1. INTRODUCTION

1.1 BACKGROUND

Globally observations point towards a climate change scenario as temperatures are increasing, sea levels are rising, with a perceivable increase in severity and frequency of extreme events (IPCC 2007a; Special Report on Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation (SREX), 2012) and the speed of the change is evidently fast. This is leading to a complex situation, whereby all spheres of our existence are being impacted. Model projections; indicate a further escalation of the situation if greenhouse gas concentrations in the atmosphere from anthropogenic sources keep on rising unabated. It is surprising that solutions to adapt or mitigate the situation essentially are emerging from indigenous knowledge, State of art technology and research in all disciplines and fields.

Due to global temperature rise and speed at which climate change is occurring, it is evident that countries are becoming vulnerable to climate change, which reduces the development path. Hence, capacity to adapt should be increased through implementation of suitable national adaptation plans. Future vulnerability depends not only on climate change but also on the type of development path that is pursued. Thus adaptation needs to be implemented in the context of national and global sustainable development efforts. The international community is identifying resources, tools, and approaches to support this effort. Adapting to climate change entails taking the right measures to reduce the negative effects of climate change (or exploit the positive ones) by making the appropriate adjustments and changes. There are many options and opportunities to adapt. These range from technological options such as increased sea defences or flood-proof houses on stilts, to behaviour change at the individual level, such as reducing water use in times of drought and using insecticide-sprayed mosquito nets. Other strategies include early warning systems for extreme events, better water management, and improved risk management, various insurance options and biodiversity conservation.

1.2 THE NATIONAL CONTEXT

India's economy and 68.8 percent of its population (Census, 2011) residing in rural areas are directly dependent on climate sensitive sectors such as agriculture, animal husbandry, fisheries etc. Since climate change is expected to impact natural and human systems adversely by inducing changes in these systems, India can be considered highly vulnerable, as the extent of exposure is very high when compared to most countries in the world. Climate change is only likely to exacerbate India's already high physical exposure to climate-related disasters as 65 percent of India is drought prone, 12 percent flood prone and 8 percent susceptible to cyclones. As a consequence, climate change is likely to impact livelihoods by disrupting social, cultural, economic, ecological systems, physical infrastructure and human assets, accentuating health risks hence posing severe risks to the development of the country.

Since climate change impacts are felt at multiple levels from the global to the local, responses to climate change also needs to be at multiple levels, calling for strategic interventions at local, sub-national, national, and global levels. At the global level, India's contribution to multilateral negotiations in the United Nations Framework Convention on Climate Change (UNFCCC) has been significant and it continues to advocate for effective, cooperative, and equitable global approaches based on the principle of 'common but differentiated responsibilities and respective capabilities'. At the national level, India has developed the National Action Plan on Climate Change (NAPCC, 2008) which comprises of eight National Missions (Box 1.1) at its core and addresses various sectoral aspects of climate change. The NAPCC seeks to promote understanding of climate change, adaptation, mitigation, energy efficiency and natural resource conservation while pursuing overall economic growth – i.e., measures that promote development objectives which also result in co-benefits for addressing climate change.

At the same time, recognising that the impacts of climate change will vary across States, sectors, locations, and that different approach will need to be adopted to fit specific sub-national contexts and conditions. All Indian States are preparing State Action Plans for Climate Change (SAPCCs) with the NAPCC. It is in this context that the Tamil Nadu State Action Plan (TNSAPCC) on Climate Change has been prepared.

Box 1.1: National Missions under the NAPCC

- **National Water Mission** sets a goal of 20 percent improvement in water use efficiency through pricing and other measures
- **National Mission for Sustaining the Himalayan Ecosystem** aims to conserve biodiversity, forest cover and other ecological values in the Himalayan region
- **National Mission for a Green India** aims at Increased forest/tree cover on 5 m ha of forest/non-forest lands and improved quality of forest cover on another 5 m ha (a total of 10 m ha), improved ecosystem services including biodiversity, hydrological services, and carbon sequestration as a result of treatment of 10 m ha.
- **National Mission for Sustainable Agriculture** aims to support climate adaptation in agriculture through the development of climate resilient crops and appropriate agricultural practices
- **National Solar Mission** (renamed as Jawaharlal Nehru National Solar Mission) aims to promote the development and use of solar energy for power generation and other uses with the ultimate objective of making solar energy competitive with fossil based energy options.
- **National Mission for Enhanced Energy Efficiency** recommends mandating specific energy consumption decreases in large energy consuming industries. It also recommends financing for public-private participants to reduce energy consumption through demand side management programs
- **National Mission on Sustainable Habitat** aims to promote energy efficiency as a core competent for urban planning. The mission calls for a greater emphasis on urban waste management and recycling including production of power from waste.
- **National Mission on Strategic Knowledge for Climate Change** is for gaining a better understanding of climate science, impacts and challenges. It envisions improved climate modelling and increased international collaboration to develop adaptation and mitigation technologies.

1.3 THE TAMIL NADU CONTEXT

Like many other States with similar developmental contexts, Tamil Nadu too has high dependence on natural resources and faces the threat of climate change and its impacts. Available evidence shows that there is high probability of increase in the frequency and intensity of climate related natural hazards and hence increase in potential threat due to climate change related natural disasters. In the (relative) absence of State level climate models and/or vulnerability studies, as well as low community awareness, Tamil Nadu is potentially mere sensitive and vulnerable to climate change and its impacts.

Tamil Nadu 'Towards Balanced Growth and Resilience'

Tamil Nadu is already undertaking a range of sectoral initiatives that are climate friendly (although these may not have been articulated as such in government documents), and the State plans to continue to foster such initiatives by providing an enabling environment.

The Twelfth Five Year Plan of Tamil Nadu aims to achieve a higher level of sustainable economic growth, which will benefit all sections of society. Sustaining services growth and accelerating industrial growth, Tamil Nadu aims at a double-digit growth rate by the end of the Twelfth Five Year Plan period. The Twelfth Five Year Plan provides an opportunity to restructure policies to achieve not just a robust and inclusive growth but also sets the goal to make Tamil Nadu "Number One" among Indian States. It will work across all sectors to further promote human development that impacts and improves the lives of all- marginalized, women, old-aged, minorities and the differently-abled. Venturing on this path to foster human development, the State aspires to see a significant reduction in the inequities across social groups, regions and gender by the end of the Twelfth Five Year Plan.

1.4 TNSAPCC PREPARATION PROCESS

The process of preparation of Tamil Nadu TNSAPCC started first in July 2010 with the formation of a Steering Committee, headed by the Chief Secretary, Government of Tamil Nadu. The composition of the Steering Committee is in Annexure 1a. Subsequently, an inception workshop was organised in August 2010, which identified the focus areas where the State needs to concentrate. The focus areas identified were

- Sustainable Agriculture (and allied sectors)
- Water Resources
- Forest & Bio-Diversity
- Coastal Area Management
- Energy Efficiency, Renewable Energy and Solar Mission
- Sustainable Habitat
- Knowledge Management

The next step was the formation of working groups, which was constituted with members drawn from various departments, universities, NGOs and other institutions

of significance (Annexure 1b for the composition of the working groups).Following this activity, the GIZ in association with Inter-coperation India, assisted the Government of Tamil Nadu and the working groups in formulating their sectoral papers. A number of working group meetings were organised to review progress (see Annexure 1c for the list of meetings organised) between March 2012 and April 2013.After the approval of each sectoral paper by the respective working group chair, they were synthesised together through May to July 2013 to formulate the State Action Plan document. Between August 2013 to April 2014, the document went through public review and Steering Committee review. The final TNSAPCC is being submitted to the MoEF&CC in July 2014. The time line of preparation of the TNSAPCC is highlighted in Table 1.1.

Table 1.1: Timeline of TNSAPCC formulation Process/Activities

Month/Dates	Process/Activity
July 2010	Steering Committee on SAPCC formulated wide chaired by Secretary, Govt of Tamil Nadu
August 2010	Inception Workshop with all concerned stakeholders to identify and finalise focus areas
October 2010	Sectoral Working Groups formulated wide GO No. 56, Department of Environment and Forests
February 2012	1st review meeting of all the working groups together
March 2012 to June 2013	Various meetings of the Working Groups
August 2013	Draft TNSAPCC ready
September 2013	Review by steering committee
October 2013	Submission of draft SAPCC
November 2013	Public review of SAPCC
March 2014	Pre-Final Draft submission of SAPCC from GIZ to DoE
April 2014	Review by State Steering Committee
May 2014	• Review of Sector wise Strategies and budget of SAPCC under the Chairmanship of Principal Secretary, Finance ,GoTN as per the follow up of the Review of the State Steering Committee • Financial re workings for all Sectors of SAPCC
June 2014	• Incorporation of Strategies with revised budgets in TNSAPCC draft • Approval of Principal Secretary, Finance, GoTN. for the Strategies with revised budgets in TNSAPCC draft • Approval of Principal Secretary, Finance, GoTN for the Strategies with revised budgets in TNSAPCC draft. • Finalisation of the Strategies with revised budgets in TNSAPCC draft
July 2014	• Finalisation of the TNSAPCC draft • Formal Submission to MoEF&CC, GoI

2. STATE PROFILE

2.1 LOCATION AND PHYSIOGRAPHY

The State of Tamil Nadu is situated in the southern part of the country between north latitude 8° 5' and 13° 35' east longitude between 76° 15' and 80° 20'[1]. The total area of the State is 1,30,058 sq.km making it the eleventh largest State in the country. Tamil Nadu has 32 districts. Tamil Nadu is one of the important Coastal States having a coastline of 1076 km. To its east is the Bay of Bengal and at its southernmost tip is the town of Kanyakumari, which is the meeting point of the Arabian Sea, the Bay of Bengal, and the Indian Ocean.

Figure.2.1

Tamil Nadu can be divided broadly into two natural divisions (a) the coastal plains and (b) the hilly western areas. The average temperature in the plains varies between a minimum of 21.6° C to a maximum of 31.8° C and in the hilly areas varies between a minimum of 9.4° C to a maximum of 22.8°C.

The north-western, western and southern parts are hilly and rich in vegetation, with the Western Ghats effectively blocking much of the rain bearing clouds of the south west monsoon from entering the State. The eastern parts are fertile coastal plains and the northern parts are a mix of hills and plains. The central and the south central regions are arid plains and receive less rainfall than the other regions. Since Tamil Nadu is heavily dependent on monsoon rains for recharging its water resources, monsoon failures lead to acute water scarcity and severe drought. The normal annual rainfall of the State is about 908 mm of which 48 percent is through the north east monsoon and 32 percent through the south west monsoon.

Tamil Nadu includes a wide range of biomes, extending east from the south Western Ghats, montane rain forests in the Western Ghats through the south Deccan plateau, dry deciduous forests and Deccan thorn scrub forests to tropical dry broadleaved forests and then to the beaches, estuaries, salt marshes, mangroves, and coral reefs of the Bay of Bengal.

[1]http://www.tn.gov.in/dept.st/TN at a glance.htm;

2.2 DEMOGRAPHIC PROFILE AND HUMAN DEVELOPMENT

The total population of Tamil Nadu as per Census, 2011 was 72.1 million which is 5.96 percent of India's population. It is the seventh most densely populated State in India with a population density of 555 persons per sq.km, significantly higher than the Indian average of 382 persons per sq.km (Census of India, 2011). Tamil Nadu the most urbanized State in India, with a population of 35 million spread over about 11 percent of the total area of the State i.e. over an area of 13,755 sq.km. The sex ratio in 2011 is estimated to be 987 females per 1000 males, which is well above the national average in 2011.

The capital of the State constituting of the Chennai Metropolitan area extends over 1,189 sq.km and its population is estimated to be about 8.8 million now. It constitutes more than 25 percent of the Tamil Nadu State urban population and more than 12 percent of the Tamil Nadu State total population. The population of the metropolitan area will be about 1.26 crore by 2026. The decadal growth rate for the period 2001-2011 has been 15.6 percent, which has increased from 11.7 percent estimated for the period 1991-2000.

Table 2.1: Key features of the State

Geographical Area	1,30,058 sq km*[1]
Number of Districts (2011)	32*[2]
Number of Blocks (2011)	411*[3]
Population (2011)	7,21,38,958*[4]
Males	3,61,58,871*[4]
Females	3,59,80,087*[4]
Population Density (2011)	555 per sq. km*[4]
Average size of agriculture land holding (2000-01)	0.89 hectare*[5]
Population below poverty line (2009-10)	17.1percent (44.07 lakh persons)*[6]
Fertility rates (2004-06)	1.7 *[7]
Birth rates- rural, urban	16.3 – 16.5, 16 per thousand*[7]
Death rates - rural, Urban	7.6 - 8.5, 6.6 per thousand*[7]
Infant mortality rates	28 per thousand*[7]
Sources: *1 Department of Statistics and Economics: TN at a Glance 2010 *2 GoTN official website http://www.tn.gov.in/district_statistics.html *3 Rural Development and Panchayat Raj Department http://www.tnrd.gov.in/databases/Blocks.pdf *4 Census 2011 *5 Compiled from Agricultural Census reports of T.N *6 Institute of Applied Manpower Research (2006-2007) *7 SRS 2009-11	

Tamil Nadu has been in the forefront of introducing social reforms and implementing a slew of welfare schemes to empower the marginalized sections of the society. The State performs well in Human Development Indicators. According to the National Human Development Report 2001, the State was ranked third behind Kerala and Punjab. Gross Enrolment Ratio (GER) and Net Enrolment Ratio(NER) have improved in both primary and middle levels. There is need to follow a three fold strategy of expansion, equity and excellence in higher education. Although, Tamil Nadu compares well with country's average performance with respect to many health indicators including Total Fertility Rate, Infant Mortality Rate(IMR), Maternal Mortality Ratio (MMR) and child nutrition, there are concerns about some of these indicators as the State is not likely to meet the Eleventh Five Year Plan targets relating to these indicators. IMR is still 28. Although about 95 percent of births occurred in health institutions, MMR is 79 (2008-09). Ensuring safe motherhood and protecting infants are the biggest challenges. Nearly 50 percent of our women (15-49) are anaemic.

The State has been implementing various welfare programmes for the socio-economic empowerment to uplift the downtrodden. As a result the social sector expenditure has increased to 49 percent in 2011-12 from 42 percent in 2006-07 in plan expenditure, which is the highest in the country.

2.3 ECONOMY

Tamil Nadu is one of the most socially developed and economically progressive States in the country and progressing faster in terms of percapita income and Human Development Indicators (HDI).The Eleventh Five Year Plan (2007-12) set a growth target of 9.0 percent against the achieved growth of 9.7 percent in the Tenth Five Year Plan. However, the State achieved an average growth of only 7.7 percent. Growth in first two years of the Eleventh Five Year Plan declined due to negative growth of agriculture. The global slow down in those years along with rising oil prices and power shortage affected the performance of other sectors too, particularly industry. In May 2011, a strategic plan-"Vision Tamil Nadu 2023" was prepared for infrastructure development to catapult Tamil Nadu to a high growth plane for the first time to identify thrust areas for growth and bottlenecks. Subsequently, the Twelfth Five Year Plan (2007-12) was formulated with the broad objective of ensuring steady economic growth placing Tamil Nadu firmly on the path of an Accelerated, Innovative and Inclusive Growth. The economy was revived through various sector-specific policies and is presently placed back on the path of prosperity and development. The overall growth rate was improved, at an average of 9.2 percent in the last three years.

Fiscal Performance

The actual GSDP (Gross State Domestic Product) between 2003-04 and 2011-2012 has increased almost four times from Rs 142295.10 crore to Rs 416549.40 crore at 2004-05 prices. However, the share of agriculture has declined substantially from 13 percent to 8 percent within this period. The State's own tax revenue as a

percentage of GSDP was 9.25 percent in 2011-12, which is one of the highest among the States and shows the efficiency in revenue mobilization. With a long history of social justice, the public expenditure on social sector in Tamil Nadu has increased from 43.82 percent in 2002-03 to 49 percent in 2011-12 as the State has been implementing various welfare schemes for the upliftment of the marginalized sections of the society. The State has to incur huge expenditure on urban infrastructure as nearly half of the State's population now lives in urban areas. Also, the State funding on energy sector, which is a critical infrastructure for attracting private investment, needs to be increased substantially.

Agriculture

Agriculture still continues to be a dominant sector and provides livelihood to nearly 45 percent of the people but its share has eroded to 8.0 percent of GSDP in 2011-12 from 13.0 percent in 2002-03.Global development experience reveals that one percent growth in agriculture is at least two or three times more effective in reducing poverty than the type of same growth emanating from non-agricultural sector. During the period 2000-2011, this sector registered negative growth in five years and positive growth in six years shows the vulnerability of the sector and is also a cause of distress arising due to the instability in production and productivity. A comprehensive package combining several components to revitalize the sector should be designed to enhance the productivity working within the water constraints and stabilizing or enabling inter and intra seasonal risk proofing of rain fed production systems.

Diversification of Agriculture into animal husbandry, non-food crops, horti culture, floriculture and sericulture has the potential to enhance the farm incomes. The food consumption basket is getting increasingly diversified and though cereal baskets dominate, this dominance is being eroded by rising expenditure on fruits, vegetables, milk, egg, meat and fish, which is the "High Value" segment, and this transformation, is in tune with development expectations. There are 13 coastal districts and 591 fishing villages with a total marine fishing population of about 8.92 lakh, of which 2.60 lakh fishermen are actively engaged in fishing. Hence, it becomes imperative to enhance the incomes of the fisher folk by augmenting marine and inland fish production through innovative technologies.The output from the agriculture sector should be reflected in higher rural incomes leading to improved health and nutrition status. Non-farm income such as post harvest operations, maintenance off farm equipment, etc. offer a virtuous cycle connecting expansion of farm activity to that of rural non-farm income opportunities.

Industrial Sector

Tamil Nadu continues to be an attractive investment destination for investors. Due to the pro-active policies of the government and the conducive environment, the State has attracted huge investments in the manufacturing sector, which accounts for 21 percent of the total investments as on March 2011. It is in the fore front of attracting Foreign Direct Investments (FDI), establishing Special Economic Zones (SEZ) and industrial parks. The State is a leading manufacturer in automobiles,

textiles and Hosiery that have been generating huge employment. The State has a share of about 26 percent of India's auto components production. The contribution of manufacturing sector to GSDP is marginally declined from 20.39 percent in 1999-2000 to 17.75 percent in 2010-11, inspite of the severe challenges faced internally and externally.

Information and Communication Technology (ICT) sector continues to grow rapidly and the contribution to GSDP has gradually increased to 9.7 percent in 2009-10 from 6.6 percent in 2004-05. The State has been promoting Special Economic Zones (SEZs) for Information Technology-Information Technology Enabled (IT-ITES) services in Tier-I and Tier-II cities. It is also strengthening Business Processing Outsourcing (BPO) services in rural areas. Micro Small and Medium Enterprises (MSME) is a vibrant sector in terms of employment, industrial production and exports and contributes10 percent to the GSDP. This sector is known for its employment opportunities next only to Agriculture.

Energy

Electricity is a critical infrastructure for the socio economic development of the State. The State has a total installed capacity of 10,364 MW (as on 31.5.2012)[2] from conventional sources and 7971 MW is the installed capacity from renewable sources (as on 30.06.2012)[2]. The demand for power is growing at the rate of 10 percent per annum. At present, the shortage is managed by resorting to power purchases, utilizing wind based energy and restriction and control measures. The State Government is planning to launch large-scale installation of solar power plants to the tune of 3,000 MW in the next 3 years[3].Focus on production of energy from renewable sources like wind, solar and other non-conventional sources like biomassis high on the government agenda. Rational energy pricing is critical for both effective demand management and a healthy supply response.

Employment and Livelihood

According to the recent National Sample Survey (NSS) 2009-10 report on Employment and Unemployment, the work force in the State has grown to 318.82 lakh in 2009-10 creating an additional employment of 29.02 lakh since 1999-2000 with a compounding growth rate of 0.96 percent per annum. The gendered demographic dividend could by way of increased women labour force participation create a multiplier effect in the economy. It could add to the growth potential provided higher levels of education, skill development and health is achieved and also an environment of rapid growth is created with good quality employment and livelihood opportunities are created in tune with the aspirations of the youth.

Tamil Nadu has been very successful in reducing poverty. According to the Tendulkar methodology, which is being followed by the Union Planning Commission, State's poverty has fallen to 18.3 percent in 2009-10 (tentative estimate) from 28.9

[2]http://www.tn.gov.in/spc/12plan_english/9-Energy.pdf.
[3]Tamil Nadu Solar Energy Policy, 2012.

percent in 2004-05.In absolute terms as many as 60 lakh persons in Tamil Nadu have been moved out of poverty line. However, as many as 130 lakh persons are still languishing in poverty.

2.4 INFRASTRUCTURE

One of the pre-requisites for social progress and economic development of a region is the availability of quality infrastructure to increase access and improve the mobility of factors of production. The Vision Tamil Nadu 2023 would identify and remove the bottlenecks in development, prioritise critical infrastructure projects and work to propel the State of Tamil Nadu to the forefront of development.

Snapshots of some key infrastructure sectors are given below.

Physical Infrastructure - Roads

Tamil Nadu has 28 National Highways running through it. The State is also an important terminus in the Golden Quadrilateral road link of the National Highways Authority of India (NHAI).The district centres are linked through 187 State Highways. Tamil Nadu is one of the first State in India to have 100 per cent metalled road connectivity even in the rural areas. The State Express Transport Corporation (SETC), formerly, Thiruvalluvar Transport Corporation was established in September 1975 and provides road transport services within the State. To upgrade road infrastructure, the State Government is implementing a World Bank-funded project at a cost of around US$ 500 million. The State had a road density of 147.89 km per 100 sq km of area, as of March 2011.

Physical Infrastructure - Railways

Tamil Nadu's railway network falls under the jurisdiction of the Southern Railways, which covers Tamil Nadu, Kerala, Puducherry and a small part of Andhra Pradesh. It has six divisions, four of which are in Tamil Nadu; they are Chennai, Tiruchirapalli, Madurai and Salem. Coimbatore is also a key railway junction. As of 2010-11, Tamil Nadu had a 4,062 km rail network with 536 railway stations. Chennai also has a well-established suburban railway network that connects it to the suburbs and the neighbouring cities. The Mass-Rapid-Transit System (MRTS) is an elevated line of the suburban railway in Chennai; it runs from the Chennai beach to the Velachery suburb, covering distance of 25 km and has 21 stations. It is owned by the Southern Railways.

Physical Infrastructure – Airports

Tamil Nadu has international airports at Chennai and Trichy; it has domestic airports at Chennai, Coimbatore, Tuticorin, Salem and Madurai. The Chennai International Airport was the first in the country to get ISO 9001-2000 certification. In 2012-13 (April to September), the Chennai Airport recorded passenger traffic of 6.35 million and Trichy Airport reported 424,401 passengers. In 2012-13 (April to September), the Chennai Airport and Trichy Airport handled 59,013 and 3,893 flights, respectively.Construction work has been completed on a new passenger

terminal at the Chennai International Airport. The terminal will have a capacity of 10 million passengers. Electronic Data Interchange (EDI) facility for customs clearance is available at the Chennai Airport, and a new integrated terminal building has been constructed at Madurai Airport.

Physical Infrastructure - Ports

Tamil Nadu has three major ports, at Chennai, Ennore and V O Chidambaranar; it has 15 minor ports. In 2012-13 (April to November), the total traffic handled at Chennai, Ennore and V O Chidambaranar ports was 35.58 million tonne, 10.75 million tonne, and 18.46 million tonne respectively. Together, the three ports accounted for about 18.0 percent of the total traffic handled at all major ports across the country. Between, 2005-06 and 2011-12, the major-port traffic increased at an average rate of 5.0 percent. The Chennai port handles, mainly, container cargo while the Ennore and V O Chidambaranar ports handle coal, ores and other bulk minerals.

Physical Infrastructure - Telecommunications

Tamil Nadu had a tele-density of 109.644 per cent as compared to an All-India average of 73.34 percent, as of December 2012. According to Telecom Regulatory Authority of India (TRAI), Tamil Nadu had nearly 73.28 million Wifi subscribers and 3.13 million wire-line subscribers, as of December 2012. As of December 2011, the State had 1.6 million broadband subscribers and as of January 2013, the State had 11,895 post offices. The Bharti-Singtel submarine cable link between Chennai and Singapore has a bandwidth of 8.4 terabits per second; a second submarine cable of 5.12 terabits per second bandwidth has been commissioned by Tata Communications Limited (formerly, VSNL) between Chennai and Singapore.

Industry

As per the Provisional Results of Annual Survey of Industries 2009-2010 (released in 30-December, 2011), the highest number of factories in India is found in Tamil Nadu (16.9 percent). At State level, Tamil Nadu with 9.8 percent has the third highest fixed capital share preceded by Gujarat (17.7 percent) and followed by Maharashtra (14.6 percent)[5] .Employment in terms of total persons engaged has increased by 16 percent in Tamil Nadu and ranks the highest in the country. Among the States, Tamil Nadu (14.3 percent) lies in the top five positions in term of compensation and has come in second after Maharashtra (19.1 percent). Tamil

[5]Provisional Results of Annual Survey of Industries 2009-2010, Ministry of Statistics and Programme Implementation, Press Information Bureau, Government of India

Nadu also comes in third with a percentage share of 10.5 percent in terms of Gross Value Added.

Major industries in the State are textiles, heavy commercial vehicles, auto components, railway coaches, power pumps, leather tanning industries, cement, sugar, paper, automobiles and safety matches (GoI, india.gov.in). Main mineral wealth of the State is granite, lignite and limestone. The State is an important exporter of tanned skin and leather goods, yarn, tea, coffee, spices, engineering goods, tobacco, handicrafts and black granite. Tamil Nadu contributes to 60 percent of the tannery industry in India (GoI, india.gov.in).

There are 7.60 lakh registered MSMEs in this State, providing employment to 52.99 lakh persons with a total investment of more than INR 39,438 crore as on 31.03.2012. As per the 4th All India Census for MSMEs, Tamil Nadu accounts for the largest number of MSMEs in the Country (15.07 percent). Further, it has the second largest number of Medium Enterprises (12.51 percent) and the third largest number of Small Enterprises in the country (9.97 percent).

Knowledge-based industries like IT(Information Technology) and Biotechnology have become the thrust areas in the industrial scene in Tamil Nadu. TIDEL, a software technology park, has been established in Tharamani, Chennai. The Software export from the State which was INR 20,700 crore in 2006-07 and expected to cross INR 25,000 crore in 2007-08. Top IT and telecom companies such as Nokia, Motorola, Foxcon, Flextronic and Dell have commenced production (GoI, www.india.gov.in).

Global auto majors Hyundai Motors, Ford, Hindustan Motors and Mitsubishi have commenced production plants. Ashok Leyland and TAFE have set up expansion plants in Chennai (GoI, india.gov.in). During the year 2010-11, Tamil Nadu Small Industries Corporation (TANSI) has achieved a production of INR 98.62 crore and sales of INR 99.08 crore[5].

Other Physical Infrastructure Sectors

Other core physical infrastructure sectors such as urban infrastructure, power, and water sector will be discussed separately in subsequent Sections of this report.

2.5 SOCIAL INFRASTRUCTURE

Education

Tamil Nadu has a literacy rate of 80.3 per cent according to the provisional data of Census 2011; the male literacy rate is 86.8 per cent and the female literacy rate is 73.9 per cent. Tamil Nadu is on the States that had to Total Literacy Campaign, the

[5]Citizens Charter (2011) Micro, Small and Medium Enterprises Department, Directorate of Industries and Commerce, Government of Tamil Nadu

Post-Literacy Mission and the Continuing Education Programme (CEP). In the State Budget 2012-13, an amount of US$ 3.03 billion has been allocated to School Education Department. As of 2011-12, the State had 34,871 primary schools, 9,969 middle schools and 10,827 and higher secondary schools. In 2011-12, students' strength in the State was about 3.17 million in primary schools, 2.15 million in middle schools and 6.14 million in high and higher secondary schools. Private participation is being encouraged in technical and vocational education.

Health

The State has a three-tier health system, comprising of Hospitals, Primary Health Centres, Health Units, Community Health Centres and Sub-Centres. As of March 2011, the State had 30 District Hospitals, 231 Sub Divisional Hospitals, 385 Mobile Medical Units, 1,204 Primary Health Centres, 8,706 Sub-Centres and 385 Community Health Centres.

3 OVERARCHING STATE FRAMEWORK

3.1 STATE VISION AND COMMITMENT

In 2012, the State brought out a Vision TN 2023 document, which envisions an enhanced economic dynamism, best in human development, a well developed infrastructure that provides universal access to basic services and an investment climate that compares with the best in Asia and would develop Tamil Nadu into India's foremost knowledge and innovation hub (Box 3.1).

Box 3.1: By 2023, Tamil Nadu envisions to

1. Be amongst India's most economically prosperous states by 2023 and be on par with the Upper Middle Income countries globally.
2. Exhibit a highly inclusive growth pattern
3. Lead in social development and have the highest Human Development Index (HDI) amongst all Indian states.
4. Provide the best infrastructure services in India in terms of universal access to Housing, Water & Sanitation, Energy, Transportation, Irrigation, Connectivity, Healthcare, and Education.
5. Be the top three preferred investment destinations in Asia and the most preferred in India with a reputation for efficiency and competitiveness.
6. Become the innovation hub and knowledge capital of India
7. Ensure Peace, Security and Prosperity for all citizens and business
8. Preserve and care for its ecology and heritage.
9. Will 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.
10. Will nurture a culture of responsive and transparent Governance that ensures progress, security, and equal opportunity to all stakeholders.

Considering that in 2023, the State will also have to be in a leveraged position to combat the impact of climate change. However, the vision notwithstanding, has already been articulated as climate change concerns in its Twelfth Five Year Plan, and as such, is committed to fostering an integrated approach to inclusive, sustainable, and climate resilient growth and development.

It is envisaged by the State that for it to be climate resilient, it needs to (a) mainstream climate concerns into all aspects of development policy and implementation, and (b) ensure complementarity with and contributing to the national agenda on climate change. Keeping in mind the overall motto of the TNSAPCC – 'Inclusive Growth for Improved Resilience', these approaches will be supported by the strategies and actions outlined in this report, and by all other necessary actions by the State Government for the achievement of the Vision.

3.2 OVERALL APPROACH, PRINCIPLES, AND STRATEGIES

The approach of the TNSAPCC is to create and define a overarching climate response framework at the State Government level to reduce vulnerability; reduce hazards and exposure; pool, transfer, and share risks; prepare and respond effectively; and increase capacity to cope with unforeseen events, while articulating flexible sector specific response strategies and actions keeping in mind the overall Vision. The State recognises that it has several existing vulnerabilities (ecological, economic, social and cultural), and that climate change is likely to exacerbate these further if not addressed adequately and holistically. Therefore the climate response

strategy of Tamil Nadu has key elements such as accelerating inclusive economic growth, promoting sustainable development, securing and diversifying livelihoods, and safeguarding ecosystems. Further, the strategy is not to be viewed as a standalone action; instead it will be integrated into the regular developmental planning process, keeping in tune with the convergence principles articulated in the State's Twelfth Five Year Plan.

'Adaptation' will be the predominant philosophy and component of the climate response strategy of Tamil Nadu, while at the same time leveraging opportunities for mitigation co-benefits. The State lays equal emphasis on both 'hard' and 'soft' adaptation approaches – where 'hard adaptation options' include options that have physical attributes (e.g. infrastructure and engineering structures) and 'soft adaptation options' include the development of skills, processes, institutions, social systems, policies and programmes. Flexibility (within livelihoods, economic, social, cultural, ecological and institutional systems), diversification (involving multiple independent flows to livelihood and natural systems), learning and education (from events at both individual and institutional levels and knowledge base required to develop new systems when existing ones are disrupted), mobility (an attribute of flexibility), operational techniques (for risk reduction before and following disruptions), convertible asset and innovation (designing new systems and options) will be the key elements of the climate response strategy for Tamil Nadu.

Specific elements of the overarching climate response framework at the State level are articulated below (additional elements will be added as and when necessary). The State will subsequently develop action oriented operational plans and budgetary frameworks for these. It has also been ensured that all actions to be undertaken as part of the TNSAPCC have broad conformity to the National Action Plan on Climate Change and the eight National Missions under it.

Scientific Knowledge, Evidence Base, and Understanding of Climate Change

The previous section has already outlined the currently available knowledge base vis-à-vis current climate variability in the State and the projected climate change scenarios and its economic circumstances, and given these circumstances, the TNSAPCC seeks to fulfil the following outcomes (which are linked to the overall knowledge management Strategy under the TNSAPCC):

- An understanding of the current status of the natural resources and sectors and the institutions that manage them
- An understanding of the State's vulnerability and risk associated with climate change through identification of concerns of the State due to climate change, as well as through specific analyses pertaining each of the sectors addressed in the TNSAPCC;
- Sectoral strategies drafted for the identified vulnerability and risk of each sector due to climate change based on stakeholder consultations
- An improved coordination between the State Departments in the State that implement the government programmes and the scientific/technical research and academic institutions (including both national and State level agencies). This will enable the government to collate available scientific information and data on climate change pertaining to the State and for taking informed actions and decisions in view of the scientific data

and evidence based on climate change issues generated by the researchers for the State

- Keeping in mind long-term requirements, the State also proposes to set up a Climate Change Cell within the State Department of Environment and entrust it with the role of coordination with all concerned stakeholders towards fulfilment of the proposed actions in its Climate Change Action Plan and for acting as a bridge between science and policy.
- The State is also proposing a Centre for Climate Change that will generate, analyse climate trends, develop projections of climate, undertake research on impacts of climate change and associated vulnerabilities. The Centre will also serve to build State capacities for understanding and tackling climate change through appropriate adaptation and mitigation actions.

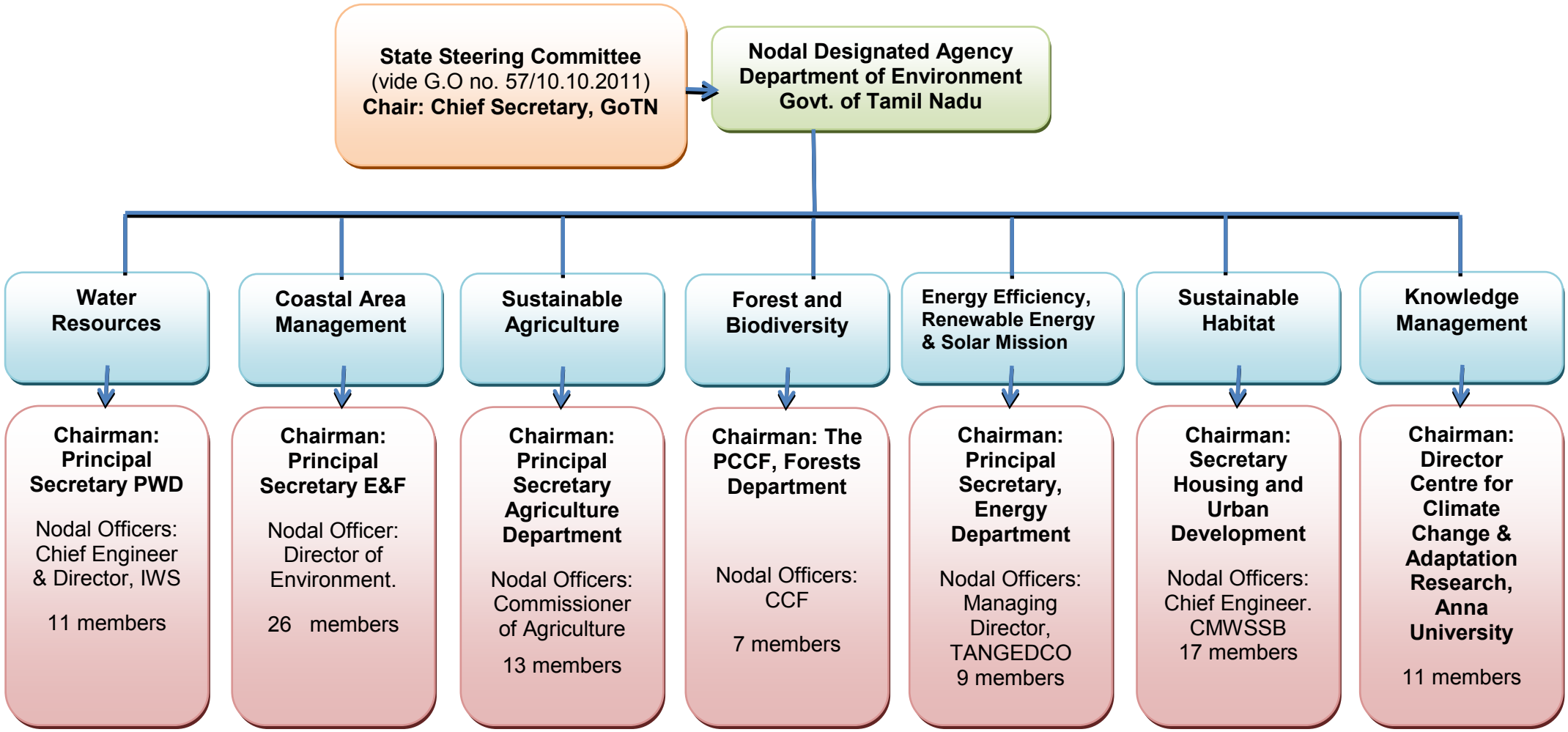
Governance Mechanisms, Institutional Decision Making, and Convergence

Tamil Nadu is already implementing a range of steps/programmes that are climate-friendly. While continuing to foster such initiatives, the State will seek to fulfil a range of outcomes including:

- Developing and putting into place overarching institutional and governance mechanisms at the State level to oversee and implement the TNSAPCC;
- Review all State policies and revise these as and when necessary to articulate and integrate climate concerns;
- Articulation and integration of climate change considerations into development strategies, plans and programmes;
- Strengthening of institutional decision-making mechanisms and processes (including monitoring & evaluation) to ensure cross-sectoral coordination related to climate change;
- Development and adoption of appropriate management approaches including regulatory, incentive, and innovation based approaches to encourage appropriate adaptation and mitigation measures
- Development and strengthening of institutional capacity for climate related disaster risk reduction and management.

The Tamil Nadu State Climate Change Cell will act as the nodal agency under the Department of Environment, GoTN for coordinating and overseeing all operational aspects of the TNSAPCC implementation and coordination at the State level. It will have a Steering Committee headed by the Chief Secretary at the decision making level and comprise of other senior State officials, and for operational aspects, will have an Executive Committee with Principal Secretaries of all relevant line State Departments or their nominees. All sectoral line State Departments and other key agencies in the State will set up Climate Change Cells in their respective State Departments/agencies. These Cells will coordinate and oversee all aspects of TNSAPCC implementation in their respective sectors, as well as liaise/coordinate with the State Centre for Climate Change and other line Departments in the State as required. The overarching State level institutional architecture is given in Figure 3.1 below.

Figure 3.1: State Level Architecture for TNSAPCC Implementation



The State will also put together and co-opt an Advisory Panel comprising of five or six academic and practitioner experts to advice and work with the State Steering Committee and the State Planning Commission in carrying out their respective mandates. It is anticipated that the Advisory panel would co-opt new members as and when required or a case-by-case basis. At the District Level, implementation will be overseen by a Coordination Committee headed by the District Collector, and carried out by existing delivery mechanisms of the line State Department through their Climate Change Cells. While TNSAPCC focuses on sectoral interventions across a selected set of government line State Departments/agencies, this will by no means exclude the role of other line State Departments/agencies and these will be co-opted to support TNSAPCC implementation processes from time to time.

Capacity Development, Education, and Awareness

The State recognises that overall awareness of climate change and its impact in Tamil Nadu is limited. Therefore, the TNSAPCC seeks the fulfilment of the following outcomes:

- Capacities of government line State Departments and agencies at all levels to analyse, plan, converge, implement and monitor programmes addressing climate change and its impacts; and
- Significantly improve awareness of climate change and its impacts in government at all levels as well as in communities, civil society, and the private sector in the State.

The State will initiate and foster a range of on-going awareness and capacity building measures aimed at targeting government and agencies at various levels, to improve overall awareness levels. The State will also put into motion a process of building awareness on climate change and its impact among the population and communities in general and also develop and widely disseminate sets of actions that the citizens of the State can take to support the TNSAPCC. In addition, the State will examine the possibility of incorporating climate change related modules into the educational curriculum across various levels, including the development of specific academic programmes on climate change at University levels. Appropriate external agencies will be co-opted as necessary to support the awareness and capacity building processes. The State will additionally seek to build and support a network of Climate Leaders - who can come from either government or elsewhere - to help foster and champion the climate agenda in the State.

Connecting Science, Policy, and Practice

As an extension of the overarching principles actions on improving scientific knowledge and evidence base articulated above, the State is committed to supporting processes that connect science to policy and practice. The following outcomes are envisaged towards this end:

- Data/research that is essential to support TNSAPCC implementation and related to policy making needs to be identified (on an on-going basis, as needs evolve);

- Mechanisms to foster dialogue with and between scientific research and academic agencies; and
- Specific mechanisms to adopt and implement practical approaches and solutions based on basic and applied research to support TNSAPCC implementation.

As such, under the TNSAPCC, the State seeks to actively consult and set up a process of dialogue with the concerned scientific organisations and academia in the formulation of State policies, to develop a culture of evidence-based policy making. It will also similarly support consultations and dialogues in the formulation of developmental and sectoral programmes by the various departments and agencies, through their Climate Change Cells as being proposed in the TNSAPCC. On an immediate basis, specific emphasis will be given to practical approaches and solutions (technological and otherwise) that have already been developed by various research centres and academic institutions that have not yet found the dissemination, outreach, and exposure that are needed to make these widely available for deployment in the development contexts (both rural and urban). It is anticipated that the proposed Tamil Nadu State Centre for Climate Change will take a lead role in anchoring this initiative.

Integrating Poverty, Livelihoods, and Equity Issues

The State already places significant emphasis on inclusive growth and development, as has been articulated in the Twelfth Five Year Plan. The document identifies governance as a common thread running through all sectors as the biggest concern for National as well as State Governments. Lack of good governance not only impedes growth, access to quality of life and human development; it aggravates poverty, vulnerability, inefficient use of resources, and ultimately leads to corruption and leakage. In a smooth functioning democracy, responsive governance is about ensuring symmetry of power in the elected representative-functionary-community praxis, citizen-centric administration, accountability and transparency of process/ procedures, strong outcome orientation, and above all, delivering public goods and services in a manner that reduces inequality and vulnerabilities.

Deficit in governance and the consequent inequality manifests itself in the form of large-scale poverty. Tamil Nadu has a poverty head count of 10.99 million and 49.4 percent of its population lives below the poverty line. This is an indicator of the inherent inequality and the fact that a significant population has not benefitted from the remarkable economic growth witnessed by the State in recent years. The State has been attempting to address this disparity by placing priority on development of sectors with high concentration of poverty like small-scale agriculture, forest based livelihoods and skill-development of those engaged in the unorganized sector. Efforts will now be required for providing them greater access to resources and benefits.

By extension, the State also recognises that since climate change can disproportionately impact the poor, women, children and the aged, and can also impact livelihoods, the sectoral planning under the TNSAPCC needs to explicitly integrate poverty, livelihoods and equity concerns. The State also recognizes the different roles that men and women play in society and because of the unequal

power relations between them. While a large number of poor, rural women depend on climate-sensitive resources for survival and their livelihoods, they are also less likely to have education, opportunities, authority, decision-making power and access to resources they need to adapt to climate change. Women's vulnerability to climate change differs from men and climate change interventions that are not gender-responsive often result in deepening the existing gender divide.

As such, the State will take the necessary steps towards fulfilling the following (but not be limited to) outcomes:

(a) Reduced intra-State inequity between the various regions of Tamil Nadu as also reduced inter-district inequality, especially in infrastructure and service provision as these have a bearing on livelihoods and thus adaptive capacity as well;

(b) Mainstreamed use of explicit gender-responsive language, data, and analysis in the detailed implementation plans to be developed under the TNSAPCC and integration of gender and equity element components in programming such as setting gender-specific indicators in programmes and schemes, carrying out gender-focused State, including gender-sensitive audits of adaptation programme and schemes, building capacities of women and men to implement participatory schemes at the village-level; building capacities on gender and adaptation within all governance institutions at all levels from PRI s (Panchayati Raj Institutions) to the State;

(c) Partnerships and collaborative arrangements with relevant agencies (to be identified) to help build capacities within the State Departments to work with gender and climate change adaptation; and

(d) Partnerships and collaborative arrangements with the Rural Development and Panchayat Raj Department to help Gram Panchayats develop participatory and gender-just Local Action Plans on Adaptation (LAPAs) at the Panchayat level in addition to their mandate of developing and implementing the village-level development Plans

It is expected that these actions will significantly enhance and contribute to equitous adaptive climate resilience in the State.

Private Sector and Financial Institutions

The private sector already plays a role in contributing to the State's economy in the secondary and tertiary sectors, and a recently concluded (November 2012) Investor Summit has only affirmed this. A range of Public Private Partnership (PPP) initiatives and projects are already underway in the State in various sectors. Such PPP models can be useful for pooling resources and expertise and for up-scaling climate change adaptation (especially in terms of climate resilient infrastructure and low carbon goods and services) and mitigation initiatives by way of explicit incorporation of climate concerns into project framework. Private Sector has great potential and competency for bringing innovative solutions and scale to the various models for climate change adaptation and is shaped by the civil society and/or government institutions. However their primary thrust so far has been limited to Clean Development Mechanism (CDM) and related projects.

There is a huge potential and need for private sector to play critical role in sectoral initiatives in the primary sector as well – bringing in new management practices, technologies and technology transfer, innovation, capital and investments, capacity building, etc. In this direction, the TNSAPCC will seek to fulfil the following outcomes:

- Review of existing initiatives by the private sector including corporate social responsibility (CSR) to examine possibility of incorporating climate agenda;
- Review of existing policies governing the private sector with the objective of incorporation of climate change concerns in the State;
- Outlining of necessary enabling framework and regulatory mechanisms for involvement of the private sector.

As in the case of the private sector, the financial sector and financial institutions will have critical roles to play in sectoral initiatives – bringing in new financial practices, products, and innovation, capital, investments, climate risk transfer mechanism, etc. As such, the TNSAPCC envisages the following outcomes:

- Developing a roadmap for exploring the potential role of the financial sector and financial institutions across the various focus sectors identified in the TNSAPCC (and in other sectors as appropriate/necessary); and
- Outlining the necessary enabling framework and regulatory mechanisms for involvement of the financial sector.

Role of Civil Society

Civil society and voluntary organizations have played a critical role in shaping the development landscape of not only Tamil Nadu, but also across the Nation. These will continue to have vital roles in the context of climate change, and have the potential to deliver programmes and services to communities and to bridge the roles of not only the government and community but also bridge the roles of scientific research institutions and the private sector with government and the community.

As such, the TNSAPCC envisages the following outcomes relating to the role of civil society:

- Developing a roadmap for exploring and articulating the potential role of civil society organisations (including NGOs and NGO networks, community based organisations (CBOs) and CBO networks, etc.) in TNSAPCC implementation including capacity building at various levels especially at district and sub-district levels, inputs to the TNSAPCC on poverty, equity and livelihood concerns, outreach and extension and bridging roles, documentation of community perceptions and best practices, participatory research, knowledge networking, and contributing to expanding the available evidence base on climate change, etc. and
- Identifying appropriate civil society organisations and their networks at various levels who can partner TNSAPCC in implementation at various levels including State, district, block and at the grassroots.

Role of International/External Support Agencies

Similarly, International/ External agencies play significant roles in supporting developmental initiatives and bringing in technical assistance to the State. A range of International organisations, including multilateral, bilateral and other agencies have supported and continue to support significant development projects across State Government departments as well as civil society. As such, it is envisaged that international organisations will also play a significant role in supporting various aspects of TNSAPCC implementation; the State will therefore proactively seek opportunities for collaborative partnerships with such organisations especially in the context of external support for financial and technical assistance, technical assistance and advisory services, bringing in international best practices, knowledge management and networking, inter-State and regional dialogues on climate change, etc. (Box 3.2)

Box 3.2: Linkages with the NAPCC and the National Mission on Strategic Knowledge for Climate Change

The above sub-sections, and in particular, those on - Scientific Knowledge, Evidence Base and Understanding of Climate Change; Capacity Development, Education, and Awareness; Connecting Science, Policy and Practice; and Knowledge Management, Knowledge Sharing, Learning, and Dialogue - are consistent with and complement imperatives outlined in the NAPCC in general and in particular, those under the National Mission on Strategic Knowledge for Climate Change.

Sharing, Learning, and Dialogue

The TNSAPCC recognises that knowledge creation, management, and dissemination/ exchange will be critical and central to the successful implementation of the SAPCC. The TNSAPCC also recognises that Tamil Nadu does not exist in an independent developmental vacuum; it exists as part of the India and the development of other Indian States would also have consumable spill over impact. Therefore the TNSAPCC will seek to fulfil the following outcomes in this regard:

- Develop protocols for new knowledge creation and documenting emerging best practices across sectors and at all levels, as well as documenting and sharing people's perceptions on climate change and its impacts on an on-going basis;
- Develop mechanisms and partnerships for sharing knowledge base and emerging experiences including best practices not only within the State at all levels but also with other States in the region and across India and elsewhere.

As such, it is envisaged that the TNSAPCC outcomes on knowledge management will be crosscutting and also closely connected to the envisioned outcomes on capacity building. Additional elements of Knowledge Management may be taken up from time to time during TNSAPCC implementation as required. Further details are given in the subsequent Section on Knowledge Management, indicating the importance the State accords to this sector.

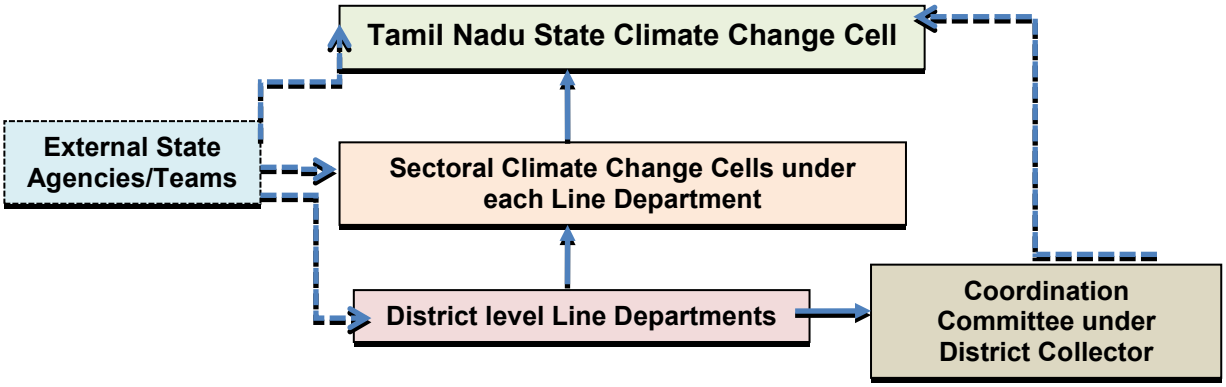
3.3 STATE FRAMEWORK

The State is committed to ensuring that TNSAPCC implementation is complemented by a robust framework and mechanisms not only as a means of ensuring that the detailed operational plans (developed under the TNSAPCC) are implemented as planned, but more importantly, as a tool for systematic review and programme improvement as the needs of the State evolve with implementation regularly.

TNSAPCC broadly covers implementation plans over a five year period, in which midterm third-party evaluation of the plan will be conducted to critically examine and recommend midcourse corrections. Other external evaluations also will be conducted at the end of the plan for systematic review and improvement. A detailed and robust monitoring framework will be developed including specific methodologies, protocols, and templates for monitoring and reporting as part of the process of developing detailed work plans under the TNSAPCC.

A tentative and indicative outline of a monitoring and reporting framework is given in Figure 3.2 below.

Figure 3.2: Tentative and indicative monitoring framework for the TNSAPCC



3.4 IMPLEMENTATION FRAMEWORK

It is envisaged that a common implementation framework will govern the TNSAPCC implementation under the various sectors of the State. The common elements will include:

- Sector policy reviews: Each sector will undergo a policy review, and where appropriate, explicit articulation of climate change concerns and sectoral responses will be articulated;
- Strengthening evidence base for sector Climatic Change impact: Each sector will put into motion, a process of building the evidence base on climate change and impact to the sector;

- Locally specific adaptation plans: To increase resilience, locally specific adaptation plans will be made; Enabling the exchange of case studies and good practices will facilitate the development of robust solutions;
- Leveraging Co-benefits: Each sector will proactively seek to identify and leverage opportunities for co-benefits arising out of TNSAPCC implementation;
- Sector public/community perceptions documentation: Each sector will carry out periodic documentation of public/community perceptions on climate change and its impact relevant to the sector;
- Periodic consultations with civil society and communities for Needs Assessment: Each sector will carry out periodic consultations with civil society and communities to gauge adaptive resilience needs;
- Incorporation of poverty, equity and livelihood concerns: Each sector will, where appropriate, incorporate and explicitly articulate poverty, equity and livelihood concerns in their policies, plans and budgetary processes;
- State protocols: Each sector will, in line with the overarching State level framework, develop and deploy State processes and protocols to guide effective programme implementation; and
- Knowledge Management (KM) activities: Each sector will, in line with the overarching State level framework, carry out KM activities, and contribute to the State level processes on an on-going basis. The State's Climate Change Cell in coordination with Centre for Climate Change and Adaptation Research, Anna University will carry out the role of a knowledge compendium and become a clearing house of all data/information on existing and planned research projects and initiatives relating to climate change in the Tamil Nadu context. Towards this, the Centre organisation will provide the following inputs:
    - Hosting of geo-portal on climate change
    - Host-hub for knowledge/information sharing related to climate change
    - Knowledge repository
    - Identification of potential research and development domains concerned with climate change issues in the State
    - Technical demonstration, research and development, extension and transfer of technology protocols, relating to climate change.

4. OBSERVED CLIMATE AND CLIMATE CHANGE PROJECTIONS

4.1 INTRODUCTION

The State of Tamil Nadu is situated at the south-eastern extremity of the Indian Peninsula, bounded on the east by the Bay of Bengal, in the west by the Western Ghats and in the south by the Indian Ocean,and in the North West by Nellore and Chittoor districts of Andhra Pradesh and Kolar, Bangalore and Mysore districts of Karnataka. It has a coastal line of 922 km and land boundary of 1200 km. It lies between 8° 5´ and 13° 35´ N latitude and between 76° 15´ and 80° 20´ E longitude. The State can be divided into two natural divisions namely, the coastal plains and hilly western areas.The Palghat gap of Kerala about 25 km in width in the great western mountain wall is the only marked break to Tamil Nadu. The slopes of the Western Ghats are covered with heavy evergreen forests, that too presently being made grey rapidly with human intervention, thus making it susceptible to animal and human conflict.

The trend of drainage is from west to east into the Bay of Bengal. The river Cauvery rises from the Brahmagiri hill in Coorg district of Karnataka and passes across eastwards across the peninsula into the Bay of Bengal. The Ponnaiyar River rises from Kolar district of Karnataka runs across the State and falls into the sea north of Cuddalore. The Vaigai river from Western Ghats and passes across the State and finally falls into the Bay of Bengal, 16 km east of Ramanathapuram.

The proximity of sea influences the climate of the eastern and southern parts of the State whereas hilly orography and inland locations play important roles in modifying the climate over rest of the State.The western portions of the State and the portions bordering with Kerala have a marine climate with mild winters and moist summers and the remaining part of the State has a tropical savanna climate that is hot and seasonally dry.

Out of 13 million hectares of geographical area, about 7 million hectares of land is under cultivation. Of this 55 percent is irrigated and rest is rain fed/ dry land. Among all the States in India, ground water has been harnessed fully in this State. Tamil Nadu has been divided into seven agro climatic sub-zones, three agro ecological zones amd 16 sub agro-ecological zones. The agroclimatic zones are North Eastern zone, North Western zone, Western Zone, Cauvery Delta zone, the Southern zone, High rainfall zone and High Altitude and Hilly zone. The three agro-ecological zones are the hot semi arid eco-region with red loamy soil, hot sub humid to semi arid eco-region with coastal alluvium derived soils and hot humid eco-regions with red lateritic and alluvium derived soils. This classification helps in the suitable planning and should be made based on these boundaries.

4.2 OBSERVED CLIMATE

Rainfall Pattern

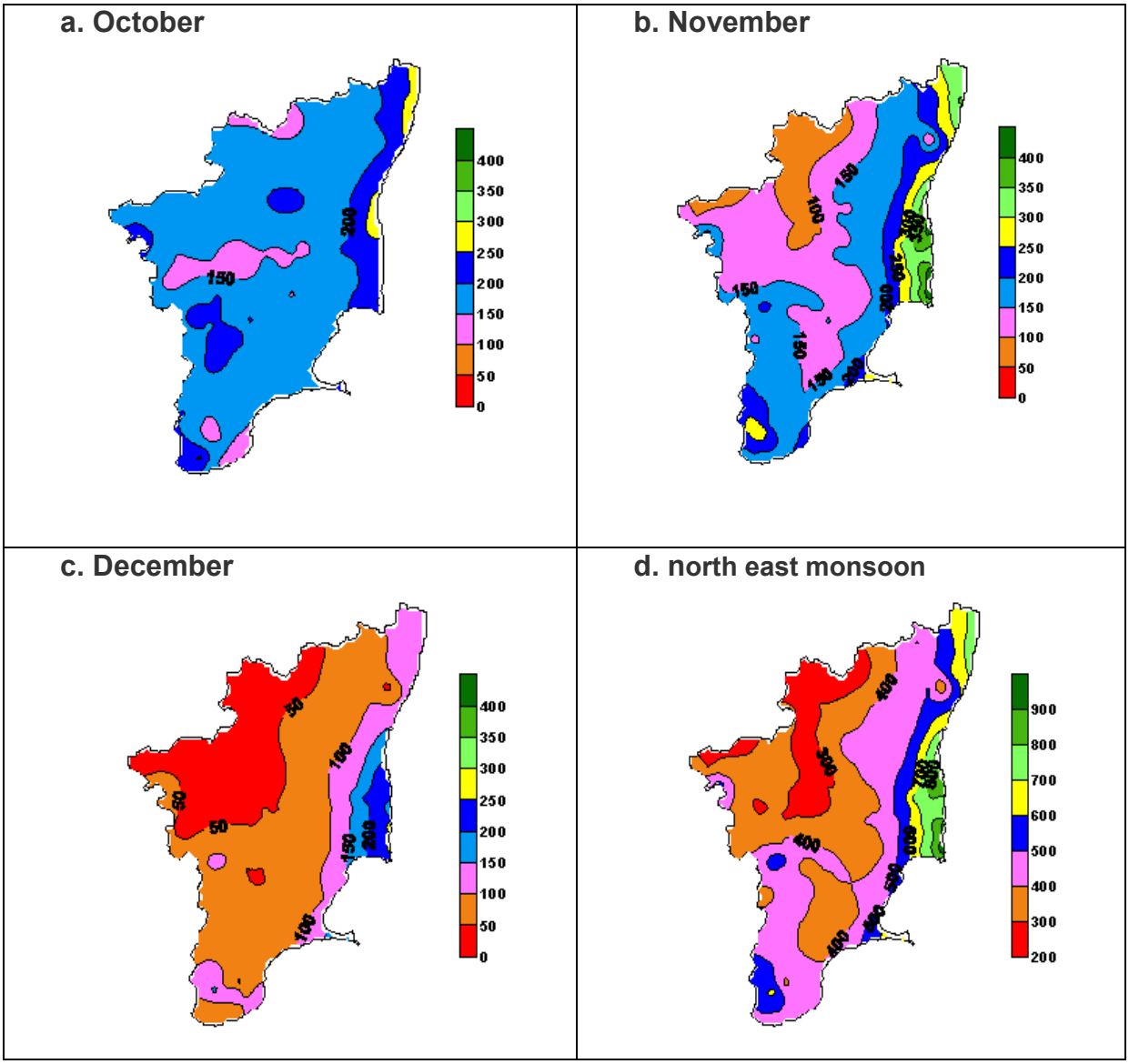
The State mainly receives its rainfall in three seasons, viz. south west monsoon, north east monsoon and pre monsoon season. The normal annual rainfall falling over the State is 958.4 mm. About 50 percent of the total annual average rainfall is received during north east monsoon, while about 31 percent is received during south west monsoon and the balance in the other seasons. The coastal districts receive about 65-75 percent of annual rainfall and interior districts get about 40-50 percent in this season. The percentage share of rainfall of different locations coastal/ inland / hilly stations for four seasons are given in the Table 4.1. The hilly regions in the west and hilly/ plain lands in north western half of the region receive major share from south west monsoon. Figure 4.1 shows the spatial pattern of rainfall during north east monsoon season.

Table 4.1: Seasonal rainfall of selected stations in Tamil Nadu (Rainfall in cm)

Stations	Lat.	Long.	Percentage share of rainfall in various seasons			
			Winter	Pre monsoon	south west monsoon	north east monsoon
Meenambakkam	13.07	80.19	2.2	5.3	33.5	59.0
Nungambakkam	13.07	80.25	3.6	5.0	30.8	60.6
Vellore	12.92	79.15	3.0	10.1	46.1	40.8
Kanchipuram	12.83	79.72	2.9	7.0	43.7	46.4
Chengulpattu	12.70	79.95	3.1	5.6	38.4	53.0
Tiruvannamalai	12.23	79.08	3.9	10.8	43.7	41.6
Dharmapuri	12.13	78.18	2.3	18.9	42.4	36.4
Villupuram	11.93	79.50	4.0	7.3	38.3	50.3
Cuddalore	11.77	79.77	5.2	6.3	26.3	62.1
Salem	11.65	78.18	1.8	17.3	49.7	31.3
Ooty	11.40	76.73	2.7	20.6	45.9	30.9
Erode	11.35	77.67	3.3	20.2	35.2	41.3
Mettupalayam	11.30	76.25	7.8	21.4	19.4	51.4
Coimbatore	11.03	77.05	3.5	20.7	24.8	51.0
Karur	10.95	78.09	2.1	16.9	26.3	54.7
Tanjavur	10.78	79.13	5.7	11.1	34.1	49.2
Tiruchirapalli	10.77	78.72	3.8	15.0	35.2	45.9
Vedaranyam	10.37	79.85	21.5	8.4	13.6	56.5
Dindigul	10.35	77.97	4.8	16.2	29.7	49.3
Adiramapattinum	10.33	79.88	6.2	11.7	27.4	54.7
Kodaikanal	10.23	77.47	6.0	21.2	34.3	38.4
Madurai	9.92	78.12	1.9	12.6	37.0	48.5
Tondi	9.77	79.03	5.2	16.2	16.3	62.3
Virudhunagar	9.68	77.97	4.5	20.0	29.0	46.5
Tuticorin	8.80	78.15	8.0	17.7	5.4	68.9
Palayamkottai	8.73	77.75	9.8	18.4	9.7	62.1
Tiruchendur	8.50	78.12	12.1	12.7	3.3	71.8
Kanyakumari	8.08	77.05	3.6	17.5	29.1	49.8
Tamil Nadu			**4.3**	**13.1**	**31.9**	**50.7**

Source: http://www.tn.gov.in/dept.st/climate and rainfall.pdf

Figure 4.1: Rainfall over Tamil Nadu during a) October b) November, c) December and during d) north east monsoon season



Source:http://mapsof.net/map/hydrographic-rainfall-map-tamil-nadu

Spatial distribution of the rainfall received over Tamil Nadu is highly variable. Rainfall over coastal areas is more and decreases in the inland areas since the rainfall causing systems are forming over Bay of Bengal and moving towards the coast of Tamil Nadu. Also the rainfall over northern end is more than the southern locations. It is probably due to the maximum rainfall zones in the north eastern sectors. Orography of the rainfall process also plays an important role in the spatial distribution of rainfall.

The windward (eastern) sides of the Eastern Ghats are having more rainfall than the leeward (western) side. The total amount of rainfall in the season is not constant and have inter seasonal and intra seasonal variability due to formation/ non-formation of rain causing mechanisms and their movements. If they move in

north westerly or westerly direction, the systems cause more rainfall than when they re-curve or move in northerly direction The coefficient of variation of annual rainfall is less than 25 percent over the central part except over the coastal area north of latitude 10° N and extreme southern part where the coefficient may even exceed 30 percent.

A review study carried out by Jain and Kumar (2012), indicates that the annual rainfall has increased by +8.5 percent and +4.4 percent in the Cauvery river basins and the river basins north to Cauvery river basin in Tamil Nadu respectively in the last 100 years with respect to the average rainfall during this period. The river basins that are in the south of the Cauvery river basin have experienced decrease in annual rainfall by -9.8 percent.. An analysis of annual rainy days indicates that there is no change in the Cauvery basin in the last 100 year period. However, the river basins north and south of the Cauvery basins have experienced decreasing trend by -3.6 percent and -32.3 per cent. The quantified changes in annual rainfall and number of rainy days is indicated in Table 4.2 at annual and seasonal levels.

Table 4.2: Changes in annual and seasonal rainfall and in number of rainy days in the last 100 yrs

Basin	Annual		Premonsoon		Monsoon		Post Monsoon		Winter	
	R f	RD	R f	RD	R f	RD	R f	RD	R f	RD
EF1[1]	0.044	-0.032	-0.345	-0.032	-0.214	-0.047	0.659	0.000	0.197	0.000
Cauvery	0.879	0.000	-0.563	0.000	0.075	0.028	1.748	0.050	0.024	0.000
EF2[2]	-0.950	-0.333	-0.800	-0.143	-0.500	-0.125	0.491	0.000	-0.246	-0.032
Rf: Rainfall in (mm/yr); **RD:**Rainy days (Days/yr)										

[1]EF2- East flowing river basins that are north of the Cauvery river Basin
[2] EF – East flowing river basins that are South of Cauvery river Basin

Temperature

In general, the maximum temperature rarely exceeds 43° C and the minimum temperature rarely falls down below 18° C. The mean annual temperature is 28.2°C in the plains and 15.2°C in the hills. The temperature is minimum in the month of December with 24.7°C and maximum in May with 37.3°C. Soil temperature data available for a few places indicate a range from 30.7°C to 32.3°C in the plains and around 14.4°C in the hills. On the basis of temperature, the coastal plain (Aduthurai) is classified as hyper-thermic (very hot), northern part (Coimbatore) and southern part (Kovilpatty) are iso-hyperthermic (steadily very hot) and hill area (Uthagamandalam) is iso-mesic (steadily cold).

Annamalai et al (2011), based on their study on temperature over Cauvery basin of Tamil Nadu reported that the average year to year variation in surface temperature lies in the range about 0.4° C with few years warmer or cooler by 0.8°C. Based on the technique of deducting the long time forced component (trend), the temperature series in both the seasons clearly indicates a warming tendency. For the period from 1951 to 2008, the warming is of the order of 0.7 to 0.8°C and this is above the natural variability. One difference is that, while the warming is gradual during south west monsoon season, it appears to occur abruptly during north wast

monsson season. Balasubramanian et al (1994) based on their analysis of the prevailed temperature in Coimbatore from 1962 to 1992 found that there was decadal variability in maximum and minimum temperature and this was on the rise level up to 0.1 to 2.7° C.

Monsoons Onset and Withdrawals

The normal onset of southwest monsoon over Tamil Nadu is predicted to take place on 1st June with a standard deviation(SD) of 7.4 days (based on data of 1901-2011). During the last 31 years (1981-2011) period, however, the normal date has advanced by a day with SD of 6 days. The earliest onset is 11th May and the late onset is 18th June. Based on the linear trend analysis, it was found that the onset is advanced by one day in every 20 years period (1901-2011).

The north east monsoon sets in over Tamil Nadu on 20th October (based on 1901-2000). The earliest onset is 4th October and late onset is 11th November. In 75 percent of years, the onset of north east monsoon took place between 13th October and 27th October. In 8 percent of years, the monsoon onset was found in November month (Asokan,2011). Northeast monsoon withdraws from Tamil Nadu on 30th December with SD of 14 days. In 51 percent of the years, the withdrawal is between 14th December and 4th January. In 2 percent of the years the withdrawal took place in November itself. In 40 percent of the years, the withdrawal occurred in January month. Table 4.3 give the onset dates of south west and north east monsoons over Tamil Nadu during 1990-2011 including percent of departure. The early or late onset does not have any bearing on the monsoon performance.

Table 4.3: Onset dates and total rainfall during south west (SW) and north east (NE) monsoons between 1990-2011*

Year	Onset dates		SW monsoon rainfall (mm)			NE monsoon rainfall (mm)		
	SW monsoon	NE monsoon	Actual	Normal	Percentage departure	Actual	Normal	Percentage departure
1990	19th May	19th Oct	270	312	-13	468	483	-3
1991	02nd Jun	20th Oct	388	341	+13	488	477	+2
1992	05th Jun	2nd Nov	345	331	+4	514	470	+9
1993	28th May	20th Oct	312	330	-6	784	479	+64
1994	08th Jun	18th Oct	252	326	-23	534	478	+12
1995	03rd Jun	23rd Oct	351	327	8	260	479	-46
1996	09th Jun	11th Oct	497	329	+51	595	477	+24
1997	01st Jun	13th Oct	298	326	-9	810	478	+70
1998	02nd Jun	28th Oct	341	327	+4	627	478	+30
1999	28th May	21st Oct	201	321	-37	517	483	+7
2000	01st Jun	2nd Nov	315	324	-3	346	483	-28
2001	23rd May	16th Oct	263	324	-19	382	483	-21
2002	29th May	25th Oct	179	323	-45	395	469	-16
2003	08th Jun	19th Oct	346	316	+7	435	469	-7
2004	18th May	18th Oct	347	316	+10	435	432	+1
2005	05th Jun	12th Oct	295	316	-7	773	432	+79
2006	26th May	19th Oct	249	316	-21	497	432	+15
2007	28th May	22nd Oct	339	316	+7	521	432	+21
2008	31st May	15th Oct	324	316	+3	564	432	+31
2009	23rd May	29th Oct	316	316	0	488	432	+12
2010	31st May	29th Oct	351	316	+21	613	432	+42
2011	29th May	24th Oct	301	321	-6	542	442	+23

* data includes TamilNadu and Puducherry

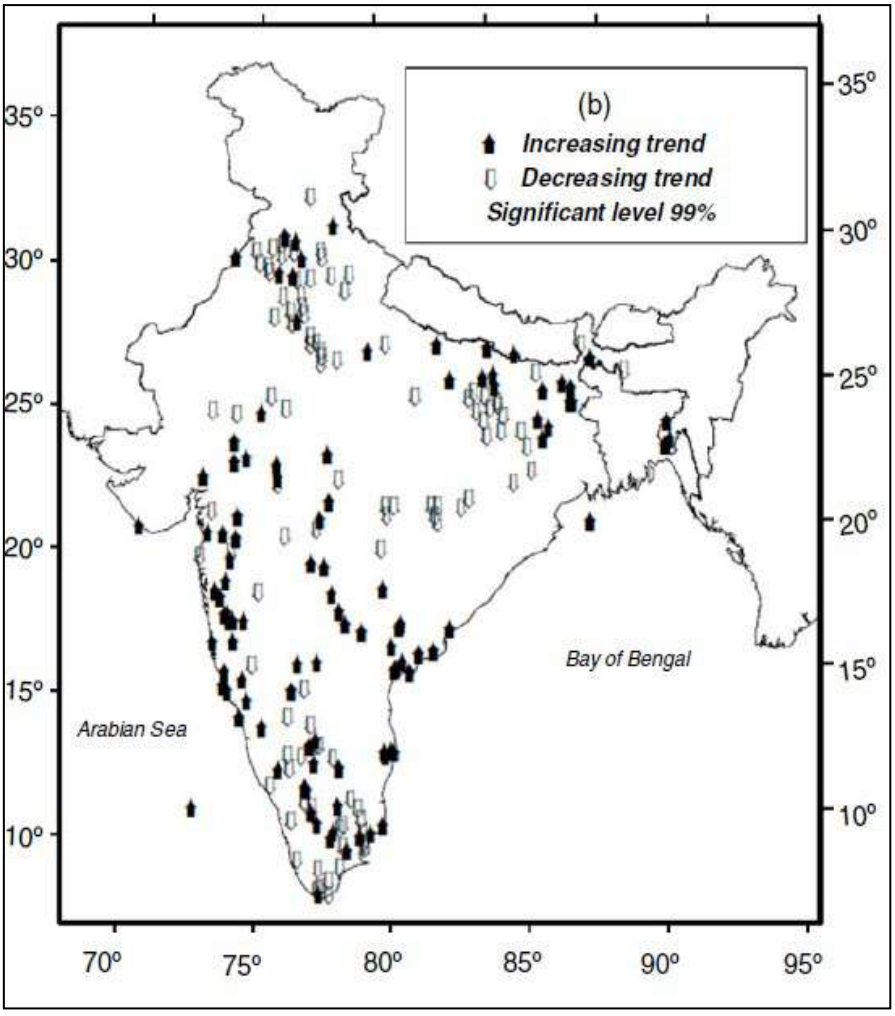
Extreme Rainfall

Long term studies carried out by Guhathakurta et al (2011), for the period 1901-2005, indicate, that Tamil Nadu is experiencing more dry days than wet days every year. However, there has been a significant increase in heavy precipitation events as indicated in the recordings of the IMD (India Meteorological Department) observing stations in the State (Figure 4.2).

Increase in one day extreme rainfall events of the order of 5 to 10 cm has been observed along the northern coast of the State.In rest of the State, the extreme rainfall event has increased by less than 5 cm or less.

The analysis of 25 year return period of rainfall shows a large variation from 10cm in the western parts of Tamil Nadu to 25 cm and more in the northern and central coastal regions of the State.

Figure 4.2: Stations with significant increasing/decreasing trends in one day extreme rainfall



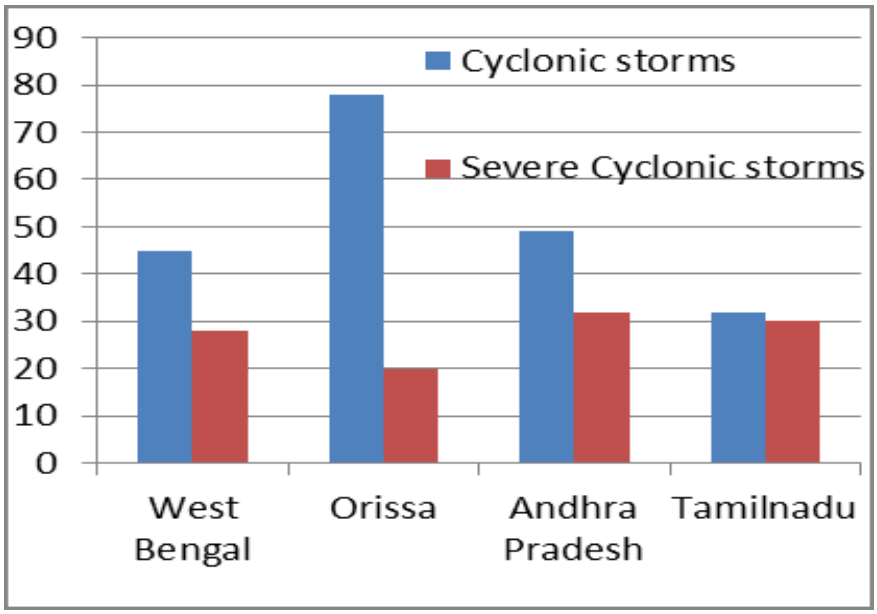
Cyclones

Situated along the eastern coast of India, Tamil Nadu has been hit by about 32 cyclonic storms between 1891 to 2006 of which 30 were severe cyclonic storms. The total number of cyclonic storms hitting the Tamil Nadu coast increased to 44 by 2011. A sharp increase by 37.5 percent between 2006 and 2011.

Maximum number of cyclonic storms tend to cross over north Tamil Nadu coast in the post monsoon season. No cyclonic disturbances crossed Tamil Nadu coast during monsoon season (June-September).The number of storms that crossed north Tamil Nadu coast is four times more than that crossed south Tamil Nadu coast during pre monsoon months during this period. Only three cyclonic disturbances crossed Tamil Nadu coast during winter months (Figure 4.3).

Linear trend analysis based on two different periods 1891- 2011 for winter, pre monsoon, monsoon, post monsoon and annual frequency shows that the formation of cyclonic disturbances in the Bay of Bengal (BOB) during winter and post monsoon months (October-February) shows an increasing trend while a decreasing trend is seen during the monsoon months (June–September).There is an increasing trend in the number of severe cyclonic storms to form in BOB in pre monsoon months (March–May) during same period.

Figure 4.3: Number of cyclonic storms crossing eastern coastal states in India between 1891 and 2006



Source: IMD (www.imd.gov.in/section/nhac/dynamic/cyclone.htm1)

Sea level rise

The mean sea level rise trend off the Chennai coast is 0.32 mm/year, estimated with a 95 percent confidence interval of ±0.37 mm/year based on monthly mean sea level data for the period 1916 to 2008 which is equivalent to a change of 0.10 feet in 100 year (http://tidesandcurrents.noaa.gov/sltrends/).

4.3 CLIMATE PROJECTION

The following section gives the projections of temperature and precipitation based on UK Met Office Hadley Centre regional climate model PRECIS with boundary data inputs from 6 out of 17- member perturbed-physics ensemble (HadCM3Q0-Q16, known as 'QUMP').The model was run at CCC&AR, Anna University at a spatial resolution of 25 km x 25 km and the GHG emission drivers are generated by the IPCC A1B SRES scenario (Box 4.1).

Box 4.1: About PRECIS and A1B Scenario

PRECIS is based on the UK Met Office Hadley Centre's regional climate modelling system (HadCM3). It has been ported to run on a work station (under Linux) with a simple user interface, so that experiments can easily be set up over any region.

For further details see http://www.metoffice.gov.uk/precis.

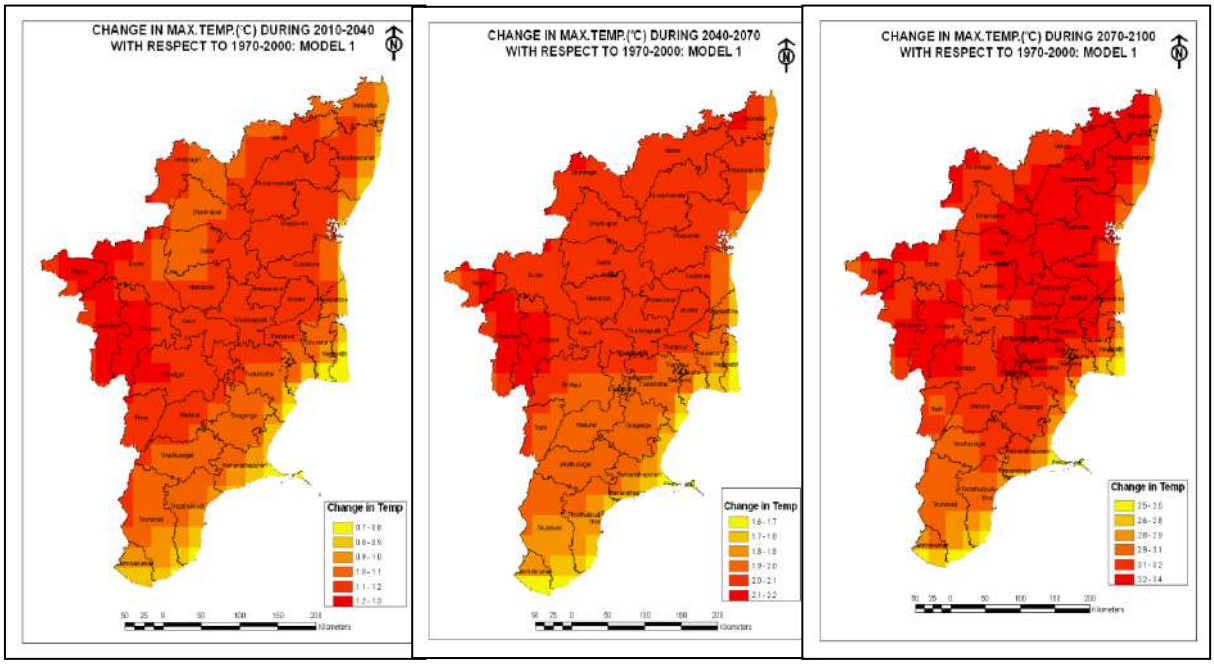
The IPCC A1B SRES scenario is a socio economic scenario that refers to a future world of very rapid economic growth, and rapid introduction of new and more efficient technologies. Major underlying themes are economic and cultural convergence and capacity building, with a substantial reduction in regional differences in per capita income. For further details see IPCC, Special report on Emission Scenarios (SRES), 2000.

https://www.ipcc.ch/pdf/special-reports/spm/sres-en.pdf).

Temperature Projections

Maximum Temperature: The maximum temperature over Tamil Nadu is projected to increase by 1.0^0C, 2.0^0C and 3.1^0C for the periods 2010-2040, 2040-2070, 2070-2100 respectively with reference to the baseline 1970-2000 (Table 4.4). District wise changes (Figure 4.4) indicate a general maximum increase of about 3.4^0C over the North western districts of Nilgiris, Coimbatore, Tiruppur and western parts of Dindigul District at the end of the century. The minimum increase of about 0.7^0C is seen along the eastern parts of coastal districts particularly over Kanyakumari, Nagapattinam, Tirunelveli and Ramanathapuram.

Figure 4.4: Change in maximum temperature (^{0}C) projections for 2010-2040, 2040-2070, 2070-2100 with reference to baseline (1970-2000).



(Source:Centre for Climate Change and Adaptation Research (CCCAR),Anna University,Chennai)

Table 4.4: District wise projected change in maximum temperature in ^{0}C with reference to 1970-2000

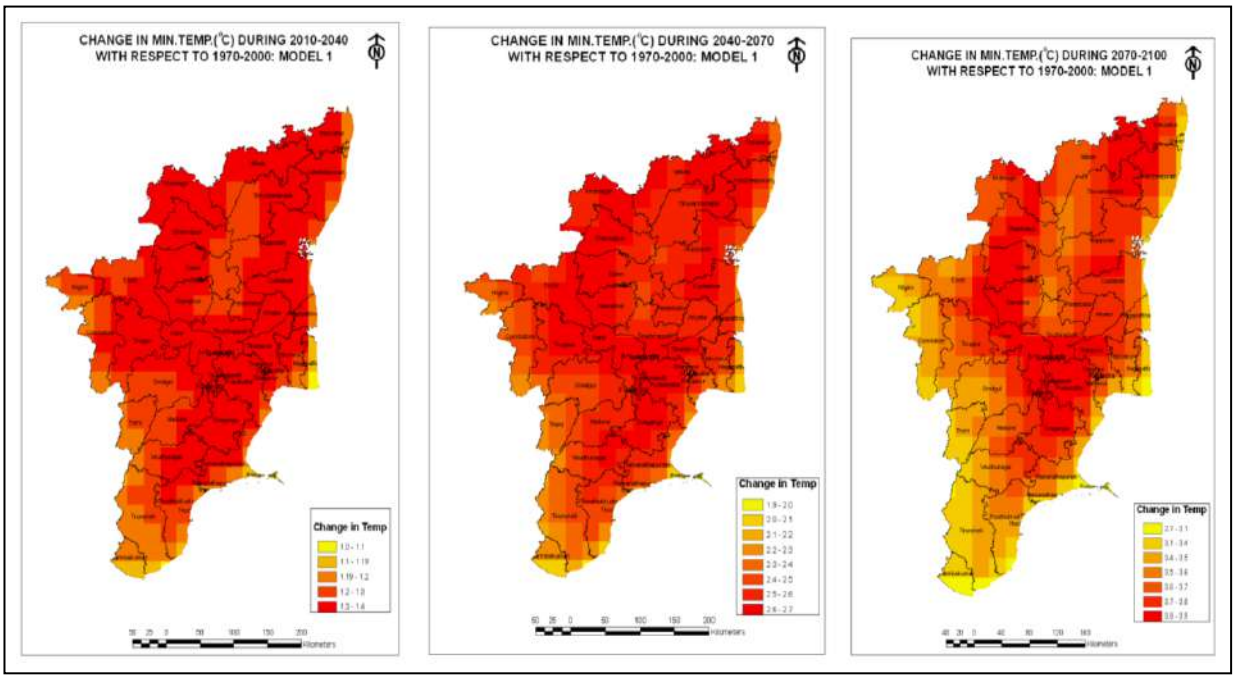
District Name	Change in maximum temperature in ^{0}C with reference to 1970-2000		
	2010-2040	2040-2070	2070-2100
Ariyalur	1.1	1.9	3.1
Chennai	1.0	2.0	3.1
Coimbatore	1.3	1.9	3.1
Cuddalore	1.1	2.0	3.2
Dharmapuri	1.1	2.0	3.2
Dindigul	1.2	2.1	3.3
Erode	1.2	2.0	3.2
Kancheepuram	1.1	1.8	3.0
Kanyakumari	1.0	1.7	2.7
Karur	1.2	2.1	2.3
Krishnagiri	1.2	2.0	3.2
Madurai	1.2	1.8	3.0
Nagapattinam	1.0	1.6	2.7
Namakkal	1.2	2.0	3.2
Nilgiris	1.3	2.1	3.2
Perambalur	1.2	2.0	3.3
Pudukkottai	1.0	1.7	2.9
Ramanathpuram	0.9	1.6	2.7
Salem	1.2	1.9	3.2
Sivaganga	1.1	1.9	2.7
Thanjavur	1.0	1.8	2.9
Theni	1.2	2.1	3.3

District Name	Change in maximum temperature in ^{0}C with reference to 1970-2000		
	2010-2040	2040-2070	2070-2100
Thiruvallur	1.1	1.6	2.8
Thiruvannamalai	1.2	2.0	3.2
Thiruvarur	1.0	1.1	2.3
Thoothukudi	1.0	1.8	2.8
Trichy	1.2	2.0	3.3
Tirunelveli	1.0	1.8	3.0
Tiruppur	1.2	2.2	3.4
Vellore	1.1	1.9	3.2
Villupuram	1.1	2.1	3.4
Virudhunagar	1.1	1.9	3.1

Minimum temperature projections: Projections of minimum temperature over Tamil Nadu as a whole for 2010-2040, 2040-2070, 2070-2100 with reference to baseline 1970-2000 indicates that it is likely to increase by 1.1 ^{0}C, 2.4 ^{0}C and 3.5 ^{0}C respectively (Table 4.5).

District wise changes (Figure 4.5) indicate generally lesser changes over the western parts and close to the coast. A general rise in temperature is seen ranging from 1^{0}C to 1.5^{0}C for the period 2010 to 2040 and between 2^{0}C to 2.6 ^{0}C for the period 2040-2070 and between 2.7^{0}C to 3.8 ^{0}C for the period between 2070 to 2100. The southern districts Kanyakumari and Tirunelvelli show minimum increase, while the central interior districts Karur, Tiruppur, and Namakkal show maximum increase in the minimum temperature.

Figure 4.5: Change in min. Temperature (^{0}C) projections for 2010-2040, 2040-2070, 2070-2100 reference to baseline (1970-2000) *



*(Source:CCCAR,Anna university,Chennai)

Table 4.5: District wise change in minimum temperature in ^{0}C with reference to 1970-2000

District Name	Change in minimum temperature in ^{0}C with reference to 1970-2000		
	2010-2040	2040-2070	2070-2100
Ariyalur	1.4	2.6	3.7
Chennai	1.1	2.2	3.2
Coimbatore	1.2	2.3	3.3
Cuddalore	1	2.2	3.3
Dharmapuri	1.2	2.4	3.6
Dindigul	1.1	2.3	3.4
Erode	1.3	2.6	3.7
Kancheepuram	1	2.2	3.3
Kanyakumari	0.8	1.8	2.7
Karur	1.5	2.6	3.8
Krishnagiri	1.3	2.5	3.6
Madurai	1	2.2	3.3
Nagapattinam	1.1	2.2	3.2
Namakkal	1.3	2.5	3.7
Nilgiri	1.2	2.3	3.3
Perambalur	1.1	2.3	3.5
Pudukkottai	1.1	2.3	3.3
Ramanathpuram	1.1	2.2	3.2
Salem	1.2	2.4	3.6
Sivaganga	1.1	2.4	3.5
Thanjavur	1	2.1	3.3
Theni	1	2.2	3.2
Thiruvallur	1.1	2.2	3.3
Thiruvannamalai	1.3	2.5	3.6
Thiruvarur	1.1	2.2	3.3
Thoothukudi	1.1	2.2	3.1
Trichy	1.2	2.4	3.6
Tirunelveli	0.55	1.65	2.65
Tiruppur	1.42	2.62	3.62
Vellore	1.3	2.6	3.7
Villupuram	0.9	2.1	3.1
Virudhunagar	0.85	1.95	2.95

(Source:Centre for Climate Change and Adaptation Research,Anna University,Chennai)

Rainfall Projections

Annual Rainfall: The rainfall projection indicates a slight decrease of about 50 mm by end of the century (2070-2100) with reference to the baseline (Fig.4.6). However district wise projection indicates variant distribution which has given in Table 4.6.

Seasonal Rainfall: South west and north east monsoons being principal rainy seasons, analyses have been carried out for these two seasons.North east monsoon may experience more intense rainfall when compared to south west monsoon by end of the century.

Table 4.6 : District wise percentage change in annual rainfall with reference to 1970-2000

Districts	2010-2040	2040-2070	2070-2100
Ariyalur	-6	-7	-3
Chennai	-9	-14	-4
Coimbatore	-3	4	6
Cuddalore	-6	-6	3
Dharmapuri	-5	-4	-3
Dindigul	-4	-3	1
Erode	-6	-6	0
Kancheepuram	-8	-12	-3
Kanyakumari	6	11	6
Karur	-3	-3	-2
Krishnagiri	-4	-5	-2
Madurai	-2	0	1
Nagapattinam	-7	-5	3
Namakkal	-4	0	-3
Nilgiri	-3	5	7
Perambalur	-6	-6	-3
Pudukkottai	-6	-1	9
Ramanathpuram	-4	2	9
Salem	-4	-1	-3
Sivaganga	-4	-2	4
Thanjavur	-6	-1	7
Theni	-7	0	4
Thiruvallur	-6	-13	-5
Thiruvannamalai	-6	-11	-7
Thiruvarur	-7	-2	8
Thoothukudi	-1	8	19
Trichy	-5	-2	-2
Tirunelveli	1	6	6
Tiruppur	-7	-3	2
Vellore	-6	-11	-6
Villupuram	-7	-9	1
Virudhunagar	-7	1	7

(Source:Centre for Climate Change and Adaptation Research,Anna University,Chennai)

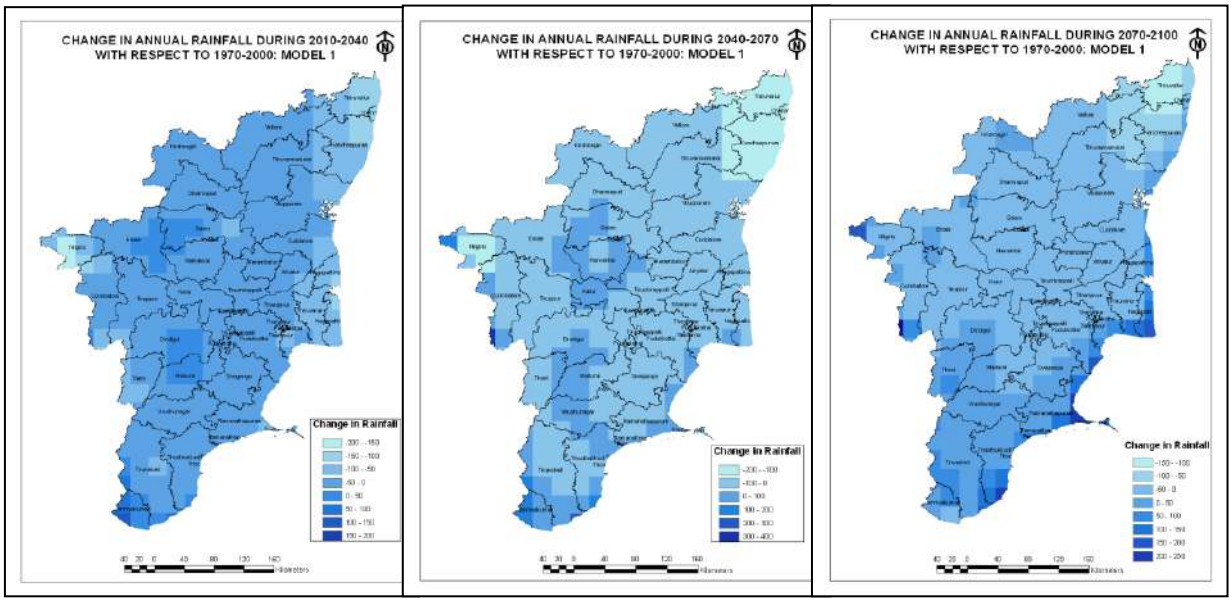
Cyclone Projections

The Climate Change and India: a 4X4 assessment: a sectoral and regional analysis for 2030's report published by the MoEF&CC,GoI in 2010, concludes, that in future, the number of cyclones hitting the eastern Indian coast including Tamil Nadu is likely to reduce, however, the intensity i.e., the wind speed of the cyclones may increase.

Projected sea level rise

Using CLIM SYSTEM - a model used for predicting sea level rise, with climate inputs from various GCMs(Global climate model).It is projected that by the end of the century i.e. by 2100 the sea level may rise of Tamil Nadu coast is likely to range from 0.19 m to a maximum of 0.73 m. See table below (Table 4.7)

Figure 4.6: Change in annual rainfall (mm) projections for 2010-2040, 2040-2070 and 2070-2100 with reference to baseline (1970-2000) *



*(Source:CCCAR, Anna university)

Table 4.7: Projection of sea level rise based on different IPCC SRES scenarios

IPCC SRES Scenarios[3]	GLOBAL PROJECTIONS 2100	REGIONAL PROJECTIONS 2100	
		1.097 m	1.252 m
B1	0.18 to 0.38m	0.19 to 0.41m	0.22 to 0.47m
B2	0.20 to 0.43m	0.21 to 0.47m	0.25 to 0.53m
A1B	0.21 to 0.48m	0.23 to 0.52m	0.26 to 0.60m
AIT	0.20 to 0.45m	0.21 to 0.49m	0.25 to 0.56m
A2	0.23 to 0.51m	0.25 to 0.55m	0.28 to 0.63m
AIF1	0.26 to 0.59m	0.28 to 0.64m	0.32 to 0.73m

[3] (https://www.ipcc.ch/pdf/special-reports/spm/sres-en.pdf)

4.4 CONCLUSION

Observations indicate that along with the rise in temperature, the total annual rainfall is decreasing in the State, both during the south west monsoon and north east monsoon. There is a distinct interannual variability and spatial variability in rainfall across the State, with the western and southern part of the State receiving maximum rainfall.

The projections are made, using PRECIS A1B scenario concluded that there is likely to be an decrease in rainfall in 2070s by about 1 to 9 percent with reference to the baseline rainfall (1970-2000).The maximum temperature is also likely to increase by about 3.1^0 C.However, as there is likely to be very high spatial variability, therefore catching water where it falls and either transferring it to water starved areas or catching the sparse rainfall in these areas will be a challenge.

5. SUSTAINABLE AGRICULTURE

Tamil Nadu is one of the most urbanized and industrialized States in India and only 22 percent of its income comes from the agriculture and allied sectors and the share has shown a declining trend over the years. The sector, which grew at 15.28 percent during 2006-07 declined to -4.46 percent during 2007-08 due to the crop damages caused by natural calamities.However, till date 40 percent of the State population is dependent on this sector for livelihood.Hence the growth in agriculture is important not only to ensure food security, but also for reducing poverty.

In addition to the frequent and recurrent hydro-meteorological events such as droughts, extreme rainfall events and cyclones impacting agriculture in the State, the growth of the sector is constrained by a number of other factors such as reduced availability of water and declining cropped area, which has declined from 33 percent of available land area in 2000-01 to 31 percent of total land area in 2010-11. Further, small land holdings, deterioration in soil health due to depletion of topsoil, decline in organic content, decrease in cropping intensity and shortage of labor besides reluctance to work in the farms, and poor adoption of crop management practices etc. are adding to the already existing pressures on agriculture.

Climate change may exacerbate the impacts and thus limit agricultural production. Notwithstanding the challenges in the agriculture sector, animal husbandry, including fisheries sector, which together account for a quarter of total agriculture and allied activities GSDP, provides opportunities for livelihood diversification in this sector.

Any impact on agriculture and allied sectors will exert cascading effect on secondary and tertiary sectors. At present, though, there is no systematic study to assess the direct and indirect effects of climate change on agriculture and allied sectors, this sectoral plan will enable the State to assess the vulnerability of the State to climate risks, prioritization of research and development issues and effective decision making to reduce risks through adaptation.

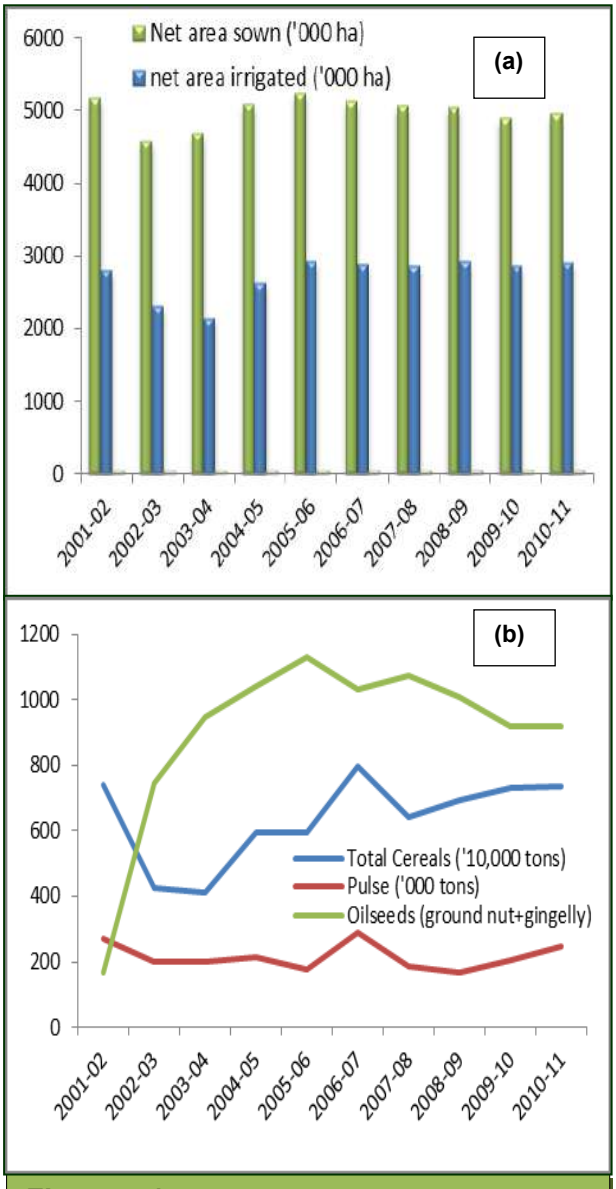


Figure 5.1: Trends of (a) net sown area and area under irrigation in Tamil Nadu in 2001-02 to 2010-11; (b) Trends of production of crop types.

Source: Statistical Handbook, 2012. Dept of Economics and Statistics, GoTN

4.1. CURRENT TRENDS

Agriculture

In the last decade between 2001-02 and 2010-11, the net sown area was at its peak in 2001-02 in Tamil Nadu, but due to the extreme drought in 2002-2003, the net sown area as well as the total production dipped significantly. Since then the net sown area has not recovered (Figure 5.1a). However, with the increase in the area under assured irrigation from 54 percent of gross sown area in 2001-02 to 58 percent in 2010-11, the production of cereals, pulses, oil seeds etc. are on the path of recovery (Figure 5.1b), and productivity of majority of the crops are on the rise, except a nominal decline in the case of rice and pulses (Table 5.1).

Table 5.1: Productivity changes of major crops in the last one decade

	2001-02 (kg/ha)	2010-11 (kg/ha)	Net change (percent)
Rice	3196	3039	-4.9
Cholum	866	1014	+17.1
Cumbu	1223	1564	+27.9
Ragi	1883	2262	+20.1
Maize	1950*	2468	+26.6
Groundnut	1885	2323	+23.2
Pulses	395	386	-2.5

*data for 2005-06

In 2011-12, the total irrigated area was 29,12,000 ha of which 56 percent was irrigated by ground water and the rest by canals, tanks and other modes of irrigation. In case of rice, 93 percent of the gross sown area is irrigated.Six percent of the gross sown area under pulses is irrigated. In the case of oil seeds, 38 percent of the gross sown area is irrigated. Tamil Nadu is the highest producer of oilseeds in the country.

The distribution of area under different crops in Tamil Nadu in 2001-02 and 2010-11 is shown in Figure 5.2. Paddy and sugar cane occupying around 57 percent and 9 percent of the gross sown area in 2010-11 are the most water intensive crops. In fact, 90 percent of the rice in the State is irrigated. The rain-fed rice productivity and sugar productivity are impacted adversely by frequent and continuous failure in monsoon which has implications on the sustainability of their productivity.

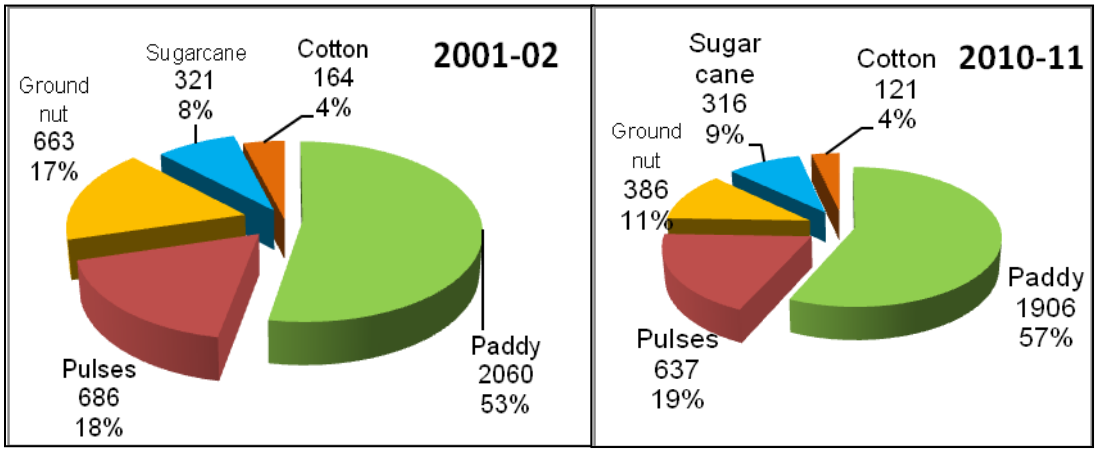
Horticulture

Since 2005-06, with the impetus received from the National Horticulture Mission of the Government of India, the horticulture production in the State has grown dramatically.The varied agro climatic zones in Tamil Nadu are being appropriately harnessed for maximizing the production of horticultural crops. Between 2006-07 and 2010-11, the vegetable and fruit production has grown by 14 percent. Spices and condiments have grown by 26 percent. Plantation crop

production has grown by 45 percent and medicinal and aromatic plant production by 52 percent. The spectacular growth has taken place in flower production which has grown by 450 percent during this period.In fact, Tamil Nadu is the largest producer of flowers in the country.Technology break throughs in horticultural crops has improved the quality and yield considerably besides, bringing higher income to the farmers leading to crop diversification.

Though the area under horticultural crops is less than one fifth of total cropped area, its share to total agricultural growth has become significantly high.Table 5.2 below gives the actual area and production figure trends between 2006-07 and 2010-11.

Figure 5.2: Area under different crops (actual values in 1000ha and percentage of total)



Source: Statistical Handbook, 2012. Dept of Economics and Statistics, Govt. of Tamil Nadu

Table 5.2: The Area and Production of horticultural crops from 2006-07 to 2011-12. (Area: lakh ha; Production: lakh MT)

Items	2006-07 (Base Year)		2007-08		2008-09		2009-10		2010-11	
	Area	Prod	Area	Prod	Area	Prod	Area	Prod	Area	Prod
Fruits	2.69	69.40	2.80	67.78	2.95	68.03	3.07	73.05	3.19	79.35
Vegetables	2.42	73.51	2.44	76.61	2.52	71.86	2.63	77.62	2.84	83.82
Spices & Condiments	1.42	8.02	1.40	7.39	1.54	8.63	1.6	9.32	1.66	10.07
Plantation Crops	2.33	7.92	2.31	7.98	2.46	9.85	2.55	10.63	2.66	11.49
Flowers	0.07	0.10	0.08	0.18	0.1	0.48	0.1	0.51	0.1	0.55
Medicinal & Aromatic Plants	0.25	1.97	0.25	2.09	0.29	2.56	0.3	2.77	0.31	2.99
Total	**9.18**	**160.92**	**9.28**	**162.03**	**9.86**	**161.41**	**10.25**	**173.90**	**10.76**	**188.27**

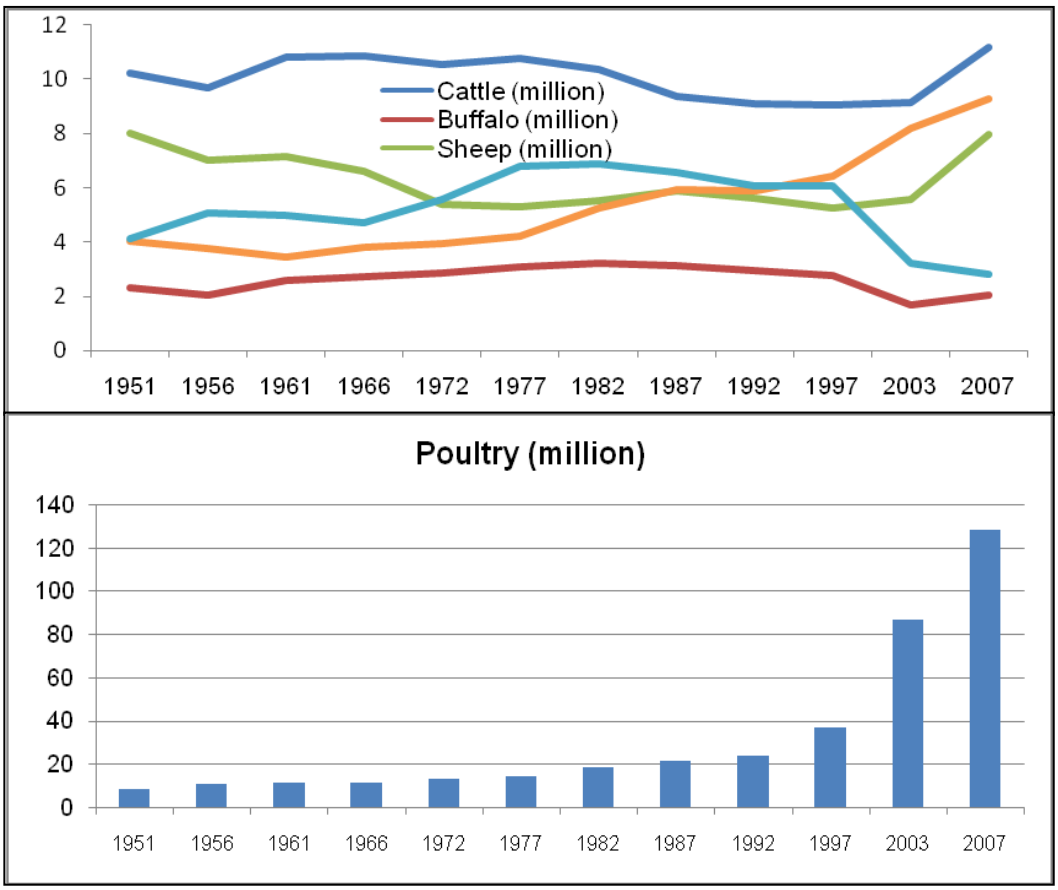
Source: Directorate of Horticulture and Plantation Crops, Department of Agriculture, GoTN

Animal Husbandry and Dairying

The contribution of livestock sector in the year 2010-11 to the Gross State Domestic product at current prices was 2.58 percent and it constitutes 24.80 percent the total agriculture and allied sector(Twelfth Five Year Plan Report of TamilNadu). The dairy sector in Tamil Nadu, is mostly in the hands of 2 million marginal and landless farmers. In addition, this sector is highly gender sensitive and about 90 percent of the activity related to the care and management of livestock are carried out by the women folk.

The livestock population in the State has shown a mixed trend since the census has been carried out in 1951 (Figure 5.3). There has been a substantial dip in cattle and buffalo population from 1982 onwards, and since 2003, it has again started increasing due to the various positive policy decisions on dairy development of the government. During the period from 1997 to 2007, the crossbreed population in Tamil Nadu has increased by 46.61 percent. This is because of the sustained cross breeding of poor milk producing indigenous cattle with Jersey / HF breeds. As a result, there has been a reduction in indigenous cattle population by 27.79 percent during this period.Similarly, indigenous buffaloes have decreased by 39.51 percent during the same period.

Figure 5.3: Livestock population trends in Tamil Nadu



Source: Statistical Abstract of Tamil Nadu, 2011-12

Tamil Nadu is known for its native breeds like Kangeyam, Umbalachery, Burghur, Pulikulam, Alambadi and Toda buffalo. They account for 5.07 percent of the total bovine population of the State. The breeds are highly adapted to local agro-climatic conditions and low management practices. The typical characteristics of the breed include high resistance to diseases, tolerance to high temperature, high fertility, adapted to the tropical environment and possess unique ability to survive even with poor quality feed (Figure 5.4)

The sheep and goat population have continuously decreased from 1951 onwards, may be due to shrinkage in grazing land, but has registered a surge as per the 2003 and 2007 census.The reasons for the positive trend in goat population may be connected with easier management practices and high remunerative prices for goat meat over other livestock products.

In 2009-10 the total milk production in Tamil Nadu was 5.02 million, which increased to 6.83 million tonnes in 2010-11. Among milk producing cows, crossbreeds contribute to 84.27 percent. As per available data, Tamil Nadu contributes 18.27 percent of egg, 8.78 percent of meat and 5.61 percent of milk production in India and stands 2nd in egg and 5th in meat, 8th in milk production in the country (AHVS Policy note, 2012).

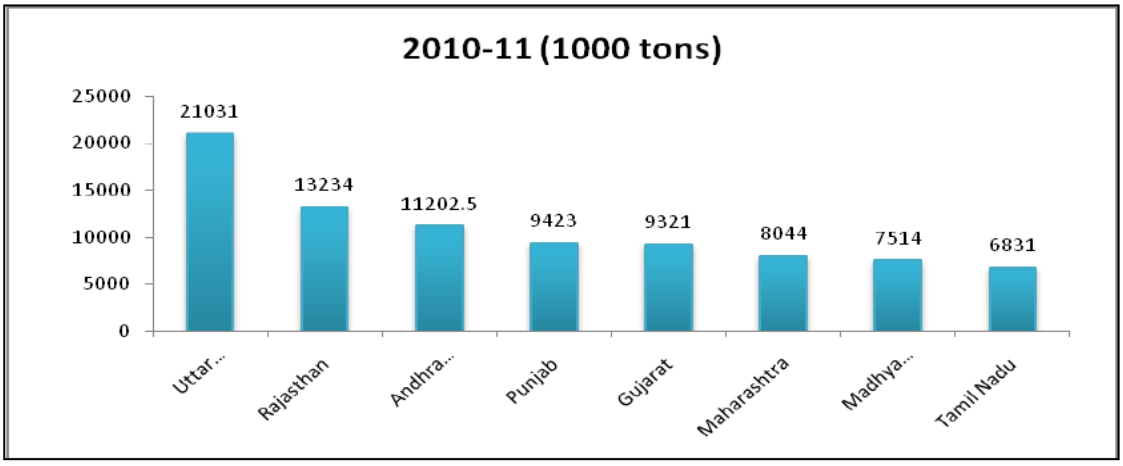
Poultry rearing is also an important activity of the people in the State. Dramatic increase in poultry population has been observed from 1997 onwards as it has been taken up on commercial scale. Reasons like access to good quality chicks, good infrastructure, veterinary health care, access to finance and market, good management practices, and updated knowledge on par with global level, proper pricing mechanism, etc. may be attributed to large scale growth in poultry in the State, making it a front runner in the Indian poultry industry. Namakkal, Salem, Erode and Coimbatore districts have large poultry rearing units.

Figure 5.4: Some of the native cattle and sheep breeds of Tamil Nadu

(Department of Animal Genetics and Breeding, VC&RI Orthanadu TN)

Milk production in Tamil Nadu during 2011-12 was around 6831,000 tonnes.The State is placed between eighth to ninth position in the country in overall milk production in the last 10 years (Figure 5.5).Cross breeds contribute 72.16 percent of total milk production in the State. Milk procurement and distribution in the State is managed by 17 government cooperatives and also by private players. Services such as mechanization, appropriate selection of animal, provided for animal shelter, making available fodder and veterinary services, procurement of milk, training to farmers and financial tie ups with banks,insurance and use of advance technologies for value addition etc. have helped the sector to grow in the recent years.

Figure 5.5: The top eight milk producing States in India

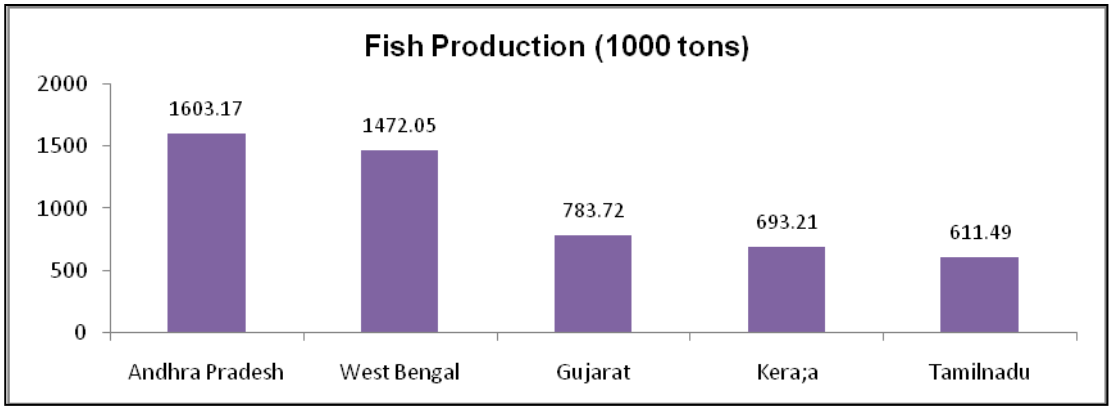


Source: http://data.gov.in/dataset/production-milk

Fisheries

Tamil Nadu with its 1076 km of coastline, 1.90 lakh sq.km of the Exclusive Economic Zone (EEZ) and a continental shelf of about 41,412 sq.km is one of the leading producers of both marine and inland fish and fish products. The marine fish potential in Tamil Nadu is estimated at 7.00 lakh metric tonnes (L.MT). The potential inland fish production is 4.50 L.MT.As of 2011-12, Tamil Nadu ranked 5th in fish catch amongst all the States in India(Figure 5.6).

Figure 5.6: The top five fish producing States in India in 2011-12



Source:Annual Report, Dept., of Animal Husbandry, Dairying and Fisheries, 2011-12

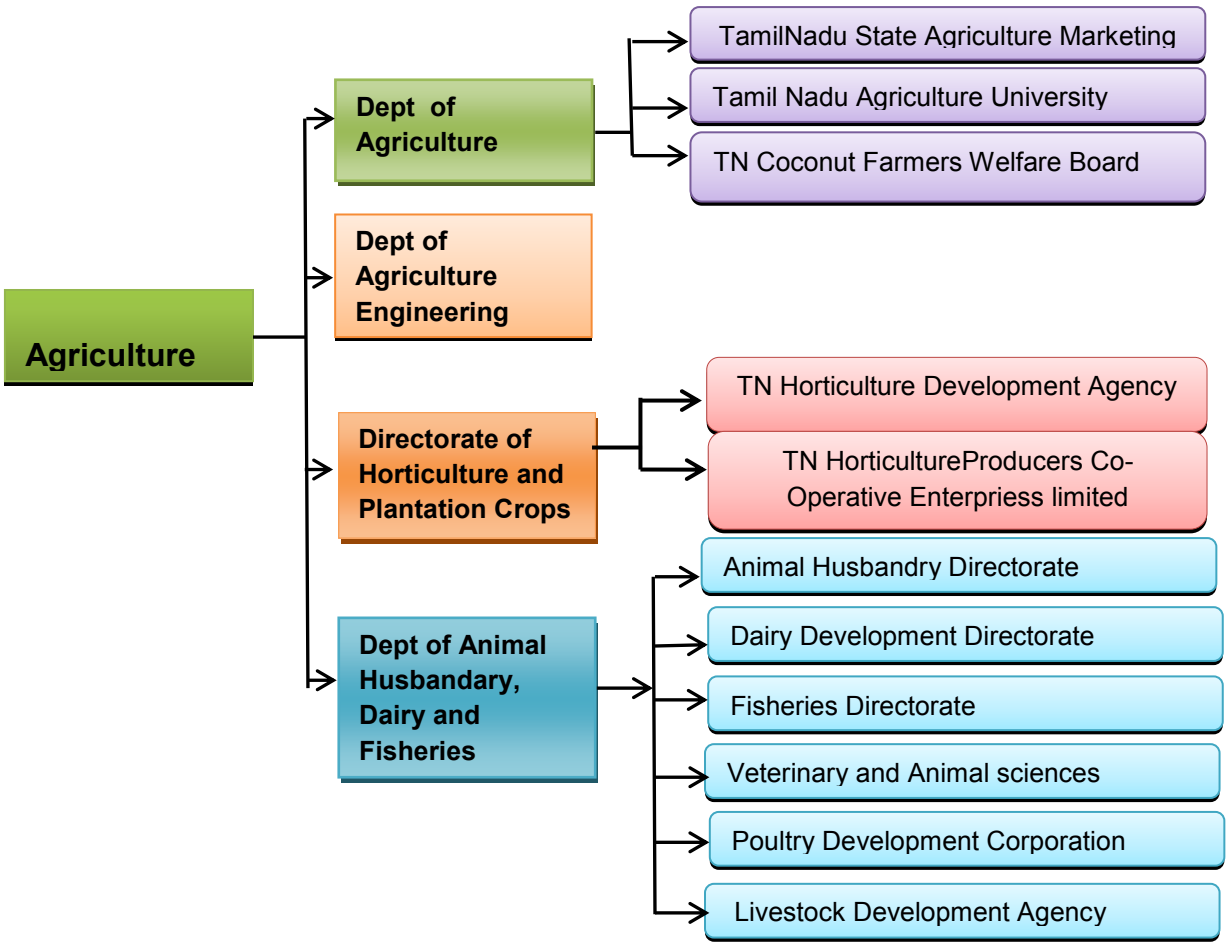
5.2 INSTITUTIONS MANAGING AGRICULTURE IN THE STATE

Agriculture in Tamil Nadu is managed by different departments so as to facilitate the support to the farmers across all sectoral inputs for maximizing production.The Agriculture Department and allied departments are involved in supporting input procurement and distribution, mechanization, storage, establishing market linkages, in scheme implementation and monitoring activities, research and dissemination through extension. The institutional arrangement for managing agriculture in Tamil Nadu is shown below.

Broadly agriculture is managed largely by four departments, namely the Agriculture department, Agricultural Engineering Department, the Horticulture and Plantation Crop Department and the Department of Animal Husbandry, Dairying and Fisheries. Various corporations, Development Boards and societies operating under these departments help the Government in marketing and developing its resources. Agriculture being the most important livelihood option for development of the State is ably supported by the following institutions.(Figure 5.7)

The line departments such as the Tamil Nadu Watershed Development Agency, Department of Forest & Environment and the Department of Sericulture are also directly or indirectly involved in the development of Agriculture in the State.

Figure 5.7 A schematic representation of the institutional arrangement for managing agriculture in Tamil Nadu.



5.3 POLICIES, ACTS AND KEY PROGRAMMES

Policies

The main policy of the State is to usher in the Second Green Revolution, and thereby raise farm based incomes. This is also the objective of the Government of India programme – The Rashtriya Krishi Viskas Yojana (RKVY). The premise of this programme, is to align agriculture according to the agroclimatic zones and to harvest the agricultural potential as per the natural resource availability, and climate characteristics of these agro-climatic zones including augmentation and sustainability of production of livestock, poultry and fishery. Figure 5.8 below, shows the agro-climatic zones in Tamil Nadu.

Figure 5.8: Agro Climatic Zones in Tamil Nadu

Agro Climatic Zones	Districts covered
North Eastern Zone	Kancheepuram, Tiruvallur, Cuddalore, Vellore, Villupuram and Tiruvannamalai
North Western Zone	Dharmapuri, Krishnagiri, Salem and Namakkal (Part)
Western Zone	Erode, Coimbatore, Tirupur, Theni, Karur (Part), Namakkal (Part), Dindigul, Perambalur and Ariyalur (Part)
Cauvery Delta Zone	Thanjavur, Nagapattinam, Tiruvarur, Trichy and parts of - Karur, Ariyalur, Pudukkottai and Cuddalore
Southern Zone	Madurai, Sivagangai, Ramanathapuram, Virudhunagar, Tirunelveli and Thoothukudi
High Rainfall Zone	Kanyakumari
High Altitude and Hilly Zone	The Nilgiris and Kodaikanal (Dindigul)

Strategies envisioned for achieving the Second green revolution in Tamil Nadu are

- Aligning agriculture with its 7 agroclimatic zones.
- Strengthening and improving agriculture infrastructure
- Providing soil health care assistance
- Promoting micro irrigation to increase water use efficiency
- Increasing cropping and irrigation intensity
- Provide access to quality inputs and access to markets for selling farm produce
- Bringing fallow lands back to cultivation.

In the anvil, therefore the policy for developing agriculture at farm level, by increasing the productivity of Paddy, Millets, Pulses, Sugarcane, Cotton, Oilseeds, Vegetables, Flowers and Fruits to bridge the present yield gap. It is envisaged that the Farm level interventions will be done through computer based Farm Crop Management System (FCMS) which would integrate the needs of the farmers with extension and research wing and ensure timely input supply, complete adoption of technology, crop growth monitoring, pest and disease surveillance and providing market linkages.

The State is promoting Integrated Farming System wherein agriculture is integrated with allied activities such as animal husbandry, poultry, aquaculture, sericulture etc., for supplementing and sustaining the income of farmers. Complementing this effort, crop diversification will be promoted for giving wider options to obtain good remuneration.

The Government of Tamil Nadu has passed an act prohibiting unnecessary and unwarranted diversion of agricultural lands to other purposes wherein District Collectors have been authorized to impose restrictions in case there is no justification for such diversion. Further, the Department of Town and Country Planning has brought outlaws to prohibit conversion of agricultural lands. This act viz., The Tamil Nadu Town & Country Planning Act, 1971 and Tamil Nadu Town & Country Planning (Amendment) Act, 2010 (Tamil Nadu Act 46 of 2010) are for planning the development and use of rural and urban land in the State and for purposes connected therewith.

Other than this, the State aims also to bring in the Second White Revolution. The target is to increase milk production by nearly 14 percent, i.e. from 68.34 LMT to 77.65 LMT, and egg production from 11,514 million to 19,718 million numbers per annum.

Towards augmenting agriculture production some of the other policies are focused on:

Water:

For making adequate water available for agriculture and for other sectors in water stressed conditions as well, the Government of Tamil Nadu has formed the Water Resources Control and Review Council to take steps to formulate water management strategies and implementation of the Water Policy. The main objectives

of the Tamil Nadu water Policy with respect to augmenting agriculture and allied sector are:

- Establishment of a Management Information System (MIS) for water resources
- Provide flood protection and drainage
- Plan for augmentation of utilizable water resources, hydro power generation and economic fisheries
- Ensure preservation and stabilization of existing water resources.
- Policy on reduction of conveyance loss in minor and medium irrigation projects for efficient use of available water in larger areas.
- Discourage cultivation of high water consuming crops in coastal areas
- Promote increased farm level storage capacity of water in farm ponds.

Land Use:

Government has come out with a vision for effective utilization of available agricultural lands with the following objectives:

- Identification and conversion of fallow lands into cultivable lands to promote less water intensive, more remunerative crops to reduce emission of greenhouse gases.
- Reclamation of saline and alkaline soils
- Improve and sustain soil health through adoption of organic farming to a larger extent
- Crop diversification to discourage the practice of mono cropping without compromising food and nutritional security
- Devising suitable land use pattern for improving the land use efficiency
- Agro climatic zone wise location specific desired cropping pattern

Crop and Cropping System:

The various policies of the government include:

- Incentives for good agriculture practices like low tillage, residue management, cover crops, etc., which promotes carbon sequestration and reduce emission of GHGs.
- Policy shift from area based fertilizer recommendation to site-specific nutrient management.
- Incentives and subsidies for conservation of agriculture practices in potential regions with deep soils and double cropping.
- Fiscal incentives for adopting INM(integrated nutrient management)and organic agricultural practices.
- Developments of suitable crop/cropping systems for changing climate scenarios.
- Policy on regionally oriented extensive crop and biodiversity cataloguing and conservation, including insect-pests, pathogen, weed, and beneficial organisms. Establishment of seed banks of contingency crops at district levels.

- Regulatory framework to prevent movement of pest, pathogen and weeds from low to high-risk zones under crop/cropping systems of changed climate regions.
- Specific international funds for agricultural adaptation need to be identified that are additional to existing development assistance.
- Strengthening the research capabilities and infrastructure to forecast vulnerability,outbreaks and transboundary movements of key pests and developing adaptation strategies
- Adopting energy saving agricultural practices, changing livestock diet and improving manure and slurry storage.
- Introduction of farming system module on cluster approach.
- Suggestion on cropping system suited to individual farmer based on soil test results.
- Introduction of ICT (information and communication technology) technologies to assist farmers to adopt right technologies during crop season.
- Developing Farm Crop Management System to bridge the yield gap enabling adoption of improved cultivation methods

Animal Husbandry & Fisheries:

The policies include

- The State aims to increase milk production through a systematic upgradation of local cattle through cross breeding.
- In the fishery sector, the State's initiatives aims at conserving the fishery resources by enforcing statutory regulations, stock enhancement and establishing artificial fish habitats; managing the fishery resources by diversifying the fishermen to exploit offshore/ deep sea resources by providing financial assistance and establishing Mid Sea Fish Processing Unit;
- Promoting sustainable eco-friendly aquaculture practices;
- Providing social security to the fisher folk through various relief Schemes etc. which is inclusive of off seasonal support income to encourage the practice of compulsory non-fishing periods.

Agriculture Programmes

- Paddy Mission, Millet Mission, Pulses Mission under National Agricultural Development programme (NADP)
- National Food Security Mission under which System for Rice Intensification has been introduced in Tamil Nadu whereby rice is cultivated with less seed, fertilizer and water (Box 5.1)
- Cereal Development Programme
- Rain-fed Area Development Program (RADP)
- Accelerated Pulses Production Programme
- Seed Village scheme

- Tamil Nadu Precision Farming Project
- System of Millet Intensification
- Micro Irrigation Programme
- Irrigated Agriculture Modernization and Water-Bodies Restoration and Management (IAMWARM)
- Integrated Farming System
- Modified National Agricultural Insurance scheme
    - Weather Based Crop Insurance Scheme
    - Coconut Palm Insurance Scheme
    - Tamil Nadu Agriculture Information Service Network (TN-AGRISNET)
    - Soil and water Conservation Programmes
    - Agriculture Mechanization Programme
    - For decision making and management for maximizing agricultural production, information on weather and climatic condition is essential in the form of short and medium range weather forecasting and for this, automatic weather stations have been established in 224 blocks of Tamil Nadu and another 161 are proposed to be established.
    - Cultivation of wastelands through the comprehensive wasteland development program, integrating watershed development.
    - Self Help Groups have been formed to reduce rural poverty through the establishment of micro-enterprises, training, credit linkages, market support, etc. Mahalir Thittam, a State wide programme has been initiated for organizing self-help groups for the social and economic empowerment of poor women
    - Oilseeds Technical Intervention (Box.5.2)

Box 5.1: Rice - Technical Intervention

In Tamil Nadu, **SRI technology** (System of Rice Intensification) was introduced in the year 2007-08 in view of the recurrent water crisis it faced. At the time of introduction (2007-08), 4.21 Lakh ha of rice area was brought under SRI out of the total rice area of 17.89 Lakh ha, which was only 24 percent. Productivity achieved during the year was 4051 kg per ha which was an increase of 66 percent over the conventional method. With the objective of increasing rice production in districts which had good potential for increasing the area and productivity, National Food Security Mission (NFSM) was implemented in Nagapattinam, Thiruvarur, Pudukottai, Ramanathapuram and Sivagangai districts. After the introduction of this scheme, there was a remarkable increase in productivity of rice and a 67 percent increase in NFSM districts was observed during the period between 2007-08 and 2010-11

Box 5.2: Integrated Scheme of Oil Seeds, Pulses, Oilpalm and Maize (ISOPOM)

Tamil Nadu ranks first in the productivity of oilseeds in the country. It occupies 9 percent of the gross sown area, of which 38 percent is irrigated. Major oilseeds grown in Tamil Nadu are Groundnut, Gingelly, Sunflower and Castor. Oilseeds are sown in a normal area of 6.18 lakh.ha, of which groundnut occupies 5.27 lakh.ha. During the Eleventh Five Year Plan,components such as procurement and distribution of quality seeds, combined nutrient spray under ISOPOM, micro irrigation and gypsum distribution for groundnut under NADP(National Agriculture Development Programme) were implemented and significant results were recorded. There was a 48 percent yield increase with water saving to an extent of 30-40 percent and higher oil content was recorded under precision farming.

Horticulture programmes

- Integrated Horticulture Development Scheme
- Horticulture Training Centers
- Integrated Tribal Development Programme
- Western Ghat Development Programme
- City Vegetable Development Scheme
- Hill Area Development Programme
- National Agricultural Insurance Scheme
- Weather Based Crop Insurance Scheme
- National Agriculture Development Programme
- National Horticulture Mission
- National Bamboo Mission
- National Mission on Medicinal plants

Animal Husbandry Programmes

- Livelihood programmes such as Pasukranthipathakam supplying milch cows; Pavala Vaddi Padhakam for providing subsidy for rearing dairy cows, sheep, goat and poultry ; Jeeva kranthi pathakam
- Fodder development scheme
- Kalnadai Pathukappu Thittam (Health Camps for animals and poultry)

- Renovation of veterinary institutions
- National Mission for protein supplement
- Conservation of indigenous species
- Bull Production programme
- Strengthening Bull mother farms
- Strengthening AI(Artificial Insemination) delivery systems
- Heifer development scheme
- Establishment of new poultry research station
- Establishment of new cattle farms
- Promoting Backyard Family Poultry

Dairy Development Programmes

- Intensive Dairy Development Programme
- Strengthening Infrastructure for Quality and Clean Milk Production
- Assistance to Cooperativesand
- National Agriculture Development Programme

Fisheries programmes

- Build, Operate & Transfer (BOT) system- Construction of fishing harbours.
- Rajiv Gandhi Tsunami Rehabilitation programme (RGTRP) - Fish Landing Centres
- Emergency Tsunami Rehabilitation Programme (ETRP)- Reconstruction and modernization of fishing harbours
- Subsidy assistance has been extended to encourage private participation in fish seed production.
- Group Accident Insurance for Active Fishermen and National Saving-cum-Relief scheme for Marine Fishermen.
- FFDA (Fish Farmers Development Agencies) and BFDA (Brackish water Fish Farmers Development Agencies) programmes

5.4 CURRENT CHALLENGES FOR THE AGRICULTURE SECTOR

Agriculture and Horticultural Crops

The major challenges of the agriculture sector in the State are related to the issue that 57 percent of the area falls under dry land agriculture (Box 5.3) and there is high dependency on rainfall for irrigation.Inadequate, untimely and polluted irrigation water source cripples production and productivity of crops. Low soil fertility, low level of farm mechanization due to small land holdings, monsoon vagaries and at present, the climate changes have compounded the problem further.

With exhausted nutrients and microbes, depleted organic carbon status and humus levels, soil deterioration is unabated. Chemical invasive agriculture, development of sodic and alkaline soils, use of salty water drawn from deeper layers through bore wells add to further complexities.

Shrinking agricultural land mainly due to urbanization and industrialization accompanied by repeated monsoon failures resulting in droughts is a concern for meeting food demand in the State. Though the vision of the State is to move towards farm mechanization for maximizing production, the size of the farm holding continues to survive and currently it is 0.83 ha in Tamil Nadu (Vision Tamil Nadu 2023).

Box 5.3: Vulnerability of Dryland Agriculture in Tamil Nadu

In Tamil Nadu, of the 5.75 million ha of cultivable area, around 3.3 million ha falls under dryland agriculture. Millet crops such as jowar, bajra, maize, ragi and other minor millets;Pulses such as blackgram, redgram, greengram, horsegram and cowpea; Oilseed crops such as groundnut, gingelly, sunflower and castor are best suited for these dryland as they are mostly grown under rainfed conditions. For example, maximum irrigated area is available for ground nut which is 38percent of the gross area. Rest of the crops has only irrigated areas ranging between 1percent to 12percent of gross sown area. As a result the yield gap between irrigated and rainfed conditions for these crops vary between 41percent in Maize to 100percent in Jowar.

About 80 percent of the areas under these rainfed crops are grown during Kharif season, specifically during June-July months (South West monsoon period which has lower rainfall than the North East monsoon in Tamilnadu). But uncertainty in production due to fluctuations in total rainfall and changes in its distribution, decrease in relative productivity in rainfed lands affect the livelihoods of poor and marginal farmers. The following points would explain lower yield under dry land of Tamil Nadu:

- Less soil moisture due to poor precipitation -annual rainfall less than 500 mm
- Uneven / erratic distribution of rainfall both in spatial and temporal means
- Deterioration in soil health due to depletion of top soils
- Decline in organic matter content
- Dearth of suitable rainfed varieties
- Low cropping intensity
- Poor adoption of crop management practices
- Adoption of generalized cropping system

A special package for climate change adaptation should be developed for rainfed areas for minimizing risk. Steps towards this could include

- Integrated farming including crops, livestock, fisheries, poultry and agro forestry;
- Promotion of homestead gardens supported by nurseries.
- Promote farm ponds, legume trees and biogas plants
- Farmers participation in selection of thermal and water stress resistant varieties
- Soil test-based INM practices for improving soil health
- Improving the seed production mechanism
- Efficient use of water through micro irrigation
- Rain water management.
- Introduction of Farm mechanization

While growth in the horticulture sector has been satisfactory, there are number of factors retarding implementation of advance technologies for promoting horticulture productivity such as Non-availability of crop specific/location specific technologies; High investment cost can not be incurred by small and marginal farmers despite government support; Firm mind set of farmers in favour of traditional agriculture; Non-availability of quality inputs on time required for high tech agriculture; low credit support to most of the small and marginal have farmers.

The State over the years has become vulnerable to various natural disasters, which is a matter of serious concern to the planners. Agriculture is the predominant occupation in Tamil Nadu and is highly dependent on the endowment of natural resources and environmental conditions. Because of its geographical position under the climate variability situations, agriculture in Tamil Nadu is affected by frequent cyclones; droughts (Box.5.4) and flood occurrences.Further, the inter-annual variability in the Inter-State river flow affects surface water resources available for irrigated agriculture.

Current estimates of Demand and Supply gap of important crops in Tamil Nadu for the year 2010 (estimated by the State Planning Commission) indicated that the State is lagging far behind in the production of various crops. As the production and productivity of crops mainly depend on the climatic conditions that prevail during the growing period, it is important to understand the changes that have happened in the climate and its related impact on agricultural production, and plan agriculture as per the anticipated changes to climate.

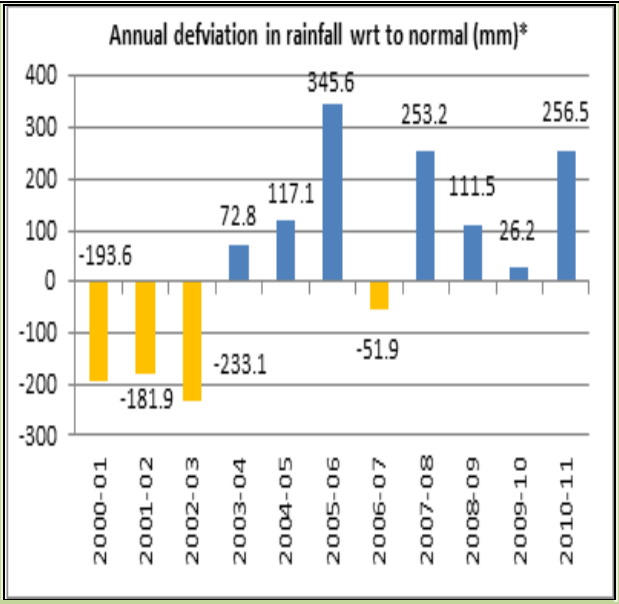
Box 5.4: Droughts in Tamil Nadu

Tamil Nadu experiences recurrent droughts and floods, and long term analysis of yearly climate data, indicates that the probability of occurrence of droughts in Tamil Nadu is every 2.5 years
(Rain-fed Authority of India, 2012).

The chronically drought prone districts in Tamil Nadu are Coimbatore, Dharmapuri, Madurai, Ramanathapuram, Salem, Tiruchirapalli, Tirunelveli, and Kanyakumari (Stephen,2012). The severity and extent of drought in the State are due to deficits in Rainfall, ground water availability and reservoir levels.

Around 15 Lakh ha of cultivable land is left fallow during severe drought years. Even during normal rainfall years, 0.5 percent of the land is left uncultivated because of vast spatial variability in the rainfall pattern.

*Sources:
Statistical Abstracts, 2012 Rain-fed Authority of India, 2012. Position paper on Contingency and Compensatory Agriculture Plans for Droughts and Floods in India, Stephen, 2012. Natural disasters in India with special reference to Tamil Nadu, J. Acad. Indus. Res. Vol. 1(2) July 2012.



The high temperature that prevails during drought increases respiration in cattle and poultry affecting their production, in extreme instance loss of cattle has occurred. This also has been experienced in fisheries and sericulture sectors.

Livestock

Introduction of exotic breeds have increased the incidence of diseases, especially Foot and mouth disease (FMD) Haemorrhagic Septicaemia (HS) Peste-des-petits ruminants (PPR), Brucellosis, Mastitis, Blood Protozoan diseases etc., The economic loss due to FMD is tremendous as it causes death of young animals, reduction in milk yield and quality and quantity of meat, abortion, infertility and poor quality of semen. FMD also restricts the possible export of livestock and livestock products.

Further, as the poor farmers are adapted to manage local breeds with low inputs and poor management practices it may not be that simple to manage crossbreds without adequate support from the department. Further, with the deficiency in green fodder, lack of capacities of farmers to purchase concentrate feed and lack of awareness on good management practices of small farmers will further impact milk production in the State.

The small ruminants like sheep and goats play a critical role in socio economic development of the rural poor. These animals also suffer many diseases of different origin most importantly PPR and Blue tongue. The population of sheep has also declined in the State. Along with decline in population there has been a shift in species. Tiruchirapalli (Zone) district with high black sheep population in the past does not have the particular sheep and now they are seen in Dharmapuri district.

The poultry industry is growing exponentially. However, it is under constant threat from various diseases like Avian influenza, infectious Bursal disease, Newcastle disease (ND), Chronic respiratory disease (CRD), Salmonellosis, Fowl Pox and Coccidiosis etc. Backyard poultry which is mostly kept by poor farmers has shown negative compounded growth during the last 30 years and if the same trend continues poor farmers are likely to face more problems.

The disease control scenario is becoming complex with the intensification of the livestock and poultry production, import of germplasm, unrestricted movement of livestock, changes in ecosystem due to climate change, selection pressure for the pathogens and the emergence of new variants. This warrants improvement of the existing vaccines / vaccination schedule, and development of new generation vaccines, including genetically engineered vaccines with concurrent development and improvement in vaccine delivery systems through the use of nano particle and immunomodulators.

Introduction of high yielding cross bred cattle and buffaloes has led to shortages in fodder. There is deficiency of green fodder availability in the State to an extent of 42.60 percent, which adversely affects the productivity of the Livestock population. Low yielding Desi cows and sheep are the livestock usually sent for grazing.They satisfy their energy requirement to some extent by grazing the stubbles and crop residue supplementation. However, meeting the protein requirement of these animals has always been a problem.The protein deficiency seriously affects the growth in young and milk yield in milch cows. The meikkal porombokes where the livestock grazed are presently in a highly degraded and denuded State containing low quality native grasses. Moreover the fodder biomass production is

also very poor ranging between 0.8 and 1.0 tonnes of dry fodder per hectare and provides grazing only for 3-4 months.

Fisheries

The total potential of fish catch in Tamil Nadu is around 11.5 M Lakh tonnes. However, fish production in 2011-12 was around 16M lakh tonnes, already overshooting the potential. Therefore the likelihood of increasing the production is minimal. Since 1985 till 2004, the marine fish catch has continued to increase from 1 lakh tonnes to 2.54 lakh tonnes in 1995, then it declined to 1.42 lakh tonnes in 2004 due to Tsunami, and has revived since then. An analysis of the catch per actual fishing hours (AFH) of mechanized sector during 2001-10 indicates that the catch rate was better in all the districts except the three districts of Thanjavur, Pudukottai and Ramanathapuram bordering the Palk Bay. Also safety of the marine fishermen is a serious issue faced by the State in this sector.

5.5 IMPACT OF CLIMATE CHANGE ON AGRICULTURE AND ALLIED SECTORS

General Impacts

The major climate change drivers that could adversely impact agriculture in Tamil Nadu are:

Continuous increase in ambient temperature

It is well known that increase in temperature leads to decrease in yields of the majority of the crops.For example, increase in temperature, causes spikelet sterility in rice affecting its productivity. Some crops may gain due to increase in CO_2 in the atmosphere, for example maize, but the temperature increase beyond $3^{o}C$ will reduce maize yields as well.

Increase in frequency and intensity of droughts

Already as indicated in the above section, Tamil Nadu is prone to droughts every 2.5 years. As a result of droughts, summer crops are likely to experience enhanced Evapo-Transpiration (ET), needing larger, more frequent irrigation. The surface water resources are likely to be depleted, creating pressure on ground water, which though may need the needs in the 1^{st} year but recurrent droughts will not enable natural recharge. Further, over extraction of ground water will enhance carbon footprint.

The droughts are spread in pockets across Tamil Nadu. A further increase in frequency is likely to lead to increased soil erosion due to pro longed dry spells and increase in fallow land, hampering the food security of the population in these pockets and a large scale migration may happen.

Increase in intensity of cyclones and floods

Along with heavy rains during the north east monsoon in Tamil Nadu, it atmospheric depression and cyclones also hit the State. With climate change as the cyclone intensities increase, it would have implications on agriculture in the coastal

zones. The cyclone frequency, though is not noticeably increasing, the wind speed of the cyclone is increasing. This means, a larger area and deeper inland areas are likely to be inundated with salt water from the sea as there is formation of higher storm surges. Districts along the Tamil Nadu coast are at risk.

Increase in heavy precipitation events

This is likely to lead to flash floods, leading to deterioration in soil health due to heavy loss of top soil caused by erosion in hilly areas, and decline in soil organic matter content thereby impacting agriculture in these areas.

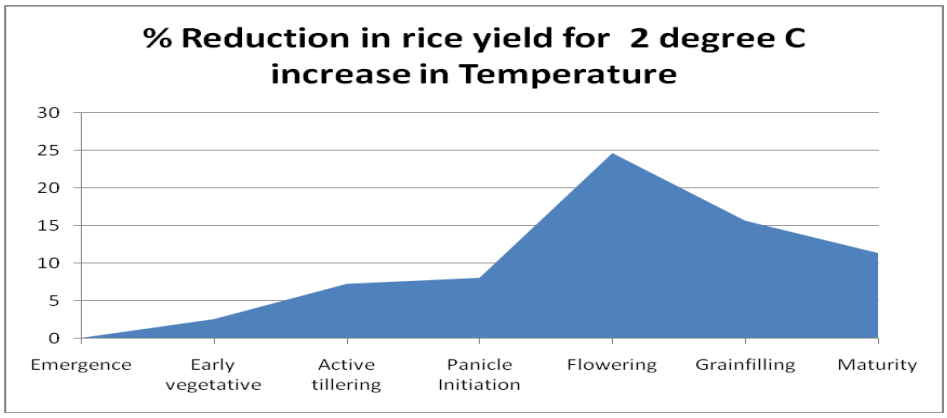
The other risk that the agricultural system may have to deal with is the emergence of new pests and diseases. All this may lead to increased cost of cultivation with more number of irrigation and climate sensitive inputs

Crop specific Impacts

Rice:

Increase in temperature at different growth stages influence rice yields, with different magnitude. Priya and Geethalakshmi (2008) have shown that the impact on yields with increase in temperature by 2^{o}C is minimal during the early vegetative stages and becomes higher as one goes along and is maximum during the flowering and grain-filling stages of rice and this is detrimental to rice production (Figure 5.9).

Figure 5.9 : Reduction in rice yield (percent) for 2°C increase in temperature



Another study by Geethalakshmi and Dheebakaran (2008), using projections of the PRECIS model (HadCM3) for A1B scenario for kharif (southwest monsoon) indicate that in 2020, a likely decrease by 10 to 15 percent in rice yield is expected due to increase in temperature and change in rainfall (Figure 5.10). In 2050, there would be a 30 to 35 percent yield reduction and in 2080, up to 80 percent yield reduction are expected during this season. Though, the reduction is found in almost all the districts, it is more pronounced in the major rice growing districts such as Thanjavur and Nagapattinam.

The same study for the northeast monsoon (rabi season) indicates that there is increase in rice yield up to 10 percent in 2020 (Figure 5.10). This might be due to the positive effect of a slight increase in temperature during the rabi season, where

the crop suffers due to low air and water temperatures at present.As the rainy season and the winter season of Tamil Nadu falls in the rabi season, most of the time the water temperatures are lower. An increase of 1 to 2 degrees would created a positive impact during 2020. In 2050, rabi rice yields would be almost same as that of the current productivity and further increase in temperature during 2080 would have a negative impact and reduce yields up to 25 percent in most of the districts of Tamil Nadu. An intercontinental collaborative- "ClimaRice: Climate Change and persistent Droughts- Impact, vulnerability and adaptation in rice growing sub-divisions in India" was implanted that also looked into the impacts in Cauvery Basin in Tamil Nadu and adaptation practices.

Figure 5.10: Deviation in rice yield due to climate change

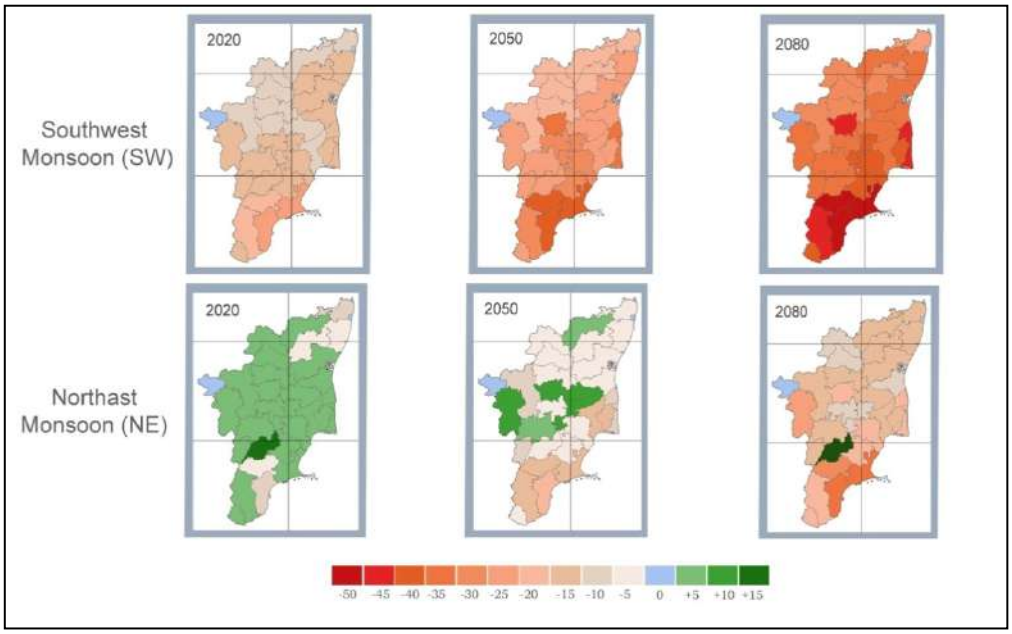
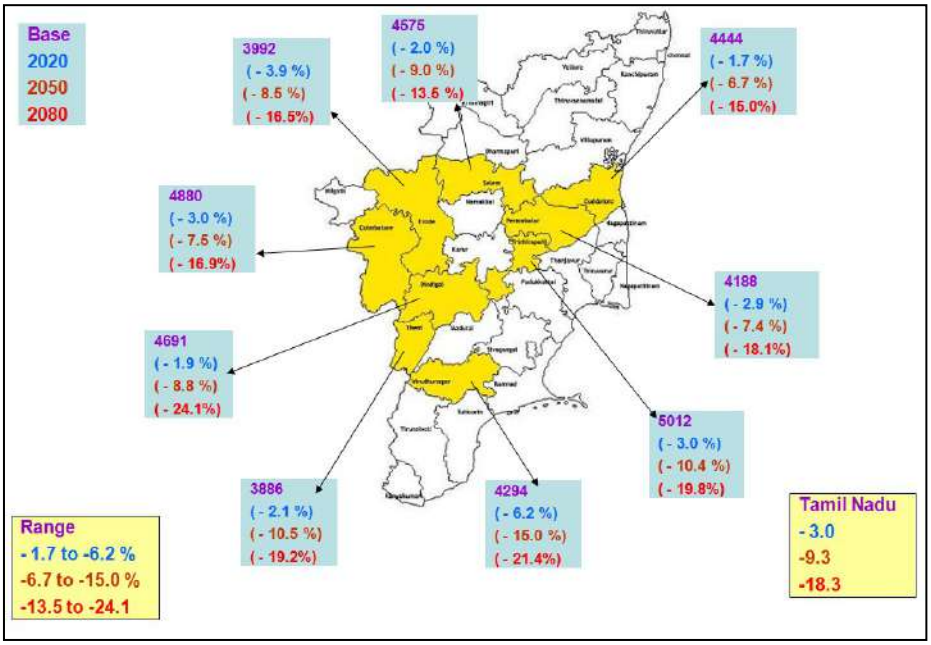


Figure 5.11: Impacts of changing climate on Maize production in Tamil Nadu

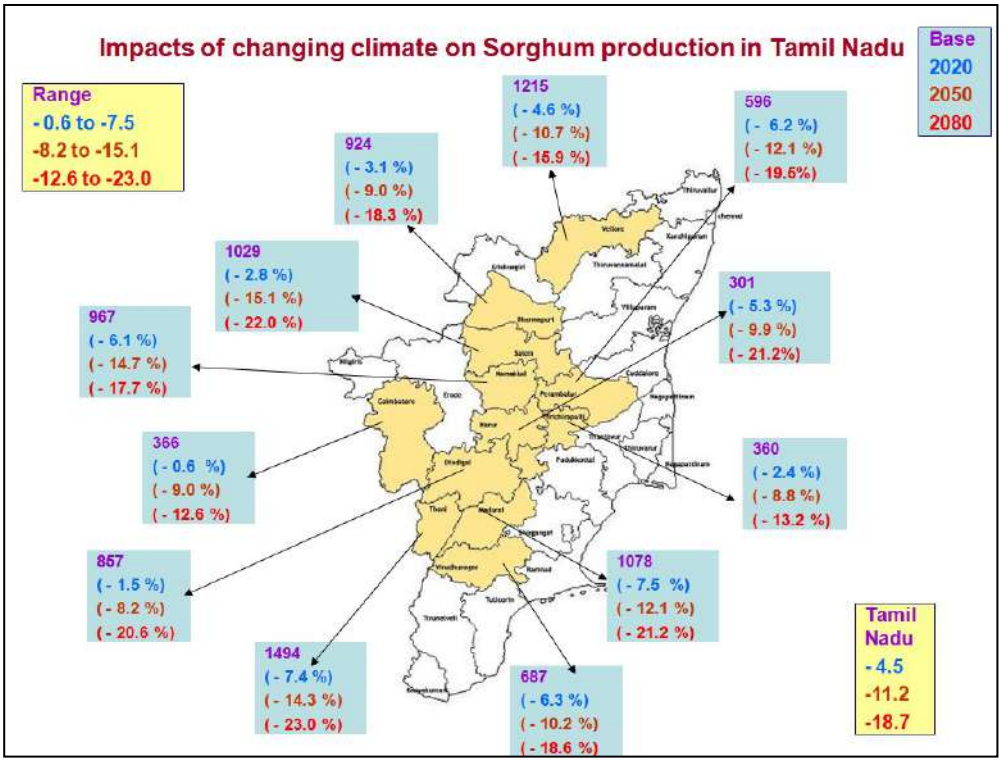


The change in climate is expected to create both positive as well as negative impacts on maize cultivation. Impact of maize yield was studied for major maize growing districts of Tamil Nadu using INFOCROP model for climate change scenarios developed for 2020, 2050 and 2080 (Geethalakshmi, 2009). Analysis projected a reduction in yield by 3.0, 9.3 and 18.3 percent by 2020, 2050 and 2080 respectively from the current yield levels (Fig.5.11).

Sorghum:

Impact of of climate change on sorghum yield was studied for major sorghum growing districts of Tamil Nadu using INFOCROP model for the climate change scenarios developed for 2020, 2050 and 2080 (Geethalakshmi, 2009) and the results are presented in Fig.5.12. The results indicated declines in yields by 4.5, 11.2 and 18.7 percent respectively by 2020, 2050 and 2080 from the current yield levels if no management intervention is made. The yield reduction could be mainly due to a quality increase in night time temperature (minimum temperature) with compared to the magnitude of increase in maximum temperature and variation in the expected rainfall.

Figure 5.12: Impacts of changing climate on Sorghum production



Impact on Other Crops:

To understand the response of cotton and red gram crops to future climate change, INFOCROP model was run using base year weather data and B2 scenario for different time periods starting from 2070 to 2100. The results indicate that the climate change is expected to negatively impact the cotton and red gram productivity (Figures 5.13 and 5.14).

Figure 5.13: Variation in productivity of cotton due to Climate change

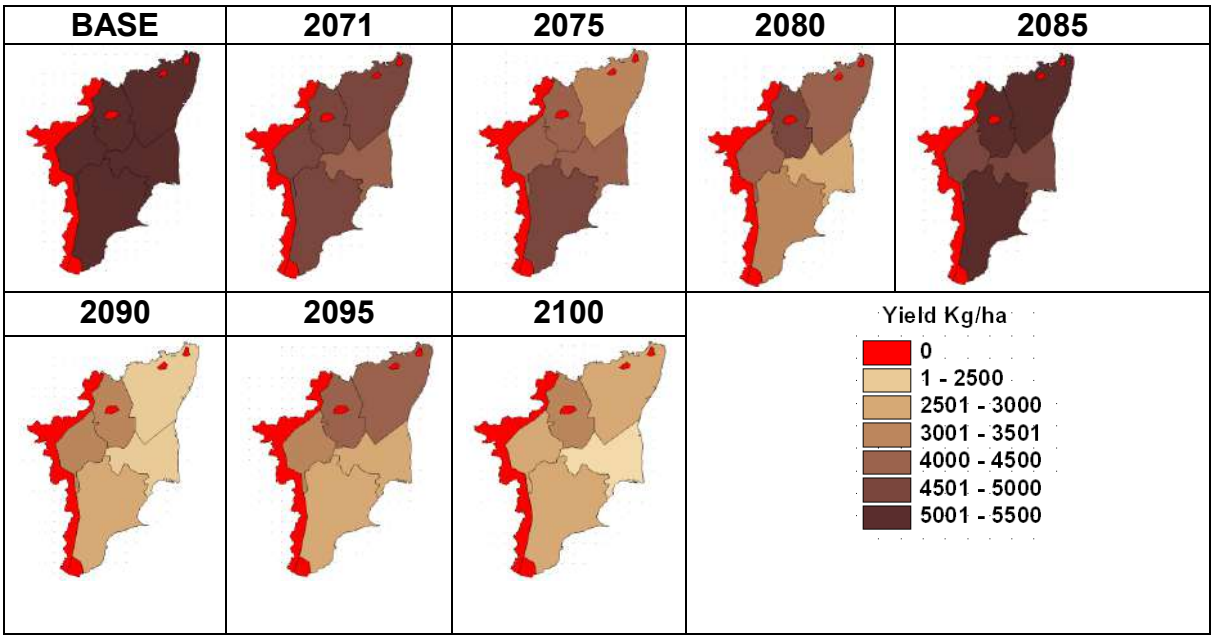
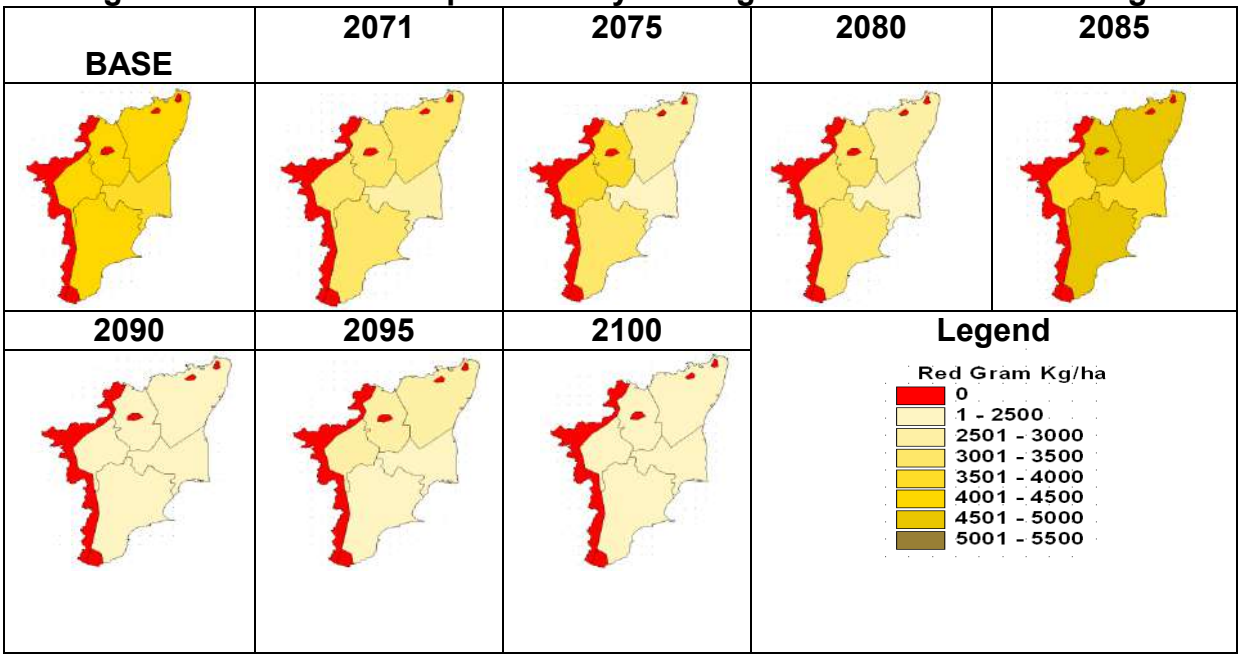


Figure 5.14: Variation in productivity of red gram due to Climate change



Impact on Livestock

The effects of climate change on livestock are direct and indirect. The direct effects are related too high levels of infertility, low conception rates, long calving intervals and low feed intake. The indirect effects are protein and mineral deficiency leading to infertility and other metabolic diseases.

Genetic progression in milk production through cross breeding of indigenous cattle and buffalo with high yielding varieties is closely related to increased food intake.High feed intake results in increased metabolic heat increment. High metabolic heat increment requires effective thermo regulatory mechanisms to

maintain body temperature in a thermo neutral zone and in physiological homeostasis.Climate changes could impact the economic viability of livestock production.Cattle in general and cross breeds in particular are vulnerable to heat stress, as with increase in temperature their feed intake reduces, leading to less milk production.

Research studies show cross breeds are more susceptible to the vagaries of climate / temperature when compared to indigenous cattle. Increase in each unit of THI (Temperature Humidity Index) affects milk production adversely in cross- breed cattle than indigenous cattle with the quantum of reduction being 0.43 lit/day/animal for cross breeds and 0.16 lit / day / animal for indigenous cattle at 72-82 THI.

Other than reduced feed intake and resultant decrease in milk yields, the rise in ambient temperature on livestock leads to altered milk composition, delayed onset of puberty, declined conception rate, increased incidence of silent heat and anestrous, ovulation failure, early embryonic deaths, higher incidence of diseases like mastitis more prevalence of pest, insects and parasitic diseases..

The increase in maximum and minimum temperatures are likely to decrease fodder and feed production, affecting milk production indirectly.

Fisheries

A study carried out by Cheung et al., 2009, estimates that, fish catch might increase as a result of climate change along the Indian coast including Tamil Nadu. Reduced snow cover across Eurasia is thought to be responsible for an increase in the strength of the south-westerly monsoon winds. Increased wind strength stirs up deep water and increases the upwelling of nutrients into surface waters where it supports increased phytoplankton (algae) production. Increases in phytoplankton production of 300 percent was recorded between 1997 and 2004.This increased availability of food at the base of the food web should boost fish production. An increase in fish catch of more than 50 percent could be anticipated.

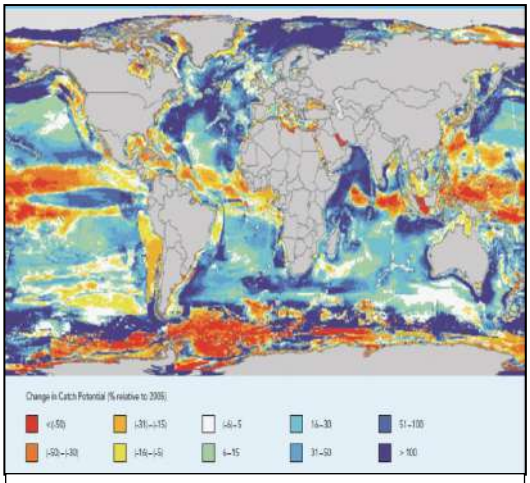


Figure 5.15: Changes in catch potential due to climate change
Source: Cheung et al, 2009

Locating Potential fishing zones in advance enhances the fish catch and hence the incomes of the fishermen. Towards this, forecasting can be carried out by integrating the coastal living marine fishery resources from Tamil Nadu coast with physical, ecological data [Sea Surface Temperature (SST) and Chlorophyll concentration (CC)] form NOAA (National Oceanic and Atmospheric Administration) and its partners (Indian National Center for Ocean Information Services (INCOIS)) (Ramesh et al (2010). This approach will provide a comprehensive view of the status of coastal marine ecosystems, including how they relate to current climate changes to living coastal marine fishery resources and human population. The climate change

scenarios, if integrated in these systems, can enable future marine fishery and aquaculture development of the State. (Figure 5.15)

5.6 STRATEGIES TO FOR ADAPTATION TO CLIMATE CHANGE

Agriculture Crops and Horticulture

Adaptation to climate change requires integrated solutions that simultaneously address livelihood improvements and environmental sustainability. Proactive measures for adaptation to climate variability and change can substantially reduce many of the adverse impacts and thus contribute to livelihood security of the vulnerable rural population. A project "Clima Rice" carried out in the Cauvery basin in Tamil Nadu has already initiated adaptation strategies that will also address climate change concerns of the region (Box 5.5).

Box 5.5 : Clima Rice

"ClimaRice" is acronym for an intercontinental collaborative project entitled "Climate Change and persistent Droughts: Impact, vulnerability and adaptation in rice growing sub-divisions in India". The project has investigated the impacts on the drought prone Cauvery basin of Tamil Nadu State in India in the current and projected climate scenarios and has developed various adaptation measures to sustain rice production therein. The strategies suggested are:

- Minimum Tillage to retain soil Carbon content
- Promotion of use of Drought and Flood Tolerant Varieties
- Promotion of Crop rotation practices like planting rice followed by short duration legumes which help in fixing nitrogen to soil, increase soil fertility and thereby reduce dependence on chemical fertilizers, pesticides and other inputs
- Encouraging the use and growing of green manure crops including Azolla besides ensuring quality seeds supply
- Introducing modified cultivation methods such as System of Rice Intensification
- Promote retention of crop residue over soil to build up soil biomass
- Encouraging the use of Bio-fertilizers such as blue green algae, Azospirillum and Phosphobacterium

The broad strategies for climate change adaptation in agriculture and horticulture sector in Tamil Nadu will include:

- Sowing or cropping in consonance with the onset of south west and north east monsoons
- Managing soil erosion through minimum or no tillage, compartmental bunding, contour farming, mulching etc.
- Managing soil health and nutrient content through a soil test based integrated nutrient management. Promote precise application of nitrogenous fertilizers as per the need of the crop; localized application of nano-fertilizers to improve yields; slow or controlled-release fertilizer forms or nitrification inhibitors; by applying nitrogen when least susceptible to loss, often just prior to plant uptake (improved timing Supplementing inorganic fertilizers with Biofertiliser

such as FYM(farm yard manure), compost, green manure and crop residues; apportioning soil nutrient through computer based farm crop management system (FCMS)

- Promoting integrated Pest and disease Management
- Improvement of water use efficiency up to 50 percent through technological measures such as center pivot irrigation, dormant season irrigation, drip irrigation, gravity irrigation and pipe & sprinkler irrigation and in rice through System of Rice Intensification (SRI). SRI can double or triple current rice yields. Abu Yamah,(2002); Uphoff,(2005). Aerobic rice cultivation where fields remain unsaturated throughout the season like an upland crop offers an opportunity to produce rice with less water and methane emission. Bouman et al (2002).

- Promote the development and introduction of crop varieties tolerant to high temperature and water Stress. In this context, breed new rice cultivars that can maintain spikelet development under high temperature and have less wasteful maintenance respiration losses. Promote tree legume cultivation on bunds to act as wind shelter to reduce ambient temperature and to control crop respiration.

- Undertake crop diversification for up-scaling livelihoods of the farming communities.Mono cropping is the prime cause for the depletion of soil fertility.

- Encourage development of Integrated Farming Systems suitable for each agro climatic zone especially for poor farmers to augment their incomes

- Undertake Risk Mitigation Measures such as compulsory Crop insurance, to avail financial support to compensate crop losses at distress times and encourage the farmers to take up progressive farming practices and use high value inputs to help them stabilize their farm income, particularly in disastrous years.

- Improve quality seed production and distribution mechanism through the establishment of more seed villages/seed banks

- Undertake capacity building through training on
    - Latest feasible and effective Farm mechanization practices
    - Rain water management practices at household and landscape level
    - Agro meteorology
    - Identification of future risks and Strategies such as location specific crop contingency plans
    - Alternate cropping strategies for "agro climatic zone based cropping pattern" to ensure maximum utilization of available land and water with an ultimate aim to increase cropping intensity
    - Land development technologies appropriate for various land types
    - INM (Integrated Nutrient Management) / IPM (Integrated Pest Management) technologies with emphasis on eco friendly agriculture.
    - Modern technologies like micro irrigation and precision farming to increase water use efficiency

- The long term measures would include continuation of capacity building through Research, Training and awareness generation.
- Develop a Statewide database on the characteristics of each farming land, such as soil, input requirements, climate, etc. to be used for developing farm specific crop management system

- Institute a long-term rice varietal development program to make available new rice varieties and conserving local gene pool through public-private partnership, and actively engaging local farmers, women, and other local agencies in the process.

- Help farmers adopt tailored farming practices including soil nutrient management, choice of crop and cultivars, and pests and disease management as per the suitability/potential of different agro climatic zones based on weather based advisories derived from climate analysis of the local area and forecasting which includes probable occurrence of pests and disease.

- Promote Integrated Farming Systems which encompasses various agricultural enterprises viz., crop husbandry, animal husbandry, fishery, forestry, etc. to facilitate changes in the farming techniques for optimizing the use of resources, maximising production, supplementing the income of the farmers and thereby improving the economic status.

- Support research on Weather based crop insurance schemes to cover risks of increasing intensities and frequencies of extreme weather events. The challenge is to develop a weather-based index to simplify the insurance claims and payment procedures.

Animal Husbandry and Dairy

- Promote leguminous feed production in degraded pasture lands in villages (Meikkalporomboke land)

- Efforts are to be made for newer non-commercial feeds including herbal and microbial feed additives, organic mineral supplements for better bioavailability and improved health and production of cross bred livestock

- Undertake genetic studies on disease resistance in domestic species of livestock.The animal biodiversity available in our country is goldmine of germplasm.The indigenous animals have unique characteristic of adaptability to adverse agro-climatic conditions, and have the ability to survive under zero management and input conditions and are immune to most diseases. To reap the benefit of these disease resistant and climate adaptable traits, shift in breeding policy is essential.

- Promoting green fodder cultivation as one of the multiple crops to bridge fodder gap and avail fodder during drought. Fodder type to be selected according to the suitability of the agro-climatic zone where it will be grown.

- Ensure adequate animal housing and dedicated ponds for bathing in villages to protect livestock from extreme heat and thus prevent morbidity and mortality and ensure livestock breeding and produce

- Intensify disease surveillance and develop forecasting of disease outbreaks for short and long term time frames using Geographic information system (GIS) based pathogen specific bio-climatographs for reliable disease forecasting and monitoring and climate as one of the input in the forecasting modelling efforts

- Promote cross breeding with indigenous varieties to improve resilience of cross bred's to climate change

- Promote dairy development in villages by training more women on animal care, animal disease reporting, and nutrition for optimizing milk production at the household level of small and marginal farmers and enabling them to participate in milk cooperatives

Fisheries

The fisheries department has various schemes and programmes to enhance fish catch as well as for the fish farming community welfare. Some of the strategies that can be applied to climate proof the sector in short and long term are

- Mapping and Tracking coastal marine ecosystem to maximize fish catch, off the coast of Tamil Nadu in conjunction with SST and distribution of Chlorophyll concentrations

- Undertaking modelling to predict fish catch in long term time scales to devise marine fisheries requirement and hence the formulation of policies

- Undertake scientific studies to identify native fish suitable for inland fisheries in a warming scenario

- Promote seed farms for fish that can withstand thermal resistance in a warming climate

- Develop bioshield in coastal villages by growing mangroves that would not only protect the coastal communities from cyclones and other sea related disasters, but will also provide nutrients for marine species that thrive in the mangrove soils.

- Training on value addition to direct fish catch through processing such as manufacturing fish, pickles, prawn pickles and tinned fish.

- Diversify livelihoods amongst coastal fishing communities by training them to develop additional skills such as masonry, electrical works, plumbing, heavy vehicle driving, andcommunication.

- Easier access to insurance and credit

- Establishing community FM station for communicating information during times of disaster.

A summary of the important strategies in this sector are outlined below

As can be seen, agriculture in Tamil Nadu is affected by frequent cyclone, rain dark area to south west monsoon (except the Nilgiris, Salem Dharmapuri, Krishnagiri and Kanyakumari districts), frequent failure of north east monsoon and flood occurrence, decline in cropped area (agriculture, horticulture) and productivity, inter-state river flow which has high annual variability and dictates the surface water source for irrigated agriculture. Effects of global warming on agriculture essentially include extreme rainfall events, floods, droughts, sea water intrusion and incursion. This will reduce net cultivable area leading to yield loss in agricultural and horticultural crops, dairy, poultry, meat production and fisheries. There will also be frequent epidemic of pest and diseases which will increase cost of cultivation with more number of irrigation and climate sensitive inputs.

Kharif crops will experience heightened risk of floods and drought, rabi crops will experience enhanced evapo-transpiration needing large and more frequent irrigation.The climatic changes influence reproductive cycles of crops will cause spikelet sterility in rice affecting the productivity.Deterioration in soil health, Inadequate water availability and depletion of ground water, increased soil erosion, increase in fallow lands, increased demand for ground water, reduced natural recharge. Marginalization of land holdings inhibit the adoption of mechanized technologies and lead to poor adoption of crop management practices. Fluctuation in market prices of the agricultural produce will lead to uneconomic returns. The direct effects on animal husbandry would be incidence of diseases, high infertility, low in conception, long calving intervals and low feed intake rate. The indirect effects would be protein and mineral deficiency leading to infertility and other metabolic disease.

The technological interventions required include research on climate resilient varieties, agronomic practices, soil and water conservation, integrated pest and nutrient management, low tillage farming, growing of nitrogen fixing crops and trees, use of pest and disease-resistant crop varieties, use of all micro irrigation techniques, water harvesting structures based on GIS & upkeep of the existing structures and imporved farm mechanization.

A set of CC Strategies have been proposed to tackle CC impacts on agriculture. They include the following:

R & D activities: These include breeding and testing of varieties tolerant to drought, high temperature, salinity, water logging, breeding and testing of high yielding varieties in different soil condition (rice, millets, pulses, oilseeds, fodder horticulture and forest trees), evaluation of C4 and CAM(crassulacean acid metabolism) pathway plants for enhanced CO_2 fixation, increased carbohydrate, protein and oil yields under stress and developing suitable synchronized maturing extra early short duration genotypes.

OtherR&D(research and development) activities include altering crop geometry to suit mechanical weeding in maize, nutrient management for hybrid maize under rainfed vertisol, yield enhancement for rainfed maize by STCR-IPNS approach on Inceptisols (red non calcareous), evaluation of maize genotypes for phosphorus acquisition, study on benefits of nano application on seed quality

improvement in maize and targeting the biochemical events responsible for seed enhancement techniques in maize. For millets, R & D work will be development of newer formulations of microbial inoculants and seed treatment methods for millets, identification of pre-sowing seed management techniques for small millets, enhancing the productivity of small millets by dry farming techniques, Rhizosphere studies in millets under water stress situation, enhancing partitioning efficiency in ragi using nutrients and Plant Growth Regulators and developing organic technologies for millet based cropping systems.

Climate profiling research on agronomic practice and popularising them, and extension strategies to mitigate extreme weather events: Another set of activities include land management for better crop establishment, minimum till seed drill, standardising water harvesting techniques and supplemental irrigation through mobile sprinklers, developing suitable hybrids, developing drip irrigation and fertigation schedule for different duration groups and changing cropping pattern to counter CC, evolution of safe AWDI (alternate wet and dry irrigation) practice. Set of activities related to rice are technology under unpuddled condition during kuruvai season, aerobic cultivation under tank-fed irrigated condition, yield maximization in traditional rice through management techniques, residue management and nutrient dynamics in combined harvester operated rice fields, development and evaluation of stage-specific microbial inoculants, mapping and management of zinc deficiency in rice grown soils of various districts and alleviating Iron toxicity problem under acid soils. Nutrient feed back crop cultivation will be done for soil health sustainability. Specific activities have been proposed for sugarcane, groundnut, oil seeds and pulses. These include intercropping of groundnut in sugarcane, evaluation of organic mulch in groundnut, mapping and management of sulphur deficiency in oilseeds grown soils, sulphur nutrition of rainfed groundnut in red and black soils of Tamil Nadu, developing a multifunctional bioinoculant (Burkholderia sp.) for groundnut, altering crop geometry to suit mechanical weeding in oilseeds, optimization of sulphur for sesame through tracer technique, seed pelleting for mechanized sowing and its storage potential in sesame, developing package of practices for pulse–oilseed cropping system and standardization of seed invigoration treatment for seed quality enhancement in groundnut are other set of research activities.

Extension strategies will be to popularize the above management practices to mitigate extreme weather events through Adaptation Research Trial and Multi Location Trial (ART and MLT). There would be specific research study on effect of impact for mid-term correction. This will include economic and social impact created due to the different CC mitigation and adaptation interventions implemented by the State Department of Agriculture and TNAU to initiate mid-term correction. Another work would be Climate proofing with Integrated Farming Systems to popularise the Integrated Farming System for wider adoption.

Countering sea water incursion: Strategies under this include recharging the aquifers using the abandoned open wells and defunct bore wells, constructions of sub-surface dykes, diversion of excess flood water at upper reaches to water deficit areas, deep ploughing to break sub surface hard pan to increase infiltration efficiency and improve ground water quality and check sea water incursion and reclamation of saline and alkaline soils

Soil conservation strategies include recharging the aquifers using the abandoned open wells and defunct bore wells, promote minimum/ no tillage during fallow period, compartmental bunding, contour farming, deep ploughing, mulching for all crops, building organic carbon content of soil with green manuring, Azolla, BGA, bio fertilisers, bio pesticides, bio agents and compost developed from municipal solid waste, bringing fallow land and degraded land back to cultivation, organic farming besides conducting awareness programmes and training.

Water conservation strategies include research on conjunctive use of Irrigation water, Increase the use of Micro Irrigation technology viz., drip, Sprinkler, Rain gun, Mobile Sprinkler in dry land, Garden land and Horticultural farming system, Strengthening existing water harvesting structures and repairing and replacing the shutters in the irrigation tanks and drainage channels,Creation of additional farm ponds to capture the runoff water and utilise the harvested water to critical stages of crop growth and to recharge the aquifers to improve the quality of irrigation water, Ensuring the lively hood of the farmers in non delta districts having surface irrigation potential with piped irrigation network by providing collection wells at regulating structures to increase the cropping intensity with assured yield and employment opportunities

Weather mitigation: To mitigate weather, it is proposed to develop and execute sustainable seed production and distribution network, establish net work of seed banks, food banks and cold storage to ensure supply at times of contingencies, GIS based village mapping for agro management system, to enhance input use efficiency and overcome effect of climate change and increase farm productivity. Other strategies include integrated voice message on weather based agro advisories, market demand and price forecasting, establishment of dedicated climate knowledge cell to monitor, forewarn and train farmers and officials of the department on management of situation arising out of extreme events,strengthening and popularising the existing crop insurance programme and finally, research project on comprehensive crop insurance products that would cover increasing extreme events.

Green cover for coastal calamities: Activities proposed for this includes development of vegetative shield for east coastal region against wind, cyclones, etc. and management and conservation of vegetative shield.

Promotion of inland fishing and inland fisheries for effective utilisation of water bodies: Strategies proposed for inland fishing and improve fisheries include development of technology for improving inland fishing, producing new breeds, popularization of technology, increasing fish production and fish farming area for rural livelihood through inland fisheries- FFDA, BFFDA, reservoir fisheries development, fish culture in pens and cages, establishment of hatcheries, undertaking repair and renovation of Government Fish Seed Farms/ Hatchery to increase fish seed production for fish farming, improving inland fisheries for tank and its command areas under IAMWARM Project, increasing fish production and fish farming area for rural livelihood through Inland Fisheries - FFDA, BFFDA, reservoir fisheries development, fish culture in pens and cages, establishment of hatcheries

Brackish water Aquaculture: This has been proposed for utilising saline areas for shrimp/fish production**.** Efforts would be taken to increase production per hectare

and encourage new species, advocating culture of SPF(specific pathogen-free) Littopenaeus vannamei and Sea bass.

Strategies for animal husbandry and dairy development sector: Strategies would include promoting development of Meikkal poromboke lands in villages for growing leguminous fodder, ensure adequate animal housing and dedicated ponds for bathing in villages to protect livestock from extreme heat, intensify disease surveillance and develop forecasting of disease outbreaks for short and long term time frames, promote cross breeding with indigenous varieties to improve resilience to CC, promote dairy development by training women in villages on animal care, animal disease reporting, and nutrition for optimising milk production at household level of small and marginal farmers and enabling them to participate in milk cooperatives.

5.7 BUDGET REQUIREMENT FOR STRATEGIES IN THE SUSTAINBLE AGRICULTURE SECTOR

The total cost for implementing the strategies during the 12th Five Year Plan (FYP) is Rs. 23251.44 crore and 13th Five Year Plan (FYP) is Rs. 25783.39 crore.Details are given below in Table 5.3.

TABLE 5.3: Summary of budget requirement for the Sustainable Agriculture Sector

S. No	Details	Cost for 12th FYP (Rupees in crore)	Cost for 13th FYP (Rupees in crore)
1	Research and development on crop season, water conservation, Integrating water usage, effect of change in temperature / humidity, varietal development for rice, pulses that will tolerate weather change and different soils.	250.00	150.00
2	Climate profiling research mainly on agronomic practice and popularising the same with extension strategies to mitigate extreme weather events	3070.00	2570.00
3	Countering sea water incursion	1720.00	2170.00
4	Soil conservation Strategies	1370.00	1670.00
5	Water conservation Strategies	13140.00	14585.00
6	Weather Mitigation	2285.00	2760.00
7	Green cover for coastal calamities	250.00	150.00
8	Promotion of inland fishing	1000.00	1500.00
9	Promoting inland Fisheries for effective utilisation of water bodies	149.61	207.64
10	Brackish water Aquaculture for utilising saline areas for shrimp/fish production	6.13	9.50
11	Strategies for animal husbandry and dairy development sector	10.70	11.25
	Total	**23251.44**	**25783.39**

The detailed budget allocations for all strategies and the actions for agriculture and horticulture crops, animal husbandary and dairy and Fisheries are given in Table 5.4.

Table 5.4 Detailed budget for strategies in Sustainable Agriculture sector (includes horticulture, inland fishing, animal husbandry and dairy development

S. No	Strategy	Agency	Cost for 12th FYP (Rupees in crore)	Cost for 13th FYP (Rupees in crore)
Strategy 1: Research and development on crop season, water conservation, Integrating water usage, effect of change in temperature /humidity, varietal development for rice, pulses that will tolerate weather change and different soils.				
1.1	• Breeding and testing of varieties tolerant to various climatic stresses • Developing and evaluating crop genotypes (rice, millets, pulses, oilseeds, fodder horticulture and forest trees) of short duration, testing of high yield potential in different soil conditions, C4 and CAM pathway plants for enhanced CO_2 fixation, increased carbohydrate, protein and oil yields under stress.	TNAU	130	80
1.2	**Maize** • Altering crop geometry to suit mechanical weeding • Nutrient management and yield enhancement [STCR-IPNS approach on Inceptisols (red non calcareous)] for rainfed hybrid • Evaluation of genotypes for phosphorus acquisition • Insight study on benefit of nano application on seed quality improvement • Seed enhancement techniques **Millets** • Development of newer formulations of microbial inoculants and seed treatment methods • Identification of pre-sowing seed management techniques for small millets • Enhancing the productivity of small millets • Enhancing partitioning efficiency in ragi • Developing organic technologies for cropping systems	TNAU	120	70
		Sub Total	**250**	**150**

S. No	Strategy	Agency	Cost for 12th FYP (Rupees in crore)	Cost for 13th FYP (Rupees in crore)
Strategy 2: Climate profiling research mainly on agronomic practice and popularizing the same with extension strategies to mitigate extreme weather events				
2.1	• Land management for better crop establishment • Suitable tillage and irrigation practices and change in cropping pattern of different duration crops to counter climate change • Standardizing water harvesting techniques • Integrated nutrient management - Nutrient feedback crop cultivation for soil health sustainability **Rice** • Yield maximization techniques of traditional rice • Residue management and nutrient dynamics • Development and evaluation of stage-specific microbial inoculants • Mapping and management of micronutrients in rice grown soils in all districts • Alleviating Iron toxicity problem under acidic soils **Groundnut** • Intercropping and evaluation of organic mulch • Sulphur nutrition of rainfed groundnut in red and black soils of Tamil Nadu • Developing multifunctional bioinoculant (*Burkholderia* sp.) • Standardization of seed invigoration treatment for seed quality enhancement in groundnut, Organic production **Oilseeds and pulses** • Mapping and management of sulphur deficiency in oilseeds grown soils • Altering crop geometry to suit mechanical weeding • Optimization of sulphur for sesame through tracer technique • Seed pelleting for mechanized sowing and its storage potential in sesame • Developing package of practices for pulse–oilseed cropping system	TNAU, DoA	1000	700
2.2	Extension strategies to popularize above management practices to mitigate extreme weather events (ART and MLT)	TNAU	500	300

S. No	Strategy	Agency	Cost for 12th FYP (Rupees in crore)	Cost for 13th FYP (Rupees in crore)
2.3	Research Study on effect of impact for mid-term correction: Economic & social impact created due to different climate change mitigation interventions implemented by DoA/ TNAU to initiate mid-term correction	TNAU	70	70
2.4	Climate proofing with Integrated Farming Systems: Popularising the Integrated Farming System for wider adoption	DOA/ CHPC/AED/ Revenue/ AMAB/ RDLA	1500	1500
		Sub Total	**3070**	**2570**
Strategy 3: Countering sea water incursion				
3.1	Recharging the aquifers using the abandoned open wells and defunct bore wells	AED/ PWD/ COA/ CHPC	120	150
3.2	Constructions of sub-surface dykes	AED/ PWD	300	300
3.3	Diversion of excess flood water at upper reaches to water deficit areas	AED/ PWD	1000	1400
3.4	Deep ploughing to break sub surface hard pan to increase infiltration efficiency and improve ground water quality and check sea water incursion	AED/ COA	200	200
3.5	**Reclamation of saline and Alkaline soils**	AED/COA	100	120
		Sub Total	**1720**	**2170**

S. No	Strategy	Agency	Cost for 12th FYP (Rupees in crore)	Cost for 13th FYP (Rupees in crore)
Strategy 4: Soil conservation Strategies				
4.1	Recharging the aquifers using the abandoned open wells and defunct bore wells	AED/ PWD/ COA/ CHPC	120	150
4.2	Promote minimum/no tillage during fallow period, compartmental bunding, contour farming, deep ploughing, mulching for all crops besides conducting awareness programmes and training	AED	200	320
4.3	**Build Organic carbon content of soil with green manuring: Azolla, BGA, Bio- fertilizers, Bio-pesticides, Bio-Agents and compost developed from municipal solid waste**	DOA	400	600
4.4	Bringing fallow land and degraded land back to cultivation	DOA/CHPC/ AED/Revenue AMAB /RDLA	500	400
4.5	Organic Farming including **Horticulture crops**	DOH/ DOA/CHPC/ AED/AMAB	150	200
		Sub Total	**1370**	**1670**
Strategy 5: Water conservation Strategies				
5.1	Research on conjunctive use of Irrigation water	TNAU	40	25
5.2	Increase the use **of Micro Irrigation technology** Viz., drip, Sprinkler, Rain gun, Mobile Sprinkler in dry land, Garden land and Horticultural farming system	CHPC/ DOA/ AED	8000	9000
5.3	Strengthening **existing water harvesting structures and repairing and replacing the shutters in the irrigation tanks and drainage channels**	PWD/AED/ Revenue/ RDLA	1000	1200
5.4	Creation of additional farm ponds to capture the runoff water and utilise the harvested water to critical stages of crop growth and to recharge the aquifers to improve the quality of irrigation water	DOA/ CHPC/ AED/ RDLA	600	360
5.5	Ensuring the lively hood of the farmers in non delta districts having surface irrigation potential with piped irrigation network by providing collection wells at regulating structures to increase the cropping intensity with assured yield and employment opportunities	PWD/AED	3500	4000
		Sub Total	**13140**	**14585**

S. No	Strategy	Agency	Cost for 12th FYP (Rupees in crore)	Cost for 13th FYP (Rupees in crore)
Strategy 6: Weather Mitigation				
6.1	**Development and execution of sustainable seed production and distribution network**	TNAU/ DOA/ CHPC	200	300
6.2	**Establishment of net work of seed banks, food banks and cold storage to ensure supply at times of contingencies**	DOA/ CHPC/ AMAB	750	1000
6.3	**GIS based village mapping for agro management system to enhance input use efficiency and overcome effect of climate change and increase farm productivity including horticulture crops**	**DOH/ TNAU/ COA**	**100**	**125**
6.4	Integrated voice message on weather based agro advisories, market demand &price forecasting	TNAU/ DOA/ AMAB	75	100
6.5	Establishment of dedicated climate knowledge cell to monitor, fore warn and train farmers and officials of the department on management of situation arising out of extreme events	TNAU/DOA/ CHPC	160	160
6.6	Strengthening and popularising the existing crop insurance programme	DOA/CHPC	800	875
6.7	Research project on comprehensive crop insurance products that would cover increasing extreme events	TNAU	200	200
		Sub Total	**2285**	**2760**
Strategy 7: Green cover for coastal calamities				
7.1	**Development of vegetative shield for east coastal region against wind, cyclones,etc.**	TNAU	250	150
7.2	**Management and conservation of vegetative shield**			
		Sub Total	**250**	**150**
Strategy 8: Promotion of inland fishing				
8.1	Development of technology for improving **inland fishing**; new breeds; Popularization of technology.	TNVASUAHF	1000	1500
		Sub Total	**1000**	**1500**

S. No	Strategy	Agency	Cost for 12th FYP (Rupees in crore)	Cost for 13th FYP (Rupees in crore)
Strategy 9: Promoting inland Fisheries for effective utilisation of water bodies				
9.1	Increasing fish production and fish farming area for rural livelihood through Inland Fisheries - FFDA, BFFDA, Reservoir fisheries development, fish culture in pens and cages, establishment of hatcheries	DOF	38.44	53.82
9.2	Undertaking Repair and Renovation of Government Fish Seed Farms/ Hatchery to increase fish seed production for fish farming	DOF	65.00	100.00
9.3	Improving inland fisheries for tank and its command areas under IAMWARM Project	DOF	7.73	-
9.4	Increasing fish production and fish farming area for rural livelihood through Inland Fisheries - FFDA, BFFDA, Reservoir fisheries development, fish culture in pens and cages, establishment of hatcheries	DOF	38.44	53.82
		Sub Total	**149.61**	**207.64**
Strategies 10: Brackish water Aquaculture for utilising saline areas for shrimp/fish production				
10.1	To increase per hectare production and encourage new species advocating Culture of SPF *Littopenaeus vannamei*	DOF	5.00	7.50
10.2	Culture of Sea bass	DOF	1.13	2.00
		Sub Total	**6.13**	**9.50**
Strategy 11: Strategies for animal husbandry and dairy development sector				
11.1	Promote development of Meikkal poromboke lands in villages for growing leguminous fodder	DOAHD	0.50	0.55
11.2	Ensure adequate animal housing and dedicated ponds for bathing in villages to protect livestock from extreme heat	DOAHD	1.60	1.70
11.3	Intensify disease surveillance and develop forecasting of disease outbreaks for short and long term time frames	DOAHD	2.40	2.60
11.4	Promote cross breeding with indigenous varieties to improve resilience to climate change	DOAHD	2.20	2.40
11.5	Promote dairy development by training women in villages on animal care, animal disease reporting, and nutrition for optimising milk production at household level of small and marginal farmers and enabling them to participate in milk cooperatives	DOAHD	4.00	4.00
		Sub Total	**10.70**	**11.25**
		GRAND TOTAL	**23251.44**	**25783.39**

6 WATER RESOURCES

6.1 OVERVIEW, CHARACTERISTICS AND STATUS

Tamil Nadu constitutes 4 percent of India's land area and is inhabited by 6 percent of India's population, but has only 2.5 percent of India's water resources. More than 95 percent of the surface water and 80 percent of the ground water have already been put into use. Major uses of water include human/animal consumption, irrigation and industrial use. The demand for water in Tamil Nadu is increasing at a fast rate both due to increasing population and also due to larger per capita needs triggered by economic growth. The per capita availability of water resources however, is just 900 cubic meters when compared to the national average of 2,200 cubic meters. Agriculture is the largest consumer of water in the State using 75 per cent of the State's water resources. Demands from other sectors such as domestic and industries have been growing significantly.

The State is heavily dependent on monsoon rains. The annual average rainfall is around 930 mm (47 percent during the north east monsoon, 35 percent during the south west monsoon, 14 percent in the summer and 4 percent in the winter). Actual rainfall for the year 2010-11 is 1165.10 mm, out of which 48 percent is through the north east monsoon, 32 percent is through the south west monsoon and the remaining 20 percent is through summer and winter rainfall. Since the State is entirely dependent on rains for recharging its water resources, monsoon failures lead to acute water scarcity and severe droughts.

Surface Water Resources

River basins of Tamil Nadu and Water Potential

There are 17 river basins in Tamil Nadu (Figure 6.1). Cauvery is the only major basin. Of the others, 13 basins are medium and 3 are minor river basins. At 75 percent dependability, the annual surface water generated in the State is 692.78 TMC (19,619 MCM). Table 6.1 detailing the surface water potential in the different districts of Tamil Nadu. The State depends on neighbouring States for considerable quantum of flows, which is about 261.70 TMC (7411 MCM) annually.Table 6.2 indicates the water received from the States of Andhra Pradesh, Karnataka, Kerala and Maharashtra. Thus, the total surface water potential of the State at 75 percent dependability is 954.58 TMC (27,030 MCM).

Table 6.1: Basin wise surface water potential at 75 percent dependability

S.No.	Basin / Basin Group	Surface Water Potential at 75 percent dependability		S.No.	Basin / Basin Group	Surface Water Potential at 75 percent dependability	
		in MCM	in TMC			in MCM	in TMC
1	Chennai	1645	58.09	8	Agniyar	1136	40.12
2	Palar	1264	44.64	9	Pambar & Kottakaraiyar	648	22.88
3	Varahanadhi	429	15.15	10	Vaigai	1372	48.42

S.No.	Basin / Basin Group	Surface Water Potential at 75 percent dependability		S.No.	Basin / Basin Group	Surface Water Potential at 75 percent dependability	
		in MCM	in TMC			in MCM	in TMC
4	Pennaiyar	1396	49.30	11	Gundar	549	19.39
5	Paravanar	379	13.38	12	Vaippar	715	25.25
6	Vellar	985	34.79	13	Kallar	128	4.52
7	Cauvery	5805	205.00	14	Tamiraparani	1374	48.49
15	Nambiyar	203	7.17	16	Kodaiyar	916	32.35
17	PAP	675	23.84		**Total**	**19619**	**692.78**

Sources:
S.No. 1,3 to 6 & 8 to 16:Micro level study reports prepared by IWS, WRD, 2010
S.No. 2: Joint Hydrological Study of Palar Basin, CWC Report, Nov 2010
S. No. 7: Cauvery, as per the Report of the Cauvery Fact Finding Committee,1971
S. No.17 : as per the inter State PAP agreement, Tamil Nadu has to get 30.5 TMC. But as per the Actual flows realized since inception of the Project it is only 23.84 TMC, at 75 percent dependability.

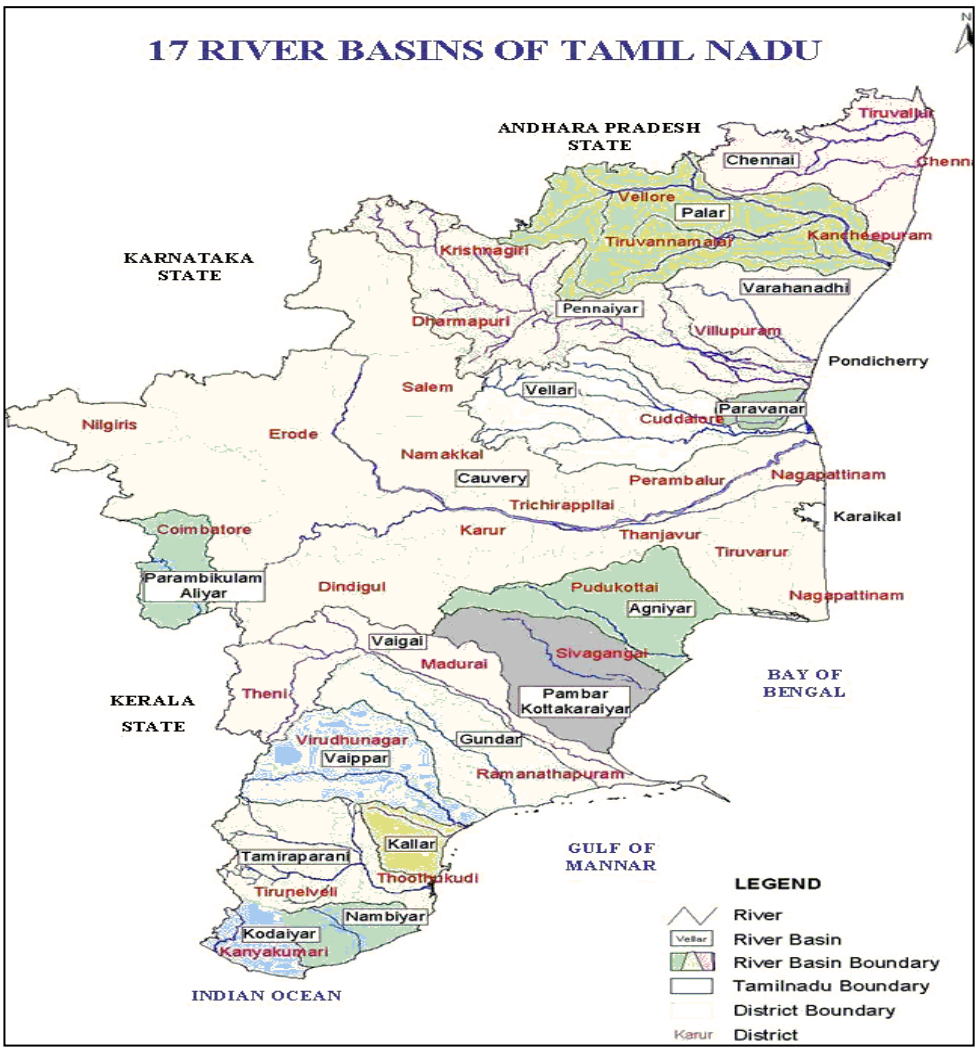


Figure 6.1: River Basins of Tamil Nadu

Table 6.2: Surface water contribution expected from neighbouring states

Sl. No	State	River	In MCM	In TMC
1	Andhra Pradesh	Araniar	28.32	1.0
		Kosathalayar	14.16	0.5
		Krishna (Total contribution – 12.0 TMC)	113.28	4.0
		Palar	62.30	2.2
		Sub total	**218.06**	**7.7**
2	Karnataka	Pennaiyar	169.90	6.0
		Krishna (Total contribution – 12.0 TMC)	113.28	4.0
		Cauvery @ Billigundulu or at any other common border	5436.86	192.0
		Sub total	**5720.04**	**202.0**
3	Kerala	Periyar	622.96	22.0
		Shenbagavalli	56.63	2.0
		Bhavani	764.55	27.0
		Amaravathy	141.58	5.0
		Neyyar	84.95	3.0
		Sub total	**1670.67**	**59.0**
4	Maharashtra	Krishna (Total contribution – 12.0 TMC)	113.28	4.0
Total			**7722.05**	**272.7**

Note*:*

- From Krishna, out of 12 TMC, about 6 TMC only received except in one year. Also from Shenbagavalli and Neyyar, the contribution is nil. After deductions, the contribution is only (272.7-6-2-3) = 261.7 TMC (7411 MCM).
- Under the contribution from the State of Kerala, the waters utilized under the PAP complex has not been included, for the reason that 66 percent of the catchment area, up to the tapping points, i.e., up to PAP reservoirs, lies in the State of Tamil Nadu, which is 28.0 TMC as per the PAP Inter State agreement.

Sources:

Araniyar: Average inflow based on the observed data at the A.P–T.N Border.

Kosasthalayar: Average inflow based on the observed data at the Andhra Pradesh –Tamil Nadu Border.

Krishna: As per the Inter State Agreement, 1986.

Palar: Average inflow as per the data observed by CWC at its gauging site at Avaramkuppam.

Pennaiyar: Average inflow based on the inflows observed at Kodiyalam Anicut, which is nearer to the Karnataka – Tamil Nadu border.

Cauvery: As per the Final order of the CWDT, dated 5.2.2007

Periyar: Average inflow based on the long time data on diversion of flows to vaigai basin.

Shenbagavalli: Based on the assessment of flows diverted in the past.

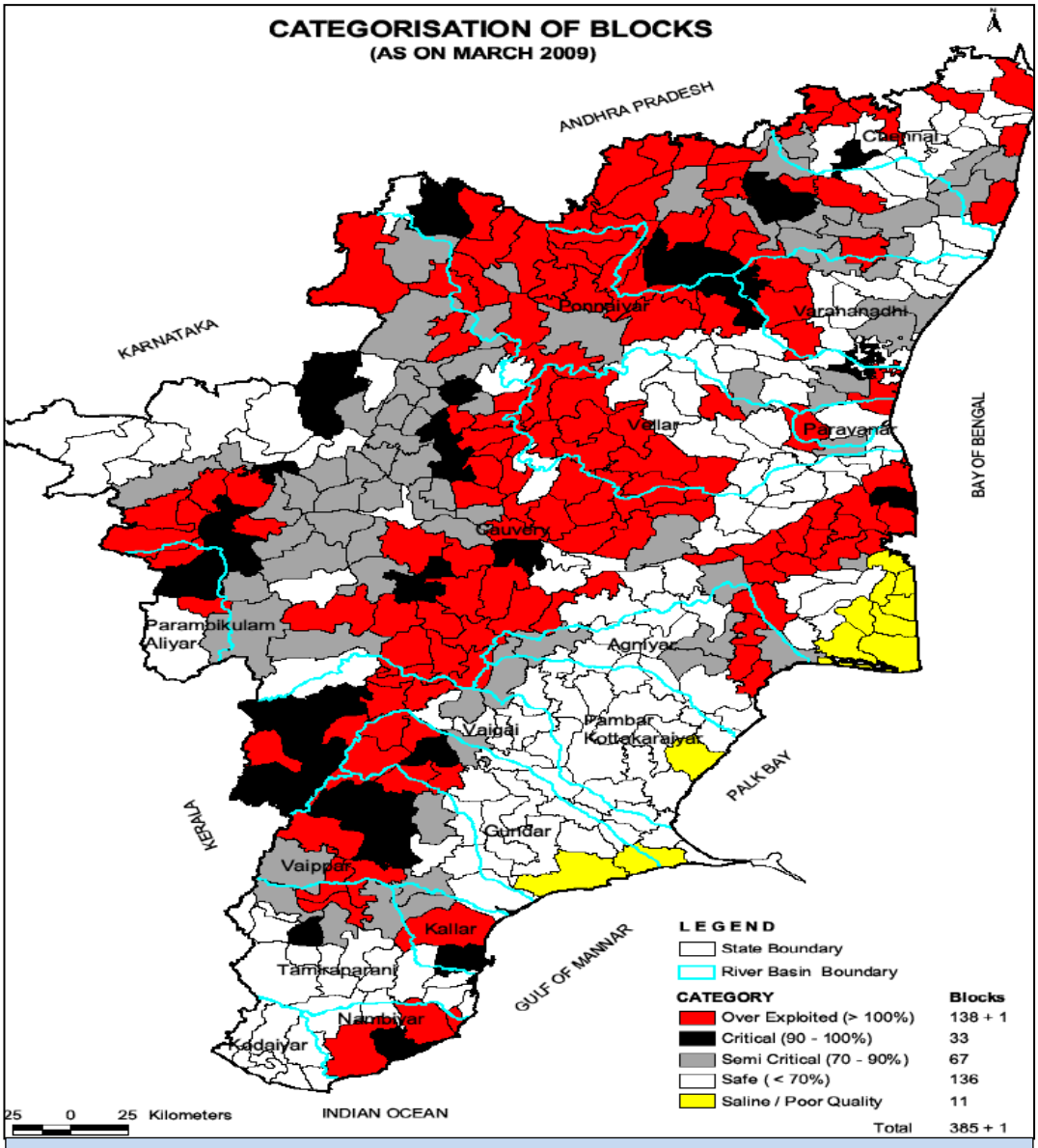
Bhavani & Amaravathy: Based on the final order of the Cauvery Water Dispute Tribunal,

Neyyar: As per the project Report of Neyyar Irrigation Project, Phase II.

Ground water

The annual ground water potential of the State is 22,943 MCM and the net annual ground water availability is 20,649 MCM, as assessed during 2009. Out of this, up to 80 percent is being used. However this utilization is not uniform. As per the recent classification, out of 385+1 blocks, 138+1 (Chennai district) are over exploited, 33 are critical, 67 are semi-critical and in 11 blocks the quality is bad. Only 136 blocks are classified as safe (Figure 6.2).Further Keelaiyur, Kilvelur, Nagapattinam, Thalainaiyar, Thirumarugal and Vedaranyam blocks in Nagapattinam district, Thiruthuraipoondi and Muthupet blocks in Thiruvarur district are classified as saline blocks. Kadaladi, Thiruvadanai and Thirubhuvanam blocks in Ramanathapuram district are classified as poor quality blocks.

Figure 6.2: Block wise categorisation of Ground water



Source: Ground water Board, GoTN

Storage Structures

Prior to independence only three reservoirs, viz., Periyar, Pechiparai and Mettur reservoir were constructed. Presently, there are about 85 reservoirs- major, medium and small put together with a total storage capacity of about 6,500 MCM. There are about 39000 tanks and their total capacity is assessed as 6000 MCM. The total capacity of storage created is about 12,500 MCM. The existing status of the storage structures created cannot be said as good or normal due to the various developments over the years. Water Resource Department is making efforts to revive them through various modernization programmes.

Per capita storage capacity in Tamil Nadu is just 175 cum where as all India average is 262 cum. This shows that we have to augment the storage capacity of the existing structures and create additional storage to manage the growing demand and also given the uncertainty in monsoon and surface water availability due to climate change. The research reports on climate change State that even though there is no apparent trend in the annual rainfall, there may be changes in the intensity of seasonal rainfall, and reduction in number of rainy days resulting in flash floods and consequent effects of it. In future, to capture and store such sudden large run-off lasting for a shorter duration, more storage structures need to be constructed.

6.2 INSTITUTIONS INVOLVED IN WATER SECTOR SERVICE DELIVERY IN TAMIL NADU

Water Resources Department (WRD)

The Water Resources Department is responsible for planning, evolving, executing and maintaining the irrigation facilities and infrastructure of the State. Sustainable development of the available water resources in a judicious and equitable manner is scientifically ensured by this department. Regulation of water from dams, flood control and mitigation, coastal protection, ground water recharge, rainwater harvesting and inter-linking of rivers to divert surplus flood flows to drought prone areas are the main activities of this department.

Water Resources Department is executing and maintaining all Irrigation Projects such as dams, canals, tanks, water harvesting structures, implementation and maintenance of water supply in rural areas. The ground water wing of this department is maintaining all weather stations owned by the department and is monitoring the ground water level and quality of water in the State. This Department owns 85 dams and reservoirs. These dams and reservoirs have got their own system canals and tanks. This State has got about 39,000 tanks out of which 13,699 tanks are owned by Water Resources Department. Out of 13,699 tanks, about 7,198 tanks are system tanks. The rest 6,501 tanks are rain fed tanks. The total length of main channels in the State is about 9700 km. These assets are the source for irrigating a total extent of about 69,00,000 acres.

TWAD (Tamil Nadu Water Supply and Drainage Board)

The Tamil Nadu Water Supply and Drainage Board (TWAD Board) was formed during 1971 as an autonomous organization for providing water supply and drainage

facilities to Rural and Urban areas of Tamil Nadu excluding the Chennai Metropolitan Area. The functions of the TWAD Board are as follows:

- Planning investigation, Design, Implementation and commissioning of water supply and sewerage schemes in rural and urban areas.
- Operation and maintenance of combined water supply schemes.
- Water quality monitoring and surveillance programme.
- Activities on sustainability of drinking water sources.

Chennai Metropolitan Water Supply and Sewerage Board

In 1978, the Chennai Metropolitan Water Supply and Sewerage Board (CMWSSB) was formed to take on the responsibility of augmenting water supply in the city. The main functions of the Board are:

- Promoting and securing the planned development of water supply and sewerage services;
- Efficient operation, maintenance and regulation of the water supply and sewerage systems in Chennai Metropolitan Area;
- Preparing immediate and long-term measures to meet future demands for water supply and sewerage services in the Chennai Metropolitan Area. At present the Board serves a population of about 7 million most of who live in the Chennai city area. To carry out all these functions, the 1978 Act gives power to the Board.
- To take over all existing responsibilities, powers, controls, facilities, services and administration relating to water supply and sewage in or for the Chennai Metropolitan Area;
- To prepare schemes for water supply and sewerage (including abstraction of water from any natural source and disposal of waste and polluted water) in or for the Chennai Metropolitan Area
- To control extraction, conservation and use of ground water in Chennai Metropolitan Area
- To prevent pollution of any water including any water sources, water course or channel utilized for the purpose of Chennai Metropolitan Area and few more.

Rural Development and Panchayat Raj Department

The Department of Rural Development and Panchayat Raj is responsible for the implementation of various rural welfare schemes and also assists Panchayat Raj Institutions to discharge their duties and functions as effective Local Self Government entities. This Government is committed to provide all the basic amenities in the rural areas at the level of habitation, promote sanitation, reduce poverty, conserve the natural resources and reduce the urban-rural divide and ensure a prosperous rural Tamil Nadu. Minor Irrigation tanks in the State are being maintained by this department.

Tamil Nadu Pollution Control Board (TNPCB)

The objective of TNPCB is to control, prevent and abate pollution of streams, wells, land and atmosphere in the State and to protect the environment from any degradation by effective monitoring and implementation of pollution control

legislations. TNPCB has delegated the power to the field officers for close monitoring. The Joint Chief Environmental Engineer/ District Environmental Engineers/ Assistant Environmental Engineers are empowered to issue/renew consent to orange and green category industries and to renew for red small category industries. They are also empowered to issue show cause notices to all the industries. TNPCB is taking effective steps for safe disposal of hazardous wastes. TNPCB creates environmental awareness in the State through the Environmental Training Institute, Environmental Awareness Cell, Environmental Awareness Programme, Environmental Pavilion constructed at the Periyar Science and Technology Centre (Chennai), NGO Cell, Publishing of Newsletters/Pamphlets on environmental issues, etc.

Educational Institutions

The Educational Institutions such as Indian Institute of Technology Madras, Chennai, Anna University, Chennai and Tamil Nadu Agricultural University, Coimbatore are involved in various research Activities in Hydrology and Water Resources Management in the river basins of Tamil Nadu. They are also being referred to, then and there for finding solution to specific issues.

6.3 EXISTING WATER RELATED CONCERNS IN TAMIL NADU

Demand- Supply Gap

The total water potential of the State including cross border contribution from Andhra Pradesh, Karnataka and Kerala is 1775.60 TMC (47,680 MCM). This also includes ground water potential of about 20,649 MCM. The sectoral demand for water in 2011 was 49,773 MCM, which is about 2000 MCM more than the potential availability. The demand is projected to increase to 48,766 MCM and 55,919 MCM in 2020 and 2045 respectively (Table 6.3).The gap between supply and demand by 2020 is expected to be 5,211 MCM (11 percent) and it is likely to go up to 17 percent by 2050, if there is no intervention. Therefore all possible measures have to be taken to reduce the gap.

Table 6.3: Total sectoral demand (MCM)

Sl. No	Sector / Year	2011	2020	2045
1	Domestic	2248	2608	3908
2	Irrigation	38032	38032	38302
3	Livestock	965	965	965
4	Industrial & Power	3884	5318	10774
5	Eco & Env Recreation & Minimum flow needs	519	1843	1970
	Sub Total	**45,648**	**48,766**	**55,919**
6	Add for existing 45 percent overall irrigation efficiency instead of 60 percent adopted in calculating irrigation for Cauvery basin	4125	4125	-
	Grand Total	**49,773**	**52,891**	**55,919**

Over-exploitation of Ground Water

As per the available data, up to 80 percent of the total ground water available is being used. This has led to the decline in ground water table in most of the blocks. According to the estimates for 2009, out of 385+1 blocks, 138+1 (Chennai District) are over exploited, 33 are critical, 67 are semi-critical and in 11 blocks the quality is bad.

Table 6.4: Over-exploitation of groundwater in Tamil Nadu

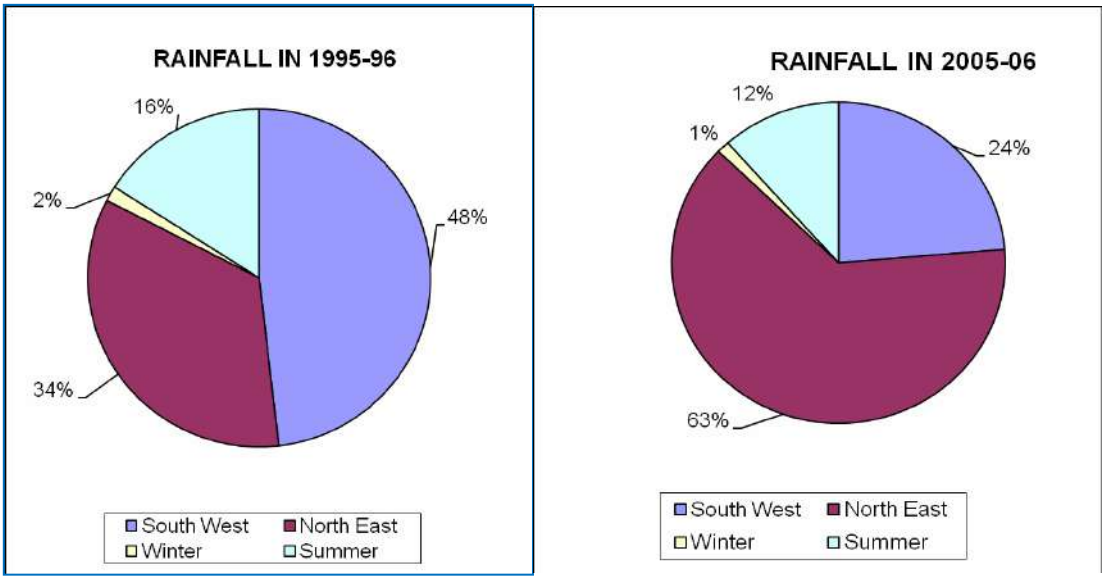
S. No	Year of Assessment	Total Number of Blocks	Categorization of Blocks		
			Dark	Grey	White
1	January1980	377	80 (21 percent)	113 (30 percent)	184 (49 percent)
2	January1992	384	89 (23 percent)	86 (22 percent)	209 (55 percent)
3	January1997	384	97 (25 percent)	88 (23 percent)	199 (52 percent)
4	January2009	385+1	183 (48 percent)	67 (17 percent)	136 (35 percent)

Source: State Ground & Surface Water Resources Data Centre, Chennai

Decreasing southwest monsoon and increasing northeast monsoon

The north east monsoon rainfall has increased from 34 percent to 63 percent and the south west rainfall has decreased from 48 percent to 24 percent, in a span of 10 years between 1995-96 to 2005-2006 respectively. (Figure 6.3)

Figure 6.3: Shifting rainfall pattern



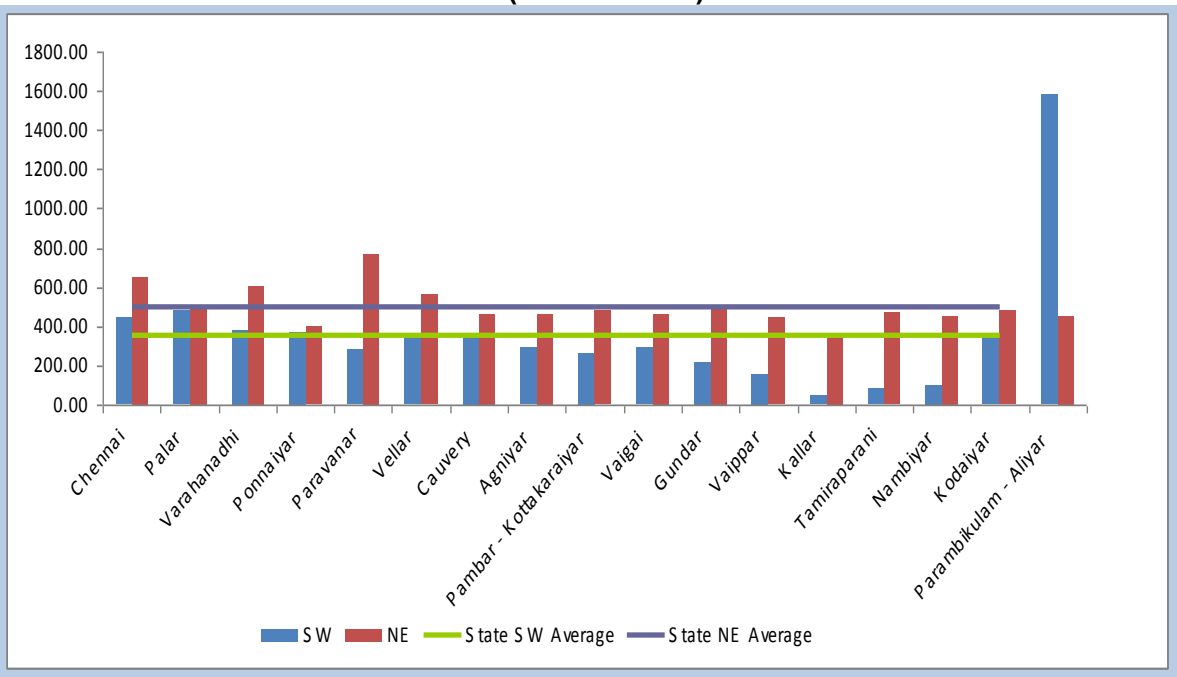
Source: Indian Meteorology Department

Table 6.5: Basin wise north east monsoon trends

Sl No	Basin	Annual Average Rainfall (RF)	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	Average NE RF (2000-2011)
1	Chennai	1355.3	381.4	833	630.3	320.5	491.9	1476	751	678	823.5	789.9	639.5	768.9	715
2	Palar	1255.8	460.4	606.4	412.5	381.4	475.5	1207.4	560.4	726	580.8	541.7	676.8	576.6	600
3	Varaganadhi	1084.7	449.1	477.3	337.8	245.2	503.9	928.9	560.6	565.3	754	708.5	816.9	624.6	581
4	Pennaiyar	1227.2	469.4	399.4	396	427.1	558.9	847.1	488.4	637.9	708.2	565.3	631.8	560.9	558
5	Paravanar		735	512	545	688	786	1052	907	895	1258	1117	1097.5	923	876
6	Vellar	1420.3	797.3	584.7	610.4	858.3	873.8	1279.4	1258.9	970.8	1219.3	986.4	839.8	878.8	930
7	Cauvery	1108.4	346.1	375.9	343.8	360	406.3	708.3	446.7	495.8	505.7	454.6	604.6	495.5	462
8	Agniyar	1083.3	538.1	421.4	430.6	444	609.6	861.6	429.2	517.9	748	663.9	671.1	649.7	582
9	Pambar - Kottakaraiar	928.6	432.8	409.6	554.6	300.1	568	894.7	487.1	500.4	627.8	721.2	859.9	725	590
10	Vaigai	1029.5	240.4	338.8	446.1	328	413.8	636.3	439.9	487.4	445.1	403.1	532.2	574.7	440
11	Gundar	805.9	266.2	338.6	437.6	304.9	430.6	617	525	499.5	509.7	395.6	599.1	510	453
12	Vaippar	808.4	288.8	450.9	364.4	308.7	425.4	540.3	644.6	459.4	550.8	343.1	587.4	485.4	454
13	Kallar		331.2	173.1	270	239	471.2	376.4	686.5	414.5	582.6	494.8	555.6	518.7	426
14	Tamiraparani	995.0	341.1	404.6	452.8	448.1	512.7	468.2	760.4	433.4	531.6	607.7	555.6	624.9	512
15	Nambiyar	751.2	328.8	311.8	372.2	403.8	546.6	408.3	465.5	391	484.6	427.2	434.7	537.1	426
16	Kodaiyar	1516.1	314.3	450.9	642.7	440.2	362.2	615.3	601.1	484.6	620.2	491.4	1019.7	557.8	550
17	Parambikulam - Aliyar	2699.7	245.7	372.4	398.6	514.8	426.8	547	421.7	435.6	362.1	502.7	652.4	674.5	463
State Average(NE)			**409.8**	**438.9**	**449.7**	**412.5**	**521.4**	**792**	**613.8**	**564.3**	**665.4**	**600.8**	**692.6**	**628.6**	
State Average(Annual)			**1131.2**	**1081.4**	**988.4**	**949.2**	**1251**	**1525**	**1204.4**	**1224.2**	**1413.4**	**1107.2**	**1354.7**	**1225.3**	
percent of NE RF to State Average Annual RF			**36**	**41**	**45**	**43**	**42**	**52**	**51**	**46**	**47**	**54**	**51**	**51**	
Source : State Ground & Surface Water Resources Data Centre, Chennai															

Table 6.5 shows trends of north east monsoon rainfall for all 17 basins in. All the basins show an increase in rain fall between 2001 and 2011.

Figure 6.4: Basin wise average south west and north east monsoon (1976 – 2011)



For Tamil Nadu, north east monsoon season is the main rainy season accounting for about 47 percent of the annual rainfall. Coastal districts of the State get nearly 60 percent of the annual rainfall and the interior districts get about 40-50 percent of the annual rainfall. It is seen that the percentage of north east monsoon rainfall to the State average rainfall, has increased from 36 percent during the year 2000 to 51 percent during the year 2011. Hence, it is essential to harness the north east monsoon rainfall for effective water management and future development. From the bar chart, it could be inferred that the River basins such as Chennai, Varahanadhi, Paravanar and Vellar which are in the northern part of the State, receive more north east monsoon rainfall when compared to the State's average north east monsoon rainfall. Also, similar trend could be seen in the case of south west monsoon rainfall pattern (Figure 6.4). Hence, suitable measures are to be taken to divert water from surplus to deficit basins by adopting suitable strategies like inter basin transfer, pumping schemes etc. Moreover, it is imperative to combat the resulting flooding and drainage problems that would be associated with fewer days of heavy precipitation.

Floods

Tamil Nadu generally receives copious rains during the Northeast monsoon. The heavy downpour in a short duration results in severe flood causing great risk of damage to life and property of the people and to the States assets like irrigation infra structure, roads, etc. Every year coastal districts such as Cuddalore, Nagapattinam, Thanjavur and Thiruvarur are the most vulnerable to floods. Urban flooding is another significant problem in Tamil Nadu. The capital city of Chennai and its suburban areas are worst affected by flood because of improper drainage and encroachment of water bodies and waterways. In the last three decades, Chennai

metropolitan area has experienced heavy floods during the years 1976, 1985, 1996, 1998, 2005, 2007 and 2008.The 2005 flooding was caused by torrential rain over four weeks in October and early November which was compounded by more monsoon storms that hit the region in late November.

Cyclones

Floods are also caused by severe cyclonic storms. Often, the area of low pressure formed as depression zone and subsequently developed as cyclone resulted in heavy rain. In Tamil Nadu, severe cyclonic storm occurred during north east monsoon period. In the last decade the cyclones such as “Nisha (2008)”, “Jal” (2010) and “Thane” (2011) caused heavy damages to the lives and properties of the people. Normally these cyclonic storms leads to heavy rains e.g. Orathanadu, Thanjavur district recorded 660 mm of rainfall within a period of 24 hours during cyclone Nisha (2008). It is important to have provisions to channelize and store this water to be used in the lean period.

Migration

Due to erratic rainfall and inflation of agricultural inputs many agricultural lands were kept fallow or converted for other uses and agricultural labourers migrated to urban areas in search of jobs to sustain their life. The stream of people moving to large urban centres with hope of better fortune increases each year and this trend has led to large number of people, especially the poor, settling and living in floodplains in and around urban areas. These areas lie outside the formal city limits (peri-urban areas) so they are unplanned and unregulated. They are ignored in urban planning systems so they continually lack adequate drainage systems, water supply and sanitation facilities. This causes stress to water sources and increases the pollution. The capital city Chennai and other city corporations in the State are experiencing such stress. The competition between rural and urban demands for scarce water resources sometimes exacerbates the water shortage. To manage the urban water demand, it needs to transfer the ground water from peri-urban and rural areas and thus the water table level decline affecting sustainability of the source. For example, Chennai in Tamil Nadu, India, is one such example (Box. 6.1)

Box 6.1 Case study of water market: Affecting sustainability of per-urban sources.

Chennai is a fast growing city in Tamil Nadu with almost 4.6 million people in 2011. The ever increasing urbanization since 2000 in Chennai has lead to decline in agriculture in South Chennai and also has increased the water demand in the city thereby leading extraction and marketing of ground water from agricultural wells in peri-urban villages. It is estimated that the deficit in supplying of water to Chennai city varies between 897-1043 MLD during the period of 2005-2008. In order to fill the demand supply gap, the private tankers move from peri-urban to urban city, transporting the ground water from the agricultural wells of the southern peri-urban areas, with a capacity of 12,000 litre to 24,000 litre. It is estimated that a quantity of about 17.1 MLD of water is being transported from the southern peri-urban villages alone. Apart from this, there are packaged water companies in and around the villages, which are extracting a huge amount of ground water. A semi-structured interview with selected owners of the packaged water industries reveal that approximately 4000-4500 water cans of the capacity of 20 litre are transported to customers everyday from the existing packaged water companies accounting to about 19.2 MLD of ground water extraction in the southern peri-urban villages of Chennai. Hence this water marketing is major negative face of the urbanization affecting the water and food security of rural areas.

Source : Centre for water Resources, Anna University, Chennai

Droughts

Tamil Nadu, a coastal State in south India, is also prone to droughts. The climate of the State ranges from dry sub humid to semiarid. An assessment of droughts in Tamil Nadu from 1977 to 1991 reveals recurrent drinking water shortages in major parts of the State and the Chennai city in particular. The worst drought years in the past 32 years were identified as 1980, 1982, 1983, 1987, 1989, 2002, 2003, 2004, 2006 and 2009. The drought of 1980 destroyed the groundnut crop in over 1,00,000 hectares in the districts of Chengalpattu and Vellore.

According to a study of rain pattern in peninsular India by the Indian Council of Agricultural Research (ICAR), the frequency of deficit rainfall and resultant drought is once in every 2.5 years in Rayalaseema and Telangana, three years in entire Tamil Nadu, four years in Vidarbha and north interior Karnataka, and once in five years in coastal Andhra Pradesh, south interior Karnataka and central part of Maharashtra.

Low Water Use Efficiency

The overall efficiency in surface irrigation like canals and tanks is only 40 percent (when compared to 75 percent in Israel) whereas in well irrigation it is 70 percent. Researchers opine that this level of overall efficiency can be increased to 50 to 60 percent in surface irrigation and to 85 percent in well irrigation. If the overall efficiency were increased in phases from 40 percent to 50 percent and 60 percent, this would annually save about 3,000 MCM for every 10 percent increase in efficiency.

6.4 CURRENT POLICIES, PROGRAMMES AND PROJECTS

Policies and legislations related to water

Policies and legislations related to the conservation, development and management of water resources have been evolved at both State and National level.

The Tamil Nadu Additional Assessment and Additional Water Cess Act 1963:

This Act provides for the collection of levy of land and water-cess on different lands with respect to source of irrigation and type of crop in Tamil Nadu. The Revenue Department was authorized to assess and collect the levy and water cess. Later, the Act was amended four times mainly with changes in tariff.

The Water (Prevention and Control of Pollution) Act, 1974:

The Water Act was enacted by Parliament Act, 1974 with a purpose for prevention of control of water pollution and the maintaining or restoring of wholesomeness of water. Till date, it is applicable in all the States of India. The CPCB and SPCB were formulated under Section 4 of this Act. The Act deals with a particular type of pollution and presents an integrated approach to tackle the

problem. It is an important legislative measure that has been enacted to implement the decision taken in the United Nation's Conference on Human Environment held in June 1972 at Stockholm.

The Water (Prevention and Control of Pollution) Cess Act, 1977:

This Act provides for the levy and collection of a cess on water consumed by persons for their industries and by local authorities, with a view to augment the resources of the Central Board and the State Boards, for the prevention and control of water pollution constituted under the Water (Prevention and Control of Pollution) Act, 1974.

The Environment (Protection) Act 1986:

This Act provides for the Protection and Improvement of Environment and it deals with all other environmental issues. This Act empowers the Government of India to take all measures that are necessary to protect and improve the quality of environment and to prevent, control and abate environmental pollution. This Act includes laying down standards for the quality of environment and for discharge of environmental pollutants from various sources.

Chennai Metropolitan Area Ground Water (Regulation) Act, 1987:

The aim of this Act was to facilitate the functioning of the Water Board and to regulate and control the extraction, use or transport of ground water and to conserve ground water in Chennai Metropolitan Area and in the surrounding notified areas. The Act envisages control, regulation, abstractions and transportation of ground water in the notified area through (i) Registration of existing wells, (ii) Regulation of sinking of new wells (iii) Issue of licenses to extract water for non domestic uses and (iv) Issue of license for transportation through goods vehicles. The Act exempts from its purview, wells used for agricultural and domestic purposes. The Competent Authority for the purpose of the Act. In the city of Chennai, the Metro Water Board and pertaining to the villages specified in the schedule, the respective Sub-Collectors / Revenue Divisional Officers of the Taluks in which the villages fall.

State Water Policy, 1994:

Taking into account the National Water Policy 2002, the State Water Policy 1994 was redrafted emphasising the need for utmost efficiency in water utilisation and public awareness of the importance of water conservation. This water policy applies to all the water resources in the State.

The Tamil Nadu Panchayat Act, 1994:

This Act vested powers with the Village Panchayats for sinking wells and let them for open use and enjoyment of all individuals, irrespective of their caste or creed under section 110(g). Under Section 236 of this Act the repair and maintenance of these wells need to be done by the Village Panchayats. This also deals with the artificial recharge of ground water through the rainwater harvesting schemes under Section 257 making it mandatory in every building and if this is not executed, the water supply connection provided to those buildings will be disconnected till rainwater-harvesting structures are provided after the Second amendment in 2003.

The Tamil Nadu Farmers Management of Irrigation Systems Act, 2000:

This Act provides for Farmer's participation in the Management of Irrigation Systems. The Act facilitates optimal water utilization by farmers for improved agricultural production through formation of Water Users Association. This Act details the procedure for formation of Water Users Association and the election of office bearers because it is considered that the scientific and systematic development and maintenance of irrigation infrastructure is best possible through Water Users Association.

National Water Policy, 2002:

The National Water Policy 2002 lays emphasis on integrated water resources development and management for optimal and sustainable utilization of the available surface and ground water. The involvement of beneficiaries and stakeholders in project Planning and participatory approach in water resources management has been focused in the policy. At present, the Draft National Water Policy 2012 has been and adopted by the National Water Resources Council on August 9, 2012 and is under deliberation by the National Water Board. In this draft, the title, “Adaptation to Climate Change” has been included with the following points:

- Importance should be given towards mitigation at micro level by enhancing the capabilities of community to adopt climate resilient technological options.
- The adaptation strategies include increasing water storage in its various forms, such as soil moisture, ponds, ground water, small and large reservoirs, and their combination, which provides a mechanism for dealing with increased variability because of climate change.
- Stakeholder participation in land-soil-water management with scientific inputs from local research and academic institutions for evolving different agricultural strategies, reducing soil erosion and improving soil fertility should be promoted.
- In view of the likely impact of climate change, there is a need to adopt compatible agricultural strategies, and cropping patterns. This may be achieved by involving the water users, sensitizing them appropriately and enhancing their capacities.

- Planning and management of water resources structures, such as, dams, flood embankments, tidal embankments, etc., should incorporate coping strategies for possible climate changes.

Tamil Nadu State Groundwater Development and Management Act, 2003:

The Government of Tamil Nadu has formulated and passed the Tamil Nadu Ground water (Development and Management) Act 2003 to protect ground water resources and to safeguard against hazards of it's over exploitation and to ensure its planned development and proper management in the State. The 2003 Act gives direct establishment of "The Tamil Nadu Ground Water Authority". This Authority has the power to direct and regulate the development and management of ground water resources in Tamil Nadu with the aim of ensuring its optimal and efficient utilisation.

The National Environment Policy, 2006:

The National Environment Policy, 2006 formulated by the Ministry of Environment and Forests, deals with direct causes of groundwater depletion, pollution and the efficient means for utilizing and conserving the groundwater.

The Tamil Nadu Protection of Tanks and Eviction of Encroachment Act, 2007:

This Act facilitates the checking, protection and eviction of encroachment in the tanks that are under the control and management of the Water Resources Department.

On-going Programmes and Projects

National Action Plan on Climate Change for Cauvery delta:

Under Asian Development Bank assistance, the National Action Plan on Climate Change programme will be implemented at a cost of Rs.1560 crore in the Cauvery delta area and this is an eight-year Programme (2012-2020). The Major components of this Programme are (i) Integrated flood and salinity management, (ii) Sustainable agriculture system, (iii) Shore line protection and management and (iv) Institutional development, training and awareness. This plan is designed to meet the key objectives of development needs, sustainability and adaptation to climate change. The Cauvery delta with an area of 5,60,000 ha is irrigated and drained by the following four main canal systems-Lower Coleroon Anicut (49,000 ha); Cauvery (2,00,000 ha); Vennar (1,90,000 ha); Grand Anicut (1,21,000 ha). The proposed program under the National Action Plan for Climate Change will modernize the surface water, ground water and coastal drainage system in the Cauvery delta.

Tamil Nadu Irrigated Agriculture Modernisation and Water Bodies Restoration and Management Project (TN IAMWARM):

The TN IAMWARM Project is being implemented with the assistance of the World Bank at an outlay of 2547 crore since 2007 to benefit 6.69 lakh ha for a period of 6 years. The Water Resources Department and seven other line departments of the Government are the implementing departments of the project. 4922 tanks, 669 anicuts and 8071 km length of supply channels are proposed for rehabilitation under the TN IAMWARM Project. The TN IAMWARN Project aims to improve the service delivery of the irrigation system and to increase the productivity of irrigated agriculture with effective integrated water resources management in a sub basin framework.

Master plan for artificial recharge:

A Master plan for artificial recharge scheme at an estimated cost of Rs.550 crore is being implemented by the Water Resources Department, TWAD Board, Agricultural Engineering Department and Forest Department. Under this scheme, construction of Check dam, percolation ponds and recharge shaft are being implemented.

Coastal Protection Works:

The 13th Finance Commission constituted by the Government of India has recommended a grant of Rs.200 crore for Coastal Protection Works over a period of 4 years from 2011-12 under the State specific needs grant to protect the coastline from sea erosion. On priority basis, vulnerable reaches have been identified and the State Government have accorded administrative sanction for 50 coastal protection works in 7 coastal districts, at an estimate of Rs. 199.93 crore and the works are in progress.

Restoration:

Restoration of the 674 traditional water bodies over a period of 4 years from 2011 -2012 have been taken and the works are under progress.

Flood Management Programme in Tamil Nadu:

The Government of Tamil Nadu has taken measures to tackle the recurrent heavy floods experienced during the Northeast monsoons. Under the National Perspective plan, the Flood Management Programme with a Centre - State share of 75:25, is under implementation in Tamil Nadu. The Schemes involved are flood protection works to the Araniar, Kosasthalaiyar, Vellar, Pennaiyar, Gadilam, Malattar, Uppanar, Paravanar and Kollidam rivers to safeguard Thiruvallur, Villupuram, Cuddalore, Thanjavur and Nagapattinam districts for a total value on Rs.635.54 crore. The above work is being executed by State Water Resources Department since 2010 and is under progress.

Dam Rehabilitation and Improvement Project (DRIP):

In order to ensure the strength and improve the safety and operational performance of the existing dams in a sustainable manner, the dam rehabilitation and improvement project with the World Bank assistance is proposed to be taken up over a period of 6 years from 2012-2013 in 4 phases. The project aims to restore the capacity of the dams, achieve effective utilization of stored water and manage the long-term performance of the dams.Three organizations, viz Water Resources Department, Tamil Nadu Generation and Distribution Corporation Limited / Tamil Nadu Electricity Board and Agricultural Engineering Department are participating in this project. The project covers 66 WRD Dams and 38 TANGEDCO dams at a cost of Rs. 745.49 crore.

Linking of Rivers within the State:

The following two Interlinking works in the State are under implementation to primarily serve as flood carriers and to divert the flood flows to reach the drought prone areas.

- Interlinking of Cauvery, Manimuthar, Vaigai and Gundar Rivers.
- Formation of a flood carrier canal from the Kannadian Channel to drought prone areas of Sathankulam and Thisaiyanvilai by interlinking Tamiraparani, Karumeniyar and Nambiyar rivers in Tirunelveli and Thoothukudi districts.

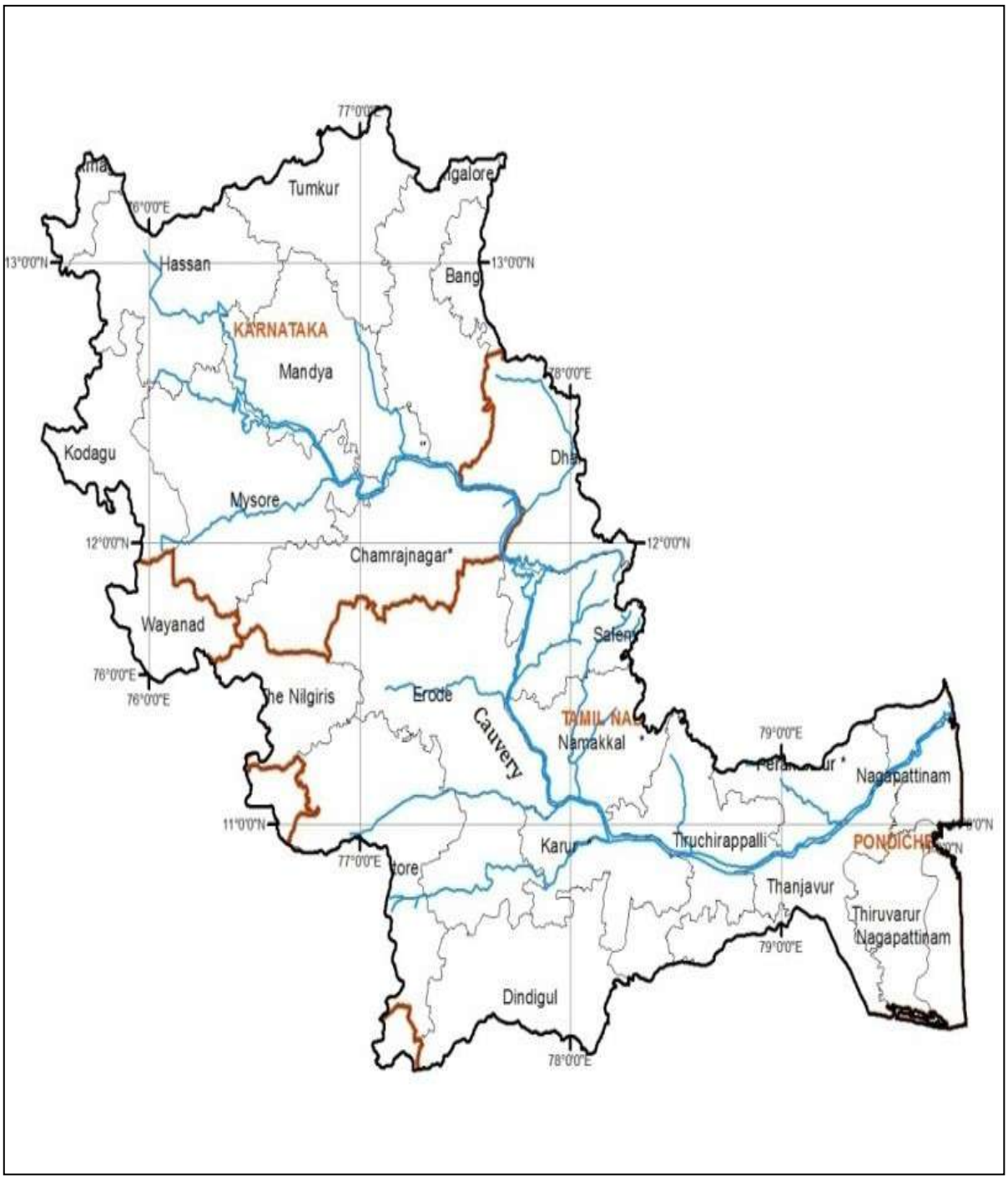
6.5 LIKELY IMPLICATIONS OF CLIMATE CHANGE ON WATER RESOURCES

Evaluating the potential impacts of climate change on water resources (precipitation) requires the application of hydrological simulation modelling techniques, driven by scenarios of changes in temperature, precipitation and potential evapotranspiration derived from global and regional climate modeling studies. Precipitation is one of the least well-represented processes in climate models at present, and the uncertainty in projections of climate change impacts on water resources is therefore high. The following section summarises a review of various studies carried out to understand the likely availability of water in the future in a changing climate scenario.

Rainfall and water balance projections in Mid Century

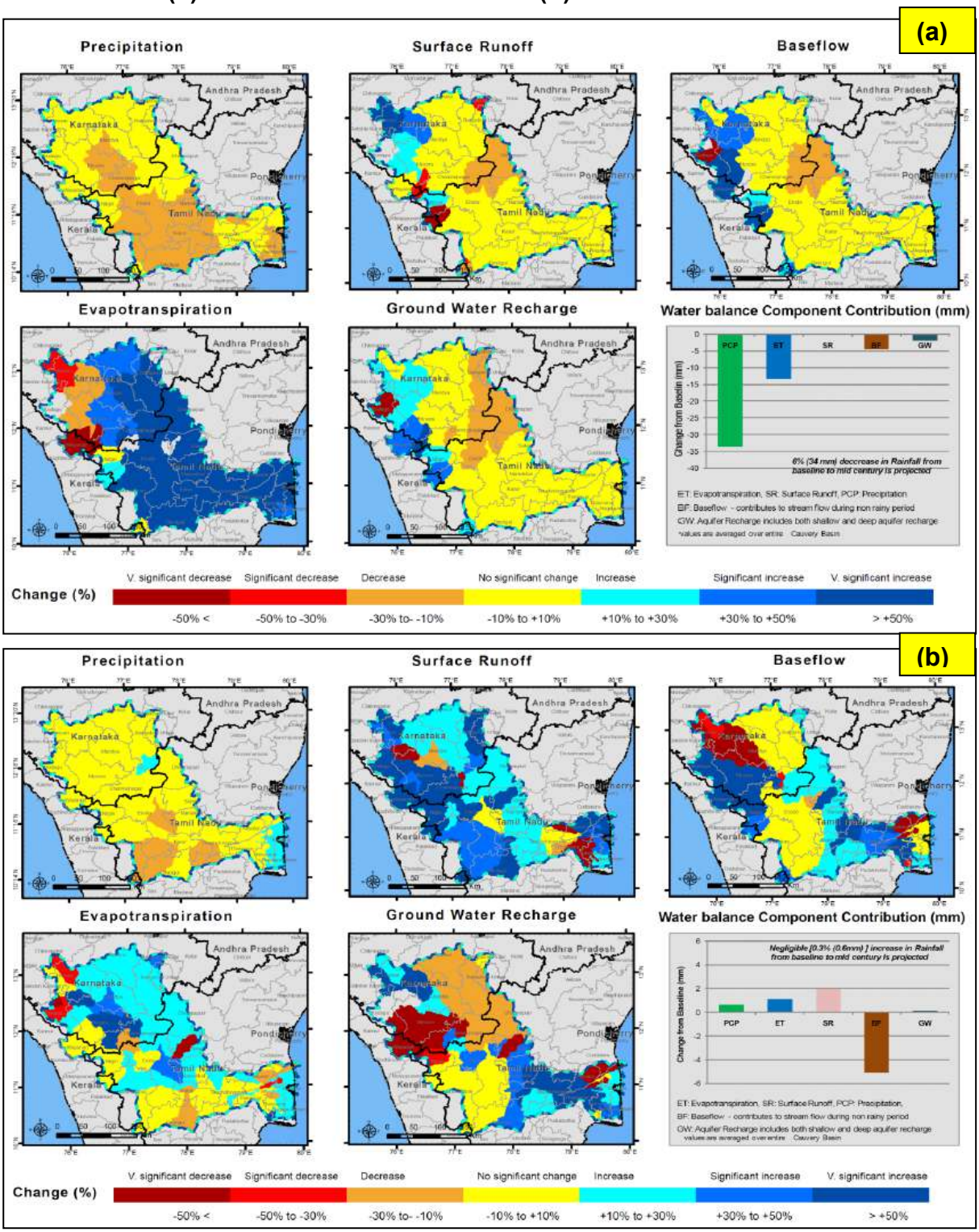
In support to the National Water Mission's National Action Plan on Climate Change (NAPCC), the Asian Development Bank has carried out a study during 2011 to assess the likely changes in water balance projections for the Cauvery river basin which occupies about one third portion of geographical area of Tamil Nadu and is the main river basin in the State, shared along with the State of Karnataka. (Figure 6.5, Table 6.5 and 6.6).The study uses SWAT (Soil and Water Assessment Tool) model with inputs from PRECIS Regional Climate Model run on IPCC A1B SRES. One realisation of the HADCM3 QUMP (Quantifying Uncertainty in Model Predictions, Q14) has provided the boundary conditions for the PRECIS run.

Figure 6.5 Boundary of the Cauvery River Basin



Spatial changes in water balance parameters across the Cauvery basin for south west monsoon and north east monsoon in mid century (2021-2050) with respect to base line (1961-1990) is shown in Figure 6.6a and b respectively.

**Figure 6.6: Change in the Water Balance to Mid Century –
(a) South West monsoon and (b) North East monsoon**



The projections under the A1B scenario indicate the following:

Average Annual changes

- Annual Rainfall – There is no significant change of annual rainfall in mid century A1B scenario. Annual precipitation is highest in the Cauvery delta and in the northwest of the basin where over 1000 mm occurs.
- Changes in annual average evapotranspiration – These values are projected to increase during mid century.

Projections for south west monsoon:

- Southwest monsoon rainfall - For the southwest monsoon, the indications of the PRECIS A1B results are that there will be a reduction in precipitation by up to 10 percent by mid-century. The implications of this projection are increased demand for irrigation water in the upper basin, coupled with a reduction in surface water availability for the delta part. The surface water resource available to the Cauvery delta is likely to decrease during the southwest monsoon under this scenario.
- Ground water demand – Ground water demand will probably increase to compensate for the estimated weakening of the south west monsoon.
- Changes in evapotranspiration – Marginal increase have been predicted leading to increase in water demand for crops during south west monsoon season.
- Surface runoff – Run-off is projected to decrease during south west monsoon season.

Projections for north east monsoon:

- For the northeast monsoon the PRECIS A1B scenario indicates a 10 percent to 20 percent increase in precipitation in the Cauvery delta. Drainage is already a problem in the lower parts of the delta, and increased north east monsoon precipitation coupled with higher sea levels will exacerbate the problems.
- Changes in ground water recharge - The ground water estimation predicts an increase in salinity issues.
- Flood risk - Increased rainfall, rainfall intensities and sea-level rise will increase flood risk during the north east monsoon. Flooding is already a problem and will likely become more significant in the future.

Rainfall Projections by End of the Century

IIT Madras in collaboration with Tamil Nadu Agricultural University carried out a study to assess the likely rainfall scenario in the mid century. This study was part of the CLIMARICE project, was supported by the Norwegian Government. The climate change data used for this study was simulated by the GCM run by the International Pacific Research Centre (IPRC) Hawaii. Climate change simulations were made using GFDL doubling of CO_2 concentration in the end-century (A1B scenario) and the GCM results were downscaled to 25km resolution using IPRC-Reg

SIM model. The results are shown in Figures 6.7 to 6.12

Figure 6.7: Annual rainfall - base line and projections

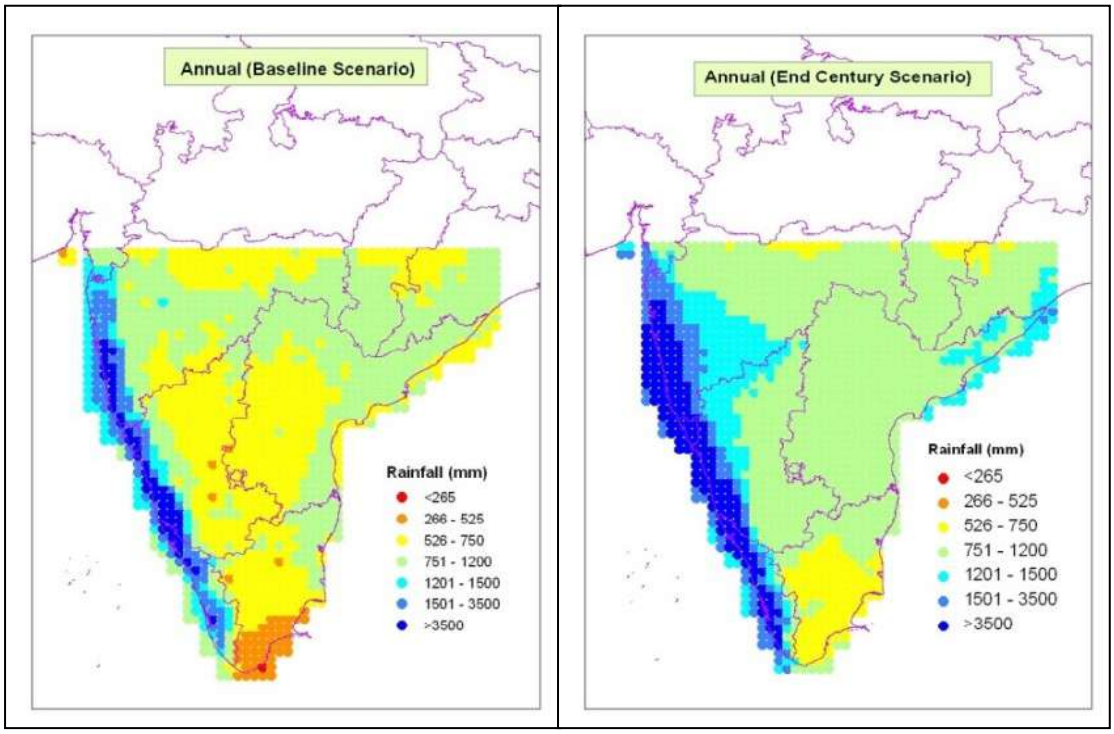


Figure 6.8: Annual rainfall days in base line and end century scenario

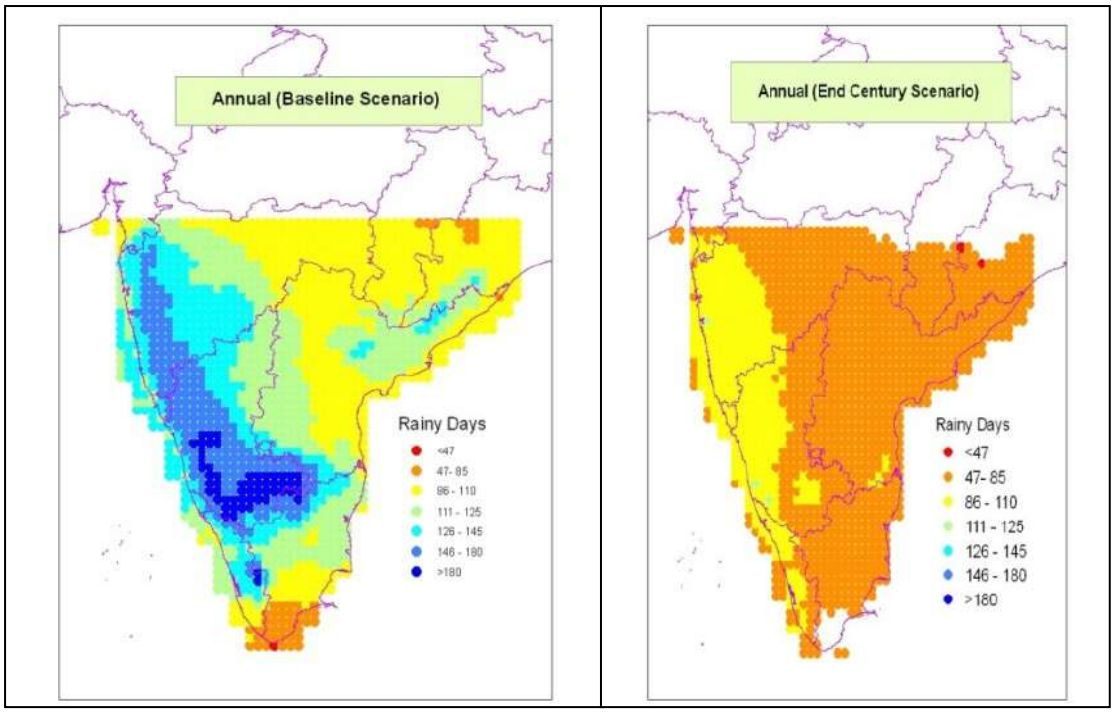


Figure 6.9: Average rainfall intensity

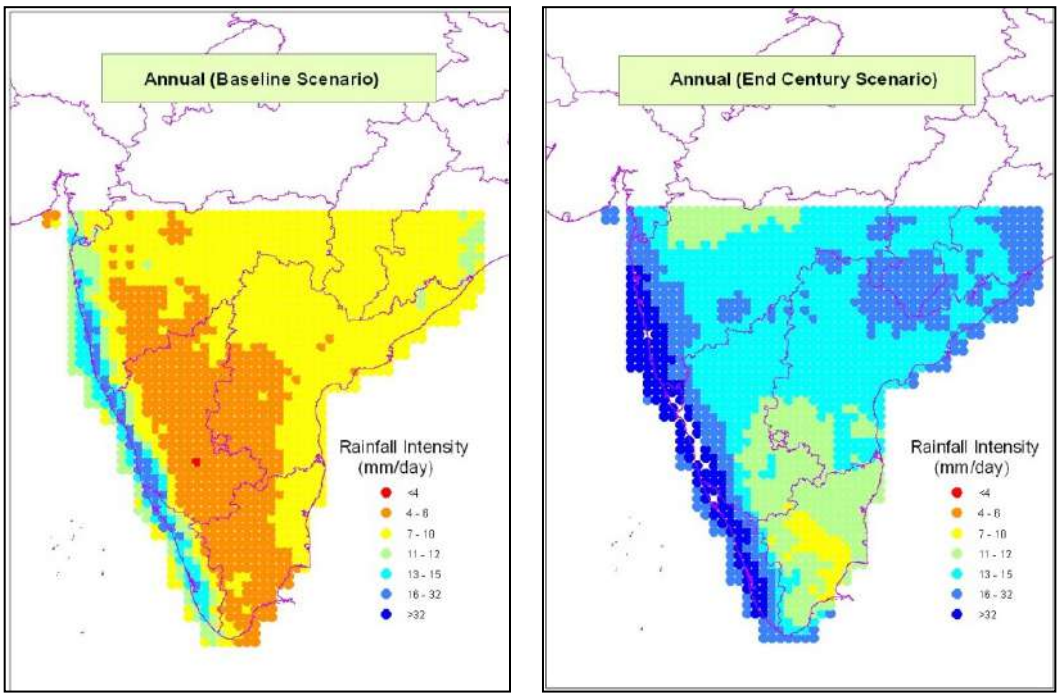


Figure 6.10: Average rainfall intensity during south west monsoon (JJAS)

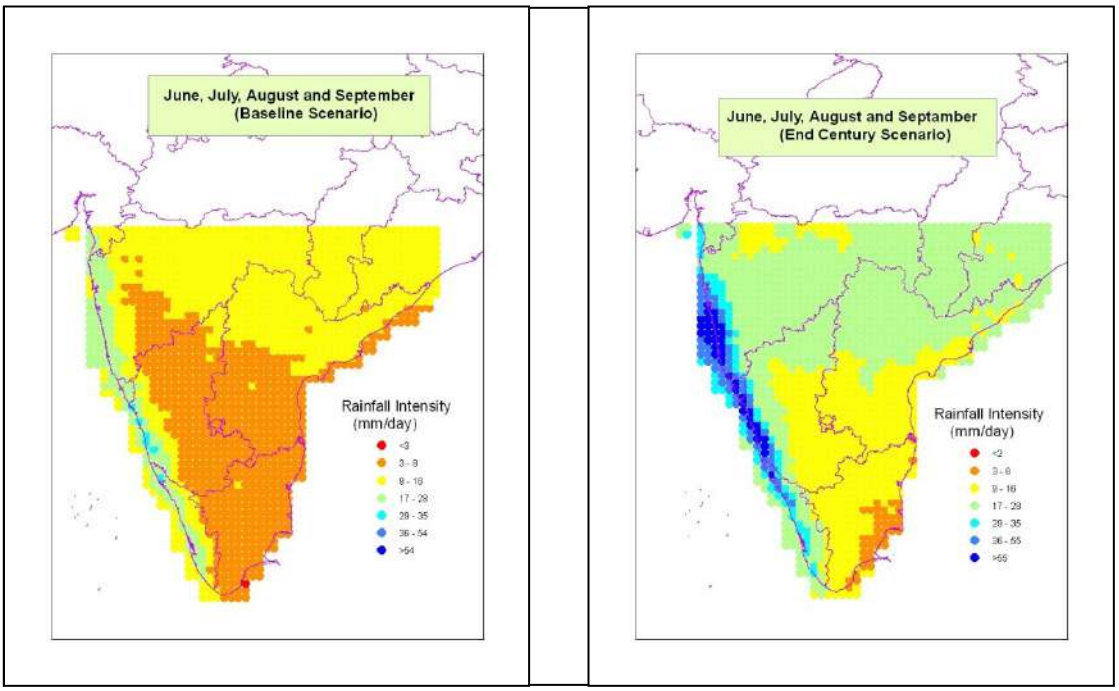


Figure 6.11: Average rainfall intensity during north east monsoon (ONDJ)

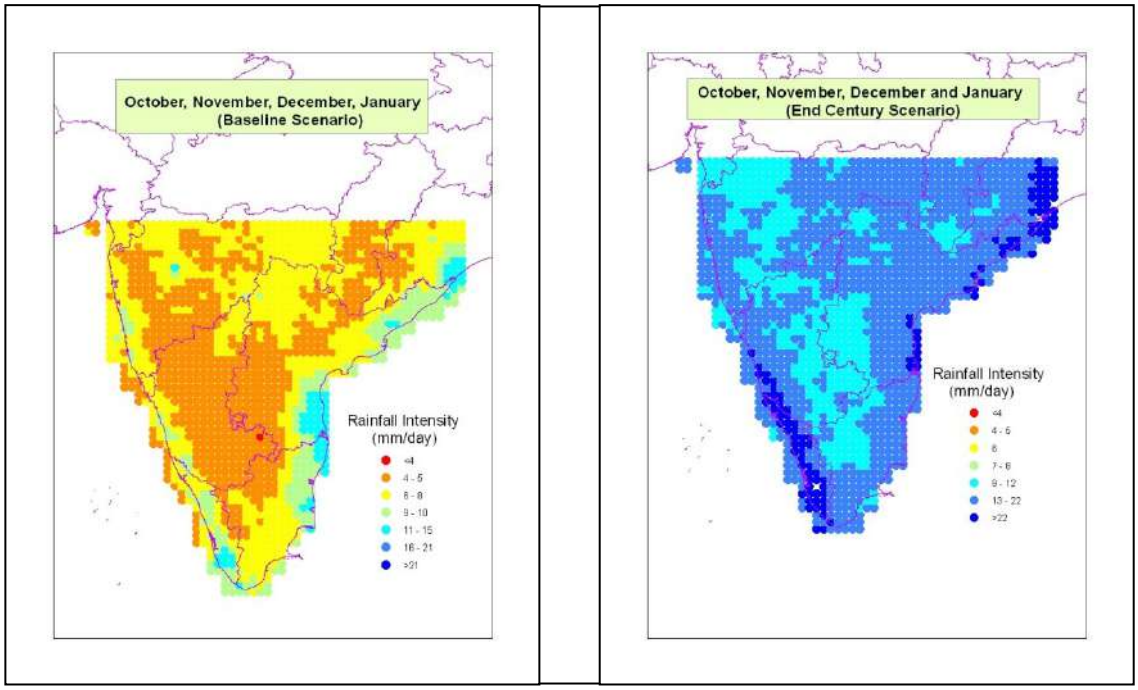


Figure 6.12: Average rainfall intensity during the dry season (FMAM)

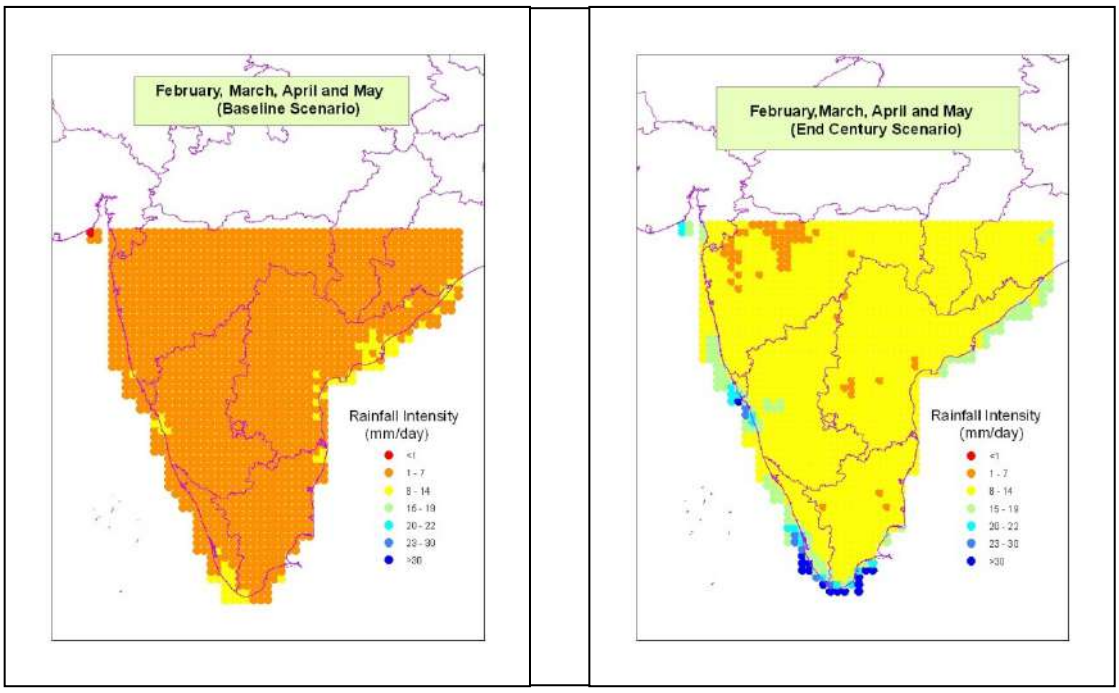


Table 6.6: Changes in precipitation in mid-century (2021-2050) in the Cauvery basin with respect to Base line (1961-1990)

Scenario / Season	Precipitation in mm
Average annual rainfall (A1B baseline)	822
Average annual rainfall (A1B mid century)	810
Net change in mm	12
percent change	1.5 percent
Average southwest monsoon rainfall (A1B baseline)	479
Average southwest monsoon rainfall (A1B mid century)	455
Net change in mm	24
percent change	5 percent
Average northeast monsoon rainfall (A1B Base line)	165
Average northeast monsoon rainfall (A1B mid century)	169
Net change in mm	4
percent change	2 percent

Source: ADB Final Report, September 2011

From these figures, it is clear that, the

- Annual rainfall is predicted to increase considerably towards the end of century (2081-2100) in Tamil Nadu. The results is agreed with the basin level study carried out by ADB (2012) and the study done by Gosain et al. (2011) and several other studies that project an increase in rainfall for most parts of Tamil Nadu.
- Though there is likely to be increase in rain fall annually, but the number of rainy days is likely to decrease by half in the end century scenario with reference to the base line
- Annual rainfall intensities are likely to increase by 7-12 mm/day
- Rainfall intensities during South West monsoon is likely to remain at 3-6 mm/day in the coastal areas but in the rest of State it is likely to increase to increase to 9-16 mm/day
- Rainfall intensity during the North East monsoon is likely to increase by 9-22 mm/day by the end of the century across the State, with heavier precipitation towards the coast
- Annual rain fall intensity is again likely to increase by 8-14 mm/day all across the State by the end of the century.

Ground Water Projections

Climate Change is projected to have an adverse impact on the ground water resources of the State. The coastal districts and islands are more sensitive to Climate Change than the inlands. The factors that are likely to create impact on ground water resources due to climate change are as follows:

- Rise in sea level due to increase in global temperature will result in shifting of shorelines towards inland, thus affecting the freshwater interface in the

coastal aquifer. The fresh water resources in thirteen coastal districts in Tamil Nadu would be affected due to seawater intrusion. The fresh ground water in Rameshwaram and other islands in the State will be affected due to rise in sea level.

- The contribution of rainfall to the ground water recharge determines the quantum of ground water available for various uses. Hence, the occurrence of flood and drought due to climate change affects the ground water recharge.
- Climate change is likely to induce changes in hydro meteorological parameters like evaporation, evapotranspiration, wind direction and wind speed etc. The changes are likely to have a direct or indirect impact on ground water resources. Area irrigated by tanks will get affected severely due to evaporation losses in the tanks, which in turn would result in over dependence on ground water. Since 1980 onwards, number of over exploited blocks has increased from 21 percent to 48 percent over a span of 30 years. This position would be further exacerbated with climate change.

6.6 STRATEGIES FOR ADAPTATION TO CLIMATE CHANGE

National Water Mission and State Objectives

The Water Mission under the National Action plan on climate change focuses on augmentation and efficient management of the water resources and within the purview of the same, the Tamil Nadu Government aims to address the climate change issues. Table 6.7 articulates the State objective vis a vis the National objectives.

Table 6.7: National and State Objectives

National Objective	The main objective of the National Water Mission is “conservation of water, minimizing wastage and ensuring its more equitable distribution both across and within States through integrated water resources development and management”.
Goals	The five identified goals of the Mission are: • Creation of a comprehensive water data base in public domain and assessment of impact of climate change on water resource; • Promote Action for water conservation, augmentation and preservation; • To have a focused approach to redeem the water levels in over-exploited areas • To increase water use efficiency by 20 percent and • To promote basin level integrated water resource management.
State Objective	Based on the likely impact of climate change and on the overall guidance provided by the National Water mission (as described above), Tamil Nadu aims to have sustainable water resource managed through an integrated approach leading to conservation, improvement in water use efficiency, controlling water pollution, minimization of wastage, and ensure equitable distribution of water across a changing climate scenario

The following strategies will be undertaken by the State to achieve the objectives of the Water Mission and to adapt to climate change. As Tamil Nadu has distinct three typical regions that require specific interventions as per their physiographic features, the interventions/strategies suggested here to address the climate change issues are suggested as follows:

- Hilly regions: where there is likely to be high run off due to more intense rainfall
- Plains: recharge of underground water, and other over ground reservoirs is a concern
- Coastal region: sea water intrusion and salinity of water due to rising sea levels and intense cyclones would be the issues that need to be addressed here.

Hilly Region Interventions

Strategies in hill areas to ensure water security in the context of climate change are as follows:

- Undertaking rainwater-harvesting measures along the hill slopes, especially in the recharge zones, to increase the percolation of rainwater, which would result in the recharge of ground water. This can be achieved through digging up of staggered trenches with hedgerow. Actions would also include identification of natural aquifers in the region.
- Constructing check dams, wherever feasible for the creation of water reservoirs for harnessing surface water.
- Increasing water storage capacity by repairing, renovating and restoring existing water bodies

Plains

- Increase reservoir storage potential of existing irrigation projects in the region. This can be done through desilting reservoirs, blocking leakages and lining of canal systems.
- Explore the feasibility of transferring water from surplus basin to deficit basin which has to be analysed.
- Limit rampant ground water extraction, the concept of region specific centralized ground water extraction systems may be created in areas which have been found suitable (connected to aquifers that have more than 80 m depth), based on sound scientific evaluation of the terrain, aquifers, rainfall receipt, and recharge zones. Facilitation should be provided for recharge of ground water in its recharge zone through rainwater infiltration.
- Promote water harvesting by construction of water harvesting tanks and ponds, and expanding the capacity of present ponds that are under direct command of the farmers and can be utilized in the water stress period. Many examples are already being practiced in the State where rain water is stored through various approaches (Box 6.2 and Box.6.3).
- Enhance Artificial Recharge Activities in over exploited ground water areas (critical Blocks) through recharge structures such as percolation tanks, check dams, recharge wells, recharge shafts/pits, and creation of subsurface dykes.

- Enhance Water use efficiency through renovating the existing systems and by educating farmers to adopt modern irrigation methods and latest technologies. Participatory approach i.e., stakeholders' involvement is to be encouraged in Planning, development, utilization and management of water resources.

Box 6.2 : Case Study: Farm Pond– An Alternate Source

Paraman is a shepherd-farmer at Sengapadai village, in Madurai district. For many years he cultivated pulses and millets in his six acres rainfed land. Usually, once in every four years, when the rainfall was good he could harvest one or two bags of grain for his family. He was rearing goats for other families in the village using the traditional method of 'varam' in which Paraman would share the profits with the owners of the goats at the end of the year. The DHAN Foundation promoted a Farmer's group in the village in 2004 as part of its intervention in rain-fed farming. Paraman joined in the Farmer's group and availed assistance to dig farm pond. His pond was filled soon after the first rains. He decided to cultivate paddy on part of his land using the water from the pond. He was able to harvest 840 kg of paddy that year.(Source : DHAN Foundation)

- Abate floods in the State, Flood control measures needs to be integrated with drainage and irrigation systems. By combining the functions of flood diversion with some form of retention in tanks, the parallel benefits of irrigation use and groundwater recharge could be achieved. Strengthening of banks of rivers and providing protective works are necessary.
- Create small reservoir schemes such as check dams.

Coastal Region Interventions

With climate change, the sea level is likely to rise further, causing larger area of inland to be inundated. Also the intensity of the cyclones is likely to increase giving rise to stronger storm surges. In view of the above, the main strategies that need to be put in place to ensure water security of this region may be as follows:

- Construct and rehabilitate tail end regulators to prevent the intrusion of saline water in channels
- Desalination plants in coastal areas are to be established to ensure availability of fresh water.
- Control volume of groundwater abstraction by strictly enforcing the ground water regulation Acts to prevent seawater intrusion.

Box 6.3: Case Study -- A Sustainable approach in water management

The Community Collaborative Water Management (CCWM) is a unique process based on Integrated Water Resources Management (IWRM) principle with a focus on shared vision planning and trade-offs with a aim of providing equitable sharing of the scarce water resources by all stake holders. In contrary to the conventional method of management, the existing water management practices has lack of ownership by the community and there is an absence of grass root level institutions. In order to overcome these drawbacks, a new approach, Community Collaborative Water Management has been evolved focusing mainly on the demand side management. The CCWM will create awareness among the rural population about the water resources and enable them realise the status of water as a finite and scarce resource through various participatory exercises. The Centre of Excellence for Change (CEC) under the IAMWARM project is implementing this CCWM in model villages in Tamil Nadu. One such village is Tiruvampattu village in Villupuram district with a population of 5,100. The village has 8 tanks with a total capacity of 0.935 Million cubic metre. The crops cultivated are Paddy, Ground nut, Pulses, Sugarcane and Mango. The Water Budgeting exercise was carried out with the involvement of the Community. This exercise was done after sensiting the community about water, conducting water walk (Transect Walk) along with the cross-section of all the stakeholders and developing a 'Vision Building' for the village through Participatory Rural Appraisal (PRA) exercise. The water deficit in the village was worked out as 11,700 lakh litres. The people realized the need for a long term Action plan for water management in their village. The people resolved to adopt water saving technologies. The women group also resolved to ensure no wastage while collecting water from the drinking water taps in the village. The village people are now able to prepare the water budgeting exercise on their own before the commencement every season and plan their cultivation Activities based on the water availability at that time and after taking all other sectoral uses into consideration.
(Source : Centre of Excellence for Change,PWD,GoTN)

Research & Capacity Building: Scientific Assessments for Better Understanding of Impacts of Climate Change

- As there is no flood forecasting station in the State, new stations are to be established at suitable locations. Dissemination systems are essential to make all farmers and the entire population aware of the impending event.
- Assess water demand by sector by factoring in climate change for short, medium and long term time lines
- Monitor quality of water to understand the impact of warming of the atmosphere and for providing remedies
- Identify vulnerable areas of ground water contamination by point sources of industrial, municipal solid waste landfills and agricultural pollutants and R&D on contamination mitigation
- Undertake mapping of water availability, Minor surface water bodies, Aquifers in time and space, and Water use in conjunction with land use and land classification.
- Introducing climate change into the curriculum at all school levels.

Policy Related Interventions

- Modernize the Irrigation system using Drip, Sprinklers systems.

- Pricing and Regulation: Lack of metering is an issue. Piped water usage for domestic and drinking water can be subjected to metering and thereby restricting unnecessary wastage of water can be avoided
- Undertake periodical census of minor irrigation projects to check sustainability and also to detect dis-functionalities and to implement remedial measures
- Variable Irrigation Water Tax on surface water use and ground water use might be levied, depending on the land holding size, to minimise use of ground water for irrigation and also to reduce wastage of the water obtained through surface resources. This may also encourage small and medium farmers to have their own water storage structure to irrigate their fields.
- Extend compulsory rain water harvesting regulation in individual houses in all towns
- Establishment and capacity strengthening of Institutions, Water Users Associations (WUAs) and Systems to achieve sub basin level Integrated Water Resources Management (including planning, monitoring and decision support systems to address the impact of climate change).

The contribution of NGO's in climate change adaptation programme is to support the government in formulating adaptation strategies and setting priorities. In setting priorities, it will be important for the NGO's to target the most vulnerable regions, vulnerable groups and sectors most affected by climate change.The NGO's play a vital role in creating awareness among the public at the local level through village knowledge centres and participatory action studies.

6.7 BUDGET REQUIREMENT FOR STRATEGIES IN WATER RESOURCES SECTOR

The total cost for implementing the strategies during the 12th Five Year Plan (FYP) is Rs.12626.00 crore and during the 13th Five Year Plan (FYP) is Rs. 5858.00 crore.(Table 6.8)

Table 6.8: Summary of budget requirement for Water Resources Sector

S.No.	Strategy	Cost for 12th FYP (Rupees in crore)	Cost for 13thFYP (Rupees in crore)
1	Strategy-Hilly Region Interventions	**371.00**	**199.00**
2	Strategy-Plain Region Interventions	**10920.00**	**4945.00**
3	Strategy-Coastal Region Interventions	**1271.00**	**651.00**
4	Strategy-Research & Capacity Building	**60.00**	**59.00**
5	Strategy-Policy Related Interventions	**4.00**	**4.00**
	TOTAL COST	**12626.00**	**5858.00**

The detailed budget allocations for all strategies are given in Table 6.9.

Table 6.9: Detailed Budget for strategies in Water Resources Sector

S. No	Strategy	Agency	Cost for 12th FYP (Rupees in crore)	Cost for 13th FYP (Rupees in crore)
Strategy 1: Hilly Region Interventions				
1.1	Undertaking rain water harvesting measures along the hill slopes	PR,RD, DoF & WRD	**1**	**1**
1.2	Construction of Water harvesting structures such as check dams, recharge shafts, farm ponds, etc.	PR, RD, WRD, TWAD & DoF	**200**	**100**
1.3	Repairing, renovating and restoring tanks and traditional water bodies	PR, RD & WRD	**15**	**10**
1.4	Interlinking of Rivers, and Construction of Mini Reservoirs	WRD	**50**	**35**
1.5	Desilting & Widening of Channels and Drains, strengthening of embankments & removing water weeds from channels	WRD	**100**	**50**
1.6	Strengthening infrastructure to manage disaster	Concerned Line Depts,	**5**	**3**
		Sub Total	**371**	**199**
Strategy 2: Plain Region Interventions				
2.1	Interlinking of Rivers and Construction of Reservoirs	WRD	**8637**	**4416**
2.2	Construction of anicuts and regulators	WRD	**290**	**30**
2.3	Construction of Water harvesting structures such as check dams, recharge shafts, farm ponds, etc.	PR, RD, DoF, WRD & TWAD	**800**	**250**
2.4	Desilting & Widening of Channels and Drains, strengthening of embankments & removing water weeds from channels	WRD	**750**	**150**
2.5	Repairing, renovating,restoring tanks and traditional water bodies	PR, RD & WRD	**433**	**89**
2.6	Strengthening infrastructure to manage disaster	Concerned Line Depts	**10**	**10**
		Sub Total	**10920**	**4945**
Strategy 3: Coastal Region Interventions				
3.1	Construction and rehabilitation of tail end regulators	WRD	**400**	**300**
3.2	Desalination plants	TWAD, CMWSSB	**100**	**100**

S. No	Strategy	Agency	Cost for 12th FYP (Rupees in crore)	Cost for 13th FYP (Rupees in crore)
3.3	Construction of Water harvesting structures - check dams farm ponds, etc.	RD,WRD,TWAD DoF	**300**	**150**
3.4	Desilting & Widening of Channels and Drains, strengthening of embankments & removing water weeds from channels	WRD	**400**	**50**
3.5	Repairing, renovating &restoring tanks and traditional water bodies	PR, RD & WRD	**1**	**1**
3.6	Strengthening infrastructure to manage disaster	Concerned Line Dept	**70**	**50**
		Sub Total	**1271**	**651**
4	**Strategy 4: Research & Capacity Building**			
4.1	Establish high resolution weather monitoring, river inflow monitoring, hydrograph monitoring, and early warning system for floods	WRD	**50**	**50**
4.2	Assess water availability by region, assess current demand of water by sector and future demand by sector by factoring in Climate change for short, medium and long term time lines	WRD, IIT Madras & TNAU	**2**	**1**
4.3	Monitor quality of water to understand the impacts of warming of the atmosphere and for providing remedies	TNPCB	**5**	**5**
4.4	Identify vulnerable areas of ground water contamination by point sources of industrial, municipal solid waste landfills and agricultural pollutants	TWAD & TNPCB	**1**	**1**
4.5	Map water availability, Minor surface water bodies, Aquifers in time and space, and Water use in conjunction with land use and land classification	PR, RD & WRD	**2**	**2**
		Sub Total	**60**	**59**
5	**Strategy 5: Policy Related Interventions**			
5.1	Introduce pricing regulation for use of piped water for domestic use and drinking water	PR&RD & TWAD	**1**	**1**
5.2	Undertake periodical census of medium & minor irrigation projects to check sustainability,detect dis-functionalities & implement remedial measures	WRD	**3**	**3**
		Sub Total	**4**	**4**
		GRAND TOTAL	**12626**	**5858**

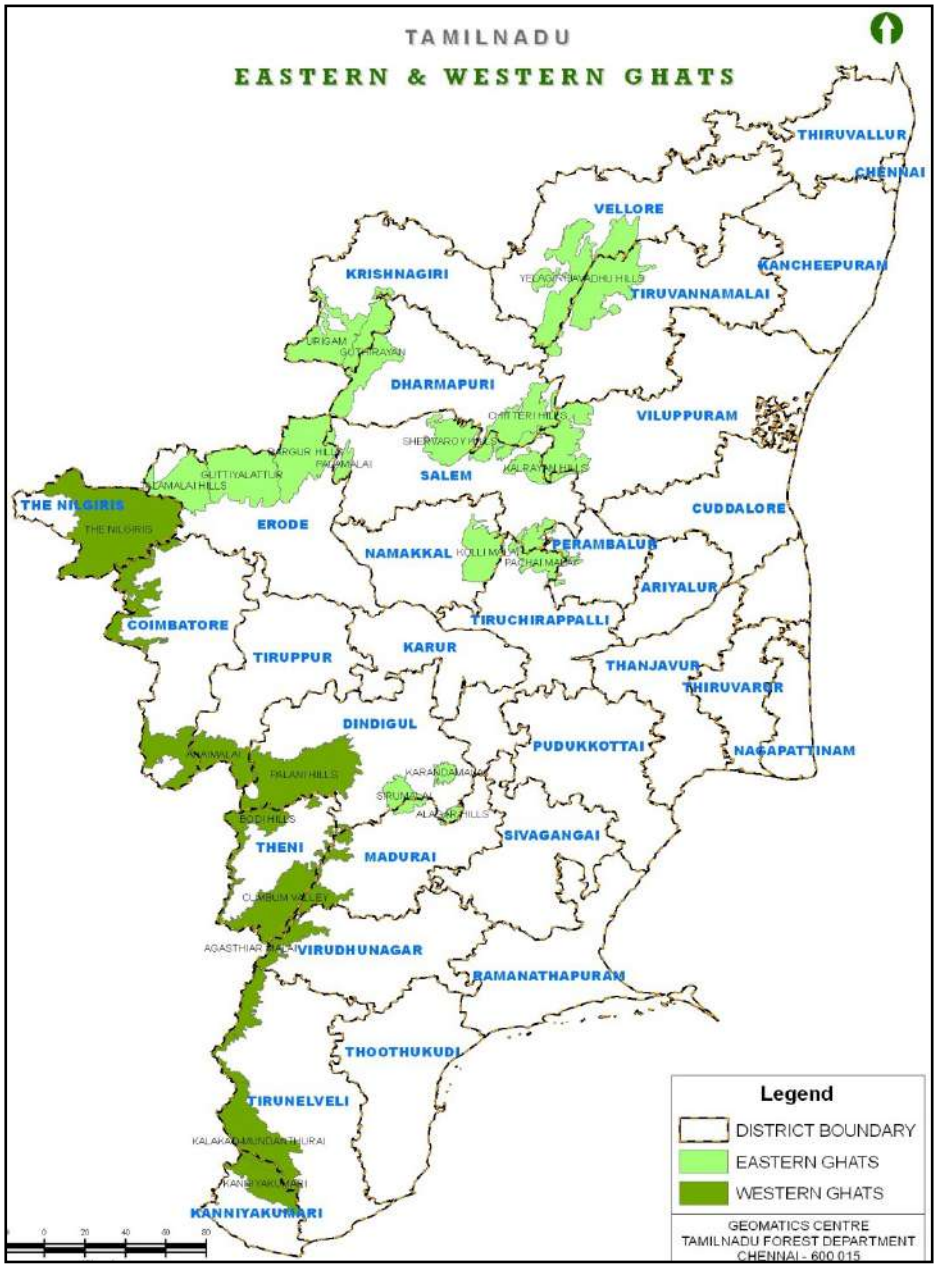
7. FORESTS AND BIODIVERSITY

7.1 STATUS

Forest Cover

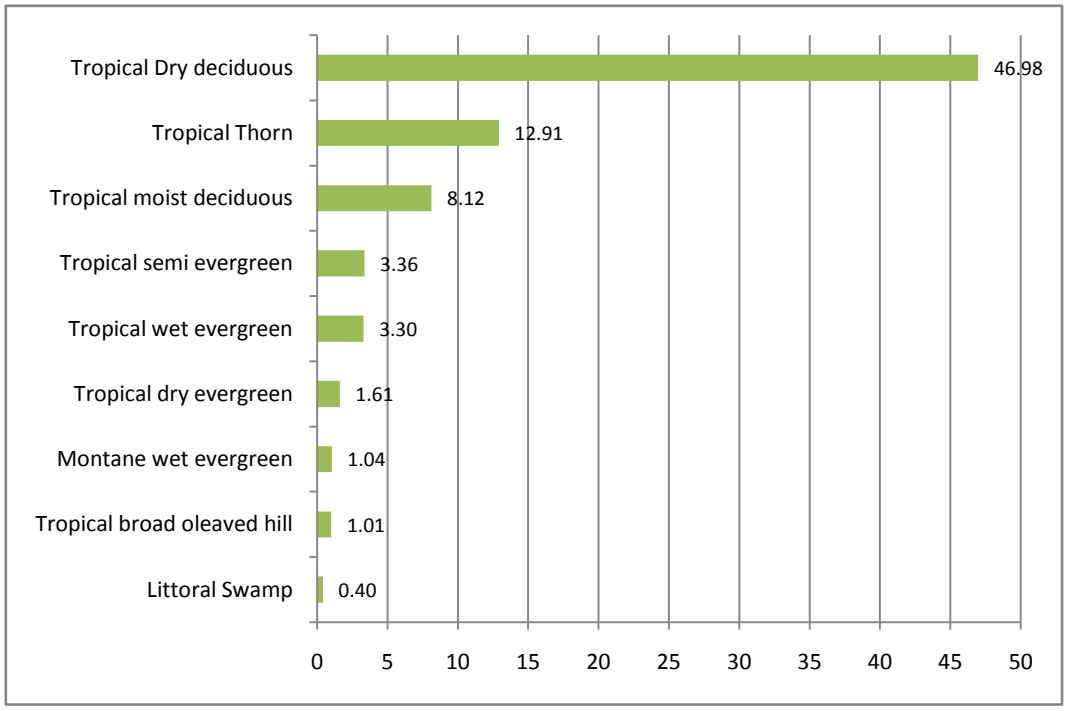
The forest cover in the State is 23625 sq.km, which is 18.16 percent of the total geographical area of the State (Forest Survey of India [FSI] report 2009). The forests are spread along the Western Ghats and in Eastern Ghats in Tamil Nadu Figure 7.1). The State ranks 13th among the Indian States and Union Territories with reference to the total recorded forest area.

Figure 7.1: Spatial Distribution of Forests in Tamil Nadu



In terms of forest canopy density in 2009, very dense forests occupied 12.47 percent (2948 sq.km) of the total forest area in the State.The moderately dense forests covered 43.77 percent (10343 sq.km), open forests covered 33.90 percent (10282 sq.km), and scrubs covered 5.079 percent (1200 sq.km) of the total forest area respectively. Between 2007 and 2009, satellite observations indicate an increase in very dense forest cover by 22 sq.km (FSI, 2011).Simultaneously, there has been an decrease of open forest cover by 22 sq.km, decrease by 74 sq.km in the moderately dense forest cover. FSI estimates indicate that in 2009, the growing stock in Tamil Nadu was 144.404 million, of which 70.328 (48 percent) growing stock is in the trees outside forests.Nine major forest types exist in Tamil Nadu (2009) and the percentage distribution of each of these types is shown in Figure 7.2.

Figure 7.2: Percentage distribution of Forest area by Type in Tamil Nadu



The trees outside forests constitute patches outside the recorded forest area and is exclusive of forest cover and is less than the 1 ha. The tree cover in Tamil Nadu is 4718 sq.km, which is 3.63 percent of the State's geographic area.

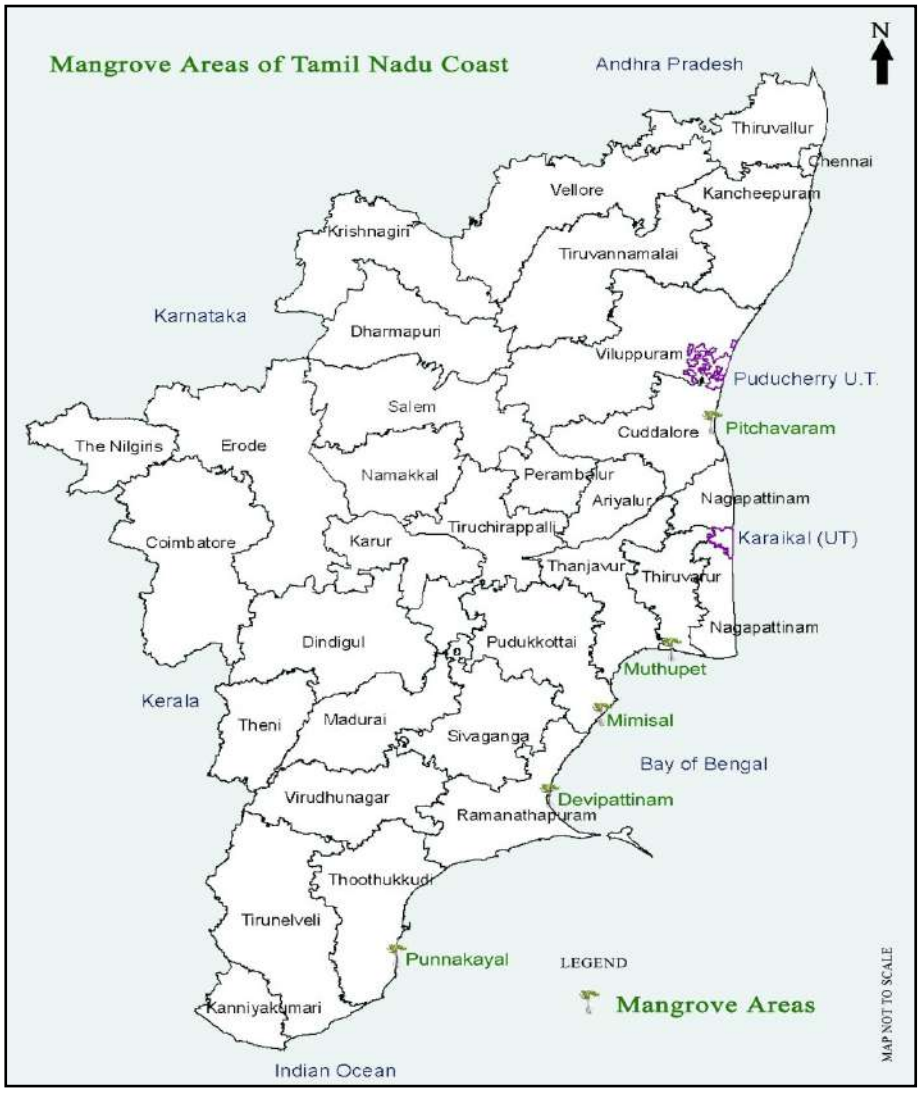
Mangroves

The mangrove ecosystem constitutes a bridge between terrestrial (land) and marine ecosystems. Area covered under mangrove vegetation as interpreted from remote sensing data is 39 sq.km and is included in the total forest cover of the State. Of this, 16 sq.km is moderately dense and 23 sq.km consists of open mangrove cover.The location of the mangroves is shown in Figure 7.3. In the

islands of the Gulf of Mannar Biosphere Reserve, mangroves are present in a few hundred hectares. These mangrove patches consist of a true mangrove species, namely, *Phemphis acidula*, which is not present in any other Indian mangrove wetland.

Mangrove wetlands function as breeding, feeding and nursery grounds for most of the sport and commercial fishes found in the deep coastal waters and inshore waters. They also provide a breeding ground for birds, reptiles and mammals.During the Tsunami in 2004, the mangrove forest patches protected the villages in coastal areas of Tamil Nadu. These had distinct zones of vegetation. The first zone, which is about 10 m wide is characterized by the presence of mainly *Rhizophora apiculata* and *R.mucornata* trees.These two species possess characteristic roots called stilt roots, which diverge from the branches and tree stems as much as 2-3 m above ground and penetrate the soil some distance away from the main stem.

Figure 7.3: Locations of the mangrove forests along Tamil Nadu coast



The primary function of these roots is breathing, but they also provide strong physical anchorage to trees. Due to this, it has been reported that *Rhizophora* trees are capable of withstanding winds with a speed as high as 140 km per hour. In the present context, it seems that these roots absorbed most of the energy of the Tsunami and reduced its speed. These root systems would have also deflected the water into the nearby canals and tidal creeks.The zone next to *Rhizophora* consists of species such as *Bruguiera, Excoecaria* etc., followed by *Avicennia marina* which is about 1000 m wide from the edge of the lagoon to the village.This species also has a special root system called aerial roots, which bind soil tightly. Next to this *Avicennia* zone, sandy area of about 10 m to 12 m breadth is present, which is characterized by mangrove associates, which are also saline.In some of the elevated portion of this sandy area, palm trees are present.

Flora and Fauna

Forest management in Tamil Nadu is focused towards conservation of biodiversity, the forefront in protecting its wildlife and has a very good network of Protected Areas. The State added about 887 sq.km of forest area to the Protected Area (PA) network by declaring a part of Sathyamangalam forest division as a Wildlife sanctuary during 2011-12. This has led to an increase of protected areas in the State from 4578 sq.km to 5465 sq.km, which was about 23.9% of the forest area. Declaration of more Sanctuaries further brought the forest area under Protected Area network to 6708 sq.km.The State at present has 14 Sanctuaries, 5 National parks, 14 bird sanctuaries and one conservation reserve, declared under Wildlife (Protection) Act, 1972. GoTN is committed to increase the extent of protected areas to 25% of forest area in the State.

Tamil Nadu wild plant diversity includes a vast number of Bryophytes, Lichens, Fungi, Algae and Bacteria (see Figure 7.4a).The faunal diversity of Tamil Nadu includes 165 identified freshwater fishes, 76 amphibians, 127 reptiles, 545 birds and 187 mammals (Figure 7.4b).The red-listed and the endemic fauna of Tamil Nadu, based on CAMP Reports is shown in Figure 7.4 c.In the State, the Tiger population is 163 (9.6 percent of India's) Elephant population is 4015 (15.5 percent of India's), NilgirisTahr population is 1250 (50 percent of India's) and Lion Tailed Macaque population is 1107 (34 percent of India's).

Forest Produce

Timber, teak poles, pulpwood, fuel wood, sandal wood, wattle bark and Babul are some of the major forest produce in the State. Between 2000-01 and 2010-11, teak wood production has increased by 33 times while there has been a marginal increase in pulp wood. Fuel wood production has decreased drastically. So has sandalwood production in the State.

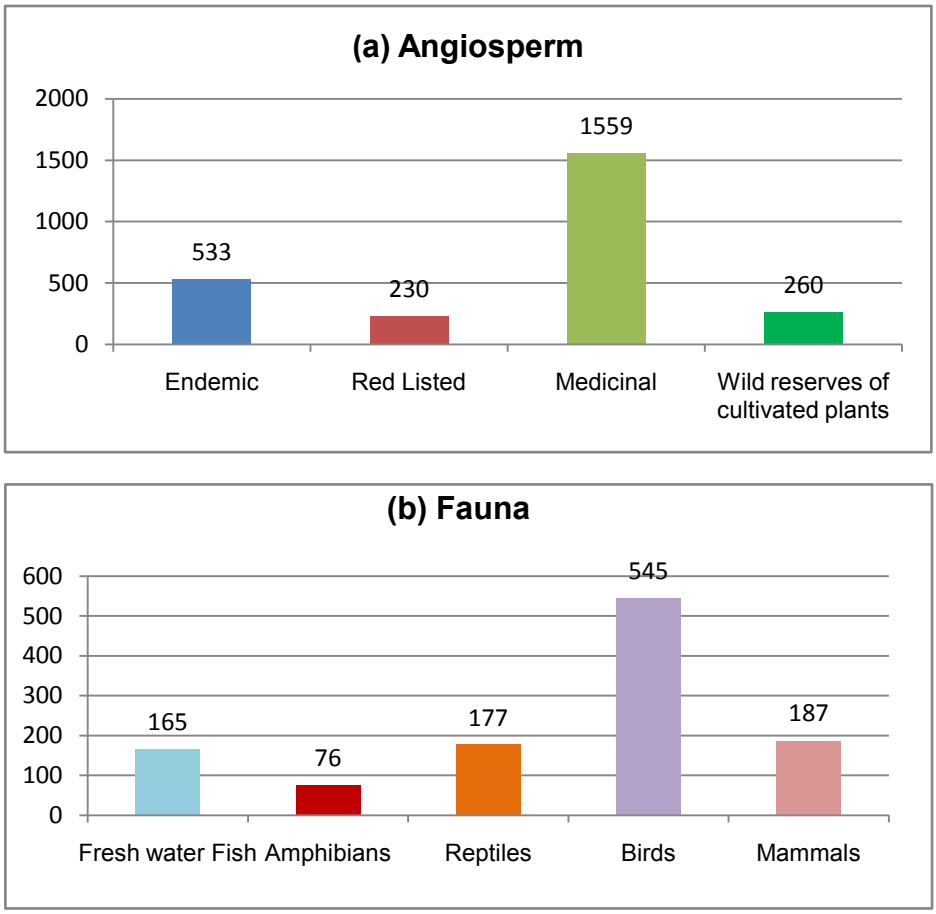
The Non Timber Forest Produce (NTFP) which includes, tamarind, cashew nuts, and other forest produce including fodder and honey are found in the State. Of the total wage employment in the forestry sector, NTFPs account for more than 70 percent amongst the tribals who live in the periphery of forests (Table 7.1)

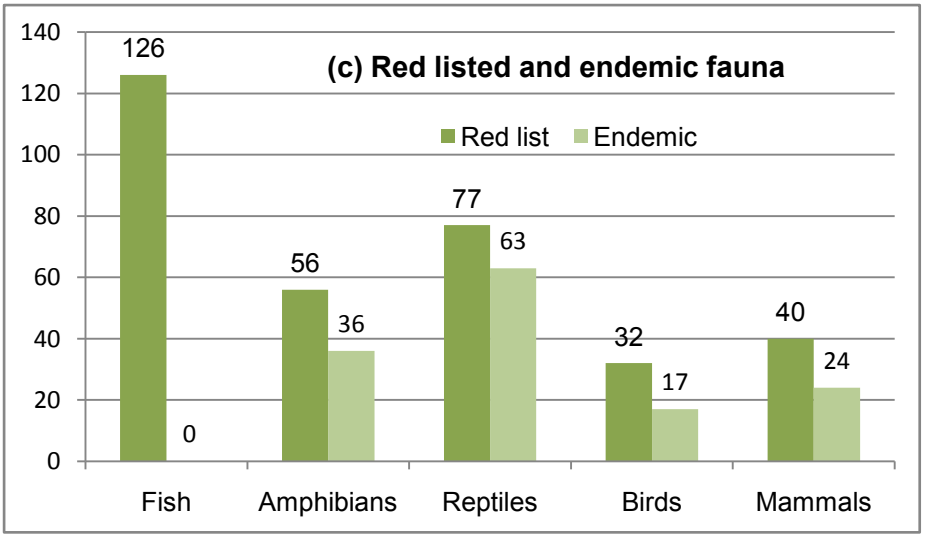
Table 7.1: Changing profile of forest produce in Tamil Nadu

Products	Unit	2000-01	2010-11
Major Forest Produce			
Teak wood	MT	194.258	6752.990
Teak Poles	No	0	0
Pulp Wood	MT	6560	7058.615
Fuel Wood	MT	45176	3060.850
Sandalwood(heart wood)	MT	1477	185.668
Sandalwood(sapwood)	No	51	2.068
Wattle Bark	MT	463	0
Babul	MT	-	73479.850
Bamboo	MT	-	3625.730
Other minor forest produce	MT	-	7301.971
Cashew nut	MT	-	49.844
Tamarind	MT	-	355.627
Charcoal wood	MT	-	0
Other minor forest produce	MT	-	7301.971

Source: Wood Balance Study:TN -MSE (2010);www.tn.gov.in/deptst/forests.pdf

Figure 7.4: (a) Number of Angiosperm species, (b) Identified Faunal biodiversity and (c) Number of Red listed and endemic fauna in Tamil Nadu





Wetlands

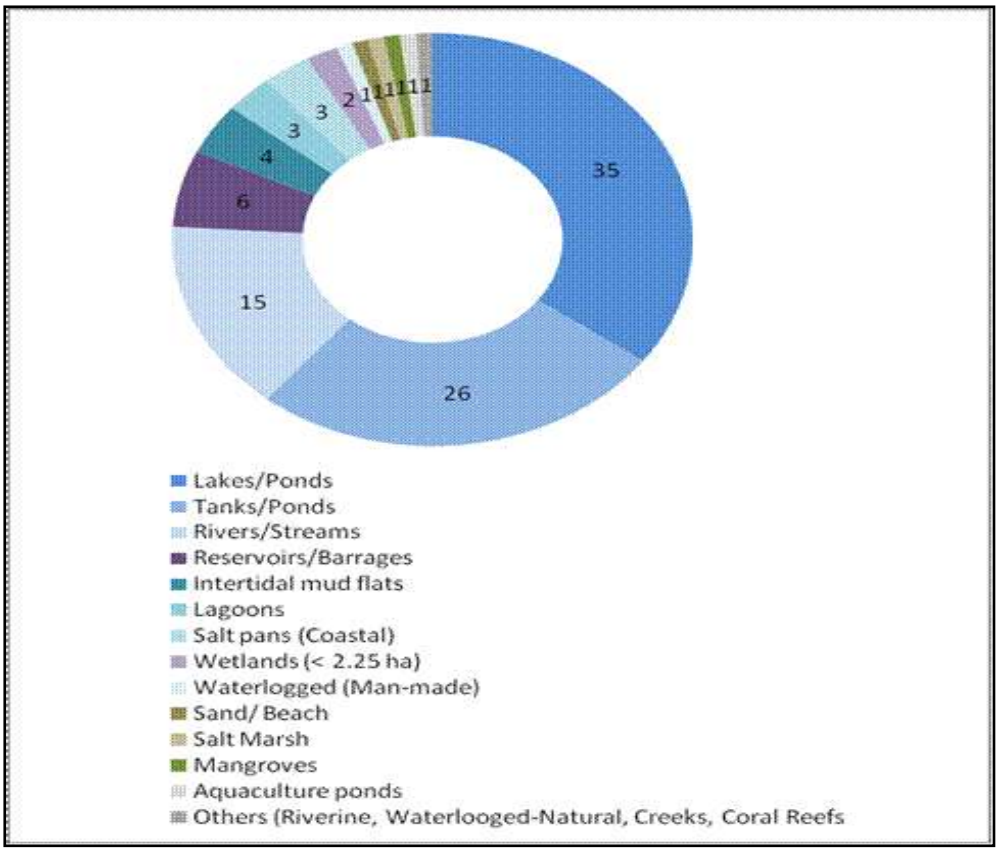
The National Wetland Atlas, prepared by the Space Applications Centre (SAC) of the Indian Space Research Organisation (ISRO), has classified Tamil Nadu as a wetland-rich State and Puducherry as a wetland rich union territory as they have 12.88 percent and 6.92 percent of the geographic area under wetlands respectively. Kancheepuram is the leading district with 80,445 ha (8.91 percent) and Chennai has the smallest area, 917 ha (0.10 percent).

Lake/pond and tank/pond are the dominant wetland types found in all the districts, accounting for 61percent (Figure 7.5). About 4,369 natural lakes and ponds exists having a total wetland area of 3.16 lakh ha and 19,343 man-made tanks and ponds exists with a total wetland area of 2.37 lakh ha. Pudukottai district has the highest area under lake/pond (38,966 ha) as well as tank/pond (26,419 ha). Most of the major lakes and tanks were created during the rule of monarchs.Only small tanks and percolation ponds have been created in the post-Independence era.

Lagoons are observed in eight districts, with Tiruvallur leading in terms of area. Salem district leads in the area under reservoir/barrage. While mangrove type has been observed in 11 districts, coral reef is restricted to Ramanathapuram and Tuticorin. Point Calimere Wildlife and Bird Sanctuary have been cited as an important wetlands of the country in the atlas (Aravind Kumar, 2011). In coastal areas, lagoons, inter-tidal mudflats and salt pans are the dominant wetland types and reported in the earlier section.

The Moyar wetland in Tamil Nadu has the highest richness (260–312 species) and endemism (103–129 species) of freshwater species. 125 species of birds, including both migratory and resident that depend on wetlands fully or partly and 28 other species are found in the vicinity of wetlands of Tamil Nadu.

Figure 7.5: Type-wise percentage distribution of Wetland in Tamil Nadu



Source:Space Application Centre, ISRO, 2011

7.2 CONSERVATION EFFORTS

Protected Areas

Protected areas in Tamil Nadu cover 5465 sq.km, which is 23.9 percent of the State Forest area.The State ranks 14th among all the States and Union Territories of India in terms of protected areas.There are 10 wildlife sanctuaries, 6 tiger reserves, 4 elephant reserves, 14 bird sanctuaries, 5 National Parks The spread of these is shown in Figure 7.6.

Tamil Nadu is also a part of the Nilgiri Biosphere Reserve (NBR) existing within the State boundary. The biosphere lies Between 10°50′N and 12°16′N latitude and 76°00′E to 77°15′E longitude. It encompasses 5,520 sq.km and in the State of Tamil Nadu it covers an area of 2537.6 sq.km in Karnataka it is spread over 1527.4 sq.km and in Kerala it is 1455.4 sq.km. It forms an almost completering around the Nilgiri Plateau. The Altitude within the NBR varies from 250 m to 2670 m. The Reserve includes all the important forest types that are to be found in South India as well as some that are just peculiar to the belt are the Evergreen Forests, Semi Evergreen Forests, Moist Deciduous Forests, Shola forests, Dry Deciduous forests, Dry Scrub Woodlands and Grasslands.There are six Protected Areas within the reserve and still larger tracts of forests that lie outside of these, known as Reserve Forests.

Another special biodiversity rich area is the Gulf of Mannar which is preserved as the Gulf of Mannar National Park. It has the core area of about 560 sq.km from Rameswaram to Tuticorin lying within the Gulf of Mannar Biosphere Reserve (GoMBR) covering an area of 10,500 sq.km. on the south-east coast of India. It covers the coast of Rameswaram, Tuticorin, Tirunelveli and Kanyakumari. It is one of the world's richest regions from marine biodiversity perspective and the first marine Biosphere Reserve in Southeast Asia. The Biosphere Reserve comprises 21 islands with estuaries, mudflats, beaches, forests of the near shore environment, including marine components like algal communities, sea grasses, coral reefs, salt marshes and mangroves. About 3600 plant and animal species have been identified here.

Figure 7.6: Wild life and bird sanctuaries in TamilNadu

Source:Department of Forest, Tamil Nadu

Urban Forestry

Vegetation plays a vital role in controlling pollution in urban and industrial areas as well as in land tracts, other than providing cooling of the heat island effect and sequestering Carbon as well. Urban greening is in many ways different from conventional planting in forest areas, as it requires special skills in nursery and planting, needs a selection of site specific mixture of species, warrants longer periods of maintenance and aftercare, uses municipal watersheds not under the control of the forest department, applies multi-managerial system, and has to consider landscape design requirements.

In Tamil Nadu, tree-planting programmes within the limits of Corporation and Municipalities have been implemented since the last few decades under State and Centrally Sponsored schemes. A major green belt development programme was taken up in all six Corporations and their peri-urban limits under a MoEF&CC sponsored project during 2000-01.The project achieved planting and nurturing of about 3,26,000 saplings. Both strip and block planting of tree species with the potential to provide dense foliage and a canopy were taken up in the margins of wider, medium roads, lanes and bi-lanes, school zones, hospitals, temples, canal/river banks, foreshores of tanks, waterways, institutional and industrial areas, parks and play fields, camp sites and major residential neighbourhoods.This scheme also introduced the concept of Honorary Tree Wardens for the Corporation Zones, who are people of repute in their locality and who can influence people in extending their support to the scheme. In the same year, a green belt programme for abatement of pollution and environmental improvement in the 102 municipalities was implemented with financial support from the industries and the MoEF&CC,GoI and 3.7 lakh seedlings were planted in all. Some of the successful people centered urban planting programmes can be seen in municipalities like Tiruppur. During the year 2007-08, a scheme of urban plantation for planting 1.18 lakh seedlings in the six Corporations at a cost of Rs.4.00 crore was implemented with 75 percent financial support from the Tamil Nadu Pollution Control Board (TNPCB). In the current financial year, 64 lakh seedlings have been planted in cities and towns, as a special initiative of Chief Minister

Wetlands

Point Calimere Wildlife & Bird Sanctuary is a Ramsar Site located along the Palk Strait and covers three districts of Tamil Nadu: Nagapattinam, Tiruvarur and Thanjavur. It lies in between 79.399 E & 79.884 E longitudes and 10.276 E and 10.826 N latitudes, covering an area of 38,500 hectares from Point Calimere in the east to Adirampattinam in the west. The Ramsar Site comprises of Point Calimere Sanctuary, Panchanadikulam Wetland, Thalainayar Reserved Forest and Muthupet Mangroves. Except the Thalainayar Reserved Forest, the remaining constituents are part of the Great Vedaranyam Swamp. Bio-geographically, the Ramsar Site is a mix of salt swamps, mangroves, backwaters, mudflats, grasslands and Tropical Dry Evergreen Forest. It has recorded the largest congregation of migratory waterbirds in the country with peak population exceeding 1,00,000.

7.3 CHALLENGES OF MANAGING THE SECTOR

Degradation of habitats

Due to the initial emphasis given to development related issues, the degradation of habitat occurred resulting to a number of projects coming up in forest lands. The number of migratory corridors also got affected, leading to fragmentation of the habitat especially, for the elephants that later on became the main reason behind human-wildlife conflict in Tamil Nadu. The other reasons include grazing, forest fires, invasion of exotic species, encroachments, quarrying and mining, destruction of the coral reefs and estuarine environments, over exploitation/ unscientific harvesting of Minor Forest Products etc.

Encroachment of forest lands

Encroachment in forest areas is mostly for cultivation purposes and for the construction of huts and houses. An extent of the 14682 ha forest area is under encroachment in the State as on 30.06.2010. Out of this, about 4327 ha is in Reserve Forest and remaining 10355 ha is Reserve Land notified under section (4) of Tamil Nadu Forest Act 1882.

Forest Fires

Fires are regular annual feature during summer months, extending from January to June and if south west monsoons fails, the fire hazards extends up-to September. Majority of the Forest Divisions including National Parks and Sanctuaries in Tamil Nadu are prone to fire hazards. In the natural forests, the outer slopes up-to elevation of 350 m are the worst affected by fire, because of topography and grazing interests. The problem gets compounded, where areas are prone to high velocity winds like Tirunelveli district. Most of the forest fires are ground fires. The after effects of such fires are generally invasion of invasive species like *Lantana* which leads to retrogression and change in the original vegetation in the longer run.

Natural disasters

In Tamil Nadu the coastal areas south of Nagapattinam are most vulnerable to high storm surges. In these locations, the beaches and coastal lands are gently sloping and therefore suffer deeper penetration of seawater.Protective mangrove cover is decreasing at an alarming rate due to increase in shrimp farming and other industrial activities. (ENVIS Centre, Department of Environment, 2006). Landslides are very common in the Nilgiri Range, characterized by a lateritic cap which is very sensitive to mass movements. One of the valleys in the Nilgiri hills is called "Avalanches Valley".

Threats to the sacred groves

The threats vary from one region to the other and even from one grove to the other like disappearance of the traditional belief systems, which were fundamental to the concept of sacred groves,rapid urbanization and developmental interventions

including commercial forestry, encroachments, invasion of exotic weeds such as *Eupatorium, Lantana* and *Prosopis* and increasing livestock grazing and fuel wood collection.

Human-animal conflict

The problem of human-wildlife conflicts poses a very severe threat to wildlife conservation. In Tamil Nadu, most commonly involved wild animals in the human-wildlife conflicts, where the damage is caused to humans and their property, are elephants, tigers, leopards, wild boars, bisons, bonnet macaques and marsh crocodiles.

Illicit removal of fire wood, bamboo, minor forest produce (MFP), timber etc:-

In 1977 fuel coupe workings were stopped in Tamil Nadu through a Government order. Further, harvests of green bamboo were also given up. This was the beginning of a new era in the State when conservation forestry took over production forestry. Yet, pressure on forests by way of over grazing, encroachment, illicit felling (mainly for fuel wood and small timber) have increased manifold necessitating strong protection measures (both preventive and detective) with people's co-operation. The 1988 National Forest Policy has laid great emphasis on maintenance of environmental stability through preservation, restoration of ecological balance that has been adversely disturbed by serious depletion of the forest.

Engagement of tribal communities in forest conservation

The symbiotic relationship between the tribal people and forests has been dealt in detail under 1952 and 1988 Forest Policies. It is imperative to mention here that tribal people and forest dwellers residing in and around forest areas must be necessarily engaged in forest protection.

Illegal trade in flora and fauna

It is recognized that the illegal trade in flora and fauna is next in size only to the trade in narcotics and may equal that of ornaments.The State is facing smuggling problem with respect to sandal, red sanders and medicinal plants.Chennai port is recognized port for trade including CITES.

Depleting NTFP

NTFP contributes to about 20 percent to 40 percent of the annual income of forest dwellers who are mostly disadvantaged and landless communities with a dominant population of tribals. It provides them critical subsistence during the lean seasons, particularly for primitive tribal groups such as hunter gatherers and the landless. Most of the NTFPs are collected and used/sold by women, and so has a strong linkage to women’s financial empowerment in the forest-fringe areas.

Depleting resource base is either because of diversion of forest land for non-forest use, or due to unsustainable harvesting practices that has been the major ecological challenge in the NTFP sector with growing and visible impacts of climate

change on crop production. On the other hand, poor research& development focus, inadequate post-harvesting practices, insufficient funds & infrastructure, and unorganized nature of the trade have made it financially vulnerable particularly for the primary collectors whereas the differential and sometimes contradictory tax & transit regimes in the States have adversely affected not only the trade but even the production of NTFPs.

Meeting fuelwood demand

Trees Outside Forests (TOF) are estimated to contribute 41 percent of the total fuel wood supply. The industrial demand for timber, poles and pulp wood is primarily met from imports, captive plantations, plantations taken up by the forest department, and farm forestry plantation taken-up by farmers. There is no production of timber and poles from natural forest to meet the industrial demand. However the supply chain of fuel wood is fairly complex.

The total demand for fuel wood under various scenarios is expected to vary between 15.17 to 23.22 million cu.m. by year 2013 according to the study. Household sector, which contributed 84.5 percent of the total fuel wood demand, continues to dominate with contribution ranging between 70 percent and 80 percent. Thus it is important address fuel wood supply through plantation outside forest etc. The Wood Balance Study for Tamil Nadu (2009) assessed the total demand for wood in Tamil Nadu for the year 2008 as 28.5 million cu.m of which fuel wood constituted 82 percent of the total demand. Households and industries demand accounts for 77 percent and 16 percent respectively of the total demand for wood (Table 7.2 and Table 7.3).

Table 7.2: Overall supply of wood in Tamil Nadu, 2008 (million cu.m)

Supply Source	Fuel Wood	Timber	Total
Forests	0.42 (1.8)	0.07 (1.3)	0.49 (1.7)
TOF	9.55 (40.9)	2.37 (46.2)	11.92 (41.8)
Farm Forestry	0.89 (3.8	1.13 (21.9)	2.02 (7.1)
Imports	0	0.97 (19.0)	0.97 (3.4)
Other Sources	12.49 (53.5)	0.59 (11.5)	13.08 (45.9)
Total	**23.35 (100)**	**5.13 (100)**	**28.48 (100)**

Source: Wood Balance Study–Tamil Nadu, MSE (2010)

Table 7.3: Overall demand for wood in Tamil Nadu by sector, 2008 (million cu.m)

Sector	Wood Demand		Total
	Fuel Wood	Timber	
Household	19.73 (84.5)	2.288 (44.6)	22.02 (77.3)
Industry	2.08 (8.9)	2.553 (49.7)	4.63 (16.3)
Services	1.54 (6.6)	0.292 (5.7)	1.83 (6.4)
Total	23.35 (100)	5.133 (100)	28.48 (100)

Source: Wood Balance Study–Tamil Nadu, MSE (2010)

Gulf of Mannar

The Gulf's 3600 plant and animal species include Sea Cow (*Dugong dugong*), globally endangered species and six mangrove species endemic to peninsular India. The majority of the inhabitants are Marakeyars, a local community principally engaged in fishing. There are about 125 villages along the coastal part of the biosphere reserve, which support about 100,000 people.This, coupled with dynamite fishing, mechanized fishing boats, the use of the destructive type of fishing nets catching marine animals and corals and over harvesting of fish makes the efforts of conservation challenging.

7.4 INSTITUTIONS MANAGING FORESTS & BIODIVERSITY IN TAMIL NADU

The Tamil Nadu Forest Department is responsible for protection and management of forest and wildlife in the State. The department implements and promotes various schemes of State Government as well as schemes sponsored by the Central Government for management and conservation of forest and wildlife.

State Environment Department

The Directorate of Environment deals with the promotion of environmental awareness in the State, co-ordinates pollution abatement projects for the Cauvery, Vaigai and Tamiraparani rivers, and the Chennai City waterways. It is also involved in the National Lake Conservation Programme, implementation of Coastal Zone Regulations and all aspects of environment other than those dealt by Tamil Nadu Pollution Control Board. To protect and improve the coastal environment and preventing environmental pollution in coastal areas of Tamil Nadu, a State Level Coastal Zone Management Authority (TNSCZA) has been established, where the Environment and Forests Department is the Chairman and Director of Environment as Member Secretary involving Engineering Experts and Scientists. River and Lake Conservation works are done by "Environment Management Agency of Tamil Nadu" (EMAT), an autonomous agency, constituted for coordination and liaising between National River Conservation Directorate,MoEF&CC,GoI and various implementing agencies for implementation of works under National River Action Plan and National Lake Conservation Plan (NLCP).

The Environmental Information System (ENVIS) Centre of the Department of Environment is engaged in collection, collation, storage, retrieval and dissemination of environmental information through the World Wide Web. State of Environment

(SoE) report preparation is another responsibility of the Department. A study on the climate change in Tamil Nadu has been taken up by the Department as it poses most serious threats to sustainable development with adverse impact on the food security, natural resources, environment, economic activity, human health and physical infrastructure.

National Biodiversity Authority (NBA) and State Biodiversity Board (SBB)

The National Biodiversity Authority (NBA) established in 2003 as an autonomous body to implement India's Biological Diversity Act (2002) with respect to regulatory and advisory function on issue of conservation, sustainable use of biological resource and fair equitable sharing of benefits of use. NBA delivers its mandate through a structure that comprises of the Authority, Secreteriat, SBBs, BMCs and Expert Committees. The State Biodiversity Board (SBB) focuses on:

1. Advising the State Government, subject to any guidelines issued by the Central Government, on matters relating to the conservation of biodiversity, sustainable use of its components and equitable sharing of the benefits arising out of the utilization of biological resources;
2. Regulates by granting of approvals or otherwise request for commercial utilization or bio-survey and bio-utilization of any biological resource by Indians.

Local Level Biodiversity Management Committees (BMCs) are responsible for promoting conservation, sustainable use and documentation of biological diversity including preservation of habitats, conservation of land races, folk varieties and cultivators, domesticated stocks and breeds of animals and micro-organisms, and chronicling of knowledge relating to biological diversity.

7.5 KEY POLICIES AND PROGRAMMES

The forests in Tamil Nadu are managed in line with the provisions of the National Forest Policy (1988) that has outlined the principles, concepts and approaches in forest management. The objectives of the Tamil Nadu Forest Policy are towards:

- Ensuring environmental and ecological stability of the State.
- Conservation of Biodiversity, wildlife and genetic resource.
- Rehabilitation and restoration of degraded forests
- Coastal eco-system conservation and management.
- Forest protection for resource management and augmentation.
- Enhancing tree cover outside forests for livelihood security.
- Water augmentation through forest conservation and catchment area management.
- Tribal development to ensure economic prosperity and ecological stability.
- Technology support, research and development for scientific forest management
- Forest extension for tree cover enhancement, outreach and conservation education for wildlife management.

- Forestry for rural energy security.
- Eco tourism for supporting conservation.
- Human resource development for forestry management.

For implementing the Forest Policy in Tamil Nadu and achieving its underlying objectives, the government is implementing

a) Specific Acts and Rules for protection and conservation of Forest and Biodiversity and
b) Implementing various developmental schemes for improving the existing growing stock and enriching the floral and faunal diversity.

Acts related to management of Forests

Tamil Nadu is one of the pioneer States in the field of Forest Protection. The oldest Central Legislation for protection and preservation of forest was Government Forest Act, 1865 enacted during British Rule, which was applicable only to Bengal, Assam, North-Western provinces, Oudh and Punjab, Central provinces and Bombay. Realizing the importance of limitation of this Act, Madras Presidency enacted a separate legislation in 1882 namely Madras Forest Act, 1882 (now Tamil Nadu Forest Act, 1882).This Act was enacted for Conservation of Forests in the then Madras Presidency. The following Acts and Rules are enforced to protect forest and wildlife in the State of Tamil Nadu:

- Tamil Nadu Forest Act, 1882 (For protection and management of Forest)
- Wildlife (Protection) Act, 1972 (For the protection of the Wild Animals, Birds and Plants)
- Forest (Conservation) Act, 1980 (To check further deforestation and to regulate the usage of Forest land for non-Forestry purpose)
- Tamil Nadu Prevention of Dangerous Activities of Bootleggers, Drug Offenders, Forest Offenders, Goondas, Immoral Traffic Offenders and Slum Grabbers Act, 1982 (commonly called Goondas Act). (For the protection of Forest)
- Tamil Nadu Rosewood Tree (Conservation) Act, 1994 (To protect and conserve the Rosewood Trees).

Rules

The following rules are framed and enforced under the provisions of said Acts, to achieve the objectives of above Acts

- Tamil Nadu Timber Transit Rules, 1968
- Tamil Nadu Sandalwood Transit Rules, 1967
- Tamil Nadu Sandalwood Possession Rules, 1970
- Tamil Nadu Timber (Movement Control) Order, 1982
- Tamil Nadu Maintenance of Accounts in Respect of Scheduled Timber for Industrial or Commercial Purposes Rules, 1988
- Tamil Nadu Wildlife (Transit) Rules, 1991
- Forest (Conservation) Rules, 1991
- Tamil Nadu Patta SandalWood Rules, 2008

- Tamil Nadu Regulation of Wood Based Industries Rules, 2010

The State of Tamil Nadu is regulating the felling of trees in private Forests and in hill areas, so as to prevent indiscriminate destruction of private Forests and to preserve the character of the hill areas by enforcing the provisions of the following Acts and Rules:

- Tamil Nadu Hill Area (Preservation of Trees) Act, 1955
- Tamil Nadu Preservation of Private Forest Rules, 1946
- Tamil Nadu Preservation of Private Forest Act, 1949
- Tamil Nadu Hill Areas (Preservation of Trees) Rules, 1957

Ongoing Programmes/schemes

State programmes for improving the ground stock and enriching the biodiversity of the State.

1. Nature Conservation
2. Community Waste Land Development Programme
3. Tamil Nadu Afforestation Project (Phase II)
4. Tamil Nadu Biodiversity Conservation and Greening Project
5. Sandalwood Plantation
6. Teakwood Plantation
7. Minor Forest Produce
8. Forest Research
9. Consolidation of Forests
10. Raising of free supply of seedlings
11. Erection of Solar Fence to protect the farm land from wild animals
12. Hill Area Development Programme
13. Eco-Development (Western Ghat Development Programme)
14. Asian Elephant Depredation and Mitigation Measures
15. Creation of fodder tree plantation in forest areas to improve the wildlife habitat
16. Eco-restoration and Conservation of Pallikaranai Marsh Land

Other than the State programmes and schemes, the Centrallysupportedones include:

1. Project Elephant
2. Project Tiger [KalakkadMundanthurai Tiger Reserve (KMTR) / Anamalai Tiger Reserve(ATR) /Mudumalai Tiger Reserve (MTR)]
3. Conservation and Management of Biosphere Reserves [GoMBR / Anamalai Biosphere Reserve (ABR) /Nilgiri Biosphere Reserve(NBR)]
4. Tamil Nadu Biodiversity conservation and Greening Project (TBGP)
5. Integrated Development of Wildlife Habitat – Wildlife Sanctuaries
6. Integrated Development of Wildlife Habitat – Bird Sanctuaries
7. Thirupudaimaruthur Bird Conservation Reserve

8. Conservation and Management of Mangroves and Coral Reef
9. Conservation and Management of Wetlands
10. Bamboo Mission
11. Urban Forestry

7.6 IMPACT OF CLIMATE CHANGE ON FORESTS AND BIODIVERSITY

Ecosystems and associated services are sensitive to changes in climate and anthropogenic changes. Forests as discussed earlier are subject to multiple stresses. Climate change brings an additional stress that can result in serious impacts on the forests.Increasingtemperatures usually result in an increase in the frequency of forest fires and pest and disease infestation in forests. Intermittent occurrences of drought and floods also result in an increase in soil erosion and degradation of the watershed, thereby affecting the forest cover. The changes in characteristics of ecosystems coupled with habitat degradation and fragmentation is likely to further weaken the ability of forests to continue to provide ecosystem goods and services.

Impact on Forests

Studies on impact of climate change on India's forests in 2030's and 2080's using IBIS with climate inputs from PRECIS run on A1B IPCC emission scenarios, indicate shifts in forest boundary, changes in species-assemblage or forest types, changes in net primary productivity, possible forest die-back in the transient phase, and potential loss or change in biodiversity (INCCA, 2010). Enhanced levels of carbondioxide are also projected to result in an increase in the net primary productivity (NPP) of forest ecosystems over more than 75 percent of the forest area (Table 7.4).

Table 7.4: Region wise Projections for Forests and Ecosystems by INCCA

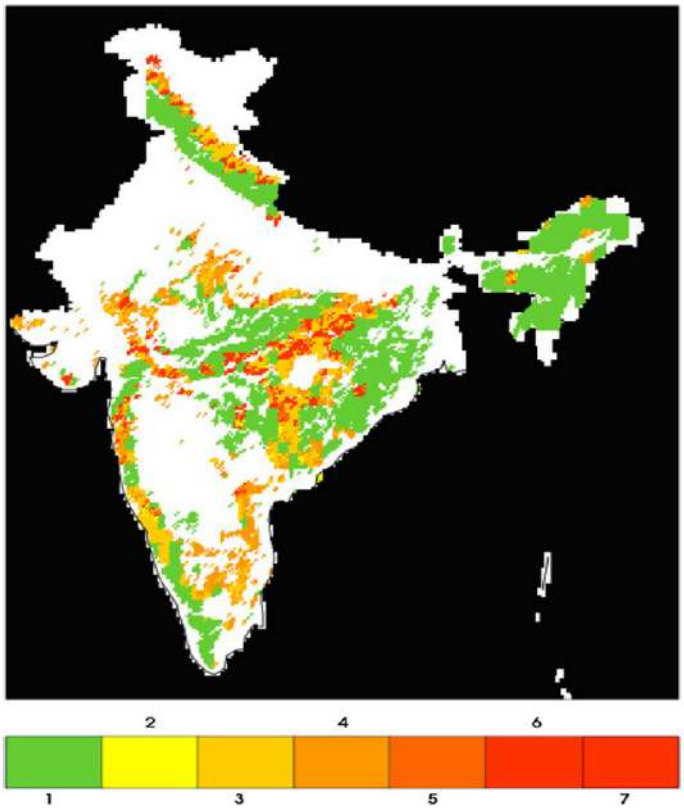
Regions	Change in Net Primary Productivity (NPP) by 2030	Vulnerability
Western Ghats	Average 20 percent increase in NPP	Moderately vulnerable
Coastal Region	Averaged 31 percent in NPP	Moderately vulnerable
North Eastern Region	Average 23 percent increase in NPP	Least vulnerable
Himalayan region	Average 57 percent increase in NPP	Most vulnerable

It is projected that in 2030's most of the forest biomes in India will be highly vulnerable to the projected change in climate and 70 percent of the vegetation in India is likely to find itself less than optimally adapted to its existing location, making it more vulnerable to the adverse climatic conditions as well as to the increased biotic stresses.

An India wide study carried out by Chaturvedi et al (2010), using IBIS with climate inputs from PRECIS run on A2 IPCC emission scenario, indicates, that the forests within Tamil Nadu are highly vulnerable due to climate change (Figure 7.7). The vulnerability index is varying between 4-7, which is associated with medium to

low forest crown cover i.e. fragmented forests, making it vulnerable to pest attacks and diseases prone and at risk of frequent fires.

Figure 7.7: Distribution of vulnerability index for A2 climate scenario



Source: Chaturvedi et al, 2010

Impact on forest soils

With the exception of the hills and coast, Tamil Nadu is classified as a hot semi-arid eco-region with red loamy soils, i.e.,H1 D2 of the agro-eco-region by the National Bureau of Soils and Land Use. Under the same scheme of classification, the coastal belt falls within hot sub-humid to semi-arid eco-region with coastal alluvial-derived soils (S7 CD2-5), and the Western Ghats falls with the hot humid to humid eco-region with red, lateritic and alluvium derived soils (E2 B/A5). Within this broad scheme, there are 94 soil types (JAICA, 2010).

Organic carbon density sampling undertaken in three representative locations from 32 different representative forest sub-types selected in Tamil Nadu, Kerala and Andaman Islands, covering 9 major forest types, and in different locations outside forests under different land use systems namely agriculture, horticulture, agroforestry and plantation indicate that among different forest types, moist and wet forests stored greater soil organic carbon(SOC),when compared to dry forests. This matches with the Indian Council of Forestry Research and Education (ICFRE) on mean soil carbon density, which recorded least value in Tropical Thorn Forests. Forest ecosystems in hills and mountain areas, as well as certain physiographic regions which appear to be the most conducive soil-climatic environment for higher

accumulation of organic carbon, thus helping in maintaining the soil quality. Diverting such areas for agricultural activity to produce more food grains will make the soil unhealthy by decomposition of organic carbon due to increase in soil temperature.

The succession of forests from wet and moist to dry types due to climate change as well as land use change from forest to non-forests will lead to loss in organic carbon in soil and is associated with consequent physical degradation of the land. Though natural forests and pure plantations sequester more carbon and hence are better options for reducing atmospheric carbon. They cannot be extended to large areas due to population pressure and high demand for land for agricultural and other purposes. Therefore, Agroforestry system seems to be the best alternative to sequester atmospheric carbon and simultaneously harness economic benefits to the society. The potential for Agroforestry systems for carbon locking differs not only with the type of species, but also with different agro climatic zones.

Impacts on grassland, mangroves, wetland, and coral reefs

According Sukumar *et al* (2004), increasing atmospheric carbondioxide(CO_2) levels is projected to favour C3 plants over C4 grasses, but the projected increase in temperature would favour C4 plants. C3 plants include cool, temperate grasses and practically all woody dicots, while C4 plants include warm, tropical grasses, many types of sedge and some dicots. The C4 plants that constitute much of the biomass of tropical grasslands, including the arid, semi-arid and moist grasslands in India, thrive well under conditions of lower atmospheric CO2 levels, higher temperatures and lower soil moisture, while C3 plants exhibit the opposing traits.

Mangroves form an important part of the forest ecosystem mainly distributed along the east coast. Studies indicate that the extent and composition of mangroves in India may undergo major change, depending on the rate of climate change and anthropogenic activities. Impact on mangrove forests will depend upon the rate of sea level rise and sediment supply from rivers, storm surges, and fresh-water flows in rivers. The rise in sea - level would submerge the mangroves as well as increase the salinity of the wetland.

Implications of climate change on Gulf of Mannar Biosphere Reserve

In the year 1989, the area between Rameswaram and Kanyakumari covering 10,500 sq.km was declared as the Gulf of Mannar Biosphere Reserve by the Government of India because of the rich biodiversity (over 4000 species of fauna and flora). The total reef area in the Gulf of Mannar is about 110 sq.km and out of this, about 32 sq.km area has already been degraded due to various human induced and natural impact over past 4-5 decades. The reef area has a depth of 0.5-3 m, and the sea surface temperatures (SST) in this region during the summer (April - June), varies between 31.0^{o} C and 33.5^{o} C.

Coral bleaching, as a result of elevated SSTs, has been noticed during summer every year since 2005. Studies carried out during 2005-09, indicate that the average percentage of bleached corals during 2005, 2006, 2007, 2008 and 2009 were 14.6, 15.6, 12.9, 10.5 and 8.93 percent respectively. The water temperature during these years started to increase in March and once it reached 31° C in mid

April, coral bleaching occurred. Massive corals especially *Porites sp.* were the first to be affected and the other dominant coral species partially or fully bleached were *Acropora cytherea, A. formosa, A. intermedia, A. nobilis, Montipora foliosa, M. digitata and Pocillopora damicornis.* This pattern was similar every year, apart from slight differences in mean temperatures recorded (Patterson, 2009).

The bleaching was not uniform every year, in terms of area and depth, but the pattern was same. Dependent on rainfall and winds, recovery began during June-July and completed in 1-4 months. The branching corals recovered quickly after temperature reduction, but massive corals took longer time. The fastest recovered coral size groups were 40-80 cm and 80-160 cm. There was no coral mortality in 3 years due to elevated SST, but 80 percent of the bleached recruits were dead in 2007 (Patterson et al., 2008).

A preliminary study had been conducted on the "Effect of climate change on big-jawed jumper, *Lactarius lactarius* fishery (Patterson and Deepak, 2004), which showed tremendous loss in catch, for example 1028 tonnes in 1969 and 175 tonnes in 1993 and change of fishing ground. Rain water plays a most important role in the productivity of the coastal environment because it flushes all the nutrients of lithogenous origin entering into the hydrogenous system of rivers. The river water finally finds the sea forming estuarine complex near the mouth region. The estuarine area, thus provide ideal shelter and required food for all larvae, juveniles, fry and fingerlings of fin and shellfishes. The entire Tuticorin coastal region has not received any proper rainfall for the past 7 years. El Nino in 1998 has caused a change in the climatic pattern by an increase in the temperature and at the same time a decrease in rainfall. The actual habitat of the *Lactarius lactarius* is silty soil that is found near estuarine region (silty clay) and in the outer reef areas. Since there is reduction in production of the coastal waters coupled with various human induced threats in this part of the country, these fishes have shifted their breeding grounds to deeper waters. Though there is a huge loss to fishery industry, there are no concrete scientific details on this loss of fishery resources due to climate except the preliminary work on *Lactaruis* fishery.

Traditional Agriculture

Wild relatives of domesticated crops are found in forests, forest edges and fallows. These form an important tool for enriching domesticated crops and varieties. Such material need to be identified, screened, protected so that they can be put to use in the future. Several tribal communities in the Eastern and Western Ghats continue to widely practice elements of agriculture that have their strong roots in traditional knowledge, practices and experience. Some of these elements include plant and animal genetic resources related to food, collection and use of medicinal plants from forests, fields and fallows that contribute to health and nutritional security. Other important knowledge rests with the use of tree species and fishes and other water living organisms.The Kangayam, Umbalamcherry,Pulikulam are some of the well known native breeds of cattle. These animals are on the verge of extinction. They are sturdy, can withstand heat, use less water and survive on poor quality feed are reared on unique land use practices like Korangadu in Erode, Dharapuram and parts of Coimbatore districts that aid in the survival of some these

breeds. Efforts need to be made to nurture some of these in a conscious manner to be able to deal with the vagaries of weather and climate.

Only a fraction of the knowledge has been documented and recorded by researchers and professionals. A large amount of knowledge, information and practical experience remains undocumented and is fast disappearing. These need to be documented, nurtured and put to use by the communities and also others within the framework of climate change. Sometimes practices such as common labour pool units in agriculture and forestry can potentially serve as models for social adaptation to climate change.

Pastoralists in Tamil Nadu

Tamil Nadu has several pastoral groups that migrate and criss-cross the State with their herds of cattle, sheep and other livestock including ducks. A large number of these migrant groups of herders possess rich traditional knowledge, while making select use of modern tools, techniques and breeds. Seasonal migration is indeed both an adaptation and a tool of adaptation to changes in weather and climate. Documentation and use of knowledge of these groups can prove beneficial to deal with climate change.

Impact on traditional honey tappers

Several tribal communities who are spread across the Western and Eastern Ghats and the coastal plains of Tamil Nadu tap honey seasonally to fulfil their livelihood needs. These include the JenuKurumbars, Paliyars, Kattunayakas, Muthuvans, Irulas and Malaiyalis. Numerous techniques, traditional knowledge and tools are used by these traditional communities to tap honey. Their knowledge of different species and types of honey, tracking methods, trapping methods are vast. In addition they have a rich repository of ritual songs and stories related to honey tapping. While it is true that forest based livelihoods are being gradually phased out, climate change is likely to affect honey production and thereby have a bearing on the livelihoods of some of these tribal communities. At a recent meeting held at Hotel Hyatt in Chennai, 75 members belonging to three tribal communities tapping honey expressed some of the problems faced by them during recent times. In some locations near Theni district they described increased wind speed as a cause for concern, since bee hives located on tall trees were being destroyed. Whether local deforestation is the cause or indeed increases in wind speed is the cause needs careful investigation. Similarly many of the members expressed their concern about the increase in forest fires in recent years as one of the causes for reduced number of colonies. Studies conducted by the Indian Institute of Science indicated that forest fires in dry deciduous forests are likely to increase in the years to come due to increased dryness. Some of the members expressed that forests have become drier in recent times corroborating the views of scientists and also attribute it to the current drought. They suggested creation of water bodies inside forests to enable beings in the wild to survive better

Impact on Non-Timber Forest Produce (NTFP)

NTFP contributes to about 20 percent to 40 percent of the annual income of forest dwellers who are most disadvantaged landless communities and are the dominant population of tribals. Most of the NTFPs are collected and used/sold by women, and so has a strong linkage to women's financial empowerment in the forest-fringe areas. However depleting resource base either because of diversion of forest land for non-forest use, or due to unsustainable harvesting practices has been the major ecological challenge in the NTFP sector. Various research data suggest changes in temperature and rainfall pattern that affects the NTFP production-both qualitatively and quantitatively (example, lac, honey) which in turn affect the dependent economy of the local people. Suitable strategies require understanding of the level of vulnerability and adaptation measures that needs to be in future. Mapping of vulnerability to NTFP management and livelihood – change monitoring, bio-geographic region specific adaptation model requires further understanding.

7.7 STRATEGIES FOR ADAPTATION TO CLIMATE CHANGE

The Green India Mission aims to respond to climate change by increasing forest/ tree cover on 5 m ha of forest/non-forest lands and improved quality of forest cover on another 5 m ha (a total of 10 m ha). This strategy along with key innovative actions is envisaged to lead towards enhancement of carbon sinks in sustainably managed forests and other ecosystems; help vulnerable species/ecosystems adapt to the changing climate; and help forest dependant local communities adapt to climate change.

The Government of Tamil Nadu, taking the Green India Mission as a guidance, also would address the climate change concerns by following the strategies given below:

1. Increase the forest cover, both inside and outside notified forest areas.
2. Enhancing Conservation efforts to sustain biodiversity- terrestrial and marine.
3. Creation of the plant diversity register of Tamil Nadu forests for documentation and associated traditional knowledge.
4. Undertake lower strata diversification
5. Management of forest fires and Alien Invasive Species (AIS)
6. Build capacity to address climate change by supporting innovation and Research to address the impact of climate change on forest & biodiversity and ecosystem services
7. Undertake awareness generation and capacity building activities that prepare institutions and communities to address the climate change concern

7.8 BUDGET REQUIREMENT FOR STRATEGIES IN FOREST AND BIODIVERSITY SECTOR

The total cost for implementing the strategies during the 12th Five Year Plan (FYP) is Rs.1567.19 crore of which Rs.39.19 crore is proposed for specific research activities and during the 13th Five Year Plan (FYP) is Rs. 1990.00 crore.(Table7.5)

Table 7.5: Summary of budget requirement for forest and biodiversity sector

Sl.No.		Cost for 12th FYP (crore)	Cost for 13th FYP (crore)
1	Increasing the forest cover, both inside and outside notified forest areas through afforestation programmes as well as restoration of degraded forests	**650**	**675**
2	Enhancing Biodiversity Conservation efforts: *in situ / ex situ* (Protected Area and Reserved Forests) under TBGP	**300**	**367**
3	Coastal & marine biodiversity conservation	**140**	**280**
4	Creation of Biodiversity Registers	**260**	**390**
5	Lower strata diversification	**30**	**44**
6	Management of forest fires and Alien Invasive Species (AIS)	**90**	**145**
7	Research &capacity building on impact of climate change on forest & biodiversity &ecosystem services	**40**	**59**
8	Awareness generation and capacity building on climate change for integrating CC in governance	**18**	**30**
	TOTAL	**1528**	**1990**
	Specific Research & related Capacity Building Activities and budgets	**39.19**	**-**
	Grand Total	**1567.19**	**1990**

The details of the strategies are given in Tables 7.6 and 7.7 respectively.

Table 7.6: Detailed Budget for Strategies in Forests and Biodiversity Sector

S. No	Strategy	Agency	Cost for 12th FYP (Rupees in crore)	Cost for 13th FYP (Rupees in crore)
Strategy 1:Increasing the forest cover, both inside and outside notified forest areas through afforestation programmes as well as restoration of degraded forests				
1.1	Participatory Forest Management or Joint Forest Management (JFM)	DoF	**200**	**200**
1.2	Promotion of Industrial and Energy Plantation (PPP)	DoF & DoI	**200**	**200**
1.3	Promotion of Climate Resilient Agro and Farm Forestry(PPP)	DoF,DoA	**200**	**200**
1.4	Regeneration of Sandal wood:(a) On degraded forest area in sandalwood Belt ;(b) On farmlands in sandalwood tract	DoF	**50**	**75**
		SUB TOTAL	**650**	**675**
Strategy 2: Enhancing Biodiversity Conservation efforts: *In situ / ex situ* (both inside the Protected Area as well as in other Reserved Forests) under Tamil Nadu Biodiversity conservation and Greening Project (TBGP)				
2.1	Biodiversity Conservation: (both inside Protected Areas as well as in Reserved Forests) including Shola Forest	DoF,TNAU+other agency identified by DOF	**200**	**220**
2.2	Establishment of fodder banks in the Protected Areas as well as in other Reserved Forests	DoF,TNAU+other agency identified by DOF	**50**	**75**
2.3	Greening of villages and Establishment of Village Seed Banks	Dept. of Plant Genetic Resources,TNAU	**10**	**15**
2.4	Conservation of genetic resources by screening and preserving existing wild germplasm for developing climate resilient varieties	DoF &TN State Biodiversity Board	**5**	**7**
2.5	Training and extension activities to develop institutional capacity for biodiversity conservation and ecosystem management	Dept. of Plant Genetic Resources,TNAU	**5**	**7**

S. No	Strategy	Agency	Cost for 12th FYP (Rupees in crore)	Cost for 13th FYP (Rupees in crore)
2.6	Collection, conservation and documentation of in Nilgiris, Kolli hills, Kodaikanal (Shola Forests), Kalakkad-Mundathurai Tiger Reserve (KMTR)	DoF,TNAU+ other agency identified by DOF	**10**	**15**
2.7	Strengthening the *ex situ* conservation facilities: Gene Banks	DPGR, TNAU	**5**	**7**
2.8	R & D on orthodox and recalcitrant seeds cryopreservation for long term storage - Establishing Cryopreservation facilities	TNAU	**5**	**7**
2.9	Renewable power generation for powering the freezer facility	TNAU	**5**	**7**
2.10	Establishment of biodiversity corridors / species garden for education purpose	DOF	**5**	**7**
		SUB TOTAL	**300**	**367**
Strategy 3: Coastal & marine biodiversity conservation				
3.1	Conducting regular assessment & monitoring of Coral reef as indicator species	DoE,DoF,GoMBR	**20**	**40**
3.2	Coral rehabilitation using resilient&resistant native species	DoE,DoF,GoMBR	**50**	**100**
3.3	Alternative livelihood for reef associated fishery dependent people	DoE,DoF,GoMBR	**50**	**100**
3.4	Conservation of mangroves and associated biodiversity	DoE,DoF,GoMBR	**20**	**40**
		SUB TOTAL	**140**	**280**
Strategy 4: Creation of Biodiversity Registers				
4.1	Mapping of floral and faunal biodiversity in State at a high spatial resolution incorporating GPS coordinates and on GIS platform	TNAU,NBA	**100**	**150**
4.2	Creation of Peoples Biodiversity Register - BMC level (Panchayat)	NBA.TNAU	**50**	**75**
4.3	Identification, conservation and protection of biodiversity of heritage sites (10 sites) and ecologically sensitive districts (9) as suggested by the Gadgil Committee.	DoF, DoE,NBA,TNSBB	**100**	**150**
4.4	Disseminate - includes devising access and benefit sharing mechanisms of resources and indigenous knowledge with communities dependent on the same	DoF, TNSBB	**10**	**15**
		SUB TOTAL	**260**	**390**

S. No	Strategy	Agency	Cost for 12th FYP (Rupees in crore)	Cost for 13th FYP (Rupees in crore)
Strategy 5: Lower strata diversification				
5.1	Identification of suitable fodder genotypes by evaluating existing germplasm-Germplasm collection and documentation	TNAU, DoF	**10**	**15**
5.2	Intensive evaluation of the collected forage germplasm suitable to the different ecosystem and testing for climate resilience-Screening of germplasm	TNAU, DoF	**5**	**7**
5.3	Large scale multiplication of seeds	DoF	**5**	**7**
5.4	Large scale testing – field trials in different agroclimatic zones where degraded forests with invasive species are identified-Approx 3 sites for each agroclimatic zones will be selected	TNAU,DoF	**10**	**15**
		SUB TOTAL	**30**	**44**
Strategy 6: Management of forest fires and Alien Invasive Species (AIS)				
6.1	Training,field review of AIS management :Procure partners; Training on management of AIS with field review of species (TNFD staff) ;Strategy and manual on management of AIS (in English and Tamil)	DOF	**10**	**15**
6.2	Survey, monitoring and reporting-Baseline survey of biodiversity in critical habitats prior to removal of ALS;Enter georeferred data in biodiversity database/ GIS	DOF	**10**	**15**
6.3	Removal of AIS ;Phased removal of Lantana, Prosopis from dry forest ;Phased removal of wattle from Shola ecosystem in the hills	DOF	**10**	**20**
6.4	Monitoring biodiversity in critical habitats after removal of ALS;Monitor impact of fencing and removal of exotics from shoal and grassland habitats	DOF	**10**	**20**
6.5	Strengthening fire fighting infrastructure to address Forest Fires	DOF	**50**	**75**
		SUB TOTAL	**90**	**145**

S.No	Strategy	Agency	Cost for 12th FYP (Rupees in crore)	Cost for 13th FYP (Rupees in crore)
Strategy 7: Research &capacity building on impact of climate change on forest & biodiversity &ecosystem services				
7.1	Estimating mitigation potential of forest in Tamil Nadu	DOF, Revenue Dept., DoE	**10**	**15**
7.2	Intensification of research on forest plant diversity conservation and utilisation to identify climate resilient plants.	DOF, NBA, MSE MIDS, TNAU	**10**	**15**
7.3	Valuation of bio resources in 3 ecosystems; Coastal;Wetland ;Forest	GoMBRT;MRI; ZSI	**10**	**15**
7.4	Focused research on impact of climate change on coral reefs and associated biodiversity	GoMBRT	**5**	**7**
7.5	Capacity building and dissemination activities	DoF	**5**	**7**
		SUB TOTAL	**40**	**59**
Strategy 8: Awareness generation and capacity building on climate change for integrating CC in governance				
8.1	Creating awareness on climate change impact on forest to rural poor, farmers, farm labourers and people lives in forest fringes by training, field visits, and field demonstrations.	DOF	**3**	**5**
8.2	Creating awareness on climate change and resilient mechanism through forestry by appropriately training NGOs, self-help groups, etc.	DOF	**3**	**5**
8.3	Capacity building through seminars and trainings for scientists and researchers to meet the challenges of climate change	DOF	**3**	**5**
8.4	Capacity building through training to forestry field staff, managers	DOF	**3**	**5**
8.5	Awareness building among all stakeholders in Gulf of Mannar Biosphere Reserve	DOF	**3**	**5**
8.6	Capacity building of frontline conservation staff and community in Gulf of Mannar Biosphere Reserve	DOF	**3**	**5**
		SUB TOTAL	**18**	**30**
		TOTAL	**1528**	**1990**

Table 7.7: Specific Research & related Capacity Building Activities and budgets

S. No	Research Programs	Institutes Involved	Approx. Budget (Rs. in crore)	Plan period	Location & area of coverage	Input requirement	Capacity building
1.	Developing & promoting climate resilient agro forestry & farm forestry methodologies for mitigating climate change	Forest College and Research Institute(FC&RI), Mettupalayam; TNAU; NGOs	10.25	12^{th}-13^{th} FYP	Semi arid regions of Tamil Nadu 500 acres	Region specific nurseries -4 Drip irrigation facilities GIS software	Training to farmers, NGOs, field staff of Agrl. Horti. & DoF
2.	Promotion of region specific tree plantation for higher carbon sequestration under climate change affected situation in TN	(FC&RI), MTU DoF;Institute of Forest Genetics and Tree Breeding(IFGTB)	13.48	12^{th}-13^{th} FYP	All agro climatic regions of Tamil Nadu	Demonstrating 600 acres of pln;Drip irrigation facilities Region specific nurseries OTC chamber	Training to farmers, NGOs, field staff of Agrl. Horti. &DoF
3.	Long term monitoring of forest biodiversity due to climate change	(FC&RI), MTU DoF;Botanical Survey of India	1.38	12^{th}-13^{th} FYP	All forest types of Tamil Nadu	Long term monitor-ing plots of 1 ha size forest types Biodiversity assessment software	Training to DoF staff
4.	Estimating carbon sequestration potential of forest types in TN through long term obsern plots	(FC&RI), MTU; DoF	3.5	12^{th}-13^{th} FYP	All forest types of Tamil Nadu	Carbon analyser Soil respiration instrument	Training to scientists DoF staff
5.	Estimation of biodiversity and Conservation of endangered / over exploited trees in agroforestry settings in TN	(FC&RI), MTU; DoF;Botanical Survey of India	2.3	12^{th}-13^{th} FYP	All agro climatic regions of TN	Development of ex-situ and in-situ tree conservation garden;	Training to scientists DoF staff

S. No	Research Programs	Institutes Involved	Approx. Budget (Rs. in crore)	Plan period	Location & area of coverage	Input requirement	Capacity building
6.	Urban forestry and carbon sequestration potential in Tamil Nadu	(FC&RI), MTU;	1.8	12th-13th FYP	All city corporations of Tamil Nadu	GIS facilities Avenue tree Planting	Training to school, colleges, corporation officials, DoF
7.	Assessing pest and diseases incidences in Tamil Nadu forest due to climate change	(FC&RI), MTU TNAU	0.78	12th-13th FYP	All forest types of Tamil Nadu	Pest and disease assessment through long term monitoring plots in forest types of TN	Training to scientist, DoF personnel
8.	Assessing invasive species in forest due to climate change	(FC&RI), MTU TNAU	1.5	12th-13th FYP	All forest types of Tamil Nadu	Assessment of invasive species through long term monitoring plots in forest types of TN	Training to scientist, DoF personnel
9.	Assessing Micro floral diversity under the climate change Scenario	(FC&RI), MTU	0.80	12th-13th FYP	All forest types of Tamil Nadu	Assessing micro flora and fauna in forest floor and their diversity	Training to scientist, DoF personnel
10.	Training&Capacity building on Forest and climate change adaptations	(FC&RI), MTU TNAU Institute of Forest genetics and Tree Breeding	2.5	12th-13th FYP	All districts of Tamil Nadu	Training, Demonstrations, field visit	Training to farmers, NGOs, staff of Agrl. Horti. and DoF school, colleges
11.	Documentation of Honey Tappers perception of environmental change from selected forest zones in TN and suggested field actions	MSSRF;Save the Eastern Ghats Org (SEGO) Sramani Institute	0.15				

S. No	Research Programs	Institutes Involved	Approx. Budget (Rs. in crore)	Plan period	Location & area of coverage	Input requirement	Capacity building
12.	Documentation of perceptions of pastoralist holding native breeds of livestock about environmental change from selected agro-ecological zones of TN	MSSRF Kangayam Cattle Research Foundation Sramani Institute	0.15				
13.	Mapping Contemporary Traditional Agriculture/ existing tree flowering stages and hotspots for honey tappers in Eastern Ghats of TN and identification of good practices for adaptation	MSSRF;Save the Eastern Ghats Org (SEGO) Sramani Institute	0.30				
14.	Local technology demonstration and dissemination to add value of the product through initiation of stakeholder consultation and; Design policy instrument to larger scale beneficiaries	MSSRF;Save the Eastern Ghats Org (SEGO) Sramani Institute	0.30				
	Grand TOTAL		**39.19**				

8. COASTAL AREA MANAGEMENT

8.1 COASTAL ZONE PROFILE

Population Density, Agro-climatic Zones and Land Use

The Coastal Zone can physically and geographically be described as a corridor where the land and adjacent ocean meet. Functionally, it is the area of interaction between land and sea where production, consumption, recreation and exchange processes of climate change takes place. Ecologically, the coastal zone is an area of dynamic biological, hydraulic, geological and chemical activities that support various human activities.

This zone has been exploited by mankind quite intensively leading to its degradation, and the main drivers of degradation being population pressure, waste water disposal, destruction of mangroves, Increasing urbanization, solid waste disposal, coastal constructions, natural disasters, operation of Ports, coastal erosion, atmospheric pollution, aquaculture, tourism, ingress of sea water, coastal mining, power plant operations, sea level rise and coastal highways.

Figure 8.1: Coastal districts of Tamil Nadu

The Tamil Nadu coast is 1076 km long along the Bay of Bengal. The continental shelf extends to about 41000 sq.km. The exclusive economic zone covers an area of 0.19 million sq.km into the sea. The coastal part of the State covers an area of approximately 4456 sq.km. (Table 8.1).

Table 8.1 : Coastal Information

Sl. No	Description	Tamil Nadu		
		East Coast	West Coast	Total
1	Coastal Length (km)	1016	60	1076
2	Continental shelf (sq.km)			41412
	Up to 50 m depth	22411	844	23255
	51m to 200m depth	11205	6952	18157
3	Exclusive Economic Zone (million sq.km) Extends to 200 nautical miles from shore	-	-	0.19
4	Territorial Waters (sq.km) approximately	-	-	19000

The coast is along the eastern side of the State across 12 districts, the State capital Chennai and the union territory of Puducherry lie along the coast line(Figure 8.1), having high population density, which ranges from as low as 320 people per sq.km to more than 3000 people per sq.km. The population density distribution is shown in Table 8.2.The other districts in Tamil Nadu have population density varying between 300 to 800 persons per sq.km.

The coastal region of the State falls into the following agro-climatic zones - North Eastern Zone, Cauvery Delta Zone and Southern Zone. In terms of land use, the State's coastal zone is divided into 59 categories. Table 8.3 gives the area covered under each land use. As can be seen, the coastal zone is dotted with habitations, industries, desalination plants, power plants, Ports and mining operations, and airport amongst many other anthropogenic influences.

Table 8.2: Population density along the Tamil Nadu coast line

District/State capital	Population density(pop/sq.km)	Agro climatic zone
Thiruvallur	1049	North Eastern zone
Chennai	26903	North Eastern zone
Kancheepuram	927	North eastern zone
Villupuram	482	North eastern zone
Cuddalore	702	North eastern zone/ Cauvery delta zone
Nagapattinam	668	Cauvery delta zone
Thanjavur	691	Cauvery delta zone
Thiruvarur	533	Cauvery delta zone
Pudukottai	348	Cauvery delta zone
Ramanathapuram	320	Southern zone
Thoothukudi	378	Southern zone
Tirunelveli	458	Southern zone
Kanyakumari	1106	Southern zone
Puducherry	3232	Southern zone

Table 8.3: Statistics for coastal land use of Tamil Nadu (2011 data)

Sl. No.	Land use	Area in ha
1	Mud Flat/Tidal-Flat	1728.53
2	Sub-Tidal	1037.31
3	Inter-Tidal	638.66
4	High-Tidal	1990.68
5	Beach/Patch	3060.57
6	Spit	1.32
7	Bar/Barrier/Island	1255.21
8	Beach-Ridge	9.88
9	Rocky-Coast	63.08
10	Rock-Exposure	15.15
11	Mangrove-Very-Dense	1767.48
12	Mangrove-Dense	2242.85
13	Mangrove-Sparse	3846.62

Sl. No.	Land use	Area in ha
14	Mangrove-Degraded	351.23
15	Salt-Marsh/Marsh-Veg	512.97
16	Salt-Marsh/Marsh-Veg-Dense	559.97
17	Salt-Marsh/Marsh-Veg-Moderate	1493.78
18	Salt-Marsh/Marsh-Veg-Sparse	666.73
19	Mud-with-Vegetation	12336.19
20	Sand-with-Vegetation	5957.86
21	Scrub-Dense	7310.25
22	Scrub-Sparse	17324.97
23	Scrub-Degraded	6515.28
24	Estuary	3699.95
25	Creek	17047.68
26	Lagoon	2986.40
27	Bay	3282.34
28	Pond/Lake	1557.76
29	Oxbow-Lake	27.91
30	Cooling-Pond	20.46
31	Water-Treatment-Plant	90.85
32	River/Stream	5953.94
33	Canal	1280.96
34	Waterlogged	2032.11
35	Reservoir/Tank	19801.88
36	Mining-Areas/Dumps	518.18
37	Rock-Outcrops/Gullied/Eroded/B	188.59
38	Brick-Kiln	0.96
39	Sandy-Area	1541.92
40	Saline-Area	113.09
41	Dune-with-Vegetation	21344.55
42	Dune-without-Vegetation	9271.30
43	Habitation	2747.70
44	Habitation-with-Vegetation	35231.80
45	Open/Vacant-Land	2251.69
46	Industrial-Area	5368.89
47	Educational Institute-Others	884.64
48	Waste-Dumping	1114.48
49	Port/Harbour/Jetty	1219.98
50	AirPort	80.21
51	Railways	60.64
52	Railway Yard	261.40
53	Agricultural-Land	123774.69
54	Plantations	80318.36
55	Forest/Plantation	3295.12
56	Other-Features	607.52
57	Aquaculture-Ponds	8081.32
58	Salt-Pans	18847.35
59	Seawall/Embankment	104.46
	TOTAL	**445697.63**

Geomorphology and Coastal Oceanographic Features

The coastline of Tamil Nadu and Pondicherry comprises a number of cusps, spits and wave cut platforms and several palaeo-shorelines. Some of the palaeo-shorelines extend inland suggesting periods of transgression and regression. The on-going geodynamic process is generally progradation along the coast, which is modified at several places by erosion and deposition by aeolian and fluvial agents. The eastern areas of the central part of the State are marked by the depositional regime of many rivers manifested by typical fluvial features like levees, channel bars and palaeo channels, back swamps and vast flood plains.

The east coast of India experiences two phases of stormy conditions during south west and north east monsoons, the south Tamil Nadu coast comparatively less sediment transport due to the presence of shallow Palk Bay, Gulf of Mannar and the Sri Lanka Island. They significantly control the long shore sediment transport along the south Tamil Nadu coast particularly form Kanyakumari to Tiruchendur region.

Coastal Development, Infrastructure, and Resources

The State's coast is not only rich in a variety of resources, but is also highly developed, with extensive infrastructure assets.

Ports and Harbours:

The State has substantive Ports and harbour infrastructure. While major Ports are under the control of the Government of India, minor Ports are under the control of Tamil Nadu Maritime Board. Major Ports include Chennai Port, the third oldest Port among the 12 major Ports, V.O. Chidambaranar Port (Thoothukudi Port), and Ennore Port. Minor Ports include Cuddalore and Nagapattinam. Pamban Port, Thiruchopuram Port, Tirukkadaiyur Port, Punnakkayal Port, Kanyakumari Port, Ennore Minor Port, PY-3 Oil Field (offshore Port), Rameswaram Port, Valinokkam Port, Colachel Port, Kattupalli Port, Manappad Port, and the Kudankulam Port.

Urbanization and Habitats:

The State has several major urban agglomerations on the coast. Chennai, the capital City of Tamil Nadu is the fourth largest Metropolitan City in India. Located on the Coromandel Coast off the Bay of Bengal, it is a major commercial, cultural, and educational centre in South India. Chennai has also witnessed unprecedented growth of population due to the development of information technology, business process outsourcing, computer related activities in addition to the already existing roles like location of the head of the government, concentration of various service activities, successive Climate Change implementation of various government policies for the development of small and medium industries, informal activities, development of entrepreneurial activities etc.

Cuddalore is located at the estuary of Gadilam and Ponnaiyar river. It is a fast growing industrial city and headquarters of Cuddalore district and has a large number of industries which employ large number of the city's population.

Nagapattinam is a town in Tamil Nadu and the administrative headquarters of Nagapattinam District. It is a prominent sea Port on the east coast of India and an important centre of trade and commerce. Sea borne trade and fishing are the major sources of income for the town.

River:

Kaduvayar runs near the town and joins in the Bay of Bengal near the Port. Thoothukudi is also known as "Pearl City". This city is also called as gateway of Tamil Nadu. The major harbour of Thoothukudi is well known as a pearl diving and fishing centre. The rapid increase in fisheries and industrial development led to the rapid urbanisation of this city.

Tourism:

The Tamil Nadu coast has lot of tourism potential sites; the tourism activities can be broadly classified into recreational, religious, archaeological and monuments/memorials. The important tourist hubs on the Tamil Nadu coast area are Mahabalipuram, Rameswaram, and Kanyakumari. Each of these gets large numbers of domestic and international visitors every year.

Energy:

The State's coast also hosts many major energy sector facilities including nuclear, thermal and wind power installations. The Madras Atomic Power Station (Indra Gandhi Centre for Atomic Research (IGCAR)) located at Kalpakkam about 80 km (50 miles) south of Chennai on the Coromandal coast is India's first fully indigenously constructed nuclear power station under the Department of Atomic Energy, Government of India. Kudankulam Atomic Power Project is a nuclear power station under construction in Kudankulam in the Tirunelveli district of the southern part of Tamil Nadu. It is an Inter-Governmental Agreement between India and Russia.

The North Chennai Thermal Power Station is situated about 25 km from Chennai on Northern side has a total installed capacity of 630 M.W comprising of 3 units of 210 M.W each. All the three units are coal based. The Ennore Thermal Power Station (ETPS) has a total installed capacity of 450 M.W, comprising 2 X 60 M.W and 3X110 M.W units. Thoothukudi Thermal Power Station (TTPS) is situated near the new Port of Thoothukudi on the sea shore of Bay of Bengal and spread over an area of 160 Ha. TTPS has a total installed capacity of 1050 M.W comprising of 5 units of 210 M.W each. The units are all coal based. The Basin Bridge Gas Turbine Power Station is located in Chennai about 3 km north of Chennai Central. The Units can be operated by multi fuels, such as Naphtha and Natural Gas with a Capacity of 120 MW. The Thirumakottai Gas Turbine Power Station is one of the most important gas turbine thermal power plants in Tamil Nadu; the power generated from this plant improves the voltage and grid stability of neighbouring areas. It has a capacity of 108.88 MW.The Kuttralam Gas Turbine Power Station is located near Mayiladuthurai, with a total grid capacity is 101 MW is the power output by the gas turbine and the steam turbine. The Valathur Gas Turbine Power Stations - I and II located at Valathur in Ramanathapuram District and has the capacities of 95 MW

and 92 MW respectively. Likewise, the Aban Combined Cycle Power Plant under Lanco is located in the Karuppur village of Thanjavur District, with generation capacity of 120 MW. Similarly, the PPN Combined Cycle Power Plants at Pillaiperumalnallur and Manickapangu villages, in Nagapattinam District operate at 330.5 MW. Also, the GMR VASAVI Diesel Power Plant located in Chennai and has the world's largest diesel engine driven electric power plant with a capacity of 200 MW power generation.

In terms of wind energy, of the country's total installed capacity, around 45 percent is contributed by Tamil Nadu. In coastal areas, windmills are located in places near Kanyakumari, Radhapuram and Muppandal in Aralvoimozhi Pass. Tamil Nadu's total wind potential is 5374 MW and the installed Capacity is 5901 MW up to March 2011.The Wind season in Tamil Nadu normally is between May and September.

Fisheries and fishery infrastructure:

Tamil Nadu has a coastal length of 1076 km and surrounded by Bay of Bengal, Indian Ocean and Arabian Sea. The coast has a huge potential of fisheries resources. The Tamil Nadu coast has nearly 26 big and small urban centres and 556 marine fishing villages located along the 12 maritime districts. Marine fish landing takes place in 362 centres.The major landing centres in Tamil Nadu coast are Ennore, Chennai, Cuddalore, Port Novo, Nagappattinam, Athirampattinam, Rameswaram, Pamban, Thoothukudi, Kanyakumari and Colachel. During 2011 -12 Marine Fish Production was 4.25 lakh tonnes.(Table 8.4)

Table 8.4: Marine Fisheries Statistics (2011-12) at a glance

Coastal length	1,076 km
Number of Coastal Districts	13
Number of Fishing Villages	591
Marine Fisher folk Population	9.15 lakh *
Registered Fishing Crafts	About 6,728 Mechanized Fishing boats 56,792 Traditional Crafts. (motorized and non motorized)
Major Fishing Harbours	3
Medium Fishing Harbours	3
Jetties	10
Fish Landing Centres	363
Marine Fish Production (2011-12)	4.25 lakh tonnes
Exports: (2011-12) (value –Rs.2,800.81 crore)	73,991 tonnes **
* Projected figure for 2012 (Census of India, 2011);** Tentative figure	

The Wadge bank located down the Cape Comorin is one of the important fishing grounds in India. The total brackish water area available for aquaculture production is 56,000 ha and shrimp culture is being undertaken in 6019.21ha

producing 15,050 tonnes of shrimps valued at Rs.451 crore annually. Major fishing harbours include Chennai Fishing harbour, Thoothukudi fishing harbour in Thoothukudi District, and Chinnamuttom fishing harbour in Kanyakumari District.

Industries (including salt production):

Tamil Nadu coast has seen lot of development in the industrial sector and more development to come in the near future. The State has major industrial clusters located on the Tamil Nadu coast at Ennore, Cuddalore and Thoothukudi. Also, salt production is an important activity on the coast; the major salt production districts are Thoothukudi, Ramanathapuram, Nagapattinam and Villupuram.

Water Supply Infrastructure:

The State's coastal zone is also home to several critical water supply infrastructure installations including the 100 MLD desalination plant at Kattupalli, the 100 MLD desalination plant at Nemmeli, the desalination plant at Naripaiyur and the Ramnad Drinking water Scheme to provide drinking water to the drought-prone Ramanathapuram district.

Agriculture:

Agriculture plays an important role in the State economy. Paddy is the major agriculture crop in the coastal areas particularly the Cauvery delta districts. Agricultural plantations includes Coconut, Cashew and Casuarina are common in the coastal districts.

Oil and Natural Gases:

Cauvery basin in Tamil Nadu is one of the potential areas for crude oil and natural gas. Tamil Nadu has at present 28 oil and Gas fields. Tamil Nadu has 2 refineries belonging to CPCL, one at Chennai (9.5 million MT) and the other in Panagudi (Narimanam) at Nagapattinam (1.0 Million MT). Nagarjuna Oil Corporation is currently setting up an oil refinery at Cuddalore with a capacity of 6.0 Million MT.

Minerals:

Heavy mineral deposits in beach sands are found in the Southern coast of Tamil Nadu. The important minerals available are Garnet, Ilmenite, Rutile, Sillimanite and Zircon. Indian Rare Earth located at Manavalakurichi in Kanyakumari is extracting the minerals from beach sand. Red sands or Teri sand are extensive along the Southeast coast of Tamil Nadu. They are of aeolian origin, that are red sediments and are basically deposited as windblown sands derived from the coastal dunes and beaches and are likely to contain heavy minerals of economic potential.

Coastal Ecosystems:

The coastline of Tamil Nadu constitutes about 15 percent of the total coastal length of India. The Tamil Nadu coast comprises of the Coramandel coast from Pulicat Lake in the north to Point Calimere and the Gulf of Mannar, which extends up to the tip of Kanyakumari and this is the southernmost point of the Indian Peninsula.

The entire region is well known for the range of ecosystems that comprise of sandy shores, estuaries, mangrove forests, sea grass beds, seaweeds and coral reefs.

Fringing and patch reefs are present near Rameswaram and Gulf of Mannar. Pitchavaram, Vedaranyam and Point Calimere have well-developed mangrove systems. In Tamil Nadu about 46 rivers drain into Bay of Bengal forming several estuaries and coastal lagoons. The Cauvery River and its tributaries form a large delta supporting extensive agriculture. The other landforms of the Tamil Nadu coast are rock outcrops of Kanyakumari, mudflats, beaches, spits, coastal dunes and strand features. Deposition is observed at Point Calimere, Nagapattinam, South Chennai, etc., while erosion is reported at Ovari Paravarnattam, Mahabalipuram and North Chennai near Ennore.

The Tamil Nadu coastline has several small existing and potential mangrove sites. The total mangrove cover of the State is 39 sq.km (SFR report 2011).The major mangrove areas are Muthupet in Thiruvarur district and Pichavaram in Cuddalore district and other districts with smaller mangroves are Ramanathapuram, Thanjavur and Thoothukudi.

The Gulf of Mannar is located on the south-eastern tip of India in the State of Tamil Nadu. The Gulf is known to harbour marine biodiversity of global significance, falling within the Indo-Malayan realm, the world's richest region from a marine biodiversity perspective. The Gulf's estimated 3,600 plant and animal species make it one of the richest coastal regions in India. The Gulf of Mannar Biosphere Reserve (hereafter referred as the Reserve) is located in the coastal marine zone of the Gulf itself. It is the first marine Biosphere Reserve not only in India, but also in all of south and south-east Asia. The Reserve has been selected as an international priority site based on criteria such as biophysical and ecological uniqueness, economic, social, cultural, scientific importance, national and global significance. The IUCN Commission on National Parks and Protected Areas, with the assistance of UNEP, UNESCO and WWF identified the Reserve as being an area of "particular concern" given its diversity and special, multiple-use management status.

Coral reefs are the largest natural structures with most diverse and beautiful marine habitats. It can be compared to rain forests of the sea for its rich biodiversity. They act as natural barriers to coasts and people from sea erosion and natural calamities such as cyclones, storms and tsunamis. They are source of livelihood to thousands of traditional poor fisher folk through high fishery production and also serve as storehouse of biodiversity by providing shelter, food and breeding spots. The total reef area in Gulf of Mannar is about 110 sq.km with 117species of corals.

Tamil Nadu has rich oyster resources in Pulicat backwaters and Ennore backwaters near Chennai, Vaigai estuary near Athankarai, Thoothukudi, Killai backwaters, Pazhayar estuary, Muthupet swamps and Thambraparani estuary. The rocky bottom of the sea where the pearl oysters occur are 'Pearl Banks' or 'Pearl beds' which are locally called 'Paars'. They are found from Pamban in the North to Manapad in the south. The sacred Chank (*Xancuspyrumo*) found here from shallow parts to depths of 20 m occupies an important place in the lives of Hindus. This is being used in worship and in the manufacture of bangles worn by ladies in Bengal

and is distributed in the coastal waters of Tamil Nadu, Kerala and Gulf of Kutch in Gujarat. The coastal districts where Chanks are distributed in Tamil Nadu are Tirunelveli, Kanyakumari, Ramanathapuram, Pudukottai, and Thanjavur.

Sea grasses are commonly found in shallow coastal marine locations, salt marshes and estuaries. Out of the 14 species of sea grasses reported in the Indian coast, 13 species are found in Gulf of Mannar. Sea grass bed serves as a feeding ground for the endangered marine mammal *Dugong dugon*. Seaweeds or marine algae are primitive plants and they constitute one of the commercially important marine living resources. They belong to four group's namely green, brown, red and blue-green algae. The seaweeds are commercially exploited in the production of various products and are in high demand.

The Tamil Nadu coastal wetlands attract migratory birds in large numbers, particularly the Point Calimere wetland complex, which was declared as Ramsar Site, because this wetland supports a large number of bird species. Black buck (*Antilopa cervicarpa*) is an endangered species found in a small pocket on the Coromandel coast at the Point Calimere. The sandy coast of Tamil Nadu serves as a nesting ground for the endangered Olive Ridley turtle.

8.2 KEY CONCERNS OF THE TAMILNADU COASTAL ZONE

Coastal Erosion

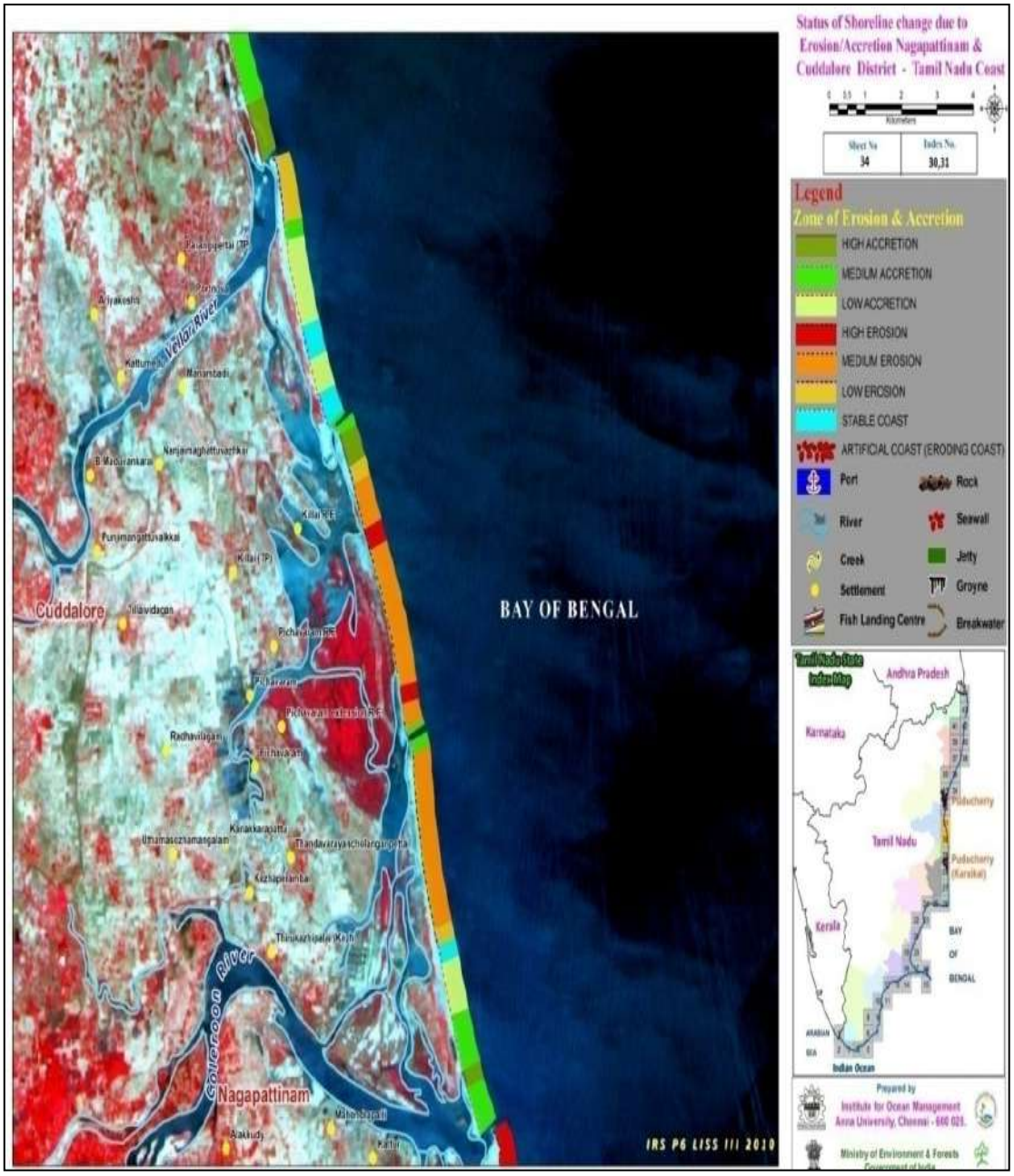
A number of locations along the Tamil Nadu coast have witnessed rapid coastal erosion since the 1970s/80s eroding land mass, converting larger beaches to smaller ones and sand dunes or islands to disappear. High Erosion Zones along the Tamil Nadu coast include the districts of Kanyakumari, Tirunelveli, parts of Tuticorin, Ramanathapuram, Pudukkotai, Thanjavur, and Thiruvarur districts, Nagapattinam, Cuddalore, Villupuram, Kanchipuram, Chennai, and Thiruvallur. The State has prepared shoreline change maps for different districts (Figure 8.2). Coastal erosion has also been compounded by the trend of storm surge heights and cyclonic intensities in the last 50 years along the Tamil Nadu coast. The districts affected includes Chennai, Cuddalore (formerly South Arcot), Nagapattinam, Thanjavur, Ramanathapuram and Kanyakumari. Storm surges ranging from 4 to 12 m have been experienced by the Tamil Nadu coast (Sundar and Sundaravadivelu, 2005). The extent of erosion along various coastal districts is given in Table 8.5. The satellite based observations of areas eroding in Cuddalore and Nagapattinam is shown in Figure 8.2.

Table 8.5: Extent of erosion along the Tamil Nadu coast

District	Extent (km)	Percent of coast
Kanyakumari	Artificial coast line	Protected
Tuticorin	2.02	1.73
Ramanathapuram	2.86	1.08
Pudukkotai	3.49	8.10
Thanjavur	0.92	2.20
Thiruvarur	AC	AC
Nagapattinam	AC	AC

Cuddalore	0.69	1.64
Villupuram	AC	AC
Kanchipuram	AC	AC
Chennai	0.4	0.92
Thiruvallur	0.31	2.69
*Artificial Coast - High erosion zones protected by artificial coast (sea walls)		

Figure 8.2: Shoreline change map of Nagapattinam and Cuddalore Districts in TN

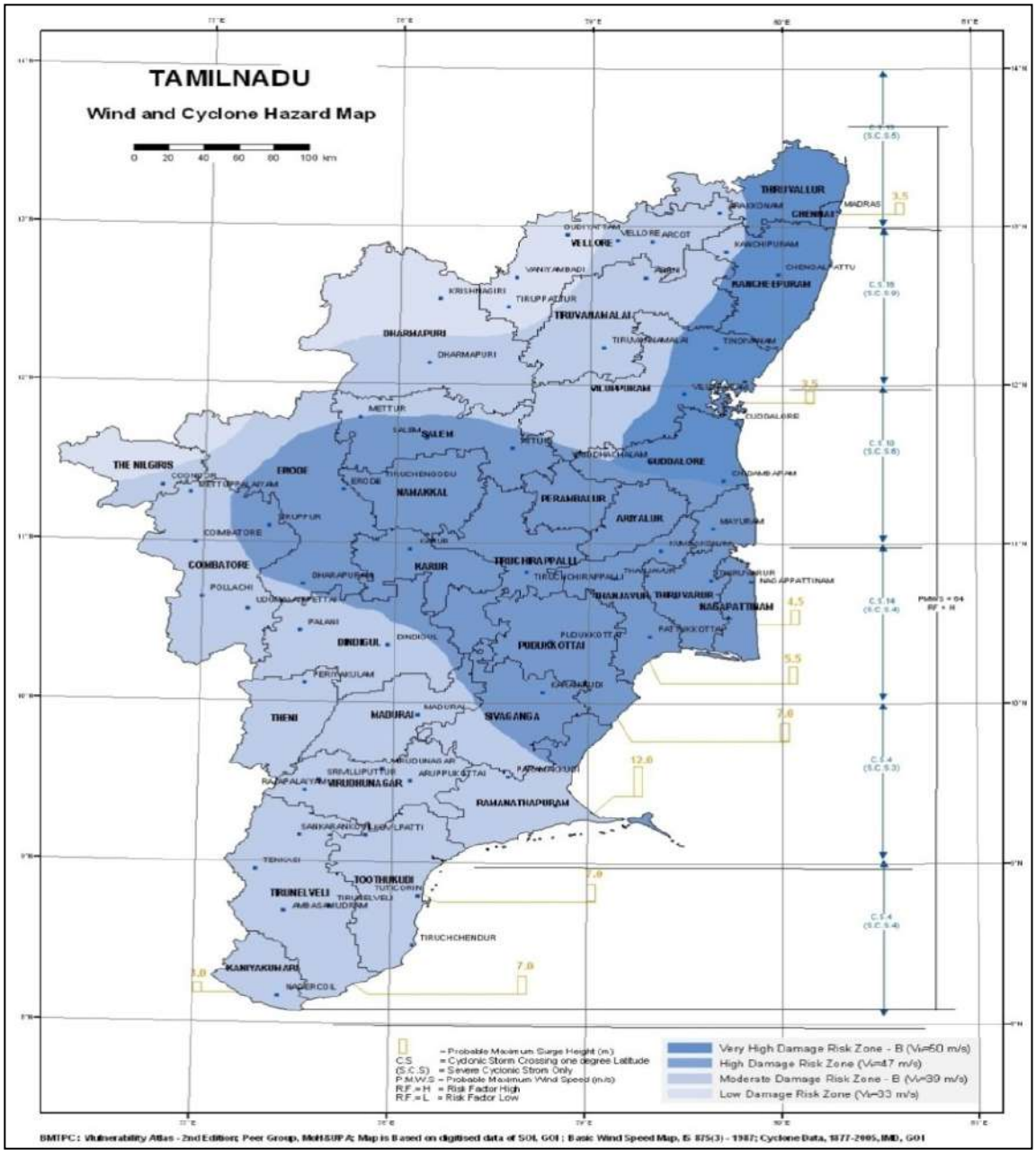


Source: Institute of Ocean Management, Anna University

Cyclones, Storm surges and Coastal Flooding

The State's coast also experiences periodic coastal flooding due to extreme storm surges, as well as storm surges riding over tides and cyclones. The coast of Tamil Nadu has been affected by cyclonic storms about 30 times with disastrous effects from 1900 to 2004. The districts affected include Chennai, Cuddalore (formerly South Arcot), Nagapattinam, Thanjavur, Ramanathapuram and Kanyakumari. Storm surges ranging from 4 to 12 m have been experienced by the Tamil Nadu coast (Sundar and Sundaravadivelu, 2005). The map below gives the risk zones associated with wind and cyclones (Figure 8.3).

Figure 8.3: Wind and Cyclone Hazard map of Tamil Nadu



Sea Level Rise

Most of the vital installations and infrastructure are located along the coast in Tamil Nadu. The sea level along the coastline is varying (Figure 8.4). This variability also puts at risk the infrastructure being developed along the coast as in most places it is not following any constant trend which can be modelled and projections can be made so as to make coastal infrastructure safe. Sea level rise due to global warming is happening in the background as well. While the quantum of sea level rise is being debated, the fact that sea level would rise due to global warming is not doubted and it is putting coastal systems at risk.

Salt Water Intrusion

Sea Water encroachment is a serious problem in some coastal areas of Tamil Nadu due to deficient rainfall as well as over extraction of freshwater for domestic as well as industrial uses. Sea Water Intrusion is monitored along all the coastal districts of Tamil Nadu.

Pollution

The immediate sea near the shore gets polluted for a variety of activities along the coast and they are:

Industries, Power Plants and Desalination:

The State has several major polluting sources such as industries, power plants and desalinisation plants along the coastal zone. Pollution from sea-based activities include sources such as near shore oil exploration; Vessel maintenance (waste oils, paints, solvents, repair wastes & batteries); Fuelling (pipe leaks); On-board tanks (sewage, vessel cleaning wastes, oily wastes & washings); and Cargo handling operations (leakages, washings & spillages).

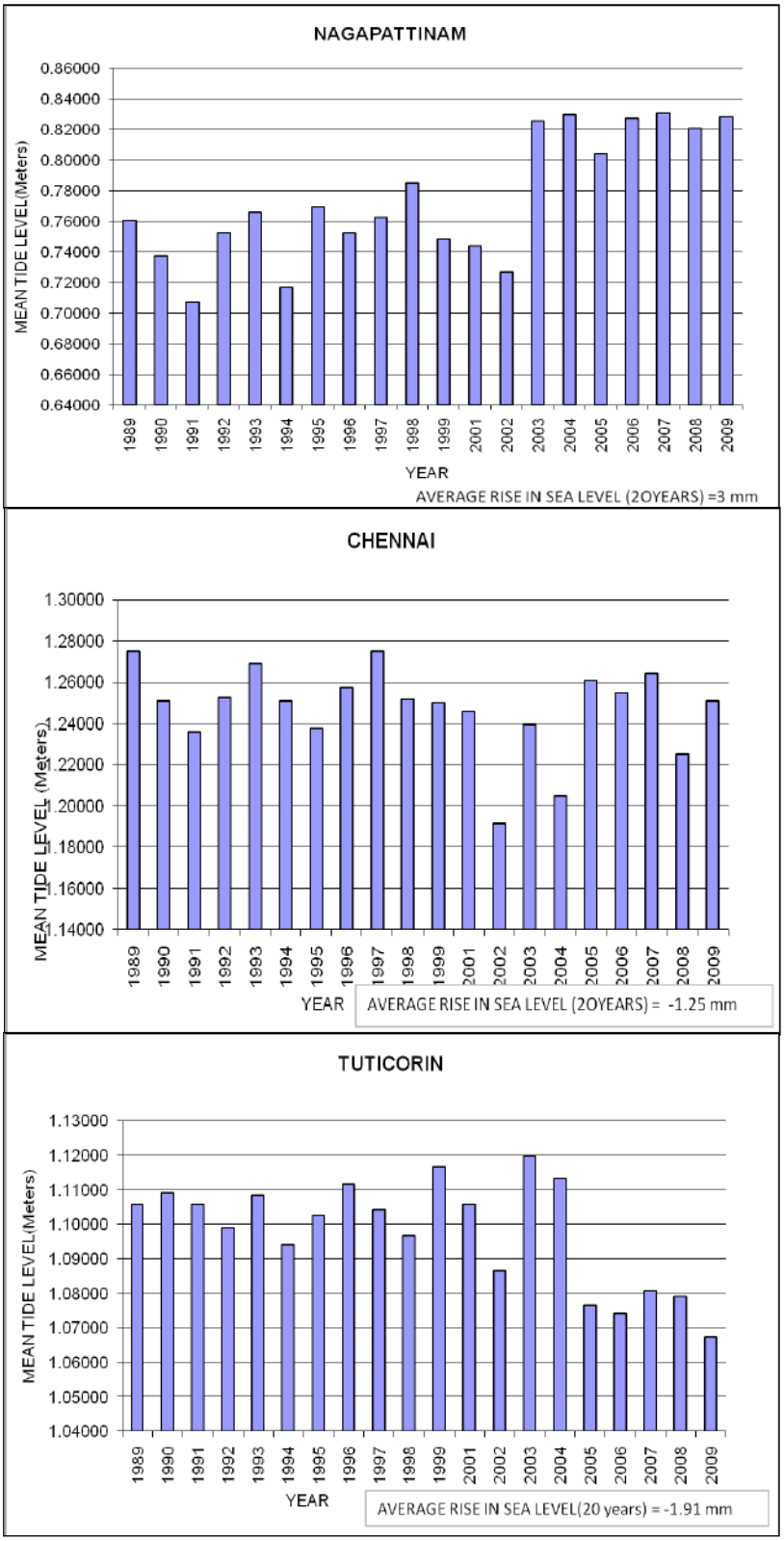
Pollution from land-based activities include pollution spilling from sewage (especially from municipalities); effluents from a variety of industries (cooling water discharge from thermal power plants, common marine disposal facilities, etc.); aquaculture farms (washings from hatcheries, aquaculture, and processing); fisheries harbours (discharges from fishing boats & disposal of used nets); non point sources (surface runoffs & agricultural runoffs); and sand mining while the industrial discharges are regulated under the statutory provisions, the coastal areas are also affected by discharge of sewage generated by the habitations located nearby.

Domestic and Industrial Sewage Discharge into the Sea:

The programme on Coastal Ocean Monitoring and Prediction System (COMAPS) is being operated along the Indian coastal areas since 1991. Data on nearly 25 environmental parameters including physical, chemical and biological including microbiological characteristics of water and sediments at about 76 locations are being collected with the participation of Research and Development institutions and academia, within the 10 km sector of the coastline of the country, covering the maritime States and UTs.

The status along the coastal waters of Tamil Nadu during the year 2007-08 indicates the following sources:

Figure 8.4: Trends of sea level between 1989 and 2009 observed in specific areas along the coast line in Tamil Nadu



Chennai harbour handles 40 million tonnes of cargo a year and it mainly includes

- Coal, fertilizers, chemicals, oils, acids, cement, etc.
- SIPCOT industrial complex comprising of pesticides, pharmaceuticals, etc. is located at Cuddalore.
- Harbour, industries like petrochemicals, fertilizers, salt pans, etc. are located at Tuticorin.
- Thermal power plants are also located at Chennai and Tuticorin.

Under COMAPS programme, coastal waters of Chennai, Muttukadu, Puducherry, Cuddalore, Karaikal, Nagapattinam and Tuticorin were monitored (May, Jul, Dec' 07). The results indicated a slightly high suspended solids concentration at Chennai and Nagapattinam (up to 110 mg/l). Dissolved oxygen was in the range of 4-5mg/l at all locations and was less during pre-monsoon, especially at Cooum (1-4 mg/l). Likewise, monitoring results of the Ministry of Earth Sciences for 2009 shows that when compared to previous year, a moderate decrease in levels of suspended solids concentration (from <190 mg/l - <100 mg/l). Dissolved oxygen level was well within normal range (3.5 – 6.8 mg/l) and biochemical oxygen demand (<5 mg/l) in all stations. Nutrient levels were also found to be at moderate level. However, a significant increase in pathogenic bacterial populations was observed in many shore locations (Ministry of Earth Sciences, Government of India, 2009-2010)

8.3 PROJECTS, PROGRAMME AND POLICIES TO MANAGE COASTAL ZONE

Developing an Integrated Coastal Zone Management Plan for Tamil Nadu

The coast of Tamil Nadu is replete with several economic activities like industry, tourism and fisheries. To minimize the conflicts of interest between various competing activities, an appropriate management plan rationally integrating the activities of all the stakeholders is essential. In order to achieve economic prosperity without sacrificing ecological security, Integrated Coastal Zone Management Plan has been prepared for the coastline of Tamil Nadu. The setback lines in the coastal areas are being identified based on the level of vulnerability of the coast to natural and manmade hazards. For the purpose of assessing the vulnerability of the coast, seven parameters were taken into consideration viz., elevation, geology, geomorphology, sea level trends, horizontal shore line displacement (erosion /accretion), tidal ranges and wave heights.

The elements of the draft plan include:

Development of an enabling environment for decision making: This includes a plan for development of an integrated GIS based State coastal data base for Tamil Nadu; preparation of a land use map, land capacity assessment, data collection on river discharge, sewage discharge from industry as well as from domestic waste, monitoring of estuarine ecosystem, dynamic monitoring and mapping of saline intrusion areas, assessment of energy that can be harnessed from the sea waves,

tides and storm surges and development of a ICZM website. Also included are communication, education, public awareness and capacity building plans.

It is also envisaged to set up a State management unit for overseeing the implementation of ICZM Plan and policies.

ICZM demonstration projects:

These are planned for understanding the sedimentation process along the coastline at Cuddalore, Tarangambadi and Manakudi.Conservation and rehabilitation activities include:

- **Shoreline management** for shoreline protection, and land use planning: Assessment of geo morphological characteristics of the zone, high resolution erosion mapping, sediment budgeting through numerical modelling, development of detailed DEM, with district of Kanyakumari taken as a demonstration site for implementation of the remedial measures to mitigate erosion.
- **Biodiversity conservation** is another element of the ICZMP for Tamil Nadu. This element will include assessment and monitoring of coastal biodiversity for developing base line data and assessment and monitoring of the environment for the entire TN coast. This element will also include conservation and rehabilitation of ecologically sensitive area such as mangroves(Muthupet, Pichavaram, Manakudi and Punnakayal); Conservation of wetlands at Point Calimere which is a Ramsar site, Pallikaranai Marsh which is a reserved forest and Pulicat lake; Conservation and rehabilitation of coral reefs and sea grass in Gulf of Mannar and Palk Bay; and Conservation and rehabilitation of forests along the coastal zone.
- **Controlling Coastal Pollution:** A solid waste management plan and implementation of the same is being developed for Cuddalore Town, Thiruvanmiyur, and Nagapattinam. Additionally, solid waste management in tourist areas such as the Marina beach, Elliot beach, Rameshwaram, Mahabalipuram, Velankanni and Nagore are also being addressed. Additionally sewage and industrial effluent management plan is being developed for the urban areas of Cuddalore town, rural area of the Kilakarai block, rural areas of Mandapam, and in industrial area (SIPCOT) in Cuddalore.
- **Livelihood improvement plans:** As the people settled in the coastal rural areas are dependent on marine fishery, agriculture, and other ecosystem services from the sea, that are vulnerable to the existing climate variability and extreme events such as cyclones, heavy rains, and long term sea level rise, therefore, the Integrated Coastal Zone Management (ICZM) plan, aims to identify alternative livelihood options, impart training to coastal communities on alternative livelihoods and support trainees to set up units.
- **Improving potable water availability, access to energy:** It is planned to set up sea water desalination plants in Nagapattinam and Tuticorin, and generating non conventional energy through algal culture, and exploring the feasibility of harnessing offshore wind from the sea along TN coast.

- **Improvement of fishery resources:** Under the aegis of the ICZM, it is also planned to create artificial reef environment at various locations, undertake hatchery production of ecologically sensitive fish species and commercially important species, encourage pen and cage culture, build capacity of fishing communities for utilising eco-friendly fishing techniques etc.
- **Encourage development of ecotourism:** Considering the ecological importance of the coastal areas and its attractiveness to tourists, it is envisaged to develop tourism here that will ensure the sustainability of the region, and hence ecotourism activities will be encouraged in Pitchavaram, Muthupet, Rameshwaram, Mahabalipuram, Manakudi, Tuticorin and in Kanyakumari town.
- **Disaster preparedness and management:** This will include the development of vulnerability map of coastal erosion and flooding due to cyclones and storm surges and sea level rise; also this element needs to include an early warning system for the coastal communities and a seamless communication system for the fishermen. The evacuation strategies and plans will also be part of this element of ICZM along with awareness and training on the same.
- **Preparation of Decision Support System (DSS)** for disaster management: This will be prepared to identify the average inundation area for various levels of cyclones that strike the Tamil Nadu coast along Cuddalore and Nagapattinam. Also the DSS will include the implications of climate change and sea level rise on the Tamil Nadu coast.

Some of the Other Key programmes and Projects

National Assessment of Shoreline Change for India:

As a part of the National ICZM Programme implemented by the MoEF&CC, GoI, mapping has been completed for all the Coastal States/ UTs along the east and west coast of India on a 1:50,000 scale. The States of Gujarat, Odisha, Kerala, Tamil Nadu and the UT of Puducherry have already approved the shoreline change maps and are available online at http://www.ncscm.org.

Coastal Sediment Cell Delineation:

Delineation of Coastal Sediment Cells (Primary cells, Sub-cells and Management Units) was undertaken in order to develop an overall Shoreline Management Plan. This study was to provide information useful for necessary policy changes towards coastal shore protection, land-use planning, and coastal resources management. The study also provides the technical basis and analytical information useful for adopting a systems approach to infrastructure development and coastal conservation. Delineation of Primary cells for the entire coast of mainland India has been done by studying the coastal processes (wave/ wind/ current, littoral drift pattern, sediment budget and bathymetry), shoreline change mapping and identifying coastal structures. Detailed sediment cell mapping with available secondary coastal process study has been carried out for Odisha coast.

Disaster Risk Management Programme:

Government of Tamil Nadu has taken many initiatives for disaster risk reduction in the coastal districts. It has established Emergency Control Centres, one at State level and six in coastal districts in order to disseminate timely disaster information. The State Government has planned to upgrade these already established Emergency Control Centers and establish seven more such centers in the remaining seven costal districts. The total financial outlay needed for the purpose is approximately Rs.185 lakhs. Complementing the GoI-UNDP Disaster Risk Management Programme, Government of Tamil Nadu is implementing an "Early Warning System" project aimed at strengthening the dissemination of warning messages to the coastal vulnerable communities thus bridging the "last mile connectivity". In a pilot initiative, 55 most vulnerable villages of Cuddalore district have been supported through installation of public address systems that links to the existing VHF Radio communication network. In the second phase, around 120 villages from Tiruvallur, Kanchipuram, Nagapattinam and Kanyakumari are selected for implementation of VHF based early warning system. A school safety programme has also been taken up by the Tamil Nadu Government with the aim of taking disaster preparedness to the level of teachers and students. The programme emphasizes on imparting training to prepare school safety plan, charting out evacuation routes and do's and don'ts for various hazards. Disaster Management has also been introduced in the school curriculum for standard eight.

Other than this, GoI-UNDP Disaster Risk Management (DRM) Programme have been instituted by way of Disaster Management Plans have been formulated at village, panchayat, block and district levels involving community and other stakeholders. Disaster Management teams have been constituted in villages and villagers are being imparted training in basic functions of first-aid, rescue, evacuation and related issues. In the first phase (2002-07), the programme is being implemented in six districts of Tamil Nadu namely, Tiruvallur, Cuddalore, Kancheepuram, Kanyakumari, Nagapattinam, and The Nilgiris. In the second phase, the DRM programme is being extended to remaining seven coastal districts of Villupuram, Tiruvarur, Thanjavur, Pudukottai, Ramanathapuram, Tuticorin, and Tirunelveli.

National Cyclone Risk Mitigation Project:

The Government of India with the assistance of World Bank has proposed to implement the Project in the Coastal States of India. The Coastal States of India have been sub-divided into two categories viz., Category I-High Vulnerability and Category II-Low Vulnerability. The State of Tamil Nadu was classified under Category I. Under this Project, Cyclone Risk Mitigation will be undertaken in following broad heads:

- Construction of Cyclone Shelter.
- Construction/Renovation of coastal canals and embankments for improved drainage.
- Shelterbelt Plantation.
- Plantation and regeneration of mangroves.

- Construction of Missing Road Links/Bridges.
- Institutional Capacity Building and Hazard Reduction Studies.
- Improvement of on-shore warning system.
- Retrofitting of life-line/key/vital installations (roads/culverts/bridges).
- Awareness generation for cyclone risk mitigation.

National Coastal Protection Project:

The National Coastal Protection Project for protection of coastal areas of Maritime States/ Union Territories from sea erosion is under formulation with a view to explore possibilities of funding through external resources or other domestic resources. The Tamil Nadu Government has submitted a proposal for an amount of Rs 167.7 crore and it includes construction of 13.824 km of sea walls/ groyne in Chennai north, Kancheepuram, Cuddalore, Nagapattinam, Tuticorin, Tirunelveli and Kanyakumari districts. Under separate "State Sector Scheme" for construction of critical anti-erosion works in coastal States, an amount of Rs 2.32 crore released to Tamil Nadu as Central share for the construction of 400m groyne at Periathali in Tuticorin district during the Tenth Five Year Plan.

Coastal Area Management Project of Tamil Nadu Forest Department:

The past experience and the experience specifically during the Tsunami of 2004 clearly brought out the importance of encouraging shelterbelt plantations and mangrove plantations along the coast. Shelterbelts act as very effective wind brakes and prevent the shifting of sand dunes. The mangrove plantations provide protection from the raging waves caused by sea borne disasters like tsunami and thus prevent loss of human life and damage to public and private property. Therefore, a sum of Rs.1451.37 lakh was sanctioned during 2006-2007 for raising 2850 ha of shelterbelt plantations and 1650 ha of mangrove plantations by the Tamil Nadu Forest Department. Further rising of shelterbelt plantations and mangrove plantations will be continued under the National Cyclone Risk Mitigation Project.

Gulf of Mannar Biosphere Reserve (GoMBR):

The Project focuses on securing multi sectoral participation in management of Gulf of Mannar Biosphere Reserve which includes 21 coral rich islands along the coastline from Rameshwaram to Tuticorin in the core area. This project funded by the Government of Tamil Nadu, Government of India and Global Environment Facility (GEF) and United Nations Development Programme (UNDP) has a total outlay of Rs.140 crore and will be implemented till 2009. The project activities include enhanced protection through infrastructure development, capacity building of all stakeholders through training, awareness creation, undertaking research and monitoring works on themes of resource inventories and ensuring participation of local communities and securing alternative livelihoods for them. There are 222 villages in the zone of influence that extends upto 10 km inland, in the districts of Ramanathapuram and Tuticorin. The Eco Development approach which was very successfully implemented in World Bank aided project in Kalakkad Mundanthurai Tiger Reserve is being followed for eliciting local people's support in marine

biodiversity conservation in the Gulf of Mannar Biosphere Reserve area. During 2007- 2008 an action plan has been implemented at a cost of Rs. 10.19 crore.

Biodiversity Conservation:

Coral reef and sea grass monitoring, conservation, management, awareness generation and supporting alternative livelihoods on communities dependent on the coral reefs in Gulf of Mannar and Palk Bay are some of the activities being carried out by several programmes launched by the GoI, Department of Environment in Tamil Nadu, the IUCN, in collaboration with various research institutions in the State such as the Suganthi Devadason Marine Research Institute, Gulf of Mannar biosphere trust, M.S. Swaminathan Research Foundation and Dhan Foundation etc. Over 80 other research projects are also being undertaken, with a total budget outlay of 1898.98 lakh.

Solid Waste Management:

A draft Integrated Municipal Solid Waste Management policy has been formulated for Development of Regional facilities with a Cluster approach. All the ULBs are instructed to adhere the Solid Waste Management (Handling & Management) Rules 2000 under the Environment protection Act 1986. The State Government issued an order vide G.O (Ms) No. 159, MA&WS Department dated 21.12.2001 to the ULBs to take steps for implementation of SWM (H&M) Rules 2000.As there is no agency involved in the management of Solid Waste in the coastal area, in the coastal municipalities the Solid Waste Management work are being carried out by the municipalities and in Thoothukudi Corporation the organisations like N.S.S, Coastal Guard employee are involved in Handling of the Solid Waste generated.

Awareness campaigns are being conducted to ban the use of plastics. Pamphlets are being issued to households and shop vendors to segregate the garbage at the source itself by stating the ill effects of handling and disposal of the solid waste especially plastics, metals, glasses etc.

Coimbatore City has come up with solid waste management (SWM) bye laws for enforcing penal clause for littering, non-segregation, polluting public places, etc., No separate mechanism is devised for collection of construction and demolition waste (debris) and for its disposal.

8.4 INSTITUTIONS INVOLVED IN THE MANAGEMENT OF COASTAL ZONE

As can be seen, the coastal zone has multiple activities spread across the districts lining the zone. It is dotted with heavy infrastructure such as Ports, roads, desalination plants, power plants, oil refineries, and various industries etc and has urban habitats that require water supply along with other essential services and these in turn put a pressure on the ecosystem. The rural habitats are dependent on the ecosystem services provided by the sea and agriculture, amongst others. Multiple agencies manage the different activities across the coast. Some of the key elements managed by the different institutions are as follows:

Table 8.6: Institutions involved in management of various aspects in the Coastal zone area in Tamil Nadu

Activity	Managing Institution
Biodiversity conservation	Department of Forests, Biodiversity Board, Gulf of Mannar Biosphere Reserve Authority
Forest conservation including mangroves	Department of Forests
Municipal Solid Waste management:	Urban Local Bodies
Urban Planning	The urban planning department along with the Urban local bodies
Desalinisation plants	Tamil Nadu Water Supply and Drainage Board, Chennai Metro Water Supply and Sewerage Board
Industrial and domestic Sewage discharge (water pollution)	Tamil Nadu Pollution Control Board
Coastal zone Regulation	Department of Environment
Erosion control, managing dams, diverting flood water, improving water use efficiency etc. and also Execution of calamity reconstruction works like Emergency Tsunami Reconstruction Project building works etc.	Public Works Department
Power plants:	Nuclear Power Corporation of India, National Thermal Power Corporation, TANGEDCO (Tamil Nadu Generation and Distribution Corporation Limited) Neyvelli lignite Corporation ltd, and some private players
Coastal tourism	Department of Tourism along with private players
Agriculture and Fisheries	Department of Agriculture and Animal Husbandry, Dairying and Fisheries
Disaster management	State Disaster Management Authority and the district disaster management plans
Disaster warning	IMD, State IMD and ISRO, NDMA

8.5 LIKELY CLIMATE CHANGE IMPACTS

Climate change impacts on coastal zones in general and specifically, along the east coast of India (including Tamil Nadu) have been briefly discussed in Chapter 2. The long Tamil Nadu coastline with thirteen coastal districts forms a fairly large contiguous and narrow coastal strip dotted with fragile ecological features and significant development activities. There are major existing and proposed, economic and infrastructure development, including Ports, power plants, highways and even airports, which are being planned very close to the shoreline along India's coast.

Tamil Nadu being a coastal State is highly vulnerable to seasonal fluctuations in terms of rainfall, temperature, relative humidity, wind speed etc.,causing uncertainty in Agricultural production. Due to the effects of cyclones and monsoon in the Bay of Bengal which causes heavy damage to the crops in coastal areas almost every year. The saline and alkaline soil in coastal areas is a major setback to agricultural activities in coastal areas.

It is likely that sea level rise will affect the coastline of India in a variety of ways, including inundation, flood and storm damage associated with severe cyclones and surges, erosion, saltwater intrusion, and wetland loss.

Coastal inundation and damages

District level analysis by Byravan et al (2011), show that

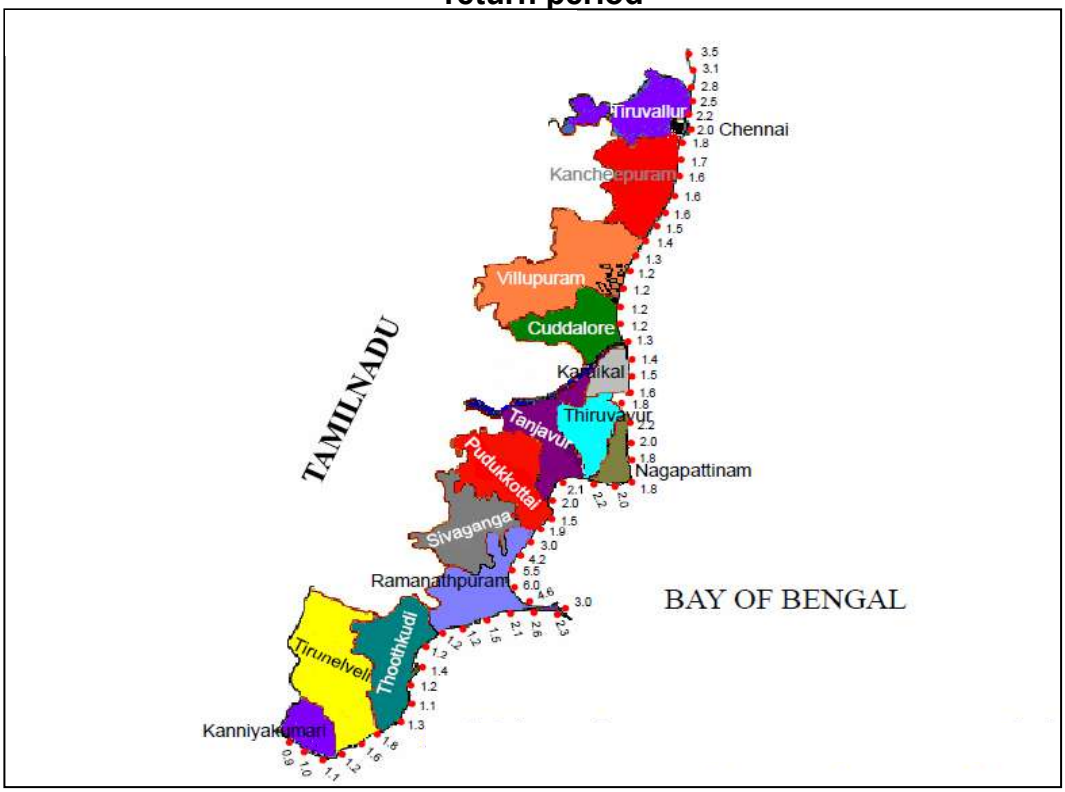
- The area at greatest risk are the five coastal districts, Nagapattinam, Thiruvarur, Thanjavur, Pudukottai, and Ramanathapuram, as along the coast line the areas in these districts are below 10m of the current mean sea level. They are constantly at risk because of the storm surges that already affect them.
- For the remaining eight coastal districts, the coastal area that lie below 5m elevation relative to current mean sea level is estimated to be at risk a 1m SLR.
- A 1m rise in average sea level would permanently inundate about 1091 square kilometres along the Tamil Nadu coast, but the total area at risk would be nearly six times as much.
- The same report estimates that the total replacement value of infrastructure (Ports, power plants and major roads) impacted by sea level rise to be between Rs. 47,418 and Rs. 53,554 crore (in 2010 terms). The present value of wetlands (estimated in terms of foregone ecosystem services through 2050) impacted by sea level rise is estimated to be between Rs. 3,583 and Rs. 14,608 crore. By far the largest impact are estimated to be on the land at risk, whose market value is estimated to be between Rs. 3,17,661 and Rs. 61,15,471 crore. In comparison, Tamil Nadu's annual Gross Domestic Product is estimated to be around Rs. 2,50,000 crore, indicating that very significant value is at risk along the coast due to climate change impacts from sea level rise alone.

Further, analysis of storm surge that can have return periods upto 50 years indicates that the return period of storms with pressure systems at 66 hPa can be every 50 years (Table 8.7). Based on this return period, its seen that the storm surge height along the sea coast of Tamil Nadu can be as high as 3-6 m at the northern tip of the State and at Ramanathapuram and Kanyakumari (Figure 8.5), inundating a large area land ward.

Table 8.7: Return periods of storm surges of different strengths

Return period (Years)	ΔP (hPa)			
	West Bengal	Orissa	Andhra Pradesh	Tamilnadu
2	14	20	26	13
5	23	43	45	25
10	34	60	58	35
20	49	77	69	48
25	54	82	72	52
50	75	94	82	66

Figure 8.5: Probable maximum surge heights (m) of surges with a 50 year return period



Impact on Coastal ecosystem and biodiversity

In Tamil Nadu the coastal ecosystem is vulnerable to climate change. Climate change may have a wide range of possible effects on ocean currents and processes that can affect fish resources.Everett (1996).Aquaculture enterprises are likely to be very vulnerable to impacts of climate change. Aquaculture activities on shore are usually in low-lying coastal areas. These are likely to be inundated as sea level rises. They are also likely to be threatened by loss of protection to the coast such as degradation of mangroves, sea grasses and coral reefs. Many impacts are

envisaged in the coastal areas/ecosystems harbouring a variety of biodiversity and associated livelihoods. However, more focused and systematic studies in these areas with respect to climate change impacts on the living resources mentioned is required for protection and conservation of coastal biodiversity. Also the impact of climate change is clearly visible in the Indian Ocean with many reefs, previously regarded as near pristine, seriously affected. The maximum numbers of affected corals are in the shallow waters. Any adverse changes to the number or intensity of the frequent seasonal cyclonic storms in the Bay of Bengal could also adversely impact the State.

Enhanced Climate impacts on accretion or erosion rates

Accretion or erosion along Tamil Nadu coast is alarming. The natural littoral transport processes along the coastal region led to changes in the shoreline during the past 25years. A large number of manmade developments towards seaward alter the coastal dynamics. The maximum accretion/ erosion has occurred in the coastal areas of Mahabalipuram (5450m), Manakudi (3650m), Ammapattinam (3600m), Rameswaram (3295m), Ennore (3265m) and Marina beach (2968m). However, due to climate change as it is perceived that there will be stronger storm surges and more intense cyclones, further erosion may extend to larger areas along the coast thus affecting infrastructure and livelihoods.

Impact on waste management

Higher temperatures could cause the following in dumping sites -- alter the waste decomposition rate, lead to reduced water availability; alter site hydrology and leachate production and in composting, alter the waste decomposition rate, reduce indoor and outdoor workers productivity, increased combustion risk, and result in increased dust potential. Precipitation changes could cause altered by waste decomposition rates in dumping sites, altered site hydrology, increased leachate strength, increase in flooding occurrence on site due to saturated waste and rising groundwater, increase risk of erosion. Similar changes might occur in composting sites too.

8.5 STRATEGIES FOR ADAPTATION TO CLIMATE CHANGE

In view of the above review it is clear that climate change concerns need to be integrated within coastal zone planning process. In this respect the following strategies are suggested:

Strategy 1: Develop a Tamil Nadu-Integrated Coastal Protection Plan (TN-ICPP) to adapt to projected sea level rise, enhanced intensities of cyclones, storm surges, and extreme rainfall.

- Assess the intensity and recurrence frequency of cyclones and storm surges and their land fall locations due to Climate Change.
- Evaluate the individual and combined impacts of sea level rise, cyclones, storm surges, extreme rain fall and Tsunami on TN coast due to Climate Change.

- Accordingly revise the norms for (i) coastal zone infrastructure development including housing, bridges, roads, power installations, Ports, etc. (ii) waste management.

Strategy 2: Avert enhanced coastal erosion due to Climate Change and protect the coastal zone.

- Undertake a study to assess impacts of different climate scenarios on coastal erosion.
- Assess the design augmentation requirement/retrofitting/preserve different coastal protection works such as sea wall, groynes, jetties, sand dunes etc. due to projected moderate and intense erosions due to climate change and implement giving protection to river banks, dredging and de-siltation and restoring river runoff and coastal soil profile budgeting.
- Identify and plant appropriate heat tolerant, location specific mangrove species for rejuvenation / afforestation in moderate and high erosion areas along the TN coast line for preventing enhanced erosion and for enhancing carbon sequestration.
- Increasing tree cover along the coastal zone with appropriate trees and identify stretches where it can be done.
- Improve and/or create channels for rainwater/river water drainage into the sea in view of extreme rainfall and for facilitation of draining out of inundated coastal water in a climate change scenario.

Strategy 3: Strengthen resilience of coastal communities in view of projected climate change

- Strengthen resilience of fishing communities by assessing the likely impact on fish catch off the coast of Tamil Nadu. Design programmes to adjust to the changes and ensuring livelihoods. There is a need for demonstration of technologies using resilient species and assess health of the resources and the diversity
- Strengthen resilience of farmers (agriculture) through –Identification of cultivars that can grow in on farm conditions in a warming scenario -Identify cultivars that are tolerant to saline soils
- Strengthen resilience of coastal rural habitats by advising measures on retrofitting/ relocation of coastal rural housing in view of the recurrence and intensity of extreme events and sea level rise due to climate change. Facilitate through policy formulation for support of the above measures financially and Build/retrofit dykes or apply appropriate locality specific measures in view of climate change impacts.

Strategy 4: Avert enhanced salt water intrusion in the ground water and ensure water security in coastal Tamil Nadu

- Increase network monitoring of wells to assess water quality on a regular basis and take appropriate timely action.
- Identify appropriate areas for new bore wells.

- Encourage soil management, through soil moisture retention measures, and continuous vegetation to support soil infiltration and groundwater recharge besides reducing erosion risk in rural areas.
- Reduce extraction of ground water through mandatory use of low horse power pumping machines.
- Identify areas where ground water has become saline and salinity is likely to increase with climate change. Establish desalination plants in such areas.
- Undertake artificial recharge of wells to secure water availability - Locally capture surface water runoff into derelict wells to restore groundwater levels and engineer infiltration with recycled wastewater.

Strategy 5: Conserve biodiversity in the coastal zone

- Assess base line flora and fauna data on biodiversity of the TN coastal zone – richness, distribution, present status, threats, anthropogenic impacts etc
- Conserve and protect marine biodiversity in Gulf of Mannar all marine and coastal sanctuaries, endangered and vulnerable bar mouths, estuaries, salt marshy lands, mangroves, in view of warming of the sea
- Ensure livelihood of fishermen in the Gulf of Mannar Tamil Nadu, through alternate technologies (solar energy/ wind energy for fishing, open sea cage culture, low intensive sea food production systems like mussels & seaweeds)
- Coastal marine habitat enhancement / restoration programmes, sea ranching, transplantation and germplasm conservation

Strategy 6: Avert pollution of water and soil in the coastal zones caused by industrial (power plants and other industries) and domestic wastewater and solid waste management practices

- Implement the integrated waste water and solid waste management plan in coastal areas. Harness energy from municipal solid waste (MSW) including provision of new technologies that reduce waste water discharge through sedimentation and filtration microbial conversion, Nutrient and mineral extraction and by composting / fermentation / biogas
- Undertake additional cooling of wastewater from power plants, RO plant, and nuclear plant by mixing with domestic effluents to reduce thermal load on the coast.
- Reuse waste water through biological treatment (social or community water budgeting-air conditioners, generators, furnaces, heaters, chimneys, ice plants, cold storages and introduction of heat tax)

8.6 BUDGET REQUIREMENT FOR STRATEGIES IN COASTAL ZONE MANAGEMENT SECTOR

The total cost for implementing the strategies during the 12th Five Year Plan (FYP) is Rs.4420.00 crore and during the 13th Five Year Plan (FYP) is Rs.5995.00 crore. (Table 8.8)

Table 8.8 Summary of budget requirement for Coastal Zone management sector

S.No	Strategy	Cost for 12tth FYP (Rupees in crore)	Cost for 13th FYP (Rupees in crore)
1	Develop a TN Integrated Coastal Protection Plan (TN-ICPP) to adapt to projected sea level rise, enhanced intensities of cyclones, storm surges, and extreme rainfall	925.00	1225.00
2	Avert enhanced coastal erosion due to Climate Change and protect the coastal zone	1775.00	2175.00
3	Strengthen resilience of coastal communities in view of projected climate change	240.00	440.00
4	Avert enhanced salt water intrusion in ground water and ensure water security in coastal Tamil Nadu	675.00	1000.00
5	Conserve biodiversity in the coastal zone	320.00	430.00
6	Avert pollution of water and soil in the coastal zones caused by industrial (power plants and other industries) and domestic wastewater and solid waste management (SWM) practices	485.00	725.00
	TOTAL	**4420.00**	**5995.00**

Detailed Budget for strategies in Coastal Area Management Sector is given in the Table 8.9

Table : 8.9 Detailed Budget for strategies in Coastal Area Management Sector

S. No	Strategy	Agency	Cost for 12^{tth} FYP (Rupees in crore)	Cost for 13th FYP (Rupees in crore)
Strategy 1: Develop a Tamil Nadu Integrated Coastal Protection Plan (TN-ICPP) to adapt to projected sea level rise, enhanced intensities of cyclones, storm surges, and extreme rainfall				
1.1	Shifting of habitations to safer areas, who are residing in vulnerable areas	DoE	**100**	**150**
1.2	Holistic integrated development of coast line of Tamil Nadu	DoE	**100**	**150**
1.3	Assess intensity &recurrence frequency of cyclones, storm surges& land fall	DoE	**50**	**75**
1.4	Evaluate the individual and combined impacts of sea level rise, cyclones, storm surges, extreme rain fall and Tsunami on TN coast due to Climate Change	DoE	**200**	**250**
1.5	Establishment of central coastal database centre	DoE	**50**	**25**
1.6	Strengthening Institutional Arrangements	DoE	**25**	**25**
1.7	Undertaking ICZM demonstration projects	DoE	**100**	**150**
1.8	Disaster preparedness - Decision Support System (DSS) for disaster mgt	Revenue Admn(OSD)	**100**	**150**
1.9	Revise the norms and implement for Coastal zone infrastructure development (housing, bridges, roads, power installations, ports, etc.);Waste management; Undertake awareness generation activities	DoE	**200**	**250**
		Sub Total	**925**	**1225**
Strategy 2: Avert enhanced coastal erosion due to Climate Change and protect the coastal zone				
2.1	Construction of coastal protection walls in vulnerable areas of coastal region	DoE & PWD	**300**	**500**
2.2	Undertake a study to assess impacts of climate change on coastal erosion	DoE/CCAR	**25**	**25**
2.3	Assess design augmentation requirement/retrofitting of coastal protection works such as sea wall, groynes, jetties, sand dunes etc &implement	IRS & PWD	**300**	**400**
2.4	Identify & plant appropriate heat tolerant location specific mangrove species for afforestation in moderate and high erosion areas along TN coast line	DoF	**50**	**100**
2.5	Increasing tree cover along coast with appropriate trees	DoF	**100**	**150**

S. No	Strategy	Agency	Cost for 12^{tth} FYP (Rupees in crore)	Cost for 13th FYP (Rupees in crore)
2.6	Desilt/create channels for rainwater/river water drainage into the sea in view of extreme rainfall and for facilitation of draining out of inundated coastal areas in a climate change scenario	DoF & PWD	**1000**	**1000**
		Sub Total	**1775**	**2175**
Strategy3: Strengthen resilience of coastal communities in view of projected climate change				
3.1	Strengthen resilience of fishing communities: Strengthen deep sea fishing activities; Assess the likely impact on fish catch off the coast &Design programmes to adjust to the changes and ensuring livelihoods	Dept of Fisheries, CMFRI, CIBA, NBFGR, CIFT	**20**	**20**
3.2	Strengthen resilience of coastal farming community -Sustainable agriculture in coastal areas ;Identify cultivars that can grow in on farm conditions in a warming scenario ;Identify cultivars that are tolerant to saline soils	DoA	**20**	**20**
3.3	Strengthen coastal communities and habitat improvement (rural) -Advise measures of retrofitting/ relocation of coastal rural housing in view of the recurrence and intensity of extreme events and sea level rise due to climate change ; Facilitate through policy formulation for supporting above measures financially ;Eco development, alternative entrepreneurship etc.,	Dept RD & PR & DoF	**100**	**200**
3.4	Strengthen resilience of coastal city habitats -Advise measures for retrofitting/ relocation of coastal urban housing in view of the recurrence and intensity of extreme events and sea level rise due to climate change, Build/retrofit coastal infrastructure for urban areas &Eco development, alternative entrepreneurship	Urban Local Bodies & DoF	**100**	**200**
		Sub Total	**240**	**440**
Strategy 4: Avert enhanced salt water intrusion in ground water and ensure water security in coastal Tamil Nadu				
4.1	Protective measures to arrest sea water intrusion & beach nourishment	PWD	**100**	**150**
4.2	Increase coverage of monitoring of wells to assess water quality in a regular basis and take appropriate timely action	GWB	**25**	**25**
4.3	Identify appropriate areas for new bore wells and operationalise	GWB	**25**	**25**

S.No	Strategy	Agency	Cost for 12tth FYP (Rupees in crore)	Cost for 13th FYP (Rupees in crore)
4.4	Encourage soil management, moisture retention measures, maintain continuous vegetation, Infiltration & groundwater recharge &reduce erosion risk in rural areas	GWB, DOA Dept RD & PR	**50**	**75**
4.5	Mandatorily reduce extraction of ground water through low horse power pumping machines; Charge pumps with renewable energy	WRD;TEDA	**75**	**125**
4.6	Identify areas supplied by ground water that has become saline and where salinity is likely to increase with climate change-Establish desalination plants	GWB;ULB WRD	**200**	**300**
4.7	Undertake artificial recharge of wells by Rain Water Harvesting; Locally capture surface water runoff into derelict wells to restore groundwater levels; Engineer infiltration with recycled wastewater	GWB; TWAD TNPCB	**200**	**300**
		Sub Total	**675**	**1000**
Strategy 5: Conserve biodiversity in the coastal zone				
5.1	Assess base line flora and fauna data on biodiversity of the TN coastal zone	DoE & DoF	**20**	**30**
5.2	Conserve/protect marine biodiversity including GoM (coral reef/ sea grass bed)	DOE,DoF,GoMB	**100**	**150**
5.3	Protecting mangroves	DoF	**75**	**100**
5.4	Management of estuaries	DoF / DoFisheries	**75**	**100**
5.5	Ensure livelihood of fishermen	Do Fisheries	**50**	**50**
		Sub Total	**320**	**430**

Strategy 6: Avert pollution of water and soil in the coastal zones caused by industrial (power plants and other industries) and domestic wastewater and solid waste management (SWM) practices				
6.1	Develop integrated SWM plan in coastal areas to avert waste entering sea using new technologies (biological methods) in urban and rural areas for industrial & domestic waste water management, municipal SWM and harnessing energy from MSW	ULBs Other agencies to be identified	**160**	**200**
6.2	Implement additional cooling of wastewater from power plants by mixing with sewage and any other new technology	TNPCB	**100**	**200**
6.3	Reuse waste water through biological treatment	TNPCB	**200**	**300**
6.4	Study & monitoring of coastal pollution (air, soil & water) along TN coast	TNPCB/ Universities	**25**	**25**
		Sub Total	**485**	**725**
		GRAND TOTAL	**4420**	**5995**

9. ENERGY EFFICIENCY, RENEWABLE ENERGY AND SOLAR MISSION

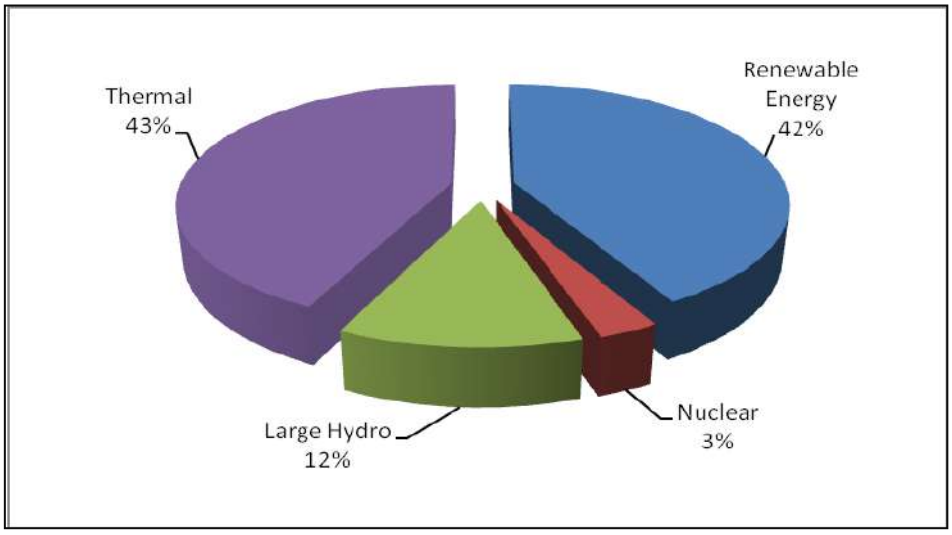
9.1 OVERVIEW, CHARACTERISTICS AND STATUS

Sector Status and Growth

The State has seen a substantial growth in its population from 193 lakh in 1901 to 721 lakh in 2011.This growth in population coupled with rapid urbanization and industrialization of the State has also resulted in a fairly steep demand for electricity and energy in the State. In more recent times, the State's electricity sector has seen a tremendous growth. The Naphtha based gas station of 10 MW capacity was commissioned at Narimanam during 1991-92.Tamil Nadu Electricity Board (TNEB) simultaneously ventured into wind generation and 120 units with a total capacity of 19.355 MW was commissioned in the period 1986-93.In 1992, power sector was thrown open for private participation and the first independent power project was established by GMR Vasavi at Basin Bridge, Chennai. Today TNEB has grown into a giant organization having an installed capacity of 10364 MW of conventional power with 7791 MW of Renewable energy power as on 31st March 2012.

Of the total electricity generation installed capacity, the installed generation capacity of large Hydro accounted to 2223 MW, while thermal generation (State sector) accounts to a total installed capacity of 2970 and share of CGS, 2956 MW.

Figure 9.1: Share of energy mix in the Installed Capacity for electricity generation in Tamil Nadu as of 31st March 2012

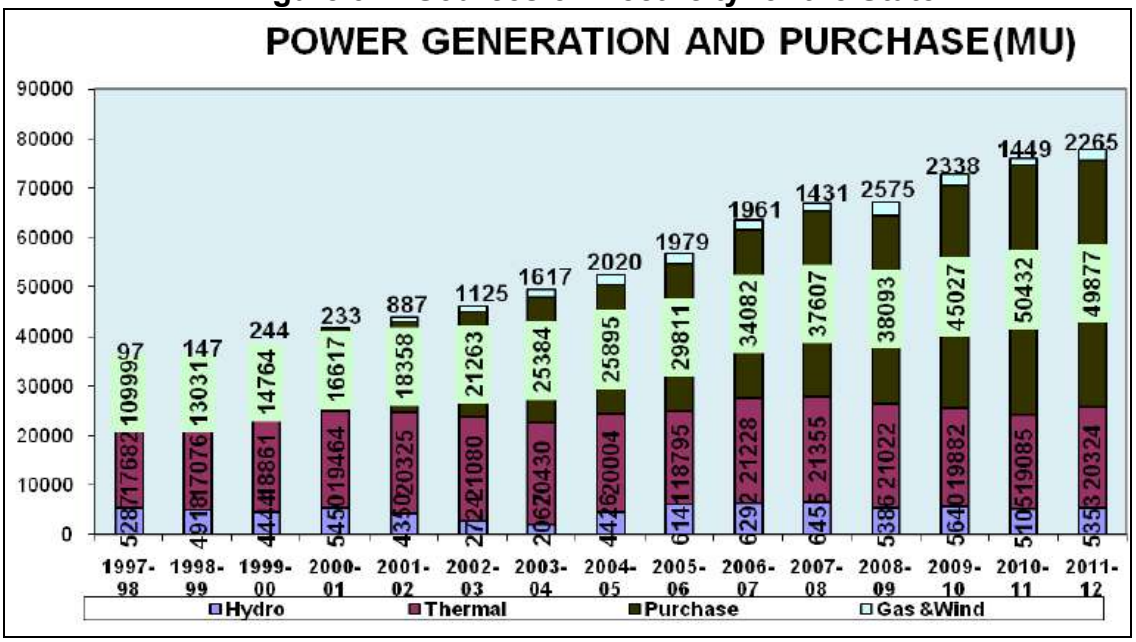


(Source: Tamil Nadu Electricity Board)

The Renewable energy sector accounts close to 40 percent of the Tamil Nadu Electricity Board's Grid Capacity, while accounting to over 36 percent of the total installed electricity generation capacity. In terms of actual energy generation, the total electricity generated as on 31.03.2012 in the State was 77,819 Million Units, which includes, 49,877 Million units of purchased electricity which is both the central

share of generation units located in Tamil Nadu as well as generation units located outside the State.

Figure 9.2: Sources of Electricity for the State



Source: Tamil Nadu Electricity Board, Statistics at a Glance, 2011-12

As can be seen from the above figures, on an average 55-60 percent of the power requirement of the State is purchased from either the central grid or from the Central Share of electricity generated from plants located in the State. Further, despite a large installed capacity of electricity generation from renewable energy sources, the actual energy generated is fairly low. Thermal generation contributes fairly significantly to the electricity requirement of the State and this is also largely due to a fairly high plant load factor of all the thermal power plants located in the State. As on 31.03.2010, Tamil Nadu had a total of 40 hydro installations, which include the various stages of some hydro power stations such as Sholayar 1 and 2, Kodayar 1 and 2, LMHEP Barrage, 1,2,3 &4 and so on. The total installed capacity of these hydro power stations totalled to 2187 MW and the average Plant Load Factor of all these hydro power station installation was 27 percent, with the highest PLF being that of Moyar Hydro Electric Plant and Kundah 1 hydro electric plant with 49 percent respectively.

The plant load factor for wind farms in Tamil Nadu ranges between 12.56 percent to 22 percent. Overall, the State's generation units have a fairly high plant load factor, whether it is thermal, hydro or wind. In terms of surplus/deficit power requirement, the State on an average has deficit power of roughly 6.5 percent or approximately 5000 million units per year. Table 9.1 below gives an overview of monthly power surplus or deficit for the State of Tamil Nadu for the year 2010-11. This trend has been more or less the same for the last five years. As can be seen from the table, the months of February, March, April and May had the highest deficit of power, while the months of June to January had a relatively low electricity deficit.

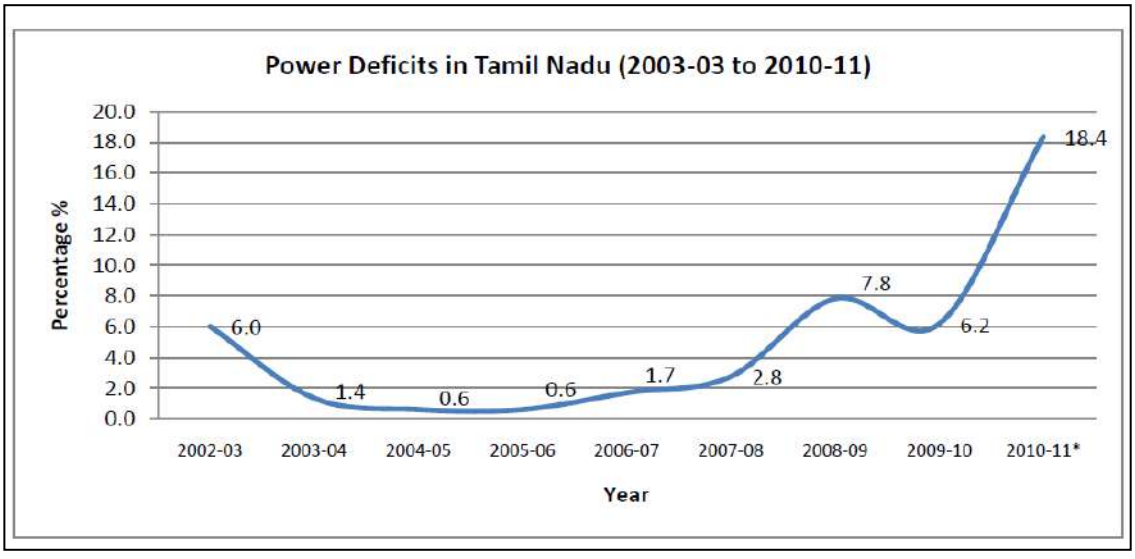
Despite the deficit in electricity generation, the State has always maintained a fairly healthy balance between installed generation capacities and sustained peak demand. However, with increasing demand, the balance is now tilting towards a peak deficit scenario.

Table 9.1: Month wise, Electricity Availability and Requirement Data during 2010-11

Details	Apr '10	May'10	Jun' '10	Jul '10	Aug '10	Sept '10	Oct '10	Nov '10	Dec '10	Jan '10	Feb '10	Mar '10	10-11
Requirement (MU)	7217	6210	6728	6892	6853	7007	6794	5888	5979	6555	6667	7524	80314
Availability (MU)	6452	5778	6289	6473	6450	6668	6485	5601	5647	6175	6199	6884	75101
Surplus (+)/Deficit (MU)	-765	-432	-439	-419	-403	-339	-309	-287	-332	-380	-468	-640	-5213
Surplus (+)/Deficit (percent)	-10.6	-7.0	-.6.5	-6.1	-5.9	-4.8	-4.55	-4.9	-5.6	-5.8	-7.0	-8.5	-6.5

Source: Central Electricity Authority, 2010-2011

Figure 9.3: Power Deficits in Tamil Nadu (2003-2010-11)



Source: Central Electricity Authority

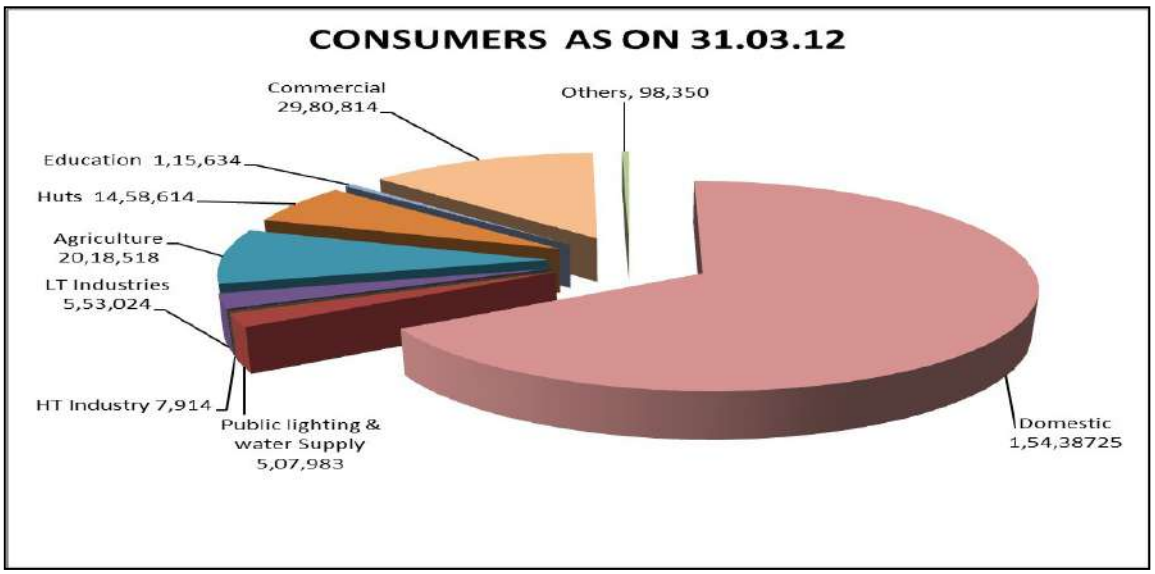
Electricity Consumption Pattern

Tamil Nadu has a fairly high per capita consumption of electricity, with 2011-12 figures indicating it to be 1065 kWh, as compared to the national average of 734 kWh and the highest in South India[1]. As on 31.03.2012, Tamil Nadu had a total of 2,31,79,576 consumers of electricity, of which the domestic sector comprised of a total of 1,54,38,725 consumers. The Commercial segment accounted for 29,80,814 consumers, while the total number of industrial consumers in Tamil Nadu was 5,53,024. Figure 9.4 gives an overview of the numbers of electricity connection under the various categories of consumers.

Over the last ten years, there has been a steady growth in electricity consumption amongst the domestic consumers of electricity, while the commercial sector consumption has more or less been static, with slight variation, year on year. Industrial consumption saw a peak in consumption in 2007-08 and then stabilised after a dip in consumption in the year 2008-09. The domestic consumption is the highest during the summers due to simultaneous use of fans, air conditioners and other electrical gadgets in the houses. The consumption of electricity for the agriculture sector has shown a fairly sharp downward trend since 2009-10 and the downward trend continuing even in 2011-12. The steady growth in the industrial demand is due to the rapid industrialisation and during the years where industrialisation was given a lot of impetus, the consumption of electricity also started to increase for the sector.

The industrial sector alone requires a connected load of 15,000 plus MW of electricity, through a combination of HT and LT. The agricultural sector is also a fairly a large consumer of electricity. As on 31.03.2012, the connected load of agricultural pump sets was over 10 million HP from over 2 million pump sets.

Figure 9.4: Category wise, percentage of consumers of electricity as on 31.03.2012



Source: TNEB Statistics Hand Book

Transmission and Distribution Losses

Tamil Nadu has is one of the States which has a fairly low "Transmission and Distribution Loss" as well as Aggregate Technical and & Commercial Losses. The T & D Loss estimated by the Central Electricity Authority for the last few years has been between 19-20 percent (Table 9.2).

Table 9.2: Transmission and Distribution Loss Trends in Tamil Nadu

	2003 -04	2004 -05	2005 -06	2006 -07	2007 -08	2008 -09	2009 -10	2010 -11
T&D loss (percent)	20.71	19.34	20.37	19.65	18.92	18.95	18.54	18.23

Source: Central Electricity Authority

The transmission and distribution line density of Tamil Nadu is amongst the highest in comparison to other States with a line density of 5.35 CtK.km/sq km (Circuit kilometre per square km). Further, the State has added 1509 CtK.km of High Tension Lines to its Transmission and Distribution Network on 2008, which has also resulted in a drop in the Transmission and distribution losses from the region of 20 percent and 19 percent to the 18 percent range. As can be seen from the table 9.2 above, the AT & C loss has more or less remained static, with this very marginal reduction. The State has the capacity and potential to further reduce its T & D Loss. The total line loss has been in the region of 18 percent on an average over the last 20 years.

The Southern Electricity Grid is heavily congested and therefore the amount of electricity that the grid can transfer cannot be further increased. The State's Electricity Demand has been growing and despite the fact that it has its own generation capacities, it also needs to buy substantial electricity from the Central or Southern Grid. Since the southern grid is already running to full capacities, the transmission or technical losses tends to be on a higher side

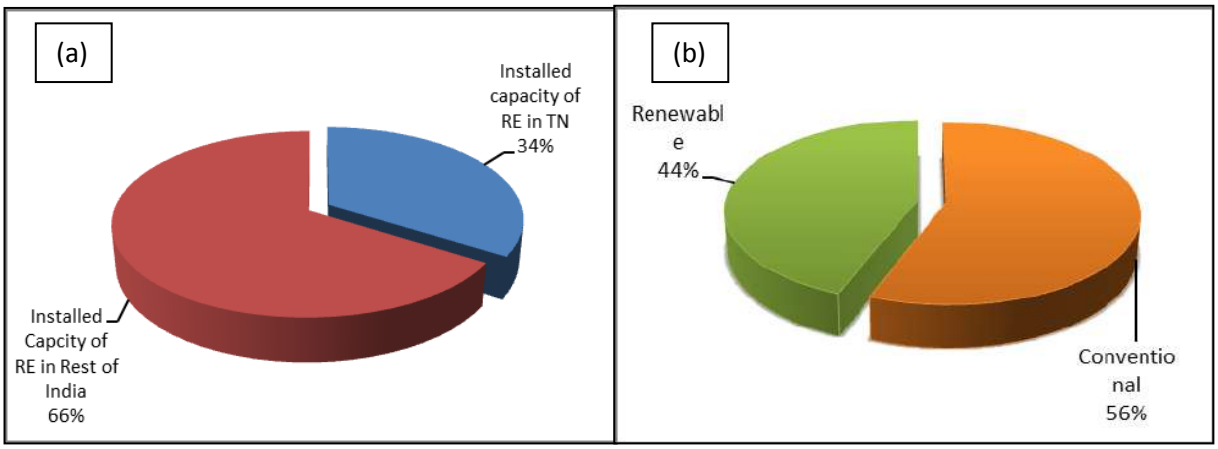
Renewable Energy Trends

From a modest beginning of approximately 4 MW of installed capacity of renewable energy generation in 1990, the total installed capacity of renewable energy generation as on 30th September 2012 was 7,979.17 MW with a CAGR of 53 percent over the past twenty years. The capacity addition for renewable energy is largely driven by the progress of the Wind Energy Sector, though in very recent times, solar energy sector and bio mass sector have also started to gain some ground, though, still in very initial stages. Tamil Nadu leads the renewable energy space in the country and accounts for 34 percent of the total installed renewable energy capacity in the country, as can be seen from figure 9.5a below. The balance of 66 percent accounts for installed renewable energy capacity across India. Within the State itself, renewable energy contributed to close to 43 percent of the total energy installed capacity, while the conventional power contributes to 57 percent of

the total installed capacity of the State. Likewise, the State has a relatively high share of renewables in its energy mix (see Figure 9.5 below).

In addition to Grid Power Renewable Energy Solutions, there has also been substantial growth of Off-Grid and stand alone renewable energy power systems. As of October 2012, the total installed capacity of renewable energy in the State was 8236 MW. Of this, 87.77percent is wind power based, 8.01percent is from bagasse, 2.47percent is from biomass power, 1.34percent is Small hydropower based, and waste to energy and solar power based energy generation constitutes only 0.34percent, .08percent respectively of the total Renewable Energy (RE) mix (Table 9.3)

Figure 9.5: (a) Installed Renewable Energy capacity in Tamil Nadu Vs. Rest of India; (b) Share of Renewable energy and conventional energy installed in Tamil Nadu



Source: Tamil Nadu Energy Development Agency

Table 9.3: Renewable Energy Installations: Achievements of TEDA as on 31.10.2013

Renewable Energy Programme/Systems	Cumulative achievement up to 30.09.2013(MW)	Upto 31.10.2013 (MW)
Wind Power	**7134.00**	**7228.41**
Bagasse Cogeneration Plant	**659.00**	**659.40**
Biomass Power	**167.15**	**203.40**
Small Hydro Power	**90.05**	**110.00**
Solar Power(SPV)	**17.00**	**27.80**
Waste to Energy	**4.25**	**7.00**
Total	**8071.45**	**8236.01**

Source: Tamil Nadu Energy Development Agency

Some of the policies that are in place for Renewable energy include:

- The Tamil Nadu Electricity Regulatory Commission has fixed a Renewable Purchase Obligation at 9 percent for the year 2011-12
- A Feed-in tariff for renewable energy is in place

- The State recently introduced a Solar Policy, 2012, which envisages the implementation of 3000 MW of solar power by 2015, out of which 350 MW would be is from solar roof top systems alone
- The Chief Minister's Solar Powered Green House Scheme is a programme that has been launched with an ambitious target of building 3,00,000 houses powered with solar lighting by 2016 for the benefit of poor in rural areas

Rural Electrification

Tamil Nadu is considered as a State which has 100 percent rural electrification and as per the Census 2011, 93 percent of the total households in Tamil Nadu have access to electricity. As per the Tamil Nadu Electricity board, most of the rural areas have electricity supply ranging from 18 to 20 hrs every day, with power outages from 4 to a maximum of 6 hours a day. Further, even agricultural pump sets have access to electricity for 9 hours a day (see table 9.4).

Table 9.4: Status of electrification in rural Tamil Nadu

	Numbers as per 2001 census	Electrified as on 31.3.2012	Percentage of electrification
Towns	439	439	100percent
Inhabitated villages	15400	15400	100percent
Hamlets	48452	48117	98percent
AD colonies	26764	26764	100percent
Agriculture Pump sets	2016324	2016324	100percent
Huts	1589894	1589894	100percent

Source: TNEB Statistical Handbook, 2011-12

Energy Efficiency and Conservation

Some of the key energy efficiency and conservation programmes being implemented in the State as of now are:

a) Distribution of CFLs in exchange of Incandescent bulbs to all the hut services of TN at no cost and to all the domestic metered consumers at the subsidized rate of Rs. 15/- per lamp, up to a maximum of 2 per household in a phased manner.

b) Perform, Achieve and Trade (PAT) Scheme aimed at industrial efficiency is being implemented in the State. A total of 41 designated industrial consumers in the State are being covered under this programme. These are mainly Thermal Power Plants (20), Textile Industries (5), Paper and Pulp (3), Cement and Chlor Alkali (12) and fertilizer (1)

c) Agriculture sector Demand Side Management (DSM), particularly to replace energy pump- sets with energy efficient pump sets. So far 149 pump sets have been replaced with 4 stars and above rated pump sets.

d) A demonstration project was done with 36 Small-scale units in the lime Kiln sector in Tirunelveli district for energy efficiency improvements successfully

e) Demand side management (DSM) has been implemented for energy use by the public works and water departments.

f) Other DSM initiatives include:

- Time of Day (ToD) tariff for HT industries - 20 percent extra charge is levied on the energy consumed during peak hours (6:00 to 9:00 hours and 18:00 to 22:00 hours) on all HT industrial consumers. Further, 5 percent rebate on energy consumption during off peak hours (22:00 to 5:00 hours) is given as an incentive (TNERC, 2010).
- Power factor penalties: In order to reduce the difference between the energy consumed and the apparent power, reactive power charges are being levied to reduce energy losses. HT consumers are stipulated to maintain a power factor of 0.90, failing which a penalty is levied. Similarly, for some of the LT consumers, the upper limit of power factor is kept at 0.85 (TNERC, 2010).

The State has also implemented a number of "awareness generation programmes" on "energy conservation" through innovative means of communication such as "street plays", "exhibition of energy efficient products and systems", "quiz and poster drawing competitions" amongst engineering colleges and Arts and Science colleges, and also have organized a number of workshops and seminars for builders, industries and Government Departments**.**

In addition to the above, energy audit was conducted in 18 iconic government buildings, in and around Tamil Nadu. The total energy consumption of these buildings put together was estimated to be in the region of 34,714,518 kWh per year and the audit result came up with a potential saving of approximately 5,596,650 kWh per year or in financial terms, a savings of approximately Rs. 26,818,450/- per year.

Under the LED Village Campaign, three villages namely, Vaddakkalur Village, Kudanur Village and Kallukadu village of Veerapandy Panchayat comprising of 205 houses has been electrified through LED lighting systems. This programme entailed the replacement of existing 60 W incandescent lamps with 5 W LED lamps. Further, all the streetlights were also installed with LED lamps in these villages. As a demonstration project for improving the efficiency of Public Water Works, a major programme to revamp the sewage water pumping system at Alandur Municipality was taken up and completed.

Some of the policy decisions that have been taken by the Government to promote energy conservation and efficiency measures are Policy Orders dated 10.11.2008 and 20.08.2010 and 02.08.2012 that mandate:

a) Replacement of incandescent bulbs with CFLs / fluorescent tube lights with electronic chokes in all Government offices
b) All electrical equipment to comply with BEE efficiency standards
c) All sodium/mercury vapour lamps for external lighting in Government offices will be phased out and no new ones will be installed
d) The order of 20.08.2010 extended the programme to all Government buildings, local bodies, corporations, cooperative societies, public sector undertaking, boards etc.

e) The 2nd August 2012 order makes it mandatory for all Government offices to purchase only 3 star rated and above electrical appliances. It also further modifies the previous order that mandated CFLs to T8 lamps and T12 lamps with electronic ballasts. The appliances which should be 3 star rated and above include, refrigerators, air-conditioners, fluorescent lights, distribution transformers, industrial motors, pumps sets, ceiling fans, gas stoves, colour televisions and washing machine.

f) Further a technical committee has been constituted to evolve and adopt guidelines for building and planning authorities and to ensure the implementation of the Energy Conservation Building Code (ECBC) in buildings with a connected load of 100 kW and above in the State.

g) A mission has been constituted under the chair of the Chief Secretary to ensure inter- departmental coordination and monitoring of various energy efficiency schemes – which has been notified as "State Energy Conservation Mission".

Other Energy Use

Firewood, kerosene and LPG are the forms of fuel mainly used for cooking purposes in Tamil Nadu As per the 2001 census, approximately 13 percent of the households in Tamil Nadu use kerosene for cooking purposes and a total of 64.3 percent of the households continue to use firewood for cooking and 19 percent of the households use CNG. Table 9.5 captures the distribution of fuel use by type comprehensively.

T - U: DISTRIBUTION OF HOUSEHOLDS BY AVAILABILITY SEPARATE KITCHEN AND TYPE OF FUEL USED FOR COOKING

		Total	%	Rural	%	Urban	%
T	Availability of separate kitchen within the house:						
T.1	Total	14,173,626	100.0	8,274,790	100.0	5,898,836	100.0
T.2	Available	9,512,484	67.1	4,743,077	57.3	4,769,407	80.9
T.3	Not available	2,858,236	20.2	2,051,899	24.8	806,337	13.7
T.4	Cooking in open	1,756,658	12.4	1,457,583	17.6	299,075	5.1
T.5	No cooking	46,248	0.3	22,231	0.3	24,017	0.4
U	Type of fuel used for cooking:						
U.1	Total	14,173,626	100.0	8,274,790	100.0	5,898,836	100.0
U.2	Fire-wood	9,107,668	64.3	7,113,737	86.0	1,993,931	33.8
U.3	Crop residue	342,810	2.4	234,953	2.8	107,857	1.8
U.4	Cowdung cake	29,675	0.2	20,235	0.2	9,440	0.2
U.5	Coal, lignite, charcoal	4,309	0.0	1,560	0.0	2,749	0.0
U.6	Kerosene	1,855,901	13.1	296,072	3.6	1,559,829	26.4
U.7	LPG	2,703,970	19.1	534,343	6.5	2,169,627	36.8
U.8	Electricity	10,958	0.1	5,307	0.1	5,651	0.1
U.9	Biogas	59,413	0.4	38,427	0.5	20,986	0.4
U.10	Any other	12,674	0.1	7,925	0.1	4,749	0.1
U.11	No cooking	46,248	0.3	22,231	0.3	24,017	0.4

Source: Table H-11 India: Census of India 2001

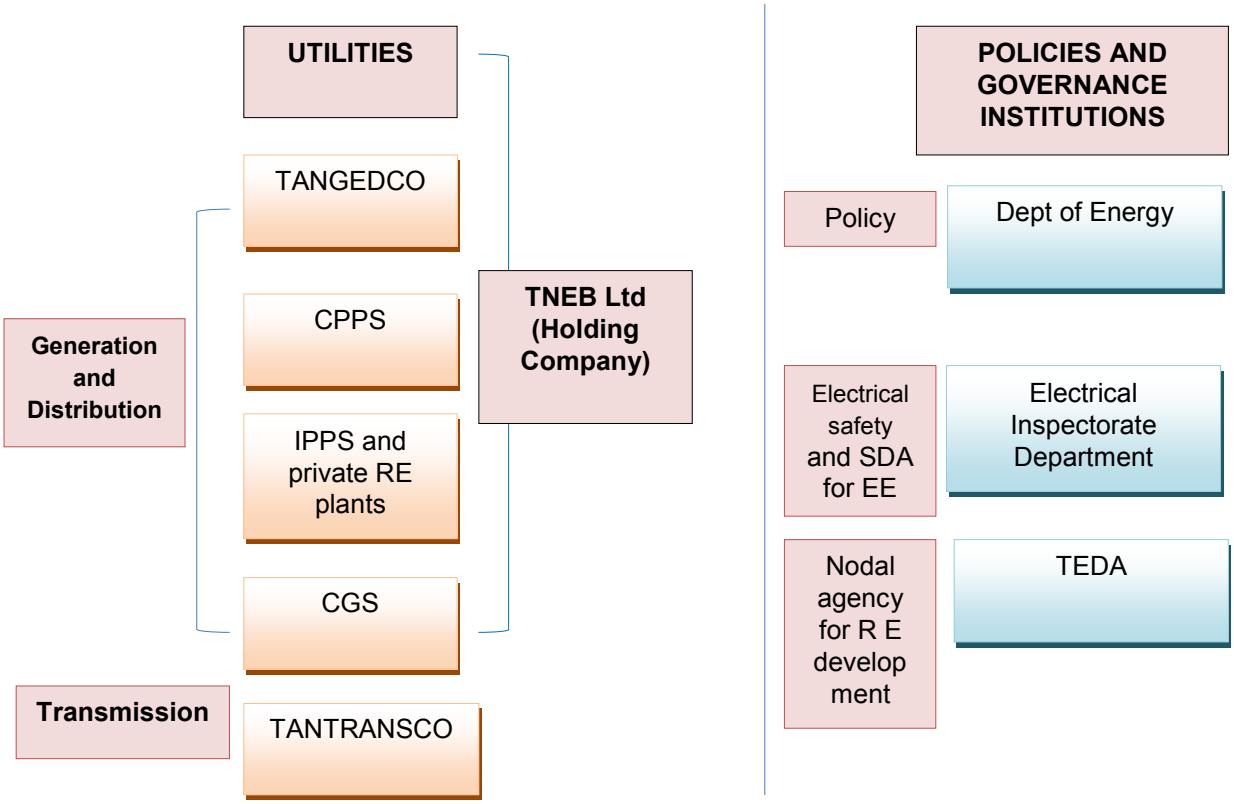
Table 9.5: Distribution of fuel use by type by rural and urban Households in Tamil Nadu

9.2 INSTITUTIONAL MECHANISMS GOVERNING THE ENERGY SECTOR

The Tamil Nadu Electricity Board (TNEB) was functioning as a vertically integrated utility responsible for generation, transmission, and distribution of electricity until 2010. In 2010, it was restructured into a holding company, viz., TNEB Ltd, and two subsidiary companies-TANGEDCO (Tamil Nadu Generation and Distribution Corporation) are responsible for generation and distribution and Tamil Nadu Transmission Corporation Limited (TANTRANSCO) is responsible for transmission of electricity. The utilities are under the regulatory purview of the Tamil Nadu Electricity Regulatory Commission (TNERC).

The policies and guidelines for power sector development are framed by the Department of Energy, Government of Tamil Nadu (GoTN). In addition, there are agencies such as Electrical Inspectorate Department responsible for electrical safety and energy conservation and Tamil Nadu Energy Development Agency (TEDA) responsible for renewable energy development in the State.

Figure 9.6: Institutional arrangement for managing energy in Tamil Nadu



9.3 KEY CURRENT CONCERNS OF THE ENERGY SECTOR

The key concerns of the energy sector are as follows:

- The State has a high level of industrialization and any negative impact on generation or availability of electricity to the State can affect industries.

- The State has very high renewable energy potential and is tapping it, but there are financial implications involved in tapping it to its full potential.
- The State has started to experience peak power shortages, due to increase in demand. This is likely to further intensify and with a climate change scenario, this is likely to increase further than a Business as usual scenario.
- The State has been implementing energy efficiency and conservation measures, but more efforts could be undertaken in this regard.
- While the A T & C losses of the State is not high, it has been static for a period of time and hence implementation mechanism of programmes aimed at reducing AT &C losses further needs to be enforced.

Some of the key concerns that could further increase due to climate change are:

- The State's domestic consumption is rather high. In a climate change induced scenario, the consumption is likely to increase drastically.
- Rapid growth of urban centres could have an impact on urban domestic consumption of electricity and this would require strengthening of electricity distribution network in urban centres.
- Due to successive failure of monsoons, farmers have increased their reliance on ground water for irrigation. In a climate change constrained world and with increasing depletion of ground water resources, farmers would have to resort to using high horse power irrigation pump sets leading to an increase in energy usage.

9.4 CLIMATE CHANGE AND ENERGY DEMAND AND GENERATION CONCERNS

Energy Consumption and Heat Island Effect

Energy consumption of a city is closely related to its ambient temperature. However, urban temperature is changing because of heat island effect and global warming. The International Panel on Climate Change (IPCC) forecasts that the global temperature will be rising in the next 100 years; the temperature rise in 2100 relative to 2000 would range from 1.4 to 5.8 $1^{o}C$ under different adaptation scenarios. Further, there have been a number of scientific studies which estimate that, with a $1^{o}C$ ambient temperature rise, the consumption of electricity would increase by 9.2 percent of domestic consumption, 3 percent of commercial consumption and 2.4 percent of industrial consumption, Funga et al, 2006. In the case of Tamil Nadu, the mean of the locations studied under the HadCM3 A1B scenario indicates likely rise changes in maximum temperature.

Based on the above, it is estimated that there would be approximately a 14-15 percent increase in electricity consumption in the State, due to temperature rise. Other factors such as increasing growth of domestic consumers, increase in consumption due to growth in GDP etc., increase in electricity coverage area, etc. would continue to have a bearing on electricity consumption.

Tamil Nadu has been plagued with acute power shortages since the last few years. The energy and peak shortages stood at 6.5 percent and 11.0 percent respectively in 2010-11. With increase in temperature and resultant increase in the use of fans, air-conditioners, the peak usage is bound to increase in a climate-constrained scenario.

Water and hydropower and generation

Further, the State is also dependent on hydro resources to a certain extent and during lean seasons, the State is bound to face shortfall in electricity generation from the hydro sources and would have to depend on renewable energy, coal and purchase from central grid to meet the short fall. The impacts of climate change on water resources have been highlighted in the Fourth assessment report of the Inter Governmental Panel on Climate Change (IPCC) indicating an intensification of the global hydrological cycle affecting both the ground water and surface water supply. The effects of climate change on water resources in India include increased drought, river system closure, and reduced flows in Himalayan river systems, extreme floods, and reduced river yields and reduced ecosystem resilience. Therefore, with the huge dependence on electricity from large hydro-electric sources and with scientific evidence that river systems in India could possibly be affected due to Climate Change, the already shortfall in electricity supply in off-season periods could intensify further.

Forests and Fuel wood use

While right now, there is not much pressure on forests due to use of firewood, it must be noted that as per the 2001 census, 64 percent of the total households in the State were still using firewood as the predominant fuel for cooking and heating purposes. In a climate-constrained world, forest protection is one of the best forms of mitigating carbon, as it acts as a carbon sink. With increasing population and continued dependence on firewood for cooking and heating, it could potentially affect the forest cover of the State. Therefore, it is imperative that the current dependence on firewood for meeting energy needs to be change drastically.

Irrigation and electricity use

The State depends significantly on irrigation for the cultivation of some of its principal crops such as paddy, sugarcane, banana, etc., which are water intensive crops. Increased reliance on ground water for irrigation purposes has led to rise in demand for electricity in the agriculture sector. Moreover, ground water level in the State has been declining with nearly 60 percent of the total 385 blocks having been exploited and in different stages of criticality. Declining ground water table has led to usage of high capacity pump sets, thereby increasing electricity usage creating a vicious circle for water-energy resources. Significant variation in load is observed across different seasons of the year. The agriculture sector is dependent on the South-West and North-East monsoons. Most of the rainfall is received during October-December. Hence, electricity demand is relatively less during these months.

The consumption of agricultural category is highest during morning between 8:00 to 10:00 hours, as agriculture consumers are being provided with nine hours of

three-phase supply, which includes six hours during daytime and three hours during night time on a roster basis.

The negative impact of climate change on water recharge of deep aquifers means that farmers will resort to deep well water pumping systems, which will be energy intensive. If unaddressed, to meet the water scarcity, the Government may also have to resort to other means to ensure water supply by setting up energy intensive desalination plants.

Adequacy of the Institutions to handle climate change

The institutional framework is fairly robust and evolved with focused set of mandates, which equips itself to perform. The clear role of each of the institutions also avoids overlaps and the tendency to pass on responsibility of implementation to another department is avoided. For instance, while both the Department of New and Renewable Energy and the Department of Power have the responsibility of setting up or promoting renewable energy generation, the mandate for each of the department is clearly outlined, with the Department of New and Renewable Energy promoting generation projects of 1 MW and below and the Department of Power promoting renewable energy generation projects of above 1 MW.

Similarly, with the Department of Electrical Inspectorate being mandated to implement energy efficiency programmes, all issues related to energy efficiency whether it is a street light efficiency programme or a village light efficiency programme comes under its ambit and responsibility. However, it must be noted while that these Departments work independently as of now, since their mandates and responsibilities are also very focused, for addressing climate change, all the departments of Tamil Nadu will have to work together and establish inter-departmental coordination to assess and plan a combined strategy to ensure that the energy sector is a zero carbon emitter to the extent possible. The inter-departmental coordination should also include departments such as the urban planning, transport, forest, science and technology amongst others.

Adequacy of current programmes to meet the challenges of Climate Change

The Programmes implemented by the sector with the exception of those programmes specifically under the National Action Plan on Climate Change are “business as usual programmes” and not necessarily programmes which have been designed to address climate change. However, since India does not need to take any emission reduction actions per se, the programmes and policies which are being implemented properly will ensure that efficiencies of the sector improves, people have access to modern energy and electricity needs, reduce the dependence on forests for energy purposes and importantly increase the fuel mix of energy generation to ensure sustainable energy production in the medium to long run.

However, in terms of programme, there is a need to factor in climate change projections in the long run and plan for generation capacity addition as well as reforms in the energy sector. In terms of implementation, some of the weak links that observed were:

- The activities of the departments were stand alone in nature.
- Actions implemented were mostly reactive and not proactive,

- Programmes did not cover the entire State comprehensively,
- Programmes had been designed keeping budgetary provisions and business as usual scenario and not necessarily aggressive actions required in view of climate change
- There is a lack of coordination between and amongst all the implementing Departments not only in the State, but also inter-State and Centre-State. The inter-State coordination is absolutely essential to counter issues such as Transmission Infrastructure amongst others.

However, the State has recognized some of these weak links and a State Mission specifically with the mandate to ensure coordination of all departments for energy efficiency and conservation has been created. Some of the other weak links are also addressed in the strategy section of this report.

Some of the key concerns and strategies proposed to address these are given below:

Table 9.6: Key Strategies to address climate concerns for the energy sector

Issues of Concern from a Climate Perspective	Strategies to Address it
Energy Scarcity in an Increased Demand, Low Supply Scenario due to climate induced circumstances amongst other contributors	• Promoting Energy efficiency and sustainable use of electricity at all levels and categories of usage such as: • Identifying and Converting the Lighting Devices in all Key Government Buildings to Energy Efficient Lighting by 2015 • In a phased wise manner, converting all street and public lighting to LED Lighting • Energy Auditing of all Government buildings • Promotion of building star rating systems and incorporate building bye-laws for energy conservation • Program for awareness building on BEE star labelled appliances • Initiating and Implementing demo projects on energy efficiency in commercial sector • Reducing T & D Losses • Stringent implementation of Demand Side Management across all key energy sectors • Investment to strengthen grid and smarten the Grid. This would also include imposing norms on Independent Power Producers

	particularly for large wind farms of 10 MW and above to a accuracy of 70 percent • Take a lead to setup as upload dispatch centre for renewable energy generation
Increasing Carbon Emissions due to temperature rise –higher consumption of conventional fuel for producing energy to meet enhanced demands	• Reducing the dependence on Central Grid of Energy Supply by augmenting own clean electricity generation capacities • In addition to promoting wind, proactive policies to promote solar generation as well • Exploring possibilities of decentralized renewable
Reducing Impacts on Forests	• Increasing de-centralised energy applications • Ensuring energy access for all

On the energy efficiency and conservation front, the State has many proactive policies and programmes, particularly related to Government procurement, Government buildings energy efficiency programme and has also undertaken to strictly implement the Energy Conservation Building Code Norms. However, the potential for the State to usher in energy efficiency and conservation are yet to be achieved.

On the A T &C loss reduction front, while the performance of the State is much better than various other States with the A T & C loss being at level of 18 percent, with the national average being 27 which have remained more or less static for the last five years. The State government now is looking to bring down the A T &C Loss levels to 15 percent by the end of 2017, through aggressive implementation plans, it will even bring it to 12 percent by 2017 and 8 percent by 2022 (though, the aggressive scenario factors only 12 percent by 2022).

9.5 GREENING THE ENERGY SECTOR IN TAMIL NADU

In a recent study done by the World Institute for Sustainable Energy with support from Shakti Sustainable Energy Foundation on the potential for renewable energy of the State, the results showed the following (Table 9.7).

On shore wind potential, together with grid-tied solar PV and solar CSP, contributes to about 535,059 MW as against a total estimated potential of 682,800 MW. In addition, offshore potential is about 127,428 MW, a majority of which comprises of high resource quality areas with net capacity utilization factors (Net CUF) of over 30 percent.

Table 9.7: Renewable Energy Potential for Tamil Nadu

Technology	Independent Potential (MW)
Wind 80m (no farmland)	36344
Wind 80m (farmland)	160510
Wind 80m (offshore)	127428
Wind – Solar Hybrid	7913
Repowering	1370
Solar PV (NREL Data)	259700
Solar CSP (NREL Data)	78505
Biomass	450
Bagasse based co generation	1073
Energy Plantations	9500
Small Hydro**	7
Total	**682800**
** Small Hydro potential for 10 nos. of dam-toe-based SHP schemes	

Source: Report on Action Plan for Comprehensive Renewable Energy Development in TN. World Institute for sustainable Energy in Partnership with Shakti Sustainable Energy Foundation, July 2012

The study further estimates the potential for Off-Grid renewable energy systems to be in the region of substantial, with the combined potential of rooftop PV and substitution potential for solar pumping together accounting to 36,890 MW, which is 100 percent more than the current installed capacity in the State. The potentials for the off-grid renewable energy system is captured in table 9.8 below:

Table 9.8: Off Grid Renewable Energy Potential for Tamil Nadu

Rooftop PV	MW	29850
Solar Water Heating	Million Units	24225
Solar pumping	MW	7041
Solar process heating*	Gigajoules	59761
*Potential only of sizing process in cotton cloth manufacturing		

To summarize the total available potential of renewable energy through a combination of Grid and off-grid systems is estimated to exceed 720,000 MW, which is enough to cater to not only to the State's electricity requirements in the coming years but also to sell the surplus energy to other States and take full advantage of the Renewable Energy Certificate programme.

The policy for promoting solar power in the State include

- Development of a road map for promotion of solar power generation systems
- Integrating biomass based power projects with energy plantations in coordination with the Forest Department
- Levying Green Energy Cess to fund renewable energy development
- Encouraging Private Public Partnership in renewable energy projects and incentivizing renewable energy investments in the State

Some of the special programmes that are proposed to be taken up in the 12th Five Year Plan period include:

- Solar Powered Green Homes to light 3,00,000 houses
- Establishment of solar parks through competitive bidding process-up to 3000 MW of solar parks
- Making solar rooftop mandatory for all (a) Multi-storeyed buildings; (b) Educational institutions; (c) IT Parks, SEZs, Telecom Towers; (d) Buildings with a built up area of 20,000 sq.m or more; (e) All Government buildings where ever feasible
- Promote R & D that would include smart grid concepts, PV driven seawater desalination plants, grid connected rooftop systems with two way monitoring systems, repowering of existing windmills, forecasting and scheduling wind evacuation, and offshore wind development

However, the Government continues to promote the other renewable energy resources as well and the proposed capacity additions by renewable energy type is given in Table 9.9.

Table 9.9: The proposed on grid renewable energy capacity development by the government for the period 2012-17 and 2018-22

Type of Renewable	Capacity as on 31st March 2012 (MW)	Proposed addition for 12th five year plan (MW)	Proposed addition for 13th five year plan (MW)
Wind	6970	6000	9000
Small Hydro	90.05	100	100
Bio energy	767.50	1285	1500
Solar	15	3000	5000
Waste to energy	4.25	250	300
Others	-	15	25
Total	**7846.80**	**10650**	**15925**

Enhanced Energy Conservation

A study conducted by the Electrical Inspectorate on Energy Efficiency and Conservation Potentials for Tamil Nadu in 2010 indicated that the total savings of energy consumption could be in the region of 18 percent, translating to 11 billion units of electricity per year. A similar All India Study to estimate the efficiency and conservation potential was conducted by the National Productivity Council in partnership with the Bureau of Energy Efficiency in 2008. Their study concluded that the total energy conservation potential for Tamil Nadu would be in the region of 7.8 Billion Units per year or 13.2 percent of the total energy consumed in Tamil Nadu annually. The breakup of energy saving potentials from the various sectors is given in table 9.10 below:

Table 9.10: Energy Conservation Potentials for various Sectors of Energy Consumers in Tamil Nadu

Energy Consuming Sector	Potential Energy Savings
Agricultural Pump Sets @ 25 percent of the total energy consumption	3 Billion Unit
Domestic Sector @ 20 percent through use of 3 star and above rated appliances	3.3 Billion Unit
Industrial Sector @10 percent	2.3 Billion Unit
Commercial buildings @ 25 percent	1.6 Billion Unit
Municipal Waterworks and street Lighting @ 20 percent	0.72 Billion Unit
Total Savings @18 percent of total energy consumption	11 Billion Unit

Source: Electrical Inspectorate, Tamil Nadu, 2011

The target of the Electrical Inspectorate is to achieve at least a 250 MW savings in electricity consumption through Energy Conservation and Building Code. Further, out of the estimated 18 percent energy saving potential for Tamil Nadu, endeavour will be made to achieve at least 5 percent savings by the end of 2017 and 12 percent by the end of 2022. Some of the activities that would continue are:

a) Initiating Pilot studies for energy conservation and demand side management-improvements and strengthening
b) Demonstration Projects
c) Awareness generation and Capacity building
d) Compliance of Energy Conservation policies in all Government and public buildings of Tamil Nadu including Energy Conservation and Building Code as part of the Municipal Corporation bye laws to ensure its strict implementation.
e) Other areas would include adopting a waste heat recovery policy for the industrial sector.

Currently the Perform Achieve and Trade, the energy efficiency programme to ensure efficiency improvements in the Industrial sector covers a total of 41 designated industrial consumers in the State are being covered under this programme. These are mainly Thermal Power Plants (20) textile industries (5), Paper and Pulp (3), Cement and Chlor Alkali (12) and fertilizer (1). For the 12th Five Year Plan period, endeavour will be to cover more industries and bring them under the PAT Scheme. A demonstration project was done with 36 Small-scale units in the lime Kiln sector for energy efficiency improvements successfully. Based on this success, it is proposed to extend similar programmes covering other small and medium enterprises segment, particularly covering the industries of Brick Kiln, Rice Mills, kopulov furnaces, lime kilns.

Other programmes that would continue include:

- Distribution of CFLs in exchange of incandescent to all the hut services in the State at no cost and to all the domestic metered consumers at the subsidized rate of Rs. 15/- per lamp, up to a maximum of two in a phased manner
- Promotion of Bureau of Energy Efficiency's "energy efficient appliances labelling and programme"
- Renewable Energy based demand side management amongst others

Further Potential of Reducing AT & C Losses

The current level of line losses in Tamil Nadu is in the region of 16 percent and the total A T & C losses\ is around 18 percent. This has been the trend since the last five years. The current plan of the Government is to ensure the reduction of A T & C losses from the current level of 18 percent to 15 percent by 2017 with an attempt to bring it down to 12 percent in later years.

The purpose of preparation of an implementation road map in this sector is to provide a pathway with key milestones to ensure the achievement of the objectives listed above. The implementation pathway is provided for both rapid renewable energy penetration, both grid as well as off-grid as well as for energy efficiency and conservation implementation.

Renewable Energy

- Adoption of an Energy Plan with Cabinet Approval for additional targets envisaged in the 12^{th} and 13^{th} Five Year plan period: (Within 1 year)
- Initiating studies to look into technical bottlenecks and possibilities of creating a transmission corridor for renewable energy (Within 1 year)
- Creating a system to ensure that proper forecasting is done by renewable energy generators up to a accuracy of 70 percent and above (Immediate)
- Preparing a detailed grid-planning document that would ensure identification of new infrastructure required, new smart grid monitoring technologies, capacities for inter-State transfers and inter-regional transfers (In 18 months period)
- A Single window clearance to boost investor confidence in renewable energy investments (in 18 months period)
- Adoption of a land policy for renewable energy solutions (Within 18 months)
- Preparation of a separate off-grid regulation that would boost investor confidence for off grid investments (in 18 months period)
- Starting of pilots for unexplored technologies such as CSP(Concentrating Solar Power), Energy Plantations, Offshore wind etc.) (between 24-36 months period)
- Creation of a special fund or a cess for renewable energy – Could be called the Green Energy Cess: (Within 1 year)

Energy Efficiency and Conservation

- Detailed Energy auditing of various Government offices and public works and public lighting for a comprehensive plan of action (Immediate)
- Pilot projects of converting iconic government buildings into energy efficient buildings (Immediate)
- Pilot projects of converting iconic roads of key cities of Tamil Nadu in to LED power street lights (within 1 year)
- Pilot projects for Demand Side Management in the agricultural sector, extending it from what has been covered so far. The pilot projects should look at converting conventional irrigation systems to solar powered irrigation systems (within 1 year)
- Incorporation of Energy Conservation Building Code in Municipal Bye laws and implementation in commercial buildings. (Within 2 year).

9.6 BUDGET REQUIREMENT FOR STRATEGIES IN ENERGY SECTOR

The total cost for implementing the strategies during the 12th Five Year Plan (FYP) is Rs. 155438.00 crore and during the 13th Five Year Plan is Rs.154310.00 crore. (Table 9.11)

Table 9.11 Summary of budget requirement for Energy sector

S.No	Strategies	Cost for 12th FYP (Rupees in crore)	Cost for 13th FYP (Rupees in crore)
1.	Enhanced Energy Efficiency and Energy Conservation in Conventional Energy Sector	**1475**	**1770**
2.	Renewable Energy and Solar Mission	**61138**	**54975**
3.	Energy efficiency and Climate Change mitigative measures (TANGEDCO)	**92825**	**97565**
	Grand Total	**155438**	**154310**

Detailed Budget for strategies in Energy Sector is given in the Table 9.12

Table: 9.12 Detailed Budget for strategies in Energy Sector

S. No	Strategy	Agency	Cost for 12th FYP (Rupees in crore)	Cost for 13th FYP (Rupees in crore)
Strategy 1 : Enhanced Energy Efficiency and Energy Conservation in Conventional Energy Sector				
1.1	**Energy Efficiency and Energy Conservation in buildings**			
1.1.1	Detailed Mapping and auditing of all existing public buildings in conformance with the Energy Conservation Building Code (ECBC)	Electrical Inspectorate	10	5
1.1.2	Incorporation of design features and consultancy services for new public building conformance with Energy Conservation Building Code (ECBC)	Electrical Inspectorate	10	5
1.1.3	Implementation of energy efficiency measures in the existing buildings through retrofit	PWD	250	250
1.1.4	Incorporation of ECBC measures in all new Government buildings at construction stage	PWD	250	250
1.1.5	Adoption of Enhanced Energy Efficient generation including supercritical technology	TANGEDCO		
2.1	**Energy Efficient Street Lighting**			
2.1.1	Energy Efficient Street lighting (world class cities programme)	Local Bodies, Municipalities, Corporation	250	250
2.1.2	Energy Efficient Street lighting (Rest of Urban Tamil Nadu)	Local Bodies, Municipalities, Corporation	375	375
2.1.3	Energy Efficient Street lighting (Chennai)	Local Bodies, Municipalities, Corporation	125	125
3.1	**Energy Efficiency in industries and awareness creation**			
3.1.1	Implementing energy Efficiency Improvements in the Small and Medium Enterprises through policy initiatives like waste heat recovery etc. by means of VAT, subsidy and grants for procurement/ implementation of Energy Efficient programme/products.	Industries	200	500
3.1.2	Awareness Generation programs on Energy Conservation and Efficiency	Electrical Inspectorate	5	10
		Sub Total	**1475**	**1770**

S. No	Strategy	Agency	Cost for 12th FYP (Rupees in Crore)	Cost for 13th FYP (Rupees in Crore)
Strategy:2 - Renewable Energy and Solar Mission				
2.1	Solar power generation program (3000 MW + 2000 MW)	TANGEDCO TEDA	24000	14000
2.2	Offshore wind generation program (50 MW + 150 MW)	TANGEDCO TEDA	625	1875
2.3	On-shore wind generation program (5000 MW + 5000 MW)	TANGEDCO	30000	30000
2.4	Solar home lights	TEDA	900	2500
2.5	Energizing street lights with solar power	TEDA	250	1000
2.6	Biomass (1000 MW + 1000 MW)	TEDA	4200	4200
2.7	Co-generation(250 MW + 250 MW)	TEDA	1113	1200
2.8	Electric vehicles	TEDA	50	200
		Sub Total	**61138**	**54975**
Strategy:3 - Energy efficiency and Climate Change mitigative measures (TANGEDCO)				
3.1	Adoption of Enhanced Energy Efficient generation including supercritical technology	TANGEDCO	200	300
3.2	Grid connected Renewable Energy Generation – Hydro Electric Projects	TANGEDCO	1950	7115
3.3	Reduction of AT&C losses (Set of activities to reduce ATC losses of 18percent-15percent in 12th plan and 15percent-12 percent in 13th plan)	TANGEDCO	45000	45000
3.4	3.1-Transmission Infrastructure strengthening works	TANTRANSCO	24000	15000
3.5	3.2-Distribution Infrastructure Strengthening works	TANGEDCO	10000	5000
3.6	3.3- Feeder separation with HVDS project	TANGEDCO	6000	10000
3.7	3.4-Smart grid initiatives	TANGEDCO & TANTRANSCO	5000	15000
3.8	DSM (Demand Side Management) Activities	TANGEDCO	315	150
3.9	Preventive measures to mitigate climate change effects	TANGEDCO	360	-
		Sub Total	**92825**	**97565**
		GRAND TOTAL	**155438**	**154310**

10. SUSTAINABLE HABITAT

10.1 OVERVIEW

Habitat is generally defined as the area inhabited by a particular species or animal, or plant or any other organism, different organisms thrive in different environments, with the different natural resources. Human settlements are influenced by the availability of basic infrastructure facilities like water, food, etc. and revenue opportunities. This leads to concentration of population in selected areas pushing the settlements vertically, closer to coast, etc. resulting in pressure on the available limited resources. Due to such urbanisation, habitats are associated with issue of shortage of food, water supply, sewerage, solid wastes, health, concretisation, absence of greenery, increased energy consumption, growth in vehicles, traffic congestion, extended travel hours, pollution, etc.

The National Mission for Climate Change identifies provision of sustainable habitat as one of the eight missions to ensure food and shelter to the population without resource depletion, in such a way that no waste is generated and to sustain life indefinitely. Within the scope of the National Mission for Sustainable Habitat, mitigation measures would encompass promotion of energy efficiency in the residential and commercial sector, capture of greenhouse gases as part of water, waste water and solid waste management, exploitation of mitigation potential in the area of urban transport and reorienting urban planning. Adaptation measures would include water efficient techniques, such as reducing leakages in the supply system, wastewater recycling, rainwater harvesting, designing of urban storm water management systems and urban planning measures, etc.

Tamil Nadu ranks first on share of urban population among large States in the country and third on absolute urban population. As per Census 2011, Tamil Nadu, with an urban population of 34.90 million, has 48.45 percent of its population living in urban areas. Tamil Nadu's population has grown by 15.6 percent between 2001 and 2011, the sixth lowest rate for that period amongst populous States (States whose population exceeded 20 million in 2011). Although its decadal rate of population growth has declined since 1971, the population growth during the last decade (2001–2011) has increased. The distribution of population by rural and urban is showing significant variation, the percentage of urban population over the two census periods 2001 and 2011 shows about 4 percent increase of urban population. This may be due to migration from rural to urban areas.

According to the 2011 Census data, the population of Tamil Nadu State stood at 7.21 crore registering an increase of 97 lakh in the period from 2001 to 2011. The decadal growth during 2001-2011 was 15.6 percent as against 11.7 percent for 1991-2001. Assuming that the natural growth rate remained constant, the present increase in growth rate may be explained by the increasing net migration into the State. Tamil Nadu has been attracting immigrants due to high industrial development and growth experienced in the State. It can be estimated that about 40-50 lakh people migrated into Tamil Nadu in last decade and this trend is likely to continue.

The total number of households in India as per 2011 Census is 24,66,92,687 and Tamil Nadu has 1,84,93,003, household which is 7.5 percent of the total households in India. Construction plays a very important role in its economy contributing on an average 6.5 percent of the GDP, Commercial and residential sectors continue to be major market for the construction industry. The sectors consume a lot of energy throughout the life cycle of buildings thus becoming a major contributor to greenhouse gas emissions.

For the TNSAPCC, nine key sub-sectors have been identified for action under sustainable habitat (Table 10.1). There are several line departments addressing each of the issues, and the major difficulty identified is with respect to the availability of data pertaining to sustainable habitat. Hence efficient data and statistics and other publications shall be brought into the single window and shared by the working group member departments. There is an immediate need to collate data from various indicators/parameters for building baseline information and for concurrent monitoring through an efficient IT enabled common platform. Similarly, studies for estimating, projecting the trends of critical parameters shall be carried out and shall be disclosed in the common website. This task may be outsourced for sustainability.

Table 10.1: The subsectors operational within the habitats sector and the interventions being implemented in the State under each sub sector

Sl. No	Key Issues	Interventions related to Sustainable Habitat
1	**Housing**	ECBC,DCR,RWH, OSR, Slum Development
2	**Drinking Water**	Rural, Urban – Energy Saving, waste water re-use, water source protection
3	**Urban Development**	Master Plan, CDP, TIP, FSI, Disaster preparedness
4	**Health and Sanitation**	Health impacts, prevention of diseases
5	**Waste Management**	Solid and Liquid Waste management
6	**Transport**	Public transport (CMRL, Mono Rail, Vehicle Growth, Bharat stage II, VEC, Alternate fuel
7	**Energy**	Energy saving, solar power, patronizing public transport
8	**Pollution**	Monitoring and Regulatory
9	**Greening of Urban Spaces**	Parks and Playgrounds, usage of Open Space Reserves, Ecological restoration of degraded water bodies.

There are eight line departments and sub-departments/agencies which are directly dealing with the above sustainable habitat sub-sectors:-

(1) Housing and Urban Development,
(2) Municipal Administration and Water Supply Department,
(3) Transport Department,
(4) Health and Family Welfare Department,
(5) Tamil Nadu Energy Development Agency,
(6) Tamil Nadu Electricity Board,

(7) Rural Development and Panchayat Raj Department and
(8) Tamil Nadu Pollution Control Board.

Other than these departments there are departments which are also indirectly supporting towards the development of sustainable Habitats.

10.2 STATUS

Housing

Tamil Nadu ranks first on share of urban population among the large States in the country and third on absolute urban population. As per provisional estimates of 2011 census, Tamil Nadu, with a provisional urban population of 34.90 million, has 48.45 percent of its population living in urban areas. According to a study by the Centre for Policy Research (2001), there appear to be 3 to 4 major urban corridors, namely

- Chennai - Salem-Erode -Coimbatore;
- Tiruchi - Madurai – Tirunelveli;
- Chennai – Cuddalore, Thanjavur and to a lesser extent,
- Tuticorin – Nagercoil.

Urbanisation is closely linked to the economic activities in a particular area. Rapid increase in urban population increases the demand for housing and results in the problems of straining or breaking-down of sanitary facilities and other infrastructure in cities and towns. There is acute shortage of housing stock in urban areas because of the mushrooming growth of urban slums. Creation of housing stock has been an important aspect of urban development.

More than 20 percent of the urban population of the State lives in slums. It is estimated that 13.98 lakh families are living in urban slums in Tamil Nadu and Chennai alone has more than 35 percent of the population living in urban slums. It is well known that the slum huts lack proper basic amenities such as living space, drainage, toilet and other facilities.

Because of this, there is a constant need to augment urban housing stock.

Drinking Water

Water supply in the State depends mostly on rainfall and receives an annual rainfall of 958 mm as against the country's average rainfall of 1250 mm. The Government has provided increased allocation in each plan for this sector for the provision of safe drinking water. There is significant increase in coverage in each plan period. However, due to the increase in demand, full coverage remains an elusive factor. Among other notable reasons are over exploitation of surface/sub surface water and quality related inconsistencies.

Tamil Nadu Water and Drainage Board (TWAD) which came into being in 1971 is vested with the responsibility of investigation, formulation and execution of water supply and sewerage schemes in the entire State of Tamil Nadu except Chennai Metropolitan Area (CMA).Tamil Nadu is divided into 32 administrative

districts including Chennai with the rural area spread over 94614 rural habitations in 12524 village panchayats. A Rural Habitation is defined as a locality within a village where a cluster of families reside. The total population should be 100 or more for consideration for coverage under the rural water supply norms. It is generally assumed that around 20 families reside in a habitation. Average number of persons in a family is taken as 5. In case of hilly areas, a habitation may have a population less than 100.

The drinking water supply to the rural people of the State is affected through surface as well as sub surface sources. The sources for most of the water supply schemes are dependent on the surface and sub surface flows of 17 major rivers flowing within the State. Ground water sources like bore wells, open wells, etc. are the main sources in the rural villages.

Rural water Supply schemes are implemented based on periodical surveys. TWAD Board has conducted the surveys in the years 1976, 1985, 1992, 2003, and recently in 2006. The status identified through these surveys is the basis for the provision of water supply to rural areas. TWAD Board has been implementing the water supply schemes in the rural areas with a systematic approach and has done the best in the field. Since its formation, TWAD has covered vast number of habitations in the rural areas and has provided protected water supply to almost all the habitations in Tamil Nadu. In fact, the micro level approach to the level of "habitations" was originated only in Tamil Nadu with the surveys, which were later adopted by the Government of India to be followed by the other States in the country. Rural Water Supply schemes were implemented as per the Guidelines of Government of India but on the basis of classification by habitations only from 1976-1977 onwards. The normal service level norm for drinking water supply to the rural population is 40 litres per capita per day (lpcd). In Tamil Nadu as on 01-04-2012 there are 94,614 rural habitations, of which 10,611 habitations are partially, covered habitations and 84,003 are fully covered.

The urban areas of Tamil Nadu are classified, depending upon the civic status, except Chennai Corporation, as follows: Corporations (9); Municipalities (150); Town Panchayats (559) as shown in Table.10.2 (Tamil Nadu 12th FYP document). The task of providing safe drinking water and sanitation facilities for the entire State except Chennai Metropolitan area rests with the Tamil Nadu Water Supply and Drainage Board. Water supply schemes on a limited scale are being implemented by urban local bodies also. The schemes on completion are handed over to the respective local bodies for maintenance.TWAD Board is maintaining schemes of composite nature covering more than one local body. Here too, the maintenance of the internal arrangements is the responsibility of the respective local body. Chennai Metropolitan Water Supply and Sewerage Board (CMWSS Board) is vested with the responsibility of providing water supply and sewerage facilities within the metropolitan area of Chennai. Norms adopted: In Tamil Nadu, the following per capita norms are adopted for Water Supply to urban Towns: Corporations (110 lpcd (litres per capita per day); Municipalities (90 lpcd); and Town Panchayats (70 lpcd). Tamil Nadu's water supply depends mostly on rainfall and the State receives an annual rainfall of 958 mm as against the country's average rainfall of 1250 mm.

Table 10.2: Status of Water Supply in Tamil Nadu

Civic status	Good	Average	Poor	Total
Corporations (excluding Chennai)	3	6	-	9
Municipalities	45	92	13	150
Town Panchayats	348	206	5	559
Total	**396**	**304**	**18**	**718**

Note:-
Corporation: Good - 110 lpcd and above, Average - 70 to 109 lpcd, Poor - Less than 70 lpcd.
Municipality: Good - 90 lpcd and above, Average - 50 to 89 lpcd, Poor - Less than 50 lpcd.
Town Panchayats: Good - 70 lpcd and above, Average - 40 to 69 lpcd, Poor - Less than 40 lpcd.

Urban Development

Urban development planning in the State involves multiple State Departments addressing different sectors. The Master Plan and District Development Plans were prepared by the CMDA (for Chennai Metropolitan Area) and by DTCP (for rest of the areas). The Provision of road infrastructure development is planned and developed by the Department of Highways and Minor Ports. Similarly roads falling under the jurisdiction of Urban Local Bodies (ULBs) were developed and maintained by the ULBs. Provision of Water Supply, Liquid and Solid Waste Management were planned and developed by the Municipal Administration and Water Supply Department. In addition to this, ULBs are preparing CDPs, DPRs for effective planning and implementation.

Health and Sanitation

Tamil Nadu has a fairly robust health infrastructure; yet the State faces shortfalls in terms of primary health centres as well as health care personnel (Table 10.3).

Table 10.3: Health Infrastructure of Tamil Nadu

Particulars	Required	Inposition	Shortfall
Sub-centre	7516	8706	*
Primary Health Centre	1249	1204	45
Community Health Centre	312	385	*
Health worker (Female) /ANM Sub - Centres & PHCs	9910	9774	136
Health Worker (Male) at Sub Centres	8706	1216	7490
Health Assistant (Female)/ LHV at PHCs	1204	1022	182
Health Assistant (Male) at PHCs	1204	1899	*
Doctor at PHCs	1204	1704	*
Obstetricians & Gynaecologists at CHCs	385	0	385
Paediatricians at CHCs	385	0	385
Total specialists at CHCs	1540	0	1540
Radiographers at CHCs	385	139	246
Pharmacist at PHCs & CHCs	1589	1465	124
Laboratory Technicians at PHCs & CHCs	1589	896	693
Nursing Staff at PHCs & CHCs	3899	6653	*

*In surplus:

Source: RHS Bulletin, March 2011, M/O Health & F.W., GOI

Sanitation is essential for enhancing the quality of life and improving productivity. The International Water Supply and Sanitation Decade had fixed goals for the sanitation sector. Yet they remain mostly unfulfilled. Although the five-year plans laid importance to urban sanitation, in the absence of sufficient financial support from the Central and State Governments, the sector did not make much headway.

In Tamil Nadu, underground sewerage schemes are in existence only in 16 towns, comprising 4 Corporations and 12 Municipalities in the State and that too with partial coverage. Sewerage schemes are normally considered for implementation only in Class I cities with a population of more than one lakh. However, the State Government has accorded priority for implementation of sewerage schemes for district headquarters and all municipalities and places of tourist importance.

During the year 2011-12, construction of 52 Integrated Sanitary Complexes in 52 Town Panchayats and renovation of 75 sanitary complexes in 65 Town Panchayats have been taken up.

Waste Management

Human activities create waste and the way the wastes are handled, stored, collected or disposed can impact the environment and public health. In urban habitats where human populations are concentrated, solid waste generation and management are critical issues and are of utmost importance to ensure healthy living condition. The quantity and quality of the solid waste generated differs based on the socio- economic status, cultural habits, commercial activity, etc. Based on the source of generation and the quality, the wastes are generally categorised into (i) Industrial or Hazardous waste, (ii) Household / municipal waste (iii) Bio-medical / hospital waste and (iv) E-waste namely the electronic wastes.

Tamil Nadu is one of the most urbanized States in India with 44.04 percent of its population living in urban areas. Population growth has enhanced the quantum of waste generation, leading to an increase in the level of pollution. Accumulation of solid waste, especially Municipal Solid Waste (MSW), is a matter of growing concern in urban areas and this problem has aggravated due to the absence of proper disposal plans.

The implementation of Municipal Solid Waste (Management and Handling) Rules 2000 has become the mandatory responsibility of the Urban Local bodies. Government of India has notified that in the case of Municipal Solid Wastes, as per the said rules, the municipal authorities are responsible for the collection, reception, transportation, treatment and disposal of the municipal solid wastes. As per the said rule, municipal authorities should improve the existing landfill site on or before December 2000.New site for landfill and composting should be identified by December 2002 and the composting facility must be commissioned by December 2003.

Municipal Corporations and Municipalities in TN generate about 10870 MT (7070+3800) of solid waste per day. The per capita solid waste generation ranges between 0.3kg/day to 0.6kg/day. Chennai, which is one of the four major metropolitan cities in India, has a per capita solid waste generation rate of 0.6kg/day, highest in the country (Table 10.4).

Table 10.4: Solid wastes generated in major cities in Tamil Nadu

S. No	City	Quantity of waste generated tonne/day
1	Chennai	3500
2	Madurai	711
3	Coimbatore	710
4	Tiruchi	408
5	Salem	330
6	Tirunelveli	210

Source: TNPCB

There are 2771 hazardous waste generating industries in Tamil Nadu generating total of 4,26,361 tonnes/year of hazardous wastes. With respect to the Bio medical waste, quantity generated from 3450 units is 25793 kg/day.

Energy

Dealt with separately in Chapter 9 of this document, and all actions for sustainable habitat will be consistent with and complementary to those in Chapter 9.

Transport

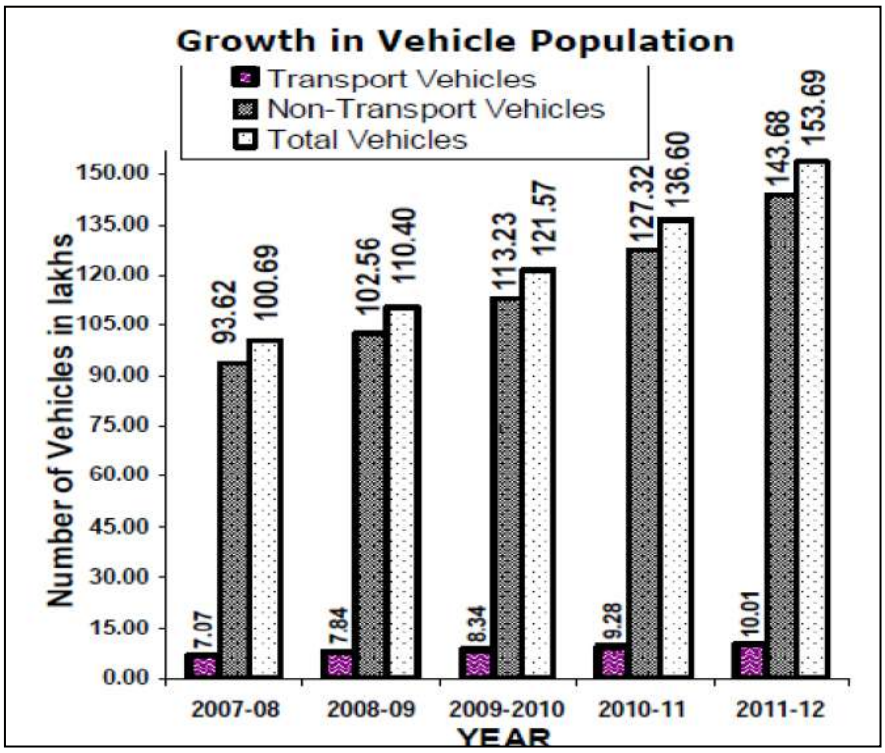
The transport sector is one area which consumes around 50 percent of the petroleum products and where 25 percent energy saving potential exists. There has been a steady increase in the vehicle population, at an annual rate of 10.06 percent to 12.5 percent between 2007-08 to 2011-12, of which significant contribution made from the non-transport vehicles sector which includes two wheelers, cars etc..In Tamil Nadu, private vehicle population has increased at a greater level compared to the public transport. The density of motor vehicles per sq.km has increased from 22 in 1996 to 52 in 2004. During the year 2011-12, the total number of transport vehicles registered is only 1,38,581; whereas the total number of non-transport vehicles registered during the same period are 16,35,422 of which two wheelers and motorcars alone amount to 16,06,603.

The number of motor vehicles has increased in the State from 46.0 lakh in 1999-2000 to 67.5 lakh in 2003-04, of which around 48 percent is concentrated in major cities like Chennai, Coimbatore, Salem, Madurai, Tirunelveli and Tiruchirapalli. Chennai itself accounts for about 24.5 per cent of the total registered vehicles and has more registered vehicles than those in the other cities. In Tamil Nadu, two-

wheeler population is nearly 1.30 crore, which accounts for 78 percent, while cars add up to only 14 percent. However, registration of new cars is also on the rise.

Increase in fuel cost has not deterred the vehicle buyers in the State. The year 2011 saw rapid increase in vehicle population with 2.22 lakh new two-wheelers and over 52,000 new cars hitting Chennai roads. Overall, the State witnessed an increase of 13.7 lakh two-wheelers and 1.45 lakh new cars (Figure 10.1, Source: Department of Transport, GoTN).

Figure 10.1: Vehicle population trends in Tamil Nadu



Note:
Transport vehicles include -Goods carriages (Lorries, National Permit lorries, Tractors & trailors, Light commercial vehicles and articulated vehicles); Private service vehicles; School bus; Ambulance; Fire fighters; Contract Carriages (Auto rickshaws, Ordinary taxi, Motor cabs, max cabs, omni buses; stage carriages (Public and private).
Non Transport vehicles include- Motor cycles, scooters, mopeds, motor cars, jeep, tricycles auto, station wagon, tractor, three wheelers, four wheelers, road rollers and others.
http://www.tn.gov.in/sta/g1.pdf

Pollution

Development results in urbanisation and urbanisation in turn results in further development, like housing, transportation, industrial growth etc. Rate of urbanisation is generally more in developing countries due to enormous activities going on compared to the developed countries. Major benefits incurred from urbanisation are improvement in economy, growth of commercial activities, Social & cultural

integration and availability of services. But the disadvantages of urbanisation are many, over crowded cities/ towns and traffic congestion, lack of adequate water supply and sanitation, increased cost of living, etc. The most critical outcome of urbanisation is the pollution from various urban activities. Air pollution caused by increased vehicular emissions due to dependence on motorised transport, heat island effect due to decreased vegetation and increased built-up area, water pollution due to disposal of wastes, emissions due to energy generation and not but not the least noise pollution. The urban sprawl also causes impact on the human health.

Tamil Nadu is one of the most urbanised and industrialised States of the country. Rapid increase in urban population results in unplanned urban development, increase in consumption patterns and higher demands for transport, energy, other infrastructure, thereby leading to pollution problems in many places of the State. Vehicles are a major source of pollutants in major cities. The number of motor vehicles has increased in the State from 46.0 lakh in 1999- 2000 to 67.5 lakh in 2003-04, of which around 48 percent is concentrated in major cities like Chennai, Coimbatore, Salem, Madurai, Tirunelveli and Tiruchirapalli. Chennai itself accounts for about 24.5 per cent of the total registered vehicles and has more registered vehicles than those in the other cities.

Apart from the growth of vehicle concentration, the other reasons for increasing vehicular pollution are the types of engines used, age of vehicles, congested traffic, poor road conditions, and out-dated automotive technologies and traffic management systems. The quantum of vehicular pollutants emitted is highest in Chennai followed by Coimbatore, Salem, Madurai, Trichy and Tirunelveli. Carbon monoxide (CO) and Hydrocarbons (HC) account for 64 per cent and 23 percent, respectively, of the total emission load due to vehicles.

Air borne emissions emitted from various industries are a cause of major concern. These emissions are of two forms viz., Suspended Particulate Matter (SPM) and gaseous emission of Sulphur dioxide (SO_2), Nitrogen dioxide (NO_2) and Carbon monoxide (CO). In 2002-03 among the 15 major States, Tamil Nadu was at the top in terms of number of factories. Small-Scale Industries (SSIs) that contribute greatly to the State's economy and this number keep on increasing. Generally these SSIs are very poorly equipped with pollution control measures, and have a high aggregate pollution potential. In Tamil Nadu, Chennai - Manali, Cuddalore, Vanniyambadi, Thoothukudi and Tirupur, are well known for petrochemical, pharmaceutical, leather and textile processing industries and the Ambient Air Quality (AAQ) of these belts is considerably contaminated. Construction and development activities contribute heavily to the suspended particulate matter in cities.

Under the National Ambient Air Quality Monitoring (NAAQM) network besides meteorological parameters, pollutants like Sulphur dioxide (SO_2), Nitrogen dioxide (NO_2), Respirable Suspended Particulate Matter (RSPM) and Total Suspended Particulate Matter (TSPM) are monitored at different parts of the city. In most of the

stations, the levels of SO_2 and NO_2 are generally within the prescribed limits, but the RSPM levels are often found to be violating the standards. In Chennai, the annual average of RSPM levels in most of the stations has been between 62-138µg/m3 during the period 2000-2011. Whereas the prescribed standard (annual average) is 60 µg/m^3. In Trichy, in traffic locations, the range of annual average of RSPM has been 72-137 µg/m^3 during 2005-2012. Similar is the case in other cities also.

There are over 3000 highly polluting red category industries in Tamil Nadu, releasing over a 6 lakh litres of effluents per day. The tanneries located in Vellore, Dindigul, and Erode districts have affected the river basins. The textile units in Tiruppur, Erode, and Karur, have contaminated the Noyyal, Amaravathy and other water bodies. River basins like Palar, Tamiraparani, Cauvery, Noyyal, Bhavani and Amaravathy face serious pollution problems due to sewage. In the coastal area of Tamil Nadu 488.02 MLD of wastewater is generated and only 226 of MLD is treated.

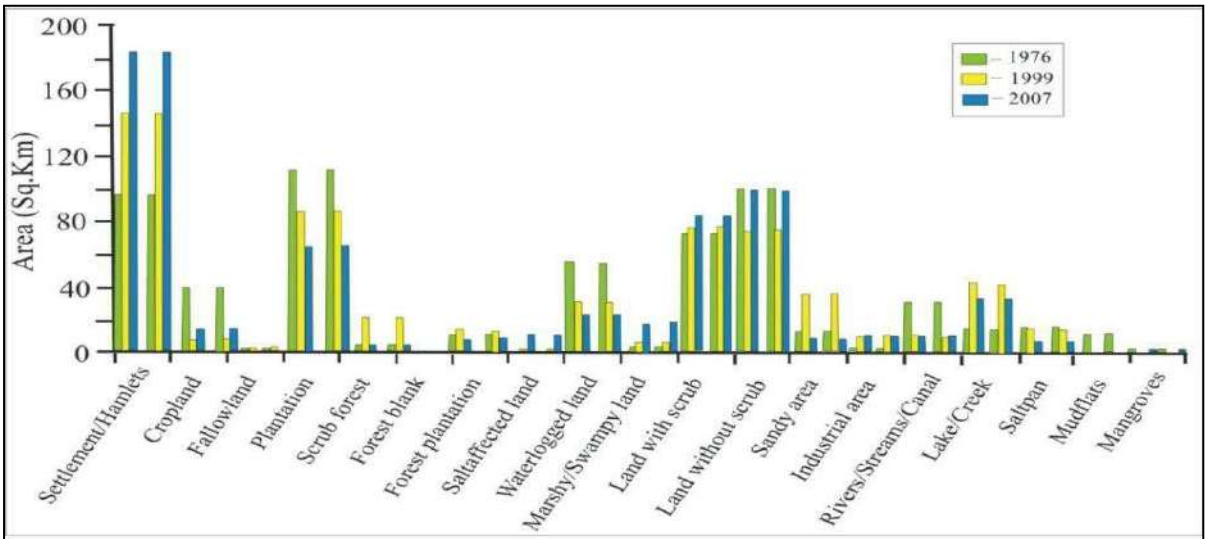
In urban areas of Tamil Nadu there are five main industrial complexes, they are Manali/ Ennore, Ranipet, Cuddalore, Mettur and Tuticorin that have chemical, petrochemical and other industries. These complexes have also become environmental hotspots. Waste generation in Tamil Nadu: As on 31.03.2012, there are 2771 hazardous waste generating industries in Tamil Nadu generating total of 4,26,361 tonnes/year of hazardous waste. With respect to the Biomedical waste, quantity generated is 25793 kg/day.

Greening of Urban Spaces

In the recent times, there has been an increase in population in urban areas, due to concentrated developmental activities with impetus on industrialisation for the economic development of the region. Such a concentrated growth results in the increase in population and consequent pressure on infrastructure, natural resources and ultimately giving rise to serious challenges such as enhanced green-house gases emissions, lack of appropriate infrastructure, traffic congestion, and lack of basic amenities (electricity, water, and sanitation) in many localities, climate change, etc. In addition, such developments leads to removal of natural landscape with built up spaces, parking lots, roads etc., through highly reflective materials, affecting the local climate in a dramatic scale.

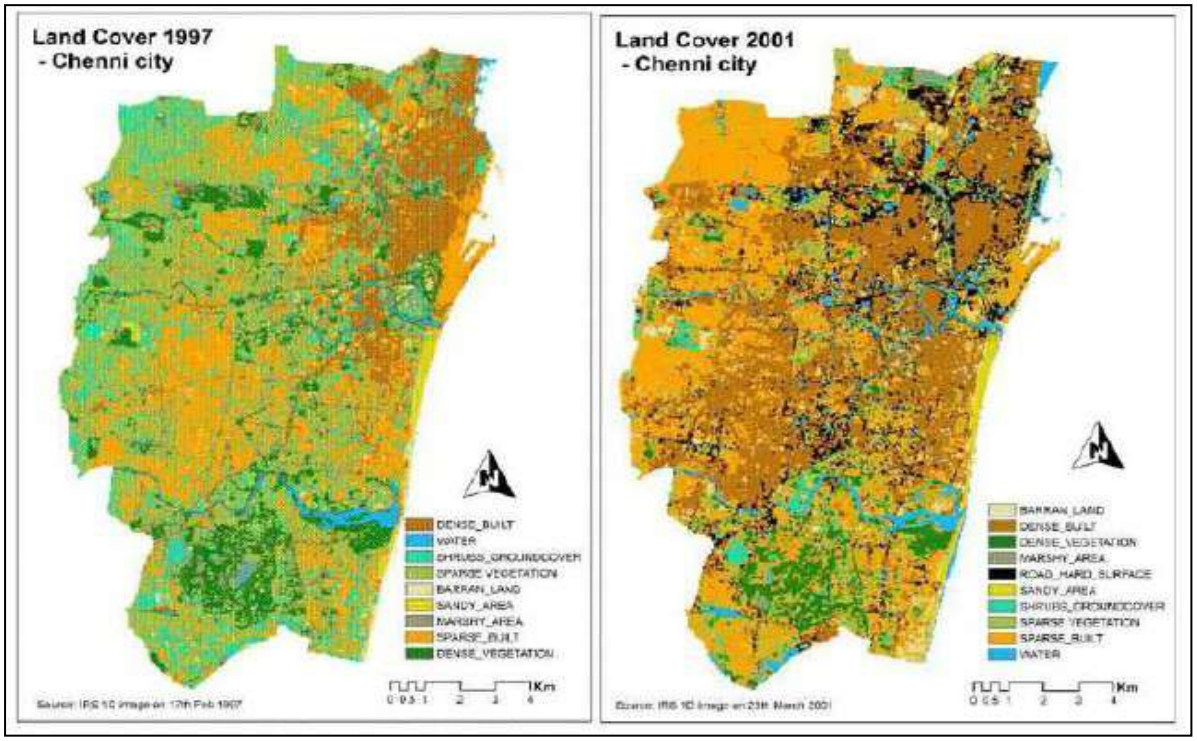
In the recent years, population of Tamil Nadu has shown a shift towards in urban areas from the rural areas. The provisional census of 2011 shows a growth of 48 percent of the population in urban areas from 44 percent in the year 2001. In addition to this, there has been immigration into Tamil Nadu due to the rapid industrial development and growth trend. With this trend, there is a tremendous increase in the land use changes, to fulfil the infrastructure and development needs. This has substantially reduced the greenery in the urban areas.

Figure 10.2: Change in Chennai's coastal land cover



Source: International Journal of Geomatics and Geosciences, Volume 1, No 3, 2010; Santhiya.G, Lakshumanan.C, Muthukumar.S, Mapping of Land use/Land cover Changes of Chennai Coast and Issues related to Coastal Environment Using Remote Sensing and GIS

Figure 10.3: Change in land cover of Chennai between 1997 and 2001



Source: http://www.gisdevelopment.net/proceedings/mapworldforum/nrem/ MWF_natural_63.pdf

Housing requirement results in expansion of built-up area. Where there once existed independent houses with plants and trees all around, apartments have come-up reducing the available greenery, encroachment have sprung up near water bodies gradually vanishing it. In Kodaikanal, which is one of the most important tourist destinations in Tamil Nadu there has been an increase in built-up area with heavy reduction of forest area. In Chennai, the corporation limits have been extended and many adjacent areas have been added to the corporation due to large-scale developments. Though in Chennai the developments are there in all directions, Chennai's coastline is under tremendous pressure. Figure 10.2 depicts the change in Chennai's coastal land cover and figure 10.3 indicates the change in land cover and land use in whole of Chennai city.

10.3 EXISTING/ON-GOING INITIATIVES

Housing

TNHB (Tamil Nadu Housing Board) has proposed to construct 5148 units of Flats / Houses / Plots for a value of Rs.904.69 crore. TNHB will also construct buildings with zero energy by following the Bureau of Energy Efficiency (BEE) that formulated the Energy Conservation Building Code (ECBC). From the inception / formation of TNHB, tree planting has been done all round the scheme area and on each side of road to reduce the temperature, dust etc. and enhance the opportunity of getting more rains. Action is taken to implement the tree planting in all the on-going / proposed project also. TNHB has implemented rainwater harvesting system in all the projects since 2000 in order to recharge the under ground aquifer and improve the quantity of water which will reduce the drought conditions. It also proposes to implement the rainwater harvesting in all the on-going / proposed projects also.

TNHB is developing schemes with under ground sewer system with treatment plant in rural / non-urban area and the effluent from treatment plant is disposed through dispersion trench and final disposal is to the existing nulla/odai. It is proposed to recycle the treated sewage and use it for gardening / planting avenue trees for conservation of water, instead of disposal of the effluent from treated plant to the existing odai.

TNHB has taken steps for effecting solar harnessing system, initially for Own Your Housing Scheme at Nerkundram, Chennai for providing street lights and subsequently spread over to the multi storied buildings and also the proposal of providing solar water heater system in MKB Nagar, Chennai under consideration either by getting subsidy from the Government or from the allottees if the plinth area rate is reasonable since the installation and maintenance cost of solar harnessing is too high to be implemented by TNHB. Further TNHB will insist the allottes to provide CFL bulb for lighting and to use star rated electrical appliances to save energy. RCC door frame with BWR grade flush door shutter for main door, PVC shutter for bath and W.C. and aluminium / steel window frame with glazed shutter has been now

adopted / provided in the on going schemes to minimize the cost and cutting of trees instead of providing teak / country wooden frame with wooden shutters.

Due to large-scale urbanisation to satisfy the demand for infrastructure, there is an ever-increasing demand for construction material. Sand, which is an essential construction material and it, is permitted with certain conditions like maximum depth of sand removal, manual mining etc. However, due to increased demand from within and neighbouring States and sky- rocketing cost, illegal sand-mining takes place which has affected the water sources in Tamil Nadu, affecting holding capacity, ground water levels, weakening the river bed, damaging bridges and river intake structures and so on. River sand takes millions of years to form and is a precious resource. Recently, Madurai Bench of the Madras High Court ruled that all quarries on the Cauvery-Coleroon riverbeds, which are more than five years old, must be closed down in three months. It is proposed to construct buildings by using fly ash products like Bricks, M sand / quick sand instead of river sand etc., in the proposed scheme. Hence Government may form a policy to promote artificial / manufactured sand to replace the river sand, in construction activities for housing, road infrastructure, etc. Further studies are need on the long-term impact of use of manufactured sand for the buildings.

Tamil Nadu Slum Clearance Board has been implementing various housing, slum development and Rehabilitation and Resettlement programmes to ameliorate the living condition of the urban slum families in Tamil Nadu. Its activities implemented in Chennai initially have been extended in phases to other urban areas in Tamil Nadu from 1984 onwards.

Drinking Water

The State has undertaken several initiatives in improving the drinking water supply situation. Some examples include the Hogenakkal Water Supply – Fluorosis Mitigation Project, aimed at providing potable Water Supply to Dharmapuri and Krishnagiri Districts in Tamil Nadu, which comprises of 3 Municipalities, 17 Town Panchayats and 6,755 rural habitations in 18 Panchayat Unions apart from mitigating fluorosis (prevalent in the area owing to high fluoride concentrations in ground water). Dharmapuri and Krishnagiri Districts are also drought prone areas. The drinking water supply as well as its management poses problems during summer and drought periods. Hence as a permanent solution to mitigate fluorosis problem in the water starved districts for providing sustainable and reliable water supply, the scheme has been proposed, with the River Cauvery flowing at Hogenekkal, 45 km west of Dharmapuri as the source of water for this project.

Reuse of secondary treated sewage is being promoted for non-potable uses. From Kodungaiyur STP, the secondary treated sewage is being supplied to industries. About 3.00 lakh litres per day of secondary treated sewage is supplied to the Chennai Municipal Corporation for watering of plants and lawns at public parks and traffic islands. In order to utilize the treated effluent, it is proposed to construct a Tertiary Treated Reverse Osmosis (TTRO) Plant of 45 MLD capacity at Koyambedu and to supply industries. Based on the recommendations of the Hydro geological

studies carried out in the Araniya and Koratalaiyar Basin by the United Nations Development Programme for harnessing of the flood water for recharge purpose in the well fields area during average and above normal years of rainfall, 3 check dams have been constructed at Melsembedu, Velliyur and Jagannathapuram.

Several desalination plants have been set up, including the 100 MLD seawater desalination plant at Kattupalli, Minjur, to supply Chennai. The 100 MLD Nemmeli desalination plant is being set up to supply Chennai city, and another 400 MLD plant is on the cards. Other efforts include the digitising of water supply and sewerage system in Chennai, and the use of telemetry System for monitoring operation and maintenance of water supply and sewerage systems in Area VII and adjacent locations in Area VI. Revamping of Chennai's reservoirs has also been taken up. Water bodies at Poondi, Red Hills, Chembarambakkam and Sholavaram are used to store water from Veeranam reservoir and Krishna river and used when scarcity surfaces.

Urban Development

Chennai Metropolitan area extends over 1189 sq.km and its population is estimated to be about 88 lakh now. It constitutes more than 25 percent of the Tamil Nadu State urban population and more than 12 percent of the Tamil Nadu State total population. The population of the metropolitan area will be about 1.26 crore by 2026. The Chennai Metropolitan Development Authority (CMDA) is the statutory body constituted under the Tamil Nadu Town and Country Planning Act, 1971 that plays a major role in the planning and development of the Chennai Metropolitan Area (CMA). The main function of the CMDA is to prepare Development Plans viz. Master Plan and Detailed Development Plans and to regulate development through Land Use Zoning and Development Regulations that form part of the Development Plans.

The Town and Country Planning Department deals with the Housing and Urban Development initiatives under the provision of the Town and Country Planning Act in line with the following aspects:

- Master Plan/Detailed Development Plan – Preparation
- Development Control Regulations.
- Open spaces such as parks
- Heritage Development
- Coastal Zone regulation.

The entire State is divided into 12 Regions and 27 Local Planning Authorities and 8 New Town Development Authorities for effecting planning functions. Till date, 123 Master plans and about 1650 Detailed Development plans have been prepared for regulating the development in municipal towns and corporation areas of the Tamil Nadu to create an orderly environment friendly development. The Master Plans aim at the proper allocation of land for the various uses and developments like Residential, Commercial, Industrial, and Educational etc. in a broader manner for achieving a sustainable environment friendly developments. The CRZ areas are

earmarked in this Master Plan and only such development that are cleared by the CZMA and permitted in those areas.

Further this department is assisting the local bodies in giving approval to various building and land development based on the Master Plan and Detailed Development Plan uses and in conformity with the Development Control Regulations (DCR) and other rule provisions like District Municipal Building Rules, 1972, Panchayat Building Rules, 1997, Multi-storeyed and Public Building Rules, 1973, Bill Area Building Rules, 1993 and relevant provisions under CRZ regulations.

The Directorate of Town and Country Planning is providing fund assistance for park development in corporations and municipal towns to a tune of Rs.10.00 lakh each for development of parks and green spaces which are owned by the local bodies. Further, Directorate of Town and Country Planning is providing funds to a maximum of Rs.1.00 crore to corporations and Rs.50.00 lakh to municipal towns under traffic improvement programme to have a free flow of traffic and to achieve pollution free environment. Also this Directorate provides fund for development of heritage towns notified by the Government at Rs.1.00 crore each for maintaining a sustainable environment in those towns.

Waste Management

Currently, the waste collection performance in Tamil Nadu ranges from 85 to 95 percent and door-to-door collection performance is 67 percent in the ULBs. The State of Tamil Nadu though has all its local bodies covered with solid waste collection, the present level of source segregation is around 28 percent, which it aims to make to 100 percent during the year 2014-15. In many places, the waste collected is generally dumped in some pre-identified site.

Land availability for siting solid waste management facilities is a critical issue in many parts of the State. For example, out of the total 134 ULBs, 31 municipalities are having insufficient land and 12 municipalities are having no land for compost yards. In order to ensure the effective handling and management of solid waste an Integrated Municipal Solid Waste Management (IMSWM) system is being adopted comprising all facilities such as Compost Yard, Material Recovery Facility, (MRF) Recycling Plant, and Scientific Land filling Facility etc. The Integrated Municipal Solid Waste Management Projects have been taken up with the financial assistance of JnNURM (Jawaharlal Nehru National Urban Renewal Mission) in Coimbatore, Madurai and Vengadamangalam (for Alandur, Pallavapuram and Tambaram municipalities) and with UIDSSMT (Urban Infrastructure Development Scheme for Small and Medium Towns) in Namakkal.

Plastics though in weight constitute only a negligible percentage, say 3-5 percent; the nuisance caused by accumulated plastic waste is enormous as it is ubiquitous. The State Government has initiated laying of roads using the waste plastics.(Table 10.5).

As part of plastic waste management, from 2003-04 schemes were taken up in urban and rural local bodies to lay plastic roads. The Rural Development and Panchayat Raj Department had taken up the initiative of laying Bitumen Tar Road mixed with plastic wastes and completed the works successfully over a length of 1031 km at a cost of Rs. 47.30 crore. Similar works were taken up in Chennai Corporation and other Municipal areas. As the performance of these roads was reported to be better than the roads laid conventionally, Honourable Chief Minister sanctioned a sum of Rs.50.00 crore during the year 2011-12. An amount of Rs. 9.11 crore has been sanctioned to Chennai Corporation, Rs. 18.00 crore to Directorate of Town Panchayats, Rs.9 crore to Commissionerate of Rural Development and Panchayat Raj and Rs. 13.89 crore to Commissionerate of Municipal Administration. Works covering a total distance of 446.50 kms were taken up by 10 Corporations, 119 Municipalities, 90 Town Panchayats and 45 Village Panchayats. It is proposed to continue the scheme of Relaying Roads using plastic wastes at a cost of Rs.100.00 crore during the year 2012-13.

A bio-methanation plant has been set up at Koyambedu, to generate power from vegetable and fruit waste collected from the wholesale market. The Rs.5.50 crore facilities, set by Chennai Metropolitan Development Authority, inaugurated in 2006 has the capacity to convert 30 tonnes of waste per day into 2,500 units daily. Of the nearly 150 tonnes of vegetable and fruit waste generated daily at the market, about 30 tonnes are segregated and those with seeds are avoided to prevent damage to the equipment. The shredded waste is fed into a digester where the particles are converted into gas.

Table 10.5: Solid Waste Management initiatives in Tamil Nadu

Initiative	Description	Cost allocated (Rs in crore)
Integrated Solid Waste Management	Coimbatore Corporation under Jawaharlal Nehru National Urban Renewal Mission (JnNURM)	96.51
	Madurai Corporation and adjoining municipalities at Vellakal Village	74.29
	Alandur, Pallavapuram and Tambaram Municipalities at Venkatamangalam village under JnNURM	44.21
	Salem Corporation in Chettichavadi Village in BOOT basis	31.30
Plastic Waste Management	BT roads using waste plastics taken up for a length of 108.76 km in 94 Town Panchayats	18.00
	Training for manufacture of eco-friendly alternatives to throw away plastics has been imparted to self-help groups for production of palm leaf plates, cups in Salem, Vellore and Cuddalore districts through the Central Palm gur and Palm Products Institute of Village Industries Commission.	

	The Nilgiris district,Hogenakkal, Kodaikannal, Rameshwaram, Valparai,Yelagiri, Yercaud and Thirumoorthy falls etc.have been declared as throw away plastic free zones.	
	Mass Drive to clear plastic wastes	10.00
E-Waste Handling	E-waste Policy with objective of minimising e-waste generation, utilizing e-waste for beneficial purposes through environmentally sound recycling and to ensure environmentally sound disposal of residual waste	

Energy

Already dealt with separately in Chapter 9 of this document.

Transport

Initiatives and achievements in the transport sector are summarised below.

- **Promotion of public transport:** Intelligent Transport: The GPS based Vehicle Tracking and Passenger Information System has been introduced by the MTC (under Secretary to Government, Transport Department Control) and has become functional.
- **Metro Rail:** The metro rail project is being implemented under CMRL, in two corridors of length 23.1 km and 22 km each in two phases. The project includes energy saving measures with regenerative braking, efficient electrical equipment, energy efficient, auto-sensor escalators etc. The project is envisaged to be put into operation by 2014 -15.
- **Monorail:** State Government has identified four corridors connecting the suburbs with the Chennai city that would be implemented in phase and the first phase of the project estimated at Rs.8500 crore.
- Studies have been carried out to provide elevated corridor with dedicated BRTS lane for different sections of Chennai city connecting to outer ring roads.
- **Emission control:** Type of vehicle fuel, vehicle maintenance, road conditions etc., determine the emissions from vehicles. To minimize the pollution, for every transaction / registration with Regional Transport Offices, after the expiry of one year from the date on which the motor vehicle was first registered it is mandatory for vehicles to carry a valid “Pollution under control” certificate issued by an agency authorised for this purpose by the State Government. 260 private emission testing centres have been authorized throughout Tamil Nadu for checking the pollution level of the vehicles under 116(B) of Tamil Nadu Motor Vehicles Rules 1989.
- In Chennai Metropolitan area, Bharath stage IV has been applied to Light Motor Vehicle/Heavy Motor Vehicle and BSIII for other vehicles. In rest of Tamil Nadu Bharat Stage III norms are followed.

- Collection of green tax for the existing Transport and Non-Transport Vehicles has been introduced since 2003.
- Alternate fuels and vehicles: In Chennai Metropolitan area, action is being taken to convert petrol driven auto rickshaws into Liquefied Petroleum Gas (LPG) mode. So far 8,525 auto-rickshaws have been converted into LPG mode.
- In Chennai Metropolitan area, new permits are issued only for LPG driven auto-rickshaws.
- Under the Alternate Fuels for Surface Transportation Programme (AFSTP) for Battery Operated Vehicles (BOVs) announced by MNRE, GOI, TEDA has promoted 1427 BOVs - two wheelers under the above scheme so far. (Provided also under energy efficiency – from energy department policy note)
- Hybrid vehicles: The Government of Tamil Nadu has given 50 percent concession of road tax for battery operated vehicles. In order to encourage the vehicle's manufacturer to manufacturing more number of battery operated vehicles and production of renewable energy vehicles, the Central Government may reduce the Central Excise duty considerably.

Proposed initiatives include:

Feeder bus services to MRTS operation

- Establishing CUMTA, Chennai Unified Metropolitan Transport Authority (CUMTA) for regulation of measures for integration of all public mass passenger transport modes through routing, scheduling and operating feeder services, besides running combined or common ticketing to facilitate seamless commuting under the provisions of Chennai Unified Metropolitan Transport Authority Act, (CUMTA) 2010.
- Prepaid Smart Card ticketing system.
- Vacation special card.
- Providing Metro/mono rail for 2 cities other than Chennai by 2023 at an estimated investment of Rs.65,000 crore.

Pollution

Air Pollution Control: Tamil Nadu Pollution Control Board is monitoring the ambient air quality in Chennai (3 stations), Coimbatore (3 stations), Tuticorin (3 stations), Madurai (3 stations) and Salem (1 station) under the National Ambient Air Quality Monitoring Programme. Under the State Ambient Air Quality Monitoring Programme, the Board has established five ambient air quality monitoring stations in Chennai city and Tiruchirappalli. The programmes monitor the air quality in residential, commercial and sensitive zones of the cities. The results of the programme are published every week in leading newspapers.

Water Pollution Control: Water pollution is being prevented and controlled by enforcing the Water Prevention and Control of Pollution Act 1974 as amended in 1988. As per the provisions of this Act, the local bodies and industries which discharge sewage/ trade effluent are required to obtain consent from the Board to establish and operate the unit. During the year 2010-2011, the Board has issued 1171 consent to establish orders and 1053 consent to operate orders under Water Prevention and Control of Pollution Act 1974.

Due to the constraints faced by the Small-Scale Industries, a total of 53 Common Effluent Treatment Plants have been formulated. Of these 15 are for tanneries, 29 for textile and one for hotels and lodges are under operation. 7 for tanneries and 2 for textile dyeing units are under various stages of implementation.

A Common Hazardous Waste Treatment Storage and Disposal Facility (CHWTSDF) has been established at SIPCOT industrial EState, Gummidipoondi for treatment, storage and disposal of hazardous waste from industries in Tamil Nadu, which is operational since January, 2008.

Greening of Urban Spaces

Any tree cutting activity within Chennai Corporation limits necessitates planting of 10 times the number of trees cut. However, the compensatory plantation is done somewhere else due to non-availability of space at the place of tree cutting, and therefore brings no relief to the microclimate to the location of reference. To ensure the greenery within the city, there have been some major actions taken by the Government of Tamil Nadu. Corporation of Chennai is maintaining 260 parks with greenery, which it proposes to improve further in the year 2012-13. One hundred new parks are proposed in 2012-13 in the added areas of Chennai Corporation.

The Development regulations of the second Master plan for Chennai stipulates that in sites with an extent of 10,000 sq.m or more, 10 percent of the area excluding road shall be reserved as Open Space Reservation (OSR) and shall be transferred to the authority or the local body designated. Since the SMP, in CMA alone around 13, 35553.111 m2 of land has been marked as OSR. These OSR lands are maintained as parks by the local body.

The most important of all the actions taken by the Tamil Nadu Government for greening of urban spaces is the restoration projects. GoTN has carried out restoration of the Adyar Poonga to an extent of 58 acres. Based on the assessment of each identified sub-sector and role of the line departments, issues relating to climate change on sustainable habitat with respect to the identified sub-sectors, action required are briefly provided in the next chapter. In addition to the strategy for addressing the climate change under sustainable sector, based on the observations during the course of the assessment the following are suggested.

10.4 PERCEIVED CLIMATE IMPACTS

Housing

It is estimated that 20 percent of the urban population are living in slums. Among them 30 percent are living on river and watercourses margin below Mean Flow Levels. These hutments will be submerged by floods or flash floods causing loss of lives or properties. Tamil Nadu slum Clearance Board has constructed 7500 tenements near sea shore in the urban areas. In case the sea level rises in the long run by 1 metre, these scheme areas will get inundated and surrounded by seawater. All the families living in these tenements need to be resettled in alternate places. Tamil Nadu Slum Clearance Board has to construct 7500 tenements in safer places to resettle these families at a cost of Rs. 525.00 crore at current prices.

Drinking Water

Water supply is a challenging task due to the factors such as increase in population, depletion in local sources due to over extraction, degradation of quality, deficient recharge of ground water due to failure of monsoon, failure of system units, etc. These factors resulting in shortfalls in water supply and impact of climate change is bound to be worsening the scenario in the years to come. Climate conditions can also impact quality and availability of water, as also cause damage to water supply and drainage/sewerage infrastructure assets. Timing and intensity of rainfall can impact the transport of disease causing organisms into the water supply systems. Further, increasing temperature will also lead to lower availability of dissolved oxygen and increased biological activity exhausting oxygen in water systems. Changed pattern of thermal mixing in water bodies can also create anaerobic conditions leading to eutrophication.

Urban Development

In Tamil Nadu an area of about 76 percent is only covered under plan area and rest of the areas are not coming under any plan. Hence unplanned development is taking place in unplanned areas. The haphazard and unregulated developments are causing environmental degradation and congestion and thereby urban heat and resultant impact on the climate change. Large-scale urbanisation causes mass removal of green cover, which affects the holding capacity of the soil causing floods during rains. The hilly regions are affected with landslides. There is a close relation between water resource management, river management, land use management, forest management, erosion control, agriculture, urban drainage and sewerage within a basin. With increase in constructions along rivers and concentration of population around submergible areas, the flood-induced damages are increasing. Climate change is only likely to exacerbate these problems and also cause damage to urban infrastructure from flooding and extreme weather events.

Health and Sanitation

Climate change has impact on weather and environmental patterns that in the past have been relatively stable. Global studies reveal that climate changes will bring severe heat waves as well as rise in sea levels. These will affect the human health in several direct and indirect ways. Climate change, as some of the studies such as NATCOM and those by INCCA suggest, may alter the distribution and quality of India's natural resources and increase water insecurity, reduce agriculture productivity, enhance exposure to extreme weather events, and pose enhanced health risks thereby adversely affecting development of the economy that are closely linked to natural resource base.

Key issues related to the State of human health with respect to climate change include:

- Heat related morbidity and mortality – Has a range of health effects from mild rashes to fatal heat stroke; can also aggravate chronic diseases including cardio vascular and respiratory diseases such as asthma. It also increases the ground level ozone concentration causing direct lung injury and increases the severity of respiratory diseases such as obstructive pulmonary disease.
- Respiratory allergies and bronchial diseases
- Vector borne and zoonotic diseases
- Water borne diseases
- Neurological diseases and disorders
- Cancer

Changes in climate can affect the potential transmission of vector borne diseases that include temperature, humidity, altered rainfall, soil moisture and rising sea level. Climate conditions affect quality and availability of water. Flooding and natural disasters may also cause sudden outbreak of diseases.

Waste Management

The concept of Solid waste Management (SWM) is that the waste must be segregated based on the characteristics, biodegradable waste should be composted, recyclable are to be recovered and the inert have to be land filled in a scientific manner. Though solid waste management is an obligatory responsibility of the local body, the growing trend in the per capita waste generation, increasing urbanisation and population makes it very difficult for the local body to provide the basic service. This results in the contamination of the groundwater sources, uncontrolled emission of methane by decomposition of waste, spreading of vector-borne diseases, rodents and so on, that result in adverse impact on the environment.

In many places, the wastes are dumped in unscientific manner in landfills, unmindful of both the nature of waste and the local environment. The landfill site in Pallikaranai Marshland in Chennai is one such case. In the recycling market operating in an unorganised manner, the workers handling the waste, rag pickers collecting recyclable material like plastics are exposed to the toxic fumes from the waste which affects their health.

Solid wastes are generally of typical composition, consisting about 50 percent of bio- degradable wastes, inert materials constituting about 30 percent and plastics around three percent of the quantity. When this is dumped in landfills, the biodegradable wastes undergo anaerobic changes resulting in the emission of methane. The estimated global land filling of 1.5 billion tonnes annually, the corresponding rate of methane generation at landfills is 75 billionNm3.Less than 10 percent of this potential is captured and utilized at this time.

In solid waste management, prioritization of activities plays a major role. As described by the International Solid Waste Association (ISWA 2009) the waste hierarchy is a valuable conceptual and political prioritisation tool which can assist in developing waste management strategies aimed at limiting resource consumption and protecting the environment'. As a result, priority is given in order to minimum waste, re-use, recycling, waste- to-energy, and finally landfill.

The climate benefits of waste practices result from avoiding landfill emissions, reduced raw material extraction and manufacturing, recovered materials and energy replacing virgin materials and fossil-fuel energy sources, carbon bound in soil through compost application, and carbon storage in landfills. Landfills reduce GHG emissions where LFG (Land Fill Gas) recovery systems generate energy that substitutes for fossil-fuel energy sources, Diversion of organic wastes from landfill and implementation of active systems for landfill gas extraction are complimentary to an extent.

The biodegradable wastes which are almost 50 percent of the municipal solid waste generated, if segregated and processed, can yield good compost, under aerobic digestion can pave way for energy generation from methane recovery, thereby avoiding emission of methane and saving the use of non-renewables for energy generation and the inert may be used for filling of low areas. Thus segregation, treatment and disposal of solid wastes achieve twin benefits of mitigation of climate change and reducing the land requirement.

Energy

Already dealt with separately in Chapter 9.

Transport

The abrupt rise in the vehicle population along with construction work eating up road space has slowed down traffic movement to a snarl on virtually every road during peak hours. The vehicular population explosion has increased not only the congestion on the already clogged city roads but also the pollution levels. This has resulted in extended travel hours, consuming excess fuel and increased emissions. Hence, there should be a greater thrust in promoting public transport with improved infrastructure, traffic management and pollution control.

Pollution

Large-scale conversion of land use is happening from urbanisation. Construction activities are going on in full swing to meet the requirements of urbanisation, which causes increase in suspended particulate matter in the air. Areas with vegetation are replaced with built-up area, affecting the microclimate increasing the local temperature. Increased temperature increases the energy consumption for cooling purpose. Urban sprawl causes dependence on motorised transport, which increases the fuel consumption causing emissions contributing to global warming.

Air quality is influenced by the technology adopted in energy production, more efficient the technology less is the air pollution. Types of vehicle fuel, maintenance, road conditions etc. determine the emissions from vehicles. Best waste management practices result in preventing water pollution and methane generation. Thus, the measures taken to achieve better efficiency, cost-effectiveness and to prevent pollution contributing to mitigating climate change.

Greening of Urban Spaces

Unplanned urbanisation affects the land use and land cover of the area affecting the local climate. The climatic changes in the urban areas are often characterized by increase in air temperatures compared to the nearby areas, which is termed as the Urban Heat Island Effect (UHIE). Major factors contributing to the elevated air temperatures include the size of the city, population, reduced vegetation cover, increased density of built-up spaces, thermal properties of materials, increased energy/ fuel consumption, waste heat from buildings and vehicular emissions.

There are studies, which establish the direct relation between green cover and difference in temperature between urban and rural areas and in different locations within the city. A study by Monsingh D. Devadas and Lilly Rose on the urban factors and UHI in Chennai confirms the existence of UHI effect in the city of Chennai and indicates an intensity of 2.48°C and 3.35°C during summer and winter respectively between green pockets and those areas influenced with built-up spaces. The increased heat in urban areas in turn leads to increased energy consumption for cooling purpose contributing to climate change.

10.4 STRATEGIES

Table 10.6 Key strategies under each of the identified sub-sectors is summarised in the table below

Key sub - sectors	Action	Responsibility
Housing	Mandatory ECBC implementation in all sectors	Necessary provision to be made in the plan approval process. By CMDA, DTCP and ULBs/RLBs
	Design considerations to withstand calamities	Obligatory
	New Housing Policy including provisions of Sustainable Habitat	H&UD
	Promotion of alternate construction material in housing like M.Sand, fly ash etc to reduce the pressure on natural resources.	Obligatory
	Research on long-term impacts on manufactured sand on quality of housing	Capacity building
Water	Revamping of existing water supply schemes to avoid loss of water	TWADB, CMWSSB, RD
	Protection of water sources	CMWSSB, COC, PWD, DTP, CMA, TWADB, RD/Panchayat Unions
	Increasing storage capacity	CMA, CMWSSB, DTP, RD
	Reuse of grey water	CMWSSB, COC, CMA, DTP, CMDA
	Recharge of groundwater	CMWSS, TWADB,
	Promotion of Manufactured sand in construction	H&UD
Urban Development	Mandatory adoption of ECBC.	CMA, DTP
	Building Rules of local body may include wastewater recycling provisions for large commercial and industrial developments as mandatory provision before issue of permission for developments.	CMWSSB, COC, CMA, DTP, CMDA
	Propose to achieve a model split of 70:30 for public and private transport	CMDA, CMA, DTCP,
	Encourage environment/ eco-friendly modes of transport -cycles, pedestrian friendly traffic.	CMDA, SH, COC, CMA, DTP
	Enlarge the segments of vehicular population	TD

Key sub - sectors	Action	Responsibility
	converted to pollution free fuels, viz., LPG/CNG/battery.	
	Strictly enforce the road users to obtain EUC	TD, TNPCB
	Establish an air quality monitoring system, which maps the quality of air across the road network periodically.	TNPCB
	Subject every major transport development measure to safety audit.	TD
	Disaster precaution in building designs	COC, CMA, DTP
	Regulation of developments in flood prone areas	PWD and Revenue Dept.
	Removal of encroachments in disaster/flood prone areas	PWD, COC, CMA, DTP
Health and Sanitation	New Sanitation Policy	Rural Sanitation Policy: RD
	Monitoring of vector-borne and water- borne diseases	HFW, DPH&PM
	Identification of indicators for monitoring	HFW, DPH&PM
	Study on vector-borne diseases	DME
	Ensuring complete coverage with sanitation	CMWSSB, TWADB, COC, CMA, DTP, RD
Waste Management	Setting up of the Material Recovery Facility within the compost yard	COC, CMA, DTP
	Energy generation from methane recovery from SWM all over TN	COC, CMA, DTP, TNPCB
	Study to identify the composition of solid wastes in different regions of TN to finalise management proposal	COC, CMA, DTP, TNPCB
	Introducing penalty provisions for non-segregation of wastes by the occupier, for littering on streets and depositing or throwing any solid waste in contravention of the provision and on the local body for deficiency in services	COC, CMA, DTP
	Preparation of “Action Plan” for all the Corporations, municipalities and town panchayats in Tamil Nadu	COC, CMA, DTP
	Conducting Training Program for officials, people and manufactures of various municipalities.	
	Providing incentives to private sector to participate in the reduction, segregation, transport, recycling and final disposal of all	COC, CMA, DTP

Key sub - sectors	Action	Responsibility
	types of solid wastes.	
	Specific responsibility to be assigned to stakeholders in the implementation of the plan	COC, CMA, DTP,
	"Polluters Pay" principle, local bodies to collect a levy from bulk garbage generators such as industries, hotels, marriage halls, markets and commercial complexes.	COC, CMA, DTP,
	Establishing safe recycling facilities for e-waste and construction debris	COC, CMA, DTP,
Improve Energy Efficiency	Compulsory Energy Labelling for Rating for commercial buildings and residences (ECBC enforcement)	COC, CMA, DTP,
	Constraints at consumer end - Reduced cost of solar panels, Waste generation,	TEDA
	Replace of old pumps with energy- efficient pump sets in existing water supply schemes	CMWSSB, TWADB, RD
	Formulate a policy to encourage LED and solar lighting in streets and buildings (subsidy, incentives etc.,)	
	Enforce labelling of domestic appliances for energy efficiency rating, capacity building on usage of Bureau of Energy Efficiency (BEE) labelled appliances	
	Replace all old pump sets with energy efficient pump set. Broadcast use of Energy efficient pump sets & solar pump sets through subsidies including agriculture	
	Promote Energy Labelling for Rating for all buildings including residential	
	Address constraints of alternate energy sources- cost (subsidies, collection& replacement of old parts, maintenance agreement with suppliers)	
	Create awareness for alternate energy	
Transport	Increase the number of bus services in over crowded routes and add new services including mini buses in added areas.	TD
	While developing road infrastructure, exclusive lanes for pedestrian and bi-cycle.	TD, CMDA, DTCP, SAP/ Anna University
	Measures to make cycling attractive with good cycling paths, cycle parking facilities, link between cycling and public transport.	COC, CMA, DTP, CMDA, DTCP, SAP/ Anna University
	Congestion taxes may be levied on vehicles	COC, CMA, DTP,

Key sub - sectors	Action	Responsibility
	Transportation Fund may be created	TD
	Single window clearance by CUMTA	TD
	Comprehensive Mobility Plan (CMP)	TD, SAP/ Anna University
	Advertisement revenue for public transport – from bus shelters	TD
	High Parking revenue to match market demand, periodical renewal, to contribute to traffic fund, and discourage private transport.	COC, CMA, DTP
	Low-floor buses for differently abled	TD, STA
	Emission based special taxes/ penalty	TD, COC, CMA, DTP,
	Providing feeder services to connect the residential areas	TD, COC, CMA, DTP,
	Encouraging car-pooling	TD
	Introducing no -driving day	
	Increased subsidy / Reduced excise duty on hybrid vehicles and battery operated vehicles.	TD, TEDA
	Improvement to all existing roads and maintenance at regular intervals	TD
	Adoption of alternate/advanced technology including mixing of plastic to ensure endurance to the roads	COC, DTP, CMA,
Pollution	Improved air quality monitoring through more stations in urban centres	TNPCB
	Air quality monitoring along roads with heavy vehicular movement	TNPCB
	Monitoring of groundwater quality	TNPCB, PWD
	Ensuring ZLD in industries	TNPCB
	Action Plan to control Pollution	TNPCB
	Strict enforcement with penalty for violation	TNPCB
Greening of Urban Spaces	Compulsory OSR for greenery under the Development regulations in DTCP.	DTCP, DTP, CMA
	Stringent compensatory plantation for tree cutting, including heavy refundable deposit upon evidence of completing compensatory plantation	COC, CMA/ ULB, DTP/ TP
	There are several residential projects coming up with the provisions for greenery around the built-up area. This may be included in the development regulations while giving approvals.	COC, CMA/ ULB, DTP/ TP
	Study to identify suitable plant and tree species for urban greenery	SAP, Anna University/ Institutions/ NGOs

Key sub - sectors	Action	Responsibility
Climate Change/ Sustainable Habitat	Sustainable habitat-Climate Change Policy and website	GoTN &DoE
	Monitoring of all climate change related activities for physical implementation, benefits, and Introduction of new technology and improvements to existing practices.	Line departments
	Capacity Building for line departments	DoE

In the Rural Areas the following strategies are stressed on

Rain water harvesting (RWH) structures

Total number of rural households in Tamil Nadu is around 92 lakh. It has been presumed that 50% of buildings will be already having rain water harvesting structure. The unit cost of the rain water harvesting structure is assumed to be Rs.1500. Total cost works out to Rs.690 crore. The expenses towards IEC activities come around Rs.4 crore. Hence, the total budget outlay is Rs.694.00 crore . The provision of RWH for public buildings of RD department is being done through respective project funds.

100% sanitized and open defecation free rural

Total number of rural households which needs IHHL in Tamil Nadu is around 65.70 lakh. The unit cost of the Individual House Hold Latrine is Rs.12,500. Total cost works out to Rs.8213 crore. The expenses towards administration, HRD and IEC activities come around Rs.1787 crore. Hence,the total budget outlay is Rs.10000.00 crore.

Sustainable solid Waste management

The total budget outlay is Rs.3200 crore (Rs.640 crore per year for 5 years).

Storage of surplus water during floods

Total number of village panchayats in Tamil Nadu is 12524.the unit cost for providing one new structure storage structure in the form of pond etc. is Rs.5.00 lakh. The total cost works out to Rs.626 crore.

10.5 BUDGET REQUIREMENT FOR STRATEGIES IN SUSTAINABLE HABITAT SECTOR

The Summary of the budget requirement for the strategies of the Sustainable Habitat Sector (Urban and Rural Component) is given in Table 10.7.

The total cost for implementing the strategies during the 12th Five Year Plan (FYP) is Rs. 207104.00 crore and during the 13th Five Year Plan (FYP) is Rs. 217333.00 crore

Table 10.7: Summary of the budget requirement for Sustainable Habitat sector

Sl. No.	Strategy	Cost for 12th FYP (Rupees in crore)	Cost in 13th FYP (Rupees in crore)
1	Promote sustainable habitats to adapt to Climate Change (CC)	2360.00	2596.00
2	Providing CC resilient water supply systems (Urban and Rural)	18081.00	9447.00
3	Urban and Rural Development	10100.00	11110.00
4	Health and sanitation	41868.00	46054.00
5	Waste Management	5150.00	5665.00
6	Energy	1500.00	1650.00
7	Developing efficient integrated transport system	125100.00	137570.00
8	Abating enhanced air and water pollution in a Climate Change (CC) scenario	2745.00	3021.00
9	Greening of Urban Spaces	200.00	220.00
	Grand Total	**207104.00**	**217333.00**

The detailed budget for each strategy are given in Tables10.8.

Tables 10.8 Detailed budget for strategies in Sustainable Habitat sector including Urban and Rural components

S. No	Strategy/Actions	Agency	Cost for 12th FYP (Rupees in crore)	Cost for 13th FYP (Rupees in crore)
Strategy 1: Promote sustainable habitats to adapt to Climate Change (CC)				
1.1	Implement ECBC norms in institutional/commercial and residential sectors	CMAs/RDPRs/TNHB/ TNSCB/PWD	100	110
1.2	Integrate design alternatives to withstand impacts of CC (extreme rainfall, flooding, cyclones and storm surges and other disasters)	CMDA/ PWD/ CMA/ CoC/ DTCP/ Hg & UD TWADB/ RDPR	500	550
1.3	Develop new housing policy including CC aspects	Hg & UD Dept.	50	55
1.4	Research and designing alternative construction materials like M. Sand, fly ash etc. to reduce the pressure on natural resources	Directive to all relevant departments involved in construction, designs and cost estimates	50	55
1.5	Promote generation of disaggregated electricity (micro-grid) in villages as a community source	RDPRs/ TEDA/ RD	50	55
1.6	Develop policies/ New regulations for • Green management of solid waste and liquid waste within houses • Standards for waste disposal	Hg & UD Dept. TNPCB	100 10	110 11
1.7	Development in flood prone areas, protecting and resettling encroachments	PWD/CMDA/DTCP/CoC/CMA/DTP/TNSCB	1000	1100
1.8	Implementation of compulsory plantation of trees in all sectors (Housing /Institutional) to reduce heat island effect	CMDA/ DTCP/ CMAs/ RDPRs/ CoC	500	550
		Sub Total	**2360**	**2596**

S. No	Strategy/Actions	Agency	Cost for 12th FYP (Rupees in crore)	Cost for 13th FYP (Rupees in crore)
Strategy 2: Providing CC resilient water supply systems				
	URBAN AREAS			
2.1	Providing water supply scheme and 24 X 7 ready water supply in extended areas	CMWSSB	1270	300
2.2	Revamping existing water supply schemes to avoid loss of water by laying new pipelines in place of damaged pipelines	TWADB/CMWSSB/RDPR	8966	1000
2.3	Regulate use of water through compulsory metering	CMWSSB/TWAD/CMA		
2.4	Sewerage in extended areas of Chennai city	CMWSSB	400	100
2.5	Plugging outfalls and improvement in core areas	CMWSSB	170	50
2.6	Waste water reclamation programme	CMWSSB	750	825
2.7	Strengthening rainwater harvesting	PWD/ RDPR	100	110
2.8	Storage of surplus water during floods	TWADB/CMWSSB/RDPR	500	550
	RURAL AREAS			
2.9	24 X 7 water supply	TWADB/ RDPR	150	165
2.10	Sewerage in un sewered areas	TWADB/ RDPR	2000	2200
2.11	Rainwater harvesting	TWADB/ RDPR	694	758
2.12	Storage of surplus water during floods	TWADB/ RDPR	626	689
	URBAN & RURAL AREAS			
2.13	Undertake regular water monitoring by establishing labs in all districts	TNPCB	400	440
2.14	Protection of water sources including traditional water bodies	CoC/ PWD	1000	1100
2.15	Increase storage capacity of water bodies / traditional water bodies	PWD/CMA/ DTP/ RD	500	550
2.16	Reuse of grey water	CMWSSB/ TWADB/ CMA/ DTP/RDPR	100	110
2.17	Recharging of ground water	PWD,DoA,DoF, CMWSSB,TWADB	455	500
		Sub Total	**18081**	**9447**

S. No	Strategy/Actions	Agency	Cost for 12th FYP (Rupees in crore)	Cost for 13th FYP (Rupees in crore)
Strategy 3: Urban and Rural development				
3.1	Include CC adaptation measures in Master Plans, DDPs, CDPs, CMPs, CRP & etc.	CMDA/DTCP/CMA/ DTP/RDPR	100	110
3.2	Developing Satellite townships to decongest Cities (Urban)	GoTN	10000	11000
		Sub Total	**10100**	**11110**
Strategy 4: Health and sanitation (urban and rural)				
4.1	Strictly enforce Panchayat Act & Corporation Municipal Act for giving priority for disposal of solid and liquid waste to avoid mosquito breeding	BDOs, BMOs (PHCs), Health Inspector CoC/CMA/DTP/ Urban PHC	50 50	55 55
4.2	Strengthen IDSP by • Instituting Rapid Response Cell at the District and Block levels • Including non-communicable diseases keeping in view the likelihood of heat stress and other impacts	DPH&PM	180 108	198 118
4.3	• Undertake research to understand short and long term impacts of CC on health • Conduct training and awareness for different target audiences on CC and health and incorporate in the curriculum of medical education	DME	20 60	22 66
4.5	Strengthen the integrated health management system at District and Block level	DPH &PM	3850	4235
4.8	Develop capacities for forecasting disease outbreaks	DPH &PM	500	550
4.9	Ensure 100% sanitized and open defecation Urban Rural	CMWSSB/TWADB/CC/CMA/DTP/RDPR/ DPH&PM	2050 10000	2255 11000
4.10	Slum free cities programme	TNSCB	25000	27500
		SubTotal	**41868**	**46054**

S. No	Strategy/Actions	Agency	Cost for 12th FYP (Rupees in crore)	Cost for 13th FYP (Rupees in crore)
Strategy 5: Waste Management (Urban and Rural)				
5.1	Information, education and communication (IEC) for general public on • source segregation and disposal of waste & usage of plastic bags • Inclusion of CC impacts on health at all levels of education	CMA/DTP/DME/RDPR	50 50	55 55
5.2	Sustainable solid waste management (urban)	CMA/DTP/RDPR/TNPCB	600	660
5.3	Sustainable solid waste management (rural)	CMA/DTP/RDPR/ TNPCB	3250	3575
5.4	Identify the MSW disposal sites in all cities/and districts	CMA/ DTP/TNPCB/RDPR	100	110
5.5	Undertake source segregation through material recovery facility at disposal sites to avoid ground water pollution	COC/CMA/DTP	500	550
5.6	Study to carry out composition of solid waste in different regions to finalise the solid waste management in the city Implement penalty for non compliance of segregation of waste at source Attempt waste to energy initiatives like biomethanation etc., Penalty for littering in public places	COC/CMA/DTP	100	110
5.7	Recycling of domestic and industrial wastewater (urban)	CMWSSB	500	550
		Sub Total	**5150**	**5665**
Strategy 6: Energy				
6.1	Formulate a policy to encourage LED and solar lighting in streets and buildings (subsidy, incentives etc.,)	TEDA	50	55
6.2	Enforce labelling of domestic appliances for energy efficiency rating, capacity building on usage of BEE labelled appliances	TEDA	100	110

S. No	Strategy/Actions	Agency	Cost for 12th FYP (Rupees in crore)	Cost for 13th FYP (Rupees in crore)
6.3	• Replace all old pump sets with energy efficient pump sets • Promote use of energy efficient & solar pump sets across the state through subsidies including agriculture	• CMWSSB/ TWADB/ Agri Dept/ TEDA	1000 50	1100 55
6.5	Assess the energy generation from SW in the state and recover energy in terms of CH_4 from waste	CMA/CoC/DTP	100	110
6.6	Promote Energy Labelling for Rating of all buildings including residential	COC/CMA/DTP	50	55
6.7	• Create awareness for alternate energy • Address constraints of alternate energy sources including cost (subsidies, collection & replacement of old parts,maintenance agreement with supplier,etc)	TEDA	50 100	55 110
		SubTotal	**1500**	**1650**
Strategy 7: Developing an efficient integrated transport system				
7.1	Introduce Multi Model Transport System such as Metro Rail, Mass Rapid Transit Systems, Mono Rail, develop BRTS corridors	CoC	6500 200	7150 220
7.2 a	Expansion of Mass Transit Public Transport-I	TD/CMDA/DTCP	16000	17600
7.2 b	Expansion of Mass Transit Public Transport-II	TD/CMDA/DTCP	15000	16500
7.2 c	Mass Public Transit System for second tire cities	TD/CMDA/DTCP	50000	55000
7.3	Implementation of CUMTA	CMDA/TD/Railways & line Departments	1000	1100
7.4	Introduce feeder services from all 37l metro stations	STUs	500	550
7.5	Create freight corridors for rails and roadways	GoTN	15000	16500
7.6	Create additional parking areas through MLCP/MLTWP	CoC/CMA/TD	500	550
7.7	Impose traffic free areas in markets	CoC/Traffic Police	100	110
7.8	Increase number of auto LPG dispension stations in cities	TD/GoTN	100	110
7.9	Introduction of Congestion tax for private vehicles, Including GHGs gases in Green Tax	GoTN	50	55

S. No	Strategy/Actions	Agency	Cost for 12th FYP (Rupees in crore)	Cost for 13th FYP (Rupees in crore)
7.10	Low floor buses to support differently abled and senior citizens (patronising public transport)	STUs	1000	1100
7.11	Mandating parking spaces for registering new cars	TD	100	110
7.12	Convert all the public transport vehicles to alternate fuel in phased manner	Agriculture Engineering Department & TNAU	1000	1100
7.13	• Developing exclusive lanes for pedestrian • Promote cycling with good cycling paths, cycle parking facilities and link between cycling and public transport • Encourage car pooling • Introducing no-driving day for private vehicles	TD/ CMDA/ DTCP/ DoH COC/ CMA/ DTP/ CMDA/ DTCP Traffic Police	100 100 50 50	110 110 55 55
7.14	Increased subsidy/ reduced excise duty on hybrid vehicles and battery operated vehicles	TD, TEDA	500	550
7.15	Improvement to all existing roads and maintenance at regular intervals	Local Bodies/ RD and MA	1000	1100
7.16	Adoption of alternate/ advanced technology including mixing of plastic to ensure endurance to the roads	CoC/CMA/DTP/SH and NH	1000	1100
7.17	World Class Arterial Roads program	NHAI, NH, SH	3750	4125
7.18	Integrated Urban Road Development program	CoC	10000	11000
7.19	Organised parking (urban)	Municipal Corporations	1000	1100
7.20	City Bus Terminals	Municipal Corporations	250	255
7.21	Inter-city bus terminals	Municipal Corporations	250	255
		SubTotal	**125100**	**137570**
Strategy 8: Abating enhanced air and water pollution in a CC scenario				
8.1	Improved quality monitoring of Air, Water, Noise pollutions by increasing monitoring locations in State	TNPCB/ TD/ Traffic Police	5	6
8.2	Monitoring Ground Water Quality	PWD, TNPCB, SGWB	5	6
8.3	Providing UGSS with STP in all towns and CETPs	CMA, DTP, TNPCB	100	110
8.4	Study of impacts of CC on air & water pollution	TNPCB	5	6

S. No	Strategy/Actions	Agency	Cost for 12th FYP (Rupees in crore)	Cost for 13th FYP (Rupees in crore)
8.5	Revision of pollution standards Strict enforcement with penalty for violation of pollution standards Ensuring ZLD in industries	RD/ CMWSSB/ TWAD/ DTP/ CMA	10 10 10	11 11 11
8.6	Awareness and Capacity Building/ Training programs for different target groups on impacts of CC and pollution	TNPCB, Education Department	200	220
8.7	Measures to reduce Urban • Water pollution • Air pollution • Noise pollution	TWADB/ CMA/ CMWSSB/ TD	 500 700 200	 550 770 220
8.8	Measures to reduce Rural • Water pollution • Air pollution • Noise pollution	TWAD/ CMA/ CMWSSB/ TD	 700 200 100	 770 220 110
		SubTotal	**2745**	**3021**
Strategy 9: Greening of Urban Spaces				
9.1	Develop greenery/green belt to be made mandatory and inclusion in DCR	CMDA/ DTCP/ CoC/ CMA/DTP	50	55
9.2	Conversion of OSR lands into parks	CMA/DTP	50	55
9.3	Stringent compensatory plantation for tree cutting, including refundable deposit	COC, CMA, DTP	50	55
9.4	Study to identify suitable plant and tree species for urban greenery.	State Forest Dept Agriculture and Horticulture Department	50	55
		SubTotal	**200**	**220**
		GRAND TOTAL	**207104**	**217333**

11. KNOWLEDGE MANAGEMENT

The Climate Services Information System (CSIS)

11.1 BACKGROUND

The Tamil Nadu Government recognises the importance of knowledge for managing its resources. In this aspect, it has already created various platforms to monitor and document various climate variability and climate change related issues and the new innovations that are being implemented as remedial steps to stop the degradation of the natural resources as well as environment due to human influences.

Climate is another key driver that influences the sustainability of the natural resources and also the livelihoods that depend on the same. In Tamil Nadu livelihood of about 70 percent of the population that reside inland and in the coastal areas are vulnerable to the observed changes in climate which is likely to exacerbate with projected changes in the future. The State and its resources are susceptible to the projected increase in temperature, varying intensities of rainfall, droughts, cyclones, storm surges, and the global sea level rise (Balachandran et al, 2006).

For informed decision making in such a situation is imperative, and it is therefore necessary to establish a Climate Services Information System (CSIS), a knowledge portal that supports the development of strategies for adapting to the consequences of changing climate and ensure secure human being of its population and hence ensure food security, economic security and environmental sustainability.

In this regard, the State has already undertaken the following initiatives:

- Department of Environment (DoE), Government of Tamil Nadu has been designated as the Nodal Department for climate change.
- Identified 7 sectors which are most vulnerable to climate change in Tamil Nadu State are (1) Sustainable Agriculture, (2) Water Resources, (3) Forest and Biodiversity, (4) Coastal Area Management, (5) Energy Efficiency, Renewable Energy & Solar Mission. (6) Sustainable Habitat and (7) Knowledge Management.
- Identified Nodal Officers for each of the sector from relevant departments.
- Formulated Working Groups for each of the sector with members drawn from each departments, research institutions and NGOs.

- It is preparing the State Action Plan on Climate Change (TN SAPCC) -which has a multi pronged, long-term integrated framework for addressing climate change as a core development issue. This is also in line with the eight missions of the National Action Plan for Climate Change which aims to ensure national water security, sustainability of agriculture, aims to green India by increasing forest areas and improving degraded forests, maintain sustainability of the Himalayan ecosystem, and ensure the sustainability of the urban habitats. It also aims to increase the share of renewable energy in the total energy mix, with a thrust on harnessing solar energy and enhancing energy efficiency in industries, commercial and in residential spaces.

The State has launched pilot projects to strengthen the capacities of rural communities to adapt to climate variability and change with financial support from the German International Cooperation (GIZ). The pilot projects launched include:

- Developing Integrated Mangrove Fishery Farming System (IMFFS) at Pichavaram, Cuddalore district to improve fish catch and thus enhance adaptive capacities of coastal communities to Sea Level Rise
- Make water available by reviving farm ponds, improve efficiency of irrigation for areas which recurrently face droughts due to failure or delayed monsoon
- Climate proof water sheds by propagating appropriate increased water conservation techniques, increased ground water tables and thus convert dry lands to fertile irrigated land.

Further the government has implemented/implementing the following projects in collaboration with GIZ

- Rehabilitation of coastal habitats - Adaptation to Climate Change in livelihood of coastal people in Gulf of Mannar.
- Assessing relevance of Traditional Knowledge for Climate Change Adaptation, Tamil Nadu, Prime Net Consulting Group, New Delhi
- Climate Proofing a Joint Forest Management demonstration Model Project in Western Ghats

11.2 STRATEGIES TOWARDS DEVLOPMENT OF STRATEGIC KNOWLEDGE FOR CLIMATE CHANGE IN TAMIL NADU

The Tamil Nadu State Mission on Strategic Knowledge aims to build a greater understanding of the climate change processes, its implications on various sectors, and vulnerabilities associated with the same to enable sustainable adaptation to climate change and mitigation of drivers of climate change (greenhouse gases emitted from anthropogenic sources).

Tamil Nadu has been one of India's most progressive States and is amongst the top three on several economic and social indicators. Key facets of Vision TN 2023 include Tamil Nadu's enhanced economic dynamism, best in human development

indicators, a well developed infrastructure that provides universal access to basic services, an investment climate that compares with the best in Asia and the evolution into India's foremost knowledge and innovation hub. This thrust on innovation has to happen across all economic activities in the State including services, manufacturing, agriculture, administration, and financing.

Establishing institutions as Centres of Excellence in various fields that will attract the best talent from across the globe is one of the goals of the State.

Preserving, and wherever possible, improving the quality of the environment and nurturing the cultural heritage of the State is an essential ingredient of Vision TN 2023. The Vision Tamil Nadu 2023 envisages setting up a Cell in the State that will assess the situation with respect to environmental issues (mainly climate change related issues) that impact Tamil Nadu and suggest policy inputs to Government so that industry and society are able to move forward in a responsible and efficient manner. Similarly, the Vision TN 2023 also emphasises an environment conducive for protecting Intellectual Property Rights and celebrating success in innovations.

In order to achieve the vision of the State in the area of climate change and effectively implement the actions suggested in the State Action Plan on Climate Change, the State has identified the following strategies:

Strategy 1: Create an enabling institutional framework for developing CSIS and disseminating strategic knowledge on climate change.

This will entail development of

1. A Centre for Excellence in an existing R&D body to address all research and technology development and demonstration issues related to climate change.
   The Centre of Excellence for Tamil Nadu is proposed to be housed within the Centre for Climate Change and Adaptation Research (CCCAR) at the Anna University (AU), Chennai.

2. Establish a Climate Change Cell within the government that will coordinate and provide policy guidance on climate change in the State.
   The Climate Change Cell could be established within the Department of Environment (DoE), Government of Tamil Nadu, Chennai.

Strategy 2: Develop scientific capacities for a deeper understanding of climate change issues

The Tamil Nadu State aims to build on the existing knowledge to further understand the key climate processes and the anthropogenic drivers of climate change. Further, it aims to understand the all possible scenario of manifestations of climate change on various sectors and identify associated vulnerabilities for developing appropriate deliverable adaptation strategies. The various aspects of research can be summarised as follows:

- Develop socio economic scenarios that depict the developmental aspirations of the State and hence depict the GHG emission trends in the future
- Analyse current climate trends
- Assess future climate change using multiple regional climate models and run on GHG emission scenarios relevant for the State
- Access/develop and run regional climate models to understand the impacts of climate change and evaluate associated vulnerabilities at higher resolutions to enable development of strategies for adaptation at local scales.

Strategy 3: Support Research & Development of innovations to address climate change impacts and vulnerabilities

The State is keen to undertake research to develop innovations suitable for different situations that can be easily replicated. The innovations can be in terms of new technologies or retrofitted technologies, policy tools or in terms of institutional mechanisms/operations that would enable overcoming barriers for adaptation to climate change. The focus areas would be, but not limited to

- Sustainable management of water resources , health and agriculture
- Protect and preserve forestry and biodiversity
- Help commercialize its indigenous crop diversity in the changing climate scenario
- Enhance efficiency of systems in agriculture and Industry including in SMEs to reduce specific energy consumption
- Develop innovations for efficient and sustainable waste management, transport, and climate proofed buildings
- Develop innovations that reduce pollutant loads in air and water in a changing climate scenario in rural and urban settings.

These technical innovations will be undertaken and supported through the Centre of Excellence and the policy and institutional innovation research will be supported through the Climate Change Cell.

Strategy 4: Undertake Demonstration, Field Implementation & Extension

An important aspect of large scale deployment of innovations is trying out the same at a small scale in a pilot mode and depending on the success of the pilot then broadcasting it at a wider scale. The process requires scientific step by step implementation of the innovation and massive outreach activities that help build capacity to absorb the technology that is developed. Therefore, this is an important element of knowledge management for the State; as a large number of technologies concerning all economic activities of the State are expected to become climate proof.

The Climate Change Cell will undertake demonstration, dissemination and capacity building for absorption of sustainable innovations in the area related to forests and environment. The Centre of Excellence on Climate Change will undertake field trials, forecast, and develop capacity building programmes for adoption of innovations in agriculture and water management practices.

Strategy 5: Support regular monitoring of critical ecological parameters and urban landscape

The Climate Change Cell will support creation of an enabling environment that identifies the ecosystems and urban landscape parameters to be monitored, and brings together the researchers and the financial mechanisms towards undertaking the same. This action is envisaged towards development of sustainable habitats within an ecologically sustainable environment.

Strategy 6: Mainstream traditional knowledge

This will help in documentation, authentication and mainstreaming traditional knowledge on adaptation in line with National Innovation Foundation. Some of these knowledge are getting lost as they are not practiced, however, with little support from the government in terms of strengthening the practices with new scientific knowledge interventions, a large scale practicing of the same could be enabled.

The traditional knowledge is built over the years and are practiced over generations and therefore are suitable for the climatic conditions under which they are practiced.

Strategy 7: Undertake capacity building initiatives to integrate steps to manage climate sensitive natural resources and mitigate climate change drivers

For this all levels of governance need to be sensitised right from policy makers, decision makers and implementing agencies of programmes and projects. The Climate Change cell therefore needs to take measures to assess the training needs and devise modules for training of concerned people at various levels of governance within the State.

Strategy 8: Support creation of Monitoring and Evaluation tools of various initiatives of the climate sensitive sectors.

It is important to regularly monitor actions within each strategy to ensure timely achievement of targets as set out under each mission, evaluate status of implementation process, understand overall impact of programmes and design relevant/desirable new strategies and actions keeping in view long term sustainable developmental issues under changing climate scenario. This will entail commissioning of baseline studies for each sector to evolve appropriate sectoral criteria/ indicators for M&E in association with respective departments.

Strategy 9: Develop an interactive a Climate Service Information System (CSIS) Portal for accessing data and for designing decision packages for policy climate sensitive making

A CSIS will essentially collate data and do data analysis for informed decision making. The data is proposed to be accessed through a Portal**.** Climate change being a multi-disciplinary subject, access to different types of datasets is required to interpret the trends not only of climate but the drivers of climate change as well. These data are already being generated by various departments of the State and their institutions as a part of their respective mandates. Considering that The National Data Sharing and Accessibility Policy has come into effect in February 2012, this can facilitate research and help synthesise, analyse and visualize data to help planners and policy makers to interpret and make informed decisions.

Based on this, an interactive knowledge portal will be developed for facilitating the use of this climate knowledge to various Government and non-Govt. organizations, the scientific community, researchers, civil society, common people, decision makers and policy planners. The data base that would be required to be accessed would include but not limited to data on

- Different sectoral data (such as temperature, rainfall, relative humidity, soil moisture, surface runoff, evapo-transipiration, sea surface temperature, wind speed, solar radiation ,pollution data etc.).
- Relevant details of programmes and projects being implemented nationally as well as internationally
- Policies, acts and notifications governing the programmes related to climate change
- Institutional mechanisms for managing the various sectoral programmes
- Relevant Research and Development (R&D) results
- Document traditional knowledge and new innovations
- Description and sources of various technologies for mitigation and adaptation within and outside the national domain
- Any technology development being done through international cooperation
- The latest on science of climate change, adaptation and mitigation
- An added interactive portal for the children
- An interactive blog for all stake holders to discuss and upload their ideas on innovations

It will be created in collaboration with State departments and their institutions, universities and other local institutions, local bodies such as the Panchayats or the Urban Local bodies, etc. Further, access to data bases of national institutions such as the Planning Commission, the Ministries, their departments and institutions such as

Census, NSSO (National Sample Survey Organisation), ICAR (Indian Council of Agriculture Research), DST (Department of Science and Technology), CSIR (Council of Scientific and Industrial Research, Industry Associations, and National Universities need to be available. The database also needs to have access to International data bases such as the IPCCDDC (Intergovernmental Panel on Climate Change- Data Dissemination Centre), WMO (World Meteorological Organisation), FAO (Food and Agriculture Organisation), IEA (International Energy Agency), BP (British Petroleum) etc. and information on Programmes and projects carried out by Bilateral and Multilaterals for having a global perspective and applying it to National and State level too.It has to be clear that the data available through this platform has to be at different levels for different category of stakeholders. Types of access will be categorized for Open access, Registered access and Restricted access.

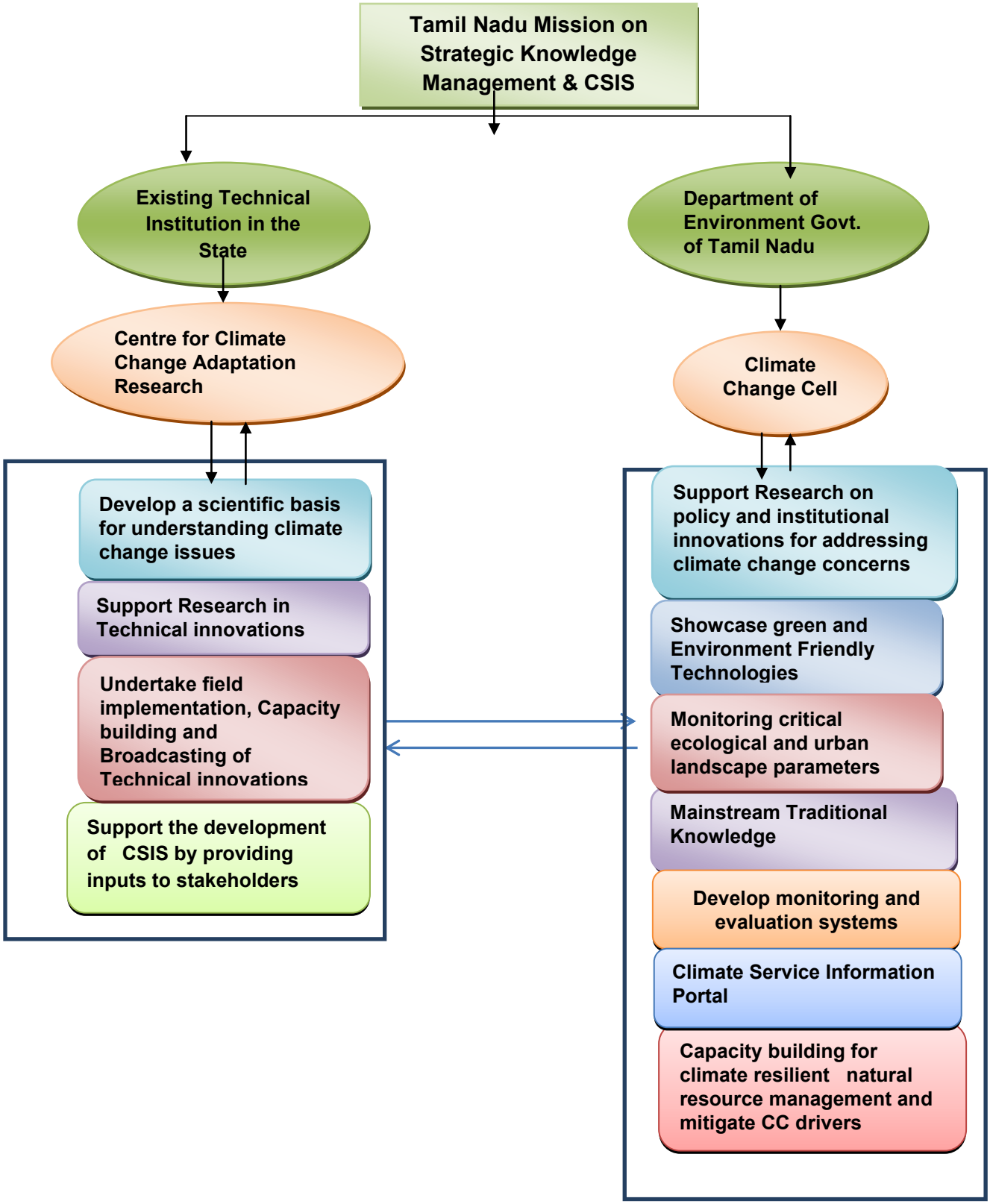
Budget requirement for strategies in Knowledge Management Sector

The total cost for implementing the strategies during the 12th Five Year Plan (FYP) is Rs 49.00 crore and during the 13th Five Year Plan is Rs.66.00 crore (Table 11.1).

Table 11.1 Summary of budget requirement for Knowledge Management sector

S. No	Strategy	Cost for 12th FYP (Rupees in crore)	Cost for 13th FYP (Rupees in crore)
1.	Create an enabling institutional framework for developing and disseminating strategic knowledge on climate change.	7.50	11.00
2.	Develop a scientific basis for a deeper understanding of climate change issues	5.00	5.00
3.	Support Research and Development of innovations	4.00	7.00
4.	Undertake Demonstration, Field implementation & Extension; Ground truth verification & Field Demo for choosing adaptation options	5.00	7.00
5.	Support regular monitoring of critical ecological parameters and urban landscape	5.00	7.00
6.	Mainstream traditional knowledge	5.00	7.00
7.	Undertake capacity building initiatives to integrate steps to manage climate sensitive natural resources and mitigate climate change drivers	5.00	7.00
8.	Creation of Monitoring and Evaluation tools of various initiatives of climate sensitive	7.50	8.00
9.	Implement CSIS through a knowledge portal	5.00	7.00
	Grand Total	**49.00**	**66.00**

Figure-11.1: Proposed Institutional Arrangement for Implementing Tamil Nadu Mission on Strategic Knowledge for Climate Change



Detailed Budget for strategies in Knowledge Management Sector is given in Table 11.2

Table: 11.2 Detailed Budget for strategies in Knowledge Management Sector

S. No	Strategy	Agency	Cost for 12th FYP (Rupees in crore)	Cost for 13th FYP (Rupees in crore)
1.	Create an enabling institutional framework for developing and disseminating strategic knowledge on climate change.	Climate Change and Adaptation Research (CCCAR) Anna University	**7.50**	**11.00**
2.	Develop a scientific basis for a deeper understanding of climate change issues around the Globe	DoE & CCAR	**5.00**	**5.00**
3.	Support Research and Development of innovations to address climate change impacts and vulnerabilities	CCCAR & DoE	**4.00**	**7.00**
4.	Undertake Demonstration, Field implementation & Extension ; Ground truth verification &Field Demo for choosing adaptation options	CCCAR & DoE	**5.00**	**7.00**
5.	Support regular monitoring of critical ecological parameters and urban landscape	CCCAR & DoE	**5.00**	**7.00**
6.	Mainstream traditional knowledge	CCCAR	**5.00**	**7.00**
7.	Undertake capacity building initiatives to integrate steps to manage climate sensitive natural resources and mitigate climate change drivers • Training/Capacity building; • Workshops/Seminars/Consultation • Exposure Visit to areas where success stories pertaining to adaption to vagaries of climate change can be studied	CCCAR & DoE DoE & Line Depts.,	**5.00**	**7.00**
8.	Support creation of Monitoring and Evaluation(M & E) tools of various initiatives of the climate sensitive sectors	DoE	**7.50**	**8.00**
9.	Implement CSIS through a knowledge portal to the end users	DoE & CCCAR	**5.00**	**7.00**
		Grand Total	**49.00**	**66.00**