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INDIA COUNTRY REPORT
CLIMATE RISK MANAGEMENT IN TAMIL NADU

Submitted to Tamil Nadu State Planning Commission
By Regional Integrated Multi-Hazard Early Warning System for Africa and Asia (RIMES)

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CRISIS PREVENTION AND RECOVERY

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LIST OF ABBREVIATIONS AND ACRONYMS

ADB	Asian Development Bank
AMFUs	Agro-Met Field Units
AP	Andhra Pradesh
BCPR	Bureau for Crisis Prevention and Recovery
BDP EEG	Bureau for Development Policy Energy and Environment Group
BOB	Bay of Bengal
CMIP3	Coupled Model Inter-comparison Project phase 3
CRM	Climate Risk Management
CRM TASP	Climate Risk Management Technical Assistance Support Project
CS	Cyclonic Storm
CV	Coefficient of Variation
DDMA	District Disaster Management Authority
DES	Department of Economics and Statistics
DESINVENTAR	Disaster Information Management System
ECHAM	European Centre/Hamburg Model
ENSO	El Niño Southern Oscillation
GCM	Global Climate Model
GDI	Gender Development Index
GDP	Gross Domestic Products
GFDL	Geophysical Fluid Dynamics Lab
GSDP	Gross State Domestic Products
HadCM3	Hadley Centre Coupled Model, Version 3, United Kingdom
HDI	Human Development Index
HYV	High Yield Varieties
IAMWARM	Irrigated Agriculture Modernization and Water bodies Restoration and Management
IEC	Information Education and Communication
IMD	Indian Meteorological Department
INR	Indian Rupees
IOD	Indian Ocean Dipole
IPCC	Intergovernmental Panel on Climate Change
IPRC	International Pacific Research Center
ITCZ	Inter-Tropical Convergence Zone
MGNREGS	Mahatma Gandhi National Rural Employment Guarantee Scheme
MJO	Madden Julian Oscillation
MSL	Mean Sea Level
NABARD	National Bank for Agriculture and Rural Development
NAPCC	National Action Plan on Climate Change
NATCOM	National Communication
NE	North East

NGO	Non Governmental Organization
NRLM	National Rural Livelihood Mission
PDO	Pacific Decadal Oscillation
PDS	Public Distribution System
PHC	Primary Health Centers
PWD	Public Works Department
RADMMD	Administration's Disaster Management and Mitigation Department
RCM	Regional Climate Model
RIMES	Regional Integrated Multi-hazard Early Warning System for Africa and Asia
SAPCC	State Action Plan on Climate Change
SCS	Severe Cyclonic Storm
SDMA	State Disaster Management Authority
SRI	System of Rice Intensification
SSH	Sea Surface Height
SW	South West
TAWN	Tamil Nadu Agricultural Weather Network
TC	Tropical Cyclone
TN IAMWARM	Tamil Nadu Irrigated Agriculture Modernization and Water bodies Restoration and Management
TN	Tamil Nadu
TNAU	Tamil Nadu Agriculture University
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change
USD	United States Dollar
WB	West Bengal
WCRP	World Climate Research Programme
WRI	World Resources Institute

FOREWORD

Climate change has the potential to exacerbate conflict, cause humanitarian crises, displace people, destroy livelihoods and set-back development and the fight against poverty for millions of people across the globe.

For example, it is estimated that over 20 million people in the Mekong Delta and 20 million in Bangladesh could be forced to move as their homes are affected by saltwater incursion from rising sea levels. Entire populations of some low lying island states, such as Nauru or the Maldives may have to be relocated. In countries like Honduras, where more than half the population relies on agriculture, climate induced risks, such as hurricane Mitch in 1998, which caused over USD 2 billion in agricultural losses, will continue to pose a staggering potential for damage. Similarly, climate risk assessments in Nicaragua show that changes in rainfall patterns, floods and drought could put human health at risk by increasing the prevalence of respiratory and water borne diseases and malnutrition.

Long-term incremental changes will mean that people everywhere must learn to adapt to weather or rainfall patterns changing, or to shifts in ecosystems that humans depend upon for food. Perhaps more worrying however, is that climate variability and change will also bring unpredictable weather patterns that will in turn result in more extreme weather events. Heat waves, droughts, floods, and violent storms could be much more common in the decades to come. Climate change is "loading the dice" and making extreme weather events more likely. These disasters will undermine the sustainability of development and render some practices, such as certain types of agriculture, unsustainable; some places uninhabitable; and some lives unliveable.

As climate change creates new risks, better analysis is needed to understand a new level of uncertainty. In order to plan for disasters, we need to understand how climate change will impact on economies, livelihoods and development. We need to understand how likely changes in temperature, precipitation, as well as the frequency and magnitude of future extreme weather will affect any sector, including agriculture, water-use, human and animal health and the biodiversity of wetlands.

This report is a product of the Climate Risk Management – Technical Assistance Support Project, which is supported by UNDP's Bureau for Crisis Prevention and Recovery, and Bureau for Development Policy. This is one in a series of reports that examine high-risk countries and focus on a specific socio-economic sector in each country. The series illustrates how people in different communities and across a range of socio-economic sectors may have to make adaptations to the way they generate income and cultivate livelihoods in the face of a changing climate. These reports present an evidence base for understanding how climatic risks are likely to unfold. They will help governments, development agencies and even the communities themselves to identify underlying risks, including inappropriately designed policies and plans and crucial capacity gaps.

This series is part of a growing body of climate change adaptation resources being developed by UNDP. The Climate Risk Management – Technical Assistance Support Project has formulated a range of climate risk management assessments and strategies that bring together disaster risk reduction and climate change adaptation practices. The project is designing a common framework to assist countries in developing the necessary capacity to manage climate-induced risks to respond to this emerging threat. The climate risk assessments discussed in this report and others in the series will feed into a set of country-level projects and regional initiatives that will inform the practice of climate risk management for decades to come.

Addressing climate change is one of UNDP's strategic priorities. There is strong demand for more information. People at all levels, including small communities want to understand the potential impact of climate change and learn how they can develop strategies to reduce their own vulnerability. UNDP is addressing this demand and enabling communities and nations to devise informed risk management solutions. UNDP recognises that climate change is a crucial challenge to sustainable development and the goal of building resilient nations.

As the full effect of climate change becomes apparent, it is assessments such as these that will become the lynchpin of national responses and adaptation strategies for many years to come. Like the threat from many disasters, there is still time to prepare for the worst impacts of climate change in developing countries if we expand our understanding now.

This knowledge must be combined with real preparedness and action at all levels. Only then will we be able to stave off the worst impacts of climate change in the most vulnerable and high risk countries of our world.

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The Project, its methodology and analytical framework was conceptualized by Maxx Dilley, Disaster Partnerships Advisor and Alain Lambert, Policy Advisor, Disaster Risk Reduction and Recovery Team (DRRT), BCPR with key inputs from Kamal Kishore, Programme Advisor, DRRT, BCPR and Ms. Bo Lim, Special CC Advisor, Environment and Energy Group (EEG), BDP.

Within BCPR, the Project implementation process has been supervised by Alain Lambert and Rajeev Issar who provided regular inputs to ensure in-depth climate risk assessments and identification of tangible risk reduction and adaptation options. From BDP, Ms. Mihoko Kumamoto and Ms. Jennifer Baumwoll provided their inputs and comments to refine the assessment and recommendations. The climate risk assessment has also benefitted immensely from the strategic guidance provided by Jo Scheuer, Global Coordinator, DRRT, BCPR and by Ms. Veerle Vandeweerd, Director, EEG, BDP.

The Project team would like to acknowledge and give special thanks to the main authors of the Report from RIMES.

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The climate risk assessments under the CRM-TASP project have been undertaken with the funding support of the Government of Sweden.

EXECUTIVE SUMMARY

In terms of socio economic indices, Tamil Nadu ranks third among Indian states. Tamil Nadu is one of the most industrialized and urbanized States in India. Tamil Nadu draws 88 percent of its annual income (2011) from industry and service sectors.

Tamil Nadu, despite its impressive development in the last three decades resulting in structural transformation of its economy from agriculture to industry and services based, and declining share of the state income from agriculture sector (40 percent in 1960s to 12 percent in 2011), has 40 percent of its population depending on agriculture sector. As 35 million rural population depends on farming sector for livelihoods, growth of agriculture sector is key to poverty reduction, food security and social wellbeing.

Growth of agriculture sector since mid-1990s has been near stagnant. Decrease in farm sizes, diversion of farm lands for non-agricultural uses, deterioration of surface water holding structures like traditional tanks and tail-end canal systems etc. have rendered agricultural productivity near stagnant. A stagnant agriculture is a serious development concern for the Government of Tamil Nadu.

In parallel, traditional adaptive strategies of rural communities of Tamil Nadu evolved to manage climate risk in the high risk production environment is on decline. These strategies were built around conserving and utilizing moisture judiciously, relying on less water demanding coarse grains, adoption of mixed farming system, fodder based livestock system, non-farm activities and collective sustenance with social adjustments. All these adaptive strategies have been weakened over the last few decades due to population explosion, neglect of traditional water harvesting structures, reliance on water intensive crops such as sugarcane, paddy over millets & coarse grains and adoption of mono cropping in place of mix cropping.

Stagnant agriculture with weakening adaptive strategies of farmers renders them more vulnerable to periodic climate shocks such as droughts, floods and storms. The farming systems currently even do not respond to normal or excess rainfall while the reduction due to deficient rainfall is very drastic, i.e., opportunities presented by beneficial climate resources in terms of good rainfall are not capitalised. There is a de-coupling of areas irrigated by tanks and rainfall since mid-1980s. Similarly, in recent years, agricultural production overall is not responding to good monsoon years.

Government of Tamil Nadu evolved and institutionalized safety net programs like provision of free rice to 18 million card holders, through a large network of public distribution system, provision for guaranteed employment of 100 days nearer the habitation of people and additional relief whenever vulnerable people suffered from impacts of natural hazards.

As more than one-third of development expenditure is being diverted annually to resource safety net programs and more than half of the state resources are utilized to support vast administrative structures, only one-fifth of the resources are available for productive development purposes. In 2011-12, out of annual plan outlay of US$20 billion; only US$4 billion is used for direct development expenditure.

The Vision 2023 document seeks to reverse a safety net based support to vast number of population to promote sustainable development. In consonance with its vision, the Vision 2023 document envisages an increase of growth of agriculture to 5 percent per annum and transfer of 20 million work force from rural areas to manufacturing and service sector. The Vision 2023 document prioritizes manufacturing sector as the key thrust area to absorb large number of unskilled labor force transferred from agriculture sector with minimum additional skills particularly in agro processing sectors.

The assessment of climate risk to agriculture, industry and service sectors reveal that the climate risk first experienced in agriculture sector will have a cascading impact on industry and service sectors through backward and forward linkages. As Drought 2001-2003 and 2012-2013 experiences show, a 20 percent reduction in primary sector caused over 5 percent drop in industry sector and 3 percent reduction in service sector. In addition to occasional manifestations of extreme events, every year loss in productivity due to weather is estimated to be 15 percent in certain crops. Hence weather influences the economic sectors in every season, regardless of occurrence of extreme events. There is no systematic research to understand, appreciate both direct and indirect influences of climate risk on agriculture sector and its cascading impacts on the other economic sectors. During phase of implementation of Vision 2023 programmes, severe climate shocks like droughts, cyclones, floods, heavy rains and unusual weather patterns could influence the development trajectory. A preliminary risk assessment in the context of Vision 2023 development trajectories reveals an annual estimated loss of around INR 33,600 crore. It is possible to potentially reduce this loss considerably to the extent of 75 percent[1] in

1 The causes of the increasing climate risk are due to non maintenance of traditional irrigation tanks, canal systems, and ground water systems. Focusing on the root causes of climate risk and evolving appropriate policy and institutional mechanism could reduce the risk considerably.

next ten years by applying climate risk management approach. Hence, incorporation of climate risk assessment, prioritization and informed decision-making to reduce risks is a prerequisite to mitigate the impacts of risks on the Vision 2023 in the next ten years.

The current strategy in Tamil Nadu, climate risk management framework is yet to be institutionalized as a cross-sectoral anticipatory risk management strategy to minimize the expected climate risk into the development strategies envisaged in 2023 document.

Natural hazard reduction in Tamil Nadu is being implemented in three distinct domains, namely Disaster Risk Reduction, Development Planning and Climate Change Adaptation in isolation. There is a need to integrate these three distinct domains into an inter-connected Climate Risk Management (CRM) framework. Climate Risk Management framework enables promotion of a cross sectoral anticipatory risk management practice to mitigate both current and future climate risks to development.

The CRM Technical Assistance Support Project has contributed in creating awareness and sensitizing all the stakeholders to adapt comprehensive climate risk management into development planning purposes. The State Planning Commission of Tamil Nadu has provided leadership and coordination arrangement for all stakeholder participation to integrate Climate Risk Management framework for guiding current and future development planning process. The State Planning Commission has evolved an applied research program to assess capacity needs for climate risk assessment, prioritization and treatment of climate risks in a holistic manner.

INTRODUCTION

BACKGROUND

Climate risk management (CRM) is an inter-disciplinary, multi-stakeholder process that involves analysis of climate-related risks leading to consensus-based identification and prioritization of risk management actions to anticipate and manage both extant and emerging climate risks.

Climate Change can further alter the observed climate mean or cause changes in nature of extremes (severity, frequency, spread, duration and timing) as well as possible surprises. The resultant climate risks could resemble current climate variability patterns, but with higher amplitude variations. Hence, the CRM suggests that pattern of risks could be anticipated and the experiences of present systems in dealing with these risks could be drawn upon towards building resilience to long-term climate change. For climate "surprises," while past climate patterns may not provide any clue as to how they would unfold and manifest, human experiences in dealing with extreme climate events may provide guidance for dealing with uncertainties associated with climate change-related risks. Thus, from a policy point of view, building the capacities of institutions and systems around managing current climate extremes and thereby a resilient development, could also assist to take care of "surprises."

Climate risk management framework has been adopted to assist countries to develop capacity to manage risks associated with climate variability and change, developed by the United Nations Development Programme (UNDP), through its Bureau for Crisis Prevention and Recovery (BCPR), responsible for assisting countries to develop capacity to better manage disaster risks, and Bureau for Development Policy, Energy and Environment Group (BDP/EEG), responsible to assist countries to develop capacity to adapt to climate change. Climate Risk Management - Technical Assistance Support Project (CRM-TASP) has been evolved to operationalize CRM framework by integrating CCA and DRR. The Regional Integrated Multi-hazard Early Warning System for Africa and Asia (RIMES) in collaboration with Asian Disaster Preparedness Center has been tasked with implementing the CRM-TASP framework in assessing risk management priorities and capacity needs into development planning in six countries in Asia, including India.

OBJECTIVES

In Tamil Nadu, agriculture sector has been identified as a priority sector for CRM-TASP analysis. The objectives of the report are as follows:

- Identify current and future climate risks, vulnerabilities and impacts on the agriculture sector;
- Assess institutional, policy, development planning gaps that contribute to magnifying climate risks;
- Identify CRM options to address climate risks to reduce vulnerabilities and improve development outcomes.

KEY CONCEPTS

The following framework (Figure 1.1) has been adopted and applied to undertake CRM assessment and to structure this report.

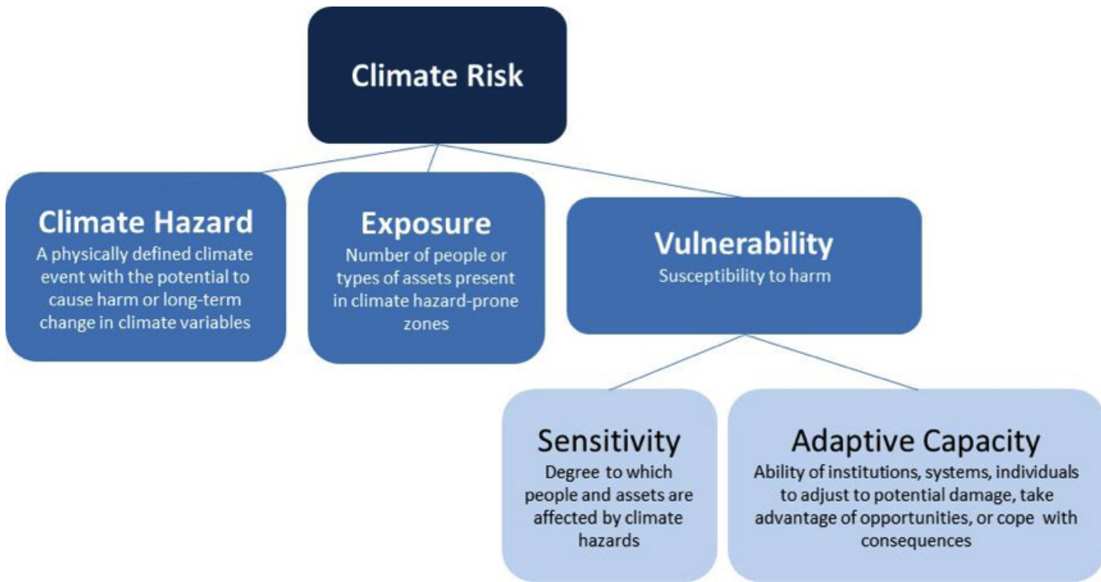


Figure 1.1 Components of Climate Risk

APPROACH AND METHODS

The CRM-TASP was initiated through a regional inception meeting organized for the UNDP focal points and key government representatives from nodal agencies/departments from six participating countries at Pondicherry, India in July 2010. In Tamil Nadu State, the project involved the Office of Relief Commissioner, the State Planning Commission, the Agriculture Department, Tamil Nadu Agricultural University and the Centre for Ecology and Research (an NGO working with farmers in Tamil Nadu) through the implementation process outlined below (see table 1.1).

TABLE 1.1: PROJECT STEPS AND METHODS.

PROJECT STEP & PURPOSE		SPECIFIC STEPS APPLIED IN TAMIL NADU
1. Initiation	• Introduce CRM TASP	• Inception Meeting and discussions with key stake-holders
2. Climate risk assess-ment	• Participatory risk assessment involving stakeholders	• Participatory data analysis (IMD, Disaster Risk Manage-ment, Agriculture, Public Works Department, Health, Fisheries, State Planning Commission) and field level validation
3. Development of CRM programme	• Identify stakeholder needs to integrate CRM into sectoral planning and practices	• Assessment of needs of departments and existing gaps in applying CRM approach, and ways to address the gaps

TABLE 1.1 CONTINUED

PROJECT STEP & PURPOSE		SPECIFIC STEPS APPLIED IN TAMIL NADU
4. Institutionalisation of climate risk management	• Integrate CRM process into development planning processes	• Preparation of concept note and discussion with Planning Commission • Meeting of stakeholder departments conducted by Planning Commission
5. Evolution of applied research programme for capacity building	• To build capacities for CRM among stakeholders	• Consensus-based identification of applied research programme focussing on capacity building
6. Documentation & Report writing	• Documentation and finalisation of CRM TASP report	• Review of the report by State Planning Commission

The Office of Relief Commissioner (also responsible for disaster risk management) identified possible priorities for the project, from which agriculture sector was selected. During the course of implementation, appreciating the need for adopting a cross-sectoral convergence to integrate CRM into development, the State Planning Commission adopted the CRM approach and provided a multi-sectoral forum to discuss its integration into the planning process.

Tamil Nadu has a rich longitudinal socio-economic data and climate database. These data has been used for analyzing socio economic vulnerabilities to climate risk. This analysis and findings has been cross checked and validated with State agriculture, animal husbandry, fisheries and disaster management departments. Field surveys were undertaken in two villages in Nagapattinam district and also tested the acceptance of climate risk management practices through climate field school program in these villages. Secondary literature survey has been undertaken to complement the primary research.

The climate analysis is based on Indian Meteorological Department datasets and the risk analysis is based on socio economic data published by Tamil Nadu Economics and Statistics department.

RIMES cooperated with Tamil Nadu Agricultural University and the Agriculture Department in developing an in-house decision-support tool integrating weather and climate information to reduce impacts of climate risks and maximise opportunities in agriculture. As an entry point activity, local farmers were consulted with, and are engaged through the Centre for Ecology and Research in demonstrating the application of the decision-support tool for agriculture sector, there-by also identifying demands for similar tools from other sectors such as animal husbandry, water resources etc.

REPORT STRUCTURE

Chapter 1 captures the process steps and methods adopted. Chapter 2 focuses on development context and trends in Tamil Nadu and the rationale for prioritization of a climate sensitive sector. Chapter 3 focuses on geo-physical environment and climate risk features of Tamil Nadu- past, current and future. Assessment of climate threats to development in the context of past climate risks and anticipated climate change projections are covered in Chapter 4. Current Climate Risk Management processes, policy and institutional systems to address the threats identified earlier are discussed in Chapter 5, while Chapter 6 focuses on ownership of CRM within the State government, assessment of capacity needs for an applied research programme, and recommendations for future actions.

DEVELOPMENT PROFILE

Vulnerability and exposure of a society to climate risks can be largely explained by the current status of its development as well as its future trends. This chapter examines the key development conditions prevalent in Tamil Nadu State, the trends observed over the past decades, and the future as seen through the vision and strategies outlined in the State Planning documents. Agriculture is the 'most significant' sector seen from perspective of climate sensitivity as well as extent of sustenance provided by the sector.

CURRENT DEVELOPMENT CONDITIONS, TRENDS AND CHALLENGES

Tamil Nadu is the southern-most State (province) of India with a coastline of over 1000 km along the Bay of Bengal and the Indian Ocean, exposing the State to tropical depressions, storms, and cyclones. Hills along the west (Western Ghats) create an insurmountable barrier for the rain-bearing South West monsoon winds for large parts of the State. The north western border adjoining Karnataka State provides Tamil Nadu State access to its most coveted water resource- Cauvery river, while Andhra Pradesh State bordering the north provides the State capital Chennai water in times of shortages.

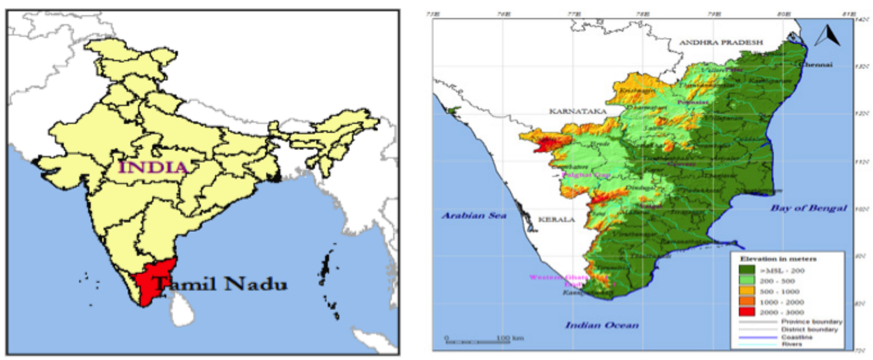
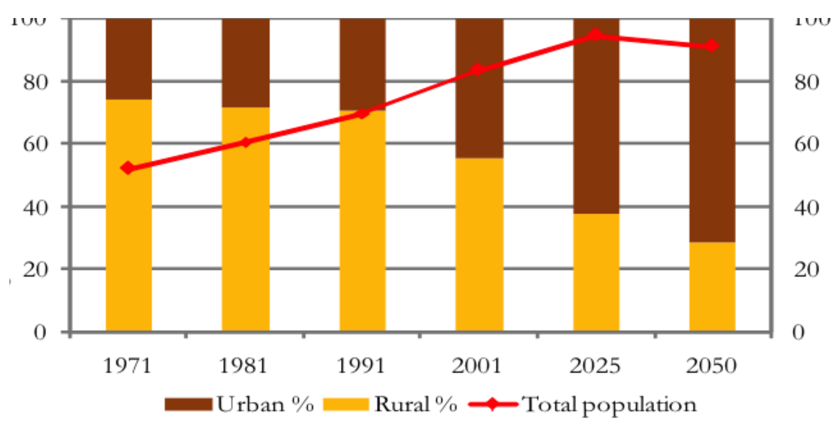


Figure 2.1 Physical Map of India and Tamil Nadu

Tamil Nadu with a land area of 130,000 square kilometres is India's sixth largest State. It comprises of 32 districts with majority (52 percent) of its 72.14 million inhabitants living in rural areas while a sizable urban population, 34.95 million (as per 2011 census) live in over 1,097 cities and towns. Rapid urbanization in the State exceeds the national rate and with over 48.4 percent of the State population living in urban areas.



(Source: Amarasinghe et al, undated[1])

Figure 2.2 Demographic trends in Tamil Nadu

Poverty and Human Development

The standard of living of people in Tamil Nadu, as reflected in their per capita income *(INR 45,058 at current prices)* compares favourably with the national average *(of INR 37,490 at current prices)*. However, majority of the population residing in rural areas are largely dependent on agriculture. Further, cultivated area is stagnant or declining. Seen from this perspective, in rural areas where over 21 per cent are poor, a significant number of people are vulnerable. Overall, though poverty levels continue to decrease, it remains high in absolute numbers (over 12 million are poor), and urban poverty is slightly lower at 12.8 per cent[2]. *(Planning Commission, Databook for DCH, April 2012)*

Education is counted as a valuable asset, and is reflected in the literacy rates-80.3 percent in 2011, against the national average of 74.04 percent. More men (86.81 percent) are literate compared to women (73.86 percent). Gender equality shows significant improvements too, especially in education - more girls pass school than boys. Larger proportion of teachers at primary, middle and secondary/higher secondary schools is women. Gender Development Index (GDI) for Tamil Nadu is higher than the national GDI, indicating it fares better than the country as a whole[3] *(Tamil Nadu Human Development Report, 2003)*.

Economy

Tamil Nadu's Gross State Domestic Product for 2009-2010 was INR 4,177 billion (approx. 53 INR= 1 USD as per 2010 prices), which made it the third largest State economy in India. The economy grew at a rate of 9.5 percent during 2002-2007 and at over 8 percent during 2007-2011. This high rate of growth over the past few decades is largely due to the rapid growth in secondary (manufacturing) and tertiary (services) sectors, while the share of agriculture has dropped to less than 13 per cent. (Table 2.1)

TABLE 2.1. CONTRIBUTION OF SECTORS TO GROSS STATE DEVELOPMENT PRODUCT (GSDP)

SECTORS	1960-61	1970-71	1980-81	1990-91	1999-00	2006-07	2008-09	2010-11
Primary Sector	**43.51**	**34.79**	**25.92**	**23.42**	**17.37**	**13.28**	**11.12**	**12.6**
Secondary Sector	20.27	26.88	33.49	33.1	29.57	29.87	28.26	25.8
Tertiary Sector	36.22	38.33	40.59	43.48	53.06	56.85	60.62	61.6

Environment

Water, however poses a larger problem. Deficient rainfall (921 mm compared to national average of 1200 mm) leading to over-reliance on irrigation for agriculture, and increasing extraction of ground water reserves (estimates show over 60 percent of reserves are already exhausted) pose a big issue for the future. Tamil Nadu being a lower riparian State has to depend to a large extent on water from neighbouring states, which are under greater pressure to increase exploitation of the rivers for their own irrigation purposes. River basins in the State are already facing severe impacts due to unsound practices.

Historically, the State has had a large number (41,000) of small water bodies (also called tanks), which were key retention areas for the erratic monsoon rains and served as significant local sources of water. Poor upkeep and maintenance of these tanks combined with land use changes, increasing and unsustainable dependence on scarce ground water resources, shift from low-water use indigenous crops to water-intensive (and more profitable) crops has compounded the water shortage issue. Increasing reliance on chemical fertilizers and pesticides has resulted in residues affecting soil structure and polluting water through leaching. Forests in Tamil Nadu cover 16.4 percent of the land area, of which a sizeable area is under degraded condition, which is less than the 33 percent targeted under the National Forest Policy, 1988[4]. *(State of Environment Report of Tamil Nadu, 2005)*

STATE DEVELOPMENT VISION, OBJECTIVES AND PRIORITIES

Tamil Nadu prepares five year plans to guide its development planning and currently the Twelfth Plan for 2012-2017 is under implementation. The State has prepared a long-term framework for development called Vision 2023 with the following key outcomes:

(1) The per capita income of Tamil Nadu's residents will reach US $10,000 per annum (at 2010 prices) - the present median income of Upper Middle Income countries - by 2023;

(2) Tamil Nadu will attain a high standard of social development, with the Human Development Index of the State matching those of developed countries by 2023, and;

(3) Tamil Nadu would provide to its residents, high quality infrastructure all over the State comparable with the best in the world.

The document identifies key development themes including the need to actively address the causes of vulnerability of the State and its people due to uncertainties arising from natural causes, economic downturns, and other man-made reasons and mitigate the adverse effects.

Marginalisation of agriculture by other sectors of the economy is reflected in Table 2.1, but the sector continues to support a large population (over 40 percent). Recognizing this, the Twelfth Five Year Plan (2012-2017) and Vision 2023 aims at 5 percent growth in agriculture through a second 'Green Revolution' by addressing the productivity gap to bring about equitable growth. A combination of crop diversification comprising high value horticulture and commercial crops besides focus on rain fed area development and convergence of schemes, mixed farming and other farm based interventions and value addition is proposed to improve the economic status of the farmers and to increase their per capita income by 2 to 3 times from the present level. Some of these strategies would need to address the increasing sensitivity to weather and climatic factors in light of the increased investment planned in and the outcomes expected from this sector.

CONDITIONS, TRENDS AND PRIORITIES

In Tamil Nadu, 37 million out of the 72 million population belong to rural areas and 90 percent of the rural population is engaged in agriculture sector through household operated farms. 90 percent of these are less than 2 hectares in size making smallholder based agriculture the predominant form of agricultural operations in Tamil Nadu that occupies over 59 percent of total agricultural land. Faster growth in agriculture sector is central to rural development and poverty reduction in Tamil Nadu. The traditional growth in agriculture sector faces major constraints like water scarcity, land degradation, population growth, declining farm sizes, urbanization, rural-urban migration and rising cost of labour.

Given these constraints diversification into high value, less water intensive products such as fruits, water, spices, and livestock may be one of the promising sources of agriculture growth. This study assesses agriculture policies in Tamil Nadu and implications of those policies for future agriculture growth, food security, rural poverty reduction and makes appropriate recommendations from a climate risk management perspective.

Land use

An analysis of land-use pattern in Tamil Nadu and its changes from 1998-1999 to 2009-2010 indicates that fallow lands keep increasing -- current fallow by 4.83 percent and other fallows by 29.43 percent. The land diverted to non-agricultural activities over a 10 year period from 1999 to 2009 is around 0.2 million ha. This increasing use of land for non-agricultural use and abandonment as fallow lands has contributed to a steadily decreasing cultivated area each year and by as much as 10.2 percent from 1999 to 2009.

Water Resources

The per capita availability of water in the state is very low, at 900 cubic meters as against the All-India level of 1980 cubic meters in 2001. (SPC,2012a[5]). The major irrigation sources in the State are canals, tanks, and wells. The trends in sources of water supply and areas irrigated are shown in Figure 2.3 and Table 2.2 (SPC,2012a[6]). There is a decreasing trend observed in both canals and wells used for irrigation between the period from 1998-99 to 2009-2010.

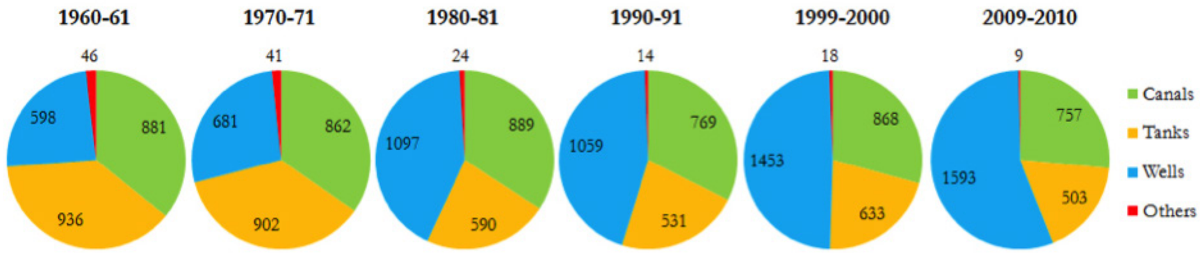


Figure 2.3: Irrigated areas (1000 ha) from canals, tanks, wells and other sources

TABLE 2.2: TRENDS IN AREA IRRIGATED BY DIFFERENT SOURCES IN TAMIL NADU (AREA IN LAKH HA)

VARIABLE	1960s	1970s	1980s	1990s	2000s
Rainfall (mm)	928	932	880	917	969
Area irrigated by					
a) Canals	8.82	8.93	8.23	8.24	7.42
b) Tanks	9.12	8.49	6.07	6.21	5.18
c) Wells	6.44	9.19	10.37	13.14	14.62
d) Other sources	0.41	0.35	0.19	0.17	0.13
Net irrigated area by all sources	24.79	26.36	24.96	27.75	27.36
Gross irrigated area by all sources	32.69	35.23	31.09	33.94	31.02

(Source: SPC,2012a[7])

The net area irrigated by surface flow source has stagnated. Due to the proliferation of wells, the total area irrigated by wells increased from 11.7 lakh ha in 1989-90 to 15.7 lakh hectares in 2006-07, i.e., from 24 to 54 percent of irrigated areas. Proliferation of wells and indiscriminate withdrawal of water has made 10 percent of the wells defunct. While land irrigated by tanks has decreased by 43 percent from 1960s to 2000s, the land irrigated by wells has increased by 127 percent in the same period. However, as seen in Figure 2.3, well irrigation, evolved to reduce dependence on rainfall, is itself affected by deficient rainfall, and in years of prolonged drought even areas irrigated by wells are stressed to varying extents depending on the drop in water levels.

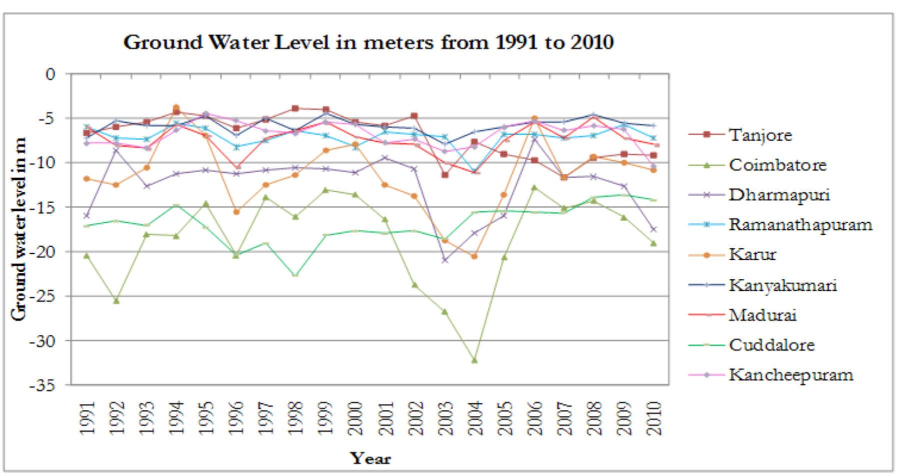


Figure 2.4: Ground Water Level (m) observed in the month of May from 1992 to 2010.

Failure in monsoon and poor aquifer recharge led to excess extraction of ground water for agriculture without proper planning which further affects the ground water table drastically. For example, impact of 2002 drought is seen for next two years in ground water level (Figure 2.4). MPW, 2012[8] report indicates that 80 percent of the available ground water in the State has been harnessed and utilised.

The Mettur reservoir based irrigation system supports around 40 percent of food grain production in the State. The drought impact on reservoirs can be observed due to insufficient water inflows into Mettur dam, which is presented in Figure-2.5. Until 1974, water inflows were not an issue for Tamil Nadu, as inflows were sufficient to manage even drought years. The inflows drastically reduced after 1974 due to construction of upstream reservoirs.

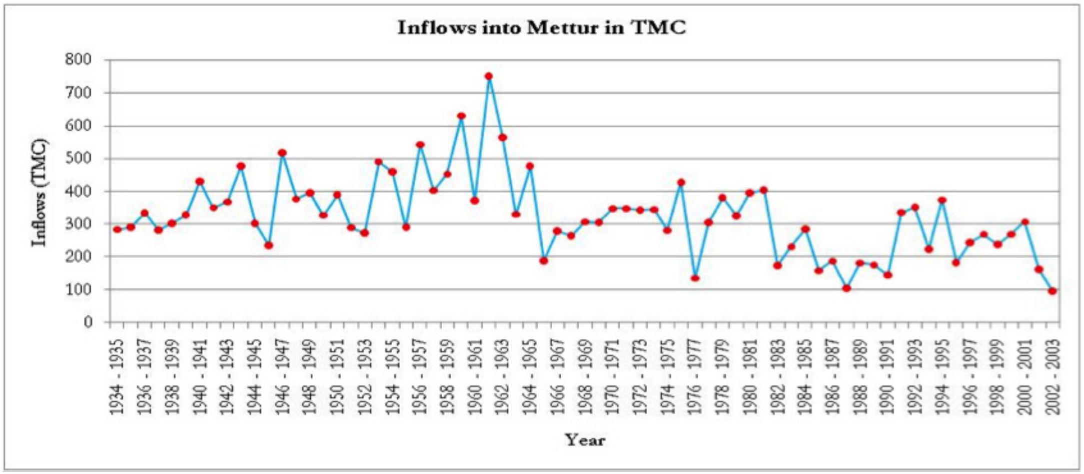


Figure 2.5 – Inflows into Mettur dam from 1934 to 2003 (Drought 2002, Ministry of Agriculture)

Crop subsector

The trends in area of major crops show that there is a significant increase of crops such as Maize, Pulses, and Fruits cultivated in the State. Paddy, Cumbu, Raagi and oil crops are cultivated over lesser areas in recent years compared to 1998-99. Rice, groundnut, sugarcane, cotton, jowar, bajra and pulses account for 73 percent of gross cropped area. Climate sensitive crops such as sugarcane and maize have increased significantly in last six decades (Figure 2.6)

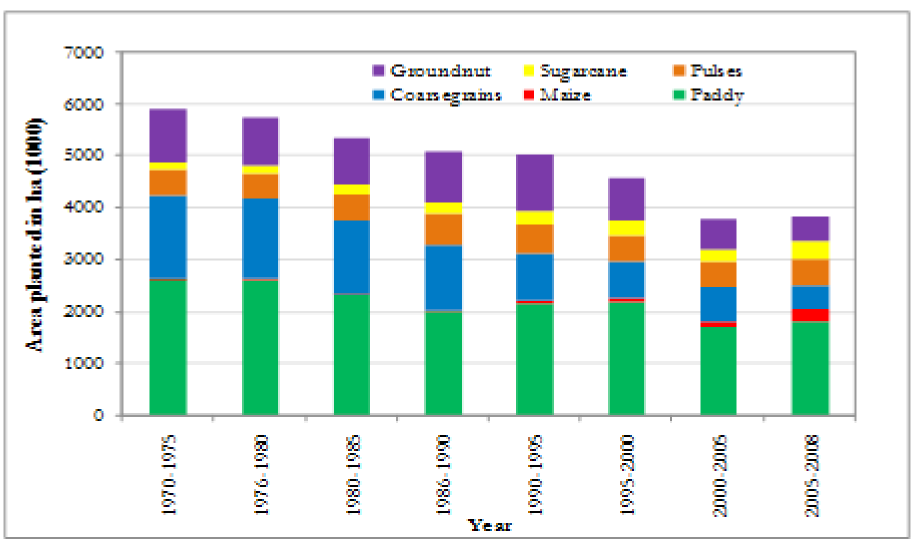


Figure 2.6: Trends in cultivation- shift to climate-sensitive crops (1000 ha)

Area under paddy decreased to 17.89 lakh ha during 2007-08 from 19.31 lakh ha in 1989-90 (Table 2.3). Area under pulses and groundnut has increased. In respect of cotton, area remains almost same. To encourage cotton growers in Tamil Nadu, contract farming is popularized with buy back arrangements, wherein the farmer is provided support in diverse areas such as marketing, input, credit, insurance coverage etc.

TABLE 2.3. STATUS OF PRINCIPAL CROPS IN TAMIL NADU

CROPS	1989-1990		1999-2000		2005-06		2006-07		2007-08	
Area	Area	Yield	Area	Yield	Area	Yield	Area	Yield	Area	Yield
Paddy	19.63	3088	21.64	3481	20.50	2541	19.31	3423	17.89	2817
Pulses	8.21	407	6.92	420	5.25	337	5.36	541	6.09	303
Sugarcane	2.22	104*	3.16	109*	3.35	105*	3.91	115*	3.54	108*
Cotton	2.81	308#	1.78	324#	1.10	260#	1.00	374#	1.00	343#
Groundnut	10.15	1195	7.59	1736	6.19	1775	5.08	1981	5.35	1957

*Area in lakhs ha and Yield in Kg/ha; *in terms of cane" # in terms of lint*
Source: Compiled from various issues of Season and Crop Reports, Government of Tamil Nadu

Productivity trend in paddy, sugarcane, and cotton was almost stagnant. Groundnut productivity has shown marginal increase. Wide variation is noticed in pulse productivity as pulses are majorly grown in rain-fed areas.

Horticulture

Horticulture crops contribute to about 30 percent of the agricultural GDP. Its contribution to State GDP is 3.5 percent (while total agriculture contribution to State GDP is about 12 percent). The area under horticulture was 10.76 lakh Ha (15.5 percent of the total cultivable area in the State), with an annual production of nearly 188 lakh tonnes in 2010-11.

Animal Husbandry

In consonance with climatic conditions, and to manage the climate-related variations in crop production, animal husbandry was taken up by farming households as a coping mechanism. Traditionally cattle and sheep have constituted predominant livestock population until 1950s. In keeping with high demand for meat products, goat population increased but cattle and sheep population decreased. Livestock population increased 24 percent in 2007 as compared to 2004, poultry increased by 48 percent in 2007 as compared to 2004. Of late the poultry industry is gaining importance due to increased demands and these trends are shown in Figure 2.7

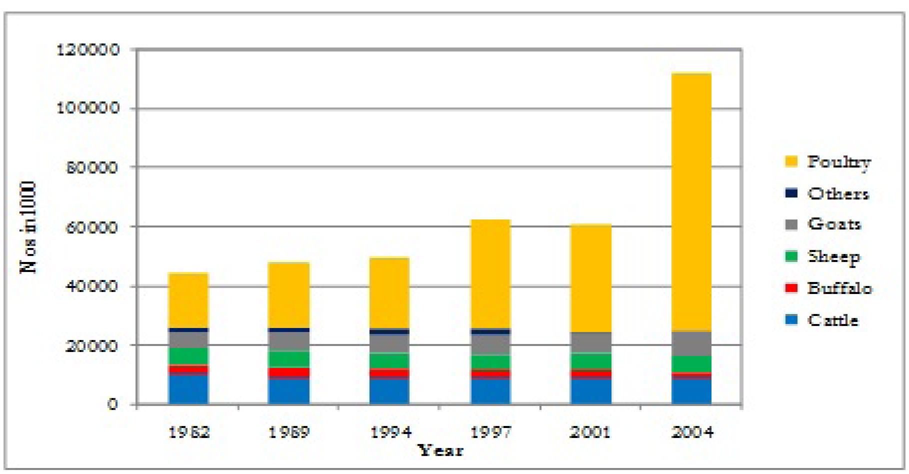


Figure 2.7: Trends in livestock- shift from cattle and buffalo to goats (in 1000s)

Tamil Nadu's poultry population accounted for 17.7 percent of the total poultry population in India.[9] *(Tamil Nadu- An Economic Appraisal 2008-09, Department of Economics and Applied Research, Government of Tamil Nadu)*. Animal husbandry and livestock sector accounted for 2.88 percent of the GSDP. The gross value of output of livestock in the State was INR 22,017.5 crore during 2010-2011 and the annual compound growth rate of value of output is 13.46 percent.

Agriculture and state economy

Since 1960-61, the share of agriculture in the State gross domestic product has been decreasing, and replaced by secondary and tertiary sectors. The agriculture and allied sector provides livelihood to almost 47 percent of 20 million work force (2011) and particularly the rural poor. Hence, despite its meagre contributions (less than 13 per cent) to the State economy, the agriculture sector may be considered as the priority sector for the purposes of the CRM-TASP study.

Agriculture development in Tamil Nadu could be classified into two major era- i) development up to mid 1990s and ii) development after mid 1990s.

Until mid-1990's, rapid growth rate in agriculture sector helped reduce the poverty rate in rural areas from 38.5 percent to 24.3 percent. 56 percent of state's population depends on agriculture sector and more than 7.5 million people derive more than 75 percent of their household income from agricultural wages. Hence agriculture growth rate is key for Tamil Nadu given its importance for rural population. In 1980s Tamil Nadu State Agricultural GDP growth rate went up to 3.4 percent which was more than all India agricultural growth rate of 2.9 percent. Favourable rainfall in early 1990s contributed to higher growth rate of 7.2 percent (between 1989/90 to 1994/95) as compared to all India growth rate of 3.1 percent.

However, after mid 1990s agriculture growth rate was stagnant. Two severe consecutive droughts during 1994-1995 and 1999-2000 pulled the agriculture growth down drastically (1.3 percent/year). Population pressure and urbanization lead to reduction in agricultural land resources after mid-1990s. The cultivable land per rural resident declined from 0.22ha (1971/72) to 0.15 ha (1997/98). Additional factors such as change in land use pattern, change in cropping system, water resource management, seasonal labour shortages and rising real agricultural wages during the past two decades, rapid rural-urban migration affected the growth in agriculture sector. *(World Bank, 2004[10])*

KEY MESSAGES (DEVELOPMENT PROFILE)

- Tamil Nadu scores relatively high among the larger states and economies in India on most human development indices and has one of the lower rates of rural and urban poverty.

- The structural transformation of the State economy to manufacturing and services sector witnessed over past five decades has marginalised agriculture, which contributes less than 12 per cent to the State economy. Along with other factors such as decreasing farm holding sizes, increasing use of land for non-agricultural use, decreasing water availability and subsistence-oriented agricultural practices has also led to agricultural stagnation and distress among the population dependent on it for livelihood.

- Yet over 40 per cent of the population is still dependent on agriculture, of whom 7 million are poor, and the development planning process appreciating this issue has envisioned an inclusive growth providing for a 5 per cent annual growth in agriculture sector.

- The means adopted to achieve this growth, including increasing productivity, crop diversification and use of hybrid varieties is likely to make the sector more climate-sensitive, as 15 per cent annual production loss due to climate factors are witnessed already.

CLIMATE PROFILE

NATIONAL WEATHER AND CLIMATE CONTEXT

Physical features

India has a diversity of climate patterns across its vast area- tropical in southern parts to temperate and alpine in northern part of the country and has four major seasons. Except Tamil Nadu State, most parts of India receive 75 percent of annual rainfall during SW monsoon period.

The State of Tamil Nadu extends from 76°15'E to 80°15' longitude and 8°N to 13°30' N latitude. Geo-physical features that influence the climate in the State are Western Ghats in west, plateau in south & interior and coastal plains in east. The Western Ghats run along the whole length of western boundary with average height of 1200 meters above Mean Sea Level (MSL) with elevation up to 2500 meters MSL acting as a formidable barrier for penetration of rain-bearing SW monsoon winds and ensuring that almost entire Tamil Nadu landmass falls on its leeward side. The proximity of sea influences the climate of eastern and southern parts of State whereas hilly orography and inland location are important factors in modifying the climate over rest of the State[11] (IMD, 2008). The eastern and interior regions are benefitted by NE monsoon which provides, for majority of the farmers, water for their agriculture production. The monthly climatology (Figure-3.1) indicates dependence on NE monsoon for rainfall.

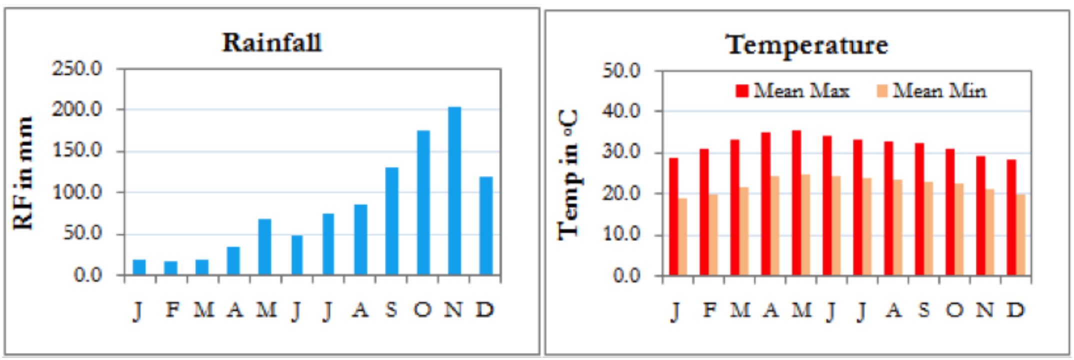


Figure 3.1- Rainfall and Temperature Climatology of Tamil Nadu

Temperature

Temperature in Tamil Nadu reaches its peak in the month of May (36°C). Winter (Jan-Feb) temperature is relatively lower than other months of year and average minimum temperature goes down to 19-20°C. Then it gradually increases in March and reaches its peak in May (Figure 3.1). The annual mean maximum temperature fluctuates between 28.7°C to 36°C and the annual mean minimum temperature fluctuates between 19.5°C to 25.5°C. The spatial distribution of mean maximum and mean minimum temperature shows that interior and western districts are cooler than the coastal, north and north eastern regions of Tamil Nadu largely because of Western Ghats.

Rainfall

The SW monsoon contributes significant rainfall in only 3 out of 32 districts due to absence of influence of western mountain ranges. For the rest (29 districts), NE Monsoon is the principal source of rains. The State receives average rainfall of 533.8 mm during SW monsoon and 502 mm during NE monsoon season. However there is huge spatial and temporal variability of rainfall distribution in Tamil Nadu. Because of the non-uniform pattern of rainfall, some districts receive deficient rainfall even in the normal years. Spatial distribution of rainfall over northeast and southwest monsoon season is presented in Figure 3.2. Figure 3.3 shows the variability of maximum SW and NE monsoon rainfall for the period 1971 to 2005 and captures clearly the significant spatial variation of rainfall over the districts.

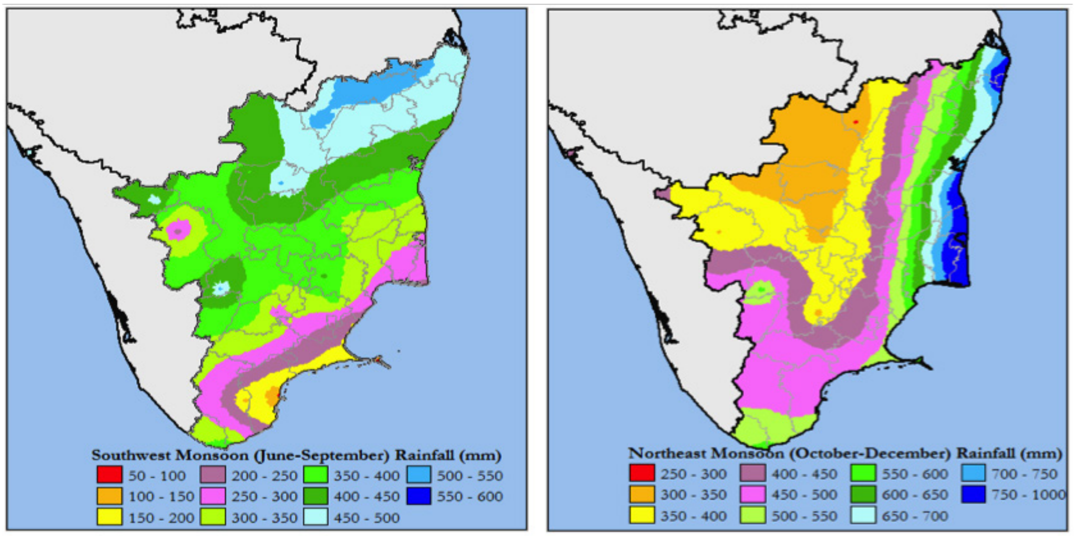


Figure 3.2: Rainfall pattern over SW and NE monsoon in Tamil Nadu (1971 to 2005)

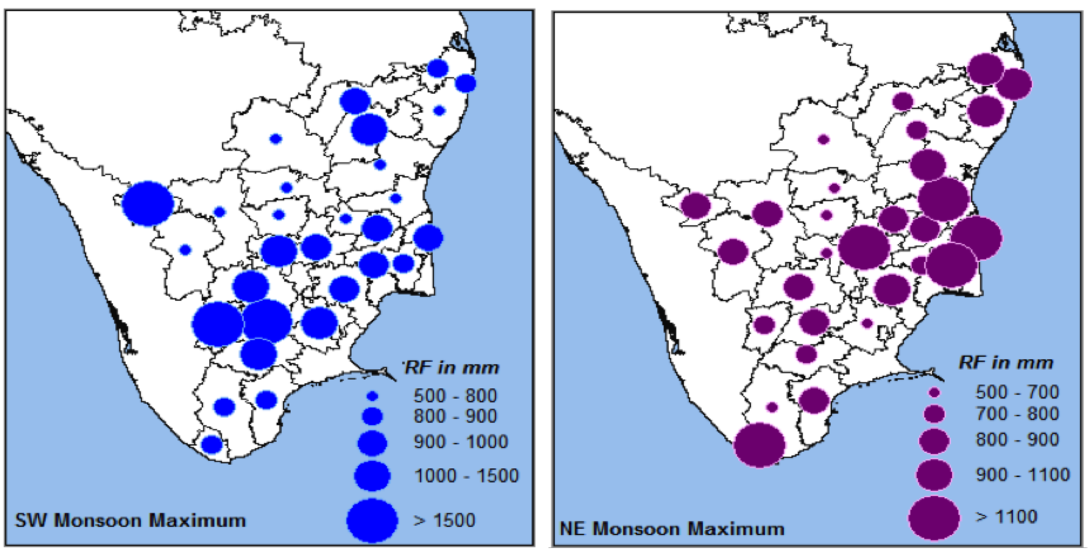


Figure 3.3: Spatial Variability of Maximum rainfall in NE and SW seasons

CURRENT CLIMATE VARIABILITY AND CLIMATE EXTREMES

ITCZ, SW Monsoon, NE Monsoon, depressions, cyclonic storms and thunderstorms are major drivers of climate variability in Tamil Nadu. Madden Julian Oscillation, Indian Ocean Dipole and ENSO influences these drivers on an intra-seasonal, inter-annual and decadal scales. Discernible synoptic patterns are linked to regional and global climate drivers (IOD, ENSO) which bring rain-bearing systems to Tamil Nadu.

Temperature

Long term temperature variability from 1901 to 2005 is presented in Figure 3.4 showing year to year variation especially in winter and monsoon seasons. Winter (Jan-Feb) and Summer (March-May) temperatures show an increasing trend.

Rainfall

Analysis of rainfall over the nine agro climate zones in Tamil Nadu indicate that the coefficient of variation of rainfall is observed to be extremely high- both spatially and temporally- in all the nine zones.

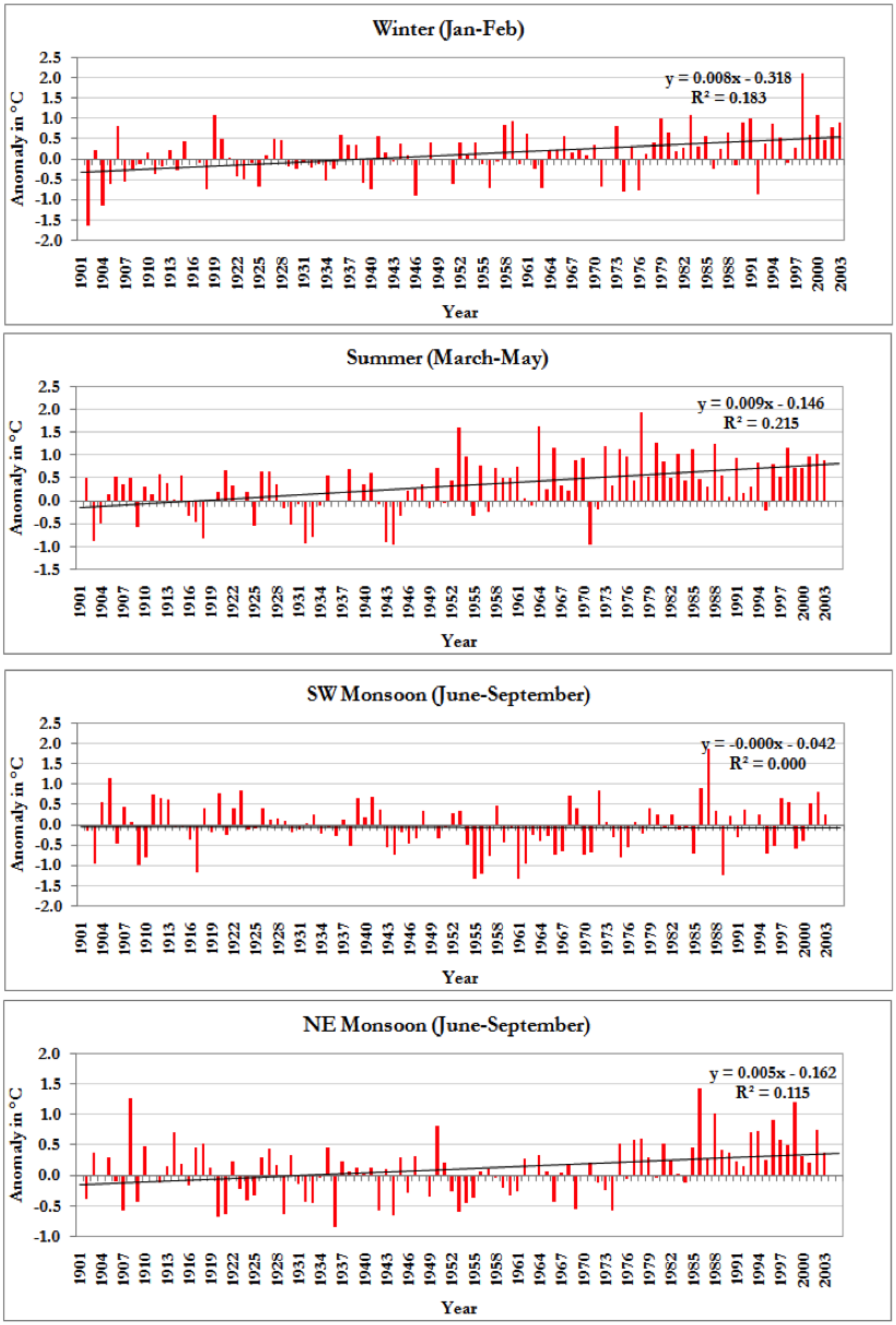


Figure 3.4: Mean Temperature Anomalies for four seasons for the period 1901-2005 in Tamil Nadu

Spatial variability of extreme rainfall events is shown in Figure 3.5 which depicts the variation in the extremes among the districts, which seems to be unevenly distributed. The coastal and western districts display the significant extremes.

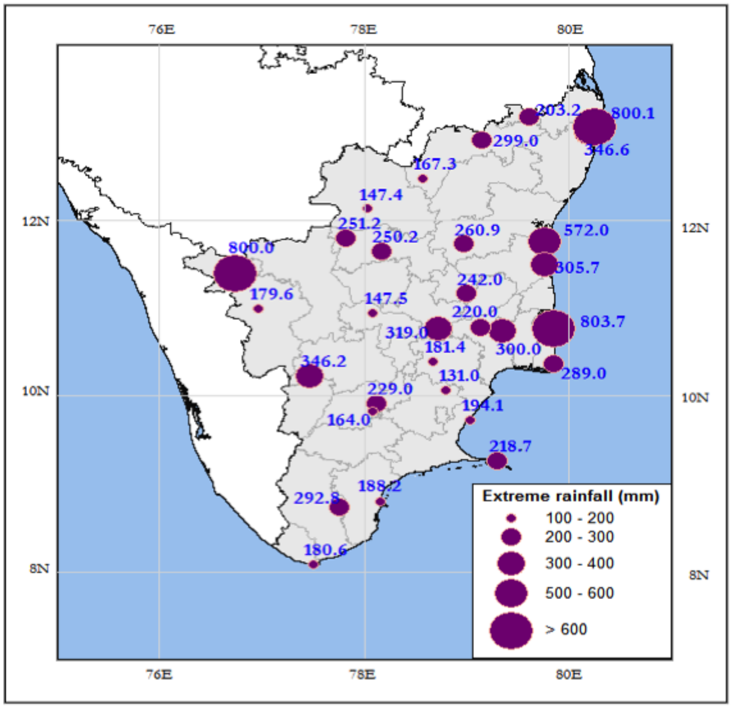


Figure 3.5: Spatial Variability of extremes.

SW (South West) Monsoon

The onset of SW monsoon is generally in June first week and the withdrawal period from second week of October. ENSO could influence rainfall on an Inter-annual scale with below normal rainfall years during El Niño and above normal years during La Niña. Figure-3.6 shows inter annual variation of SW monsoon rainfall from 1901 to 2006. From 1900-2006, excess SW Monsoon rainfall has occurred in 40 years and deficit in 28 years.

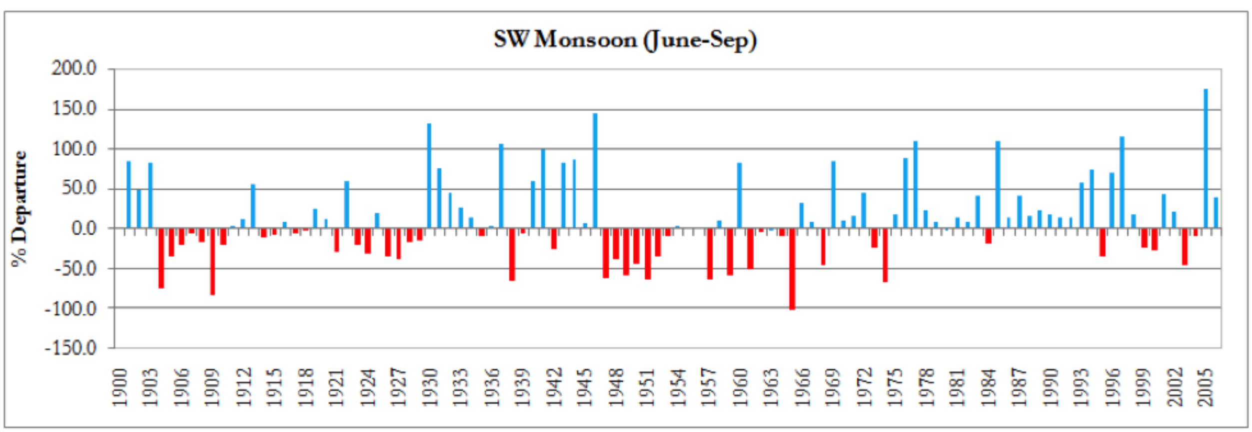


Figure 3.6: SW Rainfall anomaly from 1901 to 2006 in Tamil Nadu

The deviation in monsoon onset dates for 1941-2000 is higher than 1971- 2000[12]. (Mazumdar et al 2001). The variability in the withdrawal of monsoon has been greater during the first 30 years period as compared to the latter half, in temporal as well as spatial scales[13]. *(S. D. Attri and Ajit Tyagi, 2010)*

NE (North East) Monsoon

During October-December, cyclonic storms and depressions over Bay of Bengal are less frequent, which make possible heavy rainfall episodes in Tamil Nadu and thus this season accounts for large part of total rains. 93 percent of El Niño years are associated with either normal or excess rainfall years in Tamil Nadu. Changes in zonal wind to easterly bring excess or normal rains on 80 percent of occasions. Positive Indian Ocean Dipole also favours normal or excess rainfall. Figure-3.7 shows inter-annual variations of NE monsoon rainfall. From 1990-2006, excess NE Monsoon rainfall has occurred in 36 years and deficient in 28 years.

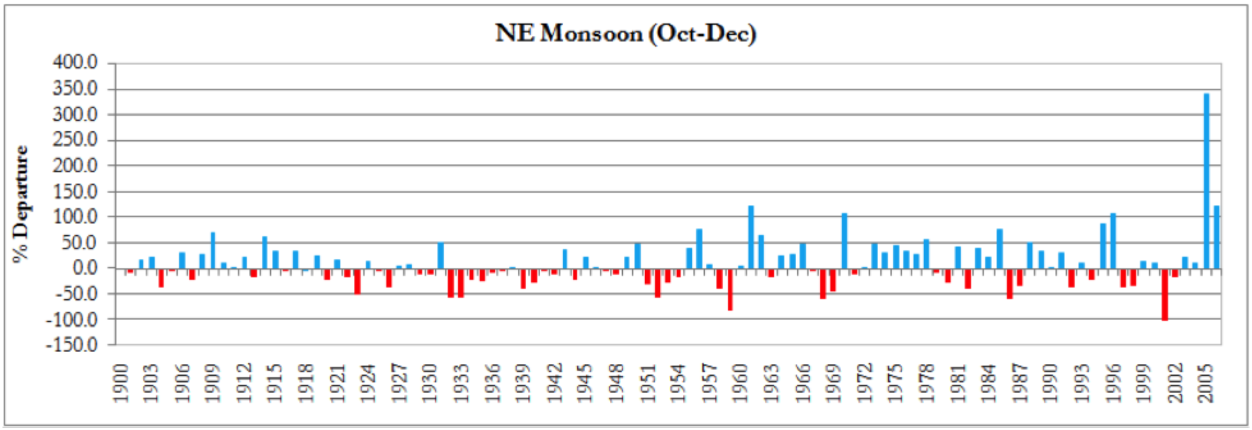


Figure 3.7: NE Rainfall anomaly from 1901 to 2006 in Tamil Nadu

Cyclonic Storm

During September and October, increased incursion of moisture brought in by approaching NE monsoon thunderstorm activity brings rains particularly in coastal zones. Inter annual variation of thunderstorm activity is very high, ranging from 50 to 140 pervent in different parts of the State. The annual variability of cyclones and severe cyclones crossing Tamil Nadu is presented in Figure 3.8.

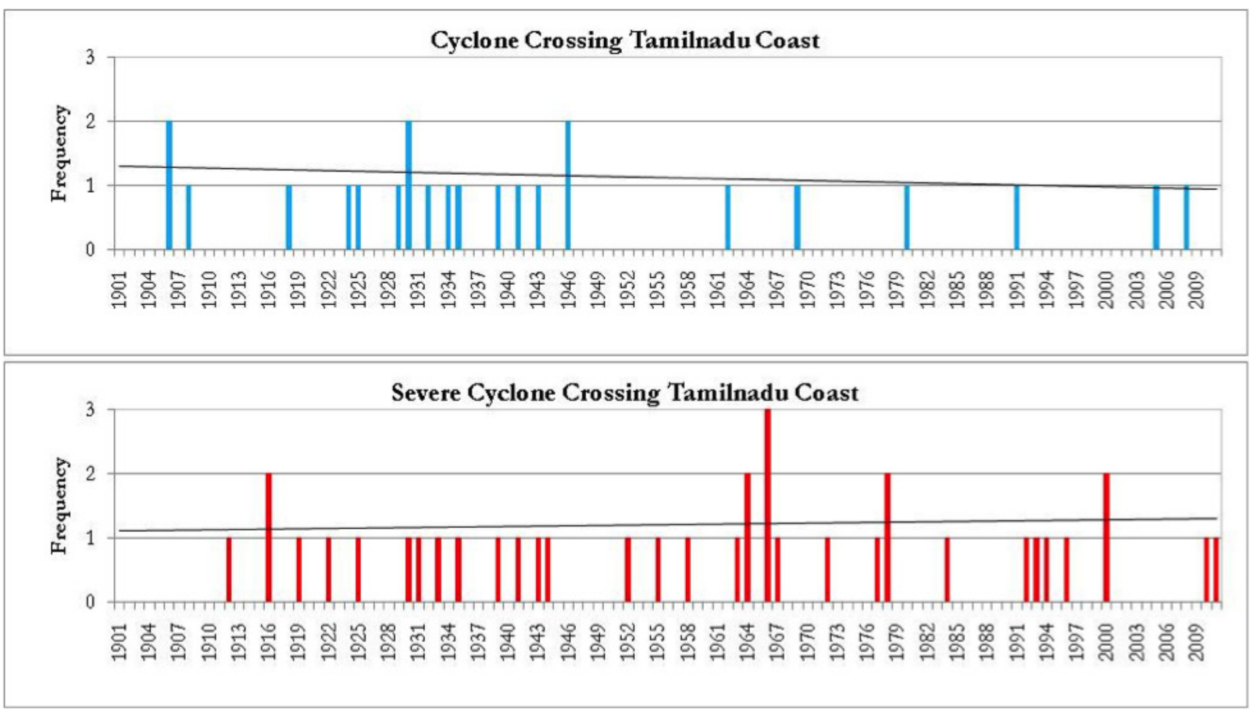


Figure 3.8 - Annual frequency of (a) Cyclones and (b) Severe cyclones (IMD, 2012)

Tropical Cyclones cross the Tamil Nadu coast mainly during the post-monsoon season with an increasing trend towards cyclonic storms intensifying into severe cyclonic storms. *(S. D. Attri and Ajit Tyagi, 2010)*

Climate hazards

Tamil Nadu is exposed to various climate hazards such as cyclone, heavy rainfall, flood, drought, landslides etc., which affect various sectors, predominantly agriculture. DESINVENTAR disaster records for the period 1951-2010 are presented in Figure-3.9.

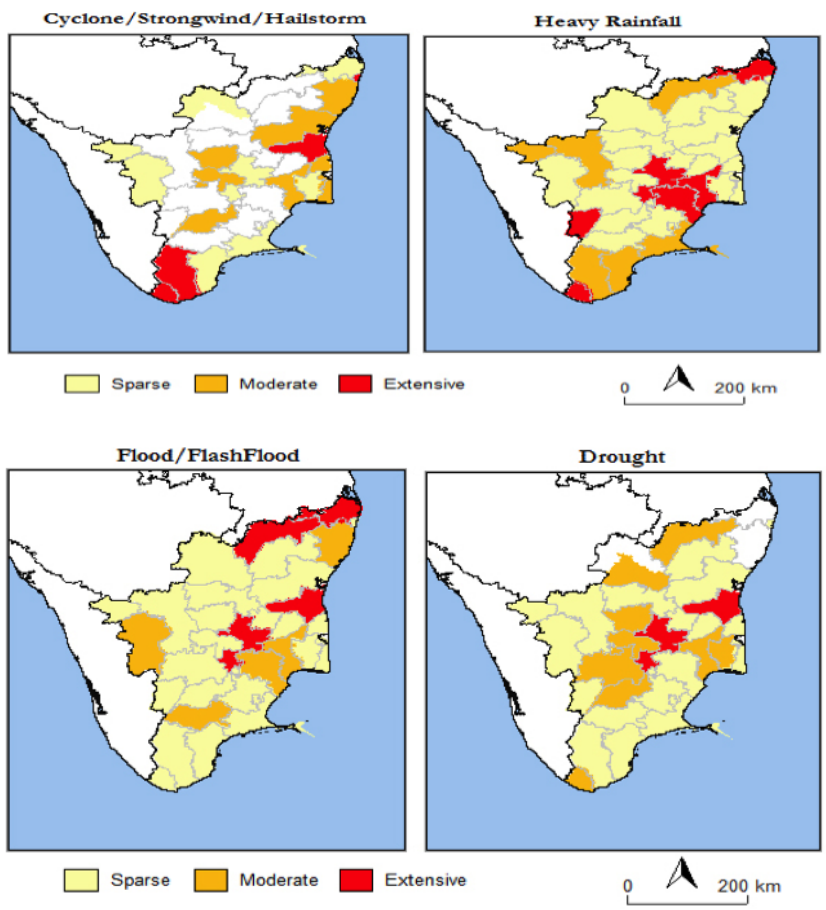


Figure 3.9–Districts affected by disasters in Tamil Nadu- 1951 to 2010 (DESINVENTAR, 2011[14])

Tropical storms and cyclones - Tropical storms and cyclones that make landfall in Tamil Nadu originate primarily from Bay of Bengal with a few from the Arabian Sea. The peak of cyclonic activity occurs during May, October and November. Cyclonic tracks and monthly distribution of cyclonic activity from 1951 to 2010 are in Figure-3.10

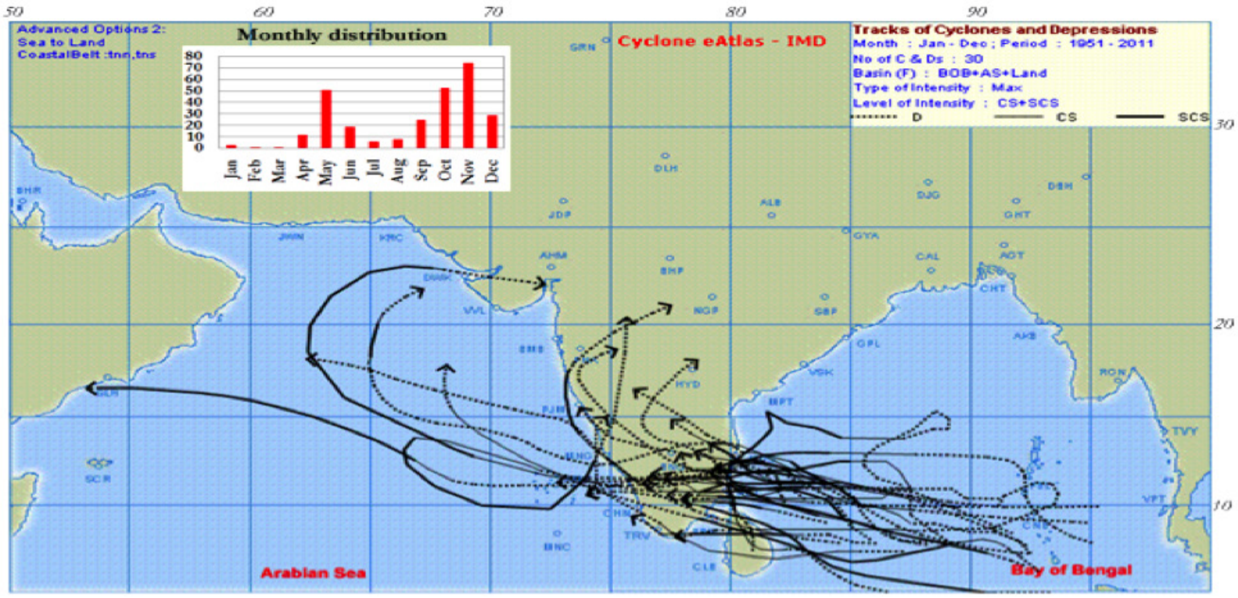


Figure 3.10 – Tropical Cyclone tracks over Tamil Nadu (1951-2011) (IMD, 2012[15])

Heavy rainfall and floods

Torrential rainfall events are always associated with cyclonic activity or meso-scale influences such as heat convection, thunderstorm activity and have severely impacted crops, triggered landslides and caused floods in many district in the past, mostly during NE monsoon period (especially October to December) and some during SW period. Eastern coast and central parts have been affected more often than other areas, consistent with higher rainfall during NE monsoon as well as peak cyclonic periods in this area.

Droughts

Droughts are recurrent phenomenon which happen when rainfall during SW monsoon is scanty or below normal in Tamil Nadu. Most of the water inflow to dams in Tamil Nadu is from river systems in neighbouring states, which depend on SW monsoon. Tamil Nadu receives normal rainfall over Northeast monsoon whereas SW monsoon recurrently yields deficit rainfall, which affects the Cauvery delta region. Tamil Nadu has 8 drought-prone districts covering about 64percent of the total area of the State viz. Coimbatore, Dharmapuri, Kanyakumari, Madurai, Ramanathapuram, Salem, Tirunelveli, and Tiruchchirappalli[16]. (K. K. Nathan, 1998)

Other hazards

A range of other hazards also impact Tamil Nadu- landslides occur regularly in the context of heavy rainfall caused by tropical cyclones. Some parts of Nilgiris districts are susceptible to landslides. Heat waves have also affected a few districts in the past.

OBSERVABLE CHANGES IN CLIMATE VARIABLES AND HAZARD

Temperature

The observed mean temperature anomalies are indicated under section 3.2.1 and Figure-3.4 above.

Rainfall

Southwest Monsoon

The onset date of monsoon is observed to show increasing trends over southern parts of India. Decadal and epochal variability analysis indicates that there is a 30 years periodicity in onset, withdrawal and duration of the monsoon. *(S. D. Attri and Ajit Tyagi, 2010)*

Northeast Monsoon

There is an increase in rainfall over the Tamil Nadu (0.265mm/year). Overall, there is a modest increase in the NEM seasonal rainfall over the eastern coast which includes Tamil Nadu and a very modest decrease in the seasonal rainfall over the western side that is Kerala and some parts of Karnataka. *(S. D. Attri and Ajit Tyagi, 2010)*

Extremes (Cyclonic Storm)

Long term linear trend in the frequency of tropical cyclones over the north Indian Ocean, the Bay of Bengal and the Arabian Sea for different seasons and annual, generally, shows a significant decreasing trend [17](Srivastava et al.2000; [18]Singh et al. 2000). However, an increasing trend in the frequency of tropical cyclones over the Bay of Bengal in the months of May and November is observed. [19](Singh, 2001).

A slightly decreasing trend in the annual frequency of cyclones that formed over Bay of Bengal during 1900-2009 is seen, but a slight increasing trend in the annual frequency of severe cyclones is seen. There is an increasing trend in the intensification of cyclones to severe cyclones as indicated in Figure 3.8 at page-25 above.

Trends in Coastal, Central and Western Zones of Tamil Nadu

Observable climate trends have been analysed using climate data for the period 1970 to 2010 for three station locations- Cuddalore (representing Coastal), Coimbatore (representing western), Trichy (representing central) and presented seasonal trend in Table-3.1

TABLE 3.1 SEASONAL TRENDS OF RAINFALL IN TAMIL NADU

SEASON	COIMBATORE (MM/DECADE)	CUDDALORE (MM/DECADE)	TRICHY (MM/DECADE)
Southwest Monsoon	-2.61▼	0.34▲	1.67▲
Northeast Monsoon	-1.20▼	-6.79▼	0.03▲
Annual	10.86▲	4.26▲	7.86▲

Trends: ▲ Increasing trend / ▼- Decreasing trend

Extreme events: Extreme events analysis focusing on number of rainy days with more than 30mm and maximum rainfall in a year has been carried out for the period 1976 to 2005 for the three stations and results summarized in Table-3.2. Number of rainy days in a year which receives more than 30mm shows the decreasing trend for Coimbatore and increasing for Cuddalore and Trichy. Though seasonal rainfall quantity is decreasing, one day extremes show an increasing trend.

TABLE 3.2 TRENDS OF EXTREME EVENTS

ANALYSIS	COIMBATORE	CUDDALORE	TRICHY
No .of days receiving rainfall >30mm in a day (no. of days/decade)	-0.04▼	0.02▲	0.07▲
Daily Maximum rainfall in a year (mm/decade)	0.39▲	1.17▲	0.99▲
Consecutive dry days (no. of days/decade)	0.35▲	0.26▲	0.21▲
Consecutive wet days (no. of days/decade)	0.03▲	-0.10▼	-0.01▼
Maximum 5 days rainfall in a year (mm/decade)	-0.17▼	2.36▲	1.98▲

Trends: ▲ Increasing trend / ▼- Decreasing trend

PROJECTED CLIMATE TRENDS

Temperatures and rainfall

GCMs GFDL and HadCM3 climate projections for three scenarios A1B, A2 and B1 are as tabulated in Table-3.3 for three time slices 2020, 2050 and 2080.

TABLE 3.3 CLIMATE PROJECTIONS FOR TAMIL NADU

MODEL	TIME SLICE	ANNUAL MEAN SURFACE AIR TEMPERATURE CHANGE IN °C			ANNUAL PRECIPITATION CHANGE IN %		
		A1B	A2	B1	A1B	A2	B1
GFDL	2030	0.85	0.86	1.82	-0.32	-5.91	0.54
	2050	1.82	1.71	1.94	-7.48	-1.10	4.29
	2080	2.57	3.02	2.09	0.41	0.76	-3.64
HadCM3	2030	1.25	0.93	1.19	-12.07	-2.62	-13.98
	2050	2.36	2.69	1.84	-8.21	-24.04	-11.59
	2080	3.69	4.19	2.77	-20.71	-21.09	-19.42

For 2030, temperature increases of 0.9 to 1.3°C can be expected for most of the State, and annual precipitation will be reduced by around 0.3 percent to -14 percent. By 2050, warming will reach 1.82 to 2.7°C, and expected annual precipitation reductions range between 8.2 and 24.0 percent. By the 2080s warming could reach 2.1 to 4.2°C, and rainfall could decrease by 19.4 percent to 21.1 percent. For all time horizons and scenarios, warming trends are generally seen from temperature parameter.

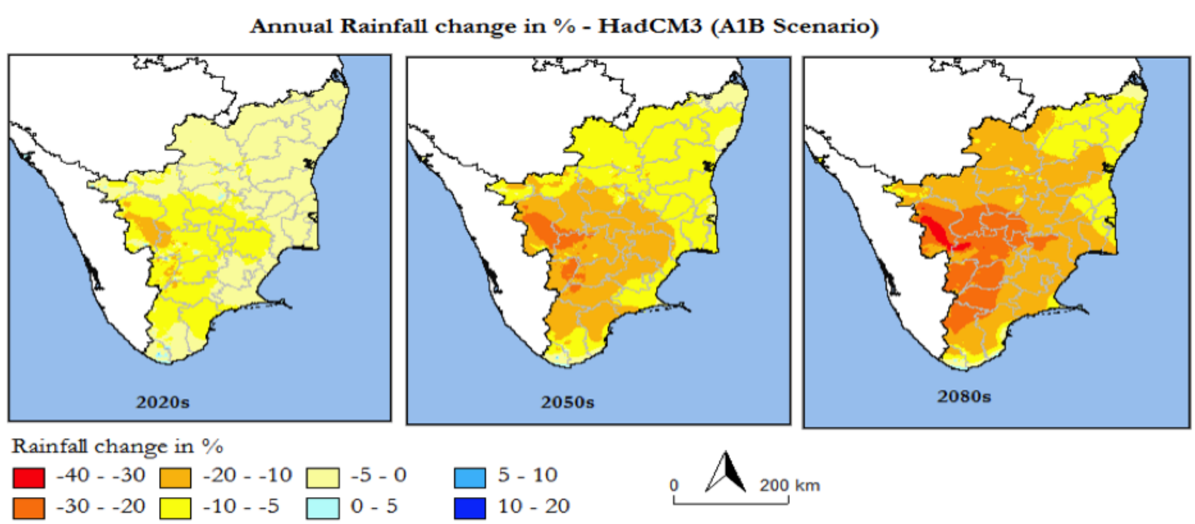


Figure 3.11 Climate Projections for the years 2020, 2050 and 2080 for Tamil Nadu (CIAT, AR4[20])

Figure-3.11 shows the 10km resolution precipitation departure from HadCM3 –A1B scenario model runs for three time slices 2020, 2050 and 2080. The precipitation departure shows rainfall decrease throughout Tamil Nadu and highlights the challenge for areas dependent on SW monsoon. But coastal districts show less departure which might be a sign of having stable NE monsoon season.

Sea level rise

Asian Development Bank, 2011[21] report indicates that in the short to medium term, sea level could rise by 0.3m as per IPCC AR4 upper envelope projections. However, Sea Surface Height (SSH) from the three scenarios (A1B, A2 & B1) of ECHAM5 model (Figure-3.12) shows that SSH is fluctuating between 0.5 to 0.7m for the period 1961 to 2100. Hence more in-depth studies have to be undertaken to model sea level rise over Tamil Nadu Coast.

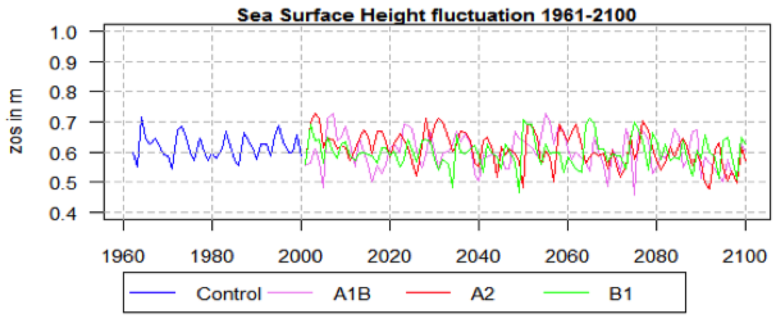


Figure 3.12 - SSH projection for Tamil Nadu (WCRP's CMIP3[22])

STATUS OF CLIMATE AND HAZARD INFORMATION AT NATIONAL AND REGIONAL LEVELS

Given the very high variability reflected in CV ranging from 30 percent to 140 percent in different parts of the State, the density of observation is inadequate to assess the local climate patterns. The number of observatories having historical datasets is limited. Tamil Nadu Agricultural Weather Network (TAWN) has installed 224 AWS, at local (block) level in the last decade but these cannot be used to make long-term climate projections. Existing observatory records have undergone quality checks and gridded data has been generated at 1°X1° and 0.5°X0.5° resolution by National Climate Data Center, Pune for scientific use. Even after considering these efforts there is a need to enhance the observation network, as:

- The analysis of climate data to develop climate information products to meet location specific diverse user requirements is limited;
- The medium term weather forecast for generating location user specific information is limited;
- The seasonal forecasts application for resource management is limited.

Climate projections rely on global circulation models (GCMs) depicting different climatologies and it is always associated with uncertainties. However, regional models at higher resolution were run on project basis and impact assessments were carried out by institutes like TNAU and IPRC. But this study did not explore RCMs because all climate projections shows warmer trend and decreased precipitation. This study addressed broader picture of climate and its change in future which might serve as input for climate sensitive sectors at State level. The projections of extreme events have not been carried out, as the GCM themselves have uncertainties in projecting the climatological cycle.

KEY MESSAGES (CLIMATE PROFILE)

- Tamil Nadu receives an average annual rainfall of less than 800 mm in two distinct monsoons- South West Monsoon contributing 36 percent and North East Monsoon contributing 60 percent.
- Variability of the monsoon is very high (CV is more than 50 per cent) bringing high risk for agriculture and water resources. Consecutive droughts spread over two to three years are possible once in two decades, while cyclonic/ severe cyclonic storms could be possible once in 3 years. Flooding, heavy rainfalls could occur along river courses and in coastal zones.
- Temperature shows an increasing trend. No significant trend is seen in rainfall patterns especially with regard to SW monsoon. However, NE Monsoon could have increased rainfall at the rate of 2.65 mm per decade. No significant trend is seen in the sea level rise in the next two to three decades. Number of cyclonic storms is decreasing and pressure lows are on increasing trend.
- As per the latest SREX Report by IPCC, natural climate variability would be a major factor in shaping future extremes in addition to anthropogenic climate change *(IPCC, 2012)* in the next two to three decades.

CLIMATE IMPACTS AND RISKS FOR AGRICULTURE

PAST CLIMATE IMPACTS

In Tamil Nadu, about 49 percent of workers depend on agriculture sector for livelihoods [23]*(Department of Economics and Statistics, 2011)*. Climate related hazards affecting agricultural sector directly impacts the production as well as livelihood of this huge population involved in agricultural sector.

Droughts

Twenty three districts out of thirty districts are drought prone [24]*(UNDP, 2009)*. The primary impacts of drought relate to loss of crop, dairy and livestock production, reduced crop yields, wind and water erosion of soils and increased levels of poverty.

Impact on Land use pattern

Farmers leave land uncultivated mainly due to insufficient rainfall. During severe drought years, 1.5 million hectares representing 10 percent of cultivable lands are left uncultivated. Even in years with sufficient rainfall, 0.5 percent of land remains uncultivated due to huge spatial variability of rainfall in the State. The impact of drought on land use pattern is shown in Table 4.1.

TABLE 4.1: RAINFALL IMPLICATION IN FALLOW LAND

YEAR	RAINFALL IN MM	DEFICIT % TO NORMAL	CURRENT FALLOW AREA (MILLION HA)	% TO TOTAL AREA
2000-01	874	(-)19.8	1.134	8.7
2001-02	775	(-)18.4	1.026	8
2002-03	748	(-)20	1.505	11.5
2003-04	868	(-)7	0.954	7.3
2004-05	1226	(+)32	0.692	5.3
2005-06	1304	(+)36	0.751	5.8

Source: Season and Crop Report of Tamil Nadu 2005-06 [25]

Impact on Water resources

The drought impact on reservoirs can be observed due to insufficient water inflows into Mettur dam discussed under Chapter-2, section-2.3.2 and Figure-2.5 above. The minimum inflows before 1974 are comparably to most of the years after 1974. Drought impacts the tank irrigation systems, which is used widely in Tamil Nadu. Further, insufficient surface water leads to reliance on ground water.

Impact on Crops

Over the last few decades area of land under paddy cultivation shows a decreasing trend due to diversion of paddy lands to other crops as well as used for non-agricultural purposes. During severe drought years the production could fall more than 40 percent. (Figure 4.1)

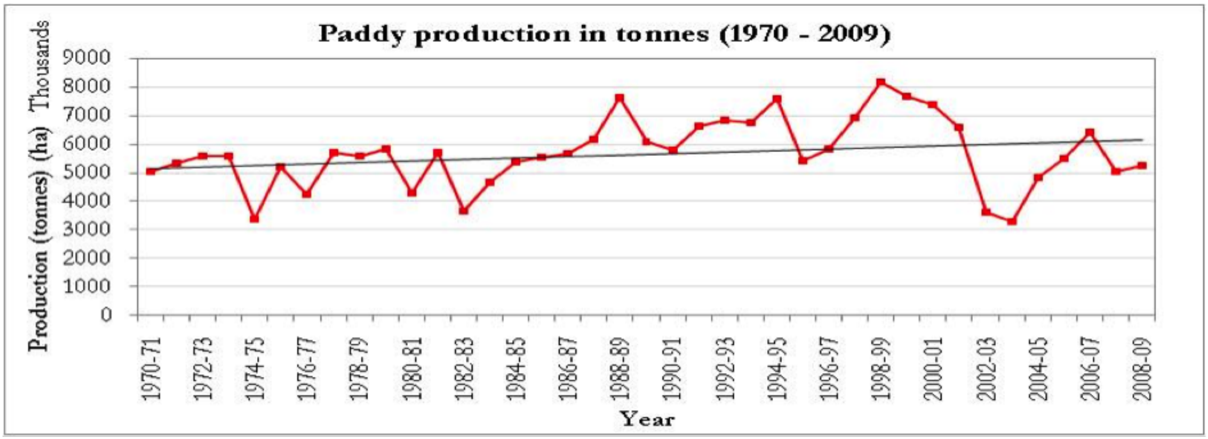


Figure 4.1 – Paddy production in tonnes from 1970-2009

Impact on State Income

Before 1990, agricultural and allied GSDP was closely linked with rainfall, i.e., increased rainfall led to rise in GSDP while decreased rainfall was associated with fall in GSDP. This trend has changed after 1990s, even with positive rainfall agriculture GSDP response is not positive as it should be (Figure 4.2)

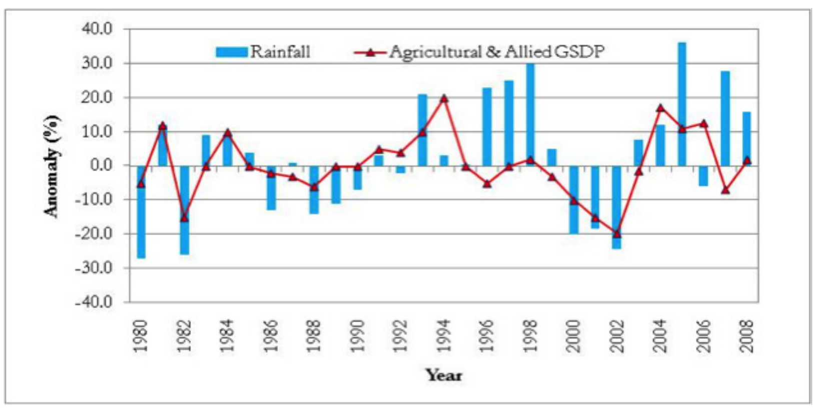


Figure 4.2: Rainfall deviation and its impact on Agricultural & Allied GSDP (DES[26])

A detailed case of drought 2002 is presented in Box 4.1

BOX 4.1 CASE STUDY – DROUGHT 2002

Drought 2002 was a very severe event that impacted all the sectors in the State because of failure of both the SW and NE monsoon in the same year. Though NE is predominant for the State, SW monsoon contributes water inflow into Mettur dam, which is used for irrigating Cauvery delta region. Hence failure of both monsoons poses high risk for the State. Summary of Drought 2002 impacts is given in Table-4.2

TABLE 4.2: IMPACT OF DROUGHT 2002 IN TAMIL NADU

SECTORS	IMPACT	
Surface water	16 Major reservoirs had less storage than previous years. Inflow to Mettur was the lowest in past 70 years.	
Groundwater	Water table went down by average of 2 to 10 m, and in some districts it went down by 20m.	
Drinking water	16.5 Million people all over the State were affected	
Crop Loss	Summer Season (Jun-Oct) Paddy - 236.31 Million USD Millets - 37.78 Million USD Pulses - 16.05 Million USD Oilseeds - 133.43 Million USD Cotton - 9.37 Million USD Sugarcane - 11.42 Million USD	Winter Season (Nov-Mar) Paddy - 554.41 Million USD Millets - -25.11 Million USD Pulses - 11.67 Million USD Oilseeds - 6.95 Million USD Cotton – 94.2 Million USD Sugarcane - 76.15 Million USD
Horticulture crops	Horticulture crops – 3,27,803 MT (Summer) & 3,99,465 (Winter). Loss worth 83.2 Million USD Coconut trees: Fully damaged: 1.1 Million & Partly damaged: 2.79 Million	
Livestock	Shortage of water and fodder affected 9.36 Million Cattle and 2.71 Million Buffalo. Milk production was down by -7.37 percent Cattle death due to viral and bacterial diseases.	
Hydro power	Total loss of 2300MU because of less inflow into Mettur dam, 153.33 Million USD spent for purchasing power from alternate sources	
Urban and Rural Developments	Loss in agricultural income affected people in rural areas. Migration of population from rural to urban areas increased unemployment. Distress sale of lands for non-agricultural purposes ensued.	
Agro Processing Industries	Rice mill, Coconut and Coir products manufacturing and vegetables processing etc., were affected because of deficit in raw material production	

Source: Drought 2002, Ministry of Agriculture [27]

Floods

Riverine plains and places which receive torrential rain (uncommonly exceeding thresholds) are prone to floods in Tamil Nadu. Flood in 2005 was one of the worst disasters in Tamil Nadu. Due to continuous influence of various low pressure areas/deep depressions along the Bay of Bengal in October and November, the State experienced intense torrential downpour repeatedly that caused loss of human lives (497) and cattle (1,520) and damaged over 300,000 houses in 22 districts of the State. Northern, Coastal and Delta region are more vulnerable to flood episodes (Figure4.3).

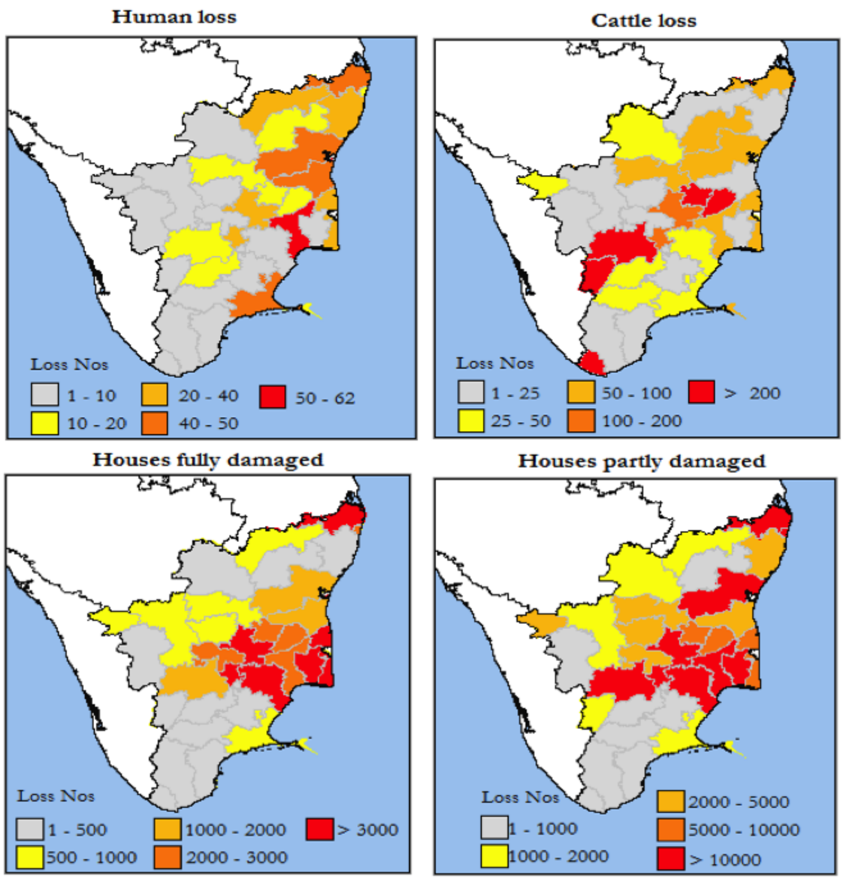


Figure 4.3 - Impact of 2005 Floods in Tamil Nadu

Tropical Cyclones

Cyclones making landfall in Tamil Nadu is a once in two years phenomenon leading to loss of lives and economic prosperity. Two of the severe cyclones to have hit Tamil Nadu badly occurred in 1964 (wiped out Dhanushkodi Island, killed thousands of people with the place not being habituated since then due to submergence and washed away a train killing all passengers etc.) and Cyclone Thane in 2011, the strongest tropical cyclone of 2011 with wind speeds of 140 kmph leaving thousands of people homeless, affecting the livelihood activities of people in Cuddalore and Villupuram districts and damaged all cashew and jackfruit trees grown over large areas in Cuddalore district, as growing trees to maturity would take another 20 years.

FUTURE CLIMATE IMPACTS

Future climate impacts for a number of important sectors have recently been identified and prioritized in the First and Second National Communication to the UNFCCC[28] *(NATCOM, 2004 & [29]2008)*. Water, agriculture, forests, marine and coastal systems, human health and infrastructure sectors are considered vulnerable to changing climate. The projected climate change is likely to adversely affect the water balance in different parts of India and quality of ground water along the coastal plains in Tamil Nadu. The annual number of rainy days for the period 2041-2060 is decreasing and overall increase in the highest one-day rainfall (20cm/day) over a major part of the India, including Tamil Nadu, is indicated from the projected scenarios. Specific to Tamil Nadu, ADB report (ADB, 2011) emphasized that in addition to the existing coastal zone problems, climate variability and climate change could lead to increased rainfall, rainfall intensities, sea level rise and severe cyclones making it even worse because of erosion, flooding, biodiversity threats, impact the estuarine rivers and salinity freshwater balance in Tamil Nadu. ADB, 2011 study indicates that Cauvery delta sandy beaches are experiencing erosion and increased sea level adds threat to the beach profile because it is likely to adjust by shifting landwards and upwards by removing sediment from the shoreline and depositing the removed sediment in the near shore zone.

Land-use

Droughts, floods, tropical cyclones, heavy precipitation events, hot extremes, and heat waves are known to negatively impact agricultural production and the livelihood of the farmers. Decreased precipitation and increasing temperature trends pose a huge threat for the water sector which in turn affects agricultural sector. The projected variability in precipitation can impact the irrigation needs and consequently increase electricity demand in agriculture sector. Simulations using dynamic crop models indicate a decrease in duration of cropping season and their yields, as temperatures increase in different parts of India between 2010 and the 2070s. *(NATCOM, 2004 & 2008)*

Water Resource

NATCOM, 2008 study indicates that Cauvery river basin is likely to experience seasonal or regular water stressed conditions. An increase of 2.7 percent rainfall is projected over Cauvery basin, but the runoff is projected to reduce by 2 percent due to increasing temperature and/or change in rainfall distribution. Hence, the severity of droughts is likely to increase by the 2050s. Salinity and ground water recharge is likely to reach critical thresholds as weaker SW monsoon will lead to higher ground water demand.

Crop sub sector

A study from Tamil Nadu Agriculture University indicates that the yields of rice over Cauvery delta zone simulated by DSSAT for ADT 43 rice variety shows decrease in production, of 356 Kg per hectare in ten years time. The results from another model PRECIS shows the decline of 217 Kg per hectare in ten years time for RegCM3 output. The report indicates that this reduction in yield might be mainly due to increase in both maximum and minimum temperatures as well as variation in rainfall. [30]*(Geethalakshmi et., al, 2012)*

Horticulture

Erratic rainfall, general warming and enhanced biotic and abiotic stresses might impact horticulture crops. Crops such as mango, cashew is likely to face negative impacts. Positive impacts of climate change on coconut yield are predicted in parts of Tamil Nadu in 2050 (Ghosh, 2012[31])

Animal Husbandry

Increasing temperature is likely to affect milk production as existing temperature variations, especially during drought years, significantly affect milk production and milk yield rate.

Temperature Humidity Index is generally used to relate the animal stress with the productivity of milk of buffaloes, cross breeds and local cows. The severity of increase in THI in Tamil Nadu may impact livestock production. It is estimated that THI exceeds 75 at 75-80 percent of places in India throughout the year and the loss in milk production in 2050 all over India might be around 15 times more than the present losses. Moreover, combination of increasing land-use change and dry temperature impacts grazing lands threatening the availability of feed for cattle. High temperature and humidity is likely to impact poultry farms, unless adaptive measures are taken by designing appropriate environment for the flocks.

Non-farm activities

It is estimated that due to impact on agricultural activities, non-farm activities would increase in the future as per the increasing trend already being witnessed.

SENSITIVITY OF AGRICULTURE TO CLIMATE

Land-use

As mentioned in sub-section 4.1 above, farmers leave land uncultivated mainly due to insufficient rainfall. The trends of crop lands decreasing and diversion of crop lands to non-agricultural uses follow a pattern. Firstly, due to deficient rainfall, farmers would leave part of the land as fallow (current fallow) and if the land is not cultivated for more than two years, then these land are treated as other than current fallow. The Act to prevent use of current fallow for non-agricultural purposes is not strictly enforced. Though climate plays a role, diversion for non-agricultural purposes is mostly driven by other socio economic drivers.

Water Resource

In Tamil Nadu, even during normal times, the demand for water outstrips the supply. Tamil Nadu has 17 river basins, 61 major reservoirs, 40,000 tanks and 3 million wells. During deficient rainfall years almost all reservoirs experience reduction of water up to 90 percent, nearly all tanks could become dry and the water level in ground water system could go down significantly. The deterioration of water quality is significant in few river basins and periodic monsoon rain is a must to keep up the quality. Ground water aquifers are at risk due to over-withdrawal in north east, northwest and central Tamil Nadu. Insufficient inflows into Mettur reservoir after 1974 have made it difficult to manage the drought years. The tank irrigation system is also declining and becoming inefficient due to poor maintenance and collapse of traditional irrigation system. Insufficient capacity of tanks makes it difficult to capture rainfall from good and heavy rainfall years[1] thus wasting precious water (Figure 4.4).

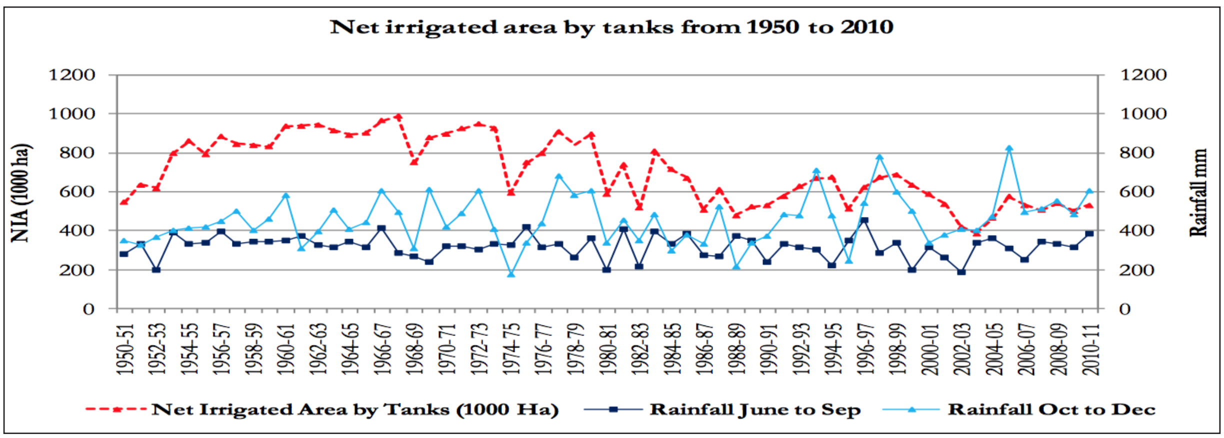


Figure 4.4: Net Irrigated Area by tanks from 1950 to 2010

Source: Sivasubramaniyan, 2006 & Season and Crop report of Tamil Nadu Government

The deterioration of irrigation tanks, over-reliance on ground water system and lack of maintenance of streams and canals increases the sensitivity of water resources[2]. Due to poor discharge during deficient years, the ground water systems could not support normal cropping patterns. Ground water level is significantly influenced by rainfall characteristics in the State. Poor monsoon year such as 1995 affects the recharge for the following year (1996) and the ground water level comes back to normal (1997 & 1998) with sufficient rainfall subsequently.

1 Tanks still dry even after heavy rains in Thirubuvanam : Though it rained heavily in Thirubuvanam, tanks in this taluk are dry because of illegal occupation of the land areas which use to be path for rain water draining to these tanks. Rain water could not drain properly and causes water logging in the roads. Government has spent so much of lakhs under rural employment program to improve and maintain the condition of the tanks, however nothing seems to be improved. Valayanenthal tank close to Pudur has not received water for last thirty years. *Source: http://www.dinamalar.com/News_Detail.asp?Id=570257 Published 21October2012*

2 Though the government has allotted 3624 crore INR for water resource management in delta regions, still no actions has been taken on the field. The sub streams and channels are not maintained properly and at many places bushes are seen and banks were broken. For example, Maharajapuram old canal which irrigates more than 350 acres are seen in worst condition with damages of banks and bushes over the canal. Farmers are suffering because of not getting the water though Cauvery water is released. Few years back, Seethai canal helped to drain the flood water to save hundreds of acres of crop. Right now the condition of this canal is worse. Similarly many canals are not maintained properly (Source: http://www.dinamalar.com/News_Detail.asp?Id=564553)

Crop Subsector

Over the last few decades, area of land under paddy cultivation shows a decreasing trend due to diversion of paddy lands to other crops as well as for non-agricultural purposes. During severe drought years (year 2002) the production could fall more than 40 percent. (Figure 4.5)

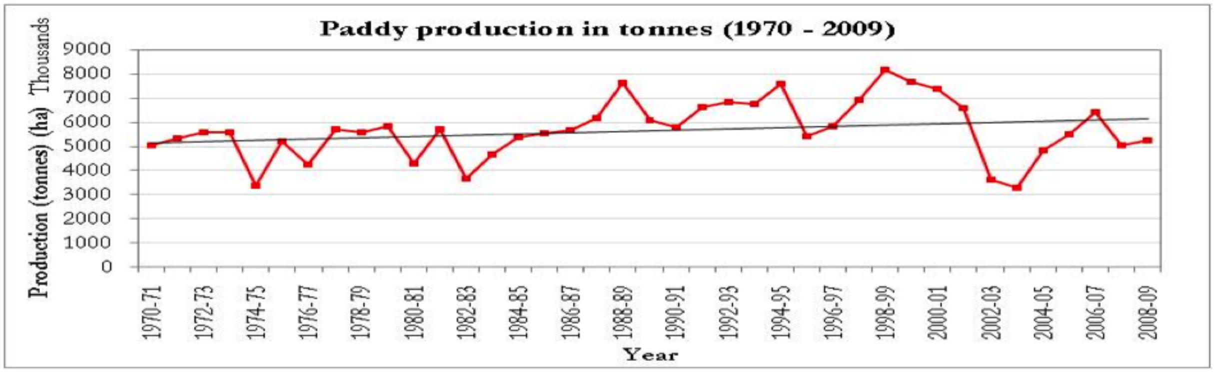


Figure 4.5 – Paddy production in tonnes from 1970-2009

During consecutive drought years most of the irrigation systems are dysfunctional and food grain production level goes down by almost 50 percent. These drastic reductions of food grains affect household food security of around 1.7 million landless households and 0.6 million small & marginal farmers. These climate shocks thus endanger food, income and nutritional security of these populations periodically. The sensitivity of the crops to climate stresses varies but around 65 percent of food grain crops such as paddy, millets and pulses are sensitive to rainfall fluctuations. Based on coefficient of variation of yields, ranking of crops in TN shows paddy crop to be most sensitive to CC. (Table 4.3)

TABLE 4.3: RANKING OF ACTIVITIES BASED ON COEFFICIENT OF VARIATION (CVT)

CVT OF ENTERPRISES	YIELDS (%)
Paddy	39.53
Maize	35.29
Groundnut	34.82
Redgram	30.53
Horsegram	29.45
Pearl millet	29.20
Sericulture	24.58
Ragi	21.81
Dairy farms	20.11

Adopted from Gajana and Sharma (1990)[32]

Impact on crops during extreme years:

Cultivation area, production and yield recorded a sharp fall during 2002-03 drought. The area of cultivation in 2002-2003 experienced decline of 660,000 hectares compared to 2001-2002. The total food production during 2002-2003 decreased by 3,290,000 tons compared to 2001-2002. Paddy production alone decreased by 3,007,000 tons in 2002-2003.

Horticulture

Horticulture in Tamil Nadu provides employment, additional income, nutritional security, raw-materials to agro-based industries and also potential for export earnings. Every year horticulture crops are affected by strong wind, heavy rainfall and some years it is most severely affected by severe drought. Horticulture crop production in 2002-2003 decreased by 22 percent compared to 2001-2002, which is almost 2,545,000 tons.

Horticulture crops are also affected by localized phenomenon such as strong winds, heavy rainfall. Almost every year horticulture crops such as banana plantations are damaged by these severe winds, heavy rainfall at various locations. Rain during flowering stage of mango and high temperature during tender mango development affects the mango production significantly.

Animal Husbandry

Animal husbandry is sensitive to climate by various degrees depending on the specific characteristics. Animal husbandry suffers climate shocks in extreme years due to reduction in availability of feed

Impacts during normal years with high summer temperature and extreme drought years:

Even in normal years, animal husbandry is sensitive to high summer temperature, resulting in reduced milk production, increased fodder prices, depressed livestock prices and increased stress on households to locate and obtain feed for the livestock. Milk production is significantly affected during extreme drought years. In 2002-2003 drought, the overall milk production dropped by 3.7 lakh tonnes compared to previous years. Reduction of average yield rate of milk in exotic and cross-breed cows was 1.51 percent and in indigenous cows was 5.27 percent.

Non-farm activities

Though non-farm economy provides some support during normal and mild drought year, the income sources from non-farm activities could be affected due to backward and forward linkages with agriculture sector. Considering the strong linkages between agriculture and non-farm activities, the climate shocks could affect non-farm sectors as well. The impact of climate on agriculture could influence non-farm income sources in at least key areas due to production, consumption and labour market linkages.

Economy

The immediate shock of monsoon failure is experienced in agricultural sector and the cascading effects pass on to secondary and tertiary sector in four major ways:

i. A backward linkage in the shortage of raw materials for agro processing industries;

ii. A forward linkage in the reduced demands of industrial goods because of reduced agricultural income;

iii. A shift in the share of the consumer demand away from industrial products because of high cost of food and agro processing necessities;

iv. A potential shift in public sector investments for development in order to finance for activities such as drought relief, etc.

Before 1990, agricultural and allied GSDP was closely linked with rainfall, i.e., increased rainfall led to rise in GSDP while decreased rainfall was associated with fall in GSDP. This trend has changed after 1990s as even with positive rainfall, agriculture GSDP response is not positive as it should be (Figure 4.6)

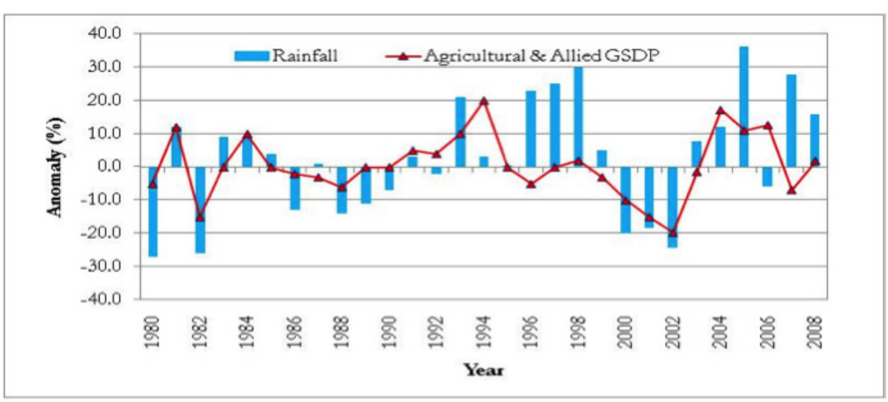


Figure 4.6: Rainfall deviation and its impact on Agricultural & Allied GSDP (DES[33])

In Tamil Nadu, secondary and tertiary sector contribute more than 80 percent of State income and are impacted by climate shocks. A preliminary study on drought impacts indicates that overall economy reduction of 30 percent of income in agriculture sector could have an impact of reducing income in manufacturing sector by 10-15 percent and in service sector by 5-10 percent. Impacts are first experienced in agriculture and then they cascade on to secondary and tertiary sectors. (Figure 4.7)

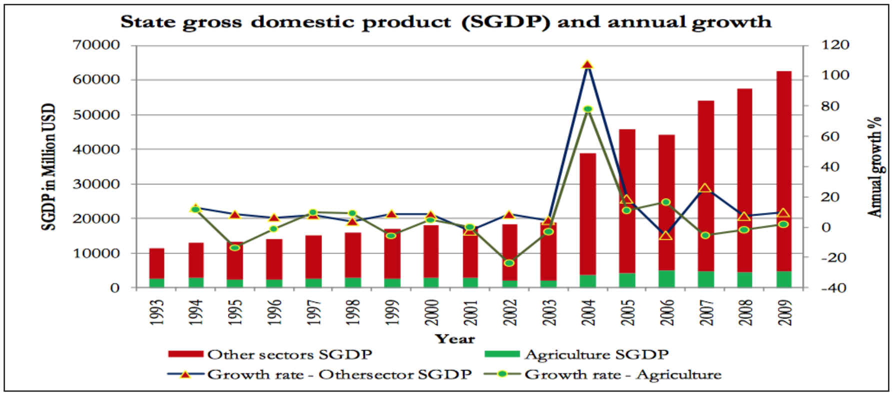


Figure 4.7: Agriculture and other sectors' gross domestic product and annual growth in Tamil Nadu from 1993 to 2009 (Adapted from Upali et. al (Data from DES)

Experience based on 2002 drought shows that reduction in agriculture sector could have an impact of 5 percent reduction in agro-processing industries sector and 2 percent reduction in service sector. Hence the likely loss could be around 12.5 billion USD in GDP because of weather and climate shocks – an amount equivalent to the annual development expenditure of the State in recent years. Hence there is a need for a thorough study on sensitivity of whole economy based not only on direct agriculture impacts but also on industries and other sectors, as indicated in Table 4.4

TABLE 4.4: ECONOMIC SECTORS AND THEIR CLIMATE SENSITIVITY

SECTOR	WEIGHT		IMPACT	CLIMATE SENSITIVITY		
	%	MI $		HIGH	MEDIUM	LOW
PRIMARY	**18.2**	**294235.3**				
1. Agriculture and Allied activities[3]	16.3	263518.4	Production loss	√		
SECONDARY	**32.9**	**531886.9**				
2. Manufacturing	24.3	392852.6			√	
2.1 Food products	3.3	52949.7	Raw material shortage	√		
2.2 Cotton textiles[4]	4.9	78570.5	Raw material & hydro-power shortage	√		

3. *Milk production:* Milk production declined from 49.88 lakh tonnes in 2001-02 to 46.22 lakh tonnes in 2002-03. The dip in milk production was engendered by monsoon failure and dry conditions. Eventually, the availability of fodder, a prime source of nutrition had become so acute. Per capita availability of milk per day was at 204 grams in 2002-03 compared 219 grams in 2001-02. Since the quantity of milk produced decreased in 2002-03, the per capita availability also correspondingly came down in 2002-03. (Directorate of Veterinary Services, DES, 2011)
Fisheries: Total catch by the source reveals that seasonal tanks and major irrigation tanks alone accounted for 72 per cent of total inland fish production of 102217 tonnes in 2002-03. There was a reduction by about 20 percent. (Commissioner of Fisheries, Chennai-6, DES, 2011)
4. *Raw materials:* During 2002-03 drought, the area under cotton cultivation in the State had declined to 75572 ha from 164169 ha in 2001-02 and production of cotton also declined to 83922 bales (170 kgs. of each bale) from 229730 bales for the same period.

TABLE 4.4: CONTINUED

SECTOR	WEIGHT		IMPACT	CLIMATE SENSITIVITY		
	%	MI $		HIGH	MEDIUM	LOW
SECONDARY						
2.3 Chemical products[5]	2.3	37150.2	Demand reduction	√		
2.4 Coal products	2.5	40139.3	Labour productivity			√
2.5 Machinery and equipment other than transport equipment	2.5	40566.3	Demand reduction			√
2.6 Other Industries[6]	0.4	6405.2	-			√
3. Electricity, Gas and Water Supply	1.8	28609.9	Hydro-power shortage		√	
4. Construction	6.2	100234.0	Labour productivity		√	
TERTIARY	**48.9**	**790555.3**			**√**	
5. Trade, Hotels and Restaurants	15.7	253818.4	Demand reduction		√	
6. Transport, storage and communications	9.1	147117.6	Demand reduction			√
7. Financing Insurance, Real Estates and Business Services	13.2	213401.4	Demand reduction		√	
8. Community, Social and personal services	10.9	176217.8	Demand reduction		√	

Weight Calculated based on % contribution by the sector to overall GSDP: Average from 1993 to 2004: Source: DES

Climate Impacts on Economy through Agriculture:

TABLE 4.5: AGRICULTURE (CROPS SUB-SECTOR) IMPACTS (2012-13 DROUGHT)

CROPS	CONTRIBUTION TO AGRICULTURE GDP		LOSS DUE TO DROUGHT IN 2012-13		REMARKS
	%	AMOUNT (RS. CRORES)	%	AMOUNT (RS. CRORES)	
Paddy- crops	19.7	8,268	50%	4,134	Complete loss of crops in some areas and significant yield reduction in others due to water shortage
Other Cereals	4.3	1,805	30%	541	Complete loss of crops in some areas and significant yield reduction in others due to water shortage
Pulses	1.3	546	75%	409	
Oilseeds	13.7	5,750	50%	2,875	

5. *Fertilizers:* The fluctuating trend in fertiliser consumption due to failure of monsoon on farm front during 2001-02 and 2002-03 reduced the uptake of fertiliser all over the country. The overall production of fertiliser in the State had declined by 5.11 per cent and overall capacity utilisation of fertilizer plants also fell to 69.6 per cent in 2002-03 from 71.8 per cent in 2001-02. The consumption of fertiliser in the State registered a significant fall of 20.8 per cent to 7.43 lakh tonnes in 2002-03 from 9.38 tonnes in 2001-02.
6. *Village Industries:* Sales declined by 29.42 per cent from Rs.22.40 crores in 2001-02 to Rs.15.81 crores in 2002-03. (DES, 2011)

TABLE 4.5: CONTINUED

CROPS	CONTRIBUTION TO AGRICULTURE GDP		LOSS DUE TO DROUGHT IN 2012-13		REMARKS
	%	AMOUNT (RS. CRORES)	%	AMOUNT (RS. CRORES)	
Sugar crops	13.5	5,666	15%	850	
Fibre crops	0.8	336	25%	84	
Drugs and Narcotics	3.2	1,343	0%	-	
Spices and Condiments	3.6	1,511	10%	151	
Banana	12.6	5,288	25%	1,322	Loss due to scorch injuries, caused by inadequate irrigation as a result of water shortages; Yield reduction
Mango	4.1	1,721	25%	430	High temperatures, lack of water
Tapioca	4.3	1,805	20%	361	
Fruits and vegetables (others)	7.2	3,022	25%	755	
Miscellaneous crops	1.4	588	20%	118	
Flowers and kitchen garden	7	2,938	25%	734	
Straw and Stacks	3.3	1,385	30%	415	
Total	100	41,968		13,180	Loss amounts to 31% of Agriculture GSDP of Rs. 41,968 crores (2011 estimated), even after excluding value addition loss of paddy
Paddy- value addition		-		1,240	At least 30 % value addition (employment at rice mills, etc) opportunities lost
G.Total				14,420	

These impacts are also more far-reaching than perceived both spatially as well as temporally. Climate impacts are not just economic but also social- as they impact the most vulnerable sections- for whom the government spends millions in subsidies and safety net programs to bring them above the poverty line.

Inflation: Decreased agriculture production has resulted in increased prices of essential commodities, eg: rice, sugar, oil, pulses, etc. across the State. The Government has had to provide an additional support of INR 1000 crores to supply these essential items at a reasonable price through the public distribution system.

Drought Impact on Macro-Economy:

Due to the structural transformation in the State economy with primary role of service sector, the state economy appears insulated from climate impacts. However, macro-economic analysis indicates otherwise - as bulk of the demand still comes from agricultural incomes. Production linkages between secondary and primary sectors have weakened over time, but demand linkages have grown as dependence of industry on agriculture (and services sector) for consumption of its outputs is now much more than earlier. Thus, a fall in aggregate demand in agricultural sector is likely to cause serious constraint in production and demand of industrial sector. Experience of past decades indicates that 1 percent fall in agriculture causes 0.52 percent fall in industrial output and 0.24 percent fall in service sector and an overall deceleration of 0.52 percent in GDP.

These percentages are more startling as indicated in Table 4.6. The 32.1 percent fall in primary sector (agriculture) growth is INR 20,474 crores but leads to reduction of INR 25,444 crores in secondary sector and INR 31,805 crores in services sector with an overall dampening of GDP by INR77,723 crores *(GSDP for 2012 taken as Rs. 634,829 crore)*.

TABLE 4.6. POTENTIAL MACRO-ECONOMIC IMPACT DUE TO DROUGHT 2012-2013

SECTOR *(EST. RS.CRORES)*	GROWTH/FALL IN SECTOR		CASCADING IMPACTS		REMARKS
	%	(RS. CRORES)	%	(RS. CRORES)	
Primary *(69,831)*	-32.1%	-20,474			
Secondary *(152,359)*			-16.70%	-25,444	0.52% fall for every 1% fall in agriculture
Tertiary *412,639)*			-7.7%	-31,805	0.24% fall for every 1% fall in agriculture
State GDP *(634,829)*				-77,723	

During the next decade considering the anticipated growth[3] as planned for under the Vision 2023, the following could be distribution of climate-related disasters and their impacts:

TABLE 4.7

	DISASTERS	NO. OF OCCURRENCES	IMPACT ON GSDP		REMARKS
			%	RS. CRORES*	
1	Severe droughts [@]	1	15%	120,000	
2	Moderate droughts[#]	2	5%	80,000	
3	Mild droughts[##]	2	1%	16,000	
4	Cyclones	2	3%	48,000	
5	Unseasonal rains/ floods	4	2%	64,000	
6	Temperature, humidity impacts on crops, animal husbandry	10	0.1%	8,000	
	Total			336,000	

(*Assuming an average GSDP per year of Rs. 800,000 crores)
[@] Severe- affects 4 seasons and over 75 percent of the state
[#] Moderate- affects 3 seasons and 50 percent of the state
[##]Mild- affects 1 season

Thus, over a 10-year period ending 2023, an estimated INR 336,000 crores *(or INR 33,600 crores annually)* could be potentially lost due to climate related impacts on agriculture and their cascading effects on the economy.

3 Vision 2023 projects an average GSDP of Rs. 1,280,802 crores for the next 10 years, whereas a more conservative estimate of Rs. 800,000 crores is considered here.

ADAPTIVE CAPACITY

Traditional Adaptive Strategies

The farmers' adaptation strategies evolved over time to anticipate and manage risks in uncertain crop production environment. Traditional adaptive strategies in the State had revolved around the key aspects of moisture security, biomass stability, collective sustenance and diversification. In Tamil Nadu, as most of the production environment is in uncertain climatic environment particularly semi-arid zones, farmers have evolved a range of Ex-ante strategies and Ex-post strategies based on historical experiences to deal with anticipated intra-seasonal and inter-annual rainfall variations.

Ex-ante strategies:

Water management:

In response to highly uneven concentration of rains, farmers harvest runoff water through water harvesting structures and store it for irrigating and sustaining crops. Farming communities devised to conserve rain water and preserve soil moisture through location specific small and large scale water harvesting structures and agronomics techniques. One of the most effective rain harvesting structures for geographical features and climatic conditions of Tamil Nadu are the Tanks - small water harvesting structures to impound water during peak rainy season to irrigate during dry season. They are arranged in a cascade with embankments, built at different elevations and arranged to collect and store the surplus water overflowing from one tank to another tank. Surplus water in upper level tank not only reaches the lower level but ensures continuous seepage to recharge ground water. In Tamil Nadu, 41000 tanks are in operation today.

Crop Diversification:

Farmers have evolved crop diversification strategies based on historical experience. Inter-cropping and planting of different crops is used by farmers to cope with uncertain rainfall situation, so that at least one or two crops survive and provide sustenance for livelihood. In areas with highly variable climate, mixed cropping with seven or eight different crops in the same field is resorted to so that during heavy rain water logging crops like paddy, sorghum could survive, and in case of deficient rain or long dry spells millets crops could survive. Thus, the farmers can harvest at least one crop to meet their requirements.

Mixed crop and livestock:

During irregular or inadequate rain years, fodder crops could survive even though the food grain crops fail. With the fodder crops, livestock system, i.e. raising goats and sheep etc. becomes feasible. They help farmers to sustain or survive during the dry period by selling animals or animal products.

Social adjustments:

In the social adjustments, there is an informal social/community arrangement to support farmers affected by low rainfall by communities having received good rainfall. If the scenario changes the other way, it is reciprocated later on. These arrangements constitute one of the strategies to adapt with climate variability.

Ex-post strategies:

In the ex-post strategies, farmers have to preserve the productive assets to anticipate good rainfall in the next season, preserving the productive assets like cattle, seeds for re-planting etc.

A hierarchy of Ex-ante and Ex-post strategies/options are adopted by farmers to adjust to the uncertain environments. But these practices are also under severe stress in the recent decades due to changes in political and socio economic conditions and due to some of the public policies. Though these practices evolved over a period of time to cope with climatic variations, public policies have rendered some of the traditional adapting strategies redundant. The climate risk management strategies now need to improve public policies to revive traditional practices and approaches *(discussed in section 4.4)*. As a result, other diversification are seen more frequently, eg: due to water scarcity in delta region, farmers start migrating from agriculture sector to brick kiln[4], which is highly profitable and requires less water.

4 Tanjore is called as rice bowl of Tamil Nadu. Rice is cultivated in three major periods Kuruvai, Samba and Thaladi. Kaveri water is main source of irrigation (Kaveri - .469 million ha Venaru – 0.465 million ha, Kalanai - .256million ha). Kaveri water is generally opened in June for Kuruvai season, but this year water was not opened in right time, hence less than 10000 ha of land are only. Hence the farmers living on the river bed of vennaru, kaveri started engaged in brick kiln. They do not employ labourers, farmers and their family themselves are working on preparing brick kilns and make the bricks. They get good profit based on the demand, for example they get 10000 to 20000 INR profit for each kiln. If they are in demand, they get higher prices. For example the stone price in October 2012 is 3.50INR where as earlier it use to be 2.80INR. Considering its less water requirement farmers feel there is no risk in it. Source: http://www.dinamalar.com/News_Detail.asp?Id=564553

Factors contributing to weakening of adaptive strategies

Factors and processes which affect traditional adaptation/adjustment strategies against drought and climate uncertainties in tropical regions relate to moisture security, biomass stability, collective sustenance, diversification, flexibility etc.

Moisture security: Traditional practices for conserving moisture took the form of tanks for irrigation. But due to the changing policies, market factors, preference for ground water due to free electricity, tanks have gone into disuse despite being a well-suited adaptation strategy to rainfall fluctuations making lands dependent on tanks for irrigation more vulnerable than ever more. (Figure 4.8)

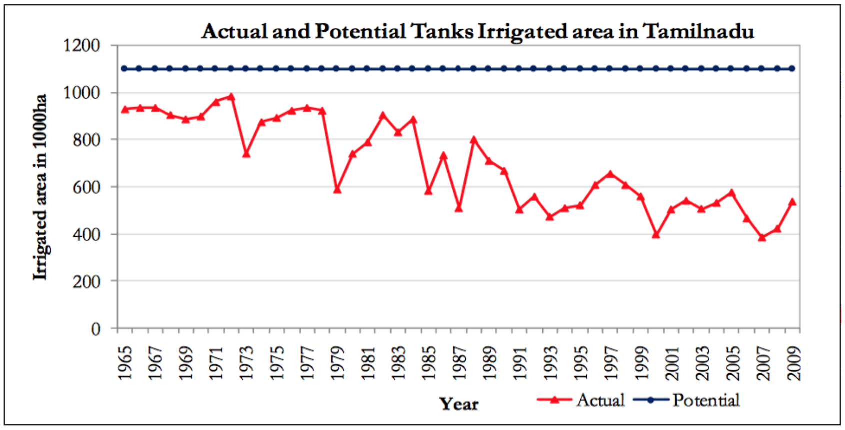


Figure 4.8: Actual and potential tank irrigated areas in Tamil Nadu from 1960 to 2009 (Adapted from V. Anbumozhi et.al)

BOX 4.2 SUNKEN PONDS IN SUPPLY CHANNELS IMPROVE WATER LEVEL

A new technique adopted for storing rainwater has shown amazing results in Dindigul district. At a time when efforts are being taken at all levels to recharge groundwater and manage drought, rainwater harvesting has become mandatory for residents in villages, towns and municipalities. Unfortunately, the rainwater that fills up the open fields and then overflows on to the roads, damages the asphalt, creates soil erosion and leads to accumulation of silt in channels and tanks reducing their storing capacities.

To tap such large quantity of rainwater that goes waste, the District Rural Development Agency (DRDA) has introduced an innovative model, known as sunken ponds (trenches) in supply channels, small streams and rivers. Two-foot wide, two-foot long and one-foot deep ponds (trenches) are dug at various points in the supply channels, mostly laid along rural roads or along agricultural fields. These trenches act as miniature storage points within the channel recharging ground water at every point in the village.

Source: http://www.thehindu.com/todays-paper/tp-national/tp-tamilnadu/sunken-ponds-in-supply-channels-improve-water-level/article3944305.ece

Biomass stability: Climate adaptive crops have been replaced by climate sensitive crops, leading to reduction of adaptive capacities. Past practice of cultivating drought resistant varieties- coarse cereals, millets etc have given way to more commercial but climate sensitive crops such as sugarcane which make farmers more vulnerable to climate risks. Over the past six decades, area of coarse grains has decreased drastically while areas for sugarcane and maize have increased significantly. Change in food consumption patterns has encouraged shift to more climate sensitive crops such as rice over coarse grains.

Diversification: The earlier mix of crops, fodder crops and diversification of enterprises to moderate climate sensitive animal husbandry sector and non-farm occupations is on the decline. Even in animal husbandry, cattle and buffalo populations has reduced while goat population has increased thereby heightening climate risk exposure and sensitivity in addition to the negative impacts on grass cover, land degradation and desertification.

Collective sustenance: Earlier practices encouraging collective sustenance with social adjustments and flexible change risk management strategies eg: collective maintenance of minor irrigation structures, regulation of water for irrigation etc. have fallen into disuse due to socio-political and economic influences and market forces. These have reduced farmers' adaptive capacities to manage climate risks.

Over a period of time, efficiency of traditional adaptive strategies gradually became ineffective to climate shocks due to population increase, changing socio-political context, market fluctuations and concomitant government policies leading to distress among people and development sectors. The State Government in consonance with national policies and programs needs to devise interventions to enhance the adaptive capacity of community to withstand periodic climate shocks.

State Interventions

With a view to enhance adaptive capacity of communities, the State government has evolved social safety net programs to support the people. These include:

Production based

National Watershed Management program

The Government of India has developed the watershed management program with an objective to establish water harvesting structures and build livelihood enhancement activities around that like improved agriculture, animal husbandry, fisheries in the rain fed areas etc. with people participation. Although it led to improvement of biophysical and socio economic factors in watershed areas and assisted rain fed farming communities, yet it did not fully insulate communities from periodic extreme climate shocks. *(DLR, 2006[34])*

Women Self Help Groups have emerged as the agents of socio economic transformation in rural areas, particularly among the poor and the downtrodden. As on date, there are 535,000 self help groups with 8.2 Million members having total savings of 1.6 billion USD in the State. They have obtained credit linkage of 750 Million USD under this scheme so far. In addition, the National Rural Livelihood Mission (NRLM), rechristened as Aajeevika, has been launched to support self-help groups (TCDW, undated[35]). These schemes have the potential to be used as support mechanisms to enhance adaptive capacity.
The State is also promoting less water intensive agronomic practices to sustain paddy production by developing contingency crop plans to manage weather operations and insulate crop production. However the lack of application of advanced climate information impacts agriculture contingency crop plans adversely.

Labour Based

Rural Employment Scheme: This program provides employment to poor for 100 days in a year at the rate of 2USD/day. Mostly they are involved in rehabilitating all irrigation tanks to restore their original capacity by dovetailing funds from various development schemes like Mahatma Gandhi National Rural Employment Guarantee Scheme (MGNREGS) and NABARD loans. National Surveys indicate that nearly 51 percent of works undertaken under this program are to reduce climate sensitivity of rural infrastructure. However these assets are not effective in imparting resilience against climate risks due to poor technical quality, inadequate operational maintenance and non-incorporation of current and future climate risk.

Trade based

Public Distribution System (PDS) is benefitting 18.5 million rice cardholders. Tamil Nadu is the only State in the country to launch such a scheme to provide total food security to all by supplying various pulses, palm oil and fortified flour at subsidised rates.

Transfer based

Disaster relief: Relief is extended to affected population through a well-administered disaster relief assistance scheme to partially compensate the losses.

Gaps in Institution, policy and development planning:

The assessment in previous sections reveals that farming communities of Tamil Nadu evolved adaptive strategies to live with highly variable climate both spatially and temporally. However the public interventions have weakened the farmers' adaptive capacities and rendered them vulnerable to climate risks. 70 percent of the population dependent on agriculture directly and indirectly is exposed to climate risks and their dependence on low productive agriculture is a major factor for keeping them below the poverty line. The industrial sector and service sector could absorb only around 30 percent of the population. Periodic climate shocks undo the development gains and the efforts to reduce poverty. While introduction of social safety net programs and transfer of resources does provide a cushion, yet these do not cumulatively reduce vulnerability and sensitivity to climate risks.

There is also lack of appreciation of the impact of climate risk on State economy in the long run. There is a gross underestimation of climate risk as methodology adopted for assessing climate risk is to primarily to guide relief and rehabilitation efforts. There is need to evolve a comprehensive climate risk assessment methodology to guide development planning. The objective of climate risk assessment is to guide development planning and there is a need to broaden and deepen climate risk assessment methodologies. A preliminary analysis of causation of key factors of assessing climate risk reveals the following:

1. Current climate risk assessment focus only on physical damages without taking into account indirect losses and higher order impacts. For example, the drought assessment methodology needs to capture cascading impact of drought from agriculture to manufacturing to service sector and state economy as whole. Even 1 percent of drop in agriculture growth could lead to 0.52 percent drop in industrial outputs, which in turn could lead to 0.24 percent reduction in service sector. Applying these figures for 2002-2003 drought could amount to US$12.5 billion.

2. The impact on private sector enterprises and farmers' livelihoods beyond the disaster period is not assessed.

3. The climate sensitivity of horticulture crops to temperature and rainfall variation at flowering and ripening stages and their consequences on quality, quantity and their market value is not assessed.

4. The impact of climate risk could lead to high inflation rates especially in urban areas.

5. The livestock and vegetable markets even in so called normal years are affected by climate risk either due to reduction or due to quality deterioration but these impacts are not assessed.

6. The Government every year spends INR 10,000 crores on social safety net programs to ameliorate the impacts of climate risks. Thus, the cost of climate risk could be estimated as INR 30000 crores.

7. The amount which government spends for reducing climate risk through development programs such as agriculture, water shed development program, irrigation and rural infrastructure amounts to INR 7,000 crores. The gap between the cost of climate risk and investment is around 28,000 crores which is also impeding the efforts to reduce poverty.

8. The development Vision 2023 provides an opportunity to evolve policy and institutional mechanisms to build capacities for CRM assessment and guide informed decision-making to reduce climate risks.

CLIMATE THREATS TO KEY DEVELOPMENT OUTCOMES

Agriculture alone accounts for half of the household income for a large rural population with nearly 7.5 million people getting three quarters of their income from agriculture. Any risk to agriculture has serious impact on large number of people in Tamil Nadu. Every year, around 15,000 hectares of land is taken out of productive use for non-agricultural purposes. Due to declining traditional irrigation system, diversion of productive lands for non-agricultural purposes, reduced size of land holdings, increased land degradation, over reliance on ground water resources, climate shocks such as droughts, around 1.2 million hectares which is 11 percent of the agriculture land becomes out of production. As a result, marginal and small farmers who form 80 percent of agricultural population lose land base for agricultural activities, hence they became further marginalized. Traditional water storage systems like tanks and drainage canal systems are unable to support irrigation for this large number of farmers. In recent years, dependence on ground water has led to falling aquifers and increased cultivation costs. In this process, agriculture has stagnated and the productivity level of various crops has reduced significantly. Low yields of crops also lead to subsequent loss of rural income, which poses serious threat to development gains in Tamil Nadu.

BOX 4.3: HOPELESS AGRICULTURE – STORY OF FARMERS TURNED TO AUTO DRIVERS!

This is the story about the people from Parameshwara Mangalam Village, Arakonam Taluk in Vellore district. Currently 200 persons from this village are in Chennai working as auto drivers for their income. Every day, one hundred of them come to Chennai Central Railway Station at 10 AM and work the whole day until the next day when they gather at Allikulam in Chennai to handover the autos to next group of one hundred from their village before returning to their villages by train. This cycle continues day in and day out.

Vijayakumar from Parameshwaramangalam village says, "I belong to agricultural family and have 1.5 acres of land. Since ground water level is down, doing agriculture becomes difficult. Depending on this rain for agriculture leads to loss instead of profit. After spending 27, 000 INR (about 500 USD) for acre we are able to get 25,000 INR (about 450 USD). So we have no choice other than traveling to Chennai to serve as auto drivers for our income".

Source: http://www.dinamalar.com/News_Detail.asp?Id=249353

The State has recognised these issues and challenges in the Vision 2023 planning document and the inadequacy of social safety nets. It proposes to transfer over 20 million people dependent on agriculture to secondary and tertiary sectors after building their capacities. Safety nets would continue for the very small proportion of the population. The significant section of agriculture dependent population is expected to benefit from the increased growth (5 percent) anticipated in the Vision 2023 through mechanisms elaborated earlier. Climate risks will however play a major role impacting development trajectories of Vision 2023.

Further, the agriculture development planning in Vision 2023 document envisaged 5 percent growth every year. As agricultural development growth is intensively linked to the secondary and tertiary sector, weather and climate risks would be transmitted in a cascading manner from primary to secondary and tertiary sectors. The critical assumption based on 2001 to 2003 consecutive droughts shows that there is a possibility of growth reduction during severe droughts, wherein 25 percent loss in primary sector leads to 7-10 percent loss to secondary sectors such as agro-processing, fertilizers and 3-5 percent to services sector, primarily on reduced demands. This links to fall in GDP growth rate approximately 5 percent during devastating droughts, cyclones and storms in a year. In order to ensure achievement of development planning trajectories against climate variability in next 10 years, the need to formulate a holistic climate risk management framework to minimize impacts on development trajectories envisaged by Vision 2023 document and integrating these into development planning assumes significance.

KEY MESSAGES (CLIMATE IMPACTS AND RISKS FOR AGRICULTURE)

- Tamil Nadu, being one of the driest states in India, drought is a major climate hazard. Every second year, there could be a drought in some part of the State, and every two decades there could be widespread, consecutive droughts (over two or three years). Climate Change is expected to further decrease number of rainy days and increase temperature leading to severe droughts which will have more intense impacts on agriculture.

- Nearly half (2.3 mi ha) of the 5.5 mi ha land cultivated annually is rain fed. Even among the 3.2 mi ha irrigated land, tanks are the source for 0.5 mi ha which makes them vulnerable to deficient rainfall and 0.3 mi ha are at the tail-end of canals which subjects them to water stress, and 1.5 mi ha are irrigated from ground water wells at high cost of pumping water from falling aquifers.

- 90 per cent of paddy, the principal crop is cultivated in irrigated conditions, while 100 per cent of sugar cane is dependent on irrigation, 30 per cent of ground nut, 27 per cent of cotton and all of maize (important for poultry) are under irrigation and pulses are entirely rain-fed. Any rainfall deficit or variation will cause serious problems.

- Since mid-1990's, agriculture has been rendered a near-stagnant economic sector due to declining contribution and disrepair of tank irrigation system, lowering of ground water levels, increasing land degradation, declining farm sizes and rising costs of labour.

- However, agriculture is central to poverty reduction as 35 million people get half or more of their household income from farm sector of which about 7.5 million draw about three-fourths of their income from agriculture wages. The near-stagnant agriculture has aggravated inequalities and poverty among these people.

- Robust adaptive strategies of Tamil Nadu farmers to manage the high risk production environment common to semi-arid tropics built around conserving moisture, less water-intensive millet crops, mixed crop systems, fodder-based animal husbandry and collective sustenance have withered away to currently very low adaptive capacities due to pressures from increased population, changes in socio-political systems and associated public policies, encouraged high productivity-oriented paddy over millets, well irrigation over tank irrigation, market-related interactions at cost of social adjustments, mono-crops over diversified cropping.

- Considering accountability and democratic governance, the government initiated safety nets artificially supporting a large population including a vast number of fair price shops operated by the Public Distribution System (PDS) to provide free rice to two-thirds of the population.

- During the 2002 drought where production of over 3 million tonnes or 50 percent food grain was lost, due to the well-functioning PDS of the government that pumped in more than 3 million tonnes of food grains the prices increased by only about 2.8 percent.

- However, since a large number of households (6.2 million) still operate the marginal agricultural land holdings (2.2 million ha), they are particularly vulnerable to climate vagaries. This indicates that the State is able to only cope with the impacts while the vulnerabilities are not yet eliminated and the underlying sensitivity of the agriculture sector and its population to climate remains.

- Climate risks are expected to play a major role in translating the Vision 2023 which has been brought about to address these vulnerabilities, thereby posing a threat to overall development itself.

CURRENT CLIMATE RISK MANAGEMENT

INSTITUTIONAL AND POLICY ARRANGEMENTS FOR CRM

In Tamil Nadu, three distinct frameworks address the climate risks, disaster management, climate change adaptation and development planning. However there is no integration of climate risk management process in Tamil Nadu.

Disaster Risk Management

The Disaster Management Act, 2005 was enacted by the Government of India on 23 December 2005, within a year of the Indian Ocean Tsunami 2004, to define the legal and institutional framework for management of disasters in India at the national, State and district levels through the National/ State/ District Disaster Management Authority and provide for institutional, administrative and financial arrangements to manage disasters at all these levels. In line with the national act, the Government of Tamil Nadu has established a State Disaster Management Authority (SDMA) with Chief Minister as a chairperson to lay down policies and plans for disaster management in the State. A State Executive Committee chaired by Chief Secretary assists SDMA in the performance of these functions, coordinates action as per its guidelines and ensures compliance of its directions[36]. *(Disaster Management Act, 2005)*

A similar structure exists at the district level with the District Disaster Management Authority (DDMA) chaired by the District Collector to monitor the disaster preparedness and relief measures in the district. There is also a national policy on disaster management approved by Government of India in November 2009, in consonance with national disaster management act of 2005. This policy details the institutional arrangements and approaches to be taken in managing disasters. It provides for institutional and financial arrangements, disaster prevention and preparedness, education, response, relief & rehabilitation, reconstruction and recovery, capacity development, research & development etc.

Tamil Nadu has also evolved a State Disaster Management Policy to provide a comprehensive approach for disaster management at State level that reduces the negative impacts of disasters. Its key objectives are to:

- advocate a proactive approach through risk reduction;
- reduce vulnerability of communities through risk assessment;
- make disaster management an integral part of development planning;
- build capacities of all relevant institutions and communities, and;
- create database on policies, resources and strategies.

The key components of the policy are convergence of disaster management & development planning, formulation of disaster management plans, focus on vulnerability reduction, foster a culture of prevention among the communities and various government departments through training and awareness campaigns involving communities at all stages in disaster management activities and creating a trained volunteer force on the lines of home guards for disaster management[37]. *(State Disaster Management Policy)*. The Revenue Administration's Disaster Management and Mitigation Department (RADMMD) is the key agency implementing and coordinating disaster management activities in the State, including disaster relief as the Secretary of Revenue Administration is also the State Relief Commissioner. This department has excellent linkages not only with the district administrations but also with the other sectoral departments at the State level, which result in very effective coordination and implementation of its activities.

In practice, disaster management currently focuses on efficient risk management through early warning dissemination and communication systems, preparedness and response mechanisms. However, it lacks adoption of anticipatory risk management aspects based on observed and anticipated climate risks.

Climate Change adaptation

Climate change adaptation framework at national level has been evolved in the form of the National Action Plan on Climate Change (NAPCC) which identifies eight priority areas or Missions focussing on (i) integrated water resource management, (ii) sustainable agriculture, (iii) sustaining the Himalayan ecosystem, (iv) enhancing ecosystem services including carbon sinks (Green India), (v) sustainable habitat, (vi) solar energy, (vii) energy efficiency, and (viii) strategic knowledge for climate change

The implementation of these missions is through respective ministries involving inter-sectoral groups of the ministries and the Ministry of Finance, Planning Commission and experts from industry, academia and civil society, overseen and guided by a National Advisory Council on Climate Change chaired by the Prime Minister[38]. (NAPCC, 2008)

The NAPCC suggests formulation of State action plans, and in Tamil Nadu the process is underway in collaboration with GIZ as technical institutional partner, under a national government (Ministry of Environment and Forests) project. The Government of Tamil Nadu has constituted a task force to evolve the State Action Plan on Climate Change (SAPCC) under the Department of Environment in consultation with the line departments and relevant stakeholders. An Environment Protection and Renewable Energy Development Fund has also been created by the State government to support implementation of schemes for protection of the environment and promotion of clean energy, with the main aim to promote mitigation and adaptation measures to combat effects of climate change.

Development planning

Government of Tamil Nadu has come up with a very comprehensive Vision 2023 development planning document. It recognises that addressing climate hazards would minimize negative impacts on development and provides a way for reducing vulnerability of the most vulnerable groups especially the rural population in Tamil Nadu and to raise the income levels to four times from current level, to target of 10,000 USD per capita per annum by 2023. Transfer of large scale rural population to secondary and tertiary sector is planned for along with growth of primary sector at the rate of 5 percent per annum until 2023. This document envisages a society in 2023 with low poverty levels, high incomes and massive development in infrastructure.

These three frameworks- climate change adaptation, disaster management and development planning- have not been integrated in a holistic way, hence these frameworks in isolation would not be able to address climate risks.

MAJOR RELEVANT ACTIVITIES ALREADY IN PLACE OR ONGOING/UPCOMING TOWARD CLIMATE RISK MANAGEMENT

The Government of Tamil Nadu in collaboration with Asian Development Bank (ADB) recently evolved and started implementing a program for climate change adaptation in the low lying area of coastal Tamil Nadu to anticipate sea level rise in the next forty years and addresses the extreme events in a development planning context. Tamil Nadu Agricultural University (TNAU) in collaboration with Government of Norway is implementing a program called CLIMRICE to address climate change adaptation issues in Cauvery delta region. Under this program, downscaling of climate change scenarios were carried out at the basin level for planning adaptation measures such as evolving suitable crop varieties, crop systems and water management etc. These measures are planned to be up-scaled during the next few years.

IMD as well as TNAU provide agro-advisories to farmers in Tamil Nadu to guide their local farm management practices. IMD's Agromet Advisory Bulletins are issued at district and State level. The district level bulletins are issued by Agro-met Field Units (AMFUs) and include crop and livestock specific advisories. These bulletins are jointly prepared by State Meteorological Centre of IMD and AMFUs and mainly used by State Government functionaries[39]. *(IMD, 2011)*

Tamil Nadu has recently approved an ambitious programme for interlinking of rivers within the State through six priority projects at a cost of INR 90 billion to transfer water from surplus basins to deficit areas, inter-basin/sub-basin areas, diversion of flood waters, optimum utilization of water resources considering spatial and temporal distribution of rainfall during the monsoon seasons.

The Tamil Nadu Irrigated Agriculture Modernisation and Water bodies Restoration and Management (TN IAMWARM) project is a six year project (from 2007-08 to 2012-13) to improve water resources in 61 selected sub basins through Water Resources Organization by integrating the activities of the departments of Agriculture, Horticulture, Agricultural Engineering, Agriculture Marketing & Agri-business, Animal Husbandry, Fisheries and Tamil Nadu Agricultural University with a focus on crop demonstration, seed village programme, capacity building, improving water use efficiency and provides 100 percent subsidy assistance to small and marginal farmers and 75 percent subsidy assistance to other farmers for putting up drip and sprinkler irrigation systems under Micro Irrigation Scheme. During 2011-2012, an area of 7408 hectares has been covered with drip and sprinkler irrigation system and an additional 6100 hectares would be covered during 2012-2013. *(Agricultural Policy, 2012)*

Tamil Nadu has embarked on a mission to bring in the Second Green Revolution to address issues plaguing the agriculture sector, by increasing cultivated area and enhancing productivity, better soil management, water resources management aimed at micro-irrigation to increase efficiency, as well as increasing irrigation intensity, increasing farmers' incomes, improving agriculture infrastructure, crop diversification and strengthening research and extension services. *(Agricultural Policy, 2012).* These initiatives are very timely and essential, but stand the risk of increasing exposure to climate risks unless they recognize and integrate the climate information as a continuous threat (or opportunity).

CAPACITY ASSESSMENT FOR CLIMATE RISK MANAGEMENT

Current Institutional System:

Current institutional mechanism does not provide for a cross-sectoral mandate for any existing institution to address climate risks utilizing probabilistic information. Even in normal weather, development processes are routinely affected as appreciation for weather and climate and its impacts is lacking. To illustrate, disruptions to daily life for at least a few days during routine heavy rainfall each monsoon season is common in some low-lying areas of Chennai and current efforts do not consider the economic costs of the disruptions and do not address them.

Current Legislative System:

Existing policies and acts, not limited to Disaster Management Act and policy, Environment policy etc, provide for and deal with application of deterministic information and do not empower decision-making for probabilistic information since there is an element of risk involved in applying the latter information. Legislation does not also mandate or provide for bringing all institutions under a single umbrella to address such risks.

Current Climate Information System:

Climate information is available in a range of time scales from few hours to days to months to seasons and years and beyond. Firstly capacities to generate such information tailored for application by sectors do not exist. Even if available, sensitive sectoral departments like agriculture, public works department, animal husbandry etc. lack capacity to apply such probabilistic information. Seasonal forecast utilising the high level of confidence in northeast monsoon forecasts based on ENSO factors are not fully utilised. Constraints and barriers exist for applying seasonal forecast information at basin level for managing agricultural and water resource sector. The wealth of past data and observations that are systematically maintained in departments in Tamil Nadu are not fully utilised yet. A very elaborate alternative cropping pattern for Tamil Nadu is available that provides for specific recommendations on crops for a normal, moderately dry or very dry year, taking into account the specific soil type.

Current District Capacities:

Districts are key administrative divisions of the State. However, district administrations lack institutional capacities and facilities to undertake informed assessments of climate risks on key district level activities including agriculture, and to formulate anticipatory response measures to minimise negative impacts.

A capacity assessment for climate risk management has been undertaken utilising the World Resources Institute's National Adaptive Capacity framework (WRI, 2009). The assessment results are as follows:

Assessment function: Individual elements of capacities for assessment exist and are utilized to undertake mapping, studies and assessments. Hazard mapping is carried out by the State government departments including the RADMMD which also maintains an up-to-date database (DESINVENTAR) on occurrence of all past disaster events including floods, droughts, thunderstorms and their impacts. Agriculture Department and TNAU have conducted impact studies for agricultural crops, eg: irrigated paddy but the results are not systematized for use by the planning apparatus of the State nor incorporated into the planning for new programmes by the sectors. In Vision 2023, there is however an emphasis on robust agricultural and water management systems capable of resisting periodic climate shocks.

Comprehensive studies at sectoral levels on anticipated impacts that consider the existing vulnerabilities of communities or systems and their performance during current climate extremes as well as their projected performance considering development trajectories, policies and changing climate are largely absent. The focus primarily has been more on exposure and impact studies than on the underlying factors of risk and vulnerability. There is no State level institutional system mandated to collect and systematise assessment results and update them. At the national level, however, the Ministry of Environment has created an institutional arrangement to undertake integrated vulnerability and impacts assessments, comprising of a large number of institutions in India, including TNAU and MS Swaminathan Research Foundation located in Tamil Nadu, involved in climate, socio economic and impact modeling and undertaking policy research in various sectoral and inter-sectoral studies. Centre for Climate Change and Adaptation Research of the Anna University, Chennai is also a State level resource institution implementing projects on climate change modelling and adaptation research.

Prioritization function: A State action plan for climate change is being evolved to articulate the priorities for addressing specific vulnerabilities and anticipated impacts -- sectorally and geographically. Presently, however, individual sectors prioritise programmes or activities that address a perceived or felt need within their mandates, but based on socio-political rather than climatic considerations, and are seen more as contribution to the department's larger development goals.

Coordination function: Risk Management in the short time-frame of upto a few days is very effectively coordinated through existing mechanisms for disaster risk management, led by the RADMMD, at both the State and the district levels. The planning functions are also well-coordinated through the State Planning Commission for the State planning horizon of five years. Adaptation planning however is nascent, and the State level committee constituted for the preparation of the State action plan for climate change is the first effort which could coordinates climate risk management actions across sectors.

Though three domains- disaster risk management, climate change adaptation and development planning exist, there is no integration among them in a holistic way. Climate Risk Management is the first program to bring these domains under one umbrella by providing synergy to ensure the climate change adaptation addresses both current risks as well as the future. The State Planning Commission has embraced a comprehensive climate risk management approach for development planning process. Based on CRM- TASP findings, the State Planning Commission has now started process for incorporating climate risks into the planning document to ensure coordination in an integrated manner.

Information management function: Information gathering mechanisms for all areas – climatic information, hazard risks, disasters and impacts, demographic, socio-economic etc. -- are quite effective in the State. However, collation and analysis of available information is neither systematic nor available in a user-friendly manner resulting in gaps in assessing vulnerabilities among sectors or geographically and its non-integration in the planning processes. In order to supplement the India Meteorological Department (IMD) observations across the State, sub-district level observation stations are operated by the TNAU to help formulation and dissemination of agro-advisories. Density of monitoring of water levels, discharge information and cross-sections of water courses maintained by the Public Works Department (PWD) needs to be increased.

Climate hazard information only of short time-scale (up to 2days) is available and integrated to minimise disaster impacts. Tamil Nadu disaster management sector has the capacity of using weather forecast information up to 48 hours to manage disaster risks in a substantial manner making a tremendous difference in terms of reducing loss of life and property to an extent. Cyclone Thane (2011) marked the first time that information was made available up to 5 days ahead of the event but the severe economic impacts indicate that capacities do not exist for utilising such probabilistic information.

Climate risk reduction function: As observed earlier, existing assessments do not rigorously cover climate vulnerability aspects and existing planning. For example, agriculture assessments do not adequately address climate risks, nor prioritize areas/crops/measures over others in a water-deficient season. Once the specific functions of assessment, prioritisation, information management and coordination are adapted and strengthened, there is a possibility that climate risk reduction function could be achieved in a comprehensive manner not just in agriculture but in all other climate sensitive sectors.

One of the reasons for low investment in climate risk management is lack of studies to provide trade-off details to the policy makers for incorporating CRM into development planning process. There is need for providing a tool to the planners to integrate CRM into their planning processes. There is a need to facilitate informed decision making at all levels.

Stakeholder consultations revealed that one of the barriers in integrating forward-looking probabilistic information is the associated uncertainty. One of the means to deal with uncertainty and utilize available information is an iterative risk management framework to enable decision-making in an uncertain decision-environment. This practice needs to be institutionalized to facilitate informed decision-making.

KEY MESSAGES (CURRENT CLIMATE RISK MANAGEMENT)

- Tamil Nadu has a robust and effective disaster risk management system institutionally and operationally, encompassing key administrative levels comprising of the State Disaster Management Authority with the State Executive Committee and the Revenue Administration, Disaster Management and Mitigation Department at State level and District Disaster Management Authority under the District Collector.

- Climate Change adaptation framework is still nascent and the State action plan for climate change is being prepared through a State level committee constituted by the government

- Development planning objectives outlined in Vision 2023 recognize the need to address climatic risks to safeguard development but operational mechanisms within sensitive sectors are deficient.

- Capacity assessment for climate risk management indicates presence of individual capacities for vulnerability and impact assessments, information management and coordination, but the lack of an adequate institutional system hinders systematic application and integration of climate risk management for risk reduction except for short time frames of up to 2 days.

RECOMMENDATIONS FOR CLIMATE RISK MANAGEMENT

Previous chapters have indicated that climate variability and change have both short term and long term impacts on the development planning process and its outcomes for Tamil Nadu. The Government of Tamil Nadu has prepared an ambitious Vision 2023 plan document to transform rural agriculture-based economy into modern sustainable economy while emphasizing the need for transferring a large number of agricultural workers into secondary and tertiary sectors. The target of 5 percent growth in agricultural sector itself proves that agriculture development is considered as central for poverty reduction, development planning and disaster reduction aspects. Moreover, since climate risks impact not just primary sector but also lead to cascading impacts on secondary and tertiary sectors, addressing climate risks in all socio-economic sectors through a climate risk management approach will be critical.

LAND USE

A two-pronged approach needs to be adopted aiming at i) climatic factors contributing to increasing fallow lands, and ii) addressing the non-climatic factors causing the trend of increasing fallow lands and conversion of agriculture land to non-agriculture uses

Climatic Factors:

Studies[5] have identified that fallow lands are more concentrated in drought-prone and low-rainfall areas of the state, i.e., southern and western districts. Hence focused attention is required to increase yields and profitability of rain-fed crops especially in these areas and promote suitable adaptation measures for irrigation, viz., tanks to halt the increasing fallow lands in these areas. Simultaneously other efforts such as shift from water-intensive crops to coarse cereals, tank-area-based and recharge-based cultivation need to go hand-in-hand to ensure more and more fallow lands are brought back into cultivation.

Non-climatic factors:

Non-climatic factors need to be addressed simultaneously to make a significant difference on the ground. *Reversing trend of increasing fallow lands:* As per projections for Tamil Nadu, by 2020 over 14 million ha of cultivated agriculture lands (excluding fodder and forests) would be needed to meet estimated demand for food production in 2020 *(State Planning Commission)* , even after taking into account productivity increases. This area is more than the geographical area of the State and this target can only be met by increasing the net sown area and gross cropped area through higher cropping intensity and by reducing current fallow and other fallow lands by at least 90 percent including taking them under government stewardship to bring back to productive use. Agriculture needs to be made profitable to ensure that more and more fallow lands are brought back into productive use. Policies for better utilization of land resources for agriculture are urgently needed, thus making this a priority area for policy formulation.

Conversion of agriculture lands: Existing laws to regulate conversion of agriculture land to non-agricultural use need to be implemented rigorously, and loopholes that allow such conversion need to be plugged to ensure that agricultural land is utilised for agricultural use only.

Availability of labour: Non-availability of reliable local labour during critical agricultural operations is often cited by many land-owners as a cause for letting lands fallow. Many households also are engaged in rural employment guarantee schemes which are felt as better and easier options for employment. Schemes to include projects that could utilise such labour for agricultural operations in fallow lands, as well as scheduling projects in non-agricultural season could also be considered.

WATER RESOURCES

Tank Management: As discussed in Section 4.3, tanks have been designed as adaptation strategies particularly for Tamil Nadu, considering unique climate variability of the State and rainfall patterns (few but heavy spells and long dry periods). Revival and rehabilitation of these 41,000 tanks in Tamil Nadu would immensely benefit farmers in their day-to-day operations. However, considering modern developments, socio-economic changes they have fallen into disuse and focussed efforts are needed for their rehabilitation. Emphasis is currently needed on the societal issues that have reduced the community stake and ownership such as land tenure, ownership, abandoning of local systems with caste abolishment, to revitalise community involvement along with consideration of climate information to create a viable tank management system.

Reservoir Management: Reservoir management is neglected due to lack of incorporation of rainfall forecasts into operational reservoir management plans. Currently 5-7 days forecast from ECMWF and IMD could be used to evolve water inflow and outflow model to guide reservoir operations.

5 2002. Ramasamy.C, Sivakumar S.D, Balasubramanian. R, Economic Analysis of Trends and Distribution of Fallow Lands in Tamil Nadu. Centre for Agricultural and Rural Development Studies, Tamil Nadu Agricultural University, Coimbatore-641003.

Canal System Management: Area covered by canal water system has stagnated since the 1970s and is showing a decreasing trend. Efficient use of canal systems needs a significant and focussed investment for upkeep and maintenance which is not factored into the development budgets. Lack of local institutional systems and alienation of the local communities acts as a disincentive for upkeep and maintenance.

Ground water Management: In order to avoid overdraft of ground water, climate information needs to be used to assess recharge potential and to evolve system to tap ground water with reference to recharge. The poor monsoon system has a lag period on ground water aquifer behaviour. Poor SW and NE monsoon as well as late or early withdrawals could impact ground water potentials. CRM models have to be developed to guide management of ground water. The climate information includes the rainfall pattern of the area so that once in a decade heavy rainfall episodes are considered to plan storage systems and channels or catchment areas to receive excess water based on advance information.

To generate such climate information, a climate watch to collect and analyse data from local observation systems relevant to particular tanks and their catchment areas and command systems has to established and linked to use of five-day, ten-day and fifteen-days forecasts. The ground water banking concept involving check dams, percolation ponds, farm ponds and other ground water recharge structures that has been successful in Gujarat, especially in its Saurashtra and Kutch areas, could be replicated at least for the western districts of Tamil Nadu where the South West Monsoon is active.

In conjunction, a refined allocation of water from the tank among its users including from wells should be regulated as per recharge. Water availability-based crop cultivation linked to agro-processing and markets needs are required to be encouraged. In all stages of this process, community involvement, weather and climate information need to play a critical role. Tamil Nadu Vision 2023 encompasses some elements of this programme viz. land consolidation, contract farming, processing and linkages to markets, which need to be strengthened through a comprehensive policy and programmatic CRM approach.

CROP SYSTEMS

Shift to Coarse Cereals: Shift from water-intensive crops to coarse cereals with value-additions to meet emerging demands for coarse cereals and to reduce climate sensitivity should be encouraged. Particularly areas at the tail ends of irrigation systems and areas where cultivation is directly rain-fed need more emphasis on coarse cereals than on water-intensive crops to ensure better conformity with climate.

Policy-Support: Due to the policy incentives for rice, wheat, sugarcane in the form of assured minimum prices, subsidised fertilisers etc. since 1960s, a huge transformation has taken place with these crops and led to development and demand for these crops. Similarly, assured minimum price support also needs to be extended for coarse cereals to wean away land from water-intensive and climate inappropriate crops.

Incorporation of CRM into SRI: In irrigated areas, SRI (System of Rice Intensification) and hybrid varieties are encouraged. However, these high input and hitech crop system are sensitive to climate at all stages of crop cycle. Hence, there is a need to incorporate farmer-centric agro advisories based on weather forecast to minimize weather/climatic risks.

Implementation of Agro Advisory Expert System: Agro Advisory Expert System is the efficient system that could minimize the potential impacts of weather/climate events through informed decision making. Agro-Advisory Expert System (Ag-ADE) is a system which assists farmers in identifying potential impacts of weather/climate events, forecasted 3 days, 7 days, 15 days and 30 days in advance at various stages of crop growth along with possible response options. Ag-ADE is a web based online system for generating and disseminating meteorological and hydrological forecast based agro-advisories for specific crops at particular growth stage and location. The system also acts as a data management system for managing and processing agro climate data. The system automatically generates an advisory, then waits for expert modification or checking and on expert approval, disseminates the advisory to registered users.

This system could be in housed at State Agriculture Department and with capability to disseminate advisories to intermediary users at district and sub-district level and for onward transmission to farmers through agriculture extension workers. Capacity building activities on using agro advisory system could be carried out through State Agriculture Department to train their staff at district and block levels. Further this training could also be given to farmers through Climate Field Schools.

Contingency Crop Plan: Seasonal forecast followed by monthly and ten days system could be used to plan crop system and undertake adaptive measures during monsoon season depending on rainfall behaviour.

HORTICULTURE

Climate Shocks are a major constraint in horticulture which has high input costs, long gestation periods and results in huge losses, severe disruption in flow of income as well as huge reinvestment costs in re-establishment of crops. Hence due to the high value, high risk and high input costs, climate risk reduction instruments should be made mandatory for horticulture crops.

Design and Establishment: Climate knowledge has to be considered as a major factor when hybrid varieties of plants are developed to assess vulnerability vis-à-vis local climate fluctuations. Considering the huge investments, long periods of continuous investments and input costs for horticulture (also the relatively larger profits), while establishing large scale horticulture cultivation farms/ areas, proper climate risk assessment have to be carried out to understand climate vulnerability/sensitivity of the identified area. Horticulture programmes being encouraged as part of the diversification process need to consider exposure to climate risks. Proper assessments including suitable zoning for horticulture activities and linkages with weather information for managing and guiding their production practices are required.

Management: Climate risk management approach for horticulture needs to be further researched and available weather information needs to be utilised in management of horticulture. Strategies such as higher density of planting, effective and timely irrigation etc. need to be evolved to reduce risks.

Further, one in five year events such as severe storms/ cyclones/ heavy rainfall episodes could wipe out the entire crop, leading to a complete loss not just for the season but several years afterwards, as witnessed in the case of cashewnut and jackfruit during Cyclone Thane. The policy shift towards high value horticulture crops enunciated in Vision 2023 necessitates development of risk instruments considering crop-specific climate risks and impacts including potential losses.

Small scale and large scale horticulture farm holders should make use of the available climate forecast technologies. Even short term weather forecasts are useful to minimize the impacts. For example, weather forecasts about heavy winds or pest outbreaks could be used to undertake some preparatory or risk management activities.

ANIMAL HUSBANDRY

Livestock acts as a buffer against climate shocks by diversifying risk among the rural households. It provides a cushion to agricultural growth and food security *(Birthal PS and Negi DS. Livestock for higher, sustainable and inclusive agricultural growth. EPW June 2012, Vol XLVII Nos 26 & 27)*. Considering the impacts of climate variability on crop production in Tamil Nadu, livestock needs to be encouraged and supported.

Management: Poultry farms and cattle are sensitive to high temperature and humidity, and these could enhance the stress on animals and also lead to disease outbreaks. Proper farm management and giving suitable set up for cattle and birds become essential to manage these risks. Farms should be designed in such a way that it could cope with climate risks. Disease surveillance system linked with climate information could be enhanced in the farms. Proper huts could be made for cattle to avoid animal getting heat stress because of severe summer heat.

NON-FARM

State Interventions

Water Shed Management program: Currently established watershed program have not taken into account the current climate variability, observable trends and future climate risk. These factors have to be analyzed, considered and incorporated into guidelines while designing and establishing new watersheds.

Rural Livelihood Mission: Guidelines should have climate risk aspects incorporated. Forward and backward linkages should be known clearly.

Women & Self Help Groups (SHGs): Currently there are over 8 million women enrolled in SHGs. Climate shocks impacting agriculture would impact medium farmers, and severely impact the small and marginal farmers and more so the Scheduled Castes, Scheduled Tribes and women and women-headed households dependent on agricultural income. The women SHGs engaged in agro-based livelihoods due to lack of other diverse skills that are impacted would not be able to repay their borrowings without external support. Hence, use of climate forecast information to help the SHGs in managing their resources better and linking them with weather risk based insurance schemes are highly essential.

Rural Employment Program: The rural employment program aims at utilizing 40 percent of the program for asset creation and 60 percent for wages. Climate risk is not at all considered while generating these assets. Hence, CRM has to be incorporated in the guidelines while planning rural employment initiatives in each location.

Public Distribution System (PDS): Currently more than INR 5,000 crores are spent for PDS. If the State utilizes climate risk information appropriately for agriculture, livelihood programs etc., it will ensure a sustainable agricultural sector and will impose lesser burden on the PDS.

Disaster Risk Management: Currently 5 days, 10 days, 30 days, seasonal forecast are not used in Disaster Risk Management activities. Hence incorporating climate forecast information at the above mentioned timescales could minimize disaster impacts through managing the risk efficiently.

Supply chain activities

Risk management measures could be incorporated into supply chain management. Availability of agro-based raw materials fluctuates due to weather variations. The first step would be an assessment of climate impact pathways and non-climate risks, such as credit, fertilizer, and seeds availability, and the role of market price in affecting a farmer's decision, through feedback pathways. Managing climate risk within the supply chain framework could pave the way for addressing production and market risks holistically. Effective CRM could minimize impacts on supply-chain disruptions.

State Economy

Planning activities of State have to include climate as a factor while modeling agriculture and economic growth. Capacity has to be built to model the rainfall pattern over longer time scale, i.e., ten years' time frame to be incorporated into the planning process. In the recent past, Tamil Nadu experienced significant deficient rainfall from 2002-2003 leading to drought, as also in 2012-13. As these are recent experiences capturing weather impacts on economic sectors more appropriately, the factors of influence evident on economic sectors in 2002-03 drought & 2012-13 drought could be adopted.

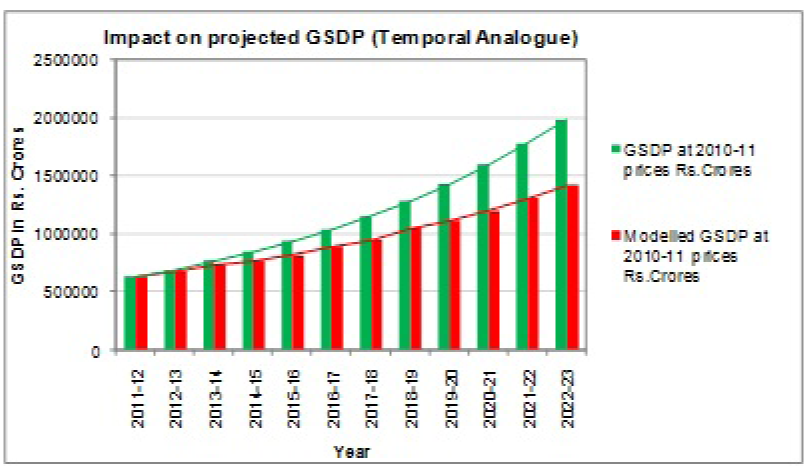


Figure 6.1 Projected GSDP and Modeled GSDP based on climate scenarios (Temporal Analogue)

Likely impacts on primary sector growth rate (and cascading impacts on other sectors) based on the rainfall deviations identified in the anticipated climate through the temporal analogue using factors of influence identified above could be modeled. A case of GSDP modeling is carried out in which significant negative rainfall deviations resulting in wide-spread droughts only are taken into account and not positive rainfall deviations leading to floods and cyclonic storms due to their localized impacts. Capacities have to be built for modeling GSDP incorporating climate risks. *(Modeled GSDP for the State based on two case of climate scenario - Figures 6.1 and 6.2)*

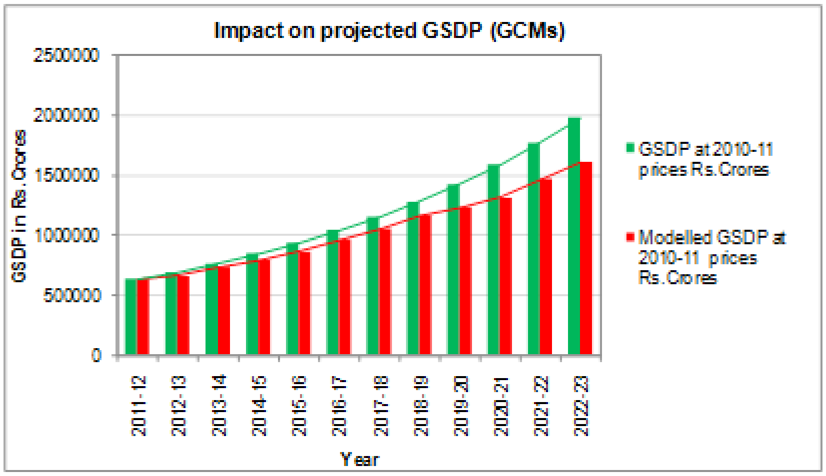


Figure 6.2 Projected GSDP and Modeled GSDP based on climate scenarios (GCMs)

As noted earlier in Section 4.4, the government spending for reducing climate risk through development programs such as agriculture, watershed development, irrigation and rural infrastructure is only INR 7,000 crores, resulting in a gap of INR28,000 crores between the cost of climate risk and investment. CRM-TASP recommendation is to increase investments that could directly contribute to reducing climate risks such as rehabilitation of tanks, improving agro processing industries, better water management practices, more reliance on surface water than on ground water could gradually free resources for investment from safety net programs to development. The development Vision 2023 provides an opportunity to evolve policy, institutional mechanisms, build climate risk assessment and management capacities and guide informed decision-making to reduce climate risks.

The major gaps identified in Section 4.3 are the absence of capacities and mechanism for a thorough assessment of climate risks to the economy. As per conservative estimates in Section 4.3, annual losses to the state economy due to climate could be about INR 33,600 crores. The spatial distribution of these losses as well as sectoral distribution needs to be assessed and the root causes for these losses identified.

Agro-processing and industrial sector:

Cyclone Thane revealed that agro-processing and industrial sector is also greatly affected by climate risks. Many micro, small and medium units do not have contingency plans. Risk management based on use of 5-day or 10-day weather information is not integrated into their operations and into managing extreme events, resulting in severe impacts for rice processing, coir, agro-processing and chemical units etc.

By facilitating linkages with district industrial centres and industrial associations, capacities need to be built among the district industrial centres and associations, at least in high-risk coastal zones, to link with and access forecast information and tailor them for utilization by specific units.

BOX 6.1: APPROPRIATE USE OF RISK INFORMATION FOR REDUCING IMPACTS-CASE OF CYCLONE THANE

Chemfab Alkalis, an industrial unit located in Puduchery, adjoining Tamil Nadu State manufactures several products including Caustic Soda Lye and liquid chlorine. On receiving information on possible impacts of Cyclone Thane a few days before landfall, Chemfab undertook an assessment of possible impacts on the unit and its facilities, including industrial equipment, buildings and trees. The assessment identified several possible measures to reduce impacts including- i) additional strengthening of the chimney structure, ii) storage of fuel (diesel) in the event of disruption to power from the grid, iii) pruning of trees to minimise damages from falling branches.

The cost of undertaking these preparatory actions was 15 – 20,000 USD, which was insignificant seen against the potential consequences of not taking these precautions and was considered as a no (or low)-regret option. This was one of the few industrial units that could resume production and operations with minimal delays after Cyclone Thane.

Source: Personal interviews

Information management:

Data sharing and collaboration between IMD and other departments in Tamil Nadu could help in consolidation of over 650 observation stations in the State. Due to absence of effective linkages, weather information collected across the State at very local levels by several departments are not being used effectively, which can in turn improve quality and accuracy of location-specific forecasts and advisories.

Current technologies enable generation of climate information in a range of time scales from few hours to days to months to seasons and years. Probabilistic forecast for 5 - 10 days timescale and even up to 15 days are available now and it could be used. Capacities for integrating this information for undertaking decision making process depending on level of risk needs to be built.

Tamil Nadu State has a vision of transforming its economy from primary based sector to secondary and tertiary based sector economy. The weather risks are transmitted directly or indirectly to these sectors; hence incorporating 5 to 10 days forecast system could be useful to reduce the direct losses and indirect losses through various climate/ weather information scales. There is a considerable capacity building required to use the robust risk communication ability to accept and adapt the probabilistic forecast information in a risk management framework.

The Planning Commission has already expressed willingness to use the inferences based on available scientific knowledge for all time scales including the decadal variability cycle for its 12th Five Year Plan. Such information may have a 60 percent probability, and could be used by the Planning Commission for recommending mid-course adjustments by sensitive sectors in the plan implementation in a substantial manner to ensure that the losses are minimized due to climate risks. The Planning Commission has also appreciated the need to utilize an iterative risk management process, such that as and when new information is available, suitable adjustments could be made.

The climate risk management approach addresses risks in short and longer term in a holistic way as they could impact the developmental process significantly. CRM approach also envisages cross-sectoral interventions instead of sectoral interventions. CRM integrates the three domains of development planning, disaster management and climate adaptation into one involving all stakeholder institutions.

Implementation of CRM through applied research programme

Appreciating this approach, Tamil Nadu State Planning Commission has adopted CRM approach for undertaking informed development process; wherein comprehensive CRM-based planning, climate information integration in development planning have been adopted as a program. Since there is a learning process involved in the beginning, this has been accepted as an applied research program in-house at Planning Commission with participation of all the stakeholder institutions. This applied research program envisages the following components:

Institutional framework for CRM

A multi-sectoral institutional framework to ensure management of climate risks by, and their integration into, all sectors at all time scales (short-term and long-term) is required.

Considering the existing institutional landscape and mandates, the State Planning Commission may be best suited to facilitate this process on a continuous basis for all time-scales up to decadal and beyond without overlapping with the few days' timescale that is already well-performed by the existing disaster management institutional set up.

This institution needs to provide outlooks on several time-scales- eg: annual plan development which integrates the climate outlooks. In addition, while the disaster management setup recognises and plans for extremes based on deterministic information, this institution needs to dynamically monitor the emerging economy of the State where in economic processes, supply chains and activities manifest on a continuous basis. As these developments are accompanied by risks as well as opportunities in response to even normal weather and climate, the institution needs to undertake this function on a continuous basis and coordinate actions by relevant sensitive sectors.

Such functions need also to be extended for utilising probabilistic information for extreme events- eg: in case of Cyclone Thane which led to massive disruptions to power supply in the affected districts of Tamil Nadu, this institutional arrangement could facilitate sufficient preparations by Electricity Board based on the probabilistic information for Cyclone Thane already available with IMD to anticipate impacts and to minimize disruptions and thereby enable industries to restart their activities earlier.

This institutional framework also needs to consider threats to development outcomes laid out in Vision 2023 in light of increased exposure to climate risks and their sensitivity (as discussed in 4.4). Assessment of risks on a continuous basis, as well as on event basis (extreme events) needs to be undertaken for the economic processes and systems contributing to implementation of the Vision 2023. Capacities need to be built through an applied research programme for understanding both the changing economic processes and systems as well as possible impacts on them are required to develop series of outlooks- decadal, annual, seasonal, and shorter-time scale utilising probabilistic weather information.

To carry out these functions, specific roles of concerned institutions- Planning Commission, Agriculture Department and others need to be clearly defined, necessitating a legislative framework providing these guidelines.

Policy and Legislative framework for CRM

For the cross sectoral integrated approach to managing climate risks recommended above, policy and legislative changes have to be brought in (to make it a permanent mechanism).

This legislation needs to encourage and empower decision-making utilising available scientific, probabilistic information to prepare potential outlooks, and the power to recommend to sectors to take appropriate anticipatory actions to minimise negative impacts from risks or maximise opportunities from favourable circumstances. Subjective probabilities, risk of using the information needs to be institutionally supported. This requires suitable legislation to provide an enabling environment.

Capacity building for seamless (probabilistic) climate information in a manner

Seamless information indicates information on all timescales- varying from few days to even a decade. Capacities are required to generate and apply such seamless information in climate sensitive sectors like agriculture, water resources(PWD) etc.

Generation of information: Global and national research going on to improve climate information generation are not currently designed to meet user needs. A dialogue mechanism is required to identify user information requirements for research institutions to utilise all available scientific advances to generate such information.

Application by climate sensitive sectors: An iterative risk management process is recommended for sensitive sectors like agriculture, water resources to utilise the best available scientific information, and improve and modify strategies and actions as new information is available. This process would need to build in each sector the following key capacities to:

i) Assess climate sensitivity, i.e., weather and climate risks to the sector;

ii) Quantify their impacts on the sector;

iii) Assess utility of currently available information to manage potential impacts and their utility;

iv) Model impacts on the sector;

v) Formulate risk management and response measures.

Articulate additional information needs to IMD through a dialogue mechanism.

Institutionalisation of past data and existing research for generation and application of climate information of various time scales

As mentioned in Chapter 3, existing research show possible linkages between local synoptic systems to regional and global influences. A mechanism needs to be established to utilize currently available information (eg: past synoptic charts) and capacities in IMD to provide improved lead time and actionable information based on applied research connecting synoptic systems to Inter Tropical Convergence Zones (ITCZ), El Niño and La Niña, Indian Ocean Dipole etc.

Past data could also be used to construct analogues and scenarios that lead to anticipatory management measures, eg: when specific influences indicate a specified number of lows in a year, their influence on rainfall and thus on water resources and agriculture could be anticipated. Possible sectoral measures based on the above scenarios need to be evolved as contingency plans.

Information on 10- 15-days timescale - ECMWF is increasingly able to generate reliable longer-lead time forecast on severe weather systems. The capacity to utilise these forecasts and customize them for local applications by providing value added products to users is recommended. Simultaneously, sectoral institutions need to be capacitated to incorporate such information into their operational plans.

Seasonal Forecast information - 90 percent of the El Niño years could result in enhanced North East Monsoon over Tamil Nadu. Positive Indian Ocean Dipoles (IODs) also influence enhanced monsoon. These forecasts are available on a seasonal time scale.Currently this information is used in a limited manner. The constraints and barriers for applying seasonal forecasting information in managing agricultural and water resource sector at basin level has to be studied. Capacity building is needed to make use of these indicators and generate customised forecast to meet various user demands, along with corresponding capacity among users to utilise such information in a risk management framework. Already available tools including the alternative cropping patterns for various weather scenarios could be utilised if such information could be made available.

Annual and inter-annual Forecast - El Niño influences both Southwest and Northeast Monsoon- since realistic El Niño forecasts are available in April, and since it persists for one year after setting in, Tamil Nadu could use such information for managing agriculture and water resources for three seasons- Season 1 (SW Monsoon season from June-September), Season 2 (NE monsoon from October-December), and Season 3 (Pre-monsoon seasons). A direct application is for over half of the irrigated areas that depend on tanks and canals where water can be used judiciously and prioritised as per indicated conditions.

Decadal scale - Research studies on NE monsoon indicate a cycle of decades with high or low rainfall. It is possible to use this information for the preparation of the Five Year plans and also for implementation of Vision 2023 to reduce impacts of climate risks. Capacities to utilise such information needs to be built in both among sensitive users and the Planning Commission. While Southwest monsoon has broader 25-30 year cycle, the Northeast monsoon has a shorter decadal cycle, and using both Tamil Nadu could develop a resource management plan for prioritising five year plan allocations among sectors and prioritising programmes and projects within sectors- eg: in agriculture sector during normal years programmes on canals and tanks could be prioritised over other activities that plan for deficit rainfall.

Institutionalisation of climate risk management at district level

Currently districts are at the cutting edge of implementation of all key development initiatives in the State. There is a need to build capacities at district levels to undertake climate sensitivity assessments for key development and economic activities in the district, and to utilise probabilistic information for generating possible response options. In fact, State level capacities should be seen as aggregate of the district level capacities.

To illustrate Namakkal, Erode currently may be considered climate insensitive despite being dry districts, as ground water is the key source for agricultural activities, whereas, this scenario cannot continue long, as water levels are falling beyond extraction. District level GDP is impacted and capacities at district level are needed for them to undertake sensitivity studies as climate sensitivity varies locally. The District Planning Unit is best placed for receiving such capacity building, and should be linked to State and national level capacities.

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