 BU. According to BEE, four energy intensive clusters have been identified in Rajasthan namely rolling mills, bearing clusters, marble cluster and textile clusters for energy consumption and savings assessment with estimated total energy consumption in rolling mills (Jaipur) to be 115 MU with 15% energy saving potential; estimated total energy consumption in marble cluster (Kishangarh, Udaipur, Makrana) to be 488.6 MU with 10% energy saving potential; estimated total energy consumption in textiles cluster (Pali) to be 46030 TOE with 20% energy saving potential.

Domestic: The annual electricity sale to domestic sector in Rajasthan is 4.46 BU which accounts for 16% of the total electricity sold. The domestic sector electricity consumption varies with respect to rural and urban segments and climatic seasonal variations. In the rural segment major use of electricity is towards lights & fans. In the urban segment the typical energy consumption pattern includes the following AC and refrigeration (56%), lights and fans (24%), coolers, TV, washing machines (16%) and others (4%). The major avenues for energy saving in rural domestic sector include replacement of GLS bulbs with CFLs, adoption of star rated domestic appliances like ceiling fans, refrigerators, AC units, tube lights etc. The savings potential in rural segment by adopting CFLs and BEE star rated products is 40-50%. The savings potential in urban segment by adopting star rated products is 15-20%. On the whole the energy savings potential in domestic sector is estimated 20-25% which accordingly works out to 0.89 BU per year.

Hence, total saving potential in Rajasthan is 4.542 BU representing 16% of the annual energy sold. *Further from the above background, it is clear that energy efficiency potential is high in commercial buildings and SME sector.*

Further analysing the sector-wise electricity consumption in 2007-08 agriculture sectors is the largest consumer at 34.43% followed by large industries (22.73 %), domestic (18.86 %), commercial (6.47%), medium industries (5.36 %), public water works (4.91%), small industries (2.66%) and public lighting (0.65%). From such an analysis, directionally it is clear that demand side measures should be targeted in the agriculture, industries and domestic sector. However, if further analysed by looking at the past trends (table 10.1), the percentage share has been increasing in the agriculture and domestic sector while decreasing in the industries. Within industries since large industries as designated consumers are covered under the national level (perform achieve and trade) PAT scheme, the state could focus on medium and small industries while also ensuring that the implementation of PAT scheme is being facilitated. The Rajasthan government has already started the pilot program on e-filling of energy consumption data which is an important first step in this regard.

Table 10.1 Percentage Consumption of Electricity

Year	Domestic	Commercial	Industrial	Public Lighting	Public Water Work	Irrigation & agriculture	Others	Total (million kwh)
1970-71	6.27	5.16	62.77	0.91	5.94	11.64	7.32	958.90
1980-81	7.57	4.90	44.20	0.67	5.10	34.31	3.25	2929.00
1990-91	11.39	4.61	44.89	0.41	4.43	29.05	5.44	7990.40
2000-01	17.16	5.18	27.05	0.48	4.43	42.21	3.48	16692.60
2006-07	18.77	6.28	31.64	0.66	5.24	33.23	4.19	20035.90

10.3 Review of existing Policies

Ongoing Government Programs/ Initiatives	Key Objectives/Goals	Salient components/strategies/activities	Implementing agencies in the State (Nodal and supporting)
Jawaharlal Nehru National Solar Mission (JNNSM)	To create an enabling policy framework for the deployment of 20,000 MW of solar power by 2022.	To create favourable conditions for solar manufacturing capability, particularly solar thermal for indigenous production and market leadership To promote programmes for off grid applications, reaching 1000 MW by 2017 and 2000 MW by 2022 To achieve 15 million sq. meters solar thermal collector area by 2017 and 20 million by 2022. To deploy 20 million solar lighting systems for rural areas by 2022	MNRE
National Mission on Enhanced Energy Efficiency (NMEEE)	Enhancing energy efficiency and creating an enabling environment	NMEEE spelt out the following four new initiatives to enhance energy efficiency, in addition to the programmes on energy efficiency being pursued by MOP and BEE. They are: A market based mechanism to enhance cost effectiveness of improvements in energy efficiency in energy-intensive large industries and facilities, through certification of energy savings that could be traded. (Perform Achieve and Trade); Accelerating the shift to energy efficient appliances in designated sectors through innovative measures to make the products more affordable. (Market Transformation for Energy Efficiency (MTEE); Creation of mechanisms that would help finance demand side management programmes in all sectors by capturing future energy savings. (Energy Efficiency Financing Platform (EEFP); and Developing fiscal instruments to promote energy efficiency name Framework for Energy Efficient Economic Development (FEEED).	MOP, BEE
Energy	Specifies the energy performance	The ECBC provides design norms for building envelope, including thermal performance requirements for walls, roofs, and windows;	BEE

Ongoing Government Programs/ Initiatives	Key Objectives/Goals	Salient components/strategies/activities	Implementing agencies in the State (Nodal and supporting)
Conservation and Buildings Code (ECBC)	requirements for all commercial buildings that are to be constructed in India. Buildings with an electrical connected load of 100 kW or more are covered by the ECBC.	Lighting system, including daylighting, and lamps and luminaire performance requirements; HVAC system, including energy performance of chillers and air distribution systems; Electrical system; and Water heating and pumping systems, including requirements for solar hot-water systems. The code provides three options for compliance: 1.Compliance with the performance requirements for each subsystem and system; 2.Compliance with the performance requirements of each system, but with tradeoffs between subsystems; and 3.Building-level performance compliance	
Electricity Act, 2003	Each state electricity regulatory commission to specify the minimum percentage of electricity that each distribution utility must source from renewable energy sources. This encourages and stimulates the market of non-conventional energy resources/renewable and cogeneration was promoted. This Act	▪ The main features of the act are s follows: ▪ Generation has been delicensed and captive generation freely permitted ▪ No license required for generation and distribution in rural India ▪ Central Government may, make region- wise demarcation of the country, and, from time to time, make such modifications therein as it may consider necessary for the efficient, economical and integrated transmission and supply of electricity, and in particular to facilitate voluntary inter-connections and co-ordination of facilities for the inter-State, regional and inter-regional generation and transmission of electricity. ▪ Transmission utility at the central and state level to be a government company-with responsibility of planned and coordinated development of transmission network ▪ Open access in transmission with provision for surcharge for taking care of current level of cross subsidy, with the surcharge	

Ongoing Government Programs/ Initiatives	Key Objectives/Goals	Salient components/strategies/activities	Implementing agencies in the State (Nodal and supporting)
	provided a huge boost to the renewable industry.	being gradually phased out. ▪ The state government required to unbuldle State Electricity boards. However they may continue with them as distribution licensees and state transmisison utilities ▪ Setting up state electricity regulatory commission (SERC) made mandatory ▪ An appellate tribunal to hear appeals against the decision of (CERC's) and SERC's ▪ Metering of electricity supplied made mandatory ▪ Provisions related to thefts of electricity made more stringent ▪ Trading as, a distinct activity recognised with the safeguard of Regulatory commissions being authorised to fix ceiling on trading margins ▪ For rural and remote areas stand alone system for generation and distribution permitted ▪ Thrust to complete rural electrification and provide for management of rural distribution by panchayat, cooporative societies, NGOs, franchises etc. ▪ Central government to prepare National Electricity Policy and tariff Policy ▪ Central electricity authority to prepare National electricity plan	
National Electricity Policy, 2005	Emphasis is on decentralized power generation and distribution which subsequently identifies	stipulates that progressively the share of electricity from non-conventional sources would need to be increased; such purchase by distribution companies shall be through competitive bidding process; considering the fact that it will take some time before non-conventional technologies compete, in terms of cost, with	

Ongoing Government Programs/ Initiatives	Key Objectives/Goals	Salient components/strategies/activities	Implementing agencies in the State (Nodal and supporting)
	renewable energy and energy efficient distribution systems.	conventional sources, the commission may determine an appropriate differential in prices to promote these technologies.	
Integrated Energy Policy Of India,	The Government of India has formulated an Integrated Energy Policy covering all sources of energy including renewable energy sources, in December 2008. The policy document has highlighted the need to maximally develop domestic energy supply options and diversify energy sources, including increased exploitation of renewable energy, especially solar	Main features of the policy include: ▪ Incentives for promoting renewables should be linked to energy generated and not just capacity installed. ▪ Creation of alternate incentive structures such as mandated feed-in-laws or differential tariffs or specifying renewable portfolio percentage in total supply. ▪ Appropriate policies, regulatory systems and fiscal measures duly leveraged by funding available under global climate mechanism should be designed to accelerate the development of solar technology for large-scale deployment.	Nodal agency is the Department for Women and Child Development
Energy Conservation Act 2001	The Act provides for the legal framework, institutional arrangement and a	Under the Energy Conservation Act, 2001, the Bureau of Energy Efficiency was established in 2005 with an objective to promote energy efficiency practices among end-users particularly in the manufacturing and building sectors. The BEE is developing	Nodal agency is the Department for Women

Ongoing Government Programs/ Initiatives	Key Objectives/Goals	Salient components/strategies/activities	Implementing agencies in the State (Nodal and supporting)
	regulatory mechanism at the Central and State level to embark upon energy efficiency drive in the country	various standards such as building codes, incentive, training and awareness programs to promote and facilitate deeper penetration of energy efficient technologies and practices. (BEE, 2002)	and Child Development
Rajasthan Solar Energy Policy, 2011 (forth coming)	The objective of this policy is to establish Rajasthan as a National Leader in solar energy in phased manner by creating the policy framework for promoting use of solar energy in various applications	Developing a global hub of solar power of 100000-12000 MW capacity in next 10-12 years Contributing to long term energy security of Rajasthan as well as ecological security by reduction in carbon emissions To achieve grid parity in next 7-8 years, the state will encourage the solar power developers to establish manufacturing plant of their technology Establishment of industrial set-up involving both domestic and foreign manpower participation which will promote Rajasthan as a global tourist destination Productive use of abundant wastelands thereby utilizing the non industrialized desert area for creation of an industrial hub Creating favourable conditions to provide solar manufacturing capabilities by providing fiscal incentives Employment generation and creation of skilled and unskilled manpower	RREC
Policy for	The objectives of this	The policy provides guidance on use of power produced, price of	Nodal agency

Ongoing Government Programs/ Initiatives	Key Objectives/Goals	Salient components/strategies/activities	Implementing agencies in the State (Nodal and supporting)
promotion of electricity generation from Wind, 2003	Policy are to support wind power generation programme based on wind resource studies and assessment and attract investment in the State.	power, wheeling and banking arrangements, grid interfacing and metering.	RREC
Policy for promoting generation of electricity through Non-conventional energy sources, 2004	To be a comprehensive policy for generation of electricity from various sources of non-conventional energy which offers solution to various problems faced by developers, investors and utilities	The policy provides guidance on use of power (captive or sale), grid interfacing arrangements, wheeling and banking, price of power, power purchase agreement, settlement of accounts etc.	Nodal agency RREC
State Government directive on Energy Conservation Building, 2011 (forth coming)			

Ongoing Government Programs/ Initiatives	Key Objectives/Goals	Salient components/strategies/activities	Implementing agencies in the State (Nodal and supporting)
Policy for promoting generation of electricity from biomass, 2010	Promoting the generation of Electricity from biomass and facilitate its development by providing enabling environment to the developers, investors, and utilities	The policy provides for guidance on issues such as use of power for captive purpose or sale, grid interfacing arrangements, power purchase agreement, settlement of accounts, incentives by the state government (exemption from electricity duty @ 50% for a period of 7 years from COD; grant of incentives available to industries, availability of water for power generation, allotment of land to power producers at concenssional rates of 10% of DLC rates) Promotion of development of Prosopis-Juliflora/ other energy plantation on government land for use as supplementary fuel in biomass power plants	Nodal Agency RREC Other: RVPN/Discoms IREDA/PFC/ REC

10.4 Summary

Given the above background, it is clear that the state could employ three broad strategies including Broad Strategies: 1) Harnessing full renewable energy potential of the state; 2) Reduction of transmission and distribution losses; 3) Demand side measures including energy efficiency; and also, have an integrated industrial policy.

10.5 Climate actions and Strategies

Key Strategy 1: Harnessing full renewable energy potential of the state

Action 1: Detailed biomass assessment study and forecasting for preparing an integrated plan for biomass dealing with production, transportation, distribution, regulation, and monitoring, etc. It should look into long term forecasting of demand, proper use of agricultural waste, establishment of awareness generation centers and technical support centres. The state has recently come up with a policy for promoting generation of electricity from biomass in 2010 that covers biomass from forestry and agro-based industrial residues, energy plantations, and other forestry or agro residues.

Action 2: Demonstrate well designed prototypes of renewable energy technology systems for various applications such as SPV domestic lighting system, street lighting system, solar pump sets, solar stills, biomass gasifiers. For example of solar still where in demonstration models can be built to predict daily output depending on geometry of construction and operational parameters of the still. This will enable communities to understand the technology and also for policy makers to conduct reliable economic evaluation.

Action 3: Detailed technical assessment of potential sites that will be suitable for large scale wind and solar farms and synergising it with the available land resources, existence of investors. This will help the state to fulfill its renewable purchase obligations.

Action 4: Creation of solar centre of excellence which would enable applied research and commercialisation of nascent technologies in case of solar. The new draft Solar Policy provides for such initiative.

Action 5: Creation of Rajasthan renewable energy infrastructure development fund for accelerated development of solar and other renewable energy systems in Rajasthan. The resources shall be collected in the form of development charges by the solar power producers.

Action 6: Development of indigenous and cost effective solar technology in the state to enable harnessing full potential and also reach grid parity in the next 6-7 years.

Action 7: The solar policy and other instruments should also provide fiscal incentives to promote setting up of manufacturing units in state. Conducting training programs to create skilled and semi-skilled man power.

Action 8: Launch a comprehensive programme for both rural and urban set-up. Efficient biomass gasification based cooking systems, solar based lighting solutions, solar based irrigation pumps, desalination systems could be launched or reinitiated (as in case of biogas and biomass) in the state. For urban areas, task force on sustainable habitats elaborates on some options including buildings and transport.

Action 9: Since the state is coming up with new clusters and growth centers which are essential for the progress of the state, it is important proper planning is done in terms of landscape planning, utilization of renewable energy applications as applicable, energy efficient technologies amongst other.

The solar policy highlights 15000 crore of investment required for the solar power plants. Calculating costs to the government is required.

Key Strategy 2: Demand side measures including energy efficiency

Action 1: It is important for the state of Rajasthan to study the impacts of climate change on its energy systems. For example, there might be further significant increases in electricity use and peak demand in Rajasthan due to temperature rise in future.

Action 2: Waste to energy- The greenhouse gases and their source categories include municipal solid waste (non-compostable portion of organic waste), domestic sewage and waste water. There are no estimates of emissions from this sector at the state level. Broad strategies and actions are covered as part of task force on sustainable habitat. Some of the options to reduce emissions from this sector include secure landfills, composting plants, and waste to energy projects. Capacity building of local bodies and municipalities for this purpose would be required.

Action 3: The total energy saving potential in Rajasthan is 4.542 BU representing 16% of the annual energy sold. A detailed assessment and technical study on various means that could be adapted in present technologies is required. The energy efficiency potential is high in commercial buildings and SME sector.

Action 4: Energy conservation buildings code to be adapted for the state. Rajasthan government is already working in this direction with a draft of buildings code prepared. The draft presents an integrated approach towards adoption of energy efficiency measures, renewable energy applications, and water harvesting. However, measures to effectively implement the building code should be ensured. Some of the details are discussed in the Task force for sustainable habitat.

Action 5: Creation of 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.

Action 6: Bureau of Investment Promotion (BIP) through Investment incentive policy 2003 was set up as a single point window with the objective to promote Rajasthan as an attractive investment destination to provide all investment related information to medium and large scale industries and ensure quick resolution of their problems. It also provides complete back-up support, right from conceptualization of projects to their implementation. This could include essential criteria of using efficient technologies and also subsidized for renewable energy applications.

Action 7: Capacity building of the municipal bodies and other local bodies need to be built for planning and implementation energy efficiency means.

Key Strategy 3: Reduction of transmission and distribution losses

Action 1: The state observes high transmission & distribution losses which have shown a decline in the recent years. As the Rajasthan Discoms are promoting the use of Compact

Fluorescent Lamps (CFLs) for street and domestic lighting; energy efficiency pump sets; providing tariff concession on solar water heaters; minimizing distribution losses; using new and efficient technologies like super critical boiler technology and integrated gasification combined cycle for thermal power projects. Further, distribution losses should be brought down by taking up improvements which are area specific. All sub stations should be modernized automated and instrumented to improve quality and minimize unaccounted energy losses. There is a need to strengthen the ongoing programs and policies which would not only address the developmental objectives of the state but also climate change mitigation.

Key Strategy 4: Integrated industrial policy

Action 1: RIICO develops industrial areas and provides infrastructure facilities to industrial units. It also provides rebates and incentives for development of small medium and large scale units in the state. It further provides financial, technical and managerial assistance to entrepreneurs. It is presently undertaking establishment of eight industrial growth centers with the assistance of central government at Sirohi, Bikaner, Dholpur, Nagaur, Jhalawar. Besides these there are many mini growth centres. Special parks including agro food parks in Kota, Jodhpur, Sriganganagr, and Alwar; Japanese park at Neemrana- alwar; Stone Park at Dholpur and Integrated textile parks are being developed. Given the employment opportunities that will be created in these clusters, it is pertinent that urban agglomeration would develop around these clusters in the due course of time. Therefore, the integrated industrial plan should also provide for urban planning including landscape, buildings, and transport.

Action 2: Industrial Shivirs are being organised at Districts and panchayat smiti levels to promote industrial development and to make people aware about the rules relating to establishment of industrial units. Besides this, work relating to registration of industrial units, preparing loan applications and releasing sanctions is also done in these shivirs. During the year 2009-10 upto December 2009, 27 shivirs at district level and 204 at panchayat samiti level have been organised against the respective targets of 34 and 245. This shivirs could further be extended to build capacities of the industrial sector.

Rajasthan Action Plan on Climate Change (Draft)

Key Priorities and Actions identified for Enhanced Energy Efficiency and Renewable Energy

(Refer to Chapter 10 in the RAPCC Draft Report for Details)

Key Strategy	Action	Time-frame (ST, MT, LT)[47]	Physical Target/ Scope	Financial Requirement
1	Harnessing full renewable energy potential of the state			
	Detailed biomass assessment study and forecasting for preparing an integrated plan for biomass dealing with production, transportation, distribution, regulation, and monitoring, etc.	ST	RREC has already issued an order on 25 Jan 2011 for biomass fuel studies in Rajasthan	-
	Demonstrate well designed prototypes of renewable energy technology systems for various applications such as SPV domestic lighting system, street lighting system, solar pump sets, solar stills, biomass gasifiers to enable communities to understand the technology and also for policy makers to conduct reliable economic evaluation	ST	Policy document will be prepared as per requirement	Not finalized
	Technical assessment of potential sites that will be suitable for large scale wind and solar farms and synergising it with the available land resources, existence of investors to help the state to fulfill its renewable purchase obligations	ST	MNRE and RREC have conducted wind resource assessments to harness wind energy in the state. many private developers are also carrying out similar assessments to develop largescale wind farms. Recently MNRE under the National Solar Mission has initiated Solar Radiation Resource Assessment at high potential sites for solar power generation under which 12 sites in the	Private investment/ MNRE support

[47] ST: Short Term (2012-2017), MT: Mid-term (2017-2022), LT: Long-term (2022 and beyond)

Key Strategy	Action	Time-frame (ST, MT, LT)[47]	Physical Target/ Scope	Financial Requirement
			state have been approved.	
	Creation of solar centre of excellence which would enable applied research and commercialisation of nascent technologies in case of solar. The new draft Solar Policy provides for such initiative.	ST	The State Government has issued Solar Energy Policy 2011 which provides for creation of solar centres of excellence which would work towards applied research and commercialization of nascent technologies to accelerate the march to grid parity (1 year)	Not finalized
	Creation of Rajasthan renewable energy infrastructure development fund for accelerated development of solar and other renewable energy systems in Rajasthan. The resources shall be collected in the form of development charges by the solar power producers.	ST	The solar energy policy supports creation of the Rajasthan Renewable Energy Infrastructure Development Fund for accelerated development of solar/ renewable energy in the state. The resources will be arranged from the solar power producers as development charges.	Not finalized.
	Development of indigenous and cost effective solar technology in the state to enable harnessing full potential and also reach grid parity in the next 6-7 years.	ST	Solar Energy policy 2011 supports to establish technology manufacturing plants to achieve cost reduction and grid parity in the next 7-8 years.	Private investment
	The solar policy and other instruments should also provide fiscal incentives to promote setting up of manufacturing units in state. Conducting training programs to create skilled and semi-skilled man power.	ST	The Solar Policy 2011 provides to set up development of solar parks in the state. A special purpose vehicle in terms of a subsidiary company of RREC will be established for development of infrastructure and management of the solar park. The State will evolve a separate package of additional fiscal incentives for solar based industries in solar parks in consultation with the	Not finalized

Key Strategy	Action	Time-frame (ST, MT, LT)[47]	Physical Target/ Scope	Financial Requirement
			finance and industries department.	
	Launch a comprehensive programme for both rural and urban set-up. Efficient biomass gasification based cooking systems, solar based lighting solutions, solar based irrigation pumps, desalination systems could be launched or reinitiated (as in case of biogas and biomass) in the state. For urban areas, task force on sustainable habitats elaborates on some options including buildings and transport.		Policy document will be prepared as per requirement	Not finalized
	Since the state is coming up with new clusters and growth centers which are essential for the progress of the state, it is important proper planning is done in terms of landscape planning, utilization of renewable energy applications as applicable, energy efficient technologies amongst other		Policy document will be prepared as per requirement	Not finalized
2	Demand side measures including energy efficiency			
	Study the impacts of climate change on the State's energy systems	ST	Following studies may be conducted in the short term: Studies of the increment in peak demands during summers and winters To formulate different schemes/ policies for the promotion of ECB directives and usage of solar water heating systems Schemes/ policies for use of SWH and for adaptation of ECB directives should be market-	Rs 20 lakhs

Key Strategy	Action	Time-frame (ST, MT, LT)[47]	Physical Target/ Scope	Financial Requirement
			linked and not in the form of subsidies. These studies maybe followed by others to see the energy efficiency	
	Convert waste to energy- municipal solid waste (non-compostable portion of organic waste), domestic sewage and waste water. Broad strategies and actions are covered as part of task force on sustainable habitat. Capacity building of local bodies and municipalities for this purpose would be required.		To consult industries department	
	A detailed assessment and technical study on various means that could be adapted in present technologies is required. The energy efficiency potential is high in commercial buildings and SME sector	ST	Need for detailed assessment on various means that can be adapted in present technologies. There is also a need of formulating mechanisms to incentivize the usage of energy efficient measures in commercial buildings and SME sector	Rs 500 lakhs
	Energy conservation buildings code to be adapted for the State. Rajasthan government is already working in this direction with a draft of buildings code prepared.		ECBC has been amended by the state as per the climatic conditions and notified on 28th March in the form of Directives. This would be effective after six months. There is a need for capacity building of different stakeholders for ensuring compliance with these directives.	
	Creation of 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.	ST	As per the Energy Conservation Act 2001 the State Government has constituted Rajasthan Energy Conservation Fund for energy conservation activities. Apart from contributions from BEE, State Government, RRECL and	Rs 50 lakhs

Key Strategy	Action	Time-frame (ST, MT, LT)[47]	Physical Target/ Scope	Financial Requirement
			Discoms have contributed to this fund. There is a need to strengthen the Energy Conservation Cell at RRECL and a consultant should be hired to assist RRECL in formulating different schemes, planning, preparation of demonstration projects to showcase the impacts of energy efficiency measures. It requires link from the fund already generated by cess on unit energy consumption.	
	Bureau of Investment Promotion (BIP) through Investment incentive policy 2003 was set up as a single point window with the objective to promote Rajasthan as an attractive investment destination to provide all investment related information to medium and large scale industries and ensure quick resolution of their problems. It also provides complete back-up support, right from conceptualization of projects to their implementation. This could include essential criteria of using efficient technologies and also subsidized for renewable energy applications.		Not pertaining to energy department	
	Capacity building of the municipal bodies and other local bodies need to be built for planning and implementation energy efficiency means		A notification for public street lighting has already been issued on 1 July 2010. Compliance is to be ensured. As these systems are being maintained by Municipal and Local Bodies, capacity building is to be stressed. The same is also being considered in Annual Energy Conservation Action Plan of RRECL	Rs 25 lakhs

Key Strategy	Action	Time-frame (ST, MT, LT)[47]	Physical Target/ Scope	Financial Requirement
3	Reduction of transmission and distribution losses			
	All sub stations should be modernized automated and instrumented to improve quality and minimize unaccounted energy losses.		New technologies have already been introduced.	
4	Integrated industrial policy			
	RIICO develops industrial areas and provides infrastructure facilities to industrial units. Given the employment opportunities that will be created in these clusters, it is pertinent that urban agglomeration would develop around these clusters in the due course of time. Therefore, the integrated industrial plan should also provide for urban planning including landscape, buildings, and transport.			
	Expanding industrial shivirs to build capacities of the industrial sector.			

Chapter 11: Urban Governance and Sustainable Habitat

11.1 Background

Rajasthan recorded a decadal population growth rate of 28.41 percent during 1991-2001, which is highest in the country. As per the 11th Five Year Plan for Rajasthan, the high rate of population growth can be mostly attributed to the high growth potential inbuilt in the existing age structure. High population growth rates together with high poverty levels can increase the pressure on natural and socio-economic resources in turn contributing significantly to high sensitivity to climate change impacts.

Apart from this, Rajasthan has shown a high decadal urban population growth rate of 31% during 1991-2001. According to 2001 census, there has been a large scale migration of population from rural areas and smaller towns to bigger towns and cities of the state. Rapid urbanization has increased the demand of and put tremendous strain on urban resources, services and infrastructure. Currently the share of urban population in Rajasthan in Rajasthan is 23.3% which is housed in 222 cities/towns out of which Jaipur and Jodhpur are two of the million plus cities in India (Brinkoff) . Apart from Jaipur and Jodhpur, cities like Kota, Bikaner, Ajmer, Udaipur, Bhilwara, Alwar, Bharatpur, Sri Ganganagar, Pali are some of the most populous cities in Rajasthan. The urban population in Rajasthan is likely to grow to about 26.1% in 2020 (Census, 2001) owing to migration and other infrastructure development projects being undertaken by the Govt. of Rajasthan.

11.2 Current Vulnerability

The major climate related vulnerabilities for the state of Rajasthan (as identified in the climate variability section) are:

- Rise in overall temperatures
- Reduction in mean annual rainfall
- Increase in frequency and intensity of extreme events, including droughts and floods

The vulnerabilities mentioned above have associated impacts, like rise in overall temperature can lead to increased discomfort levels resulting in high cost for mechanical cooling and ventilation. Reduction in mean annual rainfall can be responsible for drinking water shortage, drought situations, failure of crops and food insecurity situation. Extreme rainfall/floods come with an array of problems like water logging, destruction of settlements around water bodies, spread of water borne diseases, etc. Most of the above mentioned impacts are to the built environment, habitats and communities.

11.3 National Urban Policy Scenario

The urban policy making environment in India is leaning towards sustainable development. The introduction of national policies/schemes like JNNURM and the National Mission on Sustainable Habitats provide policy support and guidance in terms of encouraging action for various sectors like sustainable habitats, water supply, sanitation, solid waste management, transport, urban planning and urban governance leading to sustainable development. Some of these actions are:

1. Building sector- Water management, energy demand management and energy efficiency & conservation measures
2. Municipal solid waste management- adopting an integrated municipal solid waste management plan to enhance energy security
3. Urban transport- integrated land use and transport planning, modal shift from private to public mode of transport, use of non-motorized transport, improved fuel efficiency, travel demand management, etc.
4. Urban planning- implementing smart growth principles like, redensification, mixed use zones, etc, increasing green cover by land use control, restricting urban sprawl, adopting model energy efficiency by-laws for buildings, land use control/regulation.

Whereas the above mentioned actions lead to sustainable urban development, which in turn improves the quality of life of the urban citizens, some of these actions (integrated municipal solid waste management, integrated land use and transport planning, mixed use) also have tremendous potential to reduce GHG emissions and achieve mitigation co-benefits. Further, financial support from the international mechanisms such as CDM could benefit effective implementation of these projects

Thus, the current national urban policies/programs provide an inherent boost to climate response actions.

11.4 Policy Review

Although there is no specific policy targeting climate change risk reduction/ adaptation or mitigation for urban areas in the state of Rajasthan, various polices exist that have indirect implications at least at the level of reducing vulnerability of specific sectors and population. For example, the State has taken up many initiatives like setting up of urban infrastructure development scheme, increasing the number of transport facilities, augmenting the urban transport system with the introduction of BRTs, CNG using vehicles, MRTS are some of plans that would have significant impacts on the overall urban scenario of the state.

In the state of Rajasthan, the Department of Urban Development, Housing and Local Self Government is entrusted with the responsibility of formulating plans/policies/schemes/programs for matters related to urban development and governance. Thus, in order to understand the existing environment in terms of policy making related to urban adaptation and mitigation action, some of the major policies formulated by the said department are discussed below:

Ongoing Government Programs/ Initiatives	Key Objectives/Goals	Salient components/strategies/activities	Implementing agencies in the State (Nodal and supporting)
Affordable Housing Policy 2009	• To reduce the housing shortage in the State, especially in EWS/LIG categories • To take up large scale construction of Affordable Housing (with focus on EWS/LIG housing) • To bring down the cost of EWS and LIG categories of houses to affordable limits. • To promote investments in housing in Urban Sector on PPP Model. • To involve Private developers in the construction of EWS/LIG categories of houses by offering various attractive incentives. • To create Rental Housing as transit accommodation for migrants to urban areas, and • To check creation of slums	The policy framework and built in incentives are used to motivate agencies and the existing central government policies are dovetailed to achieve efficient utilization. The policy document mandates earmarking of plots/houses for EWS/LIG category in the following models: 1. Mandatory provision (Rajasthan housing board, urban local bodies and developers) 2. Private developers on land owned by them 3. Private developers on acquired land 4. Private developers on Government land (For rental housing or outright sale basis) 5. Slum housing (schemes approved by GoI and 'Mumbai Model' of slum redevelopment)	Nodal Agency- AVAS VIKAS Limited Supporting Agency- • State Government • Rajasthan Housing Board • Urban Local Bodies
Rajasthan Urban Infrastructure Development Project (RUIDP)	• Providing sustainable urban infrastructure and services for economic and tourism growth and better quality of life to the urban population.	The vision to be achieved through policy reforms to strengthen urban management and support for priority investments in urban infrastructure and services required to meet basic human needs, improve quality of life, and simulate sustainable economic development. RUIDP will (i) redress immediate infrastructure and service deficiencies to meet basic service delivery norms, (ii) act as a medium through which policy reforms are effectively executed, and (iii) provide maximum demonstration effect for replication in other cities of the State.	Nodal Agency- Local Self Government Department of Government of Rajasthan
Rajasthan Township Policy (above 10 hectares) and	• The policy promotes planned/integrated development of various towns by providing basic infrastructure facilities and	• Technical and financial parameters Development Control regulations and planning considerations	Nodal Agency- Department of Urban Development & Local Self Government,

Ongoing Government Programs/ Initiatives	Key Objectives/Goals	Salient components/strategies/activities	Implementing agencies in the State (Nodal and supporting)
Policy for Residential, Group Housing and other schemes in the private sector (upto 10 hectares).	safeguards the interest of the public at large by ensuring availability of residential plots/houses at affordable prices.		Govt. of Rajasthan.
Slum Development Policy (Under PPP)	• The policy essentially aims at involving the private sector for redevelopment/improvement of slum areas as an add on to the efforts already underway by the urban local bodies.	• Constitute an Empowered Committee for speedy and transparent approach.	Nodal Agency- Department of Urban Development & Local Self Government, Govt. of Rajasthan.

11.5 Gaps to be addressed

The above mentioned policies focus on sustainable urban development, while augmenting/facilitating the development planning environment in urban Rajasthan. However, none of the policies of the Department of Urban Development and Local Self Government address adaptation measures in terms of climate change directly. Wherever present, the policy guidelines only provide for conservation actions in terms of guidelines for conserving open space/agricultural land/existing bio-diversity and encourage an increase in the green foot print by mandating plantation. These can be termed as preliminary action to deepen the climate change agenda further.

Hence, there is a need and a potential to either align/amend the existing policies to address these impacts and/or simultaneously formulate separate policies to focus on critical sectors like urban water supply, transport, storm water drainage, etc.

Below are urban sector strategies in terms of adaptation actions for the state of Rajasthan addressing specific vulnerabilities identified above.

11.6 Climate actions and strategies

For each of the Strategy and Action points, certain financial estimates have been provided. However these need to be finalized by the Department of Urban Development in discussion with the concerned departments[48].

Key Strategy 1- Integrate Climate Risks and Responses into Urban Planning/Development Processes

Integrate risks associated to Climate Change to reap long term benefits of strategies that directly impact climate change and impacts thereof, it is pertinent to integrate efforts to mitigate climate risks into the urban planning/development process. This would include having climate proofing objectives and measures to be integrated in the development plans of all the cities.

Capacity building of municipal officials/office bearers is an inherent component of each action point. In order to take responsive action towards climate change, it is vital that the decision makers and implementing agencies are aware of the existing risks and impacts on various urban sectors.

Action 1- Preparation of Resilience Plan for each city in light of existing vulnerabilities (rise in annual temperature, reduction in mean annual rainfall, increase in frequency and intensity of extreme events i.e. floods and droughts) and incorporating the same in City Development

The cities in the state of Rajasthan vary immensely in their climate related vulnerabilities like Jaipur, Udaipur, Jodhpur, Bundi, etc are prone to floods[49], cities like Jaisalmer, Bikaner, etc are drought prone cities, and there are some cities that are prone to both drought and

[48] Written comments and suggestions were received only from the Urban Development department and the Department of Disaster Management and Relief and have been incorporated.
[49] Flood Manual prepared by Disaster Management and Relief Department, Govt. of Rajasthan

floods eg: Barmer. Hence, there is an urgent requirement to prepare a City Resilience Plan that would address city specific vulnerabilities.

Under the City Resilience Plan, a City Advisory Committee (CAC) consisting of representatives from the municipal government, academia, the private sector, civil society, and the public can be formed. Vulnerability to climate change impacts for each city can be analyzed under basic sectors like Environment, Flood Risk Management, Water Security, etc to suggest a range of interventions and adaptation options as per climate risks to the city and its inhabitants.

The strategies suggested in the resilience plan can be an integral part and also guide the City Development Plan for the particular city. An example of the Surat Resilience Strategy is provided to give an idea of the possible outcome of the proposed strategy (Box 1).

Sectors	Resilience Options/Interventions
Natural Disasters	▪ Climate Watch Group ▪ End-to-End Early Warning System ▪ Multi-Hazard Emergency Response Plan ▪ Hazard Risk Zonation and Zoning Ordinance ▪ Flood reduction infrastructure
Urban Health	▪ Disease surveillance and epidemiological research ▪ Health GIS ▪ Improved Vector control system ▪ Literacy development on Climate Change and Health Risks
Water Resources	▪ Water resources and supply management plan informed by CVCC. This includes - Water supply monitoring system - CVCC informed resource assessment - Technology options (including reuse and desalination) - Demand side management - Water conservation options - Hardening and design of resilient infrastructure to withstand sea level rise, floods - Emergency supply management - Reduction of leaks programme - Awareness Programme
Population	▪ Skill building Programme (HRD plan) ▪ Certification Programme ▪ Monitoring programme on migration, Need Assessment
Environment	▪ Integrated Public Transport System ▪ Traffic Management Plan
Economy	▪ Loss Minimization Studies ▪ Business Continuity Plan ▪ Development of health support systems for industrial workers ▪ Managed retreat of industries and high value infrastructure (from high risk to low risk zones)
Social/equity	▪ Disaster resilient and energy efficient housing for poor ▪ Awareness generation and social action ▪ Preventive action (to reduce conflicts)
Technology	▪ Energy efficiency improvement programmes ▪ Clean and sunrise industry/service sector

Box 1: City Resilience Strategy for the city of Surat (The Rockefeller Foundation)

Cost Implications[50]**-** The total cost implication for the strategy per city is estimated to be Rs. 75 lac. For conducting city risk assessment for climate change (using high-end modelling studies) - Rs. 40 lac. For integrating the risk mitigation strategies into the city level plans and policy (stakeholder consultations, policy analysis) - Rs. 35 lac.

These targets need to be finalized by the UDH and State Meteorology department.

Action 2- Restrict/control land use in areas prone to flash flood in light of increase in frequency and intensity of extreme rainfall

Extreme rainfall can cause flash flooding leading to loss of life and property. This can be avoided by strategically designating /restricting land uses in flood plains of major rivers. In order to identify land uses around risk prone areas, the Jaipur Master Plan delineates a step-by-step process:

- geo-environmental assessment that identifies eco-sensitive areas
- investigation, identification and delineation of environmental geohazards
- identification of land uses around each depending upon the geofactors based land capability

Thus, suitable land uses in older/younger flood plains identified by the above process are:

- Older flood plains- agriculture activity, farm houses, poultry and animal husbandry/agro-products and food technology and packaging industries. Encourage optimum exploitation of ground water.
- Younger flood plain, including present channel, terraces- ecological reserves, open spaces/parks for ground water recharge.

The following step-by-step process should be followed in other flood prone cities like, Jaipur, Jhalawar, Udaipur, Bundi, etc. Apart from this, the above mentioned land use regulations should be put in action urgently along the following flood prone areas identified by the Disaster Management and Relief Department of Govt. of Rajasthan.

S.No.	Name of Basin	Name of Sub-Basin	Name of District with Important Towns/Villages	
1	2	3	4	
1	Luni	Luni	Ajmer Barmer Jalore	Ajmer City Balotra, Sindri, Guda Chitalwana, Bhawatra
1A	Luni	Luni	Jodhpur	Bilada
2.	Luni	Luni	Jodhpur	Kakelav, Kankani, Dudiya
3.	Luni	Jojari	Jodhpur	Benar, Barilya, Kalyanpura
4.	Luni	Bhundh Hemawas	Pali	Pali City, Kharchi, Gurwara,
5.	Luni	Sukri	Pali Jalore	Rani, Chanod Rama, Bhavrani, Debawas
6.	Luni	Jawai	Jalore	Ahore, Jalore
7.	Luni	Bandi	Sirohi Jalore	Pandiv, Jdwal Siynna, Bagra
8.	Luni	Sngi	Jalore	Jaswatpura, Nimbawas

[50] Cost calculations for all action points are indicative only

9.	Sukli	Sukli	Sirohi	Karaunti
10.	West Banas	West Banas	Sirohi	Abu Road
11.	Banas	Banas	Udaipur	Udaipur City
12.	Banas	Berach	Chittorgarh	Chittorgarh City, Sambhupura
13.	Banas	Banas	Bundi	Khatoli, Tonk-Uniara
14.	Banas	Morel	Jaipur	Jaipur, Sanganer
15	Banas	Mashi	Jaipur	Bichun
16.	Mahi	Som	Udaipur	Chillyand
17.	Mahi	Som	Udaipur	Jhadol
18.	Chambal	Mej	Bundi	Bundi City
19.	Chambal	Chambal	Kota	Kota City
20.	Chambal	Chambal	Kota	Kathun
21.	Chambal	Kali Sindh	Kota	Khajuri
22.	Chambal	Kali Sindh	Kota	Sangod
23.	Chambal	Kali Sindh	Jhalawar	Jhalawar City
24.	Chambal	Kali Sindh	Jhalawar	Richwa
25.	Chambal	Parwan	Jhalawar	Manohar Thana
26.	Chambal	Parwati	Baran	Chhabra, Baran, Karaiahat
27.	Chambal	Parwati	Baran	Baran Town
28.	Banganga	Banganga	Bharatpur	Kaman, Pahi, Bharatpur, Deeg, Bayana, Roopwas
29.	Sabi	Sabi	Alwar	Kotkasim, Tapukra, Patiabad
30.	Shekhawadati	Mehdha	Nagaur	Kuchaman
31.	Ghaggar	Ghaggar	Sriganganagar	Hanumangarh, Pilibanga, Suratgarh, Jetsar, Srivijaynagar

The city of Jaipur has further adopted Development Promotion/Control Regulations MDP-2025 in order to promote and regulate development controls for buildings in accordance with the development policies and land use proposals contained in the Master Plan. This too can be adopted by other cities as an enforcement/implementation tool.

Cost Implications- Cost for carrying out various assessments using GIS and other packages = Rs. 15 lac/city

These estimates need to be finalized by the UDH and Disaster Management and Relief department.

Key Strategy 2- Promote Sustainable Urban Transportation

The National Urban Transport Policy (NUTP) and National Mission on Sustainable Habitats (NMSH) introduces the concepts of sustainable urban transport such as *moving people rather than vehicle, integrating land use and urban transportation, prioritizing non motorized transportation (NMT), optimizing the existing road/public transport infrastructure, promoting travel demand management (parking fees, congestion fees, etc) techniques, etc* have gained impetus. All these measures will essentially lead to increased modal share of public transportation and reduced per capita vehicle miles travelled (VMT). While these measures, largely address congestion, they may lead to significant mitigation benefits and also many ancillary benefits of such measures in terms of reduced local air pollution, positive health impacts on the urban population and better quality of life.

Action 1- Preparation of Comprehensive Mobility Plans (CMPs) for all Major Cities (population > 1 lac) in Rajasthan

City Mobility Plan has been prepared for Jaipur and Jodhpur while for Kota preparation of the CMP has been initiated. Jaipur in Rajasthan has already initiated implementation by preparing a comprehensive mobility plan. This has resulted in preparation of an exhaustive transportation profile of the city including status of transport infrastructure, existing issues, future growth characteristics of the city and phase wise targets/projects identified to promote sustainable transportation.

This has been a fruitful exercise in terms of collecting critical data, getting a clear picture of the existing issues and making specific informed recommendations. This effort needs to be replicated in all major cities of Rajasthan to guide specific action towards sustainable transportation in respective cities.

Although the process to prepare a CMP has been established and followed by many cities, certain improvements in the same can render the process more effective like:

- Stakeholder consultations with different groups like (students, corporate sector) can help integrate their needs while proposing projects.
- Address issues like equity (public transport fare), accessibility (IPT), safety for vulnerable groups like senior citizens, differently abled, women, etc.
- Identify spaces for establishing a link between the master plan and CMP document for effective implementation of recommendations emerging out of the CMP.

Thus, while preparing CMPs for other major cities, the above mentioned points should be addressed.

Cost Implications- Cost for preparing a CMP including various transport modelling exercises, surveys, data collection (passenger, freight), and a comprehensive stakeholder consultation is Rs. 95 lac/city

These targets need to be finalized by the UDH and Department for Local Bodies.

Action 2- Increase Modal Share of Public/Non Motorized Transportation

Vehicle ownership in large cities like Jaipur is increasing with an increase in the socio-economic status of the urban population, leading to increase in degradation of environment leading to negative health impacts.

As the other medium/small towns in Rajasthan leap towards rapid urbanization, this is an appropriate time to introduce measures for encouraging modal share of public/non motorized transportation in these cities. This would require a multi-pronged approach by urban local bodies as described below:

- The ULBs can begin with implementing the service level benchmarks developed by MoUD, especially those pertaining to public/non-motorized transportation.
- Put in place an education and social marketing-behaviour change campaign- to educate and urge the urban population to take public transport.
- Introduce incentives for public transport like, of-peak discount, corporate discount schemes on bus fare, etc.

- Improve the public/non motorized transport options (quality, comfort, frequency, affordability) and alternative point to point mobility options.
- Enforce stricter parking fee structures.

Cost Implications- Policy measure

These targets need to be finalized by the UDH and Department for Local Bodies.

Key Strategy 3- Improvement in Urban Infrastructure

Action 1- Urban Storm water Drainage Infrastructure Improvement in light of increase in frequency and intensity of extreme rainfall

Just like any other recently urbanized region in India, Rajasthan too is characterized by inadequate basic services. Most of the cities in the state of Rajasthan are devoid of storm water drains. This heightens the risks related to water logging and spread of water born diseases during incidents of extreme rainfall.

Thus, as a basic premise for addressing these risks, there is a need to improve the storm water drainage infrastructure in the urban centres, especially the flood prone areas in the state of Rajasthan.

Storm water drainage improvement projects are already underway in some of the big cities like Jaipur and Ajmer-Pushkar under the UIG (Urban Infrastructure and Governance) component of JNNURM. Similar works are also being carried out in Bharatpur, Jaisalmer, and Sikar under the RUDIP (Rajasthan Urban Sector Development Investment Program) and Bundi, Mangalore, Mt. Abu, Pratapgarh, Ramgangj Mandi, and Sangria under UIDSSMT (Urban Infrastructure Development Scheme for Small and Medium Towns). Thus, infrastructure with respect to storm water drainage in Rajasthan is expected to improve in the coming years in the program cities/towns.

However, there are other smaller cities and urban villages like Jhalawar and Kisangarh in Jhalawar and Ajmer districts respectively that receive heavy rainfall which are not included in any of the above mentioned programs and are prone to floods and hence the following should be taken up for these cities/towns on urgent basis:

- Development of a comprehensive drainage master plan (including background studies, phasing of projects, operation and maintenance arrangement, funding , etc)
- Construction of roadside and outfall drains in order to carry the storm water. Design of the system should be such that the storm water is fed into natural channels or ground water recharging areas.
- Provision of equipments for maintenance of drains.

Successful models emerging out of the above mentioned programs i.e. JnNURM, UIDSSMT and RUSDIP can be studied and the same can be scaled up.

Cost Implications-

The cost of construction of drainage network can be estimated to be Rs. 179 lac/km

Calculation- Figures are taken from RUIDP phase II

Length of Storm Water Drainage (km)	Total Cost (Rs.)	Cost/km (Rs/km)
2	37900000	18950000

4.09	53400000	13056235
3.95	85700000	21696203
	Average cost/km	17900812

These targets need to be finalized by the UDH and Department for Local Bodies.

Key Strategy 4- Strengthen Disaster Preparedness at Local Level

Action 1- Flood Preparedness and Management Plan at Local Level.

The Disaster Management and Relief Department, Govt. of Rajasthan has already prepared a State Disaster Management Policy and Disaster Management Rules as mandated nationally.

The Department has also prepared information Manuals and Guidelines which are hosted on the department's website i.e. http://www.rajrelief.nic.in/. The website also contains maps of hazard prone areas.

Following this, all the districts have also prepared District Disaster Management Plans. Whereas, these plans are rather comprehensive, it is suggested the Plans incorporate the following:

Local level Plans- Hazard risk mapping for areas prone to extreme rainfall and climate modelling analysis studies should be carried out at the local level (ward/zone) for each flood prone city/town. Relevant technical capacities should be developed and state-of-art equipment acquired. Apart from this, local authorities should perform constant monitoring of the seasonal rainfall to predict/forecast any disaster like situation. This disaster management plan should be formulated by the local administration through stakeholder consultations. This plan can be characterized by the following:

1. Community participation- An effort should be made to incorporate communities residing in the flood prone areas in the disaster preparedness and management plan. An IEC (Information Education Communication) campaign in order to educate the communities about the risks of extreme rainfall, and basic good practices to avoid spread of water borne diseases in case of water logging for elongated periods should be undertaken. Local communities could also be trained in monitoring water levels in the river to enable them to prepare for probable disasters. An evacuation plan should be prepared in consultation with the community and be publicized in the regional language. Maps showing low lying areas and high ground points in an easily readable format should be made available to the communities.
2. Implementation- Citizen Committees at ward/zonal level should be formed who would be responsible for spreading awareness about the local preparedness and mitigation plan, as well as for coordinating the implementation of the plan with the local authorities.

Cost Implications- Policy measure

These targets need to be finalized by the UDH and Disaster Management & Relief department.

Key Strategy 5- Regulatory Reforms

Action 1- Strict enforcement of Rainwater Harvesting directive in the light of reduction in mean annual rainfall in some areas

Under JNNURM, the State has made rainwater harvesting mandatory for all public establishments and all properties in plots covering more than 500 sq m in urban areas. This requirement has been linked with provision of water supply connection. However, only Jaipur has been instrumental in streamlining this reform at the local level. The same should be extended to all the cities in the state of Rajasthan, in order to ensure effective implementation. The Urban Development Department has already prepared Building bye-laws for all the local bodies wherein it has been made mandatory to make provisions for rainwater harvesting in plots of 300 sq. Metre of more. Additionally, amendments have also been made in the Jaipur Development Authority Act making it mandatory to construct RWH structures in plots of 300 sq. Metre or more. Stringent penalties should be levied and incentives should be introduced for ensuring implementation, like:

- In case the deadlines for RWH are not made, the local authority (PHED) to provide the structure and recover the cost from the owner in a manner similar to Property Tax
- Prizes to be given to students who motivate their parents to implement RWH and to schools, teachers who implement RWH

Cost Implications- Policy initiative

These targets need to be finalized by the UDH and Public Health Engineering Department.

Action 2- Reuse of Waste water

The condition of water supply in Rajasthan is not satisfactory due to scarcity of water channels as well as low rainfall. Only 23 out of 222 towns get more than 100 litres per capita of daily water supply against the desired standard of 135 lpcd. 40 percent towns have below 60 lpcd supply and 30 percent have water supply between 81-100 lpcd[51].

As apparent, there are huge deficits in supply. Also, according to latest ground water assessment report (March 2004) in 21 districts there is already overexploitation i,.e. withdrawal is more than the annual recharge. In another 5 districts the situation is critical because the annual exploitation of ground water is more than 90% of annual recharge.

In light of the above, there is a need to mandate reuse of waste water by all the ULBs in the state of Rajasthan.

Mandating reuse of waste water by all ULBs would result in use of recycled water for non-potable purposes and reduce the stress on ground water resources for drinking water supply.

Cost Implication- Policy measure

These targets need to be finalized by the UDH and Department for Local Bodies.

Action 3- Calculation of water footprint, linking with tax rebates for business owners and individuals

State can encourage large business owners/corporate and individuals to calculate their water footprint. Just like carbon, water footprint can also be calculated by developing a tool using a fixed set of variables for business owners and individuals like water usage in kitchen, bath, gardening, etc. This tool can also calculate possible reduction in the water

[51] PHED Rajasthan

footprint by employing certain basic water conservation principles. Well documented and result-oriented good practices can be eligible for a tax rebate program.

Cost Implication- Cost of designing the software/tool = Rs. 10 lac and an additional cost of Rs. 10,000/month to host the tool on a website.

These targets need to be finalized by the UDH and Public Health Engineering Department.

Action 4- Promoting Green Buildings

Rajasthan is one of the pioneer states to modify the Energy Conservation and Building Code (ECBC) in order to suite specific climate characteristics and risks associated to the state. Efforts to ensure effective state-wide implementation of the same should be undertaken like, the State Town and Country Planning Organization (TCPO) could take up the task to enable use of indigenous planning methods, building materials and building technologies to promote green construction and introduce planning practices specific to climatic conditions of area in question, stringent fines/penalties could be levied, tax rebates/incentives can also be introduced. Provisions in the Building bye-laws for Green buildings construction are also being considered for introduction soon. As a step towards this, instructions have already been issued to government departments to minimise the use of glasses in the new buildings to be constructed.

Apart from this, training of professionals/technicians (architects, builders, developers, engineers) with respect to energy efficiency/conservation practices can also aid in efficient implementation of the ECBC.

Cost Implication- Policy measure - additional cost of training professionals/printing manuals, etc

Inputs from UDH and Department of Energy required to finalise these targets

Key Priorities and Actions identified for Urban Governance and Sustainable Habitat

Key Strategy	Action	Time-frame (ST, MT, LT)[52]	Physical Target/ Scope	Financial Requirement
1	Integrate Climate Risks and Responses into Urban Planning/Development Processes			
	Preparation of Resilience Plan for each city in light of existing vulnerabilities (rise in annual temperature, reduction in mean annual rainfall, increase in frequency and intensity of extreme events i.e. floods and droughts)	LT	To be taken up by respective local bodies in overall guidance from LSG/ UDH departments with necessary advise from Disaster Management and Relief department*	Needs to be further discussed with the relevant departments
	Restrict/control land use in areas prone to flash flood in light of increase in frequency and intensity of extreme rainfall	MT	Master Plans already consider flood-prone regions, however these can be strengthened further with respect to flash floods, increase in frequency and intensity etc. once specialized reports for vulnerable cities is made available.	
2	Promote Sustainable Transportation[53]			
	Preparation of Comprehensive Mobility Plans (CMPs) for all Major Cities (population > 1 lac) in Rajasthan	MT	Draft Parking policy is in the process for all towns to encourage public transportation. CMPs have been prepared for Jaipur and Jodhpur and for Kota it is underway. For remaining towns with population more than 1 lakh (17) CMPs can be prepared*	
	Increase Modal Share of Public/Non Motorized Transportation	LT	Policy measures can be taken up in due course*	

[52] ST: Short Term (2012-2017), MT: Mid-term (2017-2022), LT: Long-term (2022 and beyond)
*Financial estimate inputs to be taken from UDH and identified departments for specific strategies
[53] Inputs from Department of Local Bodies to be incorporated

Key Strategy	Action	Time-frame (ST, MT, LT)[52]	Physical Target/ Scope	Financial Requirement
3	Improvement in Urban Infrastructure[54]			
	Urban Storm water Drainage Infrastructure Improvement in light of increase in frequency and intensity of extreme rainfall	LT	This will require a large physical investment programme thus requiring detailed preparation for target identification.	
4	Strengthen Disaster Preparedness at Local Level			
	Flood Preparedness and Management Plan at Local Level.		Preparation of the State Disaster Management Plan is already being undertaken by the Disaster Management & Relief department, followed by preparation of disaster-wise and department-wise and area-wise plans. Education, training and awareness generation programmes are being taken up on priority. *	A seed amount of 100 lakhs is proposed for developing the expertise and infrastructure required for the local level disaster management plans.
5	Regulatory Reforms			
	Strict enforcement of rainwater harvesting		UDH has introduced statutory provision with penal action in Jaipur Development Authority Act 1982, Jodhpur Development Authority Act, Urban Improvement Act & Rajasthan Municipal Act 2009 for rainwater harvesting. *	

[54] Inputs from Department of Local Bodies to be incorporated

Key Strategy	Action	Time-frame (ST, MT, LT)[52]	Physical Target/ Scope	Financial Requirement
			Provisions for rainwater harvesting have also been made under Township Policy 2010 (>10 Ha) and in Policy for Residential group housing and other schemes 2010 (upto 10 Ha). Rainwater harvesting provisions have also been made in building bye-laws for all towns*	
	Reuse of wastewater		Provisions for rainwater harvesting have also been made under Township Policy 2010 (>10 Ha) and in Policy for Residential group housing and other schemes 2010 (upto 10 Ha). However these need to be further strengthened*	
	Calculation of water footprint, linking with tax rebates for business owners and individuals		Consultations with PHED and RIICO required	
	Promoting Green Buildings		Apart from the above actions for rainwater harvesting, reuse of wastewater will be promoted. Provisions in building byelaws for solar water heating for various types of hospitals/ nursing homes, hotels, guest houses, dak bungalows, hotels, guest houses, lodges etc. have been made. Government departments have been directed to minimise the use of glass in the buildings constructed by them. Provisions for other measures under green buildings will be made suitably. *	

Chapter 12: Strategic Knowledge on Climate Change

12.1 Background

Knowledge is one of the key determinants for design of suitable interventions to respond to climate change. Further, the abundance and diversity of existing knowledge, which is often conflicting, inconsistent or outdated, may pose challenges on its usefulness. The situation is compounded by the low capacity of many stakeholders to assess the credibility and relevance of available knowledge. Additionally, enhanced local research capacity is essential if evidence – based policy to address climate change is to be realised. In this context, the state mission on Strategic Knowledge on Climate Change intends to create a knowledge system that would help take actions to reduce vulnerabilities as well as take advantage of the mitigation opportunities. Strategic Knowledge on Climate change is therefore, the system of knowledge that is required by various stakeholders to respond to climate change. Information and knowledge requirements of the stakeholder groups are as diverse as the groups themselves. Consequently, the mission is cross cutting in nature and is intended to serve as a support mission for generating and providing strategic knowledge to all other thematic missions under the Rajasthan State Action Plan on Climate Change, in consonance with the National Mission on Strategic Knowledge for Climate Change. The mission not only focuses on key knowledge requirements but also on knowledge management and application. The State Government established a 'Climate Change and CDM Cell' in the Rajasthan State Pollution Control Board (RSPCB) to act as a nodal agency to deal with all the issues related with Climate Change in the State. The Cell had been constituted in April 2010 and will be the nodal agency for the Mission on Strategic Knowledge on Climate Change.

The state of Rajasthan which is the largest state in the country in terms area has ten agro-climatic zones (ACZs) and seven automated weather stations at Bharatpur, Bikaner, Hanumangarh, Jaipur, Jaisalmer, JhunJunu and Jodhpur. A multi--model ensemble based district level weather forecast is provided in the state for a period of five days in association with India Meteorological Department (IMD). The State Remote Sensing Application Centre of the Government of Rajasthan is generating a number of databases related to natural resources in the state using remote sensing techniques. The centre has produced natural resource atlas, watershed atlas, ground water atlas, water harvesting structure master plan, hydro geological mapping, waste land mapping, lift irrigation master plan, ravines mapping, urban land use mapping , map wetlands, land use/ land cover. The centre is conducting an integrated resource survey as a part of its ongoing activities under the Integrated Mission for Sustainable Development (IMSD), Rajeev Gandhi National Drinking Water Mission (RGNDWM). National agencies such as the central water commission house basin wide information, whereas the central ground water board has data and information for ground water resources. Further the Department of Statistics and Planning contain socio economic information. The state has 32 ICAR Krishi Vigyan Kendras(KVK) spread across all ACZs. A district level Agromet Advisory is generated by state agriculture universities in association with NCMRWF and IMD. Owing to its unique geo—physical context, the state has a number of unique institutions such as the Central Arid Zone Research Institute (CAZRI), the Arid Forest Research Institute (AFPRI) and the Desert Medical Research Centre

(DMRC) A centre such as Desert Medical Research Centre DMRC which specifically is essential in Rajasthan because arid and semi-arid conditions pose health challenges that is specific to this type of ecology. Many climate-relevant studies are currently ongoing in the state. The survey of the 15 river basins is underway and will be completed by 2013. The study intends to assess the current water scenario in the state, current water balance in the state and thereby arrive at interventions to improve the water situation in the state. Biomass: assessment study for the state underway. Department of Science and Technology along with Indian Institute of Remote Sensing, Dehradun are conducting a study on carbon sequestration based on ultimate branch biomass. Carbon sequestration potential for different forest types of Rajasthan. Up to 5200 forest blocks in the state are covered under this project, with at least 1 block falling in each range of the State. Box 1 highlights traditional knowledge systems in Rajasthan.

Box 1. Traditional knowledge systems in Rajasthan

Rajasthan has a rich repository of traditional knowledge (Singhi and Joshi 2010). Some key areas of this knowledge that has a greater relevance in the context of climate change are provided below.

- Indigenous healthcare practices
- Climate forecasting and Disaster prediction (Pareek and Trivedi 2011)
- Veterinary practices through the use of certain species of plants that can withstand severe drought that could substitute fodder during scarcity, use of indigenous herbal coolants for combating heat stress in hot arid zone in Rajasthan (Katewa and Galav 2005; Takhar and Choudhary 2004)
- Growth of select species of crops for livelihood resilience during Drought (Singh and Mann 2011)
- Use of various parts of the plant species like Cenchrus biflorous, Prosopis cineraria, Tribulus terrestris as emergency food (Singhi and Joshi 2010) during famines or as coolants during extreme summers
- As dietary supplements during scarcity in the case of Zizyphus nummularia (Bordi)
- A comprehensive compendium of record of practice and beliefs of different ethno-medicines of tribal population of Rajasthan has been provided by Dam (2003). ICMR has been documenting quality standards and reviewing Indian medicinal plants (Gupta et al.)

12.2 Knowledge creation

Creation of knowledge can stem from theory, observations, experiments and or modeling assessments. While there is plethora of information that is available in various domains, it often offers incomplete or conflicting knowledge that often does suffice for targeted action on climate change. Further there are crucial knowledge and data gaps in some research domains. Additionally, the assessments of impacts and vulnerabilities are often at the national level but not at state and district levels. A significant amount of conceptual and

empirical work is required to better understand local climate impacts. Such an understanding is necessary to provide a better background for developing differentiated but linked responses to the different types of impacts. From a mitigation perspective, it is widely acknowledged that an alternative development model is necessary to embark on a low—carbon development path. However, other than increasing efforts to promote energy efficiency and renewable energy there is a lack of understanding of the diverse opportunities towards a low carbon development pathway. Many existing options and opportunities are under—utilized due to absence of research and analysis especially tailored to state specific social, ecological, political circumstances.

The Climate change and CDM cell had been corely involved in the drafting of the Climate Change Agenda for Rajasthan. In order to link experiential knowledge from policy side to scientific knowledge in the context of vulnerability assessments and to enhance the knowledge base in the state on climate risks, vulnerabilities and opportunities for adaptation and mitigation, the Climate Change and CDM cell has also facilitated preparation of proposals for pilot projects for adaptation, climate-proofing developmental projects, facilitating preparation of the Rajasthan State Action Plan on Climate Change and state level vulnerability assessment inter alia.

With regards to knowledge creation, it is not only important to emphasize on data requirements but also identify which data is already collected, what is missing, at what scales they should be collected, in what format these need to be collected and what their use will be. Table 12.1 presents an indicative list of some key data requirements for climate modeling, impact assessments, adaptation and mitigation assessments.

Table 12.1: Key knowledge requirements

Database	Components	Rationale
Meteorology	Precipitation (Daily), maximum and minimum temperature (Daily), solar radiation, Wind speed, Relative humidity, Evaporation data etc are and also for.	Essential input to sectoral impact assessment models such as DSSAT, SWAT or CROPWAT Extreme event analyses This information is critical for various early warning systems and decision support systems.
Land Surface	Land surface data at appropriate scales. Hydro--geological maps inclusive of: contour, drainage, Digital Elevation Models (DEM), soil type, depth, texture and physical, characteristics (composition of silt, sand, clay, rocks), drainage network, watershed boundary, Hydraulic conductivity, LRDP (land resource development plan) Time series remote sensing data on land use land cover (decadal or five year interval data for 1975 – 2010)	Essential for various sectoral impact assessment models of agriculture, surface water, and ground water etc. Extreme event assessments Land use plans Disaster planning and management

Database	Components	Rationale
		Important input for assessments pertaining to forestry, water resources, and urban systems amongst others.
Hydrological	Stream gauge stations, water level and discharge, river cross section, reservoir/water bodies characteristics etc.	Feed into surface water runoff models such as MODFlow, SWAT
	Aquifer-type, depth, extent, lithological variation, information, transmissivity, hydraulic conductivity, specific yield, storage coefficient, well-location, well type, well depth, water table data, groundwater consumption	Feed into ground water assessment methods such as the GALDIT. Hydrological data is an important input to agricultural models.
Agriculture and Livestock	A detailed ACZ wise inventory on cultivar name, planting date/method/distribution, crop management practices, crop level diseases, incidence of livestock diseases, invasive species inventory, fertility factor percentage organic carbon and nitrogen content, area under cultivation (for different crops and on the basis of land holdings) yield (farm and crop level) and types of crops cultivated is important.	This inventory could help understand the impact of climate change on various crops.
	Socio economic data relevant to agriculture like irrigation infrastructure, details on land holdings (cereals, pulses, fodder, commercial, etc.) alternative livelihood sources, tenancy, access to market, utilization of agricultural credit and insurance as well as information on traditional crop varieties and indigenous animal breeds and their special features	Critical to assess the adaptive capacity of the sector and design appropriate interventions.
Socio Economic data	Socio economic information inclusive of information on the institutions and governance.	Essential for vulnerability assessments and also for socio economic scenario building both of which are critical for responding to climate change.
	Vital Statistics (Total population, male female ratio, adult dependency ratio, crude death rate, crude birth rate, average life expectancy at birth, etc.), Education information, Occupational Structure – formal and informal, State Govt. spending on credit and insurance support including rural banking density, Number of non-financial, spread and activities of such institutions and livestock insurance participation level of industrialization and	For designing efficient interventions for climate change adaptation

Database	Components	Rationale
	urbanization are important. Rehabilitation and relief measures as well as direct economic losses, indirect losses, etc. due to extreme events are equally important. Coverage of and access to drinking water source, Coverage of sanitation facilities data.	This is essential for not just to plan for water scarcity but also for interventions in the health sector.
Forests and bio diversity	Geographical distribution of vulnerable habitats and species, information about invasive species.	Important to understand the impacts of climate change on the forestry sector.
Health Related data	Health statistics including morbidity/mortality data, distribution/Risk maps for climate sensitive diseases like diarrhoea and malaria, health infrastructure, prevalence of mal-nutrition etc.	For understanding health sector vulnerability to climate change.
Energy	Energy information on consumption patterns and conservation potential. It should include information on urban infrastructure like transport and buildings.	Help the state to take advantages of the low carbon development opportunities under the CDM mechanisms of the UNFCCC.
	Composition, quantum, and sources of waste	Help in design of waste to energy projects

12.3 Knowledge Management

While, there is an abundance of information available on climate change issues at coarser scales relevant information at local level is not accessible. This information and knowledge could be ranging from climate science and impacts to; mitigation and low carbon development paths. A strategic knowledge system should be able to integrate and organize information and assessments from multiple sources at various scales and present it to stakeholders in a useful form. The focus should also be to adapt existing knowledge and systematically organize knowledge products. The RSPCB is engaged in development of reports and working papers providing key insights for science-based policy making (accessible at http://rpcb.nic.in/).

A careful synthesis of existing knowledge is necessary through the use of information and communication technology (ICT) amongst other relevant technologies. Further, an arrangement for real time data sharing among various data sources is necessary for building strategic actions based on knowledge-led paths. In the following section we present some important initiatives in the state of Rajasthan that are intended to collate, present and manage knowledge relevant for action on climate change.

Table 12.2 Existing initiatives for knowledge management in the state

Vikas Darpan	A GIS based tool for decentralized planning – Vikas Darpan – has been made operational. This system provides complete maps of the State, 32 Districts, 241 Tehsils and 41,000 villages linking socio-economic profiles and demographic data of Census 2001. Vikas Darpan provides access to the public as well as to State Government departments in a closed user group (CUG) mode.
Mandi Online	Web based market information service that provides the daily Agriculture Mandi prices for all important agricultural commodities traded in the Mandi throughout the State. The commodity profile lists all major commodities of Rajasthan and provides useful information about the agriculture scenario in the State.
Socio Economic Data	Web based database on vital statistics
Disaster Management System	Web enabled integrated system designed and developed to monitor and control various activities being carried out under relief works
Watershed Atlas of Rajasthan	Department of Watershed and Soil Conservation in collaboration with the Department of Science and Technology: All planning in the State for watershed development is based on this atlas.
Groundwater Atlas of Rajasthan	World Bank aided project in collaboration with Groundwater Department: Consists of 9 data layers; administrative setup, geomorphology, hydrogeology, groundwater potential zones, water level trends, groundwater potability, nitrate content, fluoride content, total irrigation.
Resource Atlas of Rajasthan	Contains maps on natural resources as well as secondary information on infrastructure (based on 2001 census)
Soil Resource Atlas of Rajasthan	As per detailed taxonomical classification of soil
Ayurvedic Medicinal Plants Atlas of Rajasthan	In collaboration with the Department of Ayurveda
	Data for rainfall, temperature, humidity, dams, major and minor irrigation projects is available on the Department of water resources website
Health Management Information System (HMIS)	Hospital information management, Integrated Disease Surveillance, monitoring of disease outbreak and immunization programmes
Watershed Management Information System (WMIS)	An ARC-INFO based platform developed at SRSAC, WMIS is a model comprises of extent, nature characterization of watershed, land ownership, erosion extent, cropping pattern, irrigation status, inputs for development various treatment model, etc. It also incorporates query based retrieval of any information about watershed including characterization and development.
Watershed Management Information System (WMIS)	An ARC-Info based platform developed at SRSAC, WMIS is a model that comprises of the extent, nature of watersheds, land ownership, erosion extent, cropping pattern, irrigation status etc. Public Health Engineering Department (PHED) collects data regarding water pollution for all districts of Rajasthan.

12.5 Knowledge Application

In terms of application of knowledge, there should be an emphasis on co-synthesis of relevant knowledge related to climate change. For example conducting a training programme wherein the trainer imparts scientific knowledge to the farmers and the farmers in turn provide insights from their experiential knowledge, thus both the trainer and trainee co-producing new knowledge. Timely dissemination of information and capacity building efforts are critical to aid practical application of knowledge. Application of knowledge Communication of knowledge helps bridge information asymmetry that is critical for any action on climate change. Timely dissemination of information could help enhance the adaptive capacities of vulnerable communities, it could help government to better mobilize resources and money during a climatic extreme. However, low capacity of many stakeholders to assess the credibility and relevance of the available knowledge has been a barrier to respond appropriately to challenges of climate change. Therefore training and capacity building activities are equally critical for the strategic mission. These activities could range from short term training, mentoring and coaching assistance to enhance the capacity of various government officials, research institutions, policy makers and corporates; or a longer term strategy to create manpower for undertaking climate change research. Training and capacity building activities would also help take advantage of financial possibilities under UNFCCC and market opportunities under Kyoto Protocol, for example through CDM and REDD+ related activities.

In the year 2004 Government of Rajasthan had decided to establish Satellite based communication network (SATCOM) connecting all district and Panchayat Samiti Head Quarters. The network was intended to be used for training, distance education and extension programmes of various state departments. The state department of science and technology has undertaken an ambitious program in science communication and popularization through which science clubs are established in 1444 higher secondary schools. Through this initiative the department equips the schools with science galleries, low cost science models and equipments. Video conferencing facility has been provided to the 33 districts of the State and a Video Conferencing calendar for all the Departments has been issued. Also, there have been efforts to establish a two-way instant high capacity communication link between State Head quarter and the remote site for improving last mile connectivity that could be utilized to disseminate early warning messages as well as facilitate instant voice links between administration and disaster effected place to mobilize and to provide the adequate support. Agro advisories bulletins are being issued from the State Agricultural Universities. This contains advisories for all the weather sensitive agricultural operations form sowing to harvest. It also includes advisories for horticultural crops and livestock. These weather based advisories are disseminated to the farmers through mass media dissemination, internet etc. as well as through district level intermediaries. Climate change concerns could be mainstreamed into each of the activities discussed above.

12.6 Gaps

12.6.1 Knowledge gaps

There is an inadequate knowledge on the impacts of climate change in different sectors of the state. Insufficient observational and scientific information database discourages attempts to assess the climate change implications for the state. Further there is a lack of clear understanding of important processes like desertification, which requires the monitoring of

various parameters such as changes in water quality & quantity, biomass, biodiversity, soil salinity etc. No specific studies have been conducted to monitor this process in the state. There is no data available on present resource use, technology use or energy consumption from the industries.

12.6.2 Scale and spatial distribution of the data

Meteorological data has to be available at adequate scales for models to provide outputs that are policy relevant. There is little or no meteorological data available at the district level. A high number of observations network is essential for validating the modelling outputs. IMD has observed that there are large gaps in Rajasthan in terms of the spread of the Surface Meteorological Observatories

12.6.3 Digitization of information

Socio economic information containing in district statistical handbook is not available in digital format for all years as well as the GIS and remotely sensed data prepared by the SRSAC. There is a digitized database at the state level, but there are no such databases at the district level for socio economic data.

12.6.4 Fragmented knowledge base

Existing data and information is fragmented at multiple sources. There is a lack of systemic institutional mechanism for collating, synthesizing and delivering knowledge products for decision making on climate change. Poor connectivity between diverse knowledge generation communities is a hindering knowledge exchange process.

12.6.5 Inventorize traditional knowledge

While the benefits of traditional knowledge to enhance resilience of communities to climate change are acknowledged, there have been limited efforts to inventorize and scale up traditional knowledge. It is important to assimilate the traditional knowledge systems and reference them to the social contexts of the region.

12.6.6 Capacity building

Capacity building at various levels, including strengthening the base, creating centres of excellence in priority areas in existing institutions; and setting up new institutions in gap areas that allows a for leveraging the global and national knowledge base is important. However, an integration of perceptions and practices of people with valid chemical analysis to support and offer the alternative Bio-resolution has been attempted.

12.7 Strategies for State Mission on Strategic Knowledge on Climate Change

Key Strategy 1: Knowledge creation

Action 1: Facilitate studies related to climate change vulnerability and impact assessments for better preparedness in the state of Rajasthan- The overall aim will be to develop a cross-sectoral adaptation strategy for the State of Rajasthan based on the analysis of the projected climate change impacts and the assessment of vulnerability in the following key sectors:

- Hydrology and water resources

- Agriculture and animal husbandry
- Desertification
- Forestry and biodiversity
- Livelihoods
- Human health

Action 2: Understanding low carbon development pathways- There is need to assess likely future growth scenarios in the state using an optimization energy environment modeling framework. This will facilitate in long-term planning in identifying technological and policy choices today that would result in sustainable low carbon development in Rajasthan.

Key Strategy 2: Knowledge Management

Action 1: Periodic development of knowledge products on climate change. The objective of this action point is to synthesize existing knowledge base in the state to form knowledge products for decision-making, addressing climate risks and opportunities. These products can be in the form of working papers, technical reports, peer-reviewed articles and policy briefs to aid evidence-based policy making. For example, a potential knowledge product can be an inventory of indigenous knowledge in Rajasthan. The focus in this case will be on integration of perceptions and practices of people with scientific analysis to validate, standardize and scaling up of these traditional knowledge systems.

Key Strategy 3: Knowledge Application

Action 1: Mainstreaming of climate change concerns into developmental programmes and policies. Mainstreaming climate concerns into ongoing developmental initiatives can offer opportunities for adaptation and mitigation in the state. For example, while development is essential for adaptation, adaptation is imperative to safeguard developmental investments. Similarly it is essential to embark on a low-carbon pathway to aid adaptation efforts. This action can facilitate policymakers and vulnerable communities deploy findings of research into practice and identify potential entry points with the scope of current and planned developmental programmes and policies for reducing risks or tapping opportunities posed by climate change.

Action 2: Facilitate capacity building for the advancement of research on climate change- This action point will focus on facilitating capacity building initiatives to further the skillsets of government officials in the state, on application of climate science, GIS and remote sensing applications, Hydrological Modeling etc. through the network of national and international knowledge institutes. This would also include orientation sessions and workshops on climate change for government officials to better understand climate change dynamics and impacts, along with opportunities and issues related to adaptation and mitigation.

Institutional Arrangements

The Climate Change and CDM cell will be the nodal agency for the identified strategies and action points under this Mission. The role of the Cell will however be to act as a facilitator of knowledge creation, management and application in cooperation with other institutes and agencies at the state and national level. This include government departments and agencies such as IMD, NIDM, NCMRWF, NDMA, MoA, ICAR, MoSP, MoRD, Central Water Commission, BEE as well as different state level departments like DoE, DoST, DES, Revenue Department and institutions such as CAZRI, SAU, KVKs, State Universities and other research institutes and NGOs.

Key Priorities and Actions identified for "Strategic Knowledge on Climate Change"

Key Strategy	Action	Time-frame (ST, MT, LT)[55]	Physical Target/ Scope	Financial Requirement
1	Knowledge creation			
	Facilitate studies related to climate change vulnerability and impact assessments for better preparedness in the state of Rajasthan	ST, MT (macro assessments) and MT, LT for micro vulnerability assessments	Ongoing research	
	Understanding low carbon development pathways	ST, MT	Ongoing research	
2	Knowledge Management			
	Periodic development of knowledge products on climate change	ST, MT	Ongoing research	
3	Knowledge Application			
	Mainstreaming of climate change concerns into developmental programmes and policies	LT	Ongoing research	
	Capacity building for the advancement of research on climate change	ST, MT, LT	Ongoing research	

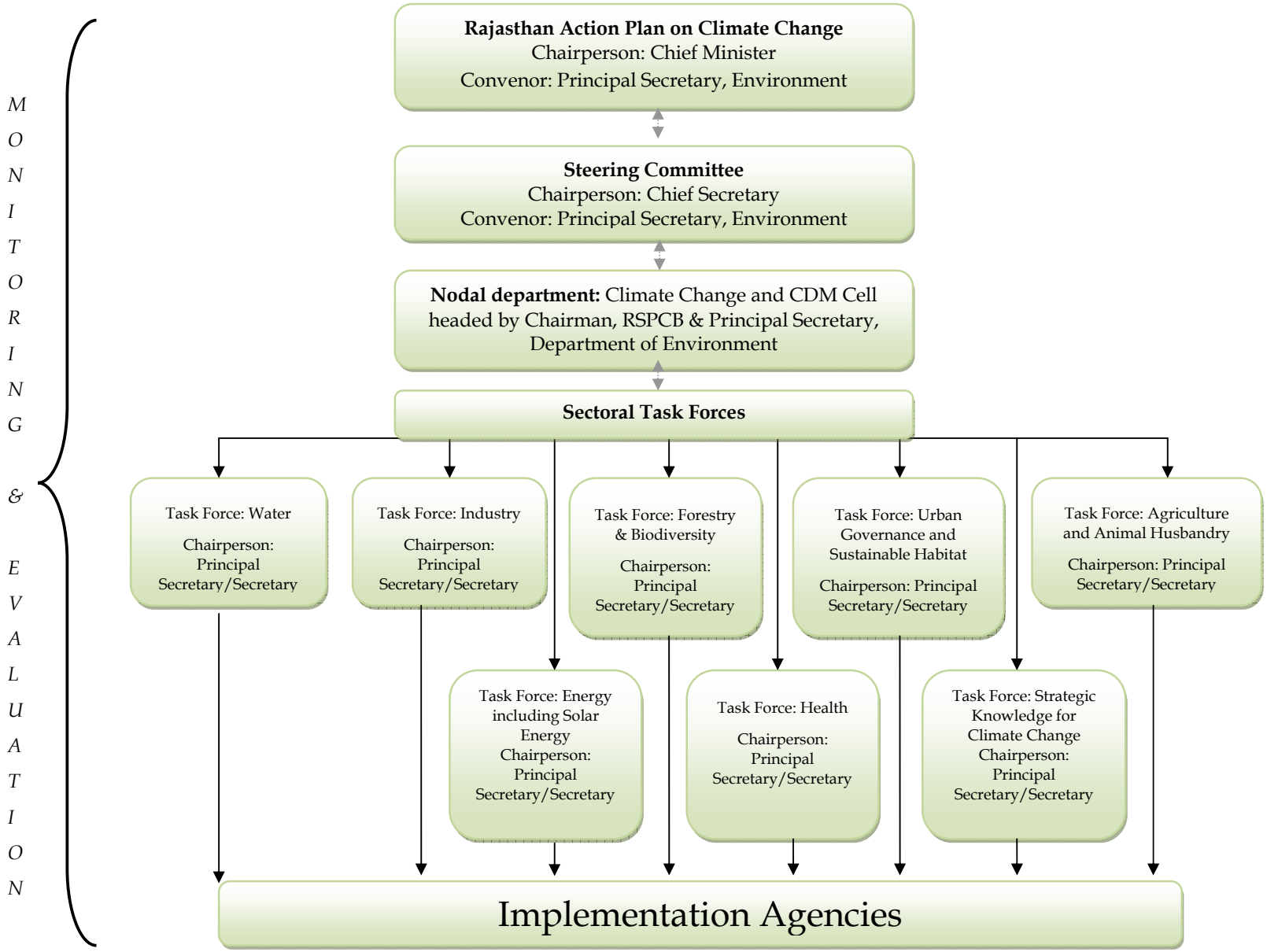
[55] ST: Short Term (2012-2017), MT: Mid-term (2017-2022), LT: Long-term (2022 and beyond)

PART D IMPLEMENTATION PLAN

Chapter 13 Institutional arrangement

The proposed institutional structure for the implementation of the SAPCC could be under the Chairmanship of the Chief Minister under whom the Steering Committee would directly operate that is headed by the Chief Secretary. The Nodal Department for overseeing all related activities to the SAPCC would be the CC & CDM Cell in the RPCB headed by the Principal Secretary and under the task forces would operate under the aegis of this department. The RAPCC will be overseen under the institutional structure of the Rajasthan Environment Mission.

To be able to implement the various strategies and actions proposed in the SAPCC, implementing agencies would be needed. These could be in the form of academic institutes, research institutes, universities in case of R & D, private sector in case of technology implementation, government departments in case of creating fiscal structures and community based organisations, scientific organisations for raising awareness and capacity building. A monitoring and evaluation plan needs to be rolled out to study the effectiveness in the implementation of the plan document over a specified time period and integration into the next phase while planning further activities under the SAPCC.


MONITORING & EVALUATION
Rajasthan Action Plan on Climate Change
Chairperson: Chief Minister
Convenor: Principal Secretary, Environment
Steering Committee
Chairperson: Chief Secretary
Convenor: Principal Secretary, Environment
Nodal department: Climate Change and CDM Cell headed by Chairman, RSPCB & Principal Secretary, Department of Environment
Sectoral Task Forces
Task Force: Water
Chairperson: Principal Secretary/Secretary
Task Force: Industry
Chairperson: Principal Secretary/Secretary
Task Force: Forestry & Biodiversity
Chairperson: Principal Secretary/Secretary
Task Force: Urban Governance and Sustainable Habitat
Chairperson: Principal Secretary/Secretary
Task Force: Agriculture and Animal Husbandry
Chairperson: Principal Secretary/Secretary
Task Force: Energy including Solar Energy
Chairperson: Principal Secretary/Secretary
Task Force: Health
Chairperson: Principal Secretary/Secretary
Task Force: Strategic Knowledge for Climate Change
Chairperson: Principal Secretary/Secretary
Implementation Agencies

Chapter 14 Financial Requirement

S No	Sectors	Proposed Strategies	Costs (INR Crores)*
1	Water Resources	Groundwater management	10.5
		Enhancing preparedness for drought monitoring, drought mitigation and development of early warning system	-
		Enhancing Water Conservation Measures	-
		Improving Water Use Efficiency	-
		Developing a comprehensive water database for assessment of impacts of climate change on water resources	-
2	Agriculture	Enhancing productivity of crops and livestock	83.11
		Restoration and development of wastelands	3.04
		Research and assessment of specific climatic risks to agriculture	0.66
		Promotion and management of multifunctional agroforestry systems	0.26
		Promotion of Horticulture	20.37
3	Health	Research-based prioritization of vulnerable regions and population groups for targeted health interventions	7.14
		Improving the disease monitoring & surveillance system to enhance response capacity	7.85
		Enhancing primary, secondary & tertiary health care to cope with potential climate risks and additional health impacts of climate change	10.68
		Mainstreaming climate concerns into policy responses and interventions in the health sector	24.8

S No	Sectors	Proposed Strategies	Costs (INR Crores)*
4	Forest and Biodiversity	Afforestation / Reforestation for maximizing mitigation potential of the forests	42
		Conservation of Biodiversity	45
5	EEE and RE	GHG inventorisation and GHG management plan	*
		Harnessing full renewable energy potential of the state	*
		Demand side measures including energy efficiency	5.95
		Reduction of transmission and distribution losses	*
6	Urban Governance and Sustainable Habitat	Preparation of Resilience Plan for each city in light of existing vulnerabilities	*
		Urban Stormwater Drainage Infrastructure Improvement in light of increase in frequency and intensity of extreme rainfall-Adaptation Action	*
		Restrict/control land use in areas prone to flash flood in light of increase in frequency and intensity of extreme rainfall	*
		Preparedness and Mitigation Plan	1
		State directive (to the urban local bodies) to incorporate water harvesting and waste water treatment and dual water supply for other uses than drinking, in building by-laws	*
		Amendments to existing urban policies in order to incorporate water conservation and harvesting principles	*
		Calculation of water footprint, linking with tax rebates for business owners and individuals	*

S No	Sectors	Proposed Strategies	Costs (INR Crores)*
		Promoting Green Buildings as a mitigation strategy	*
7	Strategic Knowledge on Climate Change	Knowledge creation	*
		Knowledge Management	*
		Dissemination and Capacity Building	*
	Total		**262 crores****

* Inputs from departments required

**Partial estimates, does not cover financial estimates for all options

Chapter 15 Monitoring and Evaluation

The objective for monitoring and evaluation (M&E) is to measure and assess performance in order to effectively manage outputs and outcomes of the key actions of each target sector. The focus of M&E is to assess the implementation process with respect to the targets envisioned, financial resources used and strategies accomplished. ***The implementation of the RAPCC will be done by respective state departments and monitoring of implementation will be done by the Rajasthan Environment Mission and Steering Committee of the Environment Mission. While state departments will be responsible for implementation of targets, these will be reported to the Climate Change and CDM cell and presented and monitored by the Steering Committee during meetings of the Environment Mission.*** The evaluation process is proposed in the form of mid-term review of the proposed activities and post- implementation impact evaluation that gives the scope for modification and improvement in the strategies being formed for the next phase. Along with this routine monitoring of the actions and outcomes need to be undertaken for generating knowledge that can be used to adapt the actions appropriately in the shorter run.

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