State of Environment Report for Tamil Nadu

Centre of Excellence in Environmental Economics

Madras School of Economics, Chennai

January 2016

CONTENTS

List of Tables

List of Figures

List of Boxes

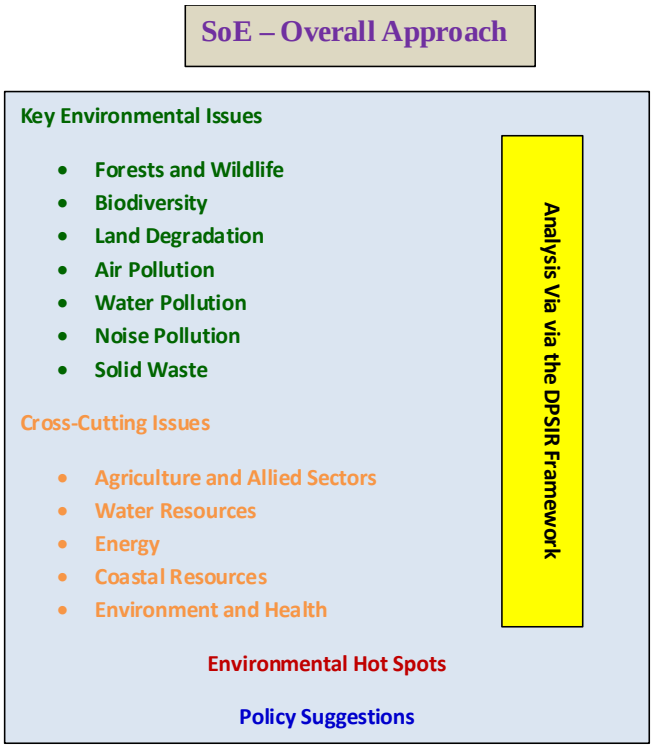
State of Environment – Tamil Nadu

Executive Summary

Tamil Nadu is at the crossroads in terms of sustainable development. On the one hand the state has registered impressive economic growth along with significant progress in human development in recent years. It is endowed with rich biodiversity that is protected and conserved through a network of five national parks, twenty wildlife sanctuaries and two biosphere reserves. On the other hand, the state has the highest level of urbanization in India bringing with it a plethora of associated environmental problems. A high level of industrialization has also brought to the forefront pollution concerns. A long coast line with a dense population will always put the region in a vulnerable position with respect to natural hazards, and the Tsunami havoc in 2004 highlighted this amply. Thus, natural and anthropogenic factors place the environment of Tamil Nadu in a precarious position, threatening sustainable development.

The state-of-the-environment studies are broadly aimed at understanding the sustainability of the development path pursued by a region. Several state governments in India have prepared State of Environment (SoE) reports by taking stock of a number of indicators representing the health of the environment, impacts of environmental degradation and factors affecting the environment. In Tamil Nadu, the Department of Environment, Government of Tamil Nadu had prepared and released the state of environment report during 2005. The present report attempts to build upon the earlier State of Environment report to develop a present status report of the state of environment in Tamil Nadu. The present study analyzes the state of the environment using driver-pressure-state-impact-response (DPSIR) framework. In general, the 'drivers' are the driving forces behind many of the subsequent activities that extract from and pollute the environment, which are more often than not demographic changes and broad development goals.

The figure below shows the broad structure of the SoE report. The key environmental issues – including, forests and wildlife, biodiversity, land degradation, air pollution, water pollution, noise pollution, and solid waste, as well as cross-cutting issues – including, agricultural and allied sectors, water resources, energy, coastal resources, and environment and health, are analyzed in this report. Both the key environmental issues and the cross-cutting issues have been analysed using the DPSIR framework. The report also discusses briefly the environmental hotspots that require urgent policy attention. A number of policy suggestions have been given in the report to facilitate sustainable development in Tamil Nadu.



DPSIR Indicators

Population growth, rapid urbanization, changing life styles, and the development goals (outlined in the Visions 2023) act as drivers to exert pressure on the environment in Tamil Nadu. In the backdrop of these overall drivers, this report examined the state of environment in Tamil Nadu by analysing the sector specific indicators of pressure, state, impact and responses. Both temporal and spatial (across districts) patterns of various indicators have been analysed using the latest available data. The table below provides an overview of the various indicators used for the analysis in the different sectors.

Issue/Topic-specific Pressure-State-Impact-Response Indicators

Topic	Indicators
Forests, Wildlife and Biodiversity	Pressure: Demand for forest produce and firewood; Demand Supply Gap for wood; Growth in tourist population; Forest fires State: Forest Cover; Wetlands; Status of endangered animals Impact: Human animal conflicts Responses: Forest certification; Eco-tourism; Reserved and protected forests; Joint forest management; Biosphere reserves; National parks; Wildlife and bird sanctuaries
Land Degradation and Solid Waste	Pressure: Agricultural practices; Land conversion for non-agricultural use; Waste generation; Mining activities State/Impact: Wastelands; Fallow lands Responses: Organic farming; Environmental clearance for mining projects; Sustainable mining practices; Waste management; Compliance with MSW2000 Rules
Air and Noise Pollution	Pressure: Motor vehicle density; Road density and connectivity; Industrial growth; Use of solid fuels for cooking; Burning of agricultural and solid waste State/Impact: Air pollution levels in major cities; Indoor air pollution levels; Greenhouse Gas Emissions; Health Impacts Responses: Air pollution monitoring network; Growth of public transport; penetration of clean cooking fuels; Integrated Transport system
Water Resources and Water Pollution	Pressure: Rainfall anomaly; Fertilizer and pesticide use; Domestic, industrial and agricultural water effluents State: Quantity and quality of water Impact: Incidence and spread of water borne diseases; Water conflicts Responses: Desalination plants; Rainwater harvesting Water treatment plants; Drip and sprinkler irrigation; Promotion of low water intensive crops; Watershed programs; Water use charges
Agriculture and Allied Sectors	Pressure: Dependence on Agriculture; Climate Change State: Declining Production and Widening Yield Gap. Impact: Implications of Food Insecurity. Responses: Universal Public Distribution System; Organic Farming; Bio-fertilizers; Vermi-composting; Performance of PDS and ICDS, and Amma Canteen.
Energy	Penetration of Renewable Energy Sources in Energy-mix; Greenhouse Gas Emissions from Energy Sector
Coastal Resources	Pressure: Commercial Fishing; Domestic and Industrial Pollution; Ports and Harbours; Coastal Tourism. State / Impact: Mangroves; Coral Reefs; Seagrasses and Seaweeds; Estuaries; Sand Beaches and Dunes; Fish Species; Olive Ridley Turtles. Responses: Integrated Coastal Zone Management (ICZM) Plan; Institutional Changes; Tsunami Rehabilitation; Mangrove Restoration; In-Situ Conservation; and Fishing Bans.

Sector/Theme Specific Findings

Forests, Wildlife and Biodiversity

- With a 11 per cent increase in very dense forests, a 4 per cent increase in moderately dense forests, and a 1 per cent increase in open forests, the total forest cover in Tamil Nadu increased by 3 per cent between 2005 and 2013. The tree cover in Tamil Nadu however, declined by 13 per cent over the same period.
- The increase in forest cover in Tamil Nadu has been attributed to better conservation and protection of forests leading to increase in moderately dense and open forest areas.
- The reserved, protected and un-classed forests in Tamil Nadu registered a marginal decline of about 0.7 per cent between 2004-05 and 2013-14.
- With about 3,337 Joint Forest Management committees involving over 10.6 lakh members, the area under JFM in the state stands currently at around 7.2 lakh hectares.
- The tiger population in Tamil Nadu increased from 76 in 2006 to 163 in 2010; whereas the wild elephants increased from 3052 in 2002 to 3867 in 2007-08.
- As many as 230 medicinal species, 126 fish species, 56 amphibian species, 77 reptile species, 32 bird species, and 40 mammals are under the red-list category in Tamil Nadu. These species require sustained attention for conservation.
- As of September 2015, Tamil Nadu has mere 16 biodiversity management committees (BMCs), compared to 4636 in Karnataka, 1043 in Kerala, 928 in Andhra Pradesh, and 710 in Telangana. For effective biodiversity conservation as well as to facilitate equitable sharing of the benefits resulting from the use of biological resources, it is important to increase the number of BMCs as they would help in understanding the perspectives of different stakeholders.
- With a focus on socially-responsible travel to destinations where flora, fauna and cultural heritage are the main attractions, the Tamil Nadu Forest Department has promoted a number of eco-tourism destinations in the state.

Land Degradation and Solid Waste

- Over the period 2003-04 to 2013-14, cropping intensity increased by 51 and 47 per cent in the districts of Thiruvarur and Dharmapuri, respectively. It has increased significantly in Nagapattinam, Cuddalore, Villupuram, Thanjavur, Salem and Krishnagiri.
- In a majority of the districts, the area under non-agricultural use has increased over the period 2003-04 to 2013-14 in Tamil Nadu.
- A whopping 14727 tonnes of municipal solid waste is generated per day in Tamil Nadu with close to 60 per cent of that coming from the 12 corporations.
- Tamil Nadu accounted for roughly 13.5 per cent of total biofertilizer production in India in 2011-12.

- Tamil Nadu has taken pioneering efforts to utilize the hazardous waste generated from Common Effluent Treatment Plants of textile processing units as fuel/raw material for co-processing in cement factories.
- Among the 12 corporations in Tamil Nadu, only six treat their municipal solid waste. In Chennai, other than the segregation done for recyclable waste by the sanitary workers, there is no further processing of municipal solid waste and it is disposed-off at two dumping yards at Kodungaiyur and Perungudi.
- The Government of Tamil Nadu has been proactive in setting up new biomethanation plants using municipal solid waste in the state. Following the successful testing of the pilot project at Arcot municipality, the Government has proposed to set up 29 new biomethanation plants of 3-5 MT capacity across 5 corporations and 24 municipalities in the state.

Air and Noise Pollution

- The total number of motor vehicles has grown in Tamil Nadu by 125 per cent during 2005-06 and 2013-14. Besides Chennai, Ariyalur and Coimbatore districts have high vehicle densities in excess of 200 vehicles per kilometre of road length.
- Tamil Nadu produced roughly 27 per cent of all-India passenger vehicles and 13 per cent of all-India commercial vehicles in 2010-11. Other major industries with potential for air pollution include sugar (which registered 72 per cent increase in production between 2004-05 and 2012-13) and cement (where the state's share increased by 75 per cent over period 2004-05 and 2011-12). The small scale industries have also increased by 73 per cent in Tamil Nadu between 2004-05 and 2012-13.
- Despite impressive penetration of cleaner cooking fuels such as LPG, close to 70 per cent of households in Tamil Nadu still use firewood and other solid fuels for cooking in rural areas, putting significant health burden on women, children and the elderly.
- Over the period 2008-09 and 2013-14, the average annual SO_2 concentrations increased in all locations in Chennai, Madurai and Trichy, whereas the same reduced in Thoothukudi and Coimbatore. Excepting some locations, the RSPM concentrations increased in all locations in Tamil Nadu over the same period.
- With regard to noise pollution, despite increased awareness campaigns organized by the Pollution Control Board, the ambient noise levels have shown increasing trend over the past five years in cities like Chennai during the Diwali festival.
- The Tamil Nadu Pollution Control Board is monitoring the status of air quality in important cities and towns of Tamil Nadu. It has installed six continuous ambient air quality monitoring stations also to monitor air quality on a continuous basis.
- With a wide network, the public transport facilities benefit close to 180 lakh passengers daily in Tamil Nadu. The bus transport network in the state has shown significant improvement over the last few years. With the inauguration of Chennai Metro Rail, the railway networks in Chennai including the existing Mass Rapid Transit System, provide

an alternative mode of transportation in the city and thereby reduce the road traffic and associated air pollution.

Water Resources and Water Pollution

- With significant dependence on ground water for irrigation compared to canals and tanks, almost all districts report more than 50 per cent of irrigation needs met through groundwater. Some districts such as Thanjavur, Perambalur, Viluppuram, Dindigul report more than 95 per cent of their groundwater for irrigation.
- Nitrogenous nutrients currently account for more than two-thirds of the total fertilizer consumption compared to 51 per cent in 2007-08. Increased use of nitrogen containing fertilizers leads to water pollution owing to non-absorption by the plant and leaching into the groundwater.
- The groundwater development is reported more than 100 per cent in several districts including Chennai, Salem, Perambalur, Krishnagiri, Dharmapuri, Tiruppur, Dindigaul, Coimbatore, vellore, Thanjavur, Villupuram and Nagapattinam, highlighting the seriousness of overexploitation in the state.
- Coimbatore tops the list of districts reporting severe water contamination, with over 40 per cent of its tested sources turning out to be contaminated in terms of fluoride, nitrate, iron and faecal contamination in 2011.
- As of 2013-14, the water supply shortfall has been recorded as 29.5 per cent across the urban areas in the State. Similar shortages are observed with regard to other amenities such as housing and drainage. In addition, Tamil Nadu accounts for nearly 9 per cent of the slum population of the country, with the five major cities (Chennai, Madurai, Tiruppur, Tiruchirapalli and Coimbatore) accounting for one-third of the total slum population in the state.
- An estimated 40 million litres per day of water is transported from the peri-urban areas to cities drawing ground water from the riverbed aquifer. Sand mining also adds to the problems of the riverbed. The conflict of interest in the use of water presents a changing picture of transportation of urban environmental problems into peri-urban areas.
- A large majority of the common effluent treatment plants established in tanneries and textile dyeing processing units have implemented zero liquid discharge system in Tamil Nadu.
- The rainwater harvesting program in the state ensured that by 2013-14, 96 per cent of the buildings in town panchayats are provided with rainwater harvesting facilities.
- Two desalination plants have been established in the state to meet water requirements in Chennai, while three more have been planned to boost drinking water supply in Chennai, Thoothukudi and Ramanathapuram districts.

Agriculture

- Despite steady increase in total food grain production and 2014-15 witnessing a record high production of 128 lakh tons, Tamil Nadu has been lagging behind India in terms of per-capita calorie and protein intake.
- Natural factors such as rainfall shortages are contributing to the pressure on agriculture. During 2004 to 2014, in 9 out of 11 years at least one district in Tamil Nadu has witnessed below normal rainfall. Further, while there were 45 instances of rainfall shortages across districts during 2004 to 2008, the number of such instances more than doubled during 2009 to 2014. Thanjavur, Thiruvarur, Cuddalore, Madurai and Nagapattinam are particularly vulnerable to rainfall anomaly, given their contributions to agricultural production in the State.
- In terms of outcomes, Tamil Nadu has showed consistent improvement in the overall status of under-nourishment over the period 1998 to 2012 and has also fared better than all India performance.
- Tamil Nadu has a number of welfare schemes to address food security issues, including the traditional schemes such as universal public distribution system, ICDS and PTMGRNMP, and innovative schemes such as Amma Unavakangal (Budget canteens).
- In addition to the welfare schemes, the Government of Tamil Nadu has also been proactive in sustainable agricultural practices such as organic farming, use of bio-fertilizers, and vermicomposting.

Energy

- Tamil Nadu remains one of the 'frontrunners' in the country when it comes to non-conventional energy sources, with about 36 percent contribution from renewable sources in the overall energy-mix as of 2015. Policies which aim at tapping the potential sources of renewable energy have set benchmarks for other states in the country to follow.
- Yet, Tamil Nadu has ambitious plans to increase its economic growth in the near future. The Vision 2023 aims at achieving 12.3 per cent industrial growth and 13.8 per cent growth for manufacturing sector and targets to get Rs. 1.5 million crore investment to achieve the growth targets. All this could put substantial pressure on future greenhouse gas emissions from the State unless appropriate policy interventions are made.
- The total greenhouse gas emissions for the year 2009-10 have been estimated as 111.86 million tons CO_2eq, with the per-capita emissions of about 1.59 tons of CO_2eq.
- The State Action Plan on Climate Change (SAPCC) has identified several strategies for tackling climate change in various sectors including agriculture, water resources, coastal area management, power generation using renewable sources, sustainable habitat, and knowledge management.
- Despite the recognition of higher solar energy potential of the state than its potential in the more volatile wind energy source, the SAPCC has highlighted greater emphasis on wind energy through more capacity addition in wind than solar energy during 12^{th} and

13th Five year plan period. Equal, if not more, emphasis on solar energy along with wind energy could be more effective in pushing the state along sustainable development path.

Coastal Resources

- Tamil Nadu is endowed with a variety of coastal and marine ecosystems – mangroves, coral reefs, seagrass beds, sand beaches and dunes, mudflats, salt marshes, estuaries and marine waters – which are ecologically sensitive regions of extraordinary biological productivity and high accessibility.
- A range of pressures affect coastal and marine ecosystems including commercial fishing (which has been gradually increasing over the past decade in Tamil Nadu), domestic and industrial pollution, ports and harbours (where the quantity of cargo handled has increased by about 90 per cent during 2001-02 and 2012-13), coastal tourism (with about 83 million visitors in 2012), and climate change and sea level rise.
- Tamil Nadu has two major mangrove forests namely the Pichavaram and Muthupet mangrove forests. Over the period 2001 to 2013 the total area under mangrove cover increased significantly in the districts of Nagapattinam and Thanjavur. As of 2013, the total mangrove area in Tamil Nadu was 39 sq. km. Coral reefs and seagrasses are mainly found in the Gulf of Mannar and Palk Bay. The current total reef area in Tamil Nadu is 94.3 sq. km. and seagrass area is 86 sq. km.
- The river Cauvery forms the major estuary in Tamil Nadu and recent studies measuring pollution load in the estuary indicate that its water quality is in a good state. On the other hand, development activities and extreme events have led to the erosion of sand beaches and dunes on the coasts of Kanniyakumari, Thiruvarur, Nagapattinam, Villupuram and Kancheepuram.
- Olive Ridley turtles nest primarily along the coasts of Chennai, Mamallapuram – Pondicherry and Nagapattinam, however they face serious threats from human activities including coastal development works, fishing etc.
- Several species of fish that were produced in Tamil Nadu in 2003 or 2007 registered significant declines (e.g. Parava) or even 100 per cent declines in production (e.g. Bombay Duck, Hilsa) in 2012. Mean per capita fish consumption declined in rural Tamil Nadu from 0.202 to 0.153 kg per person per month between 1983 and 2009-10. However fish consumption increased marginally for the urban population over the same period.
- Several policy initiatives have been undertaken by the government to protect and conserve the coastal environment including effective legislation (Integrated Coastal Zone Management plans, fishing bans), setting up the National Centre for Sustainable Coastal Management in Chennai to further scientific knowledge and research, promoting in-situ conservation in the Gulf of Mannar, Point Calimere and Pulicat Lake, and undertaking mangrove restoration and tsunami rehabilitation in affected coastal villages.

Environmental Hotspots

- Though the intention of this study is not to aggregate various indicators to arrive at a comprehensive indices such as environmental performance index, or environmental sustainability index of a region, the report summarized the findings from such exercises carried out recently for Tamil Nadu.
- A recent study constructed environmental sustainability index (ESI) for the districts of Tamil Nadu using 2011-12 as the baseline year. The ESI consists of 45 indicators spread across nine thematic areas including, population, land-use, agriculture, transport, water, forests, solid waste, energy, and output. The study identified Vellore, Karur, Perambalur, Virudhunagar, Krishnagiri, Dharmapuri and Tiruppur as the least sustainable districts.
- Another recent study assessed the agricultural vulnerability of the districts of Tamil Nadu to climate change. The study chose the growth and instability of certain performance indicators to capture the relative vulnerability of the districts of Tamil Nadu. The agricultural vulnerability index (AVI) has been estimated as a weighted index based on growth and instability in south west and north east monsoon; growth in crop diversification; growth in net cultivated area; and growth in crop intensity. The study identified Tiruchirappalli, Karur, Perambalur and Ariyalur as agriculturally most vulnerable districts of Tamil Nadu from climate change perspective.
- If one juxtaposes the above two studies and relative ranking of the districts of Tamil Nadu, it is possible to identify the districts that are currently least sustainable from environmental perspective and are also identified as most vulnerable to climate change (albeit with focus on single sector namely, agriculture). Such an exercise reveals that Karur and Perambalur are two most important districts that need urgent policy attention.

Policy Recommendations

- A large majority of responses (over 55 per cent out of 27 programs and initiatives analyzed) are aimed at restoring the state of the environment, whereas the responses aimed at reducing the pressure on the environment (about 30 per cent) and the responses aimed at ameliorating the impacts due to environmental degradation (about 15 per cent) are given relatively lower importance so far. The policies aimed at reducing impacts caused by environmental degradation have largely been in the form of compensation given by the State. With the exception of the Loss of Ecology Authority, which awarded compensation to the victims of tannery pollution, there has been relatively less emphasis on polluter-pays principle and internalization of environmental externalities in private decisions. This is one of the policy priorities for facilitating sustainable development in the state.

Municipal Solid Waste Management

The solid waste management in Tamil Nadu faces similar challenges as faced in other Indian states (cities) – including, inadequate segregation of waste at source, and improper disposal in land fill site leading to serious environmental challenges. In the midst of growing despair on solid waste management, the case of Namakkal stands tall and provides optimism that if properly addressed with people's involvement these issues can be solved with considerable ease. Recommendations applicable to waste management in Tamil Nadu include:

- State governments should make the segregation of wastes mandatory and municipalities could be authorized to levy fines if segregated waste is not made available to the municipalities for collection;
- Waste processing should be made mandatory and sufficient funding should be provided by MoEF/MoUD to set up waste processing infrastructure/technology in each municipality;
- Existing dumpsites should be made more sanitary and aesthetic, dumpsites in residential areas and near water sources/ water bodies should be closed down and dumpsites should be periodically monitored to prevent environmental contamination;
- Each municipality should identify land for setting up of landfills on a priority basis and landfilling should be restricted to non-biodegradable/inorganic waste;
- Both existing and new hospitals should have a treatment/disposal facility or join a common treatment facility, failing which they should not be allowed to continue their operations;
- Surprise checks should be conducted to verify vendors' compliance with plastic waste rules;
- PCB should maintain a database of manufacturers of plastic carry bags/containers to ensure that manufacture of the same does not occur without prior consent.
- In addition to the above recommendations, there is an overall need for better monitoring by the State PCB of waste disposal facilities like compost plants, incinerators, dumping grounds etc. For this purpose the state government should make provisions in the budget for waste management activities and moreover the state government and PCB should assess their manpower requirements and accordingly hire staff dedicated to the implementation and monitoring of waste management activities.

Environment and Forest Department and Pollution Control Board

- The ongoing afforestation programs/schemes of the state should continue to increase forest cover as well as tree cover in private lands. A more coordinated approach among various ongoing programs/schemes could achieve not only better targets but also ensure efficient utilization of resources. This would contribute towards additional carbon sink creation targeted in India's recently announced Intended Nationally Determined Contributions (INDCs).

- The operational activities of the Department of Environment and Forests are reported to have slowed down due to the lack of sufficient man power as the sanctioned staff strength is not fully placed in action. The Tamil Nadu Pollution Control Board (TNPCB) laboratories are also facing severe staff shortages that could be hampering their operations. By the year 2022 many of the senior scientists are due to retire which is likely to place considerable stain on the monitoring and regulating activities of the board. It is recommended that the posts, particularly of staff involved in the monitoring of pollution and the environment, be filled to full capacity in order that these activities may be carried out efficiently and effectively.
- As a percentage of the total plan outlay of the central and state governments, the allocation to the Environment and Forestry Sector is less than one per cent. Many of the schemes have allocations that are too small to make any real impact. This leads to a thin spread of scarce resources across various activities and the ensuing strain on the limited administrative capacity. Despite the increase in the budget allocation for forest protection under various schemes in the five years plans from 3 per cent to 6 per cent over the 12th and 13th finance commission, more financial allocation is required for this sector in order to overcome its administrative barriers.
- Presently there is no separate eco-tourism wing in Forest Department. In order to organize, direct and ensure an effective implementation and management of ecotourism objectives and principles in the State, a separate eco-tourism Board or an Authority should be established.

Renewable Energy

Tamil Nadu remains one of the 'frontrunners' in the country when it comes to non-conventional energy sources. Policies which aim at tapping the potential sources of renewable energy have set benchmarks for other states in the country to follow. For instance, recent reports highlight that the state has outperformed all its peers in rooftop solar installations. As of October 2015, with credible performance in industrial, commercial and residential sectors, Tamil Nadu topped the rooftop solar capacity addition in the country with a total installed capacity of 76 MW against the all India capacity of 525 MW. The state policies, however, need to be evaluated keeping in mind their potential to contribute towards future energy needs of its population, the evolution of geo-political discussions surrounding existing and emerging threats such as climate change. They also acquire importance in the context of India's recently announced INDCs that target to reduce emission intensity by 33 to 35 percent below 2005 level by 2030, primarily by installing 175 GW of renewable power capacity. In this context the following suggestions are made:

- The declining share of renewable energy in the energy mix in installed capacity[1] for electricity generation in the state should be addressed on priority basis;

[1] The share of renewable energy in the total installed capacity has declined from 43% in 2012 to 38% in 2015.

- Given the greater potential for solar energy in the state compared to wind energy potential, as well as factoring in the more volatile nature of wind energy, appropriate policy to achieve the right mix of the two non-conventional energy sources must be promoted;
- Capacity of existing institutions must be enhanced to handle volatile nature of renewable energy generation with emphasis on creating flexible systems;
- Following example set by Gujarat and Maharashtra, feeder separation should be done on priority basis to not only increase reliability of power supply to the rural households but also minimize the losses to the state electricity board and avoid wasteful electricity consumption;
- Again, following the lead taken by Gujarat, the state could adopt a cess on electricity generation from conventional sources to facilitate more rapid expansion of renewable sources; and
- Mandate solar power generation and use for common lightings in all the new commercial and residential structures/complexes.

Transport Sector

Operation of integrated public transit modes (including bus and rail transport) as one seamless entity such that they meet the needs of the passengers (comfort, convenience, reduced travel time and costs etc.), increase patronage of public transport, reduce pollution and congestion levels and provide last mile connectivity. To this effect, the following recommendations may be considered:

- A well networked metro rail system in all major cities of Tamil Nadu with good connectivity to bus routes. The recently inaugurated Chennai metro rail needs to be extended to the rapidly growing suburbs of Chennai city;
- Giving priorities to non-motorized transport, for instance through the undertaking of a public cycling sharing system wherein cycles may be hired to commute across the city. Delhi metro launched a public bicycle sharing scheme as per which commuters can rent cycles from residential areas and travel to the nearest metro and back[2]. There is also a need for designated cycling and walking tracks along arterial roads to ensure safety of pedestrians and cyclists;
- Putting in place a parking policy. The creation of designated parking spaces (including state of the art multi-level parking facilities like the recently inaugurated facility at Wallace Garden in Chennai) especially in highly congested areas like tourist and shopping destinations and outside hospitals, along with appropriate parking charges would reduce road and traffic congestion to a considerable extent. Chennai's parking

[2] See http://www.delhimetrorail.com/press_reldetails.aspx?id=C0KYrggV5Fslld

charges are on average about 50 times lower than those of most developed countries', thus a revision of the same is recommended in the face of growing vehicular traffic;

- Levy of congestion charges and green taxes on motor vehicles. The recent environmental compensation charge on commercial vehicles entering Delhi is a case in point. An extra charge of Rs. 700 is to be levied on light duty vehicles and vehicles with 2 axles (taxis and small trucks) and Rs. 1,300 would be charged for those vehicles with three axles and above (large truck-trailers) starting from 1st November 2015 to 29th February 2016 on an experimental basis[3]. Tamil Nadu could introduce similar charges for commercial vehicles entering the state; and
- Similarly green motor vehicle tax to discourage use of older vehicles (and thus reduce pressure on the environment), and congestion tax in selected cities (for specific locations and for specified hours) to address the twin issues of traffic management and environmental management could be considered by the state.

[3] See http://indianexpress.com/article/cities/delhi/vehicles-entering-delhi-to-pay-environment-charge-from-november-supreme-court/

Chapter 1: Introduction

The role of government in an 'ideal' world is minimal. For instance, the three fundamental questions about resource allocation, namely, who should decide, whose values count and who should pay, have clear answers in a democratic, capitalistic society operating in a risk-free environment. The individuals and corporate decision makers decide and pay for themselves, making their own values as the basis for decision. The government merely establishes the property rights and enforces them.

However, the role of government becomes larger if one moves away from this 'ideal' world. Characteristics of physical risks – uncertainty, significant consequences, and externalities, recreate a significant role for government intervention. Risk management thus presents a dilemma: challenging circumstances undermine many of the justifications for self-interested decentralized choice, but when one departs from this norm; both legitimacy and efficiency are undermined.

In several sources of risks generated by human actions the role of government intervention is rather obvious. Lifestyle choices such as excess drinking, smoking and failing to eat a nutritious diet, call for Government intervention in the form of say, providing nutrition information, nutrient supplement programs (such as ICDS and Mid-day meal schemes in India), punish public intoxication, and insist on warning labels on cigarette packages. Similarly, individuals make choices to work in riskier jobs, typically expecting certain economic gains (say, higher salary associated with riskier jobs). While such trade-offs are part of decision making by rational individuals, the rationality of trading risk for resources is often called into question. Government intervention in such circumstances includes creation of jobs, social security, and other safety regulations. The other sources of risk are externalities – examples include pollution emitted by a firm posing health risk to people living in surrounding area, and unsustainable use of resources such as water leading to environmental degradation and subsequent economic impacts. These are the most obvious candidates for government intervention.

Economic growth plays a crucial role for socio-economic development. However, economic development and environmental sustainability are not supplementary to each other. Sustained development is elusive without sustainable environment, especially for developing countries like India where a large section of the society depends on natural resources for livelihood, directly or indirectly (Dasgupta, 2001). Unlike developed countries, developing

countries do not have adequate financial resources to tackle the problem of natural resource depletion or degradation. Hence it is imperative that developing countries should protect their natural resources, rather than searching for solutions after depletion and degradation. The natural resource degradation, if not checked, will result in large-scale poverty and destitution, and can hamper the very process of socio-economic development of the populace (Agarwal, 1995; Nadkarni, 2000).

Tamil Nadu is at the crossroads in terms of sustainable development. On the one hand the state has registered impressive economic growth along with significant progress in human development in recent years. It is endowed with rich biodiversity that is protected and conserved through a network of five national parks, twenty wildlife sanctuaries and two biosphere reserves. On the other hand the state has the highest level of urbanization in India bringing with it a plethora of associated environmental problems. High level of industrialization has also brought to the forefront the pollution concerns. A long coast line with dense population will always put the region in a vulnerable position with respect to natural hazards and the Tsunami havoc in 2004 highlighted this amply. Thus, natural and anthropogenic factors are placing the environment of Tamil Nadu in a precarious position thereby threatening sustainable development.

How does one take stock of the environment of a region, so that 'effective' actions could be initiated? The anthropogenic activities causing environmental degradation are often legitimate economic activities, and their impacts can only be ascertained after a time lag. Moreover the fact that the environmental goods are non-marketed in nature makes the valuation extremely difficult. The 'effective' interventions should ideally be chosen by appropriately weighing the costs of intervention with the benefits of avoided environmental degradation. Given the large gestation periods associated with such detailed analysis, studies aimed at providing policy insights often adopt an indicator based approach to identify the 'hot spot' areas within a region.

Several recent studies used pressure-state-impact-response (PSIR) framework to analyse the state of the environment of a region. In the PSIR framework, (a) pressure indicators as observed now point to future deterioration and reflect historic (non) responses undertaken; (b) state indicators as observed now point to future likely impacts and reflect historic pressures; (c) impact indicators as observed now point to responses needed and reflect historic state of affairs; and (d) response indicators as observed now point to likely changes in future pressures, restoration of state and amelioration of impacts. Some studies

also add an additional set of indicators under the head 'driver' and analyze the state of the environment using driver-pressure-state-impact-response (DPSIR) framework.

Most state governments in India have also used, and continue to use, the PSIR framework while preparing State of Environment (SoE) reports. Some of the recent examples include GoI (2009), GoNCTD (2010), and EMPRI (2012). In Tamil Nadu the Department of Environment, Government of Tamil Nadu has made an attempt to use the PSIR framework to prepare state of environment report in mid 2000s (SoERTN, 2006). The present report attempts to build upon the earlier State of Environment reports (1999, 2001, 2006 and 2009) to develop a present status report of the state of environment in Tamil Nadu.

The report is structured as follows: The reminder of this chapter provides a brief profile of Tamil Nadu covering geographic, demographic, economic, industrial, infrastructural and ecological profile of the state. The chapter also provides a brief review of literature related to State of Environment Reports in India and elsewhere and gives a sketch of the approach followed in this report for assessing the state of environment in Tamil Nadu. Chapters 2 to 13 cover various aspects of Tamil Nadu's environment including forests and wildlife, biodiversity, land degradation, air pollution, water pollution, noise pollution, and waste management. A few chapters focus on cross-cutting issues and these include agriculture, irrigation, energy, coastal and marine ecology, and plant, animal and human health. Chapter 14 provides an overview of the environmental hotspots in Tamil Nadu. The last chapter provides policy suggestions and concluding comments.

1.1 Geographic Profile of Tamil Nadu

Tamil Nadu is situated on the south eastern side of the India Peninsula. It is bounded on the east by the Bay of Bengal, in the south by the Indian Ocean, in the west by the States of Kerala and Karnataka and in the north by Karnataka and Andhra Pradesh. The state of Tamil Nadu is the Southernmost state located between 8^{o} 5' and 13º 35' N latitude and 76^{o} 15' and 80^{o} 20' E longitudes. Tamil Nadu is bounded on the North by Andhra Pradesh and Karnataka, on the west by Kerala, on the East by the Bay of Bengal and on the south by Indian Ocean. Tamil Nadu has an area of 1,30,058 sq. km and is the eleventh largest state in India. Administratively the state is divided into 32 districts and 385 blocks. With a coastline of 1076 km, Tamil Nadu is one of the important coastal states of India. The state can be divided into two natural zones – coastal plains and hilly areas, with temperatures ranging between 21 to 36 degrees and 10 to 25 degrees Centigrade, respectively.

The north-western, western and southern parts of the state have hilly terrain and have rich vegetation. The eastern coastal parts of the state are fertile for cultivation, whereas the northern parts of the state are a mix of hills and plains. The state is heavily dependent on monsoon rains, and monsoon failures typically result in acute water shortage and drought conditions. The state receives rains through both the North East and the South West monsoons, with relative contributions of 48 and 32 per cent respectively in the normal annual rainfall of about 908 mm.

Tamil Nadu supports 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 broadleaf forests and then to the beaches, estuaries, salt marshes, mangroves, and coral reefs of the Bay of Bengal. There are about 2000 species of wildlife that are native to Tamil Nadu.

1.2 Demographic Profile of Tamil Nadu

With a population of about 72.14 million (Census, 2011a), Tamil Nadu accounts for close to 6 per cent of India's population. Tamil Nadu registered an increase in its decadal growth rate from 11.63 per cent during 1991-2001 to 15.60 per cent during 2001-2011, which is however lower than the all India values. Tamil Nadu is the sixth most densely populated state in India as per both 2001 and 2011 Census, with a population density of 480 and 555 persons per square kilometre, respectively. Tamil Nadu improved its performance with regard to child sex ratio (0 to 6 years) during 2001-2011 and fares better than all India sex ratio with 943 females to 1000 males. However, its child sex ratio is lower than its neighbouring southern states of Karnataka and Kerala. As per 2011 Census, the state has recorded a perfect balance in its sex ratio for the population aged 7 years and above. Overall, Tamil Nadu has improved its sex ratio from 987 to 996 during 2001-2011, and stood well above the national average.

Among the larger states, Tamil Nadu stands as the most urbanized state with about 48.40 per cent of its population in 2011 residing in the urban areas. The Chennai city has about 4.65 million people, whereas the Chennai metropolitan area has a population of about 8.65 million as per 2011 Census. While the Chennai Corporation area is about 426 square kilometres, the area of the metropolitan region is almost seven times more at 1189 square kilometres. The Chennai metropolitan region alone accounts for 25 per cent of the urban population and 12 per cent of the total population of Tamil Nadu. A comparison of the basic

and essential demographic statistics of Tamil Nadu with that of the All India is presented in Table 1.1.

Tamil Nadu has also done well in terms of human development indicators. It ranks fourth in terms of literacy rate and female literacy in 2011 and third in infant mortality rate (among the large Indian states). It also ranks fourth in life expectancy at birth. Tamil Nadu has improved its Human Development Index from 0.359 in 1983 to 0.633 in 2011-12 and has also improved its rank among the large Indian states from 11 in 1983 to 4 in 2011-12 (Mukherjee et al., 2014).

Table 1.1: Vital Statistics – Comparison of Tamil Nadu with India

Details	Tamil Nadu		India	
	Rural	**Urban**	**Rural**	**Urban**
Geographic Area (km^2)	130058		3287469	
Population (2011; million)	37.22	34.92	833.74	377.10
Decadal Growth Rate, 2001-2011 (%)	15.60		17.70	
Sex Ratio (per 1000 males)	993	1000	949	929
Total Fertility Rate (births per woman) (2009)	1.8	1.7	2.9	2.0
Life Expectancy at Birth (years) (2002-2006)	64.5	69.6	62.1	68.8
Average Land Holding Size (ha) 1970-71: 2010-11:	 1.45 0.80		 2.28 1.16	
Percentage of Population below Poverty Line (2009-10)	21.2	12.8	33.8	20.9

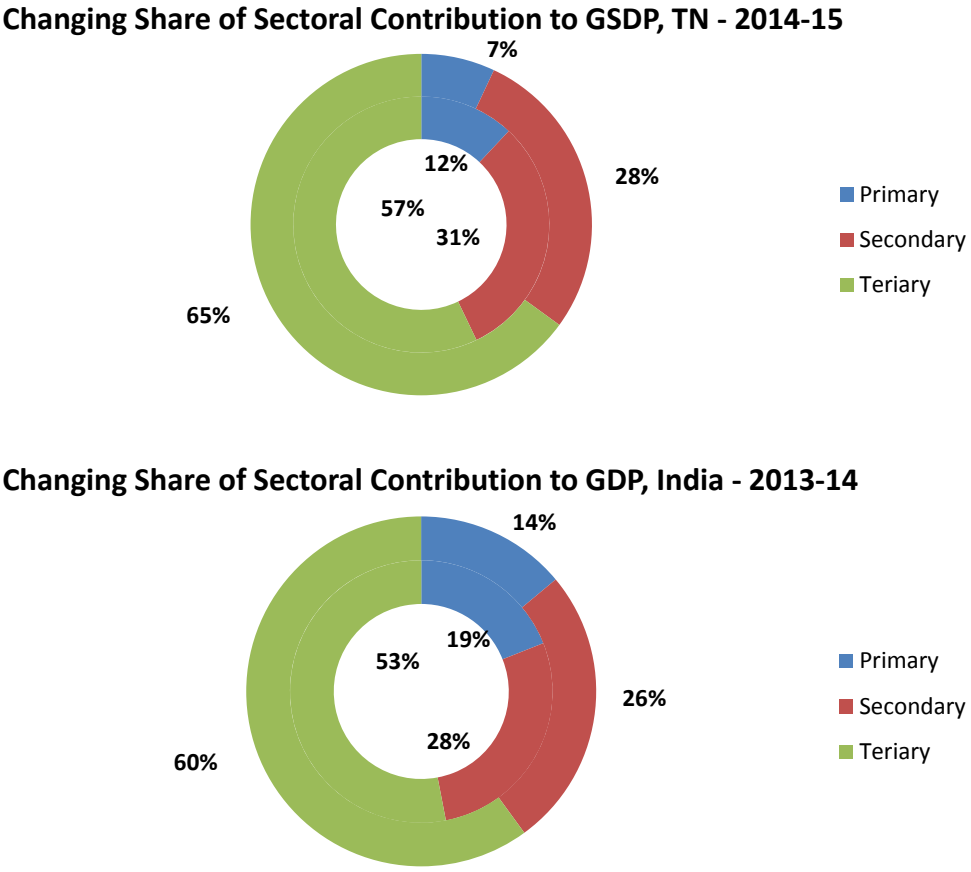
Source: Census (2011a); NABARD (2014); GoI (2012).

1.3 Economic Profile of Tamil Nadu

1.3.1 *Structure of Gross State Domestic Product*

Tamil Nadu, one of the comparatively developed states in the country, ranks first in credit deposit ratio, second in competitiveness index, third in industrial development and fourth in terms of per capita income among the major Indian states. Its gross state domestic product (GSDP) comes largely from the non-agricultural sector. Like in many other Indian States, the structure of GSDP in Tamil Nadu has been shifting away from agriculture towards non-agriculture, particularly services. The share of primary sector in total GSDP (in 1999-2000 prices) of Tamil Nadu in 1993-94 was about 23 per cent and the shares of secondary and tertiary sectors were 33.7 and 41.5 per cent respectively. The share of primary declined to about 12 per cent in 2004-05 (at 2004-05 prices) and further to 7 per cent in 2014-15. During

2004-05 to 2014-15, the share of secondary sector declined from 30.9 per cent to 28 per cent and whereas the contribution of tertiary sector has increased from 57.2 per cent to 65 per cent. At all India level too, the share primary in GDP factor cost declined from 19.03 per cent in 2004-05 to 13.94 per cent in 2013-14. The share of secondary sector also declined from27.93 per cent in 2004-05 to 26.13 per cent in 2013-14. While the share of tertiary sector increased from 53.05 per cent to 59.93 per cent during 2013-14 (see Figure 1.1).



Note: The inner circle shows sectoral shares in 2004-05 and the outer circle shows sectoral shares in 2014-15 (AE) for TN and 2013-14 (P) for India.
Source: CSO, GoI; www.planningcommission.nic.in/data/datatable/data_2312/DatabookDec2014%202.pdf

Figure 1.1: Sectoral Contribution to GSDP and GDP – Tamil Nadu and India

Comparing the share of workforce in different sectors with those in GSDP, it can be noted that the primary sector has a share in employment (43.8 per cent in 2007-08) that is far exceeding its share in output (11.85 per cent in 2007-08). Correspondingly, the services sector employs far less than its share in GSDP. It is only the secondary sector that contributes to a share in employment at 28.7 per cent in 2007-08 and is comparable with its share in GSDP at 30 per cent. Further, the growth rates in agriculture employment during 1993-94 to

1999-2000, 1999-2000 to 2004-05 and 2004-05 to 2007-08 were negative. Correspondingly, shares of other sectors had gone up. The employment pattern indicates that there will be a growing number of job-seekers moving towards the non-agricultural sectors and urban areas, putting pressure on the urban services and urban infrastructure.

1.3.2 *Sectoral Growth Pattern*

Table 1.2 shows the sectoral growth pattern during 2005-06 to 2014-15. In 2007-08, 2008-09, and 2012-13 growth rates of the primary sector and agriculture have been negative due to bad monsoon. The growth rates of manufacturing and tertiary sectors also declined significantly in those years due to global slowdown. As a result, the overall GSDP growth also declined significantly.

Table 1.2: Annual Growth Rates: GSDP and GDPfc at 2004-05 Prices (per cent)

Sectors	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15 (AE)
Tamil Nadu										
Primary *of which*	13.2	13.2	-4.4	-2.3	6.3	7.5	9.9	-11.1	7.3	4.9
Agriculture	11.5	15.4	-4.7	-2.7	6.6	7.7	11.0	-13.0	8.2	4.7
Secondary *of which*	14.1	13.4	3.9	-2.1	20.9	15.3	4.1	2.1	3.1	3.6
Manufacture	15.1	18.7	0.6	-1.3	29.2	12.3	1.4	1.1	4.6	2.6
Construction	16.2	4.4	18.6	5.3	5.2	22.5	9.2	-2.2	1.2	5.8
Tertiary *of which*	14.0	16.6	9.3	10.6	6.9	12.8	8.7	6.0	9.3	9.2
Transport, Storage & Communication	12.4	13.6	9.3	15.5	13.8	14.1	7.5	4.4	6.7	5.7
Trade, Hotels and Restaurants	16.3	20.6	4.3	3.7	4.5	13.2	7.7	2.8	7.3	7.6
Real Estate, Ownership of Dwellings	15.2	16.5	16.7	13.4	6.8	10.0	14.2	12.8	14.9	16.4
GSDP	13.9	15.2	6.1	5.4	10.8	13.1	7.34	3.4	7.3	7.2
India										
Primary *of which*	5.1	4.2	5.8	0.1	0.8	8.6	5.0	1.4	4.7	3.8
Agriculture	5.5	4.1	6.3	-0.3	0.4	9.5	5.3	0.9	4.9	
Secondary *of which*	9.7	12.2	9.7	4.4	9.2	7.5	7.8	1.0	0.3	
Manufacture	10.1	14.3	10.3	4.3	11.3	8.9	7.4	1.1	-0.7	3.5
Construction	12.8	10.3	10.3	5.3	6.6	5.7	10.8	1.1	1.7	4.8
Tertiary *of which*	10.9	10.1	12.5	10.0	10.5	9.7	6.6	6.9	7.0	
Transport, Storage & Communication	11.8	12.6	10.9	10.8	14.7	12.6	9.4	6.0	4.7	2.8
Trade, Hotels & Restaurant	12.0	11.6	10.1	5.7	7.9	11.9	1.2	4.4	2.7	
GDP at factor cost	9.5	9.6	9.3	6.7	8.6	8.9	6.7	4.5	4.7	5.7

Note: AE - Advanced Estimate. Source: CSO, GoI; available at - www.mospi.nic.in/Mospi_New/upload/sdp_2004_05/GSDPNSDPhindiexcel2015/GSDP_Tamilnadu.xls; and www.planningcommission.nic.in/data/datatable/data_2312/DatabookDec2014%202.pdf

In 2009-10, the growth rates of agriculture and manufacturing improved. After that manufacturing growth declined significantly due to global slowdown again (due to Euro crisis) and power supply. It is noted that among the services, the sector comprising the trade, hotels and restaurant registered a slow pace of growth in the recent years. This may be due to the impact of global slowdown. Overall, after 2006-07, agriculture, manufacture and the sector comprising the trade, hotels and restaurant registered a slow pace of growth except 2012-13.

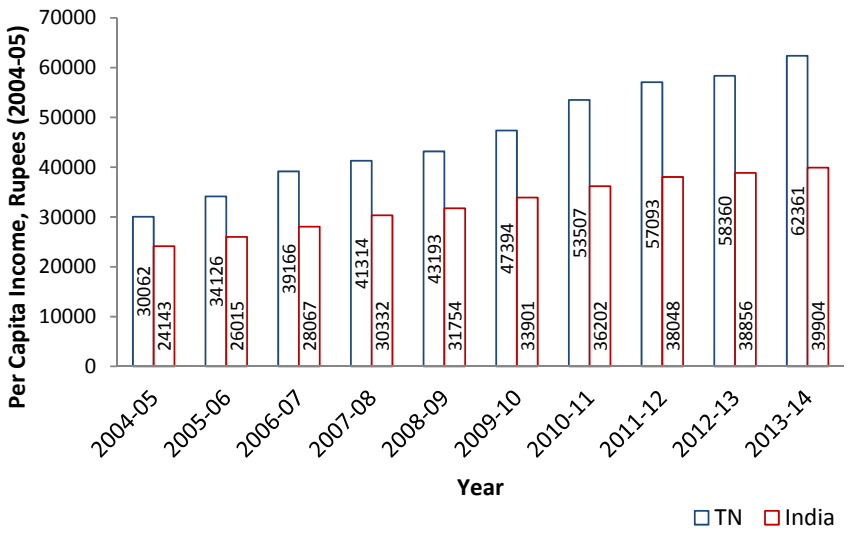
Comparing the growth performance Tamil Nadu (at constant prices) with growth of the country during 2000-01 to 2014-15, three features stand out: (a) Tamil Nadu growth is highly vulnerable to external shocks in recent years; (b) there is a greater volatility in Tamil Nadu's growth rate as compared to the GDP growth rate; and (c) GSDP growth in Tamil Nadu roughly follows the path of GDP growth. When GDP rises, the GSDP of Tamil Nadu rises faster and when GDP falls, it declines even faster. Overall, during 2005-06 to 2014-15, Tamil Nadu economy grew at an average rate of 8.9per cent while the Indian economy during 2005-06 to 2013-14 grew at 7.4 per cent. The market size as indicated by the Tamil Nadu's share of GSDP in India's GDP increased from 7.37 of GDP in 2004-05 to 8.37 per cent in 2013-14. Then it declined to 7.7 in 2008-09 as a result of global slowdown and then started increasing and reached 8.37 per cent level in 2013-14 (Table 1.3).

Table 1.3: Tamil Nadu's Share of GDP (at 2004-05 prices)

Details	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14
GSDP – TN	219003	249567	287530	305157	321793	356632	403416	433238	447944	480618
GDP – India	2971464	3253073	3564364	3896636	4158676	4516071	4918533	5247530	5482111	5741791
Share of TN (%)	7.37	7.67	8.07	7.83	7.70	7.89	8.20	8.26	8.16	8.37

Source: As in Table 1.2.

During 2005-06 to 2013-14, the average growth of per capita income of Tamil Nadu in 2004-05 prices (measured in Net State Domestic Product at constant) was 8.52 per cent and that of all India was 5.76 per cent. During this period, the per capita income of the state was always higher than that of the nation (Figure 1.2). In 2013-14, the per capita income (in 2004-05 prices) of Tamil Nadu was Rs. 62,361 per annum while the per capita income the country was Rs. 39,904 per annum.

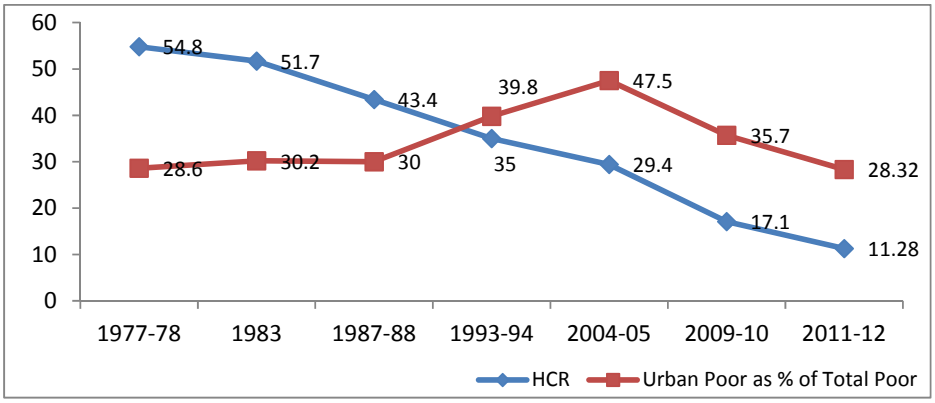


Source: CSO, GoI; www.planningcommission.nic.in/data/datatable/data_2312/comp_data2312.pdf

Figure 1.2: Comparison of Per Capita Income – Tamil Nadu and India

1.3.3 *Poverty in Tamil Nadu*

Tamil Nadu has been very successful in reducing poverty. During the period 1973-74 to 2011-12, the number of total poor decreased from 2.4 crore to nearly 0.83 crore. However, all of this reduction in the number of poor came from rural areas. The number of urban poor actually increased over time in absolute terms reaching a peak of 80.4 lakh in 1993-94. After 1993-94, there was a reduction in the number of urban poor but even in 2009-10 the absolute number of urban poor was 43.5 lakh (see Figure 1.3).



Source: National Sample Survey Organisation, Government of India. See www.mail.mospi.gov.in.

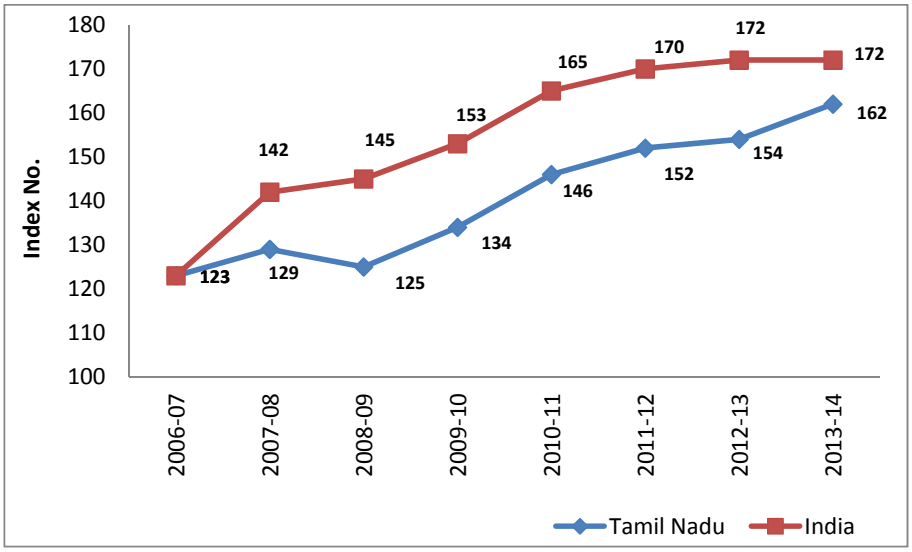
Figure 1.3: Profile of Poor in Tamil Nadu

The share of urban poor in total poor increased significantly from 30 per cent in 1987-88 to 47.5 per cent in 2004-05, the reason may be largely due to the migration of poor from rural to urban areas and subsequently declining to 28.32 per cent in 2011-12. Since comparing the poverty estimates from different years is contested, these Figures should be treated as indicative.

Three key features of the Tamil Nadu economy are (i) growing share of services sector, (ii) volatility of its GSDP and its vulnerability to global shocks; and (iii) growing urbanization and urbanization of poverty. The central challenge is to absorb population migrating from rural to urban areas into productive activities by devoting much larger resources to education and ensuing high, sustained and inclusive growth.

1.4 Industrial Profile of Tamil Nadu

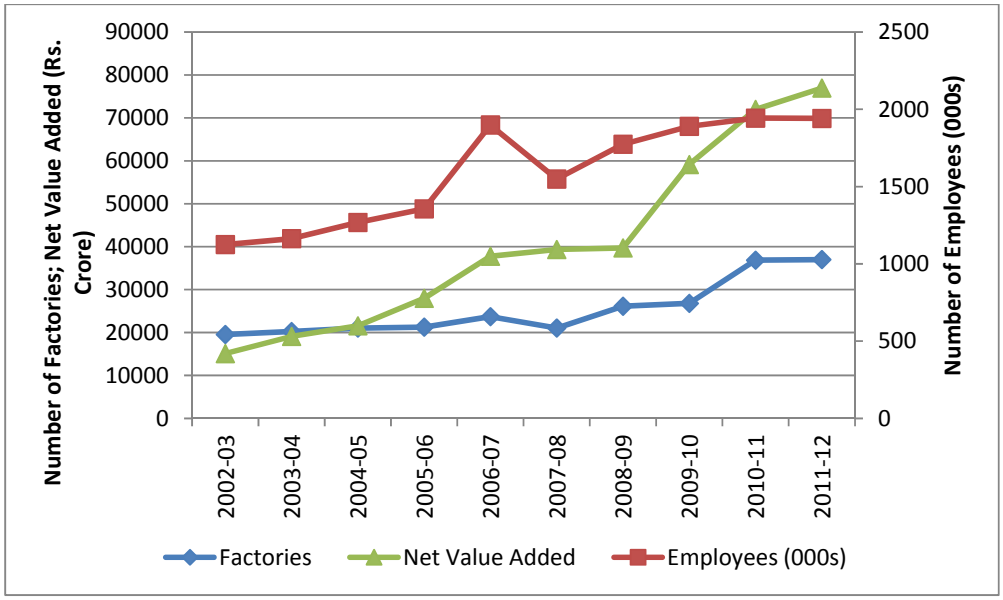
Industrial activity in Tamil Nadu has traditionally been among the top in India. Five main industrial complexes having chemical, petro-chemical and other industries in Tamil Nadu are: Manali/Ennore, Ranipet, Cuddalore, Mettur and Tuticorin. Figure 1.4 shows the index of industrial production in Tamil Nadu and all India during 2006-07 to 2013-14 (based on base year 2004-05). Over the past four years the trend and rate of on industrial production have been similar in Tamil Nadu and India.



Source: DEAR (2013-14).

Figure 1.4: Index of Industrial Production in Tamil Nadu and India (Base Year= 2004-05)

Figure 1.5 shows the number of factories, industrial employees and net value added from industrial sector in Tamil Nadu over the period 2002 to 2014. More than 3000 industrial units in Tamil Nadu have been classified under the highly polluting or 'red' category. The total effluent generated is about 6 lakh litres per day. Of which, large industries generate more than 5 lakh litres (85 per cent). About 400 units discharge directly into the rivers. Key features and environmental challenges posed some of the important industries are discussed below.



Source: DoES (2014).

Figure 1.5: Key Features of Industries in Tamil Nadu

1.4.1 *Cement*

In the non-metallic mineral segment, Tamil Nadu is the third largest producer of cement in India with its share of 14.08 per cent of annual installed capacity and 11.65 per cent of cement production of the nation (in 2011-12). Tamil Nadu has 16 major plants and 4 mini plants, with an annual installed capacity of 34.38 million tons. In 2008-09, the industry as a whole consumed 35 million tonnes of fly-ash and 7.5 million tonnes of slag. According to the Ministry of Commerce and Industry a continuous increase in the production of blended cement is expected to reduce the problem of waste disposal, improve energy efficiency and reduce carbon footprint. Recently the cement industry has started consuming 75 per cent of the fly ash recycled in the country, a hazardous waste posing problems of disposal by thermal

power plants. Similarly, the cement industry has also helped in providing a clean environment by consuming blast furnace slag, which also poses a problem of disposal.[1]

1.4.2 *Thermal Power Plants*

Thermal power plants are among the most pollution intensive industries. There are nineteen coal based thermal power stations in the state. Table 1.4 shows the level and intensity of emissions from the power plants owned by TANGEDCO. Wide divergence exists among these plants, indicating significant potential for efficiency improvements.

Table 1.4: Thermal Power Plant Emissions in Tamil Nadu

Emissions	Ennore	Mettur	North Chennai	Tuticorn
CO_2 Emission per day (Tons)	4282	26242	32879	18792
CO_2 Emission (Kg / KWH)	1.22333	0.759317	0.74861	0.745714

Source: TANGEDCO (personal communication through ENVIS Centre, Chennai).

1.4.3 *Leather*

Presently, Tamil Nadu accounts for 70 per cent of tanning capacity of India and meets 6 per cent of global leather requirement. The state has over 9000 registered small and medium firms in the leather sector, about 70 large scale firms and about 40 composite firms. Most of them are concentrated in a handful of locations dominated by the Palar river basin in Vellore district and the Cauvery river basin. Spatially, the industry is marked by distinct agglomerations near river basins—a feature that adds to the negative externalities associated with environmentally damaging effects of effluents generated by the industry.

Nearly 800 tanneries are located in Vellore, Kancheepuram, Thiruvallur, Trichy, Dindigul and Erode districts. The effluents have caused serious problems in the Palar basin. Loss of Ecology Authority, Government of India analyzed the impact of tannery pollution on agricultural land and identified about thirty six thousand individuals for paying compensation to the tune of Rs. 35 crore by the tanneries.

1.4.4 *Textiles*

Textile mills in Tamil Nadu are predominantly spinning oriented and provide mass employment. Of 3466 large, medium and small spinning mills in India, 2019 mills (58.2per cent) are located in Tamil Nadu and provide employment to 2.67 lakh persons (see Figure

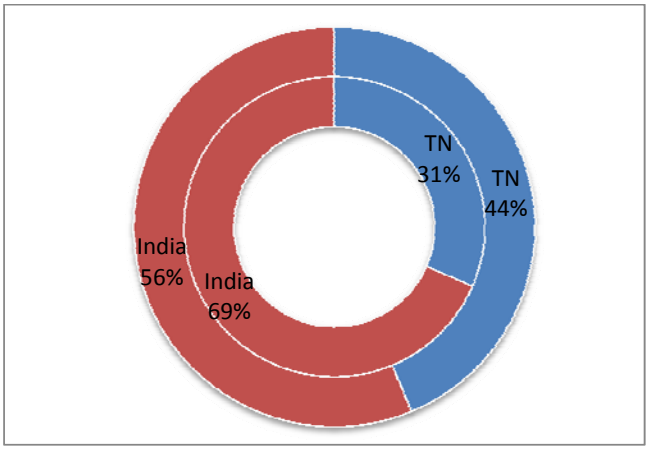
[1]Based on 95th report on Performance of cement industry, Rajya Sabha, February 2011, www.rajyasabha.nic.in.

1.6) . Tamil Nadu is also a major knitwear centre in India with more than 9000 small scale units, contributing to 56 per cent of knitwear exports from India.

There are large numbers of textile bleaching and dyeing processing units in Tiruppur, Erode, Karur and Namakkal districts which discharged their effluents into Noyyal, Amaravathy, and other water bodies. In view of continuous action taken by the TNPCB and on strict Court directives, these units have provided ETP/CETP with Zero Liquid Discharge (ZLD), consisting of Reverse Osmosis (RO) Plant with Reject Management System (RMS). The RO permeate is reused in the process, salt recovered and final rejects into Solar Evaporation Pan. Now none of the units are permitted to operate without above ZLD System.

Due to the continuous discharge of effluents by the processing units for over a decade, the level of pollution has been increased in the Tiruppur area resulted in environmental degradation. From the year 2003 onwards, based on the High Court directives, out of 754 units in Tiruppur, 437 units are treating the effluent in 18 CETPs with ZLD system and 91 units are having individual ETP with ZLD system. Remaining 226 units are under closure.

The strict directives from the High Court, it has become somewhat common practice to use the treated and semi-treated water for irrigation purposes. This has resulted in not only the agricultural output loss but also contamination of ground water that is unsuitable for drinking purposes (Mukherjee and Nelliyat, 2006). Amarnath and Krishnamoorthy (2001) have estimated the loss in yield of paddy and sugarcane crops in Vellore district and attributed more than 90 per cent of these losses to water pollution.



Note: Inner circle represents organized spinning mills; and the outer circle shows small scale spinning mills.
Source: DoES (2014).

Figure 1.6: Spinning Mills in Tamil Nadu and India: 2012-13

1.4.5 *Paper*

The Government of Tamil Nadu established the Tamil Nadu Newsprint and Papers Limited (TNPL) in 1979. The TNPL has emerged as the largest paper mill in India in a single location and the second largest in terms of paper production in the country. To convert some of the waste materials namely, lime sludge and fly ash generated in the process of manufacture of paper into high grade cement, the TNPL is operating a 600 tons per day cement plant.

1.4.6 *Sugar*

Within the food and beverages subgroup, the state contributed to 11 per cent of total sugar production in the country. Bagasse, molasses and press mud are the three by products of sugar industry which cause industrial pollution. The by-product bagasse is used as fuel to generate steam and power for operation of the mill. In the Tamil Nadu cooperative sector, 3 co-generation plants are functioning with an installed capacity of 7.50 MW each. According to the recent industrial policy initiative, it has been decided to set up co-generation plants in 12 sugar mills with a capacity of 183 MW to reduce the power and steam consumption in sugar manufacturing process and also to increase the quantity of power for export to State Grid. To meet with the requirement of 5 per cent blending with petrol, 8 ethanol plants having production capacity of 9.60 crore litres per annum were established in Tamil Nadu.

1.4.7 *Automobiles*

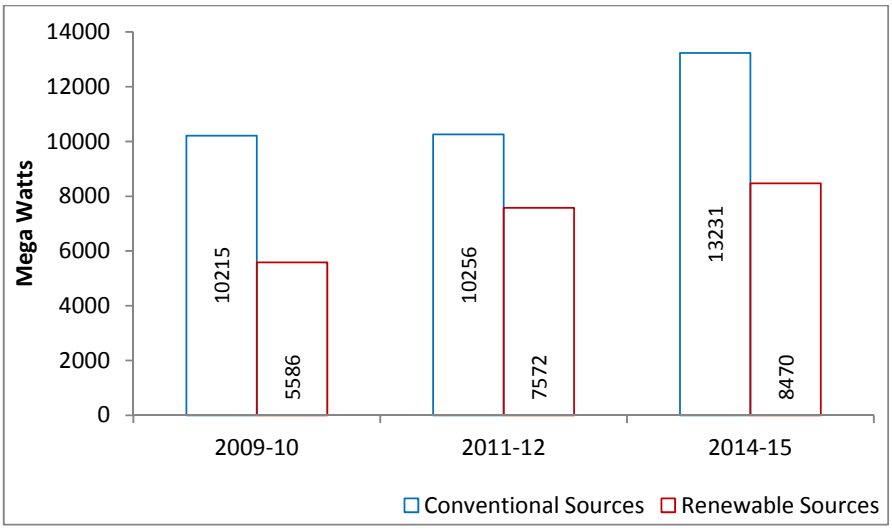
Tamil Nadu accounts for 35 per cent of the total auto component production in India. The industry has now attained a turnover of Rs. 1,65,000 Crores (34 billion USD) and an investment of Rs. 50,000 crore with an estimated share of 25 per cent in the Indian automotive Industry and its contribution to the State's Gross State Domestic Product is 7-8 per cent. Over of Rs. 35,000 Crores of investment is in pipeline. The industry is providing direct and indirect employment to 1.31 Crore people. Automobile industry is highly energy intensive and a major contributor to GHG emissions across its entire value chain from production to consumption. Tamil Nadu has major automobile units like Ford, Hyundai, Ashok Leyland, BMW, Hindustan Motors, Renault etc.

1.5 Profile of Infrastructure in Tamil Nadu

1.5.1 *Power Generation in Tamil Nadu*

Power is one of the key inputs for the overall economic development of any economy. Tamil Nadu ranks sixth in per capita electricity consumption among the major states. The Tamil

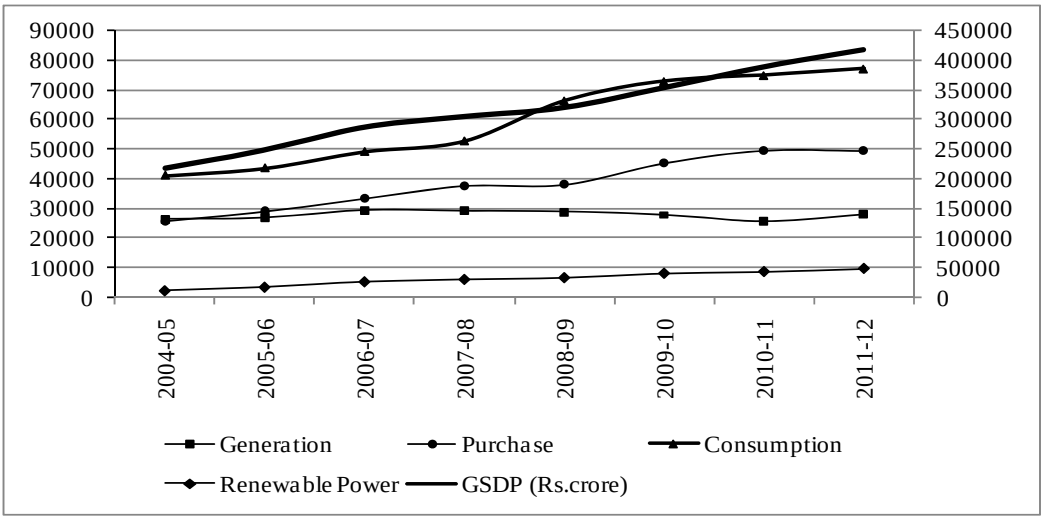
Nadu Electricity Board (TNEB) ranks third in operation size, gauged by generation capacity and volume of energy sold and size of the consumers. The installed power generation capacity (from conventional sources) of the state was 7924 MW in 2001-02 (end of Ninth Plan). It increased to 10098 MW at the end of the Tenth Plan (i.e., 2006-07) and to 13231 MW in 2014-15. The total generation capacity of renewable energy was 8470 MW in 2014-15, representing 39 per cent of the grid capacity (see Figure 1.7).



Source: TANGEDCO (personal communication through ENVIS Centre, Chennai).

Figure 1.7: Installed Capacity in Tamil Nadu – Conventional and Renewable Sources

Tamil Nadu purchases power from central sector projects and independent power producers. The own power generation and power purchases forms the gross power availability in the state. The gross power availability increased from 41764 MU in 2000-01 to 77218 MU in 2011-12. The share of purchases continuously increased during this period from 40 per cent to 64 per cent. However, it may be noted that the net power availability (after selling power to other states) has been less than gross power availability. Therefore, the power produced within the state is still higher than the net purchase (=purchases minus power sold to other states). Figure 1.8 shows the growth of GSDP (in 2004-05 prices), power generation (in MU) from conventional sources, power purchase, and power consumption in Tamil Nadu over the period 2004-05 to 2011-12. Post 2007-08, the power generation started showing declining trend while the consumption and the purchases from other sources started showing increasing trend in Tamil Nadu. However, a significant feature of power generation in Tamil Nadu has been continuously increasing share of electricity produced from renewable sources, especially through wind energy.



Note: The left hand side vertical axis shows generation, consumption, purchase and power from renewable sources in MU; the right hand side vertical axis shows the GSDP in crores of Rupees.

Source: Srivastava et al. (2014).

Figure 1.8: Power Generation and Consumption in Tamil Nadu

1.5.2 *Physical Infrastructure*

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. The district centres are linked through 187 State Highways. Tamil Nadu is one of the first states in India to have 100 per cent metalled road connectivity even in the rural areas. The State Express Transport Corporation, formerly, Thiruvalluvar Transport Corporation was established in September 1975 and provides road transport services within the state. The state had a road density of 147.89 km per 100 sq km of area, as of March 2011.

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 at Chennai, Tiruchirapalli, Madurai and Salem. 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, covers a distance of 25 km and has 21 stations. It is owned by the Southern Railways. The state is presently establishing Metro Rail to augment the transport system in Chennai.

Tamil Nadu has international airports at Chennai, Coimbatore, Madurai and Trichy; it has domestic airports at Chennai, Coimbatore and Madurai. The Chennai International

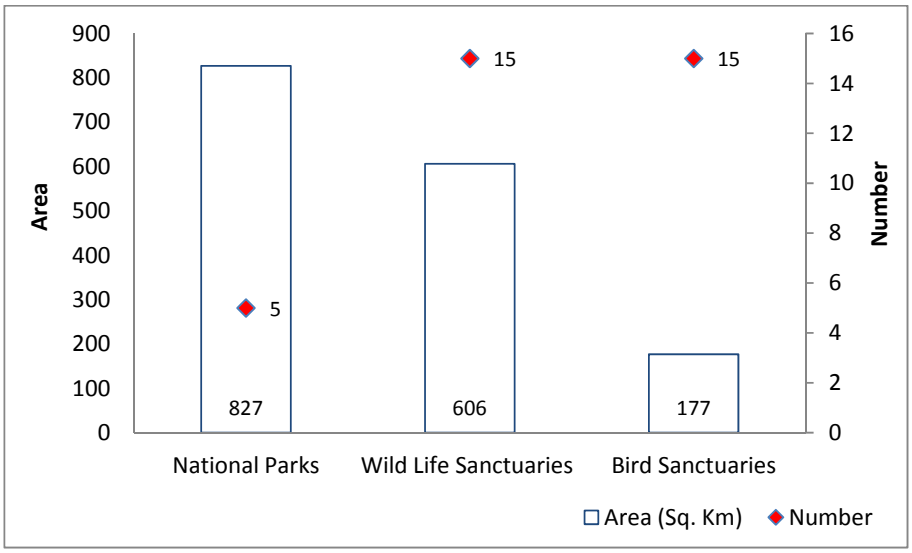
Airport was the first in the country to get ISO 9001-2000 certification. In 2012-13 (April to September), the Chennai Airport recorded passenger traffic of 6.35 million and Trichy Airport reported 424,401 passengers. In 2012-13 (April to September), the Chennai Airport and Trichy Airport handled 59,013 and 3,893 flights, respectively.

Tamil Nadu has three major ports, at Chennai, Ennore and Tuticorin; and 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 tonnes, 10.75 million tonnes, and 18.46 million tonnes, respectively. Together, the three ports accounted for about 18.0 per cent 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 per cent. The Chennai port handles, mainly, container cargo while the Ennore and V O Chidambaranar ports handle coal, ores and other bulk minerals.

1.6 Ecological Profile of Tamil Nadu

Tamil Nadu has 21.25 lakh square kilometres of area under forests as of 2013-14, which accounts of about 16.31per cent of total geographic area of the state. The per capita forest area is about 0.029 hectares. Of the total forest area 85 per cent is under reserved forests category, 9.4 per cent under reserved land category and the rest under unclassified category. In addition the state also has about 3912 hectares of area under teak plantation.

The state has five national parks with 82,751 hectares of area– Guindy National Park, Chennai; Gulf of Mannar Biosphere Reserve and National Park; Indira Gandhi National Park, Anamalai; Mudumalai National Park, The Nilgiris; Mukkurthi National Park, The Nilgiris; Fifteen wild life sanctuaries, and Fifteen bird sanctuaries with 17,666 hectares of area and two conservation reserves with 488 hectares of area as of 2014. Figure 1.9 provides an overview of the national parks, wild life sanctuaries and bird sanctuaries located in Tamil Nadu.



Source: TN Forest Department (personal communication through ENVIS Centre, Chennai).

Figure 1.9: National Parks, Wild Life and Bird Sanctuaries in Tamil Nadu - 2014

1.7 Sate of Environment – Literature and Approach

The state-of-the-environment studies are broadly aimed at understanding the sustainability of the development path pursued by a region. This section provides a brief review of literature associated with conceptualization of sustainable development and its measurement. The section also provides an overview of the approach adopted in this study for assessing the state of the environment in Tamil Nadu.

1.7.1 Sustainable Development – Concept and Measurement

Five broadly classified interpretations of SD can be inferred from its various definitions (Perman *et al.*, 1999). The interpretations are ways to operationalize the definitions of SD, or to bring them into practice. These are discussed below.

First, a sustainable state is one in which utility is non-declining over time. Economists adhere to this conventional way of interpreting the term. Robert M. Solow (1986) justifies this interpretation using the Rawlsian ethics, and defines a society as sustainable if it satisfies the criteria of 'intergenerational equity' – that is if per capita utility for all future generations remain constant. Deriving the necessary and sufficient conditions of the constancy of undiscounted utility of per-capita consumption over time is a difficult task. Hence, economists interpret sustainability as 'constant' consumption over time, as proposed by John Hartwick. More recent literature combines the notion of constant utility and constant consumption - known as the Solow-Hartwick criterion - to interpret SD.

However, the Solow-Hartwick criterion ignores the concept of minimum threshold levels of consumption, that is, it does not require any conditions of how large the non-declining level of consumption should initially be. By implication, an economy can be sustainable if living consumption standards are abysmally low, provided they do not get any worse – a rather perverse interpretation (Perman *et al.*, 1999). Its limitations motivate other interpretations.

In the second interpretation, a sustainable state is one in which resources are managed so as to maintain production opportunities for the future. Sustainability may be defined in terms *maintaining productive or consumption potential* over time. Productive capacity at any point in time depends mainly on the stock of productive (capital) assets available for use. The word 'capital' is used in a very broad sense to include natural capital (e.g., forests, & fisheries), physical capital (e.g., plant, equipment, etc.), human capital (e.g., skills, know-how, etc.), and intellectual capital (e.g., disembodied skills, stock of knowledge etc.). Human-made capital is the sum of physical, human, and intellectual capital. Therefore, maintaining the productive potential of the economy will be achieved if the *composite capital stock is non-declining* over time. This interpretation of SD leads to re-interpretation of 'sustainability' as notions of weak sustainability and strong sustainability.

A third interpretation defines sustainable state as one in which the *natural capital stock is non-declining through time*. Maintaining natural capital is a necessary condition for sustaining the economy's productive potential if natural capital is essential for production and is not substitutable by other components of capital. This interpretation is also limited by the yet unresolved debate on weak versus strong sustainability.

The fourth is a biological interpretation of SD based on renewable resource stocks, e.g., forest. In this sense, a sustainable state is one in which the resources are managed so as to maintain a *sustainable yield* of resource services. A sustainable yield is a steady state in which some stock (e.g., forest) is held at a constant level and delivers a constant flow of resource services (e.g., timber) over time. However, whether it talks about maintaining resource stock or flow of resource services constant, and whether different elements or their weighted aggregates is not clear.

The fifth interpretation arises from the ecologists' interpretation of ecosystem and defines sustainable state as one which satisfies *minimum conditions of ecosystem stability and resilience* through time. Common and Perrings define a system is ecologically sustainable if

it is 'resilient'[2]. The problem with this interpretation is that one cannot know, *ex ante*, if the system would be resilient in the presence of future shocks, but can only be determined *ex post*.

These diverse interpretations are resulted in wide-spread approaches in the literature for measuring sustainable development of a society. These measurements provide an idea whether a particular region/country is on sustainable development path or not. The measurement as such provides basis for intervention and/or assessment of performance.

Measurement of Sustainable Development

Given that a large number of initiatives on measuring sustainable development have used one or the other kind of indicators to proxy the sustainable development, the discussion here focuses on the same and describes the underlying assessment frameworks.

Driving Force-State-Response Framework

The initial set of 134 indicators suggested by Commission on Sustainable Development (CSD) published in 1996 was organized in a driving force, state and response (DSR) framework, which is a variant of pressure-state-response framework. Driving force indicators describe processes or activities that have a positive or a negative impact on sustainable development (for example pollution or school enrolment). State indicators describe the current situation (for example nutritional status of children or land covered by forests), whereas response indicators reflect societal actions aimed at moving towards sustainable development. The first CSD indicators were additionally grouped according to the dimensions of sustainable development—social, economic, environmental as well as institutional, and matched to the relevant chapters of Agenda 21. The revision of the CSD indicators in 2001 discontinued the DSR framework due to variety of reasons including its non-suitability in addressing the complex inter-linkages among issues and ambiguity associated with the classification of indicators. However, several ongoing and recent exercises still employ the broad DSR framework. CDF (2011) is one such example of developing environmental sustainability index for Indian states using driving force-pressure-state-impact-response framework.

[2]An ecosystem is resilient if it retains the organizational structure and functionality following a disturbance.

Issue- or Theme-based Framework

Issue- or theme-based frameworks are the most widely used type of frameworks, especially in official national indicator sets. In these frameworks, indicators are grouped into various different issues relating to sustainable development. The issues or themes are typically determined on the basis of policy relevance. Most countries in all regions of the world that have developed national sustainable development indicators have based them on a thematic framework. This is also true of regional strategies and indicator programmes, such as the indicators used in the Baltic 21 Action Programme and the Sustainable Development Indicators for the European Union. A main reason for the prominence of thematic frameworks is their ability to link indicators to policy processes and targets. This provides a clear and direct message to decision-makers and facilitates both communicating with and raising the awareness of the public. A thematic framework for indicators is also well suited to monitor progress in attaining the objectives and goals stipulated in national sustainable development strategies. It is flexible enough to adjust to new priorities and policy targets over time.

Capital Framework

The frameworks for sustainable development indicators based on this approach vary, but, in general, they all try to identify first what development is, and, second, how development can be made sustainable. This draws attention "to what resources we have at our disposal today, and towards the issue whether we manage these in ways that make it possible to maintain and further develop the resource base over time." Explicit in the capital approach is the notion of substitutability between different types of capital, which is indeed a complex issue. There are clear examples of substitutability—machines for human labour, renewable for non-renewable sources of energy, synthetics for some natural resources. And future technological innovation and human ingenuity may greatly expand the scope. However, there may also be assets that are fundamental and for which no substitution is possible. This could include, for example, a reasonably stable climate or biological diversity. There remain many challenges to using a capital framework. Among them are disagreement about how to express all forms of capital in monetary terms; problems of data availability; questions about substitution; and the integration of intra-generational equity concerns within and across countries. Nonetheless, the concept of using capital as a way to track sustainable development could be a powerful tool for decision-making. To infer whether a country is on the path of sustainable development or

not, Arrow et al. (2010) adopt the concept of comprehensive investment (net addition to the stock of comprehensive wealth, holding the shadow prices constant). This is equivalent to the notion of 'genuine savings' as introduced by Pearce and Atkinson. Genuine savings (S_g) refers to that level of savings, over and above the sum of all the capital deprecations in the economy. Intuitively, if $S_g > 0$ any nation must be adding to its capital base and if $S_g < 0$, then the nation is removed from its capital stock. As it happens, one cannot tell too much from the value of S_g at any point in time as the interest is in the entire consumption path, not just one point on it. However, if S_g is persistently negative then it can be interpreted that things do not look good for sustainability. If S_g is persistently positive, then there is a greater chance that the way the economy is configured is sustainable. An earlier interpretation of sustainable development in this context was by Stavins et al. (2003) wherein an economy is considered sustainable if and only if it is dynamically efficient and the resulting stream of total welfare levels is non-declining over time.

Accounting Framework

The most prominent example in this regard is the System of Integrated Environmental and Economic Accounting (SEEA), pioneered by the United Nations Statistical Commission with the International Monetary Fund, the World Bank, the European Commission and OECD. The SEEA extends national accounting to environmental aspects through a satellite system of accounts. It is, thus, clearly linked to the standard system of national accounts (SNA). The SEEA includes accounts expressed in monetary terms as well as accounts in physical terms. It allows for the construction of a common database from which some of the most common sustainable development indicators in the economic and environmental spheres can be derived in a consistent manner. Several countries are using the SEEA, and it is in the process of being proposed as an international statistical standard. The ongoing efforts of the Ministry of Environment and Forests, Central Statistical Organization, the Planning Commission etc. come under this category.

In addition to the above there have been several efforts to develop aggregate indicators to capture elements of sustainable development. Most aggregate indicators are primarily used for raising public awareness. Rather than offering a comprehensive view of sustainable development, many of these indicators are specifically focused on the environmental dimension of sustainable development and resource management. Examples of such indicators include the Ecological Footprint, the Environmental Sustainability Index

(ESI) and the Environmental Performance Index (EPI). The Ecological Footprint, originally developed by Wackernagel and Rees (1996), translates human resource consumption and waste generation in a country or any other entity into a measure of biological productive land and water and relates it to a measure of biological capacity.

Since a state's long-term sustainability is a combination of the stock (resources that a state is historically endowed with) and flow (environmental services and resource extraction leading to depreciation of the stock), environmental sustainability index (ESI) is constructed as a composite index from 40 key environmental indicators selected based on the Driving Force-Pressure-State-Impact-Response (DPSIR) framework. These 40 indicators capture the present state of the environment (State), depletion and pollution (Pressure), resulting impact on ecosystem and human health (Impact), policy and societal efforts to reduce such impacts and protecting the ecosystem (Response) and the driving forces that affect the environment (Drivers). The 40 indicators can also be grouped into nine thematic sub-indices for interpretation from a policy perspective. The nine sub-indices are: Air Quality and Pollution, Water Quality and Availability, Land Use and Agriculture, Forest and Biodiversity, Waste Management, Energy Management, Health Impact, Population Pressure, and Environmental Budget. CDF (2011) and Esty et al. (2005) are examples of ESI in the Indian and the international contexts. Esty et al. (2005) developed a measure of environmental sustainability and applied it for 146 countries.

The Environmental Performance Index (EPI) developed by the Yale Centre for Environmental Law and Policy and the Centre for International Earth Science Information Network at the Columbia University is based on extensive research over past ten years to arrive a comprehensive indicator of the environmental performance at global level (Emerson *et al*., 2010). While the initial attempts were focused on developing environmental sustainability index, the lack of consensus on defining 'sustainability' has resulted in adoption of 'performance' based approach. The EPI for Indian states was developed by Chandrasekharan et al. (2013), and Balamurugan and Ravichandran (2014) developed environmental sanitation index for Tamil Nadu.

1.7.2 State of Environment of Tamil Nadu – Approach

As a scientific tool to measure environmental performance across the geographical area, ranking on the basis of construction of environmental index has always been an important area of research both for individual researchers (see for example, Rogers et al., 1997;

Adriaanse et al., 1995; Adriaanse, 1993 among others) and various development agencies (WWF, 2002; Jones et al., 2002; RIVM/UNEP, undated). As mentioned above Esty et al. (2005) developed a measure of environmental sustainability and applied it for 146 countries.

As mentioned earlier in this chapter, several state governments in India have prepared State of Environment (SoE) reports by taking stock of a number of indicators representing the health of the environment, impacts of environmental degradation and factors affecting the environment (see, GoI, 2009; GoNCTD, 2010; and EMPRI, 2012). In Tamil Nadu the Department of Environment, Government of Tamil Nadu had prepared and released the state of environment report during 2005 (SoERTN, 2006). The present report attempts to build upon the earlier State of Environment report to develop a present status report of the state of environment in Tamil Nadu. The present study analyzes the state of the environment using driver-pressure-state-impact-response (DPSIR) framework. In general, the 'drivers' are the driving forces behind many of the subsequent activities that extract from and pollute the environment, which are more often than not demographic changes and broad development goals.

The structure of the SoE report is depicted in Figure 1.10 below. In addition to key environmental issues covering forests & wildlife, biodiversity, land degradation, air pollution, water pollution, noise pollution and solid waste, the report also covers several cross-cutting issues concerning environment with focus on sectors such as agriculture and allied sectors, water resources, energy, coastal resources, and human health. To the extent possible all analyses are presented using DPSIR framework. In other words, this implies the identification of indicators reflecting D-P-S-I-R for each sector and environmental issue and the analysis of the same over space and time. For example, the air quality may be analysed with the help of indicators (given in brackets) reflecting: its driver (urban population growth), pressure (density of motor vehicle usage, vehicular growth), state (annual average concentrations of SO_2, NO_2, SPM, RSPM), impact (incidence of acute respiratory diseases such as asthma, bronchitis, COPD etc., incidence of smog leading to low levels of visibility) and response (reduction of sulphur content in diesel, vehicle emission checks, growth in hybrid vehicles, switch to modes of public transportation such as bus, metro, increase in exclusive cycling or walking tracks on roads). An analysis of the data relating to each of the DPSIR indicators would then tell us the overall state of air quality in a particular region and how this has changed over time, i.e. whether improved or deteriorated over time

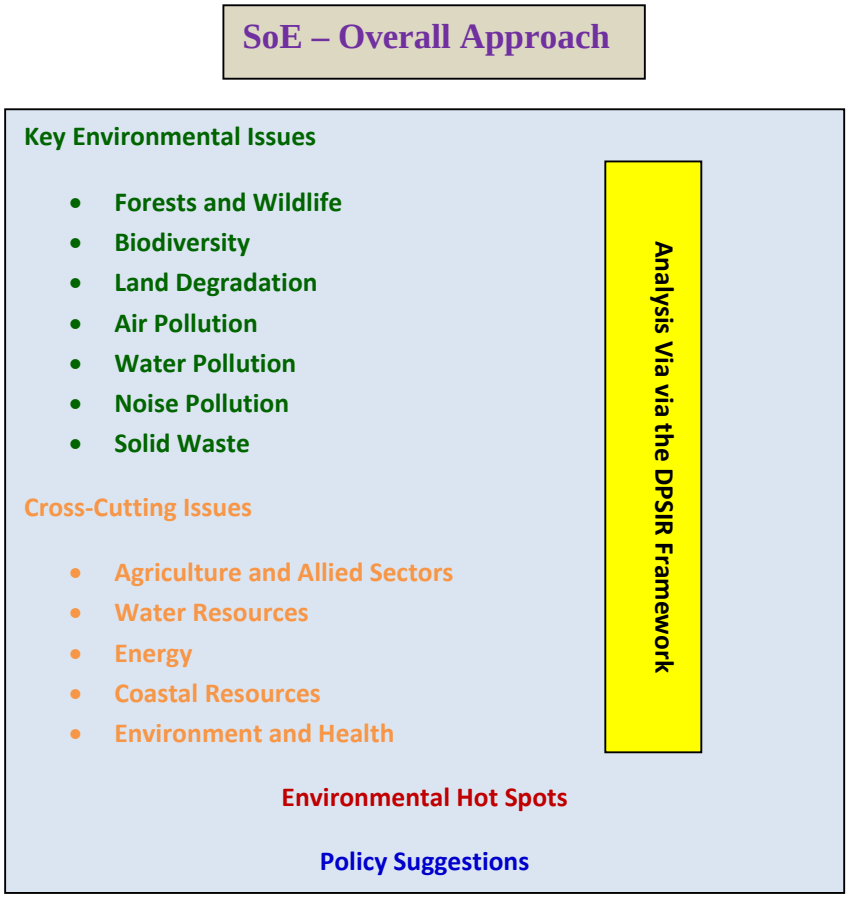


Figure 1.10: State of Environment of Tamil Nadu – Approach

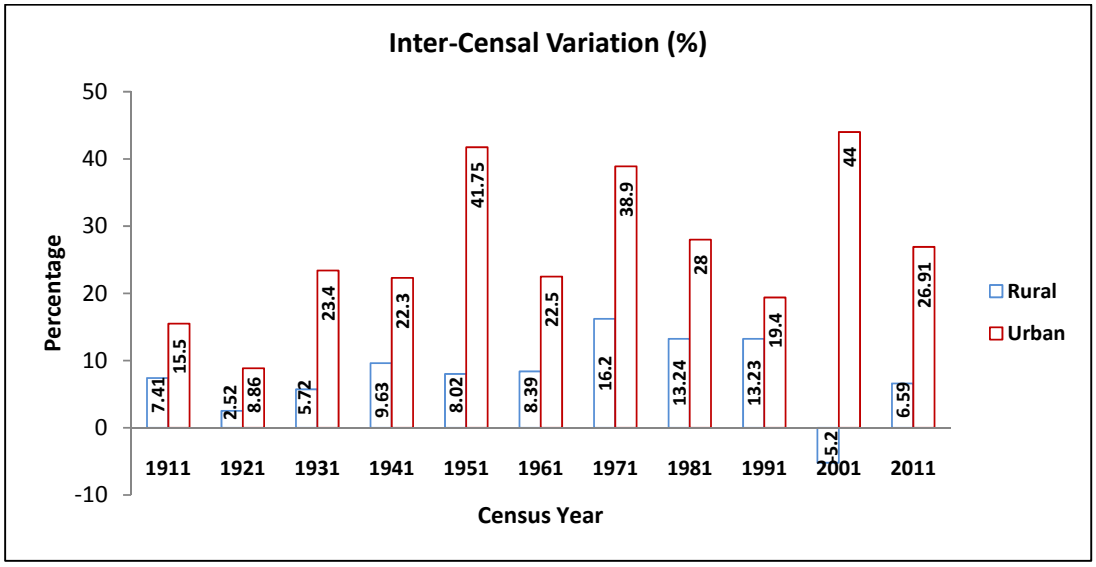
1.7.3 Overall Drivers

Two drivers common to all the sectors discussed in the subsequent chapters are demographic changes and development path adopted by Tamil Nadu. To avoid repeated discussion of these two in each chapter separately, they are discussed here in this section.

Demographic Changes

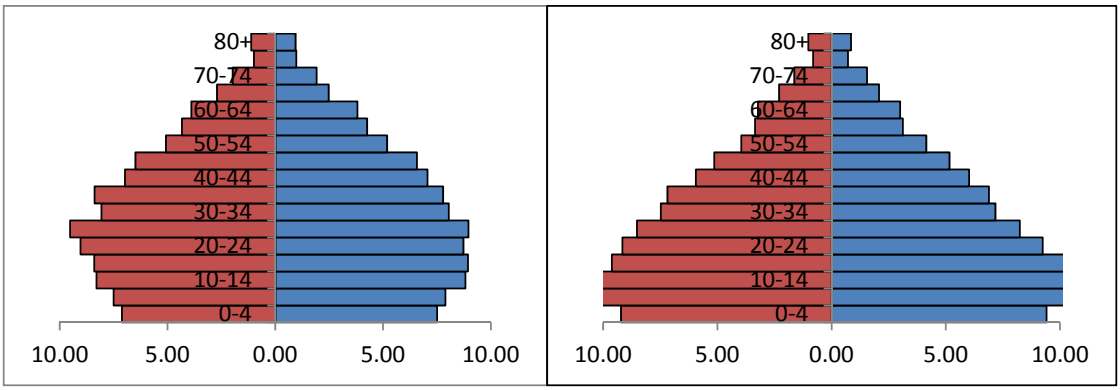
One of the prominent features of the demographic structure of Tamil Nadu is its urbanization trend. As shown in Figure 1.11, the inter-censal variation over the period 1911 to 2011 in Tamil Nadu clearly highlights the dominance of urban population growth over rural population. During the census years of 1951, 1971 and 2001, the urban population grew at a higher rate than the rural population. Tamil Nadu also more working age population compared to all India. The state has relatively larger proportion of male and female population in the age group of 15 to 50 years in comparison to all India (see Figure 1.12). This not only facilitates demographic dividend in the form of more savings, higher investment, and higher economic growth, but also puts more pressure on the environment due

to higher consumption levels associated with the working age population and improving life styles.



Source: Census (2011b).

Figure 1.11: Rural and Urban Population of Tamil Nadu – Decennial Growth



Note: Red – Female; Blue – Male
Source: Census (2011b).

Figure 1.12: Population Pyramid of Tamil Nadu and India – 2011

Development Goals

As the growth in the Eleventh Plan (7.7 per cent) has declined compared to the Tenth Plan (9.7 per cent), the newly elected Government in June 2011 identified the need for formulating a succinct strategy for rejuvenation of economic and social growth and to reclaim the top position. It has also come out with "Vision 2023: Strategic Plan for Infrastructure Development in Tamil Nadu" to identify thrust areas for growth and bottlenecks in such

areas. The Vision 2023 document has identified Ten themes: (i) Economic prosperity, (ii) Inclusive growth, (iii) Health for all, (iv) World class infrastructure, (v) Healthy investment climate, (vi) Innovation hub and knowledge capital of India, (vii) Creating conducive environment for human development, (viii) Nurturing a rich heritage and preserving the ecology, (ix) Protecting against vulnerability and (x) Improving the quality of Institutions and Governance. The details of these themes are given below.

Vision 2023 Themes

1. Tamil Nadu will be amongst India's most economically prosperous states by 2023, achieving a six-fold growth in per capita income (in real terms) over the next 8 years to be on par with the Upper Middle Income countries globally (including Argentina, Brazil, China, Costa Rica, Mauritius, Mexico, South Africa, and Turkey);
2. Tamil Nadu will exhibit a highly inclusive growth pattern – it will largely be a poverty free state with opportunities for gainful and productive employment for all those who seek it, and will provide care for the disadvantaged, vulnerable and the destitute in the state.
3. Tamil Nadu will be India's leading state in social development and will have the highest Human Development Index (HDI) amongst all Indian states.
4. Tamil Nadu will provide the best infrastructure services in India in terms of universal access to Housing, Water & Sanitation, Energy, Transportation, Irrigation, Connectivity, Healthcare, and Education.
5. Tamil Nadu will be one of the top three preferred investment destinations in Asia and the most preferred in India with a reputation for efficiency and competitiveness.
6. Tamil Nadu will be known as the innovation hub and knowledge capital of India, on the strength of world class institutions in various fields and the best human talent.
7. Tamil Nadu will ensure Peace, Security and Prosperity for all citizens and business, enabling free movement and exchange of ideas, people and trade with other Indian states and rest of the world.
8. Tamil Nadu will preserve and care for its ecology and heritage.
9. Tamil Nadu 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. Tamil Nadu will nurture a culture of responsive and transparent Governance that ensures progress, security, and equal opportunity to all stakeholders.

The VISION 2023 document estimates the expenditure on infrastructure creation in Tamil Nadu (by Government and private sector) at 5 per cent of GSDP. As the Twelfth Plan is targeting an infrastructure creation at the all India level at 10 per cent of India's GDP, the VISION 2023 document assumes progressive investment plan. The total investment in infrastructure for the Twelfth Plan period is estimated at Rs. 3.96 lakh crore in VISION 2023 and that for the whole period is estimated at Rs. 15 lakh crore (Table 1.5). Such high investment geared towards manufacturing and infrastructural development will have significant influence on the environment unless appropriate policy initiatives are undertaken to ensure sustainable development.

Table 1.5: Projected Infrastructure Investment in VISION 2023

(Rs. Crore)

Year	**2012-13**	**2013-14**	**2014-15**	**2015-16**	**2016-17**	**2017-18**
Investment	41670	61394	84801	93705	114413	126999
Year	**2018-19**	**2019-20**	**2020-21**	**2021-22**	**2022-23**	**Total**
Investment	147376	164325	191188	213175	237690	**1502129**

Source: Vision Tamil Nadu 2023 (GoTN, 2012).

Chapter 2: Forests and Wildlife

Tamil has pockets of tropical evergreen forest, mangroves along Coromandel Coast, and substantial areas under plain forests in Pudukottai and Trichy districts. On account of the variation in climatic, edaphic and physiographic factors, the forests of Tamil Nadu provide a wide spectrum of variability in terms of structure. Over the past four decades the forest cover in the state has shown significant increase. Watershed protection, biodiversity conservation and carbon sequestration are often mentioned as justification for forest conservation. Many studies highlighted that these environmental services provide greater value than timber and non-timber forest products obtained from forests.

Tamil Nadu also has a rich faunal wealth, considering that it provides habitat for the endangered species like Nilgiri Tahr and also for a variety of other forms of carnivores, herbivores, birds and fishes in the various types of forests and aquatic habitat. The Wild Life Act provides for the setting of national parks and sanctuaries. Tamil Nadu has got a unique record in setting up two biosphere reserves, with a reserve each for terrestrial and aquatic ecosystems. The following sections discuss various pressures acting on the forests and wild life in Tamil Nadu, take stock of the status of the forests and various species of wild life, and provide an overview of the various response strategies.

2.1 Pressures

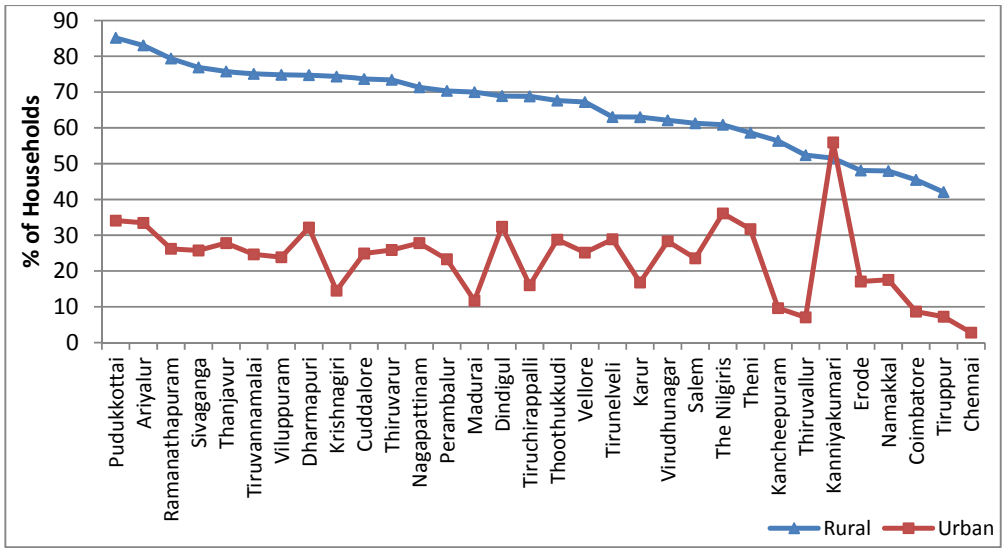
2.1.1 *Forest Produce*

The outturn of major and minor forest produce in Tamil Nadu in 2012-13 was roughly 639 cubic metres of teak wood, 1,045 tonnes of pulpwood (eucalyptus hybrid), 1,240 tonnes of firewood, 28 tonnes of sandalwood (sapwood), 73 tonnes of sandalwood (heartwood), 12,460 tonnes of babul dry, 30 tonnes of cashew nut, 57 tonnes of tamarind and 94,860 tonnes of other minor forest produce (including silk cotton pods) (DoES, 2014). In comparison to the production of major forest produce in Tamil Nadu in 2002-03, production of pulpwood fell by over 40 per cent in 2012-13 and the production of firewood, sandalwood and babul declined in excess of 85 per cent in 2012-13 (Kavi Kumar et al., 2013). Note however the values for 2012-13 are unaudited so caution needs to be exercised in making such comparisons. Having said that Kavi Kumar et al. (2013) note that over the period 2000-01 to 2006-07, all major forest produce exhibited a declining trend except for firewood and babul that recorded an increase. Timber production over this time period also increased significantly (from 194 tonnes in 2000-01 to 6,411 tonnes in 2006-07). As per official

government records, Tamil Nadu Newsprint and Papers Limited (TNPL) is the only forest based industry in Tamil Nadu operating in Villupuram, Coimbatore, Chennai, Trichy and Vellore. In 2011-12, TNPL used a total of 2,673 tonnes of eucalyptus hybrid (pulpwood) in its manufacturing process (DoES, 2014).

2.1.2 *Demand for Firewood*

In rural Tamil Nadu, about 67 per cent of total households use firewood as the primary energy source for cooking. For urban Tamil Nadu, this value is considerably lower at 18 per cent (Census, 2011). Figure 2.1 shows the district-wise percentage of rural/urban households using firewood for cooking.



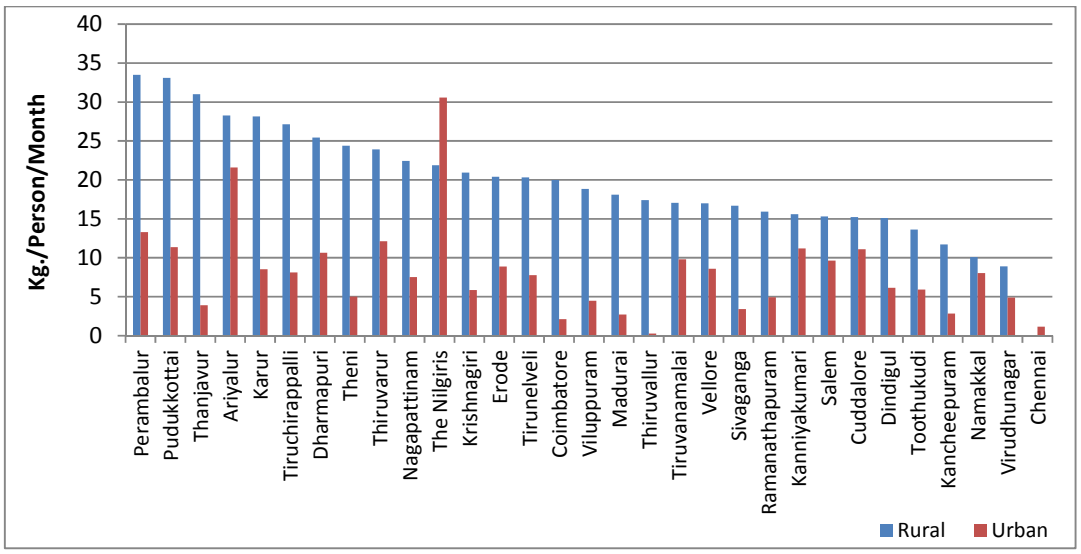
Source: Census (2011).

Figure 2.1: District-Wise Percentage of Rural/Urban Households Using Firewood for Cooking in Tamil Nadu (in 2011)

In all districts, except Kanniyakumari, the percentage of total households using firewood for cooking is higher in the rural sector compared to the urban sector. The percentage of total households using firewood for cooking is in excess of 40 per cent for rural households across all districts, with the same being the highest in Pudukkottai (85 per cent). In the urban sector, the percentage of total households using firewood for cooking is the highest in Kanniyakumari district (56 per cent) followed by the Nilgiris (36 per cent) and Pudikkottai district (34 per cent).

According to 2009-10 unit level National Sample Survey data, the average monthly per capita consumption of firewood in rural and urban Tamil Nadu was 19.3 and 5.3 kilograms per person per month, respectively. The district-wise and sector-wise break-up is

given in Figure 2.2. Peramblur and Pudukkottai had the highest monthly per capita consumption in the rural sector (about 33 kilograms per person per month each), and the Nilgiris and Ariyalur has the highest per capita consumption in the urban sector (31 and 22 kilograms per person per month, respectively) in 2009-10. Thiruvallur district had the lowest per capita consumption in the urban sector, followed by Chennai.



Source: NSSO (2009-10).

Figure 2.2: District-Wise Mean Monthly per Capita Consumption of Firewood by Sector in 2009-10 (in Kg./Person/Month)

2.1.3 *Wood – Demand Supply Gap*

Kavi Kumar et al. (2013) estimated the demand supply gap for timber and fuel wood in Tamil Nadu for the year 2008. The study was based on a comprehensive primary survey carried out with the help of the State Forest Department covering ten districts spread over the seven agro-climatic zones of Tamil Nadu. In all, about 3,500 households and 450 small-scale industrial units and service providers have been surveyed to assess fuel-wood and timber demand.

The overall wood demand in Tamil Nadu for the year 2008 is estimated as 28.5 million cu.m., with fuel-wood demand constituting about 82 per cent of the total demand. Households contribute 77 per cent of the total demand, followed by the industrial sector (16 per cent) and the service sector (6.4 per cent). The timber supply is mainly through trees-outside-forests, followed by farm-forestry, imports and other sources (including transfers from other states). The main source for fuel-wood on the other hand is attributed as 'other sources' indicating that the supply chain of fuel-wood is fairly complex. Trees-outside-forests

are estimated to contribute about 41 per cent of the total fuel-wood supply. Tables 2.1 and 2.2 provide the demand and supply for wood in Tamil Nadu.

With regard to the supply-demand gap, the main cause of concern appears to be the high fuel-wood demand in Tamil Nadu. Kavi Kumar et al. (2013) present a few scenarios of future demand for fuel-wood (for the year 2013) and timber (for the years 2013 and 2018). The total demand for fuel-wood under various scenarios would vary between 15.17 to 23.22 million cu.m. by 2013. Household sector, which presently contributes to about 84.5 per cent of the total fuel-wood demand, continues to dominate with its contribution ranging between 70 to 80 per cent by 2013. The total demand for timber under various scenarios would vary between 5.4 to 6.5 million cu.m. by 2013 and between 5.7 and 7.7 million cu.m. by 2018. The growing gap between demand and supply will put significant pressure on the biodiversity of the state.

Table 2.1: Demand for Wood in Tamil Nadu – 2008 (in 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)

Note: The figures in brackets are percentages. Source: Kavi Kumar et al. (2013).

Table 2.2: Supply of Wood in Tamil Nadu – 2008 (in million cu.m.)

Supply Source	Fuel-wood	Timber	Total
Forests	0.42 (1.8)	0.07 (1.3)	0.49 (1.7)
Trees-outside-Forests	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)	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)

Note: The figures in brackets are percentages. Source: Kavi Kumar et al. (2013).

2.1.4 *Forest Fires*

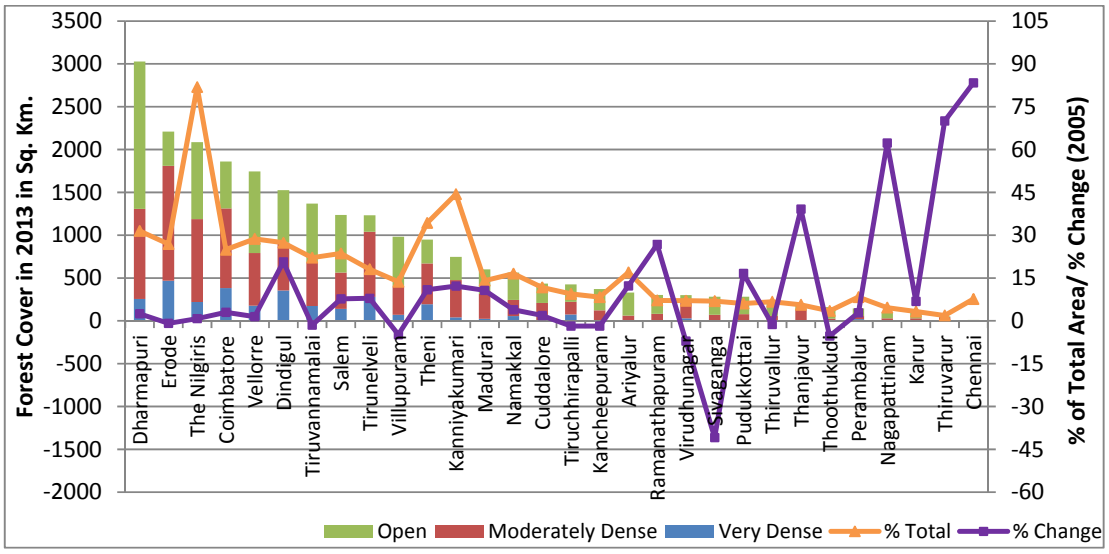
Forest fires pose a serious threat to forest biodiversity, and the ecology and environment of a region. Forest fires are more rampant during summer months and could result from natural occurrences (lightning) or man-made actions (lighting cigarettes etc.). Over the period 14th

February, 2015 to 24th April, 2015, 91 incidents of forest fires have been recorded in Tamil Nadu, 27 of those occurring in Dharmapuri district, 24 in Vellore and the remaining in the districts of Dindigul, Kanniyakumari, Namakkal, Sivaganga, Erode, Salem, South Arcot, The Nilgiris, Theni, Thiruvallur, Tirunelveli and Tiruvannamalai (ranging from 1-6 incidents in each)[1].

2.2 State and Impacts

2.2.1 *Forest Cover*

The total forest cover in Tamil Nadu in 2013 was 23,844 square kilometres, of which very dense forests (i.e. lands with tree canopy density of 70 per cent and above) accounted for 12.36 per cent, moderately dense forests (i.e. lands with tree canopy density of 40 per cent and more but less than 70 per cent) accounted for 42.77 per cent, and open forests (i.e. lands with tree canopy density of 10 per cent and more but less than 40 per cent) accounted for 44.86 per cent of total forest cover (FSI, 2013). Degraded forest land with a tree canopy density of less than 10 per cent (i.e. scrub) covered an area of 1,212 square kilometres in 2013, which represented a 33 per cent decline from area under scrub in 2005 (FSI, 2005). Dharmapuri district had the highest forest cover in 2013 (Figure 2.3).



Source: FSI (2005, 2013).

Figure 2.3: District-Wise Forest Cover in 2013 (in Sq. Km.), Percentage of Forest Cover to Total Geographical Area in 2013 and Percentage Change in Forest Cover between 2005 and 2013.

[1] For data on forest fires see http://www.fsi.nic.in/forest-fire.php.

The ‘very dense’ category of forests is mostly found in districts that already have a relatively high total forest cover (above 1000 square kilometres of total forest cover, in general). Erode district has the highest cover under very dense and moderately dense forests (467 and 1,341 square kilometres, respectively, in 2013), and Dharmapuri district has the highest cover under open forests (1,720 sq. km. in 2013).

In 2013, 18.33 per cent of the total geographical area of Tamil Nadu was under forest cover. The Nilgiris has the highest percentage of forest cover to total district geographical area in 2013 (82 per cent), followed by Kanniyakumari (44 per cent), Theni (34 per cent) and Dharmapuri (31 per cent). There was a 3 per cent increase in total forest cover between 2005 and 2013 in Tamil Nadu; a 11 per cent increase in very dense forests, a 4 per cent increase in moderately dense forests, and a 1 per cent increase in open forests over that time period. However, there were variations across districts in Tamil Nadu in terms of the change in forest cover between 2005 and 2013. Sivaganga district recorded the highest decline in forest cover during that time period (by 41 per cent), whereas Chennai, Thiruvarur and Nagapattinam recorded the highest increases. In Sivaganga, the significant decrease in moderately dense forest cover from 180 square kilometres in 2005 to 70 square kilometres in 2013, contributed to its overall decline in forest cover over time. In Chennai, Thiruvarur and Nagapattinam, the relatively higher increase in moderately dense forests compared to the increase in open forests (decrease in open forests in the case of Thiruvarur) contributed to the overall increase in total forest cover in all three districts between 2005 and 2013.

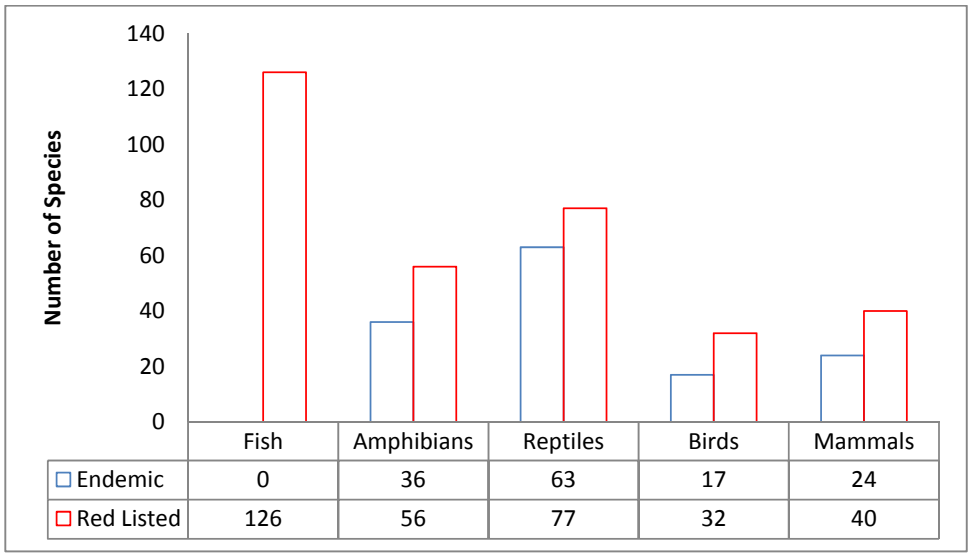
The FSI (2013) report notes that the increase in forest cover in Tamil Nadu as per the 2013 assessment is due to better conservation and protection of forests leading to increases in moderately dense and open forest areas. Further, it notes that the decline in forest area in certain districts may be attributed to the felling of agro-forestry plantations such as Eucalyptus species, Cashew, *Prosopisjuliflora*, Rubber, *Casuarina Spp.* etc.

In addition to forest cover, the total extent of tree cover (which comprises of trees outside forests that are less than 1 hectare in area) in Tamil Nadu in 2013 was 4,866 square kilometres, which accounted for almost 3.74 per cent of total geographical area of the State. The extent of tree cover in 2005 was estimated at 5,621 square kilometres, which implies a more than 13 per cent decline in tree cover over the period 2005 to 2013.

2.2.2 *Status of Endangered Animals*

Several species of mammals are found in Tamil Nadu. Among them the endangered ones are the Slender Loris, Lion Tailed Macaque, Indian Pangolin, Jackal, Indian Fox, Indian Wild Dog, Sloth Bear Ratel, Striped Hyena, Jungle Cat, Leopard, Tiger, Mouse Deer, Gaur, Blackbuck, Nilgiri Tahr, Grizzled Grey Squirrel, Common Dolphin and Dugong (DoE, 2006). The Tiger population in Tamil Nadu increased from 76 in 2006 to 163 in 2010 (MoSPI, 2013). The estimated population of wild elephants in Tamil Nadu was 3,867 in 2007-08, which was up from 3,052 in 2002 (MoSPI, 2013).

The wild plant diversity in Tamil Nadu includes a vast number of Bryophytes, Lichens, Fungi, Algae and Bacteria. There are 1559 medicinal species in Tamil Nadu. About 533 species are identified as endemic and 230 species are red listed. The faunal diversity of Tamil Nadu includes 165 identified fresh water fishes, 76 amphibians, 127 reptiles, 545 birds and 187 mammals. Figure 2.4 shows the number of red listed and endemic fauna of Tamil Nadu.



Source: GoTN (2015).

Figure 2.4: Endemic and Red Listed Fauna in Tamil Nadu

2.2.3 *Human-Animal Conflicts*

Human-Animal conflict has been increasing over the years in Tamil Nadu[2]. Incidents of human-elephant conflicts have been reported in various parts of Tamil Nadu (including Coimbatore[3], Nilgiris[4], Theni[5] and Dharmapuri[6]). Such conflicts result in severe impacts on communities in the form of crop destruction, property damage, loss of livestock, human injury and the loss of human lives. Sekar (2013) notes that there are two dimensions to the human-animal conflict; the wildlife and habitat dimension, and the human dimension, both of which result in more contact between humans and animals thereby exacerbating the problem. The wildlife and habitat dimensions include natural geographical features of animal habitat, increase in wildlife numbers, migratory pattern of animals, occurrence of stray/isolated animal population, shrinkage/degradation of habitat and corridors and diminution of habitat quality. Human dimensions include cultivation up to boundary of forests, cropping pattern and intensity, higher road density, railway lines and canals in wildlife habitats, development of human habitat space and urban infrastructure, large human presence in animal-dominated landscapes, lifestyle patterns, retaliatory response from people, unscientific restraint measures, lack of awareness and inadequacy of frontline staff. Effective management of human-animal conflicts requires due participation of the government and the community. Preventive measures include low intensity electric fencing (used only to scare elephants, not endanger their lives) and early warning systems (like alarms etc.), elephant-proof trenches to prevent elephants from venturing out of the forest, provision of waterholes for elephants in forests, anti-poaching guards, etc.

2.3 Responses

2.3.1 *Acts and Rules*

Tamil Nadu is one of the frontrunner in the field of forest and wildlife protection with a wide array of Acts and Rules. Dating back to late nineteenth century the Acts and Rules in the state

[2] See http://www.newindianexpress.com/nation/Incidents-of-human-animal-conflict-on-the-rise-MoEF/2013/05/27/article1607716.ece.
[3] See http://www.academia.edu/8094591/HUMAN_AND_ELEPHANT_Elephas_maximus_DEATHS_DUE_TO_CONFLICT_IN_COIMBATORE_FOREST_DIVISION_TAMIL_NADU_INDIA.
[4] See http://www.theglobaljournals.com/ijar/file.php?val=July_2013_1373366465_cf2bb_55.pdf.
[5] See http://www.researchgate.net/publication/267684969_RESOLVING_HUMAN_ELEPHANT_CONFLICT_IN_THENI_FOREST_DIVISION_TAMIL_NADU_SOUTHERN_INDIA_Report_to_Forest_Department_Theni_Forest_Division.
[6] See http://www.teriuniversity.ac.in/mct/pdf/new/assignment/V_Thirunavukarasu%20_Dharamapuri_division.pdf.

provide ample scope for the state administration to conserve and promote the forest ecosystem in Tamil Nadu. Table 2.3 summarizes different Acts and Rules pertaining to forests and wildlife in Tamil Nadu.

Table 2.3: Acts and Rules Pertaining to Forest Protection in Tamil Nadu

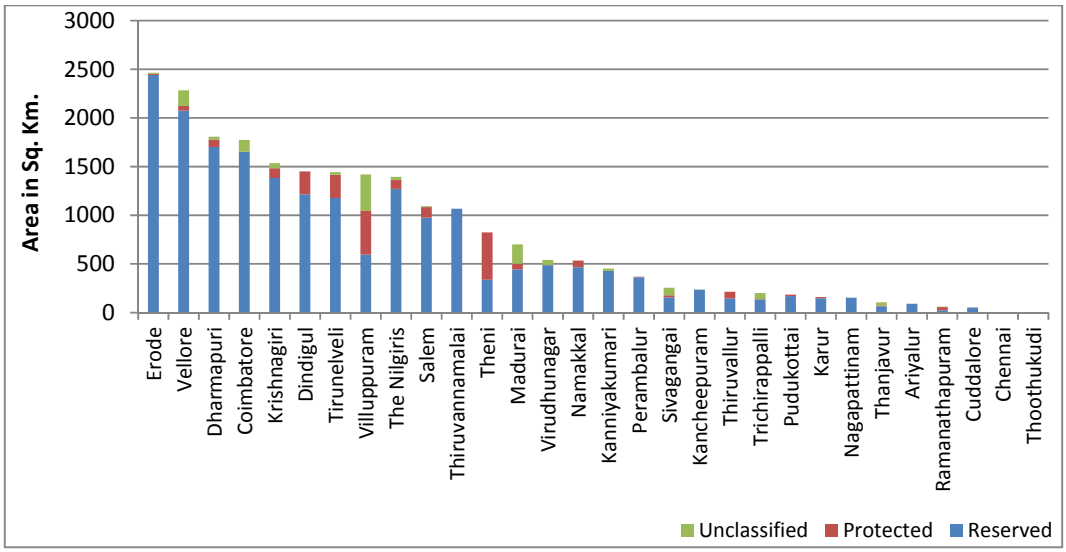
Act/Rule	Intended Objective
Madras Wild Elephants Preservation Act, 1873	Enacted to prevent indiscriminate destruction of wild elephants
Tamil Nadu Forest Act, 1882	Enacted by the Madras Presidency for protection of forests and wildlife
Tamil Nadu Preservation of Private Forests Act, 1949 and Tamil Nadu Hill Areas (Preservation of Trees) Act, 1955	Enacted to regulate felling of trees in private forests and hill areas
Wildlife Protection Act, 1972	Enacted to protect wild fauna and flora
Forest Conservation Act, 1980	Enacted to regulate diversion of forest land to non-forest purposes
Scheduled Tribes and other Traditional Forest Dwellers (Recognition of Forest Rights) Act, 2006	Enacted to recognize community rights of tribes in forest lands
Tamil Nadu Sandalwood Transit Rules, 1967 Tamil Nadu Timber Transit Rules, 1968 Tamil Nadu Timber (Movement Control) Order, 1982 Tamil Nadu Wildlife (Transit) Rules, 1991	Rules to regulate forest products and wildlife

2.3.1 *Reserved and Protected Forests*

Reserved, protected and un-classed are the three major legal classes of forests in India. A legal notification in a government gazette under the Indian Forest Act; 1927 creates or defines the boundaries of 'reserved' and 'protected' forests in India and accords them with a certain degree of protection. These forests by definition are owned by the government. The rest of the forests areas recorded in government land records as forests are called un-classed forests. In reserved forests, most activities like hunting, grazing etc. are prohibited unless allowed. In protected forests, most activities are allowed unless prohibited.

The district-wise extent of reserved and protected forests in Tamil Nadu is presented in Figure 2.5. Reserved forests form a higher proportion of total forests in each district compared to protected and un-classed forests. Erode and Vellore districts both have reserved forests in excess of 2,000 square kilometres. The total extent of reserved forests in Tamil

Nadu in 2013-14 is 19,459 sq. km., of protected forests is 2,152 sq. km., and un-classed forests is 1,266 sq. km., giving a total forest area of 22,877 sq. km. Thus, reserved forests account for approximately 85 per cent of total forest area. Compared to 2004-05 levels, reserved, protected and un-classed forests decreased marginally by 0.7 per cent in 2013-14- the higher declines in protected and un-classed forests (by about 3 per cent each) contributed to this overall decline in total forest area in 2013-14 compared to 2004-05.



Source: DEAR (2013-14).

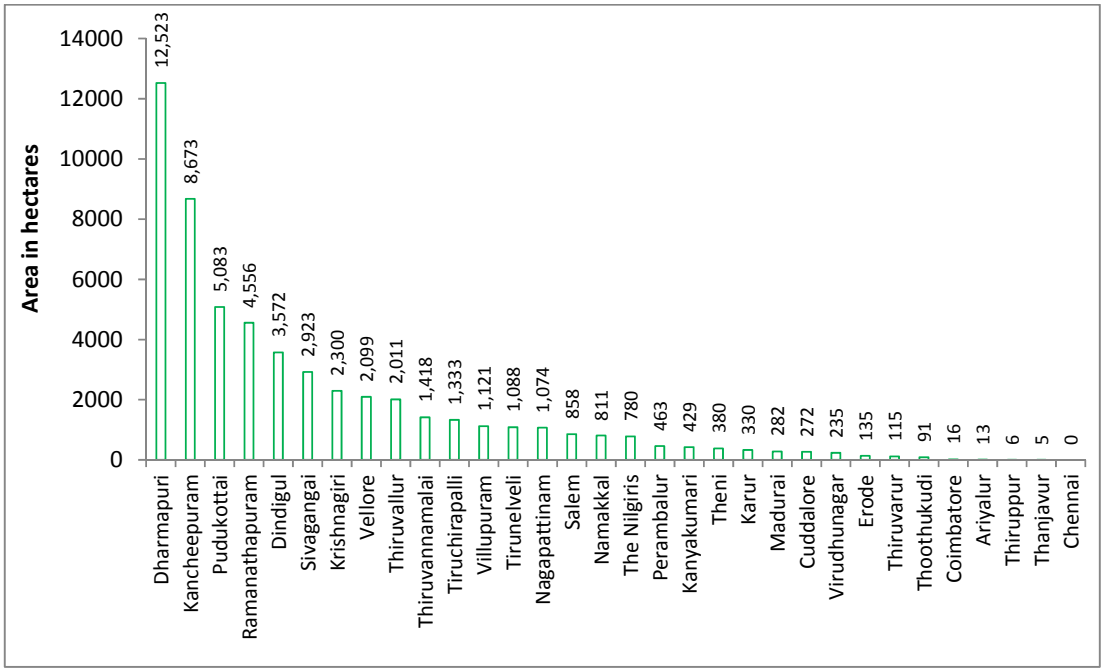
Figure 2.5: District-Wise Extent of Reserved and Protected Forests in Tamil Nadu in 2013-14 (in Square Kilometres)

2.3.2 *Social Forestry and Joint Forest Management (JFM)*

The main objective of social forestry is to involve the rural communities in the creation and maintenance of village woodlots, and in raising tree plantations in community lands, private lands and in homesteads for meeting their local needs. As such, it is forestry undertaken outside conventional forests which aims at providing a continuous flow of goods and services (such as fuelwood, small timber, fodder etc.) for the benefit of the people, thereby taking the pressure of currently existing forests. Social forestry also involves the promotion of commercial tree growing by farmers on their own lands (farm forestry), the planting of shelterbelts for protection against the natural elements, the rehabilitation of degraded forests, and recreation forestry.

Figure 2.6 shows the district-wise area under social forestry in Tamil Nadu in 2013-14. A total of 54,995 hectares of land area were under social forestry in the State in 2013-14. The area under social forestry in the districts of Dharmapuri and Kancheepuram accounted

for 22.8 per cent and 15.8 per cent, respectively, of the total area under social forestry in the State during that period.



Source: DoES (2013-14).

Figure 2.6: District-Wise Area under Social Forestry in Tamil Nadu in 2013-14 (in ha)

The JFM programme is an initiative undertaken by the Government that aims to protect, regenerate and develop degraded forest lands through the involvement of village communities. In Tamil Nadu, there are currently 3,337 JFM committees with over 10.6 lakh members, and the area under JFM is approximately 7.2 lakh hectares (MoSPI, 2013).

The Tamil Nadu Afforestation Programme (TAP) follows the JFM framework with the aim of regenerating the forests of the State through afforestation with active community participation, and it also aims to reduce poverty and improve the standard of living of participating communities. In Phase I of the project, 430 thousand hectares of land have been targeted, followed by 180 thousand hectares in Phase II. The Forest Department is also bolstering forest management through a geographic information system utilising satellite images. As a poverty-reduction initiative, support is also given to finding alternative sources of income and improving the standards of living for the residents living in the vicinity of the forest. Specifically, small-scale infrastructure improvements are being carried out according to the needs of residents, and actions are being taken to improve earnings, with a central focus on self-help groups (SHGs). During the period 2012-13, roughly 47,500 hectares of

forest land were maintained via funding from the Japan International Cooperation Agency (JICA), and another 31,050 hectares were maintained through State funds. Thus, a total forest area of 78,550 hectares was maintained under this project in 2012-13. In addition, 100 check dams and 100 percolation ponds were constructed for the purpose of rainwater harvesting during this period (DoES, 2014). Phase I of TAP was implemented at a cost of Rs. 688 Crores, and Phase II was initiated in April, 2005 with an outlay of Rs. 567.42 Crores.

2.3.3 *Forest Certification*

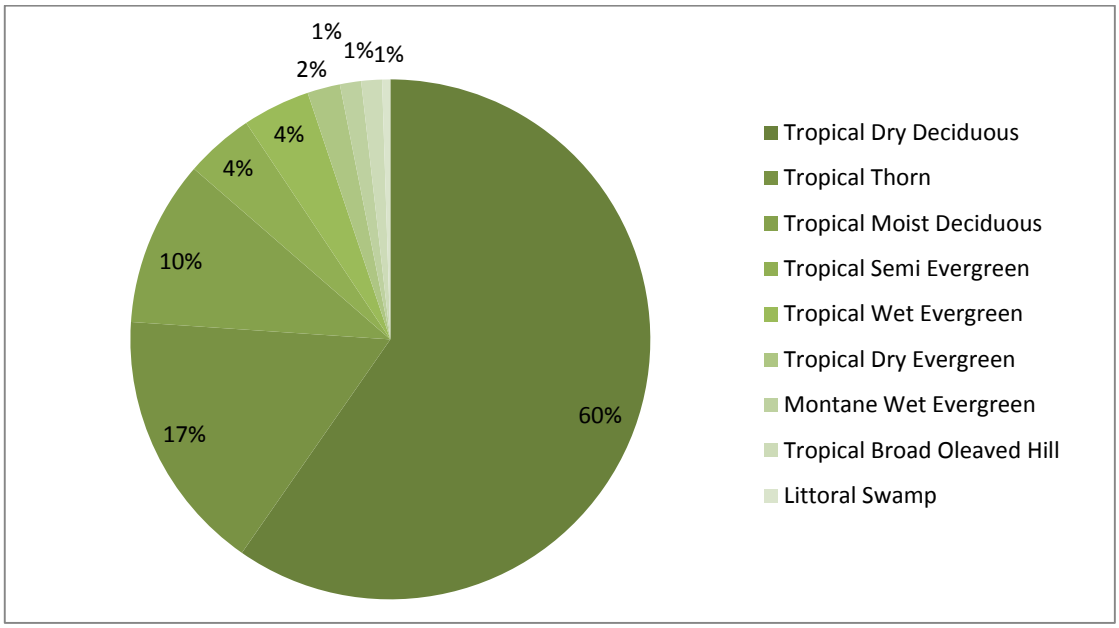
Forest certification is a mechanism for forest monitoring, tracing and labelling timber, wood and pulp products, and non-timber forest products where the quality of management from environmental, social and economic perspectives is judged against a series of agreed standards. It is a process that leads to the issuing of a certificate by an independent party, which verifies that an area of forest is managed to a defined standard. Forest certification refers to two separate processes i.e., forest management unit certification (FMU) and chain of custody certification (COC). Forest management certification is a process which verifies that an area of forest /plantations from where the wood, fibre and other non-timber forest products is extracted is managed to a defined standard. COC certification is a process of tracking forest products from the certified forest to the point of sale to ensure that product originated from a certified forest.

The Forest Stewardship Council (FSC) certification is one of the most popular and credible certification schemes globally. Tamil Nadu Newsprint and Papers Limited (TNPL) obtained a FSC Forest Management and Chain of Custody certificate from Rainforest Alliance, USA, which is valid from 6th July, 2012 up to 5th July, 2017, for its farm forestry and captive plantations in about 19,561 hectares, which is the largest FSC certified forest plantation in India. It also received a Chain of Custody and Controlled Wood Certificate from Smart Wood Programme of Rain Forest Alliance, USA, which is valid from 21st July, 2010 up to 20th July, 2015, to manufacture FSC certified products[7].

[7] See TNPL website for details- http://www.tnpl.com/DisplayPage.aspx?file=Plantation.htm.

Chapter 3: Biodiversity

Tamil Nadu has rich biodiversity supported by natural forests, mangroves and wetlands. There are nine major forest types in Tamil Nadu (see Figure 3.1), dominated by tropical dry deciduous forest type that covers close to 50 per cent of the total forest area in the state as of 2009. The state has mangrove forests at Pichavaram, Muthupet, Mimisal, Devipattinam and Punnakayal covering about 39 square kilometres of area. A true mangrove species, *Phemphisacidula*, is found in the Tamil Nadu mangroves and nowhere else in India. Tamil Nadu is also classified as a wetland rich state with about 12.88 per cent of its geographic area under wetlands.



Source: GoTN (2015).

Figure 3.1: Percentage of Forest Area Covered by Different Forest Types in Tamil Nadu

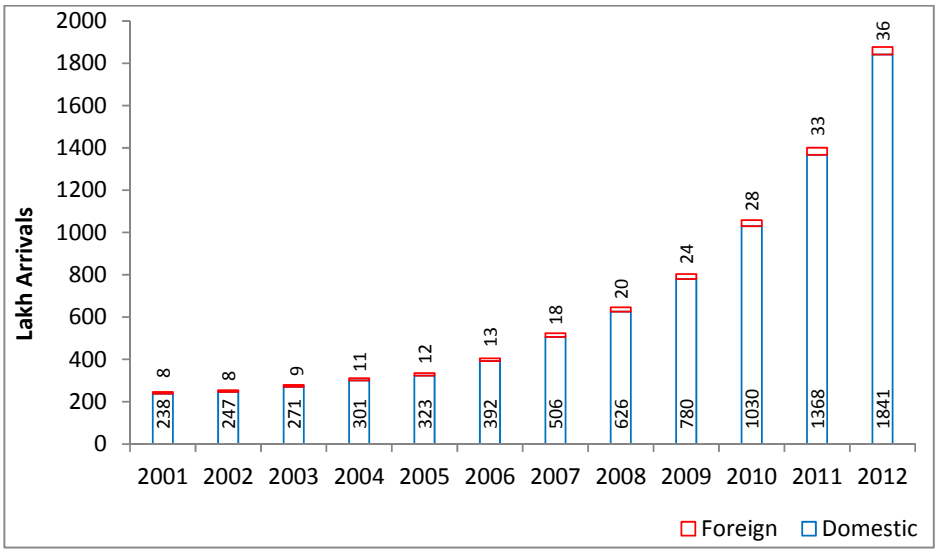
The following sections describe the pressures acting on the biodiversity in Tamil Nadu, the status of various aspects of biodiversity in the state, and the response strategies adopted by the state government and other stakeholders in conserving biodiversity. It may be noted that several pressures acting on forests and wildlife also affect biodiversity.

3.1 Pressures

3.1.1 *Growth in Tourist Population*

In the absence of suitable management standards and guidelines that seek to promote biodiversity conservation, the growth in tourism can lead to an increase in the production of waste and pollutants, unsustainable development in ecologically sensitive areas, conflict between tourists and locals etc., all of which contribute to biodiversity loss. Having said that, tourism development implemented according to the principles of sustaining the environment, conserving nature, and contributing to the well-being of local people will have a net positive or a neutral impact on biodiversity (see Section 3.3.2 on Eco-Tourism).

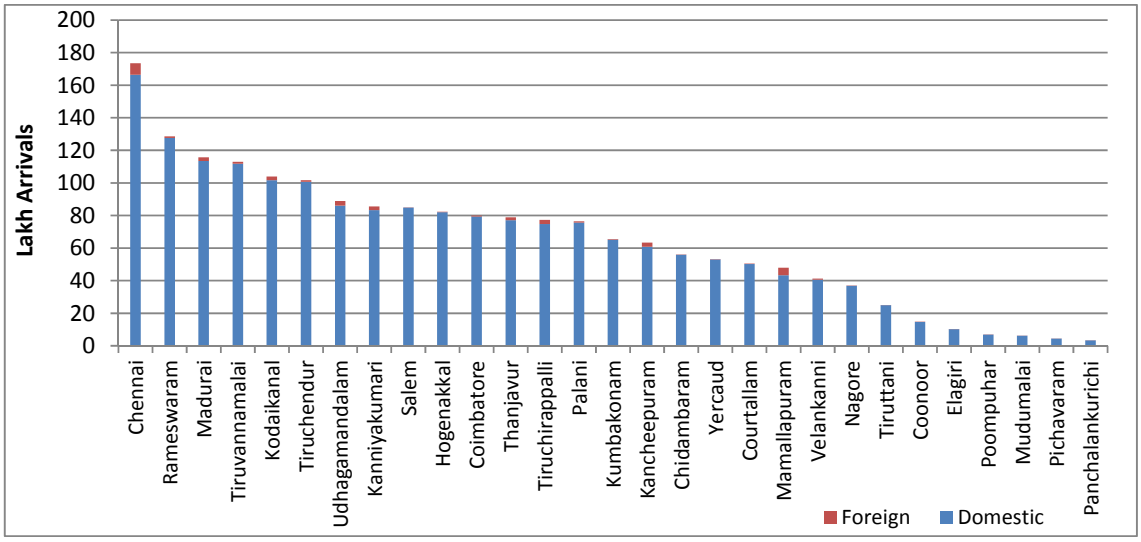
The total number of tourist arrivals in Tamil Nadu has grown exponentially over the period 2001 to 2012 (Figure 3.2). Domestic tourist arrivals make up more than 95 per cent of total tourist arrivals in Tamil Nadu, although foreign tourist arrivals have been on the rise in recent years.



Source: DoES (2014).

Figure 3.2: Tourist Arrivals in Tamil Nadu over Time (in Lakhs)

There have been approximately 184 million domestic and 3.5 million foreign tourist arrivals in Tamil Nadu in 2012. Centre-wise number of tourist arrivals is shown in Figure 3.3. Chennai accounted for about 9 per cent of total arrivals in 2012 making it the biggest tourist destination in Tamil Nadu. Rameswaram and Madurai accounted for roughly 7 and 6 per cent of total tourist arrivals in 2012, respectively. Between 2006 and 2012, centre-wise number of tourist arrivals increased by several thousand per cent in all destinations, particularly in Hogenakkal (DEAR, 2005-06).



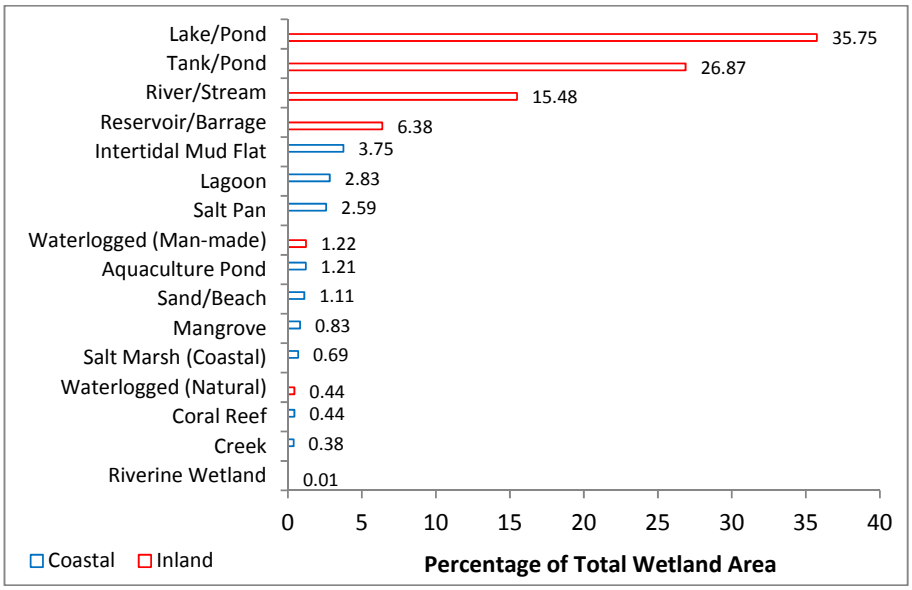
Source: DoES (2014).

Figure 3.3: Centre-Wise Number of Tourist Arrivals in Tamil Nadu in 2012 (in Lakhs)

3.2 State and Impacts

3.2.1 *Wetlands*

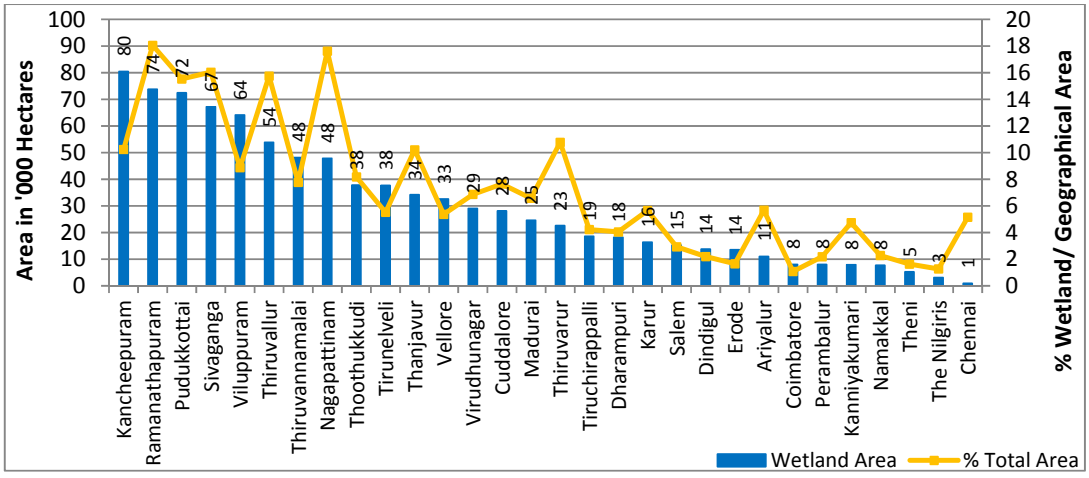
In 2011, Tamil Nadu had a wetlands area of 8,84,240 hectares and an additional 18,294 hectares of wetlands less than 2.25 hectares, giving a total wetlands area of 9,02,534 hectares (SAC, 2011). Figure 3.4 shows the area of different types of wetlands present in Tamil Nadu as a percentage of total wetland area of the State in 2011. Inland wetland types including lakes, ponds, tanks, rivers, streams, reservoirs, barrages, waterlogged areas (man-made and natural) and riverine wetlands account for roughly 86 per cent of total wetland area. On the other hand, coastal wetland types including lagoons, creeks, sandy beaches, intertidal mud flats, salt marshes, mangroves, coral reefs, salt pans and aquaculture ponds account for 14 per cent of total wetland area. Lakes, ponds and tanks alone account for 63 per cent of total wetland area, and rivers and streams account for roughly15 per cent of total wetland area. Total wetland area (i.e. area of wetlands less than and greater than 2.25 hectares) was approximately 7 per cent of total geographical area of Tamil Nadu in 2011.



Source: SAC (2011).

Figure3.4: Area of Wetland Type as a Percentage of Total Wetland Area in Tamil Nadu in 2011

Figure 3.5 shows the extent of total wetland area in the districts of Tamil Nadu. Kancheepuram district has the largest wetlands area and Chennai district, the smallest. Ramanathapuram and Nagapattinam districts, however, have the highest percentage of wetlands area to total district geographical area (about 18 per cent each), whereas Coimbatore and Nilgiris have the smallest percentage of wetlands area to total geographical area (about 1 per cent each). In general, districts with relatively higher wetland areas also have a higher percentage of wetland area to total district geographical area, and *vice versa*.



Source: SAC (2011).

Figure 3.5: District-Wise Wetlands Area (in '000 Hectares) and Percentage of Wetlands Area to District Geographical Area in 2011

Table 3.1 lists the important wetlands in Tamil Nadu. These are important sites of biodiversity as a variety of flora and fauna inhabit them, notably mangroves, coral reefs, seagrasses, waterfowl, fish and other mammals.

Table 3.1: Important Wetlands of Tamil Nadu

S. No.	Name	Wetland Type	Area (ha)	Key Vegetation	Key Fauna	Threats
1.	Pichavaram Mangroves	Mangroves	570.75	Mangroves, seaweeds and seagrasses	Resident and migratory waterfowl	-
2.	Point Calimere Wildlife and Bird Sanctuary	Lagoon, intertidal mud flats, mangroves and salt pans	32010	Forest trees, insectivorous plants, grasses, mangroves, shrubs	Commercially important shellfish and fish; land and sea mammals; resident and migratory birds	-
3.	Pulicat Lake	Natural lake	5324 (in TN)	Algae and phytoplankton	Resident and migratory waterfowl	Siltation
4.	Gulf of Mannar Marine National Park	Islands	-	Coral reefs, seagrasses, mangroves, littoral and swamp forests	Chank and pearl fisheries; marine fish and mammals	Degradation of coral reefs
5.	Madurai Tanks	Tanks/ponds	2064.97	Wild rice and other monocots, weeds, reeds, shrubs, trees	Waterfowl; resident peacocks	-
6.	Sathanur Reservoir	Reservoir	2203.81	Forest trees in surrounding areas	Birds, fish; mammals in surrounding forests	Deforestation in the catchment area and siltation
7.	Kallur Santhai Reservoir	Reservoir	741.3	-	-	-
8.	Koothakulam and nearby tanks	Tanks/ponds	105.05	-	Migratory birds	-

Source: SAC (2011).

3.3 Response

3.3.1 *Biosphere Reserves, National Parks, Wildlife and Bird Sanctuaries*

One of the ways in which the conservation of biodiversity takes place is by establishing biosphere reserves, national parks and wildlife sanctuaries that aim to monitor, conserve and protect plant and animal species endemic to a particular region. Tamil Nadu has two biosphere reserves, one in the Nilgiris and the other in the Gulf of Mannar. A Tiger Reserve has also been established in the State by combining the Kalakad and Mundanthural Wildlife Sanctuaries in Tirunelveli district. In addition, a modern Zoological Park, complete with open moat enclosures, was established in Vandalur (near Chennai) over an area of 602 hectares of reserved forests. Table 3.2 gives details of the wildlife sanctuaries, bird sanctuaries and national parks in Tamil Nadu, along with a list of major animals founds in each of them.

Table 3.2: Wildlife Sanctuaries, Bird Sanctuaries and National Parks in Tamil Nadu

S. No.	Name	District in which Located	Area in ha	Year Decl.	Major Animals Found
	Wildlife Sanctuaries				
1.	Mudumalai Wildlife Sanctuary	Nilgiris	21776.00	1940	Elephant, Gaur, Sambar, Chital, Panther, Tiger, Birds, Reptiles
2.	Indira Gandhi Wildlife Sanctuary	Coimbatore	84149.00	1976	Elephant, Gaur, Tiger, Panther, Sloth bear, Wild boar
3.	Mundanthurai Wildlife Sanctuary	Tirunelveli	58207.58	1962	Tiger, Bonnet Macaque, Langurs, Slender Loris, Sloth Bear, Sambar, Chital, Wild Dog
4.	Kalakad Wildlife Sanctuary	Tirunelveli	22358.00	1976	Lion Tailed Macaque, Nilgiri Tahr, Sambar, Sloth Bear, Elephant, Panther, Tiger
5.	Srivilliputhur Grizzled Squirrel Wildlife Sanctuary	Virudhunagar	48520.00	1988	Grizzled Giant Squirrel, Flying Squirrel, Nilgiri Tahr, Elephant, Lion Tailed Macaque
6.	Point Calimere Wildlife Sanctuary	Nagapattinam	1726.00	1967	Black Buck, Bonnet Macaque, Wild Boar, Flamingoes, variety of birds such as Teals, Gulls
7.	Vallanadu Black Buck Sanctuary	Thoothukudi	1641.00	1987	Black buck, Spotted deer, Macaques, Jungle cat, Mongoose, Hares
8.	Kanyakumari Wildlife Sanctuary	Kanyakumari	40239.55	2007	Bonnet Macaque, Nilgiri Langur, Slender Loris, Tiger, Panther, Elephant, Bird, jackal, Nilgiri Tahr
9.	Sathyamangalam Wildlife Sanctuary	Erode	141160.94	2011	Elephant, birds etc.
10.	Megamalai Wildlife Sanctuary	Theni& Madurai	26910.82	2009	Elephant, birds etc.

11.	Point Calimere Wildlife Sanctuary Block A & Block B	Thanjavur&Tiruvarur	12407.27	2013	Black Buck, Bonnet Macaque, Wild Boar, Flamingoes, variety of birds such as Teals, Gulls
12.	Kodaikanal Wildlife Sanctuary	Dindigul&Theni	60895.48	2013	Nilgiri Langur, Common Langur, Bonnet Macaque, Indian Giant Squirrel, Common Giant Flying Squirrel, Tiger, Leopard/Panther, Birds, Reptiles, Elephant
13.	Gangaikondan Spotted Deer Sanctuary	Tirunelveli	288.40	2013	Spotted Deer
14.	Cauvery North Wildlife Sanctuary	Krishnagiri&Dharmapuri	50433.48	2014	Grizzled Giant Squirrels, Panthers, Elephants, Dhole, Sloth Bear etc.
15.	Nellai Wildlife Sanctuary	Tirunelveli	35673.33	2015	India Gaur, Leopard, Nilgiri Tahr, Sambar, Wild Boar, Sloth Bear, Indian Elephant, Lion Tailed Macaque etc.
	Total		***606386.85***		
	Bird Sanctuaries				
16.	Vedanthangal Birds Sanctuary	Kancheepuram	30.00	1998	Cormorants, egrets, gray heron, spoon billed stork, migratory birds like garguney, teals, shovallers
17.	Karikili Birds Sanctuary	Kancheepuram	61.21	1989	Cormorants, egrets, grey heron, spoon billed stork,
18.	Pulicat Lake Birds Sanctuary	Tiruvallur	15367.00	1980	Flamingoes, ducks, osprey, avocet, cormorants, herons, spoon bills, gulls and other migratory birds
19.	Vettangudi birds Sanctuary	Sivagangai	38.40	1977	Cormorants, egrets, herons, teals, pelicans
20.	Kanjirankulam Birds Sanctuary	Ramanathapuram	104.00	1989	Cormorants, egrets, herons, teals, pelicans
21.	Chitrangudi Birds Sanctuary	Ramanathapuram	47.63	1989	Cormorants, egrets, herons, teals, pelicans
22.	Udayamarthandpuram Birds Sanctuary	Tiruvarur	45.28	1998	Little cormorant, darter, spoon bill, Indian Reef Heron, Grey heron, white necked stork
23.	Vaduvoor birds Sanctuary	Tiruvarur	128.10	1999	Cormorants, egrets, ibis, herons and many variety of birds
24.	Koonthankulam-Kadankulam Birds Sanctuary	Tirunelveli	129.00	1994	Grey pelican, painted stork, white Ibis, jackal, rat snake
25.	Karaivetti Birds Sanctuary	Ariyalur	453.71	1999	Egrets, pelican, grey heron, white ibis, spoon bill
26.	Vellode Birds Sanctuary	Erode	77.18	2000	Spoon bill, teals, pintail ducks, darter
27.	Melaselvanur-Kilaselvanur Birds Sanctuary	Ramanathapuram	593.08	1998	Grey pelican, painted stork
28.	Theerthangal Bird Sanctuary	Ramanathapuram	29.29	2010	White-breasted kingfisher, spot-billed pelican, brahminy kite
29.	Sakkarakottai Tank Birds Sanctuary	Ramanathapuram	230.49	2012	Spot-billed pelican, egret, common myna, grey heron, little cormorant, black kite, etc.

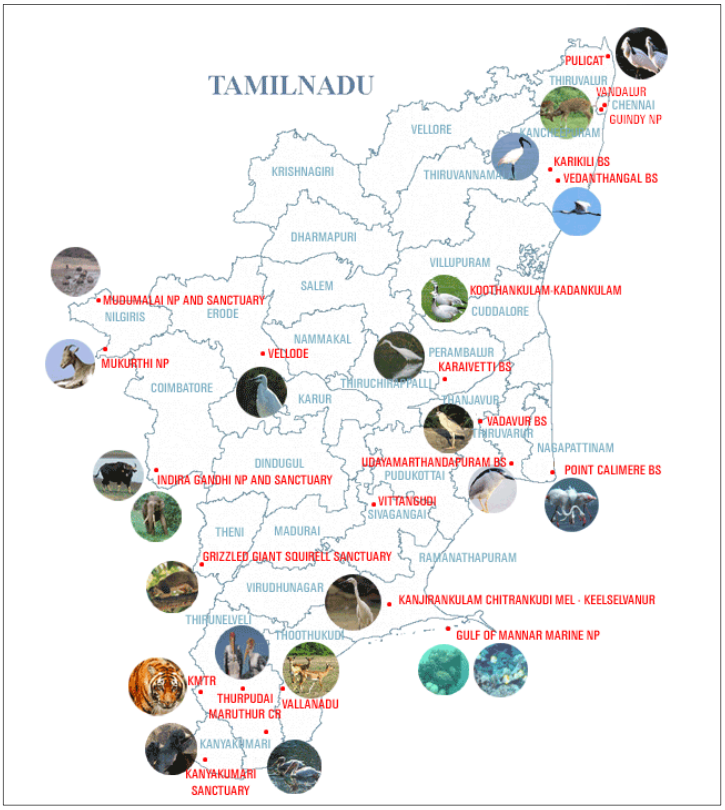
30.	Oussudu Lake Birds Sanctuary	Villupuram	331.79	2015	Spot-billed pelican, egret, common myna, grey heron, little cormorant, black kite, etc.
	Total		***17666.16***		
	National Parks				
31.	Mudumalai National Park	Nilgiris	10323.00	2005	Elephant, Gaur, Sambar, Chital, Tiger, Birds, and reptiles
32.	Indira Gandhi National Park	Coimbatore	11710.00	1989	Elephant, Gaur, Tiger, Panther, Sloth Bear, Wild Boar
33.	Mukurthi National Park	Nilgiris	7846.00	2001	Nilgiri Tahr, Jackal, Otter, Jungle cat, Sambar, Barking deer.
34.	Guindy National Park	Chennai	270.57	1978	Black Buck, Chital, Jackal, Pangolin and variety of birds
35.	Gulf of Mannar Marine National Park (21 Islands)	Ramanathapuram &Thoothukudi	52602.00	1986	Characteristic tropical flora & fauna of coral reefs, Dugong, Turtles, Dolphins and Balanoglossus
	Total		***82751.57***		
	Conservation Reserves				
36.	Thiruppudaimaruthur Birds Conservation Reserve	Tirunelveli	2.84	2005	Birds
37.	Suchindrum-Theroor-Managudi Conservation Reserve	Kaniyakumari	484.77	2015	Birds
	Total		***487.61***		

Source: Tamil Nadu Forest Department (personal communication through ENVIS Centre, Chennai).

3.3.2 *Eco-Tourism*

Eco-tourism is a form of travel that involves preserving and sustaining the diversity of the world's natural and cultural environments. It is intended to be low-impact (on the environment), and a small-scale alternative to commercial tourism. It focuses on socially-responsible travel to destinations where flora, fauna and cultural heritage are the main attractions. It also focuses on environmental sustainability by offering tourists insights into the impact of human beings on the environment and by fostering greater appreciation of our natural habitats.

The Tamil Nadu Forest Department has identified a number of eco-tourism destinations in Tamil Nadu that are depicted in Figure 3.6. They include national parks, wildlife and bird sanctuaries that have been described above.



Source: TN Forest Department (http://www.forests.tn.nic.in/ecotourism/ecotourism_home.html)

Figure 3.6: Eco-Tourism Destinations in Tamil Nadu

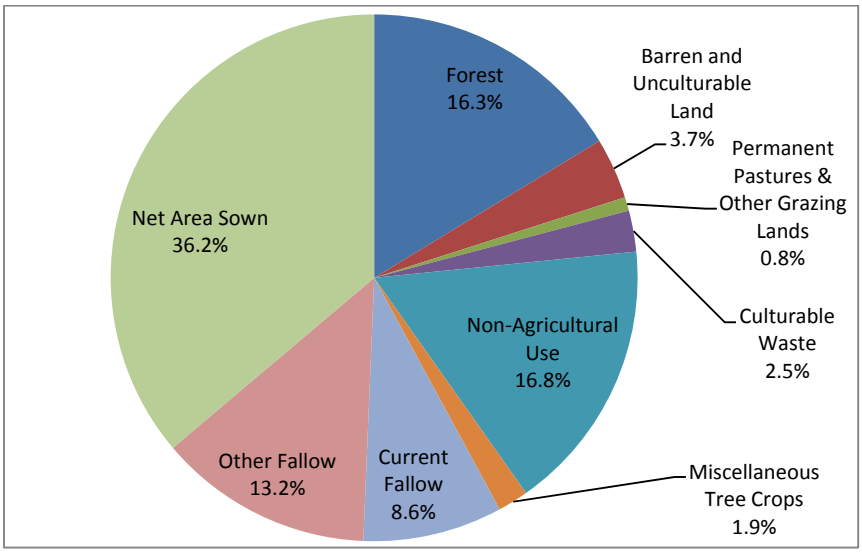
3.3.3 Biodiversity Management

The Biological Diversity Act, 2002 is the overarching framework for biodiversity conservation and equitable sharing of the benefits arising out of the sustainable use of biological resources. The National Biodiversity Authority with the support of various state biodiversity boards has the mandate to implement the Act. While Tamil Nadu has established the State Biodiversity Board, it has been somewhat slow in establishing the other networking mechanism, namely biodiversity management committees for facilitating biodiversity conservation. Tamil Nadu has relatively small number of biodiversity management committees (BMCs) compared to other states. As of September 2015, the state has mere 16 BMCs, compared to 4636 in Karnataka, 1043 in Kerala, 928 in Andhra Pradesh, and 710 in Telangana[1]. For effective biodiversity conservation as well as to facilitate equitable sharing of the benefits resulting from the use of biological resources, it is important to increase the number of BMCs as they would help in understanding the perspectives of different stakeholders.

[1] See http://nbaindia.org/content/20/35/1/bmc.html for more details.

Chapter 4: Land Degradation and Desertification

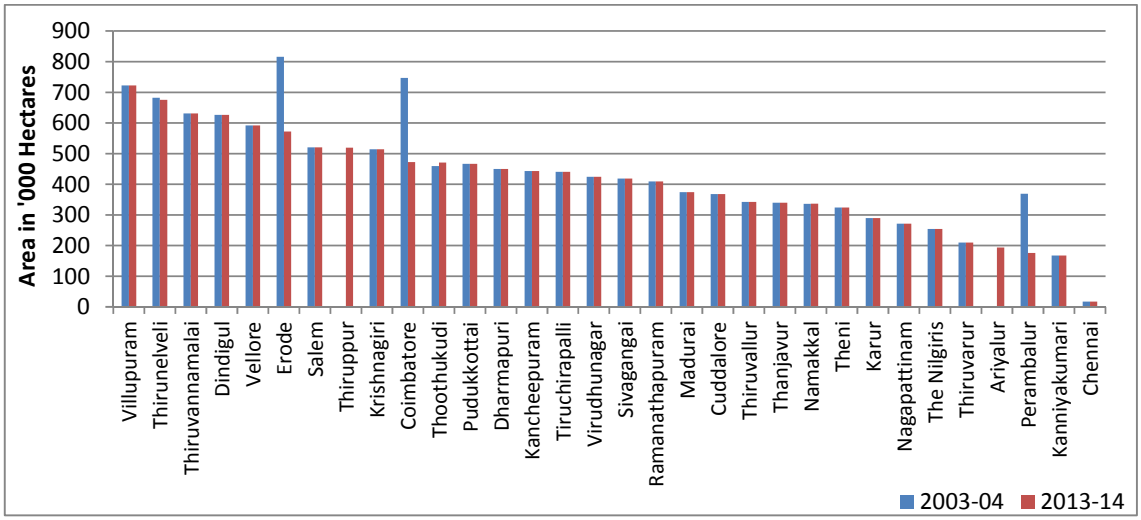
Tamil Nadu has a total geographical area of 130.33 lakh hectares, 36.2 per cent of which was put to agricultural use, 16.8 per cent of which was used for non-agricultural purposes, fallow lands (current and other) made up 21.8 per cent, forests accounted for 16.3 per cent and the remaining 8.9 per cent of total land area was distributed between barren and unculturable lands, culturable waste lands, miscellaneous tree crops and permanent pastures and other grazing lands in 2013-14 (see Figure 4.1). The land use pattern observed in 2013-14 has more or less stayed the same over the past decade other than a few exceptions: current fallows have increased drastically from 6.92 to 11.15 lakh hectares between 2004-05 and 2013-14 (a 61 per cent increase) and, area under culturable waste, area under miscellaneous tree crops and net area sown have declined by 12, 16 and 8 per cent respectively, over that time period.



Source: DoES (2013-14).

Figure 4.1: Land Use Classification of Tamil Nadu in 2013-14

Total geographical area of the districts of Tamil Nadu is shown in Figure 4.2. Villupuram has the largest geographical area in the State (5.54 per cent of total land area in Tamil Nadu) and Chennai accounts for the smallest (0.13 per cent of total) in 2013-14. In 2007, Ariyalur district split from Perambalur district and 52 per cent of land area of the latter made up the former. In 2009, Thiruppur district split from the districts of Erode and Coimbatore, and 30 and 37 per cent of these districts' land area respectively was allocated to Thiruppur. Other minor changes in land area between 2003-04 and 2013-14 include a 1 per cent decline in land area of Thirunelveli district that was allocated to Thoothukudi district.

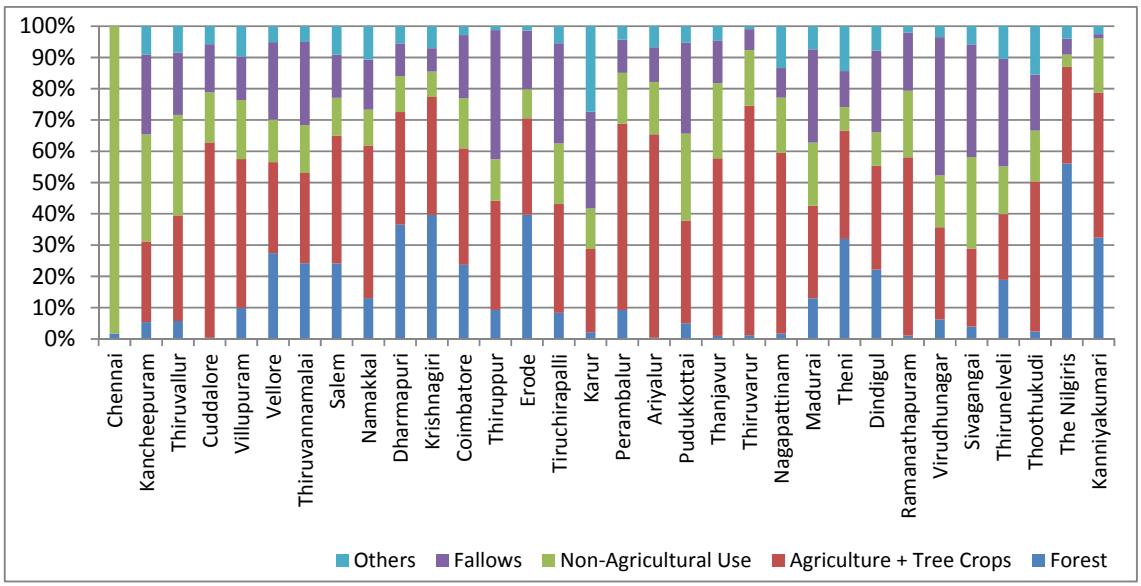


Source: DEAR (2003-04); DoES (2013-14).

Figure 4.2: District-Wise Total Geographical Area in Tamil Nadu (in '000 Hectares)

Figure 4.3 shows land use classification in the districts of Tamil Nadu in 2013-14. In a majority of the districts, the highest percentage of district land area is used for agricultural purposes (including the cultivation of tree crops) and the smallest percentage of area makes up permanent pastures and other grazing lands, barren and unculturable land and culturable waste land. In Chennai and Kancheepuram districts the majority of land area is used for non-agricultural purposes including land occupied by industry, buildings, roads and railways, canals etc.

In Dharmapuri, Krishnagiri, Erode and the Nilgiris, the highest percentage of district area comprised of forest area in 2013-14. Land area that was kept fallow in the current year (current fallows) and land area that has been kept fallow for a period of over a year but less than five years (other fallows) accounted for the highest percentage of total district land area in Thiruppur, Karur, Virudhunagar, Sivagangai and Thirunelveli in 2013-14.



Source: DoES (2013-14).

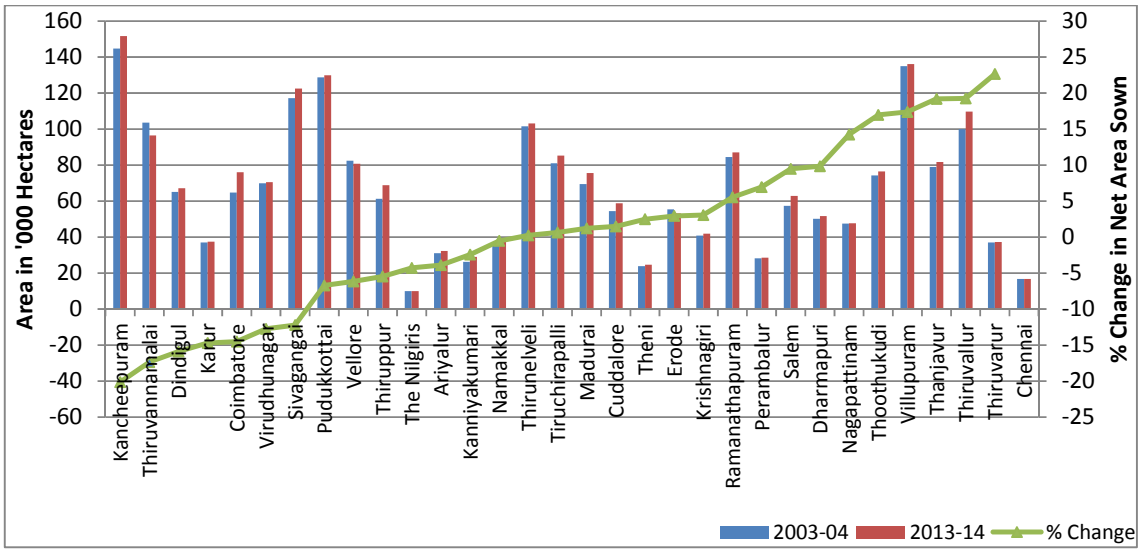
Figure 4.3: District-Wise Land Use Classification in 2013-14 (in Percentage of Total District Area)

4.1 Pressures

4.1.1 *Land Conversion for Non-Agricultural Use*

Figure 4.4 shows that in a majority of the districts, the area under non-agricultural use has increased over the period 2003-04 to 2013-14. The figure also shows that the percentage change in net area sown has declined over the same period in a large number of districts whose land area for non-agricultural purposes has increased. This could at least partly imply

that agricultural land is being converted in certain Tamil Nadu districts for non-agricultural use. There are exceptions however; in almost all districts to the right of Namakkal in Figure 4.4, both the land area for non-agricultural use as well as the net sown area has increased between 2003-04 and 2013-14. Conversely in other districts such as Thiruvannamalai and Vellore both the land area for non-agricultural use as well as the net sown area has decreased between 2003-04 and 2013-14.



Note: a) Area under non-agricultural use and net sown area for Thiruppur in 2003-04 is estimated in proportion to geographical land area allocated from Coimbatore and Erode to Thiruppur, and similarly for Ariyalur (in proportion to land area allocated from Perambalur). b) In the Figure, the position of the zero value differs on the primary and secondary axes scales.

Source: DEAR (2003-04); DoES (2013-14).

Figure 4.4: District-Wise Area under Non-Agricultural Use (in '000 Hectares) and Percentage Change in Net Area Sown between 2003-04 and 2013-14

4.1.2 *Mining Activities*

Tamil Nadu is a mineral rich state and the leading major minerals produced in the state are lignite, natural gas (ut.), limestone, petroleum (crude) and magnesite. The state had a significant share in the country's production of certain minerals in 2013-14 including lime kankar (100 per cent), dunite (98.5 per cent), garnet (abrasive – 77.6%, graphite (r.o.m. – 60.6 per cent), lignite (60.1 per cent), fireclay (22.9 per cent) and vermiculite (21.6 per cent) (MoM, 2014-15). As of 2013-14, there were 354 reporting mines in Tamil Nadu. The State's index of mineral production during 2013-14 was 120.87, up from the previous year's value of 117.28 (base 2004-05=100). The value of mineral production in Tamil Nadu in 2013-14 was

Rs. 6,464.93 crores, which represented an increase in value by 4.73 per cent compared to the previous year. Out of 3318 mines that reported mineral production (excluding minor minerals, petroleum (crude), natural gas and atomic minerals) in India in 2014-15, 272 are located in Tamil Nadu. As of 31st March 2013, 924 mining leases were granted in Tamil Nadu out of an all-India total of 11,104 (PIB-MoM[1]). Table 4.1 gives details of important mineral deposits in Tamil Nadu in 2014-15 and the districts in which they occur. Details of illegal mining cases in Tamil Nadu are presented in Table 4.2.

Table 4.1: Important Mineral Deposits in Tamil Nadu in 2014-15

S. No.	Minerals Found	Reserves (Million Tonnes)	Production (Tonnes)	Districts in which they occur
1	Bauxite	25	86800	Yercaud, Kodaikanal, Kolli Hill Ranges and Nilgiris District.
2	Crude Oil	-	235077	Nagappattinam, Tiruvarur, Thanjavur, Ramanathapuram and Cuddalore Districts.
3	Fire Clay	110	300588	Ariyalur, Perambalur, Cuddalore, Tiruchirappalli and Kanchipuram Districts.
4	Garnet	28.35	680160	Occurs as placer deposits along the coastal tracts.
5	Granite	559.44	79169 m^3	Krishnagiri, Villupuram, Dharmapuri, Erode, Salem, Vellore and Tiruvannamalai Districts.
6	Granite (multi-colour)	-	364328 m^3	Coimbatore, Krishnagiri, Karur, Pudukottai, Madurai, Salem, Namakkal, Tirunelveli, Virudhunagar and Vellore Districts.
7	Graphite	7.91	71594	Sivagangai and Madurai Districts
8	Gypsum	27.31	1200	Perambalur, Tiruchirappalli, Coimbatore, Ramanathapuram and Tirunelveli Districts.
9	Ilmenite	108.02	-	Occurs as placer deposits along the coastal tracts.
10	Iron ore	482	-	Salem, Namakkal, Dharmapuri and Tiruvannamalai Districts
11	Lignite	32892.92	24.20 MT	Cuddalore District.
12	Limestone	199243	19.26 MT	Ariyalur, Perambalur, Tiruchirappalli, Madurai, Dindigul, Salem, Namakkal, Karur, Thoothukudi, Tirunelveli and Virudhunagar Districts.
13	Magnesite	40.5	177753	Salem, Namakkal, Karur and Tiruppur Districts.
14	Natural Gas	-	1190.65 Million m^3	Nagappattinam, Tiruvarur, Thanjavur, Ramanathapuram and Cuddalore Districts.
15	Quartz & Feldspar	9.48	Q – 23571 F – 85548	Erode, Salem, Coimbatore, Karur, Namakkal, Dindigul and Madurai Districts.
16	Rutile	8.76	-	Occurs as placer deposits along the coastal tracts.
17	Silica Sand	171	125461	Distributed in Coastal areas in Nagapattinam, Cuddalore, Kanchipuram and Thiruvallur Districts.
18	Zircon	0.2	-	Occurs as placer deposits along the coastal tracts.

Source: Department of Geology and Mining, GoTN (personal communication through ENVIS Centre, Chennai).

[1] See http://pib.nic.in/newsite/PrintRelease.aspx?relid=124170.

Pink Coloured Granite Mine At Shokkanur Village, Pollachi Taluk

Table 4.2: Details of Illegal Mining Cases in Tamil Nadu

Year	No. of cases detected for illicit mining /quarrying	No. of vehicles seized	Total Penalty amount collected (Rs. in crores)	No. of criminal cases filed	No. of cases booked under Goonda's Act
2011-12	105	9321	26.74	2093	7
2012-13	228	10547	26.05	3198	11
2013-14	105	10822	32.37	4268	14
2014-15	99	10523	35.39	4798	7
2015-16 (up to July-15)	7	3254	13.45	1466	--

Source: Department of Geology and Mining, GoTN (personal communication through ENVIS Centre, Chennai).

4.1.3 *Climate Change and Land Degradation*

The ratio of precipitation (P) to potential evapotranspiration (PE) provides a simple method of estimating the moisture status of a region. If the ratio is less than one, it would imply that the moisture content of the soil is not sufficient to cope with the needs of evapotranspiration, reflecting dry climate of the region. On the other hand, regions with the P/PE ratio greater than one represent humid climate. Gore et al. (2011) calculated two sets of P/PE values using data from different meteorological stations across Indian states for the periods 1901-1950 and 1941-1990. The changes in P/PE values over the two periods have been examined for understanding the implications of climate change for different moisture conservation zones and associated impact on land. Table 4.3 shows the estimated moisture index for Tamil Nadu. The districts Madurai and Salem (dry sub-humid region) show increase in the ratio P/PE with significant increase at Salem. The district Coimbatore (semi-arid region) and district Thanjavur (dry sub-humid region) show decrease in the ratio P/PE with significant decrease at Coimbatore. The study concludes that in semi-arid regions Coimbatore, Tiruchirappalli, Tirunelveli and Ramanathapuram show land degradation. Thanjavur shows land degradation among the dry sub-humid regions. Out of 18 identified land degraded districts in the semi-arid and dry sub-humid regions, the most significantly degraded parts of the country include Coimbatore district of Tamil Nadu.

Table 4.3: Climate Change and Moisture Index – Tamil Nadu

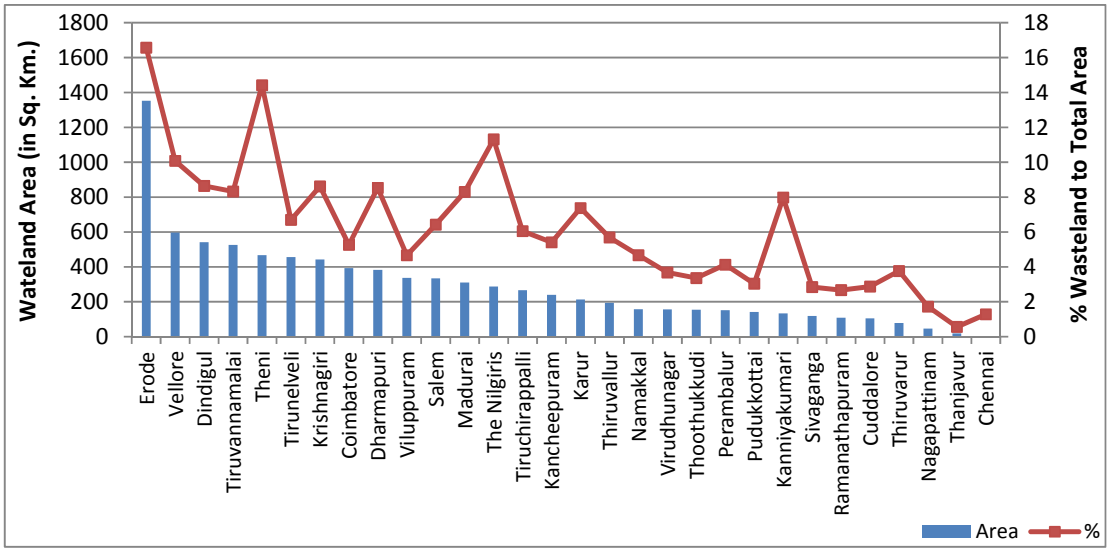
Semi-Arid (P/PE = 0.21-0.50)			**Dry Sub-Humid (P/PE = 0.51-0.65)**		
District	**1901-1950**	**1941-1990**	**District**	**1901-1950**	**1941-1990**
Coimbatore	0.53	0.38	Madhurai	0.51	0.52
Tiruchirappalli	0.42	0.41	Salem	0.49	0.54
Tirunelveli	0.45	0.44	Thanjavur	0.53	0.51
Dharmapuri	-	0.50			
Ramanathapuram	0.50	0.46			

Source: Gore et al. (2011).

4.2 State and Impacts

4.2.1 *Wastelands*

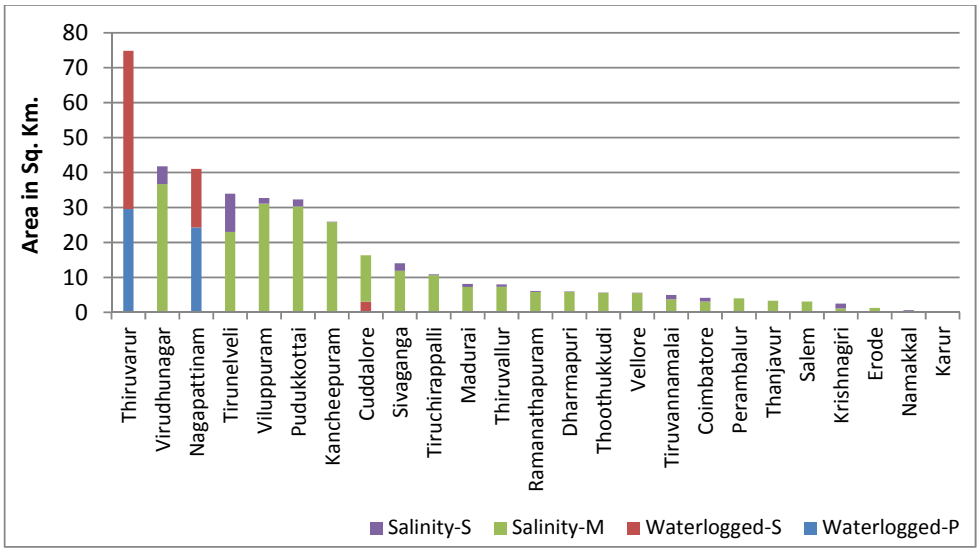
Wastelands include gullied and/ or ravinous land, land with dense/open scrub, waterlogged and marshy land, land affected by salinity/alkalinity, land under shifting cultivation, underutilised/ degraded forest land, degraded pastures/ grazing land/land under plantation crops, riverine/coastal/desertic/semi stab. to stab. sands, mining wastelands, industrial wastelands, barren rocky/stony waste and snow covered/ glacial areas (DoLR and NRSC, 2011). Erode district had the highest wasteland area as well as the highest percentage of wasteland area to total district area in 2008-09, latest year for which data is available (Figure 4.5). Other districts with a high percentage (greater than 10 per cent) of wastelands relative to their total geographical area include Theni, Nilgiris and Vellore. Total area classified as wastelands in Tamil Nadu was around 8,722 square kilometres in 2008-09, which accounted for almost 7 per cent of the total geographical area of the state. The extent of wasteland decreased in the State by 427 square kilometres in 2008-09 vis-a-vis 2005-06 and the wasteland classes – 'degraded pastures', 'degraded forest (scrub dominant)', 'salt affected land (including moderate and strong)' and 'scrubland' contributed to this decrease. Most of these areas were recorded to be converted into 'cropland' and 'plantations' (DoLR and NRSC, 2011). However, during the same period 23 square kilometres of non-wasteland became wasteland, which gives a net decrease of 404 square kilometres of wasteland that was converted to non-wasteland in 2008-09.



Source: DoLR and NRSC (2011).

Figure 4.5: District-Wise Wasteland Area (in Square Kilometres) and Percentage Wasteland Area to Total District Area in 2008-09

In 2008-09, around 387 square kilometres of land was affected by water logging and salinity/alkalinity in Tamil Nadu, which was 23 per cent lower than the area affected in 2005-06. The extent of water logged and marshy area (both seasonal and permanent) was the highest in the districts of Thiruvarur and Nagapattinam (Figure 4.6). All other districts were affected by salinity/alkalinity (medium) to varying degrees (Virudhunagar being the worst affected). Between 2005-06 and 2008-09 almost all districts recorded a decline in the area water logged and affected by salinity except for Maduri, Erode and Thiruvarur, in which the same increased marginally over time. There is some emerging literature documenting the impact of soil salinity in Tamil Nadu (Amarnath and Velmurugan, 2015). However, to carry out detailed analysis one requires comprehensive database on salinity as was reported in a recent study from Bangladesh (Dasgupta et al., 2014).



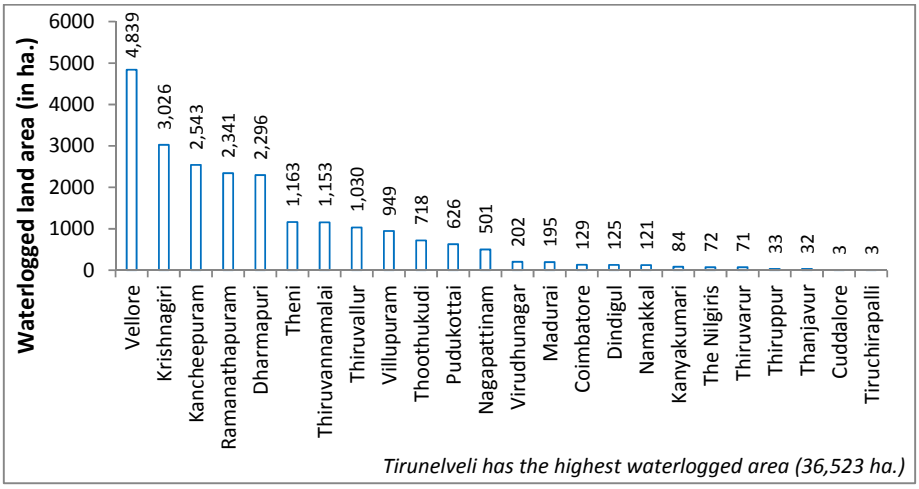
Note: Waterlogged-P= waterlogged & marshy land (permanent); Waterlogged-S= waterlogged and marshy land (seasonal); Salinity-M= land affected by salinity/alkalinity (medium); Salinity-S= land affected by salinity/alkalinity (strong).

Source: DoLR and NRSC (2011).

Figure 4.6: District-Wise Waterlogged & Marshy Area and Land Affected by Salinity/Alkalinity in 2008-09 (in Sq. Km.)

On the basis of the land use classification data for Tamil Nadu (DoES, 2013-14), the total area of land that was waterlogged in Tamil Nadu in 2013-14 was 58,778 hectares. The district-wise breakup is depicted in Figure 4.7. Tirunelveli had the highest waterlogged area by far (36,523 hectares), which accounted for 62.1 per cent of the total waterlogged area in

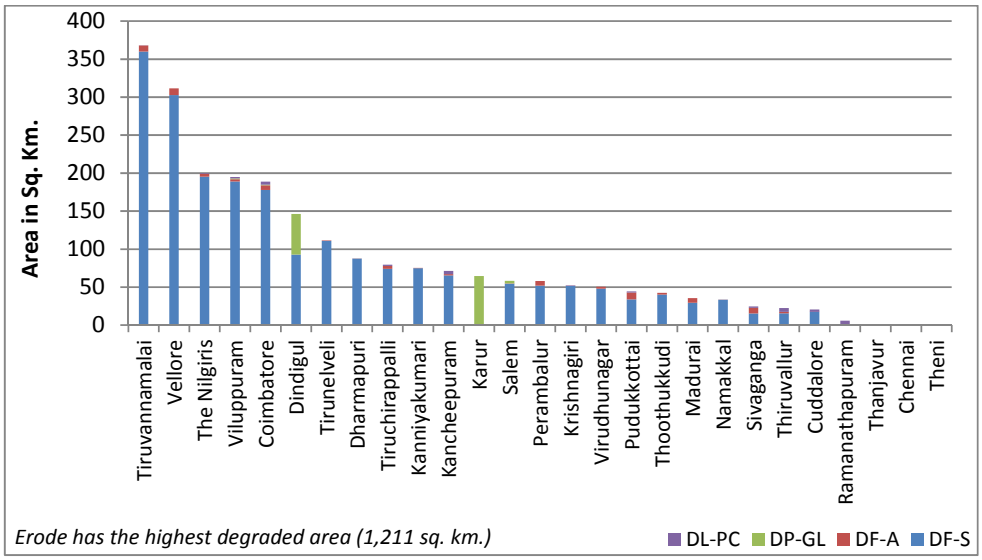
the State in 2013-14. During this year, the districts of Chennai, Salem, Erode, Karur, Perambalur, Ariyalur and Sivagangai had no land area that was waterlogged.



Source: DoES (2013-14).

Figure 4.7: District-Wise Waterlogged Land Area in 2013-14 (in Hectares)

In terms of degraded forest area and degraded pastures and grazing lands, Erode had the highest area under both categories (i.e. 399 square kilometres under degraded forest land, and 812 square kilometres under degraded pastures and grazing land, giving a total of 1,211 square kilometres) in 2008-09, latest year for which data is available (Figure 4.8), however this represented a decline from the 2005-06 total by 8 per cent. In almost all districts, the scrub dominated degraded forest land category dominates the other degraded forest and degraded pasture categories. Between 2005-06 and 2008-09, the area under these wasteland categories declined drastically in the district of Theni (by 99 per cent), however it increased in Tiruchirappalli district by 27 per cent. Overall most districts recorded a decline in the area under degraded forests and pastures over the period 2005-06 to 2008-09, thus total area under this category for Tamil Nadu as a whole declined by 5 per cent from 3,745 to 3,561 square kilometres over that time period.

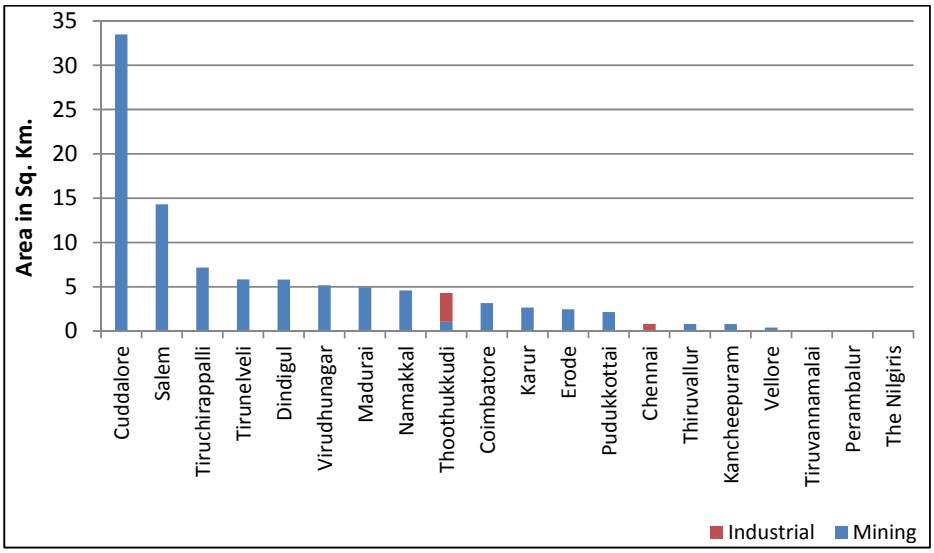


Note: DF-S= underutilised/degraded forest (scrub dominated); DF-A= underutilised/degraded forest (agriculture); DP-GL= degraded pastures/grazing land; DP-PC= degraded land under plantation crops.

Source: DoLR and NRSC (2011).

Figure 4.8: District-Wise Degraded Forest Area and Degraded Pastures in 2008-09 (in Square Kilometres)

District-wise extent of industrial and mining wastelands in Tamil Nadu in 2008-09, latest year for which data is available, is depicted in Figure 4.9. Only two districts namely, Thoothukkudi and Chennai have industrial wastelands, whereas all other districts have a higher proportion of mining wastelands. Cuddalore had the highest extent of mining wastelands in 2008-09 (almost 35 square kilometres), followed by Salem (about 15 square kilometres). Total mining wastelands in Tamil Nadu was 95 square kilometres and industrial wastelands was 4 square kilometres, giving a total of 99 square kilometres in both categories in 2008-09, which represented an increase of about 5 per cent since 2005-06. In a majority of districts, wastelands in these categories increased over the period 2005-06 to 2008-09, particularly in the districts of Namakkal, Tiruchirappalli and Pudukkottai. Perambalur and Vellore, on the other hand, recorded relatively big declines in the area under mining and industrial wastelands over this period.



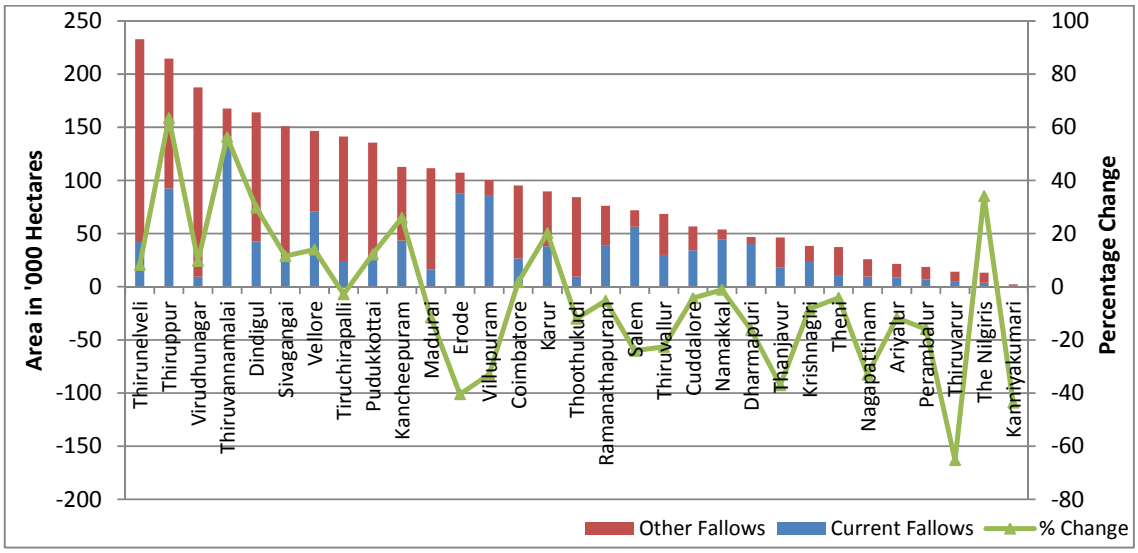
Source: DoLR and NRSC (2011).

Figure 4.9: District-Wise Mining and Industrial Wastelands in 2008-09 (in Square Kilometres)

4.2.2 *Fallow Lands*

Fallow lands comprise of current fallows, which is cropped area that is kept fallow in the current year, and fallow lands other than current fallows that include all land that was under cultivation before but is temporarily out of cultivation for a period of not less than one year and not more than five years. Agricultural land is usually kept fallow to restore its productivity.

Figure 4.10 shows the district-wise extent of fallow lands in Tamil Nadu in 2013-14. Land that has been kept fallow for over a year but less than five years accounts for a greater proportion of total fallow land in a majority of the districts except in Thirvannamalai, Erode, Villupuram, Ramanathapuram, Salem, Cuddalore, Namakkal, Dharmapuri and Krishnagiri in which current fallows dominate. Thirunelveli and Thiruppur districts had the greatest extent of fallow lands in Tamil Nadu in 2013-14, whereas Kanniyakumari had the lowest. Between 2003-04 and 2013-14, there has been an increase in fallow lands in almost all districts that have a high extent of fallow lands in 2013-14. Conversely, many of the districts that have low levels of fallow lands in 2013-14 also experienced a decline in total fallows over the time period 2003-04 to 2013-14.



Note: Area under fallow lands for Thiruppur in 2003-04 is estimated in proportion to geographical land area allocated from Coimbatore and Erode to Thiruppur, and similarly for Ariyalur (in proportion to land area allocated from Perambalur).

Source: DEAR (2003-04); DoES (2013-14).

Figure 4.10: District-Wise Area under Fallow Lands in 2013-14 (in '000 Hectares) and Percentage Change in Fallow Lands between 2003-04 and 2013-14

Table 4.4 shows that the current fallow is inversely proportional to the amount of rainfall. However, in the case of other fallows, this relationship does not hold. One suitable strategy could be to increase the area under cultivation through reclamation of cultivable waste and fallow lands and use of modern irrigation and farm practices to increase farm production in the present conditions of frequent monsoon failures and water scarcity in the state. The other fallows and cultivable waste can be brought under cultivation by suitable reclamation practices, involving investments that will yield very low return. Farmers may not be in a position to make such investments, because most of them are marginal and small farmers.

Table 4.4: Influence of Rainfall on Current Fallow Lands – Tamil Nadu

Year	Rainfall (mm)	Current Fallow (000 ha)	Current Fallow as % of Total Area	Other Fallow (000 ha)	Other Fallow as % of Total Area
1999-00	897	1085	8.4	1140	8.8
2000-01	785	1134	8.7	1228	9.5
2001-02	795	1026	7.9	1409	10.8
2002-03	731	1503	11.6	1491	11.5
2003-04	1035	954	7.3	1863	14.3
2004-05	1079	692	5.3	1704	13.1
2005-06	1304	759	5.8	1518	11.7
2006-07	860	907	7.0	1493	11.5
2007-08	1165	981	7.5	1499	11.5
2008-09	1023	1013	7.8	1498	11.5
2009-10	938	1117	8.6	1542	11.8
2010-11	1165	1015	7.8	1580	12.1
2011-12	937	967	7.4	1594	12.2
2012-13	743	1308	10.0	1696	13.0
2013-14	791	1115	8.6	1718	13.2

Source: DoES (2013-14).

4.3 Responses

4.3.1 *Environmental Clearance for Mining Projects*

All new mining projects and the expansion and modernisation of existing mining projects require environmental clearance from the concerned regulatory authority, which is the Ministry of Environment, Forest and Climate Change (MoEFCC) for mining activities covering 50 hectares or more of the mining lease area (category 'A' projects), and the Tamil Nadu State Environmental Impact Assessment Authority (SEIAA) for mining activities covering less than 50 hectares but greater than or equal to 5 hectares of the mining lease area (category 'B' projects). Central and State –level Expert Appraisal Committees (EACs) are constituted to undertake the screening, scoping and the appraisal of projects. Based on the recommendations provided by the EACs the decision regarding the clearance of the project is taken by MoEFCC or SEIAA for category 'A' or 'B' projects, respectively. Between the period 1st April, 2014 to 31st March, 2015, the Tamil Nadu SEIAA received 1,005 minor

mining lease applications for the mining of minerals in districts all across Tamil Nadu. Over the same period Tamil Nadu SEIAA issued environmental clearance to 642 category 'B' mining project applicants[2].

4.3.2 *Sustainable Mining Practices*

A Sustainable Development Framework (SDF) that comprises of principles, reporting initiatives and good practice guidelines for the mining sector in India has been developed by the Ministry of Mines (MoM, 2011). For this purpose, extensive state level consultations were held with all relevant stakeholders in Tamil Nadu, among other States. Some of the core principles of the SDF include the incorporation of environmental and social sensitivities in decisions on mining leases, managing environmental, social, health and safety impacts at the mine level, addressing resettlement and other social impacts as a result of the displacement caused by mining projects, community engagement and benefit sharing, mine closure and post closure mining operations, and performance reporting. The expected outcomes of the SDF in the long-term include reduced environmental and social conflicts in mining areas, potentially reduced delays in obtaining environmental clearances for mining projects, opening up of illegal mining activities to intensive stakeholder scrutiny and stronger monitoring and assessment systems and processes.

[2] See www.seiaa.tn.gov.in for details.

Chapter 5: Air Pollution

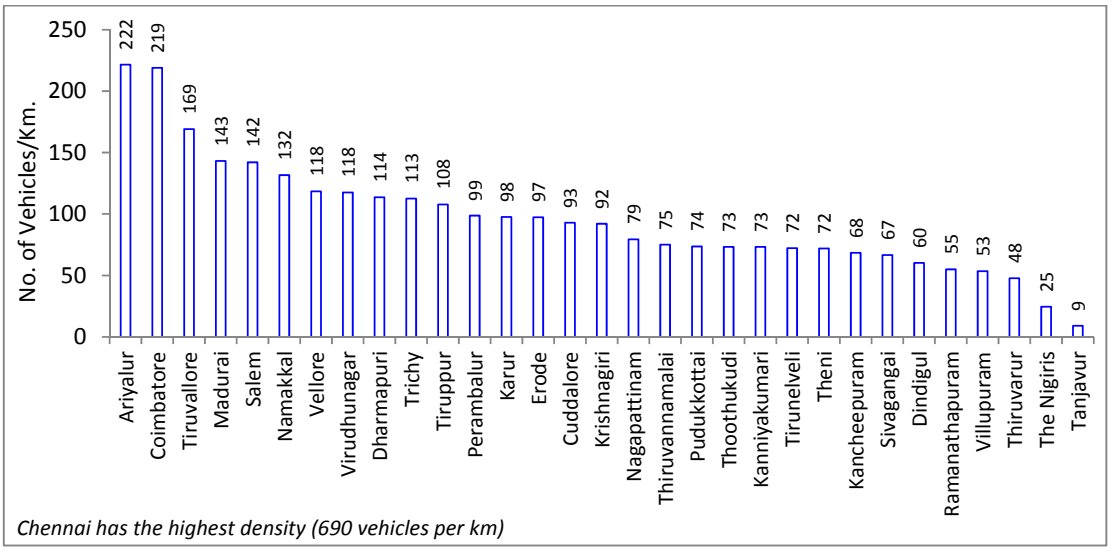
The Indian constitution recognises the need for a clean environment and considers the right to a clean environment synonymous with the right for life. Since clean air is one of the fundamental requirements for the sustenance of life, it is imperative that the maintenance of air quality is one of the main responsibilities of all stakeholders concerned including government agencies. While air pollution has local, regional and global dimensions associated with it, this chapter focuses largely on local and regional air pollution.

5.1 Pressures on Air Quality

5.1.1 *Motor Vehicle Density*

Vehicular pollution is one of the biggest causes of air pollution in cities. The total number of motor vehicles in Tamil Nadu has grown by 125 per cent, from about 8.2 million in 2005-06 to roughly 18.7 million in 2013-14. Figure 5.1 shows the district-wise motor vehicle density in terms of the number of vehicles per kilometre of road length. Chennai, being a metropolitan city, has the highest vehicle density by far in comparison to all other districts. Ariyalur and Coimbatore districts also have relatively high vehicle densities (in excess of 200

vehicles per kilometre of road length). Higher vehicle density implies more traffic congestion and higher emissions of air pollutants from vehicles. The average vehicle density for Tamil Nadu was 123 per kilometre of road length in 2012-13.

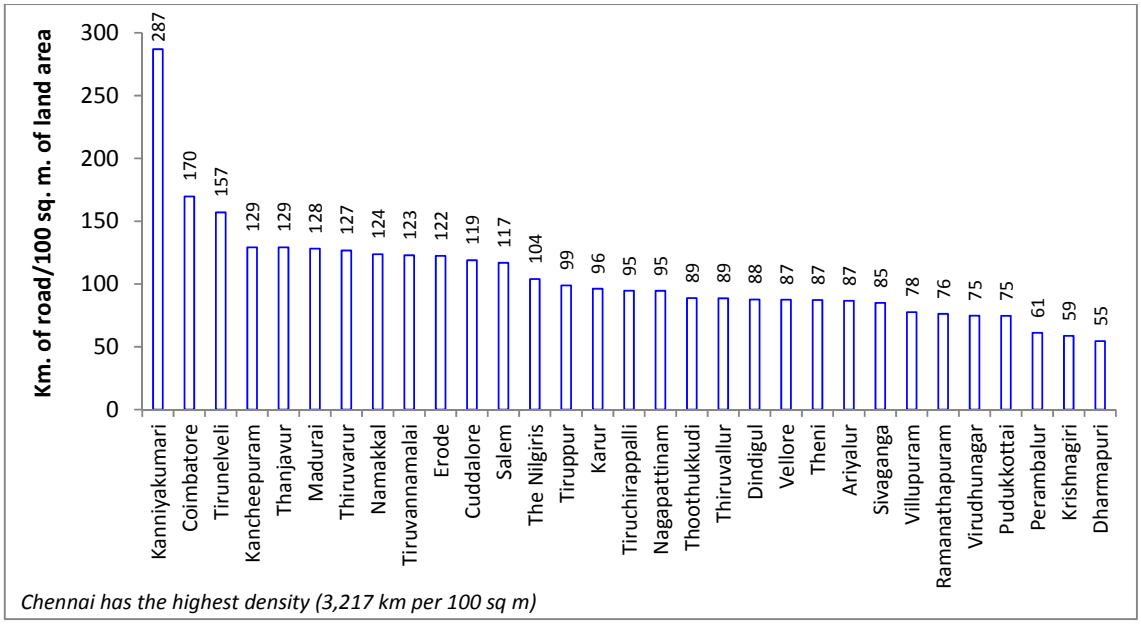


Source: DEAR (2013-14).

Figure 5.1: District-Wise Vehicle Density in Tamil Nadu in 2012-13 (Number of Vehicles per Kilometre of Road Length)

5.1.2 *Road Density and Connectivity*

Road density in terms of kilometres of road per 100 square metres of land area can be used as a proxy for economic development since higher road density implies better connectivity in a given area which in turn leads to higher economic/ industrial growth. High economic development is another major cause of air pollution. Figure 5.2 shows that, the road density in Chennai is the highest. It is about 3,200 kilometres of road per 100 square metres of land area. Kanniyakumari district has the second highest road density in the State at close to 300 kilometres of road per 100 square metres of land area, on average. In terms of rural road connectivity, between 94 to 100 per cent of all rural habitations are connected by roads in all districts of Tamil Nadu (SPC, 2012).



Source: DoES (2014).

Figure 5.2: District-Wise Road Density in Tamil Nadu in 2012-13 (Kilometres of Road per 100 Square Metres of Land Area)

5.1.3 *Industrial Growth*

The sector-wise index of industrial production in Tamil Nadu is as follows (base year 2004-05): mining sector index was 100.5 in 2005-06, which increased by 22 per cent to 122.3 in 2013-14; manufacturing sector index was 116.2 in 2005-06, which increased by 45 per cent to 168.6 in 2013-14; and, electricity sector index was 101.7 in 2005-06, which increased by 28 per cent to 129.7 in 2013-14 (DEAR, 2009-10 and 2013-14).

As discussed in Chapter 1, the major industries in Tamil Nadu are the automobile, sugar, cement, fertiliser and textile industries. The tables that follow (Table 5.1 to 5.3) give an indication of their performance in recent years and their production trends in comparison to all-India trends. Significant industrial activity has the associated environmental externalities, in particular air pollution.

Table 5.1: Production Trends of the Automobile Industry with a base in Tamil Nadu (in Numbers)

Category/ Company	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11
Ford India	27,119	41,465	38,287	26,708	39,222	1,12,615
Hyundai	2,60,466	3,14,654	3,67,242	5,02,218	5,89,536	5,94,601
Nissan	0	0	0	0	0	75,029
BMW	0	144	2,107	2,426	2,765	5,740
Hindustan Motors	15,115	13,420	12,240	8,928	10,656	9,757
Passenger Vehicles (a)	3,02,700	3,69,683	4,19,876	5,40,280	6,42,179	7,97,742
% TN Share in All-India Prodn.	*23*	*24*	*24*	*30*	*27*	*27*
All India Passenger Vehicles Total	13,09,300	15,45,223	17,77,583	18,38,593	23,57,411	29,87,296
Ashok Leyland	65,085	83,549	84,006	54,049	64,673	95,337
JCBL	0	0	0	0	179	67
Kamaz Vectra Motors	123	61	43	10	0	0
Daimler	4,958	4,325	4,060	2,378	4,189	4,826
Hindustan Motors	338	201	16	54	278	345
Commercial Vehicles (b)	70,504	88,136	88,125	56,491	69,319	1,00,575
% TN Share in All-India Prodn.	*18*	*17*	*16*	*14*	*12*	*13*
All India Commercial Vehicles Total	3,91,083	5,19,982	5,49,006	4,16,870	5,67,556	7,52,735
Two and Three Wheelers (c)	13,97,287	15,46,081	13,12,802	13,66,445	15,88,158	21,29,592
Tamil Nadu Total Production (a+b+c)	17,70,491	20,03,900	18,20,803	19,63,216	22,99,656	30,27,909
% TN Share in All-India Prodn.	*18*	*18*	*17*	*18*	*16*	*17*
All India Automobile Production	97,43,503	110,87,997	108,53,930	111,72,275	140,57,064	179,16,035

Source: DEAR (2009-10, 2013-14).

The automobile industry in Tamil Nadu is mostly concentrated in Chennai. Tamil Nadu produced roughly 27 per cent all-India passenger vehicles and 13 per cent of all-India commercial vehicles in 2010-11.

Table 5.2: Production Trends of the Sugar Industry in Tamil Nadu

Parameters	Tamil Nadu			All India		
	2004-05	2009-10	2012-13	2004-05	2009-10	2012-13
Total Number of Mills	34	37	46	400	490	526
Installed Crushing Capacity (Tonnes Crushed Per Day)*	1,01,150	1,40,150	1,39,900	190	238	250
Cane Utilisation (Lakh Tonnes)	115	146	215	1,248	1,855	2,506
Sugar Production (Lakh Tonnes)	11	13	19	127	189	251
Recovery Rate (%)	10	9	9	10	10	10
Levy Sugar Ratio	-	80:20	90:10	-	80:20	90:10
Minimum Statutory Price (Rs. Per Tonne)	-	-	-	745	1,298	1,700
State Advised Price (Rs. Per Tonne)	1,014	1,537	2,350	-	-	-

Note: * unit is Lakh Tonnes for all-India values. Source: DEAR (2009-10, 2013-14).

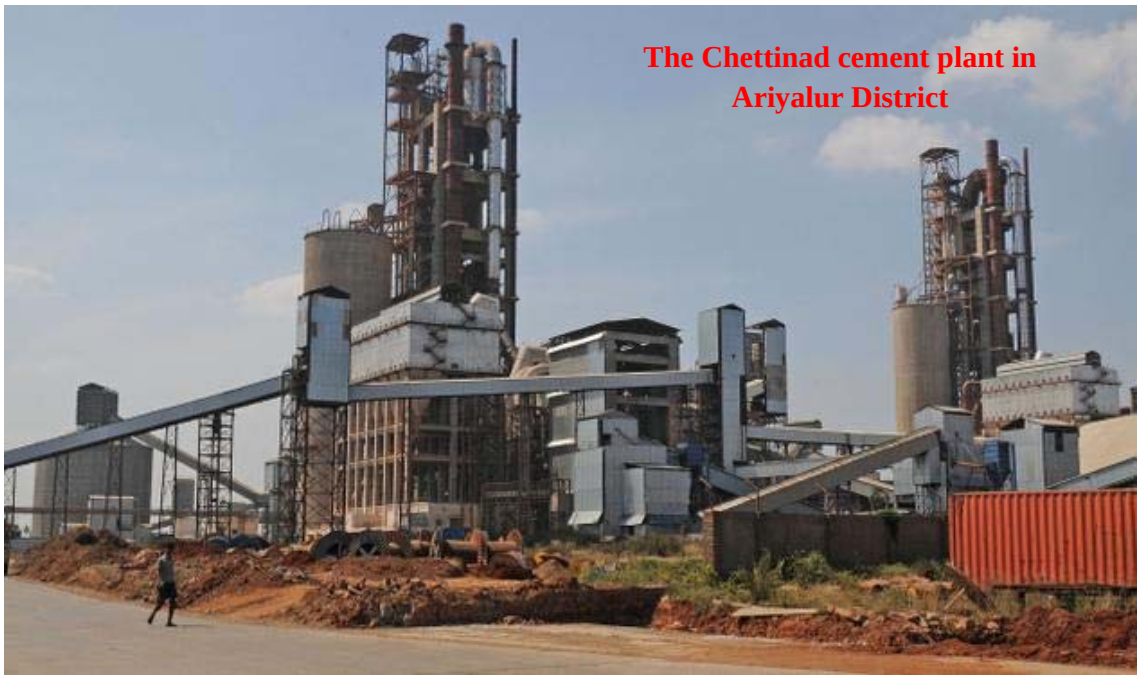
Tamil Nadu's sugar production increased by approximately 72 per cent between the period 2004-05 and 2012-13. The share of Tamil Nadu's sugar production in all-India production was roughly 8 per cent in 2012-13.

Table 5.3: Performance of the Cement Industry in Tamil Nadu

Sector/Group	Annual Installed Capacity (Million Tonnes)			Production (Million Tonnes)			Capacity Utilisation (%)		
	2004-05	2009-10	2011-12	2004-05	2009-10	2011-12	2004-05	2009-10	2011-12
I. Private Sector	**13.66**	**32.14**	**34.66**	**11.79**	**20.13**	**21.17**	**86**	**69**	**62**
ACC, Madukkarai	-	0.96	1.18	-	-	0.72	-	-	61
Chettinad Cement	-	8.20	10.50	-	4.00	5.13	-	49	66
Dalmai Cement	-	6.50	6.50	-	3.32	4.15	-	51	40
India Cements	-	5.86	5.86	-	4.72	4.04	-	81	68
Madras Cement	-	8.12	8.12	-	5.78	5.35	-	71	64
Ultra Tech Cement	-	2.50	2.50	-	2.31	1.78	-	92	72
II. Public Sector (Tancem)	**0.90**	**0.90**	**0.90**	**0.81**	**0.72**	**0.90**	**90**	**80**	**56**
III. Tamil Nadu Total	**14.56**	**33.04**	**35.56**	**12.60**	**20.85**	**22.07**	**87**	**63**	**61**
IV. All-India Total	**159.8**	**203.98**	**244.05**	**125.56**	**160.30**	**180.59**	**84**	**79**	**75**

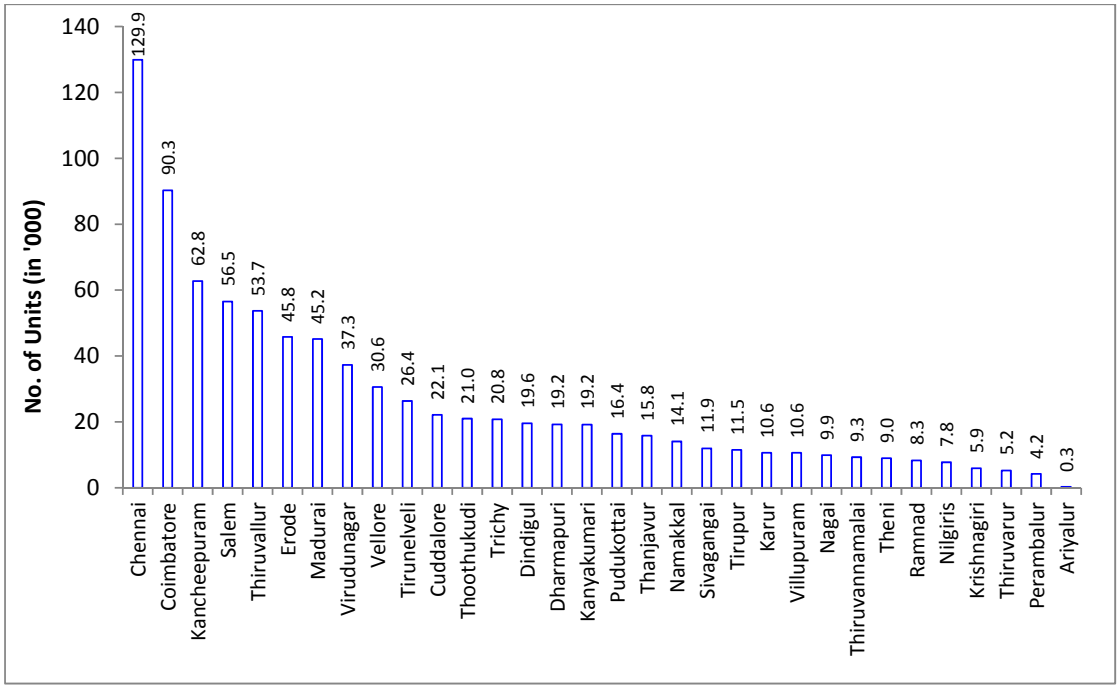
Source: DEAR (2009-10, 2013-14).

In 2011-12, Tamil Nadu produced 12 per cent of the total cement production in India. Moreover, Tamil Nadu's own share of cement production increased by 75 per cent between 2004-05 and 2011-12.



The Chettinad cement plant in Ariyalur District

Figure 5.3 presents district-wise number of SSI permanent units or Micro Small and Medium Enterprises (MSME) in Tamil Nadu in 2012-13. Chennai has the highest number of SSIs, followed by Coimbatore and Kancheepuram districts. Total SSIs in Tamil Nadu were in excess of 851 thousand in 2012-13, with 20 per cent of the total units belonging to the hosiery and readymade garments industry group and about 7-8 per cent each belonging to the food products, textiles and metal products and parts industrial groupings. Total SSIs in Tamil Nadu increased by about 73 per cent between 2004-05 and 2012-13.



Source: DEAR (2013-14).

Figure 5.3: District-Wise Number of Small Scale Industry Permanent Units in Tamil Nadu in 2012-13 (in '000s)

Tamil Nadu has five thermal power plants, which accounted for almost 82 per cent (see Table 5.4) of the State's own generation of electricity in 2012-13 (DoES, 2014).

Table 5.4: Tamil Nadu Thermal Power Plant Specifics in 2014-15

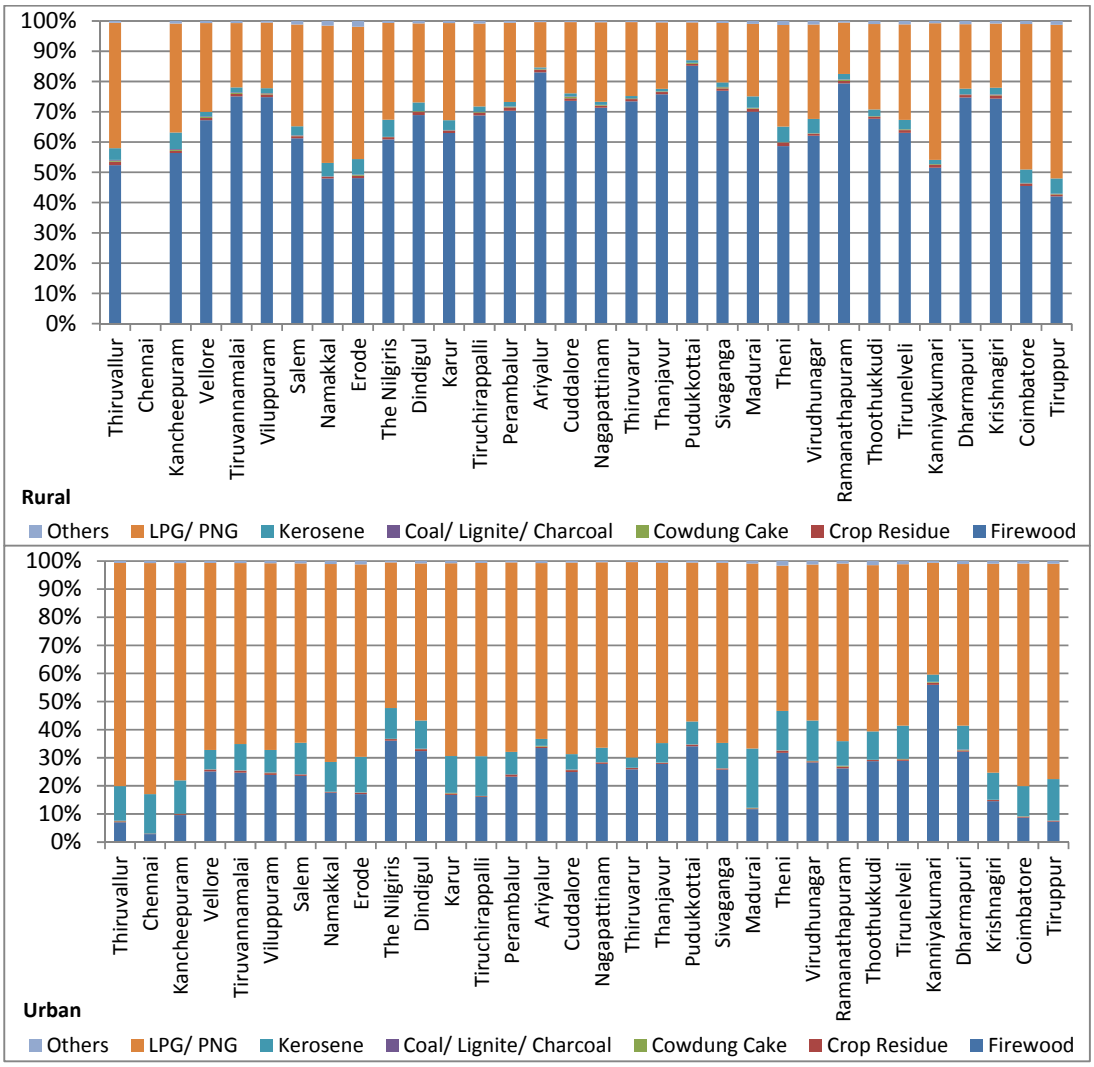
Thermal Power Station	Installed Capacity (MW)	Gross Generation (MU)	Plant Load Factor (%)	Coal Consumption (Lakh tons)	Heat Rate (kCal/kWh)
Ennore	340	604.831	20.31	7.21	3845
North Chennai – I	630	4260.807	77.211	31.93	2512
North Chennai – II	1200	5585.682	53.14	43.496	2843
Tuticorin	1050	7673.24	83.42	63.73	2543
Mettur – I	840	6232.972	84.71	48.384	2620
Mettur – II	600	3022.33	57.50	21.59	2502

Source: DEAR (2013-14); TANGEDCO (personal communication through ENVIS Centre, Chennai).

5.1.4 *Use of Solid Fuels for Cooking*

In rural Tamil Nadu, 67 per cent of households use firewood as primary fuel for cooking, 1 per cent use crop residue, 3 per cent use kerosene and 29 per cent use LPG. Thus, approximately 68 per cent of all households use solid fuels as primary fuel for cooking in rural Tamil Nadu. In urban Tamil Nadu, 69 per cent of all households use LPG, 18 per cent use firewood and 11 per cent use kerosene. Thus, the number of households using solid fuels for cooking is significantly lower in urban Tamil Nadu compared to the rural sector (Census, 2011).

Use of solid fuels contributes to indoor air pollution, and effects women, children and elderly people within the house. The district-wise distribution of households by the type of fuel used for cooking is presented in Figure 5.4. The district-wise trends are largely reflective of the State–level trends for each sector. Within the rural sector, Viluppuram, Vellore and Tiruvannamalai districts have households in excess of 3,50,000 that use solid fuels as their primary source of cooking. Within the urban sector, Kanniyakumari has the highest number of households using solid fuels (in excess of 2,00,000).

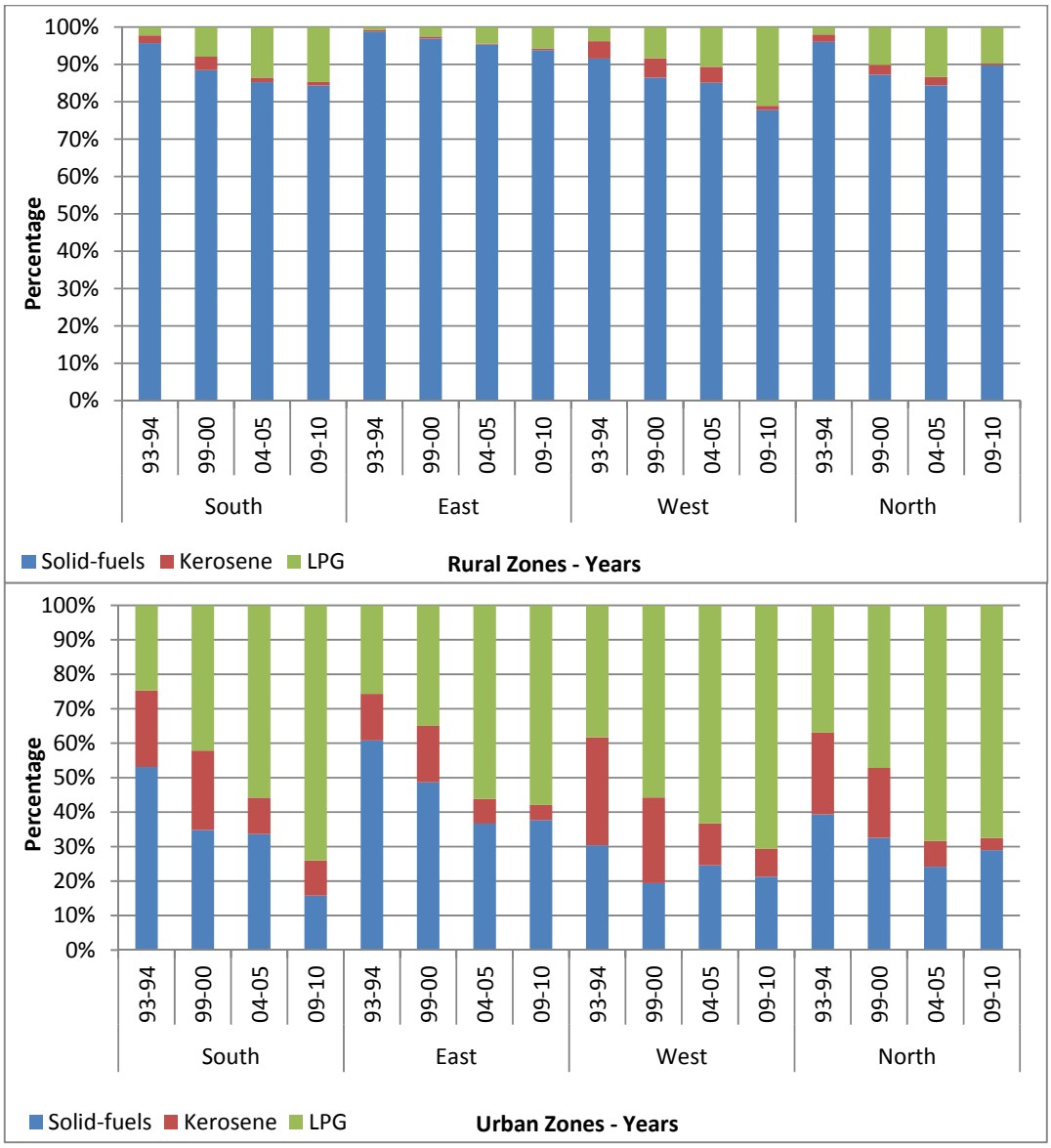


Source: Census (2011).

Figure 5.4: District-Wise Distribution of Households in Tamil Nadu by Type of Fuel Used for Cooking in 2011 (in Percentage)

There are significant regional differences in India in terms of the consumption of solid fuels. Using the National Sample Survey data, Figure 5.5 shows the percentage of households using solid fuels (including firewood, coal/coke, dung cake etc.), kerosene and LPG as primary source for cooking in different geographical zones for four different years in the past fifteen years for rural and urban India, respectively. In rural India, barring the Eastern Indian states, the rest of the states showed some penetration of LPG with about 10 to 14 per cent of households reporting this fuel as primary source for cooking in the year 2009-10. The Western Indian states showed a dramatic shift towards LPG largely from firewood in the period between 2004-05 and 2009-10.

In urban India, penetration of LPG has been very impressive with all the regions having more than 55 per cent of the households consuming LPG as primary cooking fuel in the year 2009-10. Further, in all the regions, kerosene served as transition fuel. In terms of the solid fuels, the Southern states (that include Tamil Nadu) have registered impressive reduction during the period between 2004-05 and 2009-10 compared to other geographic zones.



Note: Zones are groups of states: South Zone – Andhra Pradesh, Karnataka, Kerala, Tamil Nadu; East Zone – Bihar, Orissa, Assam, West Bengal; West Zone – Gujarat, Maharashtra, Rajasthan; North Zone – Haryana, Punjab, Madhya Pradesh, Uttar Pradesh.

Source: Kumar and Viswanathan (2013).

Figure 5.5: Distribution of Cooking Fuels across Years and Zones of India

5.1.5 *Burning of Agricultural and Solid Wastes*

According to IARI (2012), Tamil Nadu generates about 19.93 million tonnes of crop residue per year (mainly comprising of residue generated from cereal, sugarcane, oilseed and fibre crops) of which the remaining surplus is 7.05 million tonnes per year. Crop residue burnt in Tamil Nadu ranges from 3.62 – 4.08 million tonnes per annum, based on different estimates (IPCC, Pathak et al. etc.). Burning of crop residue leads to the release of soot particles, which can have an adverse impact on human health. Open burning of solid waste is one of the largest sources of air pollution in India. It releases particulate matter, carbon monoxide and hydrocarbons that are harmful to human health. While the burning of solid wastes is not permitted by law, compliance is an issue. Waste is burned on a regular basis on dumping sites as well as on the roadside.

5.2 State of Air Quality

5.2.1 *Air Pollution Levels in Major Cities*

The annual average concentrations of air pollutants in the major cities of Tamil Nadu in 2013-14 are given in Table 5.5. The annual average levels of both SO_2 and NO_2 were well within the prescribed standards (of 50 $\mu g/m^3$ for SO_2 and 40 $\mu g/m^3$ for NO_2 for industrial, residential, rural and other areas) in all locations. Having said that, the maximum recorded NO_2 values exceeded the standard in two locations in Chennai. Mean RSPM levels exceeded the prescribed standard (of 60 $\mu g/m^3$) in almost all locations except, among others, those in Madurai, in which mean RSPM levels were the lowest. Three locations each in Chennai and Trichy and one location in Thoothukudi recorded mean RSPM levels in excess of 100 $\mu g/m^3$; stations in which such high levels were observed are situated mainly at traffic intersections or in commercial and industrial areas.

A comparison of the 2013-14 air quality data for Tamil Nadu (Table 5.5) with the same in 2008-09 (DoE, 2014) reveals that the average annual SO_2 concentrations increased in all locations in Chennai (by between 10 – 70 per cent), Madurai (35 – 60 per cent) and Trichy (10 – 30 per cent) whereas the same reduced in all locations in Thoothukudi (by roughly 50 – 65 per cent) and Coimbatore (by about 20 – 30 per cent), over time. During the same period, mean NO_2 concentrations decreased in all industrial locations in Chennai (by 10 – 15 per cent) and in all locations in Coimbatore (by 15 – 25 per cent) and Madurai (by about 5 per cent). However, the same increased in most residential and commercial locations in Chennai

(by 5 – 75 per cent) and Trichy (by 5 – 15 per cent), and in the industrial locations of Thoothukudi (by 16 per cent). During the period 2008-09 and 2013-14, RSPM concentrations decreased in certain locations in Tamil Nadu including Thiruvottiyur, SIDCO, AVM Buildings, M/s. Susee Cars and Trucks (P) Ltd. and Salem (by between 5 – 45 per cent). The same increased in all other locations of Tamil Nadu (by about 1 – 50 per cent).

In a recent study, Mariappan et al. (2013) analysed the pollution from vehicles and thermal power stations in Tamil Nadu. The study showed that while pollution from vehicles exerts more influence on SO_2 and NO_x concentrations, the pollution from thermal power plants contributes more to the SPM levels.

The National Air Quality Index, launched recently by the Central Pollution Control Board (see Box 5.1 for more details) is expected to provide a comprehensive picture of the state of air quality and the impacts associated with worsening air quality.

Table 5.5: Annual Average Concentrations of Air Pollutants in Major Cities of Tamil Nadu in 2013-14 (in µg/m^3)

City	Location	Category	SO_2			NO_2			RSPM		
			Max	Min	Avg	Max	Min	Avg	Max	Min	Avg
Chennai	Kathivakkam	Industrial	18	13	15	19	15	17	75	37	53
	Manali	Industrial	18	13	15	19	16	18	71	28	46
	Thiruvottiyur	Industrial	17	13	15	19	16	18	78	36	54
	Anna Nagar	Residential	17	8	13	36	16	22	159	72	101
	Adyar	Residential	16	9	12	30	16	21	69	41	55
	Kilpauk	Commercial (Traffic intersection)	23	16	12	42	18	27	169	80	111
	Thiyagarayanagar	Commercial (Traffic intersection)	26	10	16	42	20	29	189	90	121
Coimbatore	DCO	Mixed	5	4	4	31	22	25	55	29	44
	Ponaiyarajapuram	Residential	4	4	4	31	19	23	62	23	49
	SIDCO	Industrial	5	4	4	34	23	28	77	45	60
Thoothukudi	Raja Agencies	Industrial	15	11	13	28	19	22	160	58	102
	AVM Buildings	Mixed	12	9	10	29	17	13	105	44	67
	SIPCOT	Industrial	16	12	14	25	19	22	98	49	74
Madurai	M/s. Susee Cars & Trucks (P) Ltd.	Industrial	21	12	15	31	19	23	52	24	33
	Madurai Corporation Office (SZ)	Mixed	19	13	16	28	21	24	63	33	44
	Highways Project Buildings	Residential	17	10	14	28	18	22	41	29	35
Salem	Sowdeswari College Building	Mixed	9	8	9	29	23	25	85	48	61
Trichy	Gandhi Market	Commercial	19	14	17	23	19	21	120	17	105
	Main Guard Gate	Traffic intersection	19	17	14	24	18	21	131	109	118
	Bishop Heber College	Mixed	12	10	11	16	13	15	50	39	43
	Golden Rock	Residential	15	11	12	17	14	15	95	40	51
	Central Bus Stand	Traffic intersection	18	14	16	22	19	21	224	108	127
Cuddalore	Eachangadu Village	Residential	12	7	9	25	13	20	102	29	65
	DEE Office	Commercial	12	6	8	25	13	20	98	27	63
	SIPCOT	Industrial	9	6	8	22	13	19	85	35	58
Mettur	Raman Nagar	Residential	8	5	7	25	19	21	67	39	49
	SIDCO	Industrial	11	9	10	30	20	27	89	44	64
Prescribed standards (annual average) for industrial, residential, rural & other areas				***50***			***40***			***60***	

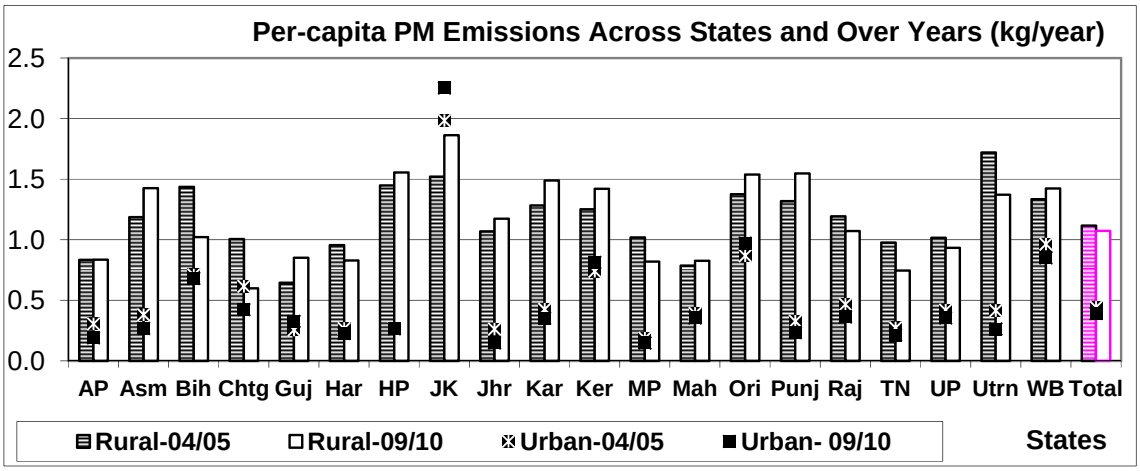
Source: TNPCB (personal communication through ENVIS Centre, Chennai).

5.2.2 *Indoor Air Pollution Levels*

Several factors including the kitchen dimensions, ventilation, fuel composition and stove efficiency can influence the particulate matter concentration resulting from the use of solid cooking fuels. Thus, continuous monitoring is essential to know the exact status of particulate matter emissions and concentrations within the household. However, with reasonable assumptions about the kitchen and fuel, it is feasible to arrive at reasonably accurate estimates of particulate matter emissions based on the information about the consumption of various fuels by the household. Kumar and Viswanathan (2013) provide state-wise per-capita estimates of particulate emissions from the rural and urban households for the years 2004-05 and 2009-10.

Figure 5.6 reports the particulate matter emissions estimated across states by Kumar and Viswanathan (2013). As can be seen from the figure, the particulate matter emissions are lower among the urban households on an average across all states in both 2004-05 and 2009-10. The per-capita particulate matter emissions in Jharkhand are an exception to this general observation. This could possibly be due to greater availability of solid fuels like coal. The per-capita local pollution among the rural households shows substantial changes for several states over the two years considered. While per-capita PM emissions increased in Assam,

Gujarat, Jammu and Kashmir, Himachal Pradesh, Jharkhand, Karnataka, Kerala, Orissa, Punjab, and West Bengal, they decreased in Bihar, Chhattisgarh, Haryana, Madhya Pradesh, Rajasthan, Tamil Nadu, Uttarakhand, and Uttar Pradesh.



Source: Kumar and Viswanathan (2013).

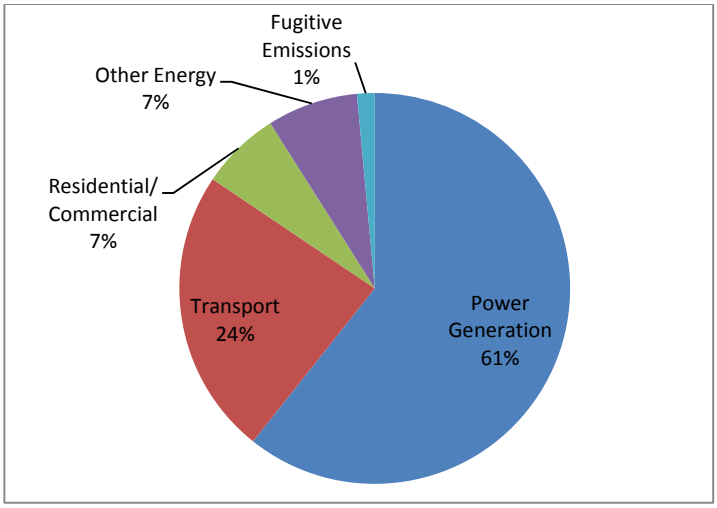
Figure 5.6: Per-capita Particulate Matter Emissions across States and Years (in kg/year)

5.2.3 *Greenhouse Gas Emissions*

Greenhouse gases including carbon dioxide, methane, nitrous oxide and other gases also constitute air pollution, albeit these emissions adversely influence the climate and lead to global warming/climate change. The greenhouse gas emissions are associated broadly with the sectors such as energy (e.g., electricity generation, transport, residential and commercial activities); agriculture (e.g., enteric fermentation, rice cultivation, burning of crop residue); industries (e.g., minerals, metals, cement); land use, land use change and forestry (e.g., forest land and crop land conversion); and waste (e.g., municipal solid waste, waste water). A recent study by CII (2012) provided an estimate of Tamil Nadu's carbon footprint for the year 2009-10. This section draws largely from the findings of this report.

Electricity generation from eight TNEB power plants – Ennore Thermal Power Station, Tuticorin Thermal Power Station, Mettur Thermal Power Station, North Chennai Thermal Power Station, Basin Bridge Gas Thermal Power Station, Kuttalam Gas Thermal Power Station, Valuthur Gas Thermal Power Station, and Thirumakottai Gas Thermal Power Station; Neyveli Lignite Corporation; captive power plants and independent power producers has been considered in estimating the GHG emissions. Total GHG emissions from electricity generation were estimated as 51.4 million tons of CO_2eq for the year 2009-10.

Considering roadways and railways as main constituents of GHG emissions from the transport sector, CII (2012) estimated the total emissions for 2009-10 as 20.9 million tons of CO_2eq, with the roadways contributing to almost 90 per cent of these emissions. The emissions from the aviation and navigation sector have not been included in the transport sector emissions due to difficulty in attribution. At the residential level, greenhouse gas emissions are mainly due to cooking and lighting fuels consumed namely kerosene and LPG. Total GHG emissions attributed to this sector for 2009-10 stands at 5.5 million tons of CO_2eq. Overall, the total GHG emissions from the energy sector are estimated as 84.72 million tons of CO_2eq. Figure 5.7 shows the distribution of GHG emissions from the energy sector.



Source: CII (2012).

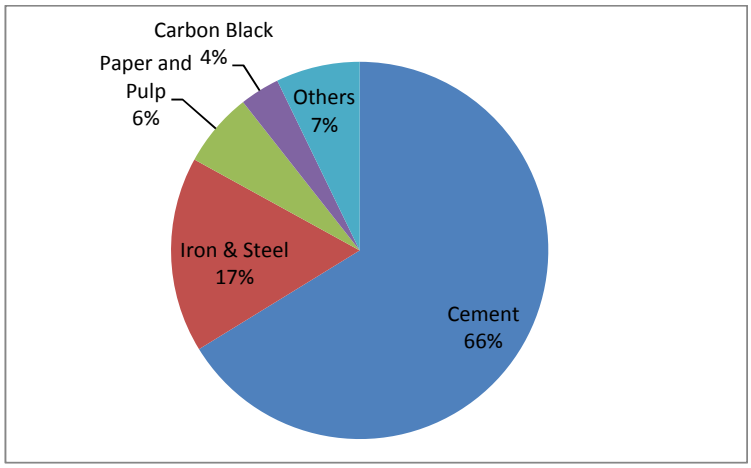
Figure 5.7: GHG Emissions from Energy Sector in Tamil Nadu

Based on the livestock census data corresponding to the years 1997 and 2003, the livestock population for the year 2009 has been estimated. The livestock includes 9236 cattle, 1003 buffalo, 5948 sheep, 10421 goats, and 169 pigs. Methane emissions from enteric fermentation are estimated by multiplying the livestock population of each species with the respective emission factor. For the year 2009 it is estimated that the bovines contributed around 0.3 million tons of methane emissions.

The rice fields being one of the largest sources of methane emissions, CII (2012) study estimated the methane emissions from the paddy fields of Tamil Nadu to be 0.17 million tons for the year 2009. The other GHG emission sources from agricultural sector include agricultural soils and burning of crop residues. Overall the GHG emissions from the agriculture sector have been estimated as 16.42 million tons of CO_2eq.

Emissions and removals of GHGs are estimated by calculating the sum of changes in stocks over a period of time, which are then averaged further to assess annual stock change. The land use change matrix is constructed by analysing the land use for the years 2008 and 2009 in Tamil Nadu. In addition to land use changes, emissions are also accounted for the use of fuel wood by the households for cooking purposes. Overall, for the year 2009-10, CII (2012) estimated removal of GHG emissions to the tune of 7.56 million tons of CO_2eq.

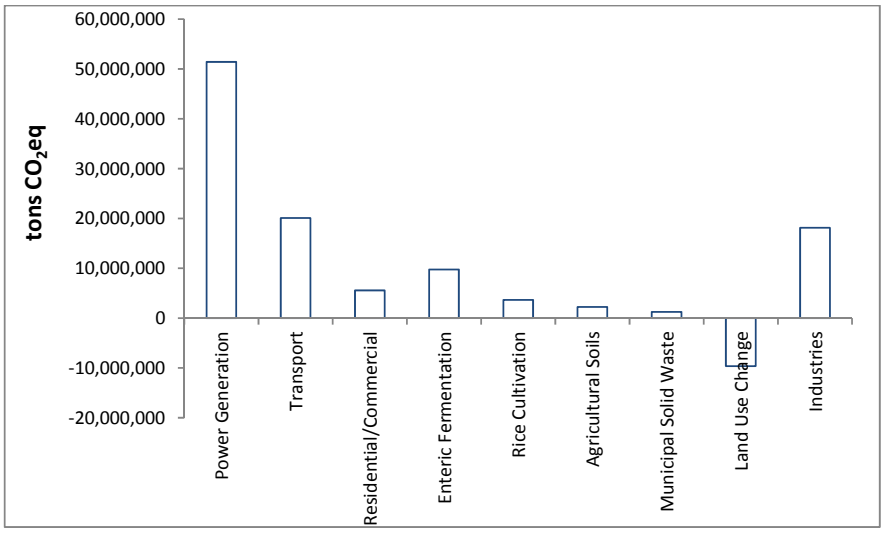
With an installed capacity of 21 million tons per annum, cement is one of the main sources of GHG emissions in the industrial sector in Tamil Nadu. The other major contributors include iron and steel, paper and pulp, textile and fertilizer industries. The export oriented industries (leather) and engineering units, though present in high concentration in Tamil Nadu consume relatively large amount of electrical energy compared to thermal energy, which has already been accounted under the energy sector emissions. Overall emissions from the industrial sector for the year 2009-10 were estimated as 18.1 million tons of CO_2eq. Figure 5.8 shows the distribution of GHG emissions from the industrial sector in Tamil Nadu.



Source: CII (2012).

Figure 5.8: GHG Emissions from Industrial Sector in Tamil Nadu in 2009-10

Overall, the total GHG emissions for the year 2009-10 have been estimated as 111.86 million tons CO_2eq, which correspond to the state per capita emissions of about 1.59 tons of CO_2eq. Figure 5.9 provides details of the sectoral emissions for Tamil Nadu.

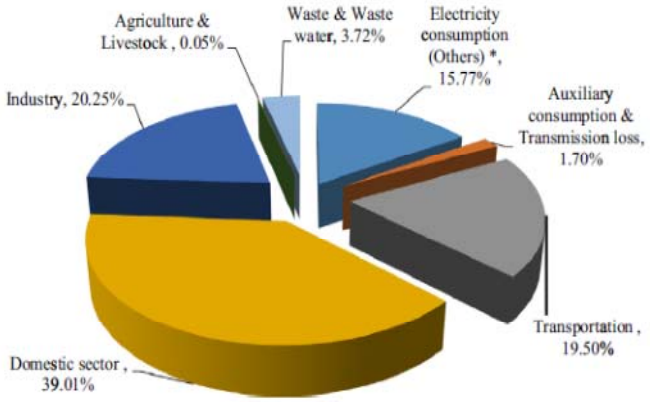


Source: CII (2012).

Figure 5.9: Greenhouse Gas Emissions from Major Sources in Tamil Nadu, 2009-10

A recent study by Ramachandra et al. (2015) provided estimates of GHG emissions from major cities of India including Delhi, Mumbai, Kolkata, Chennai, Hyderabad, Bangalore and Ahmedabad for the year 2009-10. Figure 5.10 shows the GHG footprint of Chennai for the year 2009-10. With about 4.79 tons of CO_2eq emissions per person, Chennai tops the list of major cities in terms of GHG emission. The study further indicates that

Chennai emits the highest CO_2eq emissions per GDP at 2.55 tons of CO_2eq per lakh rupees. Notwithstanding slightly lower population data used by Ramachandra et al. (2015) for Chennai (which resulted in fairly high per capita emissions from the city), the study highlights the significant pressure that metropolitan cities such as Chennai exert through their GHG emissions on climate change.



Source: Ramachandra et al. (2015).

Figure 5.10: GHG Footprint of Chennai, 2009-10 (CO_2eq emissions, Gg)

5.3 Impacts due to Air Pollution

Several studies have been conducted on the health and economic impacts of pollution. For example, World Bank (1995) for the first time provided an aggregate economy-wide estimate of cost due to environmental pollution in India. The study estimated the health impact of water pollution to be $5,710 million and the agricultural output loss due to soil degradation as $1,942 million. The health impacts of air pollution were assessed as $1,310 million and the loss of live-stock carrying capacity due to rangeland degradation was found to be $328 million. The cost of deforestation was $214 million while the loss of international tourism was $213 million. The total environmental damage was $9.7 billion per year, or 4.5 per cent of GDP in 1992 values.

In a subsequent estimate, the World Bank (2005) assessed that the annual economic cost of damage to public health from increased air pollution alone based on RSPM measurements for 50 cities with the total population of 110 million was close to US$ 3 billion in 2004. Recently Mani et al. (2012) provided an estimate of social and financial costs of environmental damage in India by focusing on urban air pollution, indoor air pollution and inadequate water supply, poor sanitation and hygiene. This study estimated the total annual

cost of environmental degradation in India at 3.75 trillion rupees, equivalent to 5.7 per cent of gross domestic product in 2009.

Balakrishnan et al. (2001) in a study of Thiruvottiyur municipality in North Chennai carried out the health risk assessment and economic valuation of health damages associated with pollution using the dose response information. The study also performed health impact assessment and economic valuation from cross-sectional epidemiological information gathered through a household survey. The total cost was obtained by summing the cost of treatment, wage loss and defensive expenditure for respiratory, gastro-intestinal and vector-borne illness. The total annual cost was found to be Rs. 1,652 lakhs of rupees for respiratory illness, Rs. 2,363 lakhs of rupees for gastro-intestinal disorders and Rs. 1,757 lakhs of rupees for vector-borne illness. The annual treatment cost was found to be Rs. 3,052 lakhs of rupees; the wage loss came to Rs. 2,391 lakhs of rupees and the defensive expenditure has been estimated as Rs. 328 lakhs of rupees. The calculations from the study showed that the health costs associated with air pollution were high in the North Chennai region. With the increase in pollution levels the health costs now could be much higher.

The use of solid fuels for cooking leads to serious health hazards due to particulate matter that is inhaled from household air pollution. Health impacts of indoor air pollution include premature death from non-communicable diseases such as stroke, ischaemic heart disease, chronic obstructive pulmonary disorder (COPD) and lung cancer. The NFHS-3 data for Tamil Nadu (IIPS, 2008) shows that in 2005-06, 648 out of 1,00,000 people who suffered from tuberculosis used solid fuels for cooking, whereas only 297 out of 1,00,000 people who suffered from tuberculosis used other fuels for cooking. This disparity is higher for the rural sector with 805 out of 1,00,000 people who used solid fuel for cooking suffering from tuberculosis as opposed to 168 out of 1,00,000 people who used other fuels suffering from the same in 2005-06. The data for Chennai gives a similar picture; 1,792 out of 1,00,000 people who suffered from tuberculosis used solid fuels for cooking, whereas only 366 out of 1,00,000 people who suffered from tuberculosis used other fuels for cooking in 2005-06.

5.4 Response

5.4.1 *TNPCB Monitoring Network*

The Tamil Nadu Pollution Control Board monitors the status of air quality in important cities and towns of Tamil Nadu including Chennai, Coimbatore, Thoothukudi, Madurai, Salem, Trichy, Cuddalore and Mettur (as detailed in Table 5.5) under the National Air Quality

Monitoring Programme (NAMP). This information is published as annual, monthly and even daily data records for certain cities (e.g. Chennai[1]). The National Ambient Air Quality Standards (NAAQS) are shown in Table 5.6.

Table 5.6: National Ambient Air Quality Standards (in µg/m^3)

Pollutant	*Time Weighted Average*	*Concentration in Ambient Air*	
		Industrial, Residential, Rural and Other Areas	*Ecologically Sensitive Areas*
Sulphur Dioxide (SO_2)	Annual *	50	20
	24 Hours **	80	80
Nitrogen Dioxide (NO_2)	Annual *	40	30
	24 Hours **	80	80
Particulate matter (Size less than 10 µm) or PM_{10}	Annual *	60	60
	24 Hours **	100	100
Particulate matter (Size less than 2.5 µm) or $PM_{2.5}$	Annual *	40	40
	24 Hours **	60	60
Ozone (O_3)	8 Hours **	100	100
	1 Hour	180	180
Lead (Pb)	Annual *	0.5	0.5
	24 Hours **	1	1
Carbon Monoxide (CO)	Annual *	2	2
	24 Hours **	4	4
Ammonia (NH_2)	Annual *	100	100
	24 Hours **	400	400
Benzene (C_2H_2)	Annual *	5	5
Benzo (a) Pyene (BaP)-particulate phase only	Annual *	1	1
Arsenic (As)	Annual *	6	6
Nickel(N)	Annual *	20	20

Note: * Annual Arithmetic Mean of minimum 104 measurements in a year taken twice a week 24 hourly at uniform intervals; ** 24 hourly /8 hourly values should be met 98% of the time in a year. However 2% of the time it may exceed but not on consecutive days.

Source: DoES (2014).

TNPCB also monitors air pollution arising from all industrial activities every year. In 2013-14, TNPCB visited 1,156 industries and collected 6,991 ambient air quality survey samples and 3,644 stack emission survey samples from these industries for the purpose of monitoring and ensuring compliance of air quality standards by industries.

In order to monitor the ambient air quality on a continuous basis, TNPCB has installed six Continuous Ambient Air Quality Monitoring Stations (CAAQMS). Four stations are located in Chennai at Koyambedu, Royapuram, Perungudi and Kodungaiyur, one station in SIPCOT Gummidipoondi, and one station in SIPCOT, Thoothukudi. These CAAQMS monitor PM_{10}, $PM_{2.5}$, SO_2, NO_2, NH_3, O_3 on a continuous basis. In addition CPCB operates three CAAQMS in the Chennai Metropolitan area at Velachery, Alandur and Manali.

[1] See http://www.tnpcb.gov.in/ambient_airquality.htm.

In order to monitor both source emissions and ambient air quality on a real time basis from industries located in the State, TNPCB has established a Care Air Centre for assessing the real time air (quality) information reports from industries, at the Head office in Guindy, Chennai. This is a continuous real time emissions monitoring system of connected industries belonging to 'red' category, which functions on 24 x 7 basis. It is the first of its kind in the country. When the emissions levels exceed the norms, the inbuilt system informs the concerned industry and the District Environmental Engineer/Member Secretary, through an automated SMS and e-mail service, so that remedial action may be undertaken immediately. So far, 280 industries are connected to the Care Air Centre for online air quality monitoring. Out of the 280 industries, 228 industries are connected to the Care Air Centre to monitor stack emissions, 70 industries to monitor ambient air quality and 67 industries to monitor the quality of trade effluents.

In order to reduce vehicular pollution, the Ministry of Environment and Forests has also recommended the notification of emission norms for passenger vehicles fitted with and without catalytic converters. These norms have been notified by the Ministry of Surface Transport. The phased tightening of exhaust emission standards for Indian automobiles is given in Table 5.7. Moreover, cleaner fuels like unleaded petrol, petrol with 3 per cent benzene level and low sulphur fuel (0.05 per cent) have also been introduced in the Chennai metropolitan area. Auto manufacturers are also incorporating technological changes towards this end.

Continuous Air Monitoring Station At Perungudi

Table 5.7: Phased Tightening of Exhaust Emission Standards for Indian Automobiles

S. No.	*Category*	*1991*	*1996*	*2000 (Euro II)*	*2005 (Euro III)*	*2008*
1.	**Petrol Vehicles: (in grams/km)**					
i.	**Two wheelers**					
	(a) CO	12-30	4.5	2.0	1.5	1
	(b) HC	8-12	-	-	-	-
	(c) (HC+NOX)	-	3.6	2.0	1.5	1
ii.	**Three Wheelers**					
	(a) CO	12-30	6.75	4.0	2.25	1.25
	(b) HC	8-12	-	-	-	-
	(c) (HC+NOX)	-	5.40	2.0	2.0	1.25
iii.	**Cars with CC:**					
	(a) CO	-	4.34-6.20	2.72	2.2	-
	(b) HC	-	-	-	-	-
	(c) (HC+NOX)	-	1.5-2.18	0.97	0.5	-
iv.	**Cars without CC:**					
	(a) CO	14.3-27.1	8.68-12.4	2.72	2.2	-
	(b) HC	2.0-2.9	-	-	-	-
	(c) (HC+NOX)	-	3.00-4.36	0.97	0.5	-
2.	**Diesel Vehicles:**					
i.	**Gross Vehicles Weight > 3.5 ton (Heavy Duty Vehicles)-in grams/kWh**					
	(a) CO	14.0	11.2	4.5	4	-
	(b) HC	3.5	2.4	1.1	1.1	-
	(c) NOX	18.0	14.4	8.0	7	-
	(d) PM > 85 KW/g/KWh	-	-	0.36	0.15	-
	(e) PM < 85 KW/g/KWh	-	-	0.61	0.15	-
ii.	**Gross Vehicles Weight < 3.5 ton (Light duty Vehicles)-in grams/km**					
	(a) CO	14.3-27.1	5.0-9.0	2.72-6.90	1.06	-
	(b) (HC+NOX)	2.7-6.9	2.0-4.0	0.97-1.70	0.71	-
	(c) NOX	-	-	-	0.566	-
	(d) PM	-	-	0.14-0.25	0.080	-

Notes: CO: Carbon Monoxide, CC: Catalytic Converter, HC: Hydrocarbon, PM: Particulate matter, NOX: Oxides of Nitrogen.
Source: MoSPI (2013).

5.4.2 *Growth of Public Transport*

Tamil Nadu has a good network of State operated buses that serve all of its districts. The main bus transport corporations in Tamil Nadu are: Metropolitan Transport Corporation (Chennai) Ltd. (MTC) that operates in the Chennai metropolitan area; State Express Transport Corporation Ltd. (SETC) that operates within the State and inter-State; Tamil Nadu State Transport Corporation, Villupuram (VPM) that operates in the districts of Villupuram, Cuddalore, Vellore, Tiruvannamalai, Kancheepuram and Thiruvallur; Tamil Nadu State Transport Corporation, Salem (SLM) that operates in the districts of Salem, Namakkal, Dharmapuri and Krishnagiri; Tamil Nadu State Transport Corporation, Coimbatore (CBE) that operates in the districts of Coimbatore, Nilgiris and Erode; Tamil Nadu State Transport Corporation, Kumbakonam (KUM) that operates in the districts of Thanjavur, Nagapattinam, Thiruvarur, Tiruchirapalli, Karur, Perambalur, Ariyalur, Sivaganga, Ramanathapuram and Pudukkottai; Tamil Nadu State Transport Corporation, Madurai (MDU) that operates in the districts of Madurai, Theni, Virudhunagar and Dindigul; and, Tamil Nadu State Transport Corporation, Tirunelveli (TNV) that operates in the districts of Tirnelveli, Thoothukkudi and Kanniyakumari.

Select indicators of overall performance of state bus transport operations in Tamil Nadu in 2012-13 are given in Table 5.8. Table 5.9 shows the performance of the State's bus transport network over the last few years. The fleet strength, number of routes, number of new routes introduced and number of villages benefitted by new routes have all increased over time. As of 2012-13, 182 lakh passengers were transported via state operated buses per day and 1.01 lakh village population was benefitted by the State's bus transport network.

In addition, the soon to be inaugurated Chennai Metro Rail and the existing Mass Rapid Transit System in Chennai are railway networks that provide an alternative mode of transportation to thousands of passengers commuting within Chennai city limits, thereby reducing road traffic and associated air pollution (see Box 5.2 for more details on Chennai Metro Rail and its environmental implications). To further reduce pressure on urban air quality from the vehicular traffic efforts must be made to address the skewed distribution of vehicles and mobility options in metropolitan cities such as Chennai (see Box 5.3 for further details) and provide disincentives in the form of higher parking fees (see Box 5.4) and congestion taxes to own private vehicles.

Table 5.8: Select Indicators of Overall Performance of State Transport Operations in Tamil Nadu in 2012-13

S. No.	*Item*	*MTC*	*SETC*	*VPM*	*SLM*	*CBE*	*KUM*	*MDU*	*TNV*	*Overall*
1.	Fleet strength	3,637	1,079	3,558	2,236	3,267	3,784	2,503	1,989	22,053
2.	Distance operated per day in lakhs	9.43	5.59	16.36	10.11	12.49	16.81	10.63	8.36	89.78
3.	Passengers carried per day in lakhs	48.34	0.94	23.75	16.38	25.32	29.35	18.91	19.01	182.00
4.	Fleet utilisation (%)	85.09	89.48	95.19	95.94	96.38	94.83	95.78	95.35	94.43
5.	Kilometre efficiency (%)	93.91	102.27	103.26	102.75	101.70	101.76	101.54	103.86	103.52
6.	Distance run/ litre of diesel (km./ltr.)	4.34	5.05	5.58	5.42	5.16	5.58	5.37	5.42	5.27
7.	Number of routes	771	231	1,724	1,254	1,724	1,825	1,306	1,394	10,229
8.	New routes introduced during the year	52	22	138	62	69	141	56	50	590
9.	New villages benefited during the year	0	0	71	35	17	32	5	72	232
10.	Benefitted village population in lakhs	0	0	0.58	0.12	0.08	0.1	0.07	0.06	1.01
11.	Staff strength	21,100	5,955	22,629	13,075	17,555	22,106	15,073	11,790	1,29,283
12.	New buses introduced in the year	143	365	496	315	448	345	128	215	2,455

Source: DoES (2014).

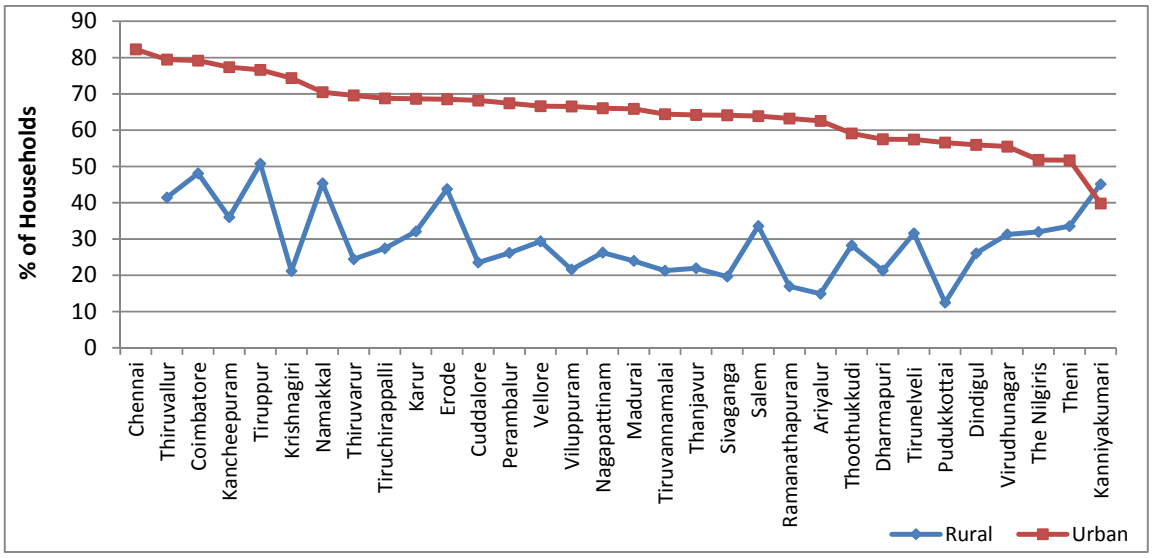
Table 5.9: Performance of All State Transport Undertakings in Tamil Nadu

S. No.	*Particulars*	*2009-10*	*2010-11*	*2011-12*	*2012-13*
1.	Fleet strength	20,399	21,154	21,207	22,053
2.	Effective kilometres (in lakhs)	31,099.57	31,969.78	32,368.79	32,770.57
3.	No. of routes	9,640	9,482	9,675	10,229
4.	No. of new routes introduced	152	252	213	590
5.	No. of villages benefited by new routes	199	165	149	232
6.	Village population benefited (in lakhs) by new routes	1.04	1.96	1.10	1.01
7.	Total no. of employees	1,25,980	1,27,881	1,24,876	1,29,283

Source: DoES (2014).

5.4.3 *Penetration of Clean Fuels (LPG)*

According to the 2011 Census, 29 per cent of all rural households and 69 per cent of all urban households in Tamil Nadu used LPG/PNG as their primary source of fuel for cooking. The district-wise and sector-wise break up is shown in Figure 5.11. Chennai has the highest percentage of households (roughly 82 per cent) using LPG, whereas Kanniyakumari has the lowest percentage of urban households that use LPG for cooking (about 40 per cent). Kanniyakumari is also the only district in which the percentage of rural households using LPG (45 per cent) is higher than in its urban counterpart. Among rural households of Tamil Nadu, Pudukkottai district has the lowest percentage of households using LPG (approximately 12 per cent) and Tiruppur district has the highest (51 per cent). A comparative picture of Tamil Nadu and other states has been presented in Figure 5.5 above that highlights greater penetration of cleaner cooking fuels in the state as evidenced by the NSS data.



Source: Census (2011).

Figure 5.11: District-Wise Percentage of Total Households Using LPG/PNG for Cooking in Tamil Nadu in 2011

Box 5.1: National Air Quality Index

CPCB's National Air Quality Index (AQI) that was developed at IIT-Kanpur is based on eight major pollutants namely, particulate matter with a diameter of less than 10 micrometers (PM_{10}),particulate matter with a diameter of less than 2.5 micrometers ($PM_{2.5}$), ozone (O_3), nitrogen dioxide (NO_2), carbon monoxide (CO), sulphur dioxide (SO_2), ammonia (NH_3) and lead (Pb). Each monitoring station in a particular city gives information on the concentration of a particular pollutant at any given point in time and its average over a period of time. For CO and O3, this average is taken over eight hours, while for the other six pollutants a 24-hour average is considered. The unit of measurement of pollutants is microgram (or milligram in the case of CO) per cubic meter. The AQI value for a particular city is the average concentration of the pollutant that records the maximum value during that day among all pollutants considered. For example, if a city records the highest readings for $PM_{2.5}$ compared to all other pollutants on a particular day, then $PM_{2.5}$ is considered the prominent pollutant and the average daily $PM_{2.5}$ value is that city's AQI value for that day. The AQI value of the prominent pollutant is then evaluated against a colour-coded scale (see table below) to judge how good or bad the air quality in a particular city is. For instance if the AQI value based on the prominent pollutant $PM_{2.5}$ is 179, then this implies that the air quality level in a particular city is "moderate", which in terms of health impact means that children, the elderly and those with lung and heart diseases are likely to experience breathing discomfort. The AQI scale uses "breakpoints" or boundary values that tip a pollutant from say the "good" category to "satisfactory".

Breakpoints for AQI Scale 0-500 (µg/m3 unless specified otherwise) and Possible Health Impacts

AQI Category (Range)	PM_{10} 24-hr	$PM_{2.5}$ 24-hr	NO_2 24-hr	O_3 8-hr	CO 8-hr (mg/m^3)	SO_2 24-hr	NH_3 24-hr	Pb 24-hr
Good (0-50)	0-50	0-30	0-40	0-50	0-1.0	0-40	0-200	0-0.5
Satisfactory (51-100)	51-100	31-60	41-80	51-100	1.1-2.0	41-80	201-400	0.6 –1.0
Moderate (101-200)	101-250	61-90	81-180	101-168	2.1- 10	81-380	401-800	1.1-2.0
Poor (201-300)	251-350	91-120	181-280	169-208	10.1-17	381-800	801-1200	2.1-3.0
Very poor (301-400)	351-430	121-250	281-400	209-748*	17.1-34	801-1600	1201-1800	3.1-3.5
Severe(401-500)	430 +	250+	400+	748+*	34+	1600+	1800+	3.5+

AQI Category (Range)	Possible Health Impacts
Good (0-50)	Minimal impact
Satisfactory (51-100)	Minor breathing discomfort to sensitive people
Moderate (101-200)	Breathing discomfort to the people with lung/ heart disease, children and older adults
Poor (201-300)	Breathing discomfort to people on prolonged exposure
Very poor (301-400)	Respiratory illness to people on prolonged exposure
Severe(401-500)	Respiratory effects even in healthy people

*One hourly monitoring (for mathematical calculation only). Source: CPCB (2014-15).

A recent newspaper report^ indicated that Chennai's air quality was worse than Delhi's based on the number of days from January 1st to June 30th in 2015 that various cities' AQI values fell into the categories of severe, very poor or poor. SO_2 and CO emerged as the prominent pollutants for Chennai and "severe" days constituted 17.7 per cent during this period, and a third of all days were of severe, very poor or poor air quality. The IIT Chennai monitoring station recorded by far the most "severe" air quality days – over 47 per cent of all days in the last six months.

^ The Hindu, July 16, 2015, available online here - http://www.thehindu.com/news/national/the-quality-of-air-you-breathe-in-chennai-is-worse-than-in-delhi/article7422559.ece

CPCB (2014-15) National Air Quality Index, Central Pollution Control Board, Government of India.

Box 5.2: Chennai Metro Rail and Its Environmental Implications

Chennai Metro Rail Project came into existence in the year 2007, recognizing the inadequacy of the existing public transport infrastructure in the city in meeting the future demand. Despite having a good network of public bus and train transport systems, the city has faced rapidly increasing traffic congestion issues, mainly due to increasing population and tumultuous growth of private vehicles. One of the main objectives of the Metro Rail project in the city is therefore to alleviate traffic congestion, while improving the urban environment. The project is expected to yield benefits mainly in terms of its reliance on clean energy, energy efficiency, lower vehicular pollution, reduced congestion on roads, and reduced road accidents.

In the year 2008, the Japan International Cooperation Agency undertook an *ex ante* evaluation of the Metro project and has suggested 'minimal' adverse impacts on the natural environment of the city. The Chennai Metro Rail Limited (CMRL) has also made provisions for environmental impacts of the project covering various protection works, compensatory measures, compensation for loss of trees, compensatory afforestation and fencing, monitoring of water quality, etc.

Nevertheless, the net benefits of such developmental projects are unclear. This is mainly owing to the changes in urban environment that the project is likely to bring changes to the ecologically important sites such as the Guindy National Park, Pallikaranai marshes, and rocky hillocks. Further, flows of water bodies such as Buckingham canal, Coovum River, and groundwater recharge and lowering of groundwater tables could occur affected owing to underground construction activities. Another important concerns raised is surrounding the loss of tree cover in the city due to uprooting of old, fully grown and, at times, rare trees (Barringtonia acutangula, Berrya cordifolia, etc.). The Metro Rail Corporation however has made a pledge of planting 10 trees for every tree cut to make up for the loss of green cover.

Box 5.3: Skewed Distribution of Vehicles and Mobility Options – Chennai

As discussed elsewhere in this report, the vehicle population in Chennai (and other major cities of Tamil Nadu) has grown significantly in recent years putting enormous pressure on the environment. The growth in vehicle population however is not quite in tune with the mobility requirements of the cities. The motor vehicles – especially two wheelers and cars – are meeting the transport needs of only a small percentage of population.

Figure B8.3.1 shows the modal split of trips in urban India and the distribution of motorized vehicular population in the country. It can be seen from the Figure that cars and two-wheelers constitute nearly 86 per cent of vehicles on the road but they account for only 29 per cent of the trips. The scenario in Chennai is no better compared to all India picture. Figure B8.3.2 shows the modal split of trips in Chennai and the distribution of vehicular population in Chennai. As can be seen from the Figure, cars and two-wheelers constitute 92 per cent of vehicles on the road but they account for mere 31 per cent of the trips.

This skewed distribution of vehicles and mobility options highlights the scope for enhancing mobility without increasing the vehicular traffic on the roads, which not only reduces the pressure on the environment, but also eases the congestion problems that are fast becoming synonymous with urban life in India.

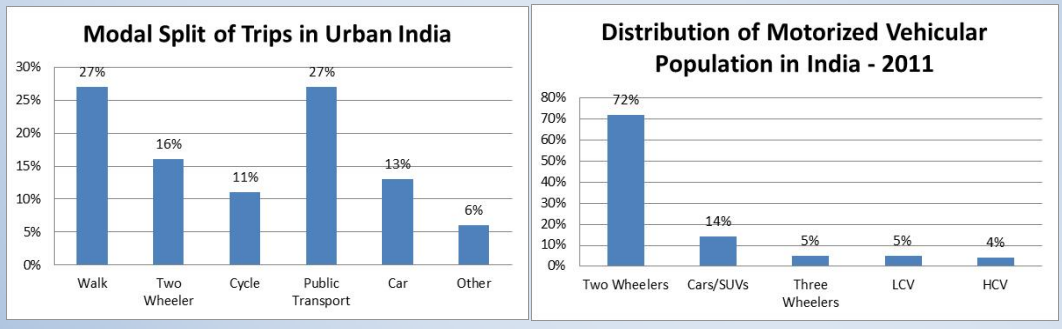


Figure B5.3.1: Skewed Distribution of Vehicles and Mobility Options – Urban India

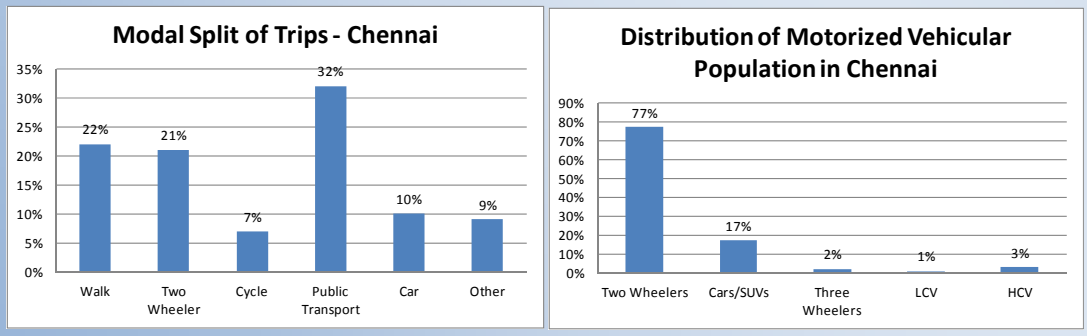
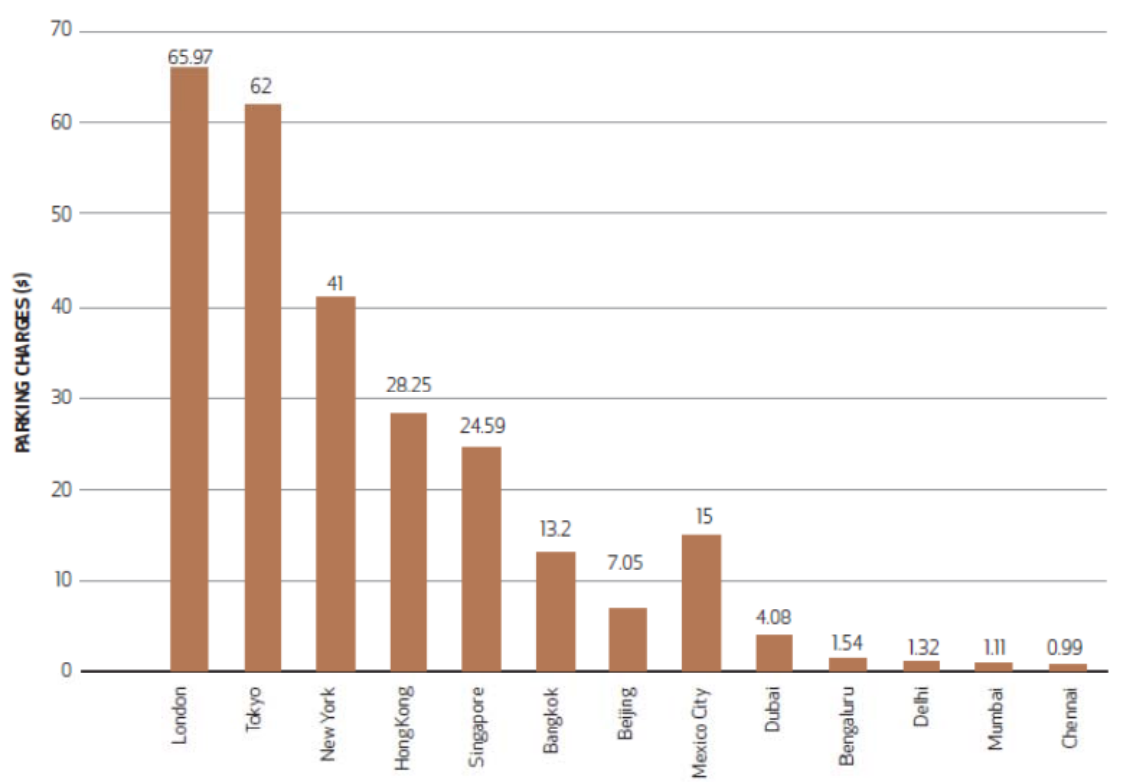


Figure B5.3.2: Skewed Distribution of Vehicles and Mobility Options – Chennai

Box 5.4: Comparison of Parking Charges in Various Cities – 2011

Several economic instruments are being explored for sourcing urban investment in addition to reorientation of the Central and State government funding. A comparison of parking charges (per day) across cities in the world shows that the parking charges in Chennai metropolitan city is 50 times lower than those levied in developed country cities like London, Tokyo and New York; 20 times lower than those levied in cities like Hong Kong and Singapore; and 10 times lower than those levied in cities like Bangkok, Beijing and Mexico City (see Figure B8.4.1). National Urban Transport Policy has identified parking as a restraint measure but this has not yet reflected in the urban planning. Similarly recently studies carried out by the Centre of Excellence in Environmental Economics, Madras School of Economics on Environmental Fiscal Reforms have identified several measures including congestion tax and green motor vehicle tax for attaining twin objectives of sustainable urban development and environmental management.



Source: National Transport Development Policy Committee, Planning Commission, 2013.

Figure B5.4.1: Comparison of Parking Charges (per day) across Cities - 2011

Chapter 6: Water Pollution

Both quantity and quality issues relating to water are of environmental concern in Tamil Nadu. While the present chapter discusses the issues surrounding the water pollution, Chapter 10 provides a comprehensive discussion on water availability in the state. Being an industrialized state, Tamil Nadu faces significant challenges with regard to water pollution. A number of pressures discussed in the previous chapter in the context of air quality are also applicable in the case of water quality. Likewise some of the pressures discussed here under water pollution are also relevant in the context of air pollution.

6.1 Pressures on Water Quantity and Quality

6.1.1 *Fertilizer and Pesticide Use – Trends and Spreads*

With the objective of increasing productivity, the agriculture sector in the state has heavily relied upon increasing use of fertilizers and pesticides. However, this leads to deterioration in soil quality and significant water pollution through leaching and renders water resources unfit for other uses. In the year 2012-13 the total consumption of fertilizer was 14.1 lakh tons compared to 10.8 lakh tons in 2007-08 (see Figure 6.1). Over the years, not only fertilizer consumption has increased significantly, but also the composition of various nutrients has undergone change. Nitrogenous nutrients currently account for more than two-thirds (nearly 69 per cent) of the total fertilizer consumption compared to 51 per cent in 2007-08 (see Figure 6.2).

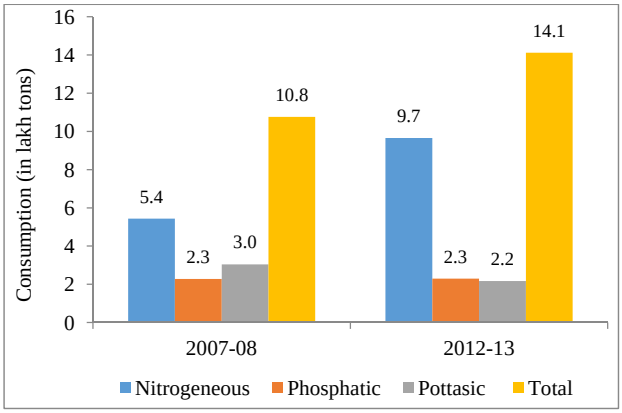


Figure 6.1: Quantity of Fertilizer Use in Tamil Nadu

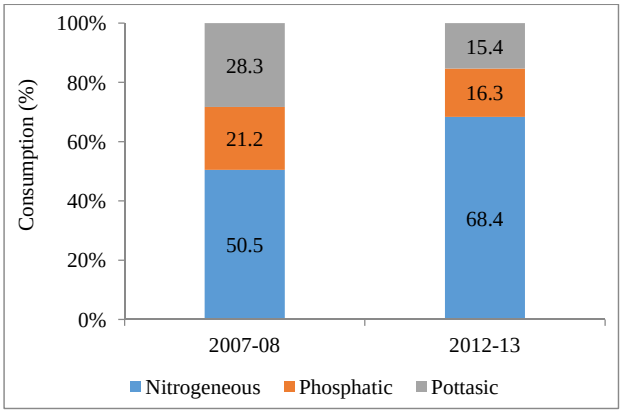


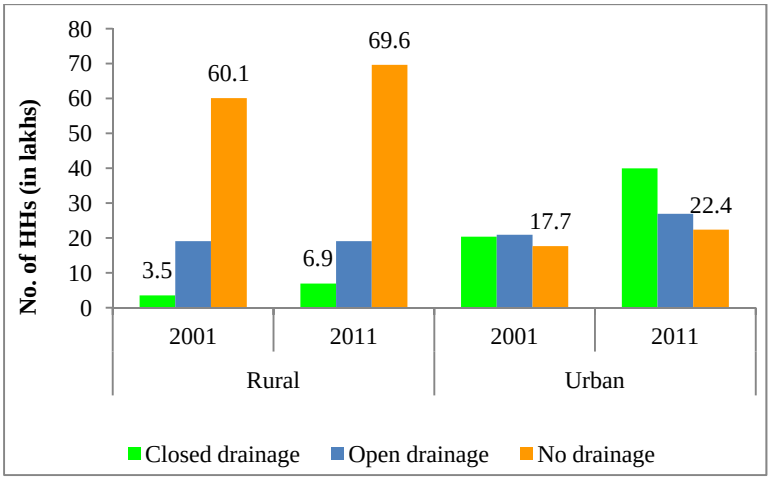
Figure 6.2: Composition of Fertilizer Use in Tamil Nadu

Source: DoES (2008, 2014).

Increased use of nitrogen-containing fertilizers therefore has particularly adverse consequences in terms of water pollution, given that much of the nitrogen that is not taken up by the plant is transformed into nitrate which is easily leached into groundwater.

6.1.2 *Domestic and industrial effluents*

Environmental degradation due to polluting wastewater discharges from both domestic and industrial sources is an important concern. In 2011, Tamil Nadu had 92 lakh households with no wastewater drainage facility compared to 78 lakh households in 2001. Rural households account for nearly 75 per cent of the total households having no drainage (see Figure 6.3). Without proper drainage of wastewater the domestic effluents generated by these households can directly pollute the nearby water bodies (e.g., rivers, lakes, etc.) and therefore put significant pressure on available water resources for other use.



Source: Census (2011).

Figure 6.3: Access to Drainage Facility – Rural and Urban Households

Industrial effluents are the other major source of water pollution in the state. Tables 6.1 and 6.2 summarize the changes in the activity of two industries relevant from water pollution perspective. Total number of textile mills increased by roughly 8 per cent in Tamil Nadu between the period 2005-06 and 2010-11. Production of yarn increased by about 33 per cent, however the production of fabrics reduced dramatically by about 81 per cent, mainly due to the decline in cotton fabric production, over that same time period. Fertiliser production on the other hand has been on the decline in Tamil Nadu; reducing by about 29 per cent over the time period 2004-05 to 2012-13. Tamil Nadu's share in all-India fertiliser production was only 5 per cent in 2012-13.

Table 6.1: Performance of the Textile Industry in Tamil Nadu

Details	Unit	2005-06	2010-11 (P)
Number of Mills			
Cotton man-made fibre textile mills	No.	841	953
Spinning mills (SSI)	No.	909	1,039
Spinning mills (Non-SSI)	No.	815	923
Composite mills (Non-SSI)	No.	26	30
Exclusive weaving mills (Non-SSI)	No.	19	19
100% Export Oriented Units (EOUs)	No.	21	4
Power loom units	No.	73,493	78,948
Man-made fibre units	No.	2	2
Man-made filament yarn units	No.	2	2
Capacity Installed			
Spindles (Non-SSI + SSI)	'000 No.	16,432	17,747
Rotors (Non-SSI + SSI)	No.	1,71,929	1,64,041
Looms (Composite & Exclusive weaving units)	No.	7,505	5,886
Power looms	No.	3,73,521	3,95,537
Man-made fibre	Mn. kg.	95	95
Man-made filament	Mn. kg.	17	17
Production of Fibres			
Raw cotton	Lakh bales	5	5
Man-made fibre	'000 kg.	29,332	25,755
Cotton Consumption by Mills			
Non-SSI	'000'kg.	11,86,159	16,37,112
SSI	'000'kg.	2,20,347	2,59,092
Production of Yarn			
Cotton yarn	'000 kg.	11,48,068	15,50,856
Blended yarn	'000 kg.	1,25,994	1,62,786
100% Non-cotton yarn	'000 kg.	94,865	1,03,871
Total spun yarn	'000 kg.	13,68,927	18,17,513
Fabric Production (Mill Sector)			
Cotton	'000 sq. mtr.	99,353	10,755
Blended	'000 sq. mtr.	7,740	10,351
100% non-cotton	'000 sq. mtr.	3,990	40
Total	'000 sq. mtr.	1,11,083	21,146

Note: P – Provisional. Source: DEAR (2009-10).

Table 6.2: Performance of the Fertiliser Industry in Tamil Nadu

Particulars	Tamil Nadu			All India		
	2004-05	2009-10	2012-13	2004-05	2009-10	2012-13
No. of Plants (No.)	**12**	**10**	**9**	**138**	**155**	**152**
a. Nitrogenous (N)	4	4	3	55	55	42
b. Phosphatic (P2O5)	8	6	6	83	100	110
Installed Capacity (Lakh Tonnes)	**13.05**	**11.88**	**11.88**	**178.56**	**191.47**	**195.22**
a. Nitrogenous (N)	8.35	7.29	7.29	122.55	129.45	131.51
b. Phosphatic (P2O5)	4.70	4.59	4.59	56.01	62.02	63.71
Production (Lakh Tonnes)	**10.20**	**3.72**	**7.25**	**153.43**	**162.98**	**160.60**
a. Nitrogenous (N)	7.20	2.70	5.41	113.05	119.24	122.37
b. Phosphatic (P2O5)	3.00	1.02	1.84	40.38	43.74	38.23
Capacity Utilization (%)	**78**	**30**	**61**	**86**	**85**	**82**
a. Nitrogenous (N)	86	37	74	93	99	93
b. Phosphatic (P2O5)	69	22	40	74	72	60
Consumption (Lakh Tonnes)	**-**	**-**	**7.98**	**-**	**-**	**234.74**
a. Nitrogenous (N)	-	-	5.75	-	-	168.21
b. Phosphatic (P2O5)	-	-	2.23	-	-	66.53

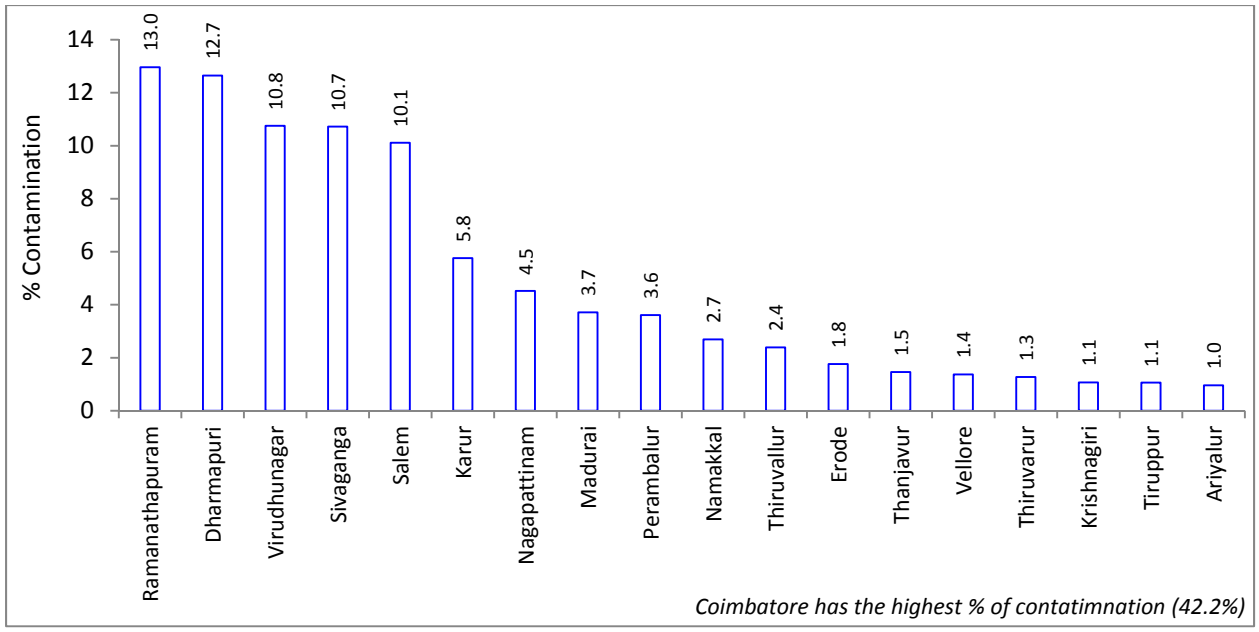
Source: DEAR (2009-10, 2013-14).

In Tamil Nadu there are 16724 industries generating effluent from their operations of which 1363 units fall under red-large category. 16656 units have provided Effluent Treatment Plants (ETP). The remaining units are directed to provide ETP. None of the units are however permitted to operate without providing ETP.

6.2 State and Impacts of Water Contamination

6.2.1 *Quality of Water*

Figure 6.4 shows the percentage of contaminated water sources tested across districts of Tamil Nadu in 2011. The sources were tested for fluoride, nitrate, iron and fecal contamination. Coimbatore tops the list with over 40 per cent of its tested sources turning out to be contaminated followed by Ramanathapuram, Dharmapuri, Virudhunagar, Sivaganga and Salem districts – each reporting about 10 per cent of their tested sources as contaminated.



Note: Excluding Coimbatore, all districts reporting more than 1 % of the sources as contaminated are shown in the figure.

Source: Planning Commission (2012).

Figure 6.4: District-wise Percentage of Water Contaminated Tested Sources – 2011

6.2.2 *Impacts Due to Water Contamination*

A report by the Blacksmith Institute included Ranipet in Tamil Nadu among the top ten worst polluted places[1] of the world (Blacksmith Institute, 2006). While the state government has ordered closure of Tamil Nadu Chromates and Chemicals Limited a decade ago, the legacy of the same still continues with no solution still in sight for the safe disposal of 1,500,000 tons of solid waste generated by the factory over two decades before its closure. Blacksmith Institute and Asian Development Bank estimate 3.5 million people as potentially affected people due to ground and surface water contamination. The same report also highlights the effects of effluent discharge from the tanneries. Within five kilometer distance around 68 tanneries operate in Dindigul leading to severe ground water pollution. Tannery effluents are reported to have left only 16 out of 56 wells in Kamatchipuram village uncontaminated which forces people to walk long distances for water. The water and soil pollution from the tannery effluents has the potential to affect about 450,000 people.

[1] Worst polluted places are selected on the basis of size of affected population, severity of the toxin involved, impact on children's health and development, evidence of a clear pathway of contamination, and existing and reliable evidence of health impact. While the top ten list is not based on a comprehensive database, it may not be prudent to debate the methodology per se.

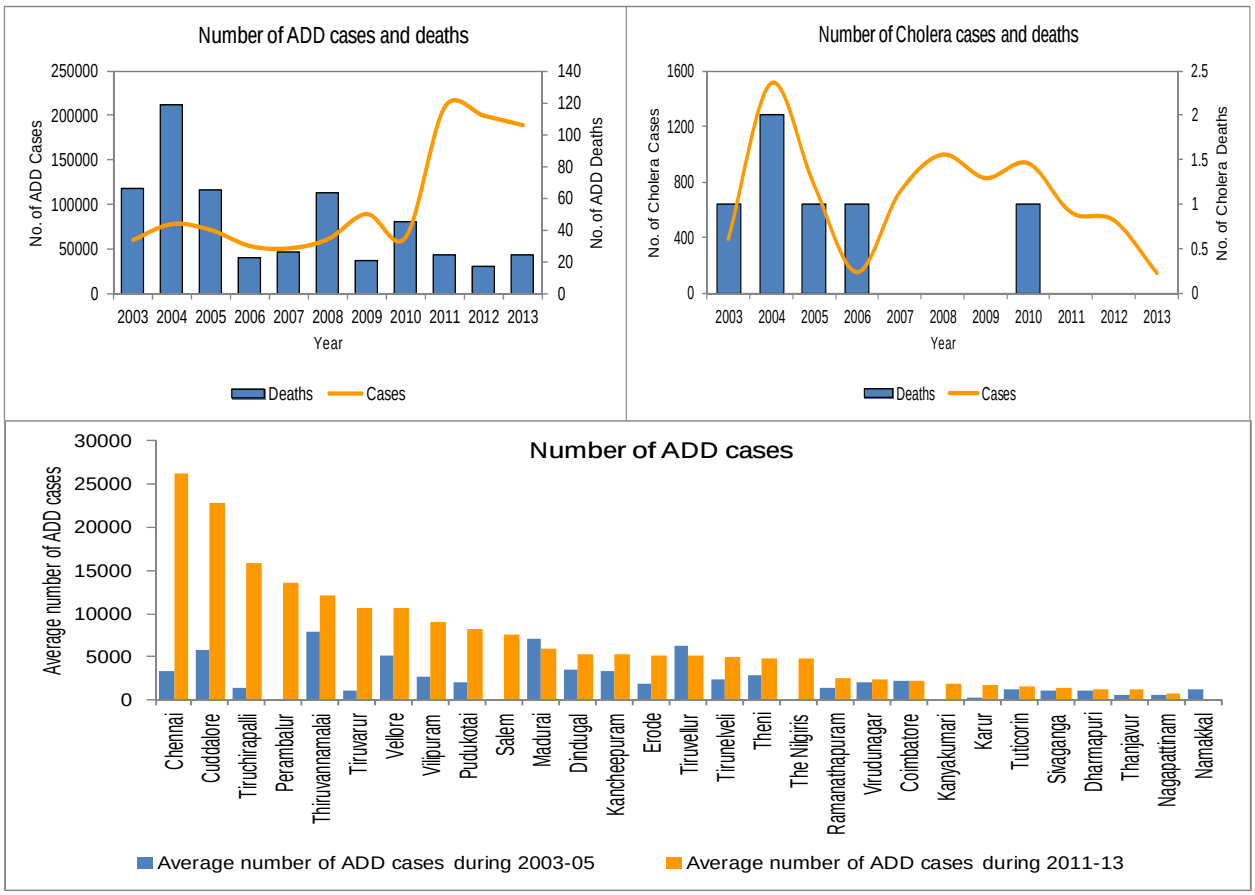
The impact of tannery pollution on agriculture land was analysed by Loss of Ecology Authority, Government of India. About thirty six thousand individuals were identified by the Authority for paying compensation to the tune of Rs. 35 crore by the tanneries. Similarly the impact of pollution from textile units on agricultural pollution was analysed through several studies at Madras School of Economics and significant losses were reported.

Following strict directives from the High Court that polluting industries should not release their treated effluent into the water ways, it has become somewhat common practice to use the treated and semi-treated water for irrigation purposes. This has resulted in significant contamination of ground water and resulted not only in loss to agricultural output but also made the ground water not suitable for drinking (Mukherjee and Nelliyat, 2006). Amarnath and Krishnamoorthy (2001) have estimated the loss in yield of paddy and sugarcane crops in Vellore district and attributed more than 90 per cent of the loss to the water pollution.

6.2.3 *Water Borne Diseases – Incidence and Spread*

Water pollution can lead to a number of health issues. The prevalence of water borne diseases such as Acute Diarrheal Diseases (ADD) and Cholera increases as the quality of water deteriorates due to water pollution. Although improvement in health facilities have kept check on the number of deaths due to these water borne diseases, the number of cases reported under such diseases are alarming. More than 1 million ADD cases have been reported in the state during the period 2003-2013, cumulatively. There has been particularly an increasing trend in the number of ADD cases in recent years (2011-13). Similarly, more than 7500 cholera cases have been reported during the same period (see Figure 6.5).

A comparison of average number of ADD cases across districts suggests significant jumps for few districts in the number of cases reported between 2003-05 and 2011-13. Particularly, Chennai, Cuddalore, Thiruchirapalli, Perambalur, Thiruvarur, Salem, Viluppuram, Pudukottai, and Vellore reported significant increase in the number of reported cases between the two periods. These districts also accounted for the majority of the reported ADD cases during the period 2011-13.



Source: TNPCB (2014).

Figure 6.5: Incidence of ADD and Cholera in Tamil Nadu – Spatial and Temporal Trends

6.2.4 *Water Conflicts*

Several areas surrounding the urban regions (peri-urban areas) often face the brunt of urban environmental problems in terms of providing scarce resources like water to the urban areas and also absorbing considerable amount effluent from the cities. Palar river basin provides an interesting case for conflicts that arise between urban, peri-urban and rural areas in the context of water. In the upper Palar basin the conflict is between agricultural, industrial and domestic users of water, whereas in the lower basin it is between urban domestic users and farmers. While the tannery pollution in the upper Palar basin area and the resulting impact on agriculture is well documented and discussed, the case of lower Palar basin deserves special mention in the context of growing rural-urban divide.

An estimated 40 mld of water is transported from the peri-urban areas to cities drawing ground water from the riverbed aquifer. The peri-urban dwellers lured by the short-term gains

enter into the water market potentially at the cost of their future as continuous pumping of water puts permanent damage on the ecology of area. For even those who wish to retain water for long-term use, there is little hope as the water in the aquifer is like a public good and hence carries with it the perils of public goods. For instance non-participation in the water trade by an individual may not provide the intended benefits as her neighbors continue to exploit the resource for short-term gains. Sand mining also adds to the problems in the riverbed. The existing institutional mechanisms are inadequate to handle the situation and a small section of 'new' beneficiaries in the peri-urban areas (such as the water sellers) exercise considerable power with relatively short-term vision. Thus the conflict of interest in the use of water present a changing picture of transportation of urban environmental problems into peri-urban areas, demanding urgent need for policy intervention.

6.3 Responses

6.3.1 *Status of Common Effluent Treatment Plants*

TNPCB plays a supportive role towards the establishment of Common Effluent Treatment Plants (CETPs) for clusters of small-scale industries in various parts of the State. Small-scale industries often express financial difficulties, lack of space and other reasons which prevent them from putting up the required individual Effluent Treatment Plant (ETP). The Board assists in the technical scrutiny of the plan proposals for the CETPs. CETPs are established in the following sectors: Tanneries – 13 schemes; Textile Bleaching & Dyeing Units – 30 schemes; and Hotels & Lodges – 1 scheme.

Out of 13 CETP schemes established for tanneries, 11 CETPs are under operation with Zero Liquid Discharge (ZLD) system. The remaining two CETPs for tanneries have opted for dilution of tannery effluent with sewage to achieve the standards prescribed by the Board.

Out of 30 CETPs established for textile dyeing processing units, 19 CETPs have implemented the ZLD system. The remaining 11 CETPs are closed in view of orders of Honourable High Court due to their inability to achieve ZLD standards. The one CETP provided for treatment of wastewater from hotels and lodges is under operation in Kodaikanal hills.

6.3.2 *Water Quality Monitoring*

TNPCB is monitoring the water quality of major rivers and its tributaries and major lakes under the Monitoring of Indian National Aquatic Resources (MINARS) programme and under the Global Environmental Monitoring System (GEMS) as detailed in Table 6.3 below.

Table 6.3: Water Quality Monitoring Stations in Tamil Nadu - 2015

Sl. No.	Water Bodies	No. of Stations
1	Cauvery and its tributaries	33
2	Tamirabarani	12
3	Palar	1
4	Vaigai	1
5	Lakes	8

Source: TNPCB (personal communication through ENVIS Centre, Chennai)

6.3.3 *Online Water Quality Monitoring Stations*

In order to monitor the water quality of river Noyyal and Kalingarayan canal on continuous basis in the textile industrial belt, TNPCB has installed online continuous water quality monitors at three locations each in Noyyal river and Kalingarayan canal. These stations monitors pH, total dissolved solids, dissolved oxygen on continuous basis. These stations are functioning from October, 2014. TNPCB is also in the process of installing continuous water quality monitoring stations in three locations each in river Thamirabarani and river Cauvery.

Chapter 7: Noise Pollution

Sounds that are unpleasant and exceeding the normal hearing level are said to be noise which is considered as pollution in the environment. Noise becomes pollution when the intensity and frequency of the sound is likely to affect the quality of environment (Rodgers, 1977, p. 55). Broadly, noise becomes a pollutant when it contaminates the environment and affects the health of persons, their activities and mental abilities. The presence of noise in the open atmosphere or in confined space is generally considered undesirable, except possibly by the person responsible for it. Noise levels are measured in decibels. The zero on a decibel scale is at the threshold of hearing, the lowest sound pressure that can be heard. On this scale, 20 dB is whisper, 40 dB is the noise in quiet place, 60 dB is normal conversation, sound levels 80 dB and 100 dB, are considered normal in bus and train, respectively, whereas beyond 140 dB sound becomes physically painful.

Any sound which becomes excessive, unnecessary or unreasonable has to be put under regulation in order to shield public interest against its undesirable and harmful effect or for its cessation. Noise is more than just a nuisance. It constitutes a real and present danger to people's health. Therefore, noise pollution is now recognized as a kind of air pollution and noise is included as an air pollutant[1] in Section 2(a) of the Air (Prevention and Control of Pollution) Act, 1981.

Noise pollution like other pollutants is also a by-product of industrialization, urbanization and modern civilization. Broadly speaking, the noise pollution has two sources – industrial and non-industrial. The industrial source includes the noise from various industries and big machines working at a very high speed and high noise intensity. Non-industrial source of noise includes the noise created by transport/vehicular traffic and the neighbourhood noise generated by various activities. The other sources of noise pollution include aircrafts (commercial and military), railroads, and construction activities. In Indian context on special occasions such as Dussehra and Diwali festivals and social gatherings, use of firecrackers generates significant noise pollution necessitating regulation by the pollution control board.

[1]Inserted by Act 47 of 1987, which came into effect from l-4-1988.

7.1 Status of Noise Pollution

In India, the Noise Pollution (Regulation and Control) Rules, 2000 have been framed under the Environment (Protection) Act,1986. These are a set of guidelines for regulation and control of noise. The standard ambient levels of noise for different areas/zones specified in the rules are indicated in Table 7.1.

Table7.1: Ambient Air Quality Standards in respect of Noise

Area Code	Category of Area / Zone	Limits in dB* (A) Leq*	
		Day Time	Night Time
(A)	Industrial Area	75	70
(B)	Commercial Area	65	60
(C)	Residential Area	55	45
(D)	Silence Zone	50	40

Note: 1. Day time shall mean from 6.00 a.m. to 10.00 p.m. 2. Night time shall mean from 10.00 p.m. to 6.00 a.m. 3. Silence zone is an area comprising not less than 100 metres around hospitals, educational institutions, courts, religious places or any other area which is declared as such by the competent authority 4. Mixed categories of areas may be declared as one of the four above mentioned categories by the competent authority. * dB(A) Leq denotes the time weighted average of the level of sound in decibels on scale A which is relatable to human hearing. A "decibel" is a unit in which noise is measured. "A", in dB(A) Leq, denotes the frequency weighting in the measurement of noise and corresponds to frequency response characteristics of the human ear.

Leq: It is an energy mean of the noise level over a specified period.

Source: The Noise Pollution (Regulation and Control) Rules, 2000 (see rule 3(1) and 4(1)).

As directed by the Central Pollution Control Board (CPCB) all the State Pollution Control Boards (SPCBs) & Union Territories (UTs) have to carry out ambient and noise level monitoring during Diwali/Deepawali festival every year. The ambient air quality monitoring is carried out at 163 locations and noise monitoring is carried out at 209 locations across the country covering 21 States. In Tamil Nadu State, ambient air quality monitoring carried out in eleven cities and noise monitoring carried out at 28 locations in eleven cities. Table 7.2 shows the status of ambient noise level across Tamil Nadu on normal and festival days.

Table 7.2: Status of Ambient Noise Level in Major Cities in Tamil Nadu, 2014

District	City	Area/Zone	Normal Day	Festival Day
Chennai	T. Nagar	Commercial	75	81
	Sowcarpet	Commercial	79	84
	Triplicane	Residential	70	86
	Basant Nagar	Residential	61	78
	Nungambakkam	Residential	64	87
Vellore	Main Raod, Gandhi Nagar	Residential	66	83
	Sainathapuram	Residential	62	88
Cuddalore	Imperial Road	Commercial	75	76
	Sekar Nagar	Residential	53	68
Hosur	Devaki Nursing Home	Commercial	64	83
	Transi House	Residential	63	82
	ESI Hospital	Silence	60	75
Salem	Shiva Tower, Meyyanur	Commercial	61	74
	Sri Saradha Balamandir School	Residential	51	81
Trichy	Thillai Nagar	Residential	67	84
Madurai	Madurai Corporation South	Commercial	70	87
	Thirunagar	Residential	59	84
	Alagar Nagar	Silence	68	82
Tirunelveli	Samathanapuram	Commercial	64	88
	Tirunelveli Town	Residential	82	74
	Pettai	Silence	67	90
Dindigul	Municipality Building	Commercial	61	73
	NS Nagar	Residential	65	84
	Dist. Court	Silence	57	65
Coimbatore	Saibaba Kovil Signal	Commercial	72	68
	Ponniarajapuram	Residential	67	82
Trippur	Kumaran Complex	Commercial	61	65
	Rayapuram	Residential	68	79

Source: CPCB (2014).

Since Diwali festival is one of the main events concerning noise pollution, several reports by both State Pollution Control Board and the CPCB have analyzed the noise data recorded in cities on the festival day over the years. Based on noise data recorded during Dewali 2015, in Chennai, Guindy (under the industrial category) has the highest record of noise level during day and night, in the commercial areas category Pallikaranai recorded the lowest and Washermanpet recorded the highest, in the silence areas category Anna Nagar has reported the lowest noise level (see Table 7.3).

Table 7.3: Ambient Noise Data in Chennai - Diwali, 2015

Sr. No.	Limit in dB(A) Leq		StationName	Leq (24hrs.) ValuedB(A)	DayLeq.dB(A)	Night Leq.dB(A)
	Day 06 AM to 10PM	Night 10 PM to 06 AM				
1	50	40	Chennai, Eye Hosp. (S)	69	69	68
2	65	55	Chennai, T.Nagar (C)	75	77	68
3	65	55	Chennai, Perambur (C)	N/A	N/A	N/A
4	75	70	Chennai, Guindy (I)	78	80	74
5	55	45	Chennai, Triplicane (R)	69	71	62
6	65	55	Chennai, Pallikaranai (C)	72	74	66
7	55	45	Chennai, Velachery (R)	74	73	77
8	65	55	Chennai, Washermanpet (C)	75	76	75
9	50	40	Chennai, Anna Nagar (S)	65	66	62
10	55	45	Chennai, Sowcarpet (R)	71	72	69

Note: N/A: Not Available
Source: CPCB - Press Release Ambient Noise Level Assessment at 70 Locations in 07 Metro Cities during Diwali 2011, 2012, 2013, 2014 and 2015 (http://www.cpcb.nic.in/PressReleaseNoiseDiwali2015.pdf).

Recently CPCB conducted the Ambient Noise Level assessment at 70 locations in seven cities (Delhi, Mumbai, Chennai, Kolkata, Lucknow, Bangalore and Hyderabad) during Deepawali festivals over the years 2011 to 2015. The main observations include:

- Out of 70 locations, only 7 locations at Peeniya (Industrial) and Whitefield (Industrial) in Bangalore; Jeedimetla (Industrial) and Addapotharam (Industrial) in Hyderabad; Tartala (Industrial) in Kolkata; Talkatora (Industrial) in Lucknow and Andheri (Industrial) in Mumbai are meeting both the day time and night time standards. All these 7 locations lying in Industrial zone.
- All the locations are above the prescribed limits for day and night time in Delhi and Chennai.
- Among the 70 locations, 16 are meeting the prescribed limits for day time standards (06 AM to10 PM**)** and 09 are meeting the prescribed norms for night time (10 PM to 06 AM).
- In case of Chennai, the report observed that at four of the five stations, the ambient noise levels have shown increasing trend over the past five years (see Table 7.4).

Table 7.4: Trends in Ambient Noise Data in Chennai – Diwali, 2011 to 2015

SN	Stations	2011 Leq (24hrs)	2012 Leq(24 hrs)	2013 Leq(24 hrs)	2014 Leq(24 hrs)	2015 Leq(24 hrs)	Trend
1	Triplicane	69	63	65	66	69	↑
2	T.Nagar	69	70	69	72	75	↑
3	Guindy	75	74	69	76	78	↑
4	Perambur	75	86	65	69	N.A	
5	EyeHospital	65	60	66	66	69	↑

Note:-All values are measured in Leq [dB(A)]
Source: CPCB - Press Release Ambient Noise Level Assessment at 70 Locations in 07 Metro Cities during Diwali 2011, 2012, 2013, 2014 and 2015 (http://www.cpcb.nic.in/PressReleaseNoiseDiwali2015.pdf).

7.2 Impact of Noise Pollution

Human beings are the common receptors of noise pollution. Noise tends to be unpleasant and irritating to the ear. In urban centres it is becoming a serious health menace. This is to a great extent due to increasing industrialization, traffic density, overcrowding due to population explosion and urbanization. The problem of noise is further aggravated by widespread use of loud speakers and exploding of crackers. Metropolitan cities of Delhi, Mumbai, Chennai and Kolkata are among the noisiest cities in the world. It is estimated that in Mumbai noise levels range from 57 to 91dB 50. The noise levels in Chennai according to a study report of the Tamil Nadu Pollution Control Board, varied between 52.7 dB to 119.4dB.

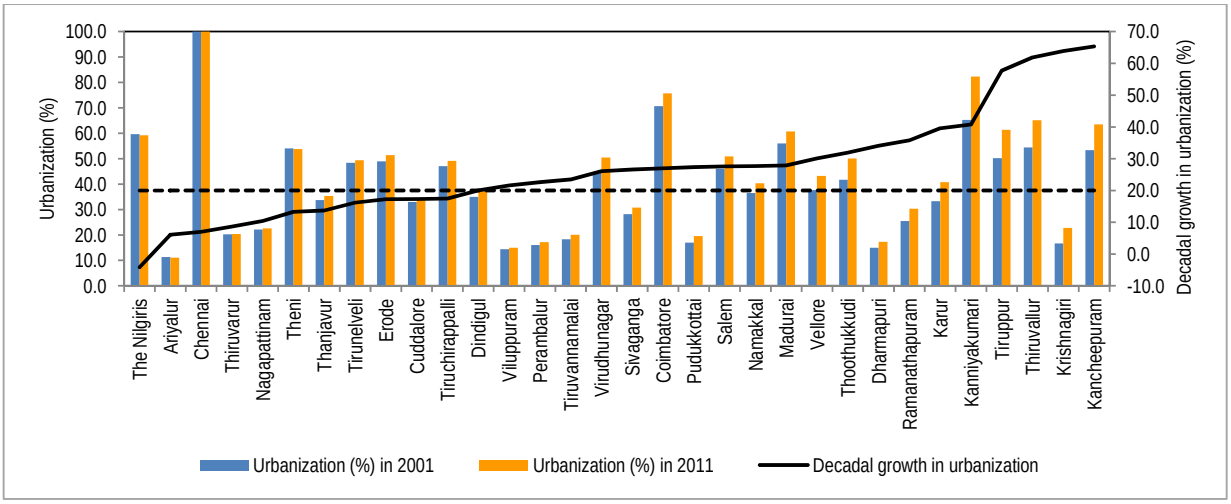
Noise can produce serious physical and psychological stress on human beings. Impact of noise depends upon the sound's pitch, its frequency, time pattern and length of exposure. Noise has both auditory and non-auditory effects depending upon the intensity and the duration of the noise level. It affects sleep, hearing and communication, mental and physical health. It may even lead to adverse mental effects in human beings.

Chapter 8: Solid Waste

As discussed in Chapter 1, Tamil Nadu has all along been one of most urbanized states in India. The rate of urbanization has been significantly high over the past two decades. The demographic changes, especially urbanization has direct implications for solid waste generation. In addition to solid waste generation, the urban population and their growing needs bring into focus a plethora of environmental concerns including biomedical waste, hazardous waste, and electronic waste. This chapter discusses the urbanization trends in Tamil Nadu and presents the status of different waste along with the response strategies adopted by the State.

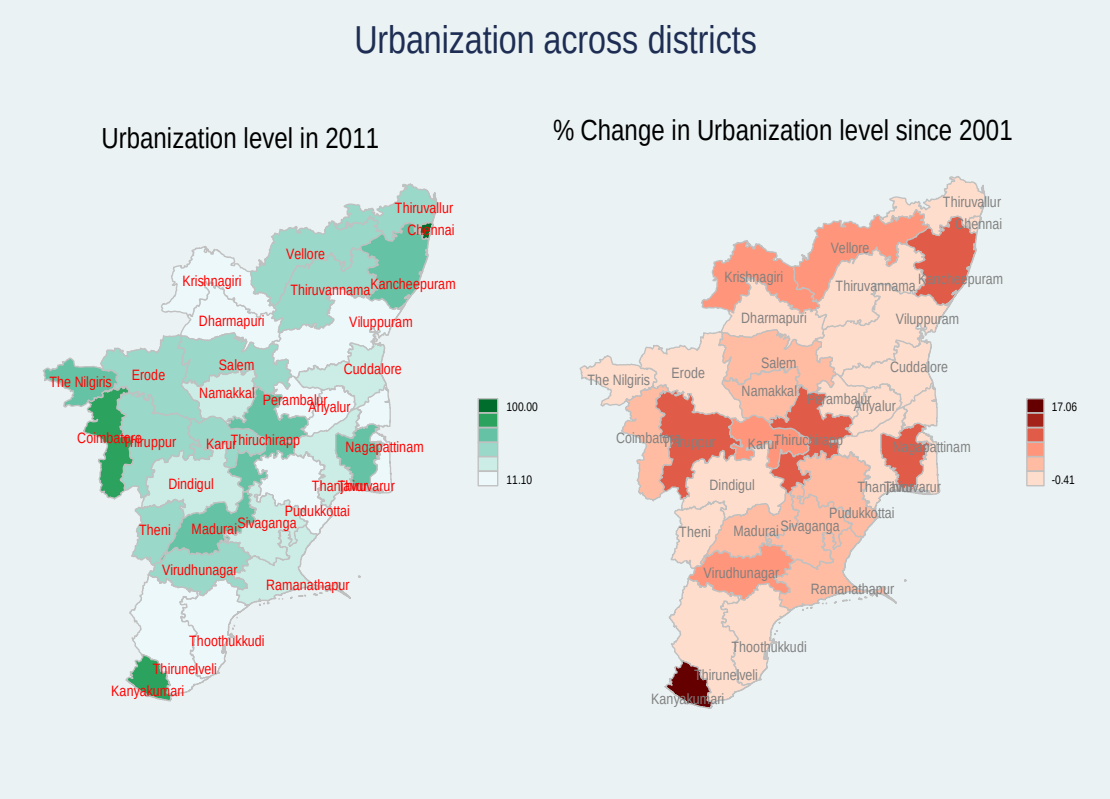
District-wise Urbanization Trends

As of 2011, nearly 48.4 per cent of the population of Tamil Nadu lived in urban areas, making it the third most urbanized state in the country. During 2001-2011, the decadal growth in the State's urban population (27 per cent) significantly outweighs that of its rural population (6.6 per cent). The annual growth rate of population in urban areas was 2.4 per cent compared to 0.6 per cent in rural areas. Urbanization trends across various districts of Tamil Nadu are presented in Figures 8.1 and 8.2 below.



Source: Census (2011).

Figure 8.1: Urbanization trends across districts of Tamil Nadu



Source: Census (2011).

Figure 8.2: Urbanization across Districts in Tamil Nadu

Except The Nilgiris, all districts in Tamil Nadu had a positive decadal growth in its urban population. Unlike previous decades, the rate of urbanization has not remained a concentrated phenomenon in the state. This is evident from the fact that two-thirds of the districts in Tamil Nadu witnessed more than 20 per cent decadal growth in urban population during 2001-2011. However, few districts (*viz*. Kanyakumari, Thiruppur, Thiruvallur, Krishnagiri and Kancheepuram) have registered significantly higher (more than 40 per cent) decadal growth in its urban population. These districts are also characterized by high rates of annual population growth in urban areas and high absolute changes in the rate of urbanization between 2001 and 2011. Table 8.1 provides district-wise urban population density and its growth rate over the decade 2001-2011.

Table 8.1: Total and Urban Population Density Trends and Decadal Growth across Districts

	Total Population Density		Urban Population Density		Decadal growth in population density (%)	
District	**2001**	**2011**	**2001**	**2011**	**Total**	**Urban**
Ariyalur	358	389	1482	1572	9	6
Chennai	24963	26553	24821	26553	7	7
Coimbatore	616	731	1269	1609	19	27
Cuddalore	617	704	1642	1927	14	17
Dharmapuri	288	335	2172	2913	16	34
Dindigul	317	358	1175	1436	12	22
Erode	350	391	1285	1507	12	17
Kancheepuram	668	892	2302	3819	39	66
Kanniyakumari	995	1111	1650	2323	12	41
Karur	323	367	1098	1533	14	40
Krishnagiri	304	367	1503	2624	21	75
Madurai	698	819	4549	5818	18	28
Nagapattinam	616	629	1759	1942	9	10
Namakkal	439	505	1791	2316	16	29
Perambalur	282	322	947	1161	15	23
Pudukkottai	314	348	1470	1873	11	27
Ramanathapuram	284	330	1583	2150	14	36
Salem	575	665	2057	2626	15	28
Sivaganga	279	316	1846	2337	16	27
Thanjavur	638	705	2043	2323	9	14
The Nilgiris	299	287	781	748	-3	-4
Theni	381	434	1991	2255	14	13
Thiruvallur	776	1098	2790	4546	35	62
Thiruvarur	492	556	2312	2513	8	9
Thoothukkudi	336	369	1603	2114	10	32
Tiruchirappalli	536	604	2443	2870	13	17
Tirunelveli	404	460	1238	1438	14	16
Tiruppur	370	478	1158	1827	29	58
Tiruvannamalai	353	398	2299	2839	13	24
Vellore	572	648	2391	3129	13	31
Viluppuram	412	481	2120	2578	17	22
Virudhunagar	409	458	1721	2194	11	28

Source: Census (2011).

Growing urbanization has led to significant increase in the number of urban local bodies in the past decade. The number of towns have increased to 1097 in 2011 from 832 in 2001 (see Table 8.2). The number of municipal corporations and municipalities have increased significantly during this period. By 2011, the state had 10 municipal corporations (150 municipalities) compared to 6 corporations (104 municipalities) in 2001. Both these local bodies, taken together, account for 60 per cent of the urban households and population of the state. During 2001-2011, the decadal growth rate of urban population living in corporations, municipalities and town panchayats has been 11 per cent, 18 per cent and 17

per cent respectively. This implies an increase pressure on existing environmental resources in the top-tier cities and urban agglomerations.

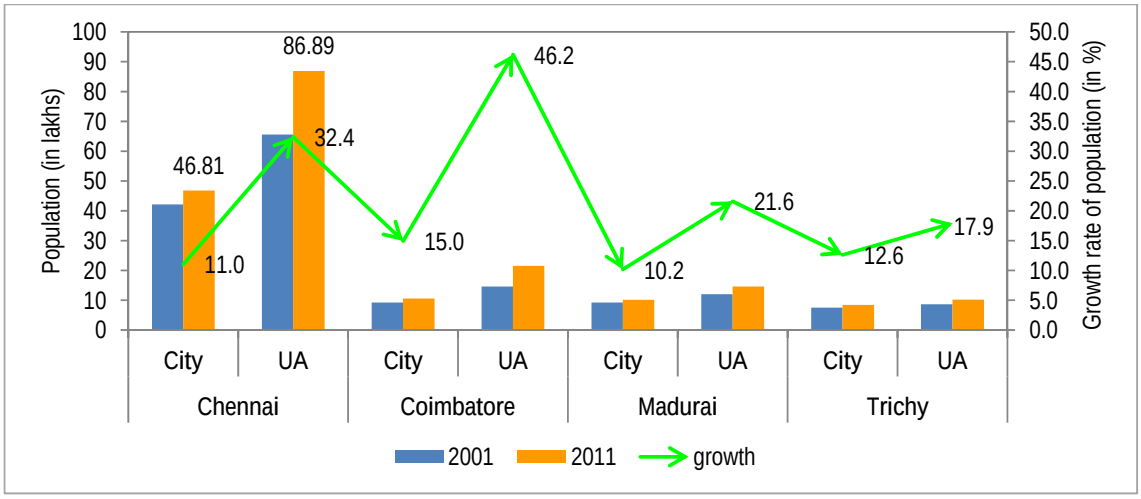
Table 8.2: Trends in Urban Area, Households and Population by Urban Local Bodies

	No. of Towns		Area (sq. km.)		Households (*lakhs*)		Population (*lakhs*)	
Category	**2001**	**2011**	**2001**	**2011**	**2001**	**2011**	**2001**	**2011**
Corporations	6	10	678	740	18.3	25.3	89.5	98.9
Municipalities/Cantonments	104	150	1583	3189	19.0	28.4	93.7	110.6
Town Panchayats	611	561	8857	6934	22.9	23.4	76.5	89.7
Census Town	111	376	936	2772	3.7	13.0	14.7	50.0
Total	**832**	**1097**	**12054**	**13636**	**63.8**	**90.0**	**274.3**	**349.2**

Source: Census (2001, 2011).

Million Plus Cities Growth

As per the 2011 census, the 10 Municipal corporations of the state account for 28 per cent of Tamil Nadu's urban population (Census, 2011). Tamil Nadu has four large cities/urban agglomerations (UA) with population exceeding 1 million, *viz*., Chennai, Coimbatore, Madurai, and Tiruchirapalli. The Chennai UA accounts for a population of nearly 9 million, while the city has a population of 4.6 million. During the past decade, population growth rate in the UA has been higher compared to the growth rate in the cities. Urban population in Coimbatore has witnessed decadal growth rate of 46.2 per cent (see Figure 8.3).



Source: Planning Commission (2012); Directorate of Census Operations, TN (personal communication through ENVIS Centre, Chennai).

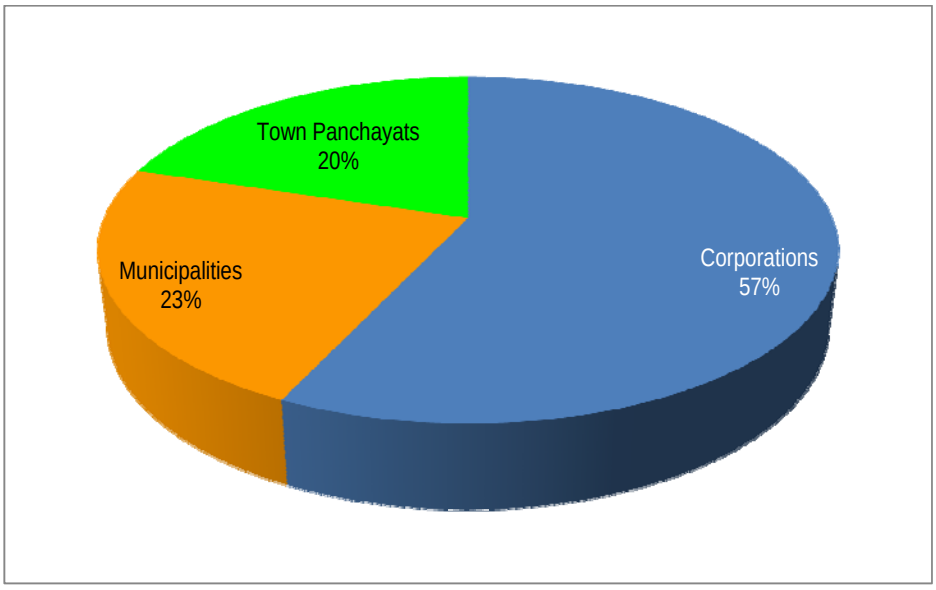
Figure 8.3: Population and Decadal Population Growth in Million Plus Cities/UAs of Tamil Nadu

8.1 Status of Waste Generation

Municipal Solid Waste

In Tamil Nadu, a total of 14,727 tonnes of municipal solid waste is generated per day, of which 57 per cent is generated by the 12 corporations, 23 per cent by the 123 municipalities and 20 per cent by the 529 town panchayats. MSW generation by 2013-14 was thus 12.6 per cent higher compared to its level in 2010-11, (12,504 tons/day). The total MSW generated in the municipalities and the town panchayats were 3207 and 2842 tons/day, respectively (see Figure 8.4).

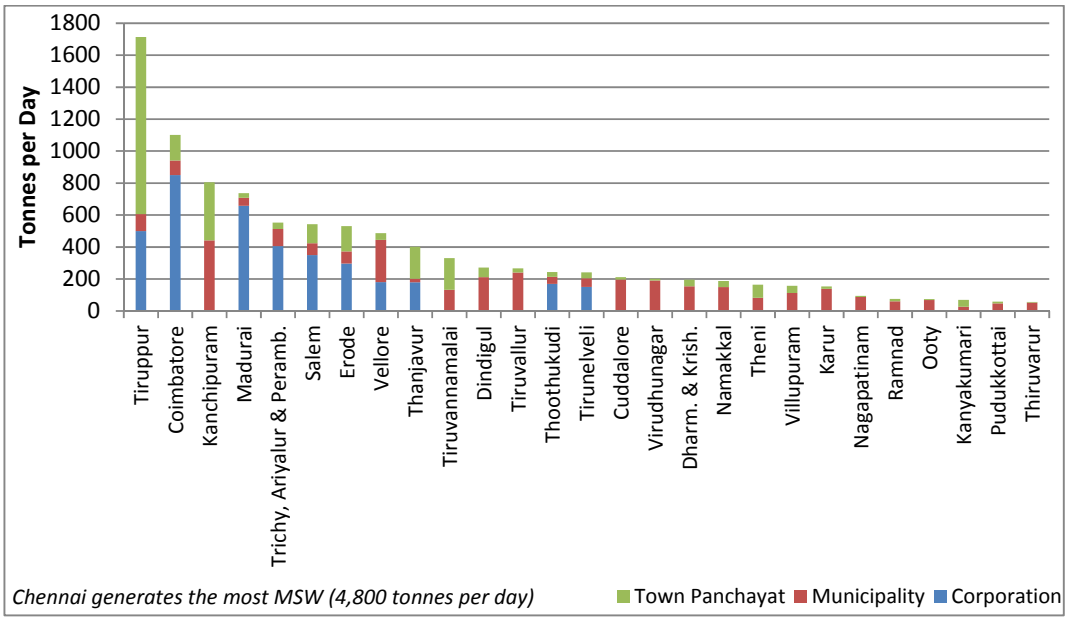
Burning of garbage at Chennai Corporation's Facility at Perungudi



Source: TNPCB Annual Report (2013-14).

Figure 8.4: Contribution of Different Sources to Municipal Solid Waste Generated (2013)

Figure 8.5 gives the district-wise break up of municipal solid waste generation in Tamil Nadu in 2013. Reported MSW generation across districts suggest that Chennai alone accounts for more than one-third of the total inventory of MSW in the state (34 per cent) and stands at 4800 tons/day. This makes Chennai as the major contributor to total MSW generated in the state. Compared to its 2004-05 level, this is a 58 per cent increase in the total stock of MSW generated. Other districts which are major contributors to MSW in the state include, Tiruppur, Coimbatore, Kancheepuram, Madurai and Salem. These 6 districts (including Chennai) account for 70 per cent of the total stock of MSW generated in Tamil Nadu.



Source: DoE (2014).

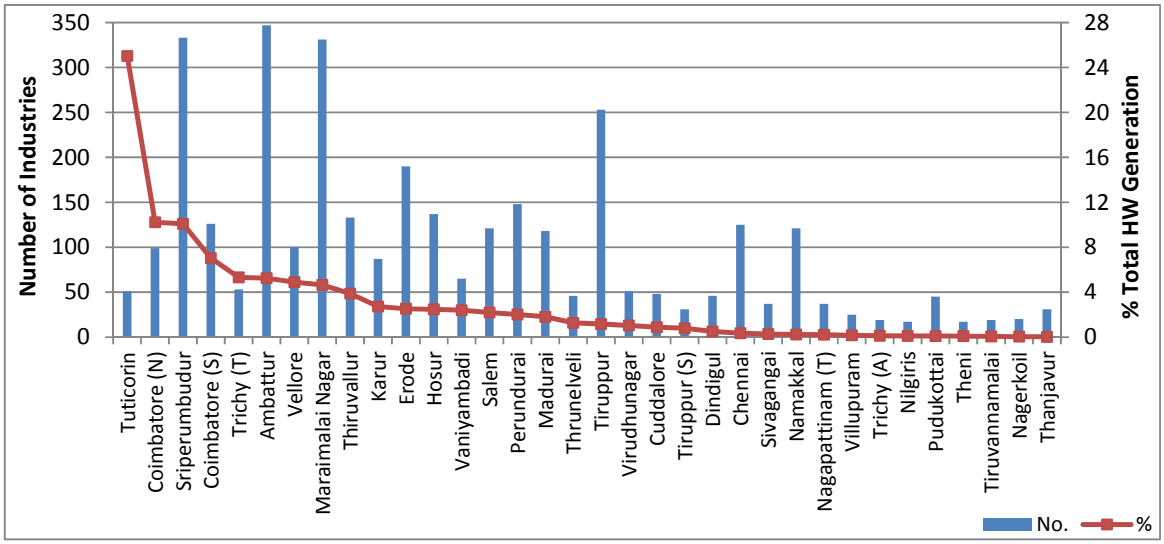
Figure 8.5: Solid Waste Generation in Tamil Nadu in 2013 (in Tonnes per Day)

Hazardous Waste

Industrial activities, mining extraction, tailings from pesticide based agricultural practices, etc. are the main sources of hazardous waste. Industries such as textile, tannery, petrochemicals, pharmaceuticals, pesticides, paint and dye, petroleum, fertilisers, asbestos, caustic soda, inorganic chemicals and general engineering industries are the main contributors to the generation of hazardous waste in the state. Thus, significant impacts on the ecosystem and the environment (including impacts on health) could occur unless proper methods in collection, storage, handling, transportation, treatment and disposal of hazardous waste are followed. For example, waste generated from the tanneries (e.g., effluents) could not only pollute the receiving streams/water bodies, but also persistence of such waste generation could affect the local groundwater tables by polluting them permanently. The use of such groundwater would produce harmful effects on human health. Continuous dumping of hazardous waste on land also results in land degradation.

As on 2008, a total of 2532 industrial units were identified to produce hazardous waste in the state. By the year 2014, there has been almost 35 per cent increase in the number of hazardous waste generating industries, taking the number of such industries to 3427. The total quantity of hazardous waste generated as on 2014 was 617891 Metric Tonnes per annum

(MTA) (see Figure 8.6). It is evident from Figure 8.6 that Tuticorin, Coimbatore, and Sriperumbudur account for nearly 52 per cent of the total stock of hazardous waste generated in the state. Of the total waste generated 51.1 per cent are recyclable, 42.9 per cent are land fillable, and 6 per cent are incinerable in nature.



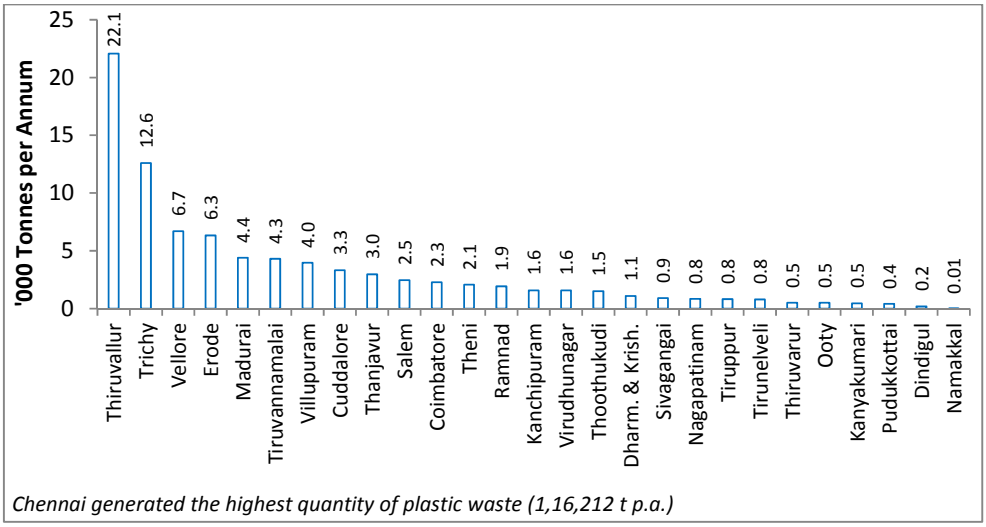
Note: Coimbatore (N) is Coimbatore North; Coimbatore (S) is Coimbatore South; Trichy (T) is Trichy – Thuvakudy; Tiruppur (S) is Tiruppur South; Nagapattinam (T) is Nagapattinam – Thiruvarur; Trichy (A) is Trichy – Ariyalur.

Source: TNPCB (personal communication through ENVIS Centre, Chennai).

Figure 8.6: District-Wise Number of Industries Generating Hazardous Waste and Percentage of Total Generation as on 31st December 2014

Plastic Waste

Chennai generated the highest quantity of plastic waste in 2013 (Figure 8.7), much more than any other district in Tamil Nadu. Thiruvallur district generated 22.1 thousand tonnes per annum. Districts to the right of Dharmapuri and Krishnagiri in Figure 8.7 generated less than 1000 tonnes per annum.



Source: DoE (2014).

Figure 8.7: District-Wise Plastic Waste Generation in Tamil Nadu in 2013 (in '000 Tonnes per Annum)

Electronic Waste

E-waste or "Electronic waste" may be defined as discarded computers, office electronic equipment, electronic entertainment devices, mobile phones, television sets, refrigerators and other electronic equipment. As urbanization and economic prosperity is closely associated with electronic waste generation, only about 10 states contribute to 70 per cent of the total e-waste generated in the country, and about 65 cities generate more than 60 per cent of the total e-waste in India. Among the 10 largest e-waste generating states, Maharashtra ranks first followed by Tamil Nadu, Andhra Pradesh, Uttar Pradesh, West Bengal, Delhi, Karnataka, Gujarat, Madhya Pradesh and Punjab. Significant amount of the e-waste generated in Tamil Nadu comes mainly from the urban areas. A total of 13486.2 tonnes of e-waste was generated in the year 2011 in Tamil Nadu (DoE, 2014). Among the top ten cities generating e-waste, Mumbai ranks first followed by Delhi, Bengaluru, Chennai, Kolkata, Ahmedabad, Hyderabad, Pune, Surat and Nagpur.

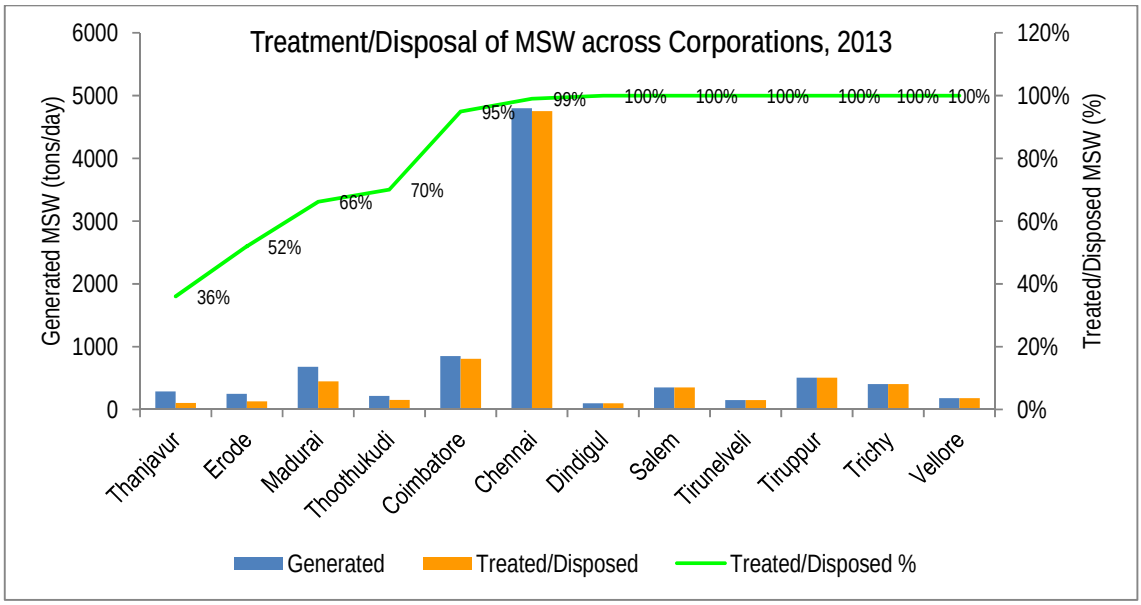
8.2 Waste Management

Compliance with MSW2000 Rules

Municipal Solid Waste Rules, 2000 (MSW2000) under the Environment (Protection) Act 1986 required the local bodies in each state to set up waste processing and disposal facilities by year-end of 2003. The rule further requires improvements in the existing landfills along with identification of sites for future landfills. Accordingly, the Tamil Nadu Pollution Control Board has urged all local bodies to take necessary steps towards compliance with MSW2000. The TNPCB further advocates segregation at the source keeping in view the high cost involved in construction, and operation of landfill. Segregation of wastes at source (individual houses) helps in reducing the wastes coming to landfills by 60 per cent.

The MSW2000 Rules lay out several compliance criteria pertaining to the collection, segregation, storage, transportation, processing and disposal of MSW that municipalities are required to follow. Biodegradable waste is usually processed via composting, mixed waste containing recoverable resources are recycled, incineration with or without energy recovery is used in certain cases, and land filling is restricted to non-biodegradable, inert waste and other waste that is not suitable for recycling or for biological processing (DoE, 2014). Among the 12 corporations in Tamil Nadu, only 6 treat their MSW, these include Coimbatore, Dindigul, Erode, Madurai, Salem and Thanjavur. In Chennai, sanitary workers collect and segregate recyclable wastes at the household level, other than that there is no processing of MSW and it is directly disposed-off in two dumping yards namely the Kodungaiyur dump yard (2100-2300 tonnes per day) and the Perungudi dump yard (2200-2400 tonnes per day) (TNPCB, 2014).

Figure 8.8 shows the status of treatment and disposal of MSW across municipal corporations in Tamil Nadu. The Municipal Solid Waste Rules of 2000 prescribe composting of organic waste and disposal of the inerts/residuals in a sanitary landfill. However, none of the cities in Tamil Nadu including Chennai have a sanitary landfill. See Box 8.1 for Namakkal success story with regard to solid waste management and see Box 8.2 for details of converting waste to energy in biomethanation plants.



Source: TNPCB Annual Report (2013-14).

Figure 8.8: Treatment and Disposal of MSW – Municipal Corporations in Tamil Nadu, 2013

Plastics make up 14 percent of MSW in Tamil Nadu (DoE, 2014). The largest amount of plastics are found in containers and packaging, durable and non-durable goods. The Plastic Waste (Management and Handling) Rules; 2011 sets out criteria for the use of plastics, their dimensions, thickness and colour and prescribes standards that they must adhere to. Tamil Nadu has banned the use of plastic carry bags less than 40 microns in thickness across the State and has stipulated that they should either be white in colour or in a pigment that conforms to the bar prescribed by the Bureau of Indian Standards (BIS). Moreover, recycled and compostable plastic bags need to conform to specific BIS standards. As a result many supermarkets (especially in Chennai city) have started charging the customer roughly Rs. 2 per carrier bag for packing groceries in. These Rules also explicitly recognise the role of waste pickers and requires the municipal authority to constructively engage with these groups of people to ensure effective plastic waste collection and disposal.

Hazardous Waste Management

Hazardous wastes are mostly generated from industries and can cause serious harm to human health and the environment. They may be identified by the characteristics that they exhibit including ignitability, corrosivity, reactivity and/or toxicity and thus proper management of these wastes is mandatory. The Hazardous Waste (Management, Handling and Transboundary Movement) Rules; 2008 classify the different industrial processes giving rise to hazardous wastes and provides details on how hazardous wastes should be handled and treated. In general hazardous waste is managed via recycling (when resource recovery is possible by reprocessing the waste), incineration (when it is possible to incinerate waste for destruction and energy recovery), and land fill (when waste is not suitable for either resource or energy recovery but may be suitable for dumping with or without treatment). TNPCB notes that as on 31st December 2014, the total quantity of hazardous waste generated in Tamil Nadu was 6,17,891 tonnes per annum (from 3,427 industrial units) of which the amount land fillable was 2,65,177 tonnes; recyclable was 3,15,710 tonnes; and, incinerable was 37,004 tonnes. A common hazardous waste Treatment Storage and Disposal Facility (TSDF) is in operation in the SIPCOT Industrial Estate in Gummidipoondi. Tamil Nadu has taken pioneering efforts to utilise the hazardous waste generated from Common Effluent Treatment Plants (CETP) of textile processing units as fuel/raw material for co-processing in cement factories. A detailed study and evaluation was undertaken by TNPCB to establish the compatibility of using hazardous wastes from textiles for co-processing in cement factories.

Similar trials are being conducted for the use of hazardous waste generated from tannery CETPs for co-processing and incineration, also in cement factories.

E-Waste Management

Tamil Nadu is the first state in the country to come up with a separate e-waste policy in 2010 and the policy of collection of electronic waste by community-based organizations (CBOs). The E-waste (Management and Handling) Rules, 2011 provide the rules on how e-waste should be managed and handled, and the procedure for storage, transportation of E-wastes and duties of the respective authorities. At the all India level the e-waste laws came into effect in May 2012. The law requires every producer and consumer who is involved in the manufacture, sale, procurement, and processing of electrical and electronic goods to channel their e-waste only through authorized processors for the collection, dismantling and recycling of e-waste. The laws require producers, consumers and recyclers to document several processes related to proper disposal of e-waste, and there are penalties for non-compliance.

In order to manage the e-waste in the state, the Tamil Nadu Pollution Control Board has seven authorised e-waste collection centres in Chennai, five e-waste recycling units and nine dismantling units in Tamil Nadu (see http://www.iwma.in for more details). The total capacities of these units are 38,927 tons per annum.

Bio-medical Waste Management

The Bio-medical Waste (Management & Handling) Rules; 2011 classifies waste into ten categories including, human anatomical waste, animal waste, microbiology and biotechnology waste, waste sharps, discarded medicines and cytotoxic drugs, soiled waste, solid waste, liquid waste, incineration ash and chemical waste, and in each case specifies the requisite treatment and disposal of the same. TNPCB has issued directions to both government and private hospitals to dispose their biomedical waste through Common Biomedical Waste Treatment Facilities (CBWTFs). Components of CBWTFs include an autoclave, shredder, compactor, and incinerator for anatomical waste, secured landfill facility, laboratory and vehicles for transportation of wastes (DoE, 2014). Table 8.3 shows biomedical waste, collected and disposed by the 12 CBWTFs in Tamil Nadu. Close to forty thousand kilograms of biomedical waste is collected and treated each day in Tamil Nadu. The treatment equipment used in these CBWTFs typically includes an incinerator, autoclave, hydroclave, microwave, shredder, deep burial and effluent treatment plant. In addition, almost all CBWTFs also have air pollution control systems attached to the incinerator such as scrubbers etc.

Table 8.3: Biomedical Waste Generation and Treatment in Tamil Nadu

S. No.	Name of CBWTF & Location	Districts/ Cities Covered by CBWTF	No. of HCFs Covered	No. of Beds Covered	Qty. of BMW Collected, Treated & Disposed (Kg/day)	Cost of Treatment of BMW Charged by Operator	
						Pvt. (Rs./bed/day)	Govt. (Rs./Kg)
1	G. J. Multiclave (India), Kanceepuram	Chennai, Kancheepuram, Tiruvallur	564	24450	7335	4	26
2	Taminadu Waste Management Ltd., Kancheepuram	Chennai, Tiruvallur, Cuddalore, Villupuram, Kancheepuram	502	21520	7125	4	26
3	Medicare Enviro Systems, Thanjavur	Thanjavur,Trichy, Tiruvarur,Nagapattinam, Karaikal, Pudukottai, Perambalur, Sivagangai, Ariyalur	593	17320	3225	3.5-4	28-31
4	Ken Bio Links Private Ltd., Vellore	Vellore, Tirvannamalai, Vaniyambadi	305	7162	2900	4.5	29
5	Society for Ilia Medical Waste Management, The Nilgiris	Nilgris	161	961	2450		(Rs.20000 for hosp./yr; Rs. 3500 for clinic/yr; Rs. 4000 for lab./yr)
6	Neat and Clean Service Squad, Ramanathapuram	Ramanathapuram	108	810	1894		(Rs. 5/ Kg)
7	Ramky Energy and Environment Ltd, Salem	Salem, Namakkal, Erode, Dharmapuri, Krishnagiri	810	17250	3560	6.5	40.5
8	Techno Therm Industries, Coimbatore	Coimbatore, Pollachi, Udumalpet, Mettupalayam, Tirupur, Sathyamangalam	317	10440	2400	5.5	29
9	Aseptic System Bio Medical Waste Management Co., Tirunelveli	Tirunelveli, Tuticorin, Kanyakumari	1126	20210	3659	3-4.5	26
10	Ramky Energy and Environment Ltd., Virudhunagar	Madurai, Virudhunagar, Dindigul, Theni, Ramnad	1670	23020	4165	3.5	27
11	Kovai Bio Waste Management Pvt Ltd., Coimbatore	Coimbatore, Nilgiris	90	735	220	5.5	29
12	Environ Bio Waste Systems (India) Pvt Ltd, Tiruvallur	Yet to be commissioned	-	-	-	-	-
	Total		**6246**	**143878**	**38933**	**-**	**-**

Source: DoE (2014).

Box 8.1: Solid Waste Management – The Case of Namakkal

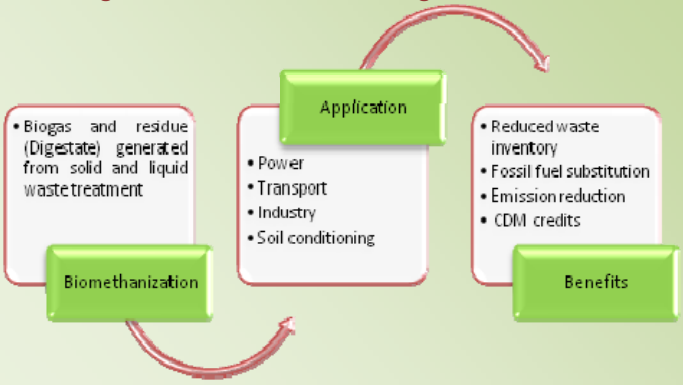
In the midst of growing despair on solid waste management, the case of Namakkal stands tall and provides optimism that if properly addressed with people's involvement these issues can be solved with considerable ease. Namakkal is a small district headquarter town situated on the main highway from Salem to Dindigul. It is the first municipality in the country involved in privatisation of all components in solid waste management. By institutionalisation of door-to-door collection with segregation at source, manufacturing of vermi-compost from organic waste and sale of recyclable from inorganic waste, Namakkal has the distinction of becoming the only zero garbage town in the country. Some of the main features of solid waste management in Namakkal include:

- Door-to-door collection with segregation at collection point
- Levy of service charges on heavy polluters such as hotels and commercial complexes
- Manufacture of vermi-compost from organic waste through voluntary organizations and private agencies on B.O.T. basis and selling inorganic recyclable garbage

Box 8.2 – Waste-to-Energy: The case of Biomethanation plants in Tamil Nadu

Biomethanation is the process of natural degradation of organic wastes producing 'biogas' and digestate (residue). Biogas as a renewable energy source can be used directly as a fuel and indirectly in generating electricity. Generation and use of biogas therefore acts as a potential source of fossil fuel substitution in various sectors including household, power, transport, industry, etc. The residues coming out of the biomethanation process acts as environment friendly soil conditioner, enabling moisture retention and organic content for soils and supplying nutrients for plant growth.

The benefits from a biomethanation plant is thus realized ultimately in terms of reduced inventory of generated wastes and reduced dependence on fossil fuels leading to significant reduction in greenhouse gases. Emission reductions achievable through this process can be translated into earning the Certified Emission Reduction (CER) credits for gaining financial support through the Clean Development Mechanism (CDM) proposed under the United Nations (UN).



Benefits of Biomethanation plants

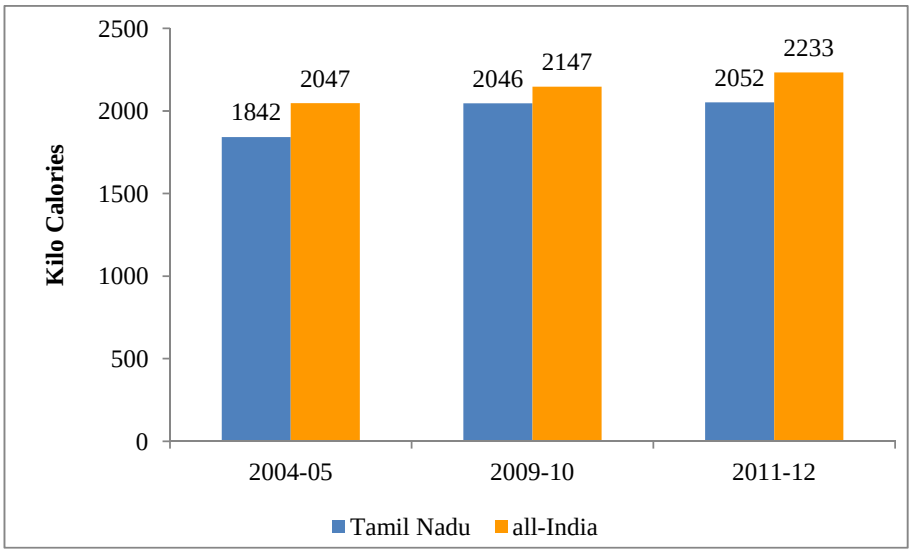
Koyambedu Biomethanation Plant

Tamil Nadu is a leading example in the country in showcasing its efforts towards conversion of wastes to energy through biomethanation plants. The biometnation plant based on *vegetable market wastes* at the Koyambedu wholesale market complex is a classic example. With an intake of 30 tons/day, the plant can produce 2500 m^3/day of biogas and 10 tons/day of biosludge or residue. In addition to using vegetable wastes, the plant now plans to use wastes from hotels, treated sewage sludge, banana stems and slaughter houses. The generated biogas could be supplied to 2000 households in the neighbouring locality.

The Government of Tamil Nadu has been proactive in setting up new biomethanation plants using Municipal Solid Wastes (MSW) in the state. The pilot project of 3MT capacity at Arcot Municipality, producing 240 Units of electric energy/day to light 500 No. of 40 watts street lights, was a success. The Government has therefore proposed to set up 29 new biomethanation plants of 3-5 MT capacities across 5 Corporations and 24 Municipalities. With establishment of these plants, a (net) generation of 48,18,000 units of electric energy and 4095 tons of CO_2 emission reduction per year is projected.

Chapter 9: Agriculture and Allied Sectors

Food security means ensuring sufficient, safe and nutritious food for all. Ensuring sustainable access to food for the entire population, taking into account the dietary needs and food preferences is the main concern under food security. In general, an assessment of food energy intake (both quantity and quality) at the household level provides sufficient insights into food security situation of any particular region. Figure 9.1 shows the per-capita calorie intake across different years in Tamil Nadu and India. Tamil Nadu has been lagging behind India in terms of the calorie intake. The average daily calorie intake per capita in the state was 2052 Kcal for rural areas and 2112 Kcal for urban areas during 2011-12 compared to 2233 Kcal for rural areas and 2206 for urban areas in the country. In terms of protein and fat intake Tamil Nadu is behind the country average both in rural and in urban areas. The daily average intake of protein intake in rural (urban) areas of Tamil Nadu is 53.3 gm (55.7 gm). Majority of the protein intake comes from cereal consumption (47 per cent for rural areas) (NSSO, 2014).



Source: NSSO (2014).

Figure 9.1: Per-capita Calorie Intake in Tamil Nadu and India

Agriculture provides both livelihood security and food security to a significant proportion of the population of Tamil Nadu. The sector thus continues to be the backbone of the state economy. The year 2012-13 witnessed severe drought in the state that reduced the total production of food-grains in the state. However, 2013-14 saw a significant recovery in the total food grain production (110.02 lakh tones compared to 56.05 lakh tones in 2012-13) owing to good monsoon, backed by an increase in both area and yield of crops (DEAR, 2013-

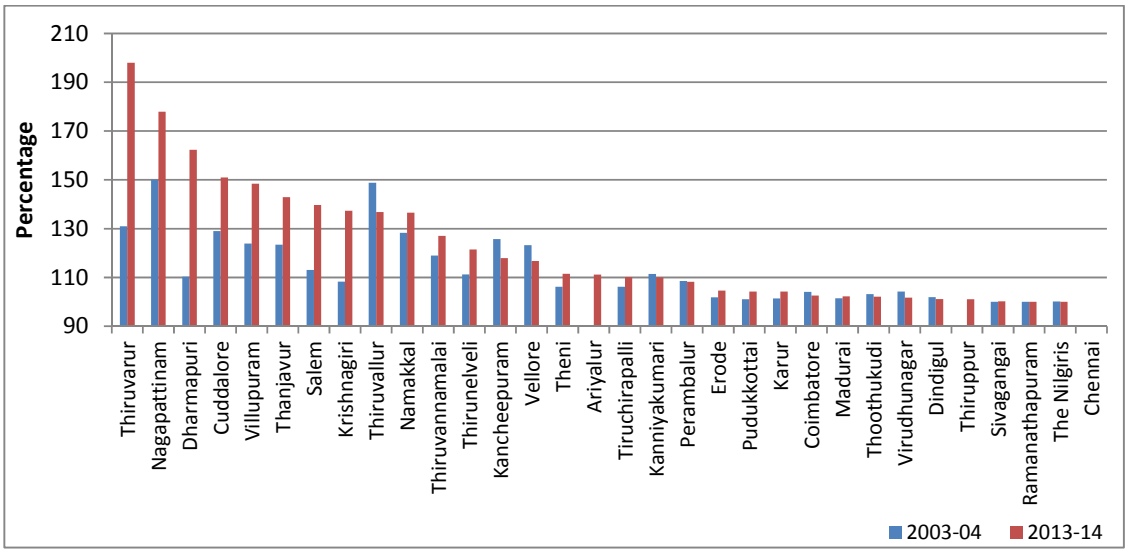
14). Further, the year 2014-15 witnessed a record high production of food-grain with a total of 128 lakh tons (Department of Agriculture, personal communication through ENVIS Centre, Chennai). Nearly 20 per cent of the population depends on agriculture in the State. Of the total workers, nearly 42 per cent depend on agriculture either as cultivators or agricultural labourers. Although the number is declining, the share of population dependent on agriculture is still significantly high.

There are however, longer-term issues confronting agriculture in the state. These include, but not limited to, reduction in area cultivated, mismatch between water extraction and recharge, growing conversion of agricultural land for non-agricultural uses, wide disparities in yield of various crops across the state, unsustainable application of chemical nutrients, etc. Against this background, this chapter looks at the pressures acting on agriculture and allied sectors in Tamil Nadu, the status of food security in the state, the impacts of food insecurity and responses undertaken by the state in advancing sustainable agricultural output in Tamil Nadu.

9.1 Pressures on Agricultural Sector

9.1.1 *Agricultural Practices*

District-wise cropping intensity which is defined as the gross cropped area divided by the net sown area, is presented in percentage terms in Figure 9.2 for the years 2003-04 and 2013-14. Higher cropping intensity means that a higher proportion of the net sown area is being cropped more than once in a particular agricultural year, implying greater pressure on agricultural land to produce food. In 2013-14, Thiruvarur district had the highest cropping intensity (almost 198 per cent). Over the period 2003-04 to 2013-14, cropping intensity increased substantially in the districts of Thiruvarur and Dharmapuri by 51 and 47 per cent respectively. Cropping intensity also increased by between 15 – 30 per cent in the districts of Nagapattinam, Cuddalore, Villupuram, Thanjavur, Salem and Krishnagiri, whereas it declined in the districts of Vellore, Kancheepuram and Thiruvallur by between 5 – 10 per cent over that same time period.

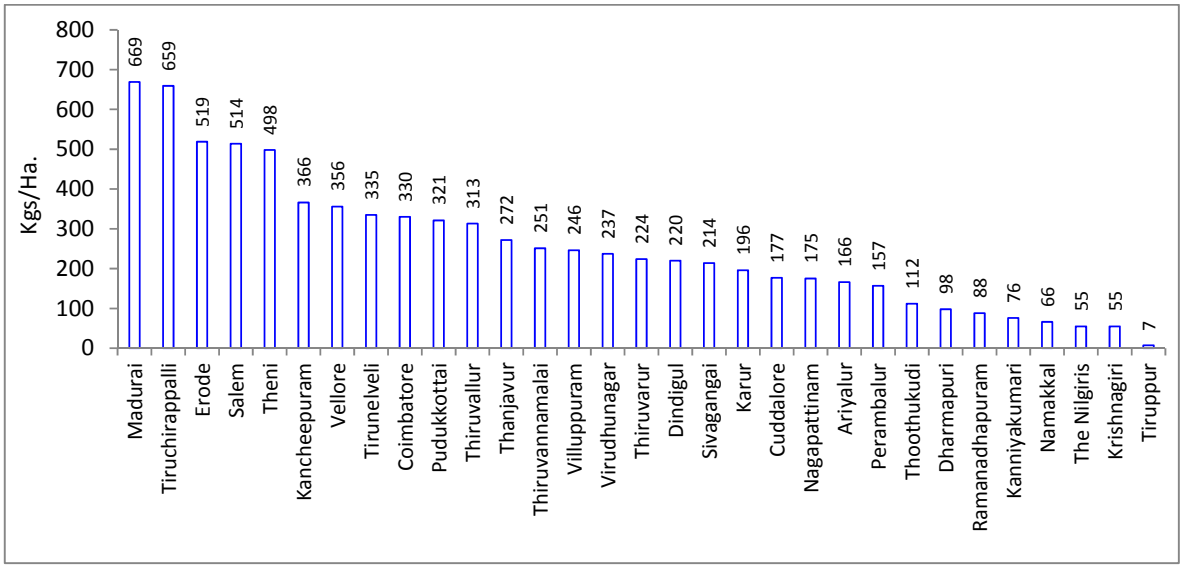


Source: DEAR (2003-04); DoES (2013-14).

Figure 9.2: District-Wise Cropping Intensity (in Percentage of Gross Cropped Area/ Net Area Sown)

9.1.2 *Fertilizer and Pesticide Use – Trends and Spreads*

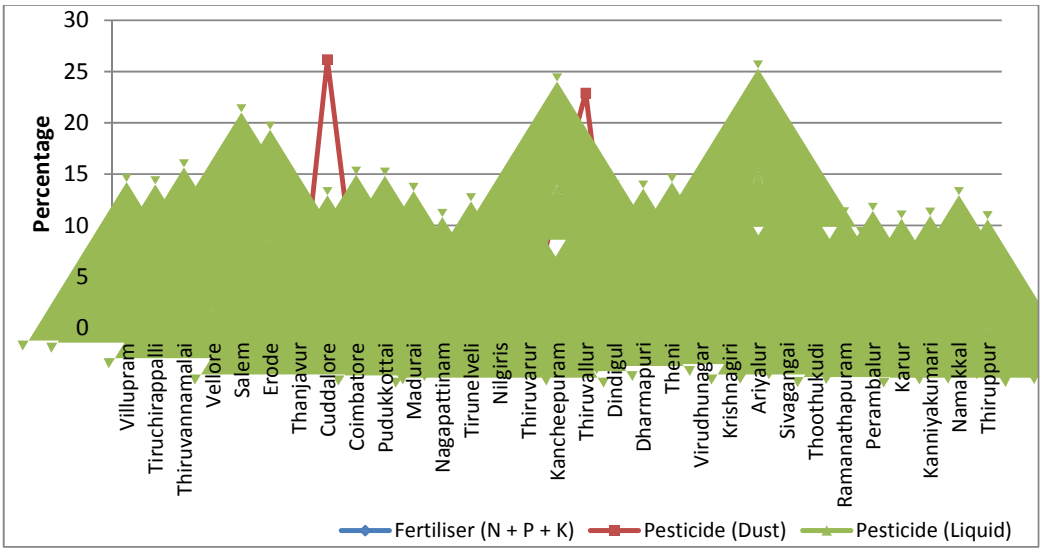
Figure 9.3 shows the district-wise consumption of fertilizer in Tamil Nadu. In addition to water quality issues discussed in Chapter 6, the excessive fertilizer use observed in Tamil Nadu is widely seen as critical issue of long-term consequence.



Source: DEAR (2013-14).

Figure 9.3: Fertilizer Consumption across Districts in Tamil Nadu – 2012-13

In 2012-13, total fertiliser consumption in Tamil Nadu was 14,11,639 million tonnes, which was an increase from 2007-08 levels by about 31 per cent. In the same year, total pesticide consumption was 3,210 million tonnes of dust and 4,85,210 litres of liquid. Compared to 2007-08 levels, consumption of pesticide in dust form declined by approximately 50 per cent, and liquid pesticide consumption decreased by 9 per cent in Tamil Nadu in 2012-13.Figure 9.4shows that Villupuram had the highest percentage of total fertiliser consumption in 2012-13 (about 9 per cent). Cuddalore consumed more than a quarter of total pesticide in dust form (26 per cent), followed by Thiruvallur that consumed about 23 per cent, and Kancheepuram that consumed 12 per cent of the same. The district with the highest consumption of liquid pesticide was Ariyalur (15 per cent of total), followed by Kancheepuram and Salem (13 and 10 per cent of total respectively).

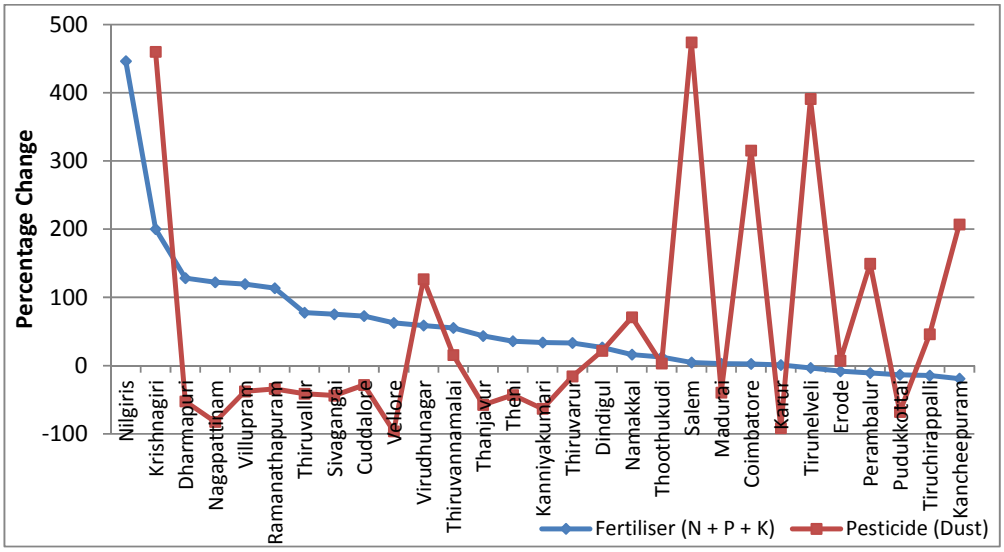


Source: DoES(2014).

Figure 9.4: District-Wise Fertiliser and Pesticide Consumption in 2012-13 (Percentage of Total Consumption)

Over the five-year period between 2007-08 and 2012-13, fertiliser consumption increased in almost all districts of Tamil Nadu, increasing the most in the Nilgiris (by over 400 per cent), however the same declined by close to 20 per cent in Kancheepuram (Figure 9.5). On the other hand, pesticide (dust) consumption declined in a majority of the districts, declining the most in the districts of Vellore and Karur (by over 90 per cent in each), however increasing significantly in the districts of Salem, Krishnagiri, Tirunelveli, Coimbatore and Kancheepuram (by over 200 per cent in each). Moreover, while liquid pesticide consumption also declined by more than 30 per cent in a majority of districts, it increased significantly (in

excess of 100 per cent) in the districts of Cuddalore, Theni, Coimbatore, Krishnagiri and Vellore.



Source: DoES (2014).

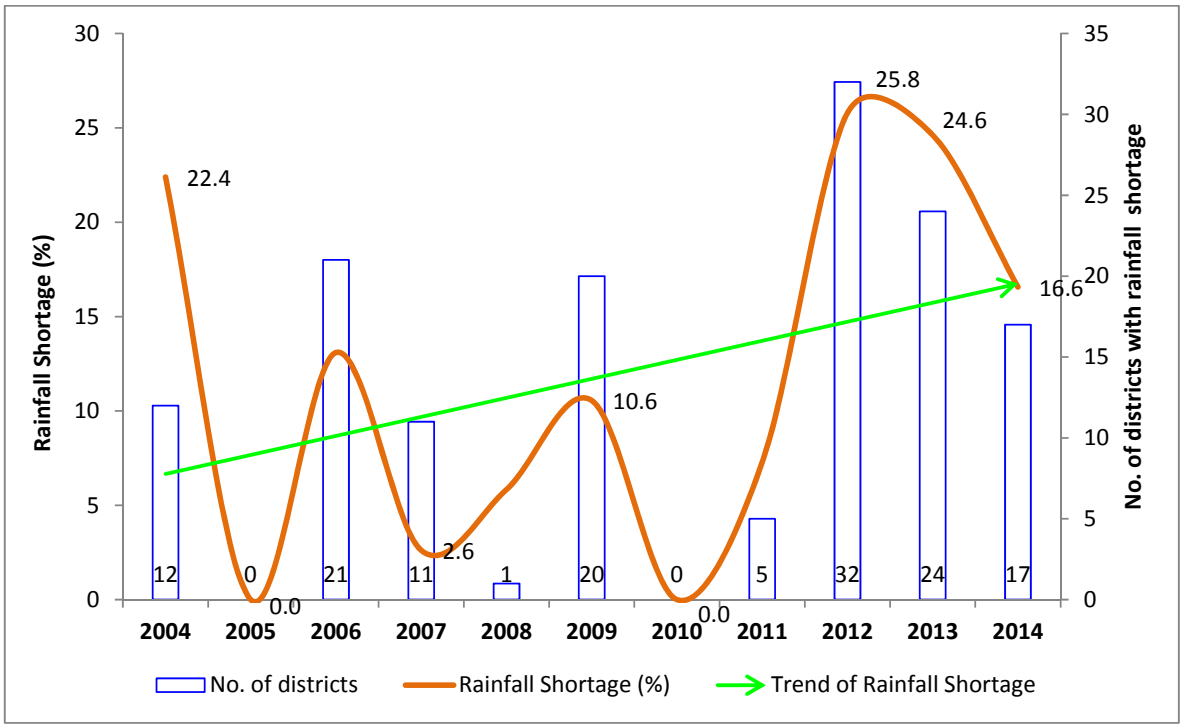
Figure 9.5: District-Wise Percentage Change in Fertiliser and Pesticide Consumption between 2007-08 and 2012-13

In general, districts that have recorded a small increase or a decline in fertiliser consumption over the past five years have also recorded big increases in pesticide consumption over that period, and *vice versa*. There are some exceptions however, in Krishnagiri and Virudhunagar both fertiliser and pesticide consumption increased drastically over the past five years.

9.1.3 *Rainfall Variability*

Rainfall anomaly suggests the extent to which actual rainfall in a particular year differs from its long-term average at any given location. Below normal rainfall (rainfall shortage) trends over the period 2004 to 2014 suggests that in 9 out of the 11 years, at least one district in the state has witnessed below normal rainfall. During the period 2004 to 2008, there were 45 instances of rainfall shortage across districts compared to 98 instances of rain shortfall during the period 2009 to 2014. Hence, there has been an increasing trend in the number of districts experiencing shortage in rainfall (see Figure 9.6).

A comparison of the average shortfall in rain between the same two periods also suggests an increase from 8.78 per cent during the 2004-2008 to 14.14 per cent during the 2009-2014. With climate change, rainfall becoming more erratic is likely to increase the number of instances a district witnessing rainfall shortage. Compared to an older climate's normal rainfall this may also imply that the average shortfall in rain for the districts could be higher.

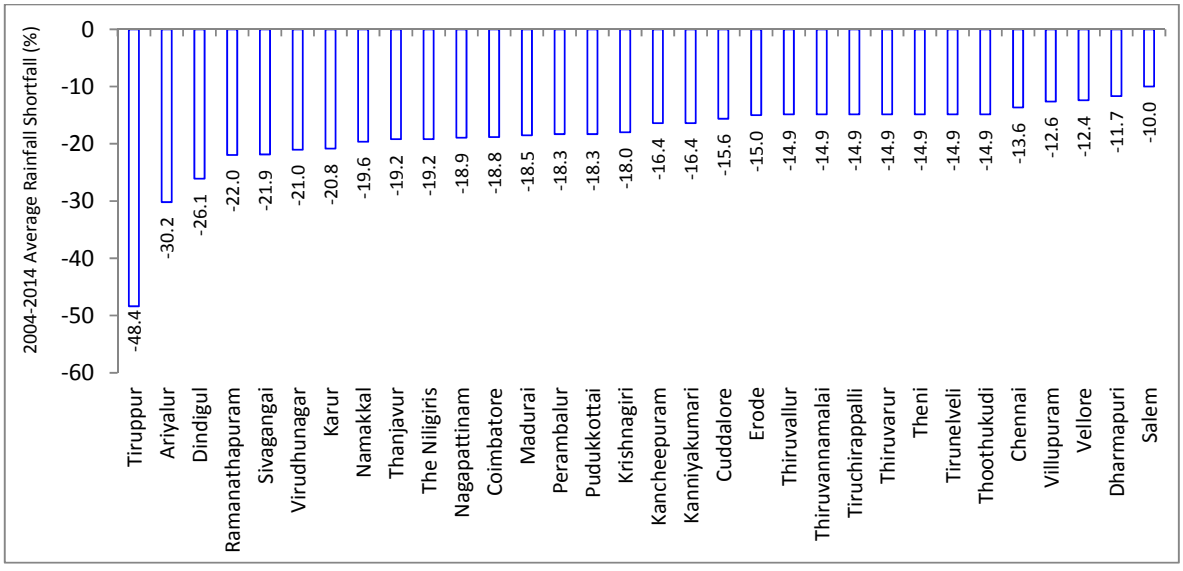


Source: Same as Table 9.1.

Figure 9.6: Trend in Rainfall Shortage in Tamil Nadu (2004-2014)

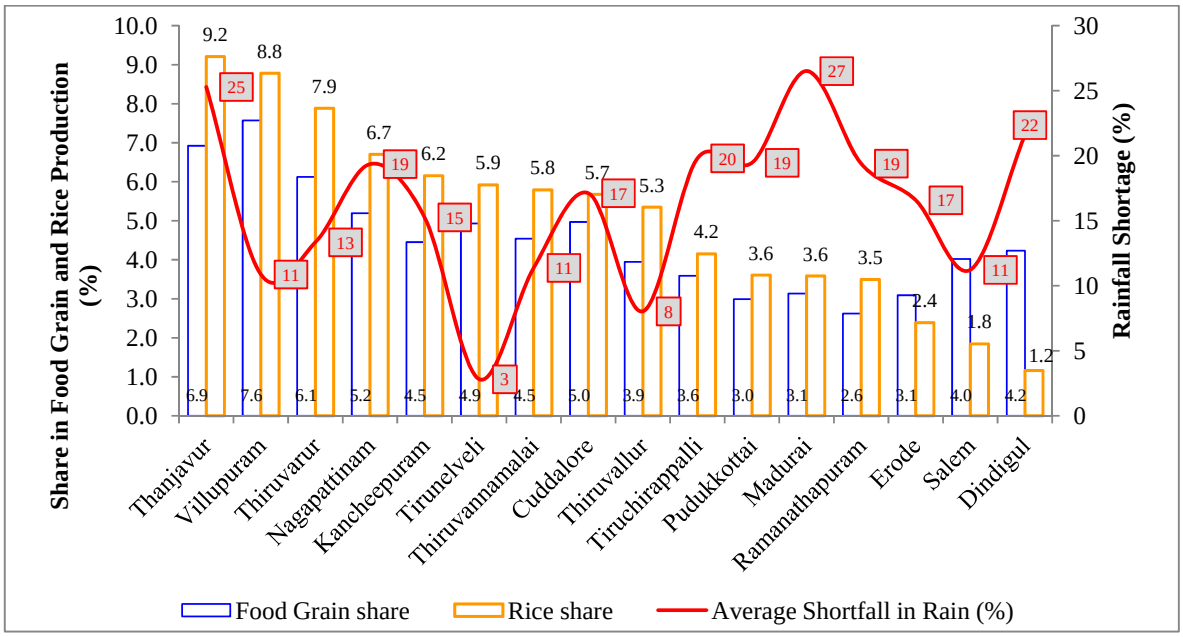
District-wise analysis of rainfall shortage over the period 2004 and 2014 reveals that the range of rainfall shortage in the past 11 years varies between 10 per cent for Salem and 48.4 per cent for Tiruppur (see Figure 9.7). Some of the districts which showed an average shortfall of more than 15 per cent include Ariyalur, Dindigul, Ramanathapuram, Sivagangai, Virudhunagar, Karur, Kanniyakumari, Madurai, Thanjavur, and Cuddalore. The State has received nearly 18.3 per cent below normal rainfall. Table 9.1 below shows that almost all districts have shown an increase in the exposure to rainfall shortage during 2009 and 2014 compared to 2004 and 2008. This suggests the increasing frequency of low rainfall events. Chennai, Salem, Dharmapuri, Thanjavur, Nagapattinam, and Nilgiris witnessed more frequent rainfall shortages in the second sub-period (2009 to 2014).

Such significant anomalies in rainfall in the longer-run could pose significant problems for food production and food security, given the direct dependence of agriculture on rainfall. Comparison of rainfall shortages during 2008-09 and 2013-14 across agriculturally important districts suggests that some of the districts which are major contributors to total foodgrain (or rice) production in the state also faced significant shortage in rainfall during 2008-09 and 2013-14 (see Figure 9.8). Thanjavur, Thiruvarur, Cuddalore, Madurai and Nagapattinam are particularly vulnerable to the rainfall anomaly, given their large contributions to agricultural production.



Source: Same as Table 9.1.

Figure 9.7: District-wise Average Rainfall Shortage during 2004-2014



Source: DEAR (2003-04, 2012-13); DoES (2013-14).

Figure 9.8: District-Wise Average Rainfall Shortage (%), Food Grain and Rice Production Share (%) in Tamil Nadu (2008-09 to 2013-14)

Table 9.1: Rainfall Anomaly and Distribution of Rainfall Shortage Years – Districts

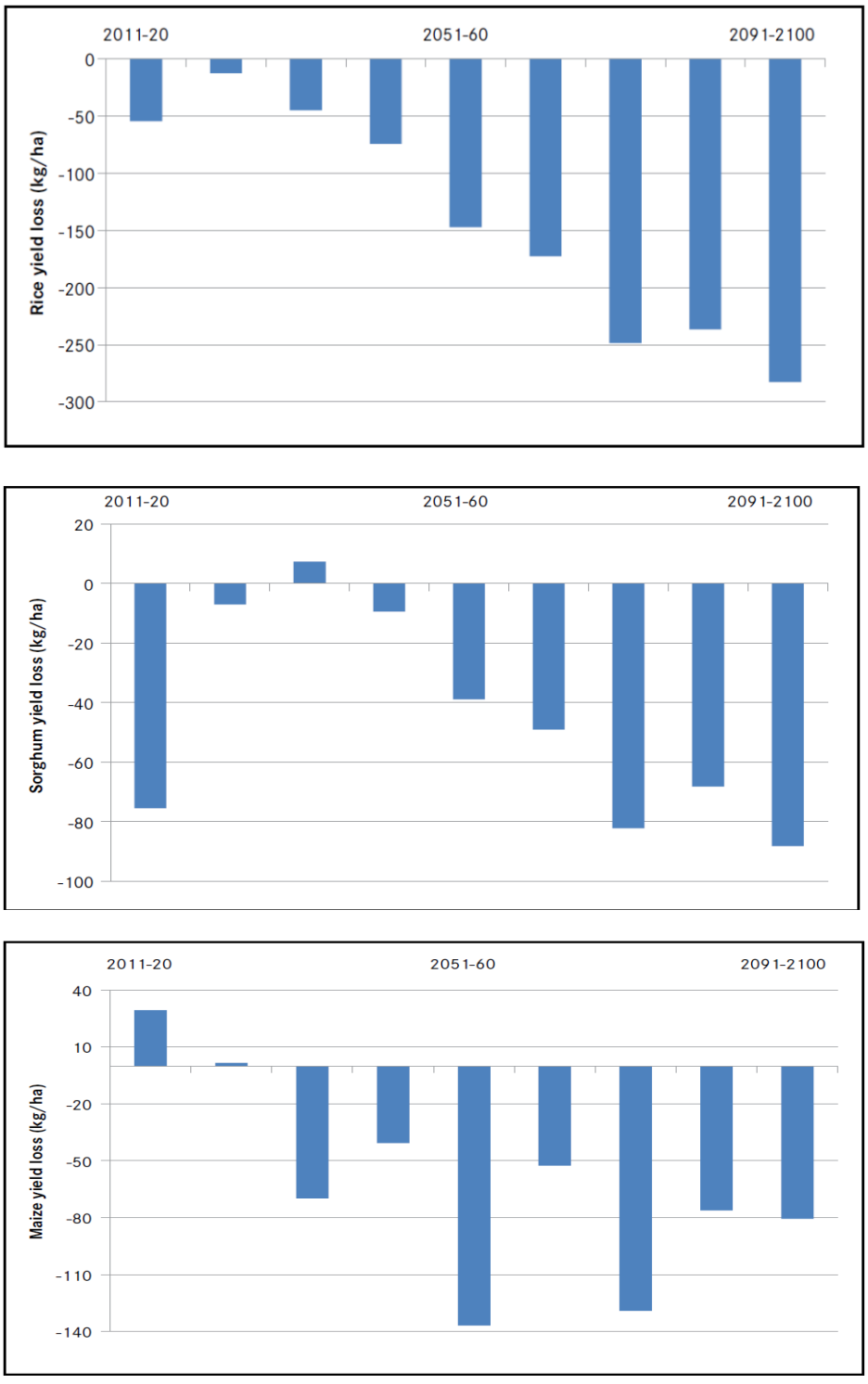
	Rainfall Anomaly (%)											Rainfall Shortage Years					
	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2004-2008		2009-2014		2004-2014	
District												No.	%	No.	%	No.	%
Chennai	0.0	91.2	8.3	-0.3	7.2	-19.3	7.1	27.5	-29.6	-16.2	-2.8	1	20	4	67	5	45
Kancheepuram	-9.8	54.5	-13.8	-2.2	11.5	-10.1	11.4	20.2	-26.5	-26.3	-26.1	3	60	4	67	7	64
Thiruvallur	-30.9	34.7	-11.2	4.9	25.1	-2.3	41.9	45.9	-15.0	18.1	30.4	2	40	2	33	4	36
Cuddalore	29.8	53.9	9.3	-1.1	49.6	12.1	25.9	23.4	-26.8	-19.0	0.9	1	20	2	33	3	27
Villupuram	52.3	34.5	4.1	16.6	39.2	2.8	34.6	11.4	-11.2	-21.9	-4.8	0	0	3	50	3	27
Vellore	-1.4	43.7	-6.7	25.3	-5.8	-17.3	7.8	5.0	-13.5	-15.3	-26.8	3	60	4	67	7	64
Thiruvannamalai	-30.9	34.7	-11.2	4.9	25.1	-2.3	41.9	45.9	-15.0	18.1	30.4	2	40	2	33	4	36
Salem	9.3	35.4	-2.4	5.8	26.9	-0.1	26.7	11.8	-16.7	-16.7	-14.0	1	20	4	67	5	45
Namakkal	-8.8	52.4	9.5	-2.8	23.3	-21.0	9.3	8.5	-38.0	-21.6	-25.7	2	40	4	67	6	55
Dharmapuri	25.7	59.0	-9.2	10.9	7.5	-2.7	16.3	6.5	-20.2	-11.2	-15.1	1	20	4	67	5	45
Krishnagiri	-	-	-32.8	9.1	18.2	6.0	18.1	7.1	-18.3	-10.0	-10.9	1	33	3	50	4	44
Tiruppur	-	-	-	-	-	-	22.9	14.2	-41.7	-55.1	17.5	0	-	2	40	2	40
Coimbatore	2.8	44.7	10.3	4.0	77.8	77.1	6.1	36.5	-18.8	30.3	77.3	0	0	1	17	1	9
Erode	16.5	67.4	-1.9	0.4	11.3	3.8	38.8	24.3	-22.5	-20.6	8.5	1	20	2	33	3	27
Tiruchirappalli	-30.9	34.7	-11.2	4.9	25.1	-2.3	41.9	45.9	-15.0	18.1	30.4	2	40	2	33	4	36
Karur	10.4	48.6	-25.1	-1.6	13.9	-20.8	27.9	16.6	-25.9	-29.7	-21.9	2	40	4	67	6	55
Perambalur	16.8	41.4	-20.4	-4.3	9.8	-21.4	9.0	2.6	-42.2	-15.8	-5.8	2	40	4	67	6	55
Pudukkottai	16.8	41.4	-20.4	-4.3	9.8	-21.4	9.0	2.6	-42.2	-15.8	-5.8	2	40	4	67	6	55
Thanjavur	24.4	39.1	-20.1	1.8	37.8	13.7	34.7	-4.1	-32.3	-29.4	-10.1	1	20	4	67	5	45
Thiruvarur	-30.9	34.7	-11.2	4.9	25.1	-2.3	41.9	45.9	-15.0	18.1	30.4	2	40	2	33	4	36
Nagapattinam	33.7	25.7	-7.3	10.6	38.4	37.6	14.5	-15.5	-26.9	-26.1	1.6	1	20	3	50	4	36
Madurai	9.0	49.9	-3.0	-1.5	20.4	-11.6	30.4	6.8	-40.9	-34.2	-19.8	2	40	4	67	6	55
Theni	-30.9	34.7	-11.2	4.9	25.1	-2.3	41.9	45.9	-15.0	18.1	30.4	2	40	2	33	4	36
Dindigul	25.5	57.4	3.4	10.7	33.7	-3.8	28.5	8.0	-31.6	-42.9	6.8	0	0	3	50	3	27
Ramanathapuram	36.0	52.7	4.2	-4.1	81.8	12.6	37.2	1.2	-33.6	-28.2	15.8	1	20	2	33	3	27
Virudhunagar	-22.4	19.8	18.4	-4.1	29.0	-35.4	4.5	-2.0	-37.7	-24.7	-20.9	2	40	5	83	7	64
Sivagangai	26.0	47.2	10.3	1.2	34.3	2.5	32.2	16.7	-26.8	-17.0	10.5	0	0	2	33	2	18
Thiirunelveli	-30.9	34.7	-11.2	4.9	25.1	-2.3	41.9	45.9	-15.0	18.1	30.4	2	40	2	33	4	36
Thoothukudi	-30.9	34.7	-11.2	4.9	25.1	-2.3	41.9	45.9	-15.0	18.1	30.4	2	40	2	33	4	36
The Niligiris	24.4	39.1	-20.1	1.8	37.8	13.7	34.7	-4.1	-32.3	-29.4	-10.1	1	20	4	67	5	45
Ariyalur	-	-	-	-	-	-	6.6	-10.7	-37.6	-37.7	-34.8	0	-	4	80	4	80
Kanniyakumari	-9.8	54.5	-13.8	-2.2	11.5	-10.1	11.4	20.2	-26.5	-26.3	-26.1	3	60	4	67	7	64

Note: Author's calculation using annual total rainfall actuals and normals for the period 2004-2014. Annual total rainfall (actuals) for 2004-2010 are from India Meteorological Department (IMD) available at India Water Portal (IWP). Data for 2011-2013 are based on IMD last five-year district-wise rainfall data series. Data for 2014 actual rainfall is provided by IMD (Chennai). Recent year Normals are provided by IMD (Chennai). Older year normals obtained from Season and Crop Reports 2004-05 and 2005-06.

Source: DEAR (2003-04, 2013-14), DoES (2004-05, 2005-06).

9.1.4 *Climate Change and Agriculture*

Putting together a unique 39 year (1971 to 2009) panel dataset of agricultural performance of the districts of Tamil Nadu, Saravanakumar (2015) examined the impact of climate change on the yields of food crops, viz., rice, sorghum and maize. The study finds that rice and sorghum are quite sensitive to changes in rainfall and temperature compared to maize. Projected temperature and rainfall using the RegCM4 model for the period from 2011 to 2100 indicate that observed warming and anomalies in rainfall in Tamil Nadu will continue. Projections suggest that there will be a reduction of 283 kg per ha per decade of rice and 88 kg per ha per decade of sorghum by 2100. This represents a 10 per cent decline in rice productivity and a 9 per cent decline in sorghum yield by the end of the 21st century, relative to the average yield during the base period 1971-2009. Figure 9.9 shows the projected yield changes under climate change scenario for rice, sorghum and maize crops.



Source: Saravanakumar (2015).

Figure 9.9: Projected Yield Losses in Rice, Sorghum and Maize Crops in Tamil Nadu (base period 1971-2009)

9.2 Status of Agriculture Sector

9.2.1 *Declining Production and Widening Yield Gap*

Index of Agricultural Production is the summary measure which shows the pulse of the performance in agricultural sector. In view of the fact that the performance of the agricultural sector displays wide variations from year to year, the trends in area, yield and production are analyzed during the 10th (2002-03 to 2006-07) and 11th (2007-08 to 2011-12) Five Year Plan periods. The overall agricultural production in the State had gone up at an annual average growth rate of 7.29 per cent during the 10th Five Year plan period (2002-2007).This accomplishment is mainly due to the increase in yield of crops. There was an overall decline in area by 0.42 per cent in this period. During this Plan period, the production of food crops fared better than non-food crops. Turning to 11th Five Year Plan period (2007-2012), the overall agricultural production in the state declined at an annual average rate of 2.37 per cent. The fall both in area and yield of crops was mainly responsible for this decline during the 11th Plan period. As between food and non-food crops, even though the latter registered a growth of 0.33 per cent, the decline in the production of food crops by an annual average 3.08 per cent engendered the fall in the overall agricultural production in the State. In the case of food crops, both area and yield rate witnessed negative growth in this Plan period. In respect of non-food crops, only the area under the crops registered a fall and the increase in yield rate of crops compensated the fall in area and contributed to the overall increase in production.

The yield gap is also a major issue that contributes to agricultural stagnation in the State. There is considerable yield gap between on-farm trials and yield actually realized by the farmers. Except paddy, there is significant yield gap in other crops. The yield gap is around 50.0 per cent of the potential yield. This is because the adoption of agronomic practices has not been uniform and widespread. Agricultural strategy has to focus attention towards bridging the gap between the potential yield and the actual yield realized.

9.2.2 *Horticulture*

Horticulture is a growth engine for the agricultural sector and the way forward for attaining nutritional security in the state. The population of Tamil Nadu has increased from 62.41 million to 72.14 million in last decade which necessitates increasing the production of horticulture crops to meet the growing nutrition demand. The Horticulture crops grown in Tamil Nadu have been classified into six categories viz., fruits, vegetables, spices and condiments, plantation crops, flowers and medicinal and aromatic plants.

Major fruit crops grown in Tamil Nadu are Banana, Mango, Citrus, Grapes, Guava, Sapota, Papaya, and Pineapple. These are grown in 2,93,146 hectares mainly in districts like Krishnagiri, Dindigul, Thirunelveli, Vellore, Theni, Erode, Trichy, Thiruvallur, Dharmapuri and Madurai. Major Vegetable crops grown are Tapioca, Onion, Tomato, Potato, Brinjal, Bhendi, Drumstick, beans and Carrot in an area of 2,26,502 hectares mainly in districts like Namakkal, Salem, Dharmapuri, Trichy, Thiruppur, Dindigul, Erode, Villupuram, Krishnagiri, Perambalur, Nilgiris and Theni.

Important spices and condiments grown are Chillies, Turmeric, Tamarind, Coriander, Pepper, Cardamom and Cloves in an area of 1,45,559 hectares in districts like Ramnathapuram, Thoothukudi, Erode, Salem, Virudhunagar, Dindigul, Dharmapuri and Sivagangai. Tea, Coffee, Rubber and Cashew are the important plantation crops grown in an area of 2,32,988 hectares in districts like Nilgiris, Ariyalur, Cuddalore, Kanyakumari, Dindigul, Coimbatore, Pudukottai and Salem.

In addition to the traditional flowers like Jasmine, Crossandra, Tuberose, and Chrysanthemum, cut flowers like Rose, Carnations, and Gerbera are also being produced in the State. The cut-flower industry is growing due to high export prospects. Flowers are grown in an area of 25,309 hectares in districts like Dindigul, Dharmapuri, Krishnagiri, Salem, Madurai, Tirunelveli, Thiruvallur, Vellore and Thiruvannamalai. Medicinal and aromatic crops like Gloriosa, Senna, Coleus, Lemon-grass and Periwinkle are grown in an area of 11,230 hectares in districts like Virudhunagar, Dindigul, Thiruvallur, Ariyalur, Madurai, Thiruvarur, Dharmapuri, Salem, Nagapattinam, and Trichy.

Horticulture crops in Tamil Nadu account for nearly 17 percent of the total cropped area. There has been a steady increase in the area covered under horticulture cropsin the recent past (see Table 9.2). The total area covered under horticulture crops in the State moved up from 10.01 lakh hectares in 2011-12 to 10.81 lakh hectares in 2012-13 (8.0 per cent) and would further rise to 11.46 lakh hectares in 2013-14 (6.0 per cent). Fruits, vegetables, spices and condiments and plantation crops together claimed a share of 96.0 per cent of the total area covered under horticultural crops. The overall yield rate exhibited a steady improvement. The average yield rate of horticultural crops per hectare improved from 15.24 tonnes in 2011-12to 16.09 tonnes in 2012-13 (5.6 per cent) and would further improve to 16.69 tonnes in 2013-14(3.7 per cent). The increase in area and yield rate helped to augment the total production of horticultural crops from 52.62 lakh tonnes in 2011-12 to 173.99 lakh tonnes in 2012-13(14.0 per cent) and further to 191.31 lakh tonnes in 2013-14 (10.0 per cent).

Table 9.2: Performance of Horticulture Crops in Tamil Nadu

Crops	2011-12			2012-13			2013-14		
	A	Y	P	A	Y	P	A	Y	P
Fruits	2.87	20.48	58.77	3.10	21.62	67.00	3.29	22.43	73.70
Vegetables	2.54	27.25	69.27	2.74	28.77	78.96	2.90	29.95	86.79
Spices & Condiments	1.65	6.11	10.05	1.78	6.44	11.46	1.88	6.69	12.61
Plantation Crops	2.55	4.12	10.50	2.75	4.34	11.97	2.92	4.51	13.16
Medicinal and Aromatic crops	0.14	9.20	1.29	0.15	9.73	1.48	0.16	9.91	1.62
Flowers	0.26	10.35	2.74	0.29	10.92	3.12	0.31	11.12	3.43
Total Crops	10.01	15.24	152.62	10.81	16.09	173.99	11.46	16.69	191.31

Note: A –Area in lakh hectares; Y–Yield in tonne per hectare; P- Production in lakh tonnes
The figures for 2013-14 indicate forecast estimates.
Source: DEAR (2013-14).

9.2.3 *Implications of Food Insecurity*

Manifestations of food insecurity in the state are captured through status of under-nourishment (see Table 9.3), percentage of children with low birth weight (see Figure 9.10), children reporting anaemia (see Figure 9.11), and infant mortality rate (see Figure 9.12). In terms of the overall status of under-nourishment, Tamil Nadu has showed consistent improvements over the period 1998 to 2012 and has also consistently fared better than all-India performance.

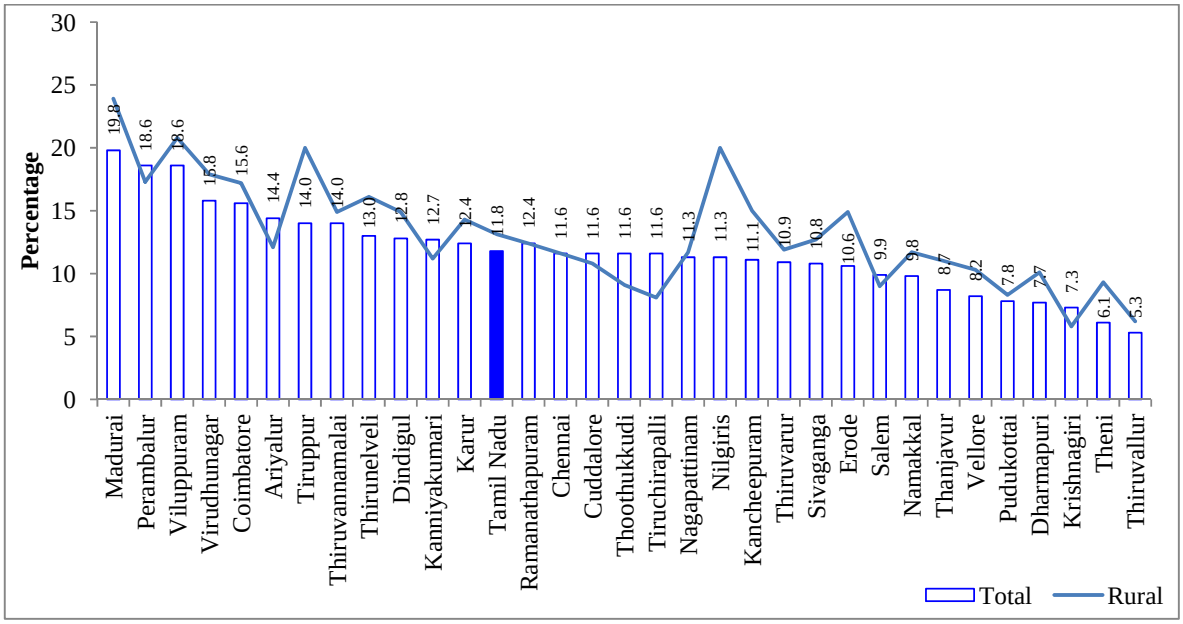
About 12 per cent of children are born with low birth weight in the urban areas and a slightly higher percentage of children reported low birth weight in the rural areas. Thiruvallur districts reported lowest per cent of under-weight children (at birth) in both rural and urban areas. Iron deficiency anaemia is the most widespread form of malnutrition. It may have detrimental effects on the health of women and children and may become an underlying cause of maternal mortality and perinatal mortality. Early detection of anaemia can help to prevent complications related to delivery as well as child development problems. As can be seen through Figure 9.11, districts like Karur and Ariyalur have reported high percentage of children have anaemia as well as severe anaemia.

Malnutrition is one of the important causes of infant mortality. The infant mortality rate in the state has shown a steady decline since the 1980s. Both rural and urban Tamil Nadu recorded sharper decline in the infant mortality rate than all-India.

Table 9.3: Status of Under-nourishment – Comparison of Tamil Nadu with All India

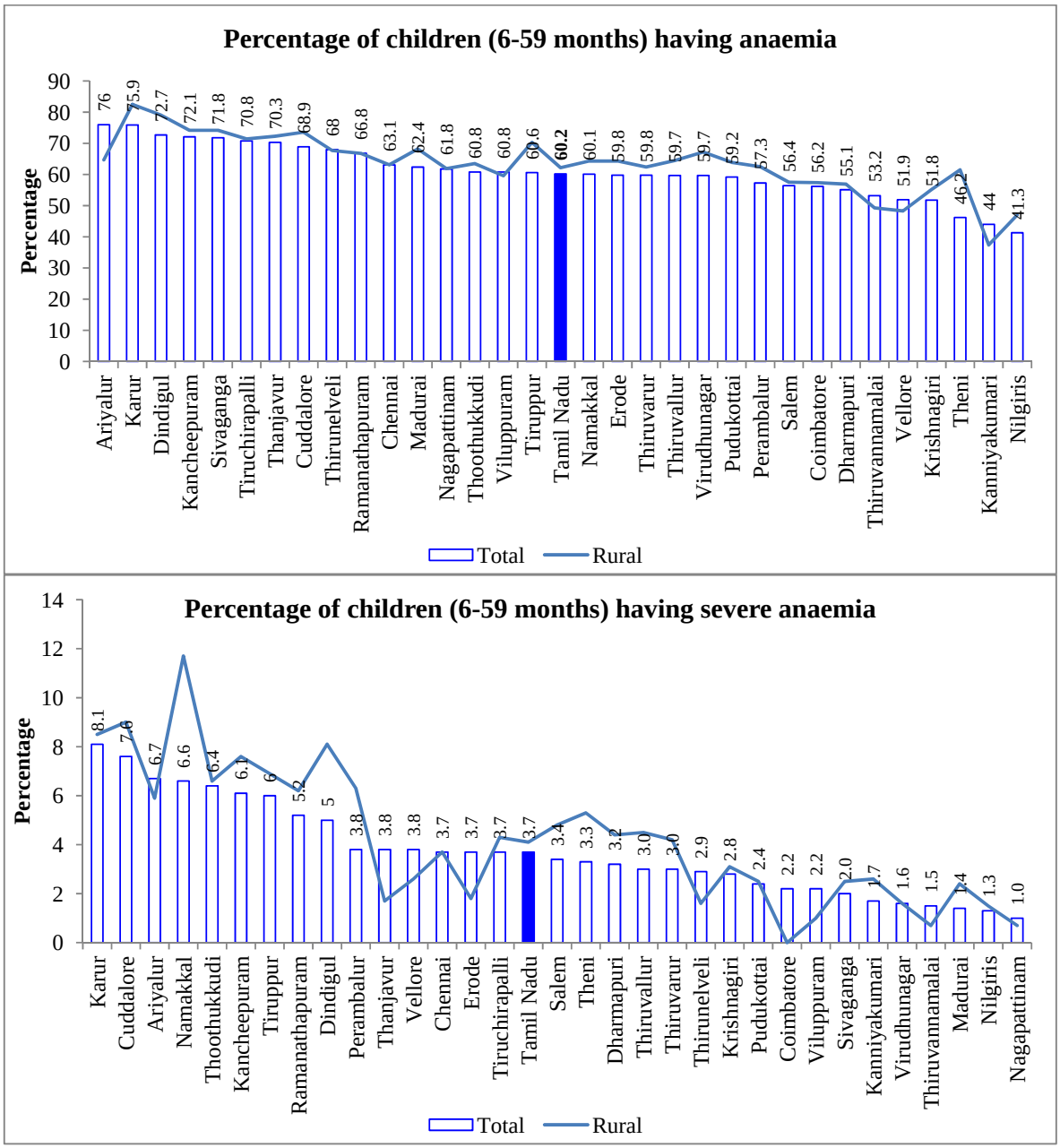
Indicator	NFHS II (1998-99) India	NFHS II (1998-99) Tamil Nadu	NFHS III (2005-06) India	NFHS III (2005-06) Tamil Nadu	DLHS 4 (2012-13) India	DLHS 4 (2012-13) Tamil Nadu
Stunting (children <-3SD)	51	35	45	31	-	11.8
Wasting (children<-3SD)	20	23	23	23	-	13.9
Underweight (children<-3SD)	43	32	40	26	-	10.7
Anaemia (<11g/dl) (children 6-35 months)	74	69	79	73	-	60.2#
Women with anaemia	52	57	56	54	-	49.2

Source: Planning Commission (2012); DLHS (2014).
Reported number is for children aged 6-59 months



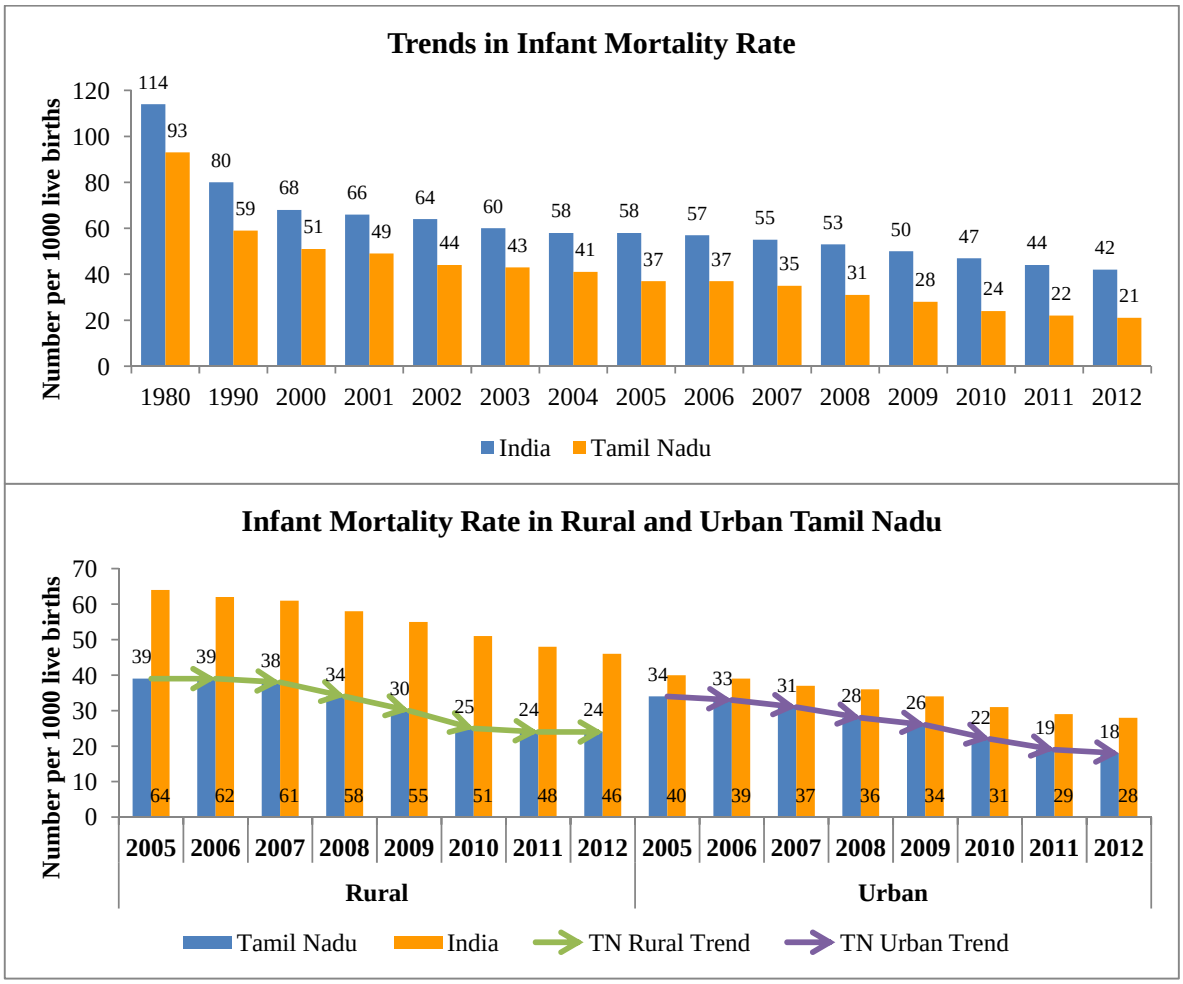
Source: DLHS (2014).

Figure 9.10: Percentage of Children with Low Birth Weight – Tamil Nadu (2012-13)



Source: DLHS (2014).

Figure 9.11: Percentage of Children Having Anaemia and Severe Anaemia – Tamil Nadu (2012-13)



Source: Top panel - DoH (2014-15); Bottom panel - DoES (2014).

Figure 9.12: Trends in Infant Mortality Rate in Tamil Nadu

9.3 Response

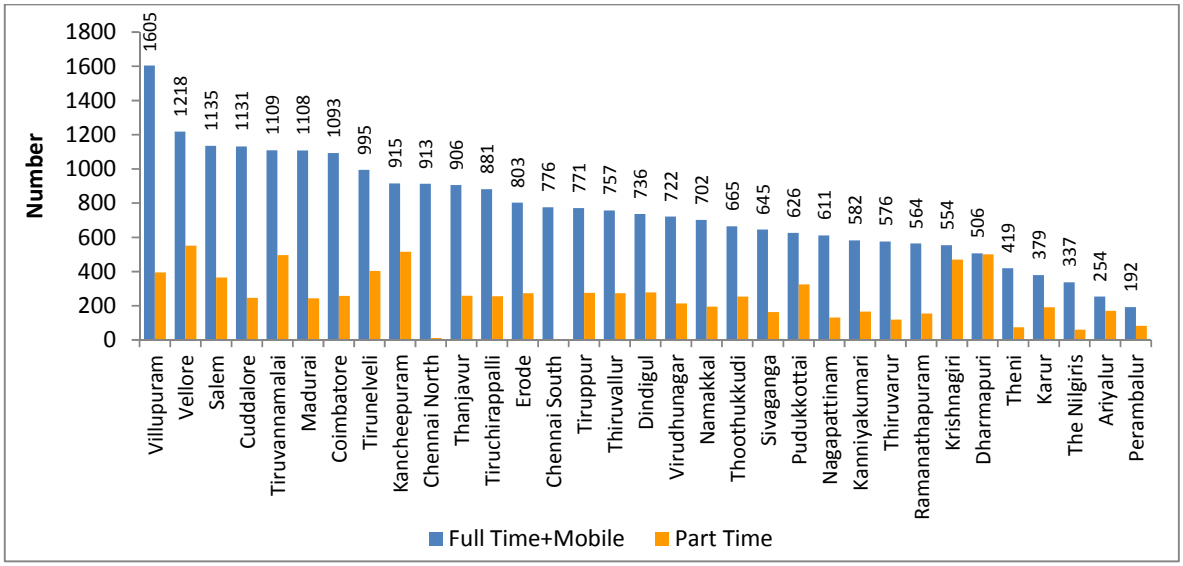
9.3.1 *Performance of PDS and ICDS*

The Government of Tamil Nadu's Policy for **"A Malnutrition Free Tamil Nadu"** guides the State's long-term multi-sectoral strategy for eliminating malnutrition. The goal is "*reducing human malnutrition of all types to the levels of best performing countries*". In pursuit of such objective, the state has undertaken a number of measures to ensure food and nutrition security amongst its population. These include ensuring sufficient food access through a Universal Public Distribution System (PDS), enabling food and nutritional security and education through programmes such as the Integrated Child Development Services (ICDS) and Puratchi Thalaivar MGR Nutritious Meal Programme (PTMGRNMP).

9.3.2 *Universal Public Distribution System*

The state of Tamil Nadu pursues a universal Public Distribution System (PDS) to ensure non-excludability, ease of access and adequate availability of food grains at affordable prices. In pursuing this objective of universal distribution, the government has paid significant attention towards poor households, ensuring their participation in the system. The system of PDS administered through the Commissioner of Civil Supplies and Consumer Protection (CCS&CP) where the Tamil Nadu Civil Supplies Corporation (TNCSC) acts as a facilitator for procurement and storage. In times of drought, the dependence of people on PDS is greater.

As of 2011, there were 33,222 fair price shops serving 1.98 crore families, of which 31,232 (94.1 per cent) are run by cooperatives, 1394 (4.2 per cent) are run by the TNCSC and 596 (1.79 per cent) are run by Women Self Help Groups. The PDS has also taken initiatives to ensure dietary diversity amongst the poor which is an important food security challenge. The 12th Plan has therefore proposed the provision of 3 kgs of any available millets to all card holders on a 100 per cent subsidy basis to rice card holders, and a lesser subsidized rates for other card holders (Planning Commission, 2012). This would enable distribution of nearly 59,100 tons/month or 7 lakh tons per annum. The state has also initiated mobile fair price shops. Figure 9.13 shows the distribution of fair price shops across the districts of Tamil Nadu. As of 2013, a total of 15 mobile shops were operating in the state (DoES, 2014).



Source: DoES (2014).

Figure 9.13: District-Wise Distribution of Fair Price Shops by Type in Tamil Nadu (2013)

9.3.3 *ICDS and PTMGRNMP*

The problem of malnutrition is multi-dimensional in nature and arises not only due to food non-availability (or shortage), but also from lack of *access* to food and its inadequate *utilization*. With the objective of improving the quality of food intake and its absorption in the body at the initial stages of growth, the ICDS address the nutrition and food security issue by providing a combination of supplementary feeding, health and nutrition education and regular health check-ups and acts as a critical link between child and women healthcare systems. ICDS in Tamil Nadu is implemented through 54,439 Child Centres (which includes 49,499 Anganwadi Centres and 4940 Mini Anganwadi Centres). By 2011, the ICDS has been operating in a total number of 434 Child Development Blocks which includes 385 rural blocks 47 urban blocks and 2 trial blocks.

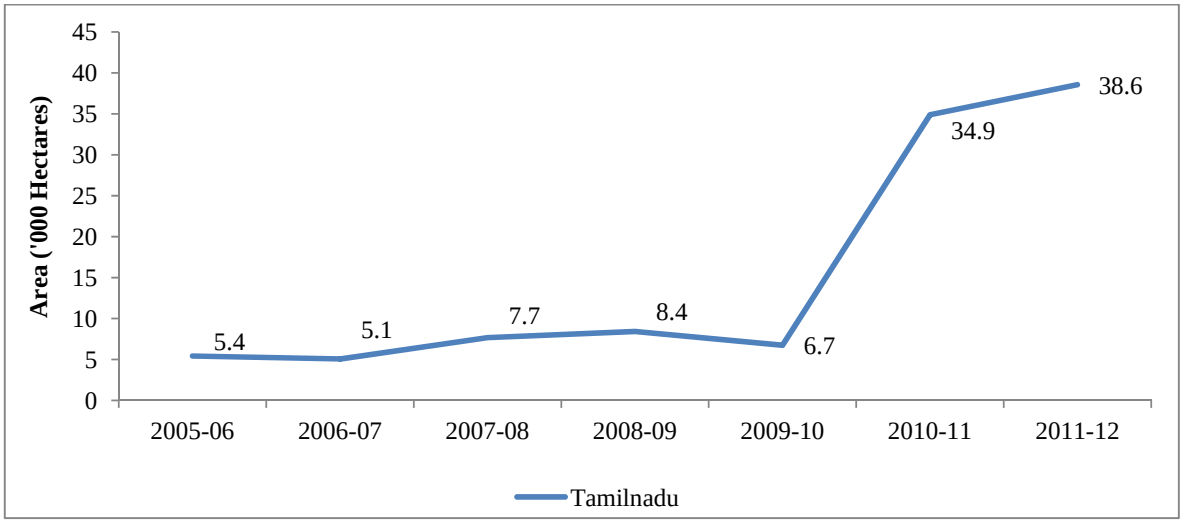
Tamil Nadu has been a leading state in the country in terms of its successive budget outlays for nutrition and healthcare. The PTMGRNMP is considered to be the largest noon meal programme in the country for combating malnutrition among children, increasing primary school enrolment and reducing dropout rates that have benefited a large number of its child and adult population. The programme therefore has three main components such as nutrition, preschool education and healthcare. The Centrally Sponsored Scheme of National Programme of Nutritional Support to Primary Education is implemented along with

PTMGRNMP in Tamil Nadu. The programme was aimed at combating hunger of pre-school going children (2+ to 5 years) expanded in a phase-wise manner to cover urban areas, school children upto 15years of age, pregnant and lactating women and various categories of pensioners for social security. During the year 2012-13 a total of 72165.7 MTs of foodgrains has been lifted for the program.

9.3.4 *Organic Farming*

The state of soil for cultivation is an important component in sustainable agriculture and therefore food security. Multiple cropping, excessive use of chemical fertilizers and inadequate application of organic manure are some of the main causes for deterioration in the organic manure content in the soil. Decline in organic content brings about significant changes in soil biodiversity and ultimately affects soil fertility and productivity. In view of this, the Government of Tamil Nadu encourages farmers to take up organic farming practices through the Integrated Plant Nutrient Management Technology by increasing the applications of organic and green manure, green leaf manure, vermi-composting, composting of farm wastes through Pleurotus and use biofertilizers instead of chemical nutrients. Total area under organic farming in the state has increased from 5.42 thousand ha in 2005-06 to 38.6 thousand ha in 2011-12, with a 10.5 per cent increase over 2010-11 (see Figure 9.14). As on 2011-12, the total organic manure (including rural and urban compost, farmyard manure, vermicompost, green manure and other manure) produced/available was 8.37 lakh MT. The

Tamil Nadu Government has also provided different economic incentives like subsidies in promoting the use of Green Manure in agricultural practices. In 2013-14, 207MT of Green Manure Seeds were procured and distributed to the farmers at 50 per cent subsidy (DoA, 2014).



Source: NCOF (2013).

Figure 9.14: Area under Organic Farming in Tamil Nadu

9.3.5 *Bio-fertilizers*

Bio-fertilizers are a cost-effective, eco-friendly, organic and renewable source of plant nutrient and are an important component of Integrated Nutrient Management. Bio-fertilizers like Blue Green Algae and Azolla are desirable bio-fertilizers that reduce the use of chemical fertilizers up to 25 per cent. At present Tamil Nadu has 15 government owned Bio-fertilizer Production Units functioning with an annual capacity of 3850 MT to be distributed at Rs. 6/- per 200 gm packet. The target level of production for the year 2014-15 is 2500 MT. With respect to bio-fertilizers the government has plans to produce new bio-fertilzers that will solubilize Potash and Zinc contents in the soil. Similarly, the government has taken steps to strengthen 5 existing Bio-Fertilizer Production Units (BFPUs) towards producing liquid bio-fertilizers.

9.3.6 *Vermicomposting*

Vermicomposting of agricultural waste is advantageous in improving soil structure, texture, aeration and water holding capacity increasing the beneficial micro flora and improving the quality and shelf life of the produce. The Government of Tamil Nadu has taken initiatives to train the farmers through demonstration programmes. In the year 2013-14 a total of 250 demonstration cum training program on vermicomposting happened with the objective of benefiting the farmers. Moreover, under the Rainfed Area Development Programme (RADP), the government has established 753 vermicompost units during the year 2013-15.

Chapter 10: Water Resources and Irrigation

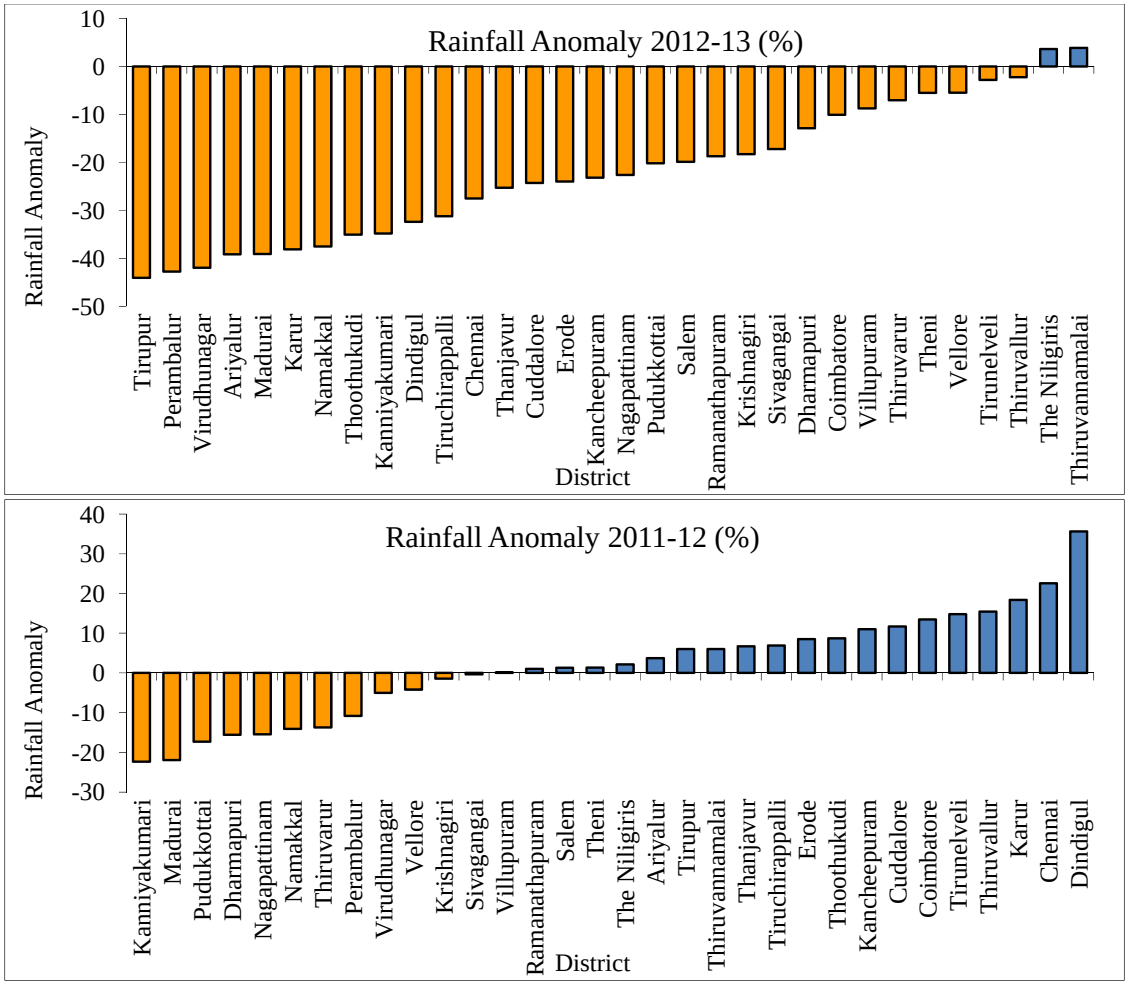
There are 17 major river basins in Tamil Nadu with 61 reservoirs and about 41948 tanks (SoERTN, 2006). Despite rich resource availability, the per capita water availability in the state at 900 cubic meters a year is well below the national average of 2200 cubic meters a year. Agriculture continues to be the single largest user (75 per cent) of available water resources, while demands from both domestic and industrial sectors are also increasing. Complementing the water quality issues discussed in Chapter 6, this chapter discusses the quality issues relating to this life resource.

10.1 Pressures on Water Quantity

10.1.1 *Rainfall Anomaly*

Rainfall anomaly measures the extent to which actual rainfall in a particular year differs (percentage) from the normal (long-term average) rainfall. Annual total rainfall is an important contributor to groundwater recharge. In 2011, rainfall accounted for nearly 42 per cent of the groundwater recharge in Tamil Nadu (CGWB, 2014). Therefore, lower than normal rainfall, as evident from the rainfall anomalies, could have significant impacts on current as well as future water availability. 2012-13 was a drought year for Tamil Nadu. The

state received significantly (19 per cent) lower than normal rainfall during 2012-13. The lower average rainfall can be attributed to significantly lower than normal South-West and North-East monsoon rainfall (23.5 per cent) and North-East monsoon (15.9 per cent). Figure 10.1 below shows the rainfall anomalies across districts of Tamil Nadu for the year 2012-13 compared to 2011-12. In 2012-13, all districts received significantly lower rainfall compared to their normal, barring two districts (The Nilgiris and Thiruvannamalai) that received slightly above normal rainfall. Compared to 2011-12 rainfall anomaly, rainfall anomaly for 2012-13 seemed quite severe. In the year 2011-12, the state average rainfall was 1.7 per cent higher than the normal and is reflected from positive rainfall deviations for majority of the districts.



Source: DEAR (2013-14).

Figure 10.1: Rainfall Anomaly across Districts in Tamil Nadu – 2011-12 & 2012-13

In addition to rainfall anomalies, the changes in the normal rainfall also put pressure on water availability in the state. Tamil Nadu receives rainfall in three seasons – south west monsoon, north east monsoon, and pre-monsoon. About 45 per cent of the normal

annual rainfall (of 958 mm) is received during the north east monsoon, 35 per cent is received during the south west monsoon, and the rest in the other season. Jain and Kumar (2012) analysed the past 100 years of rainfall data in Tamil Nadu and suggest that the rainfall has increased by about 8.5 per cent in the Cauvery river basin and by about 4.4 per cent in the river basins of north Cauvery. The study further suggests that river basins of south Cauvery have experienced a decline (of about 9.8 per cent) in their annual rainfall. While there is no statistically significant change in the annual rainy days in the Cauvery basin, the river basins towards the north and south of Cauvery basin have experienced decrease in their annual rainy days. Table 10.1 shows the observed changes in the annual rainfall and rainy days over the past 100 years.

Table 10.1: Changes in Annual Rainfall and Rainy Days – Tamil Nadu

River Basin	Annual Rainfall (mm/yr)	Annual Rainy Days (days/yr)
River Basins to the North of Cauvery Basin	0.0445	-0.032
Cauvery Basin	0.879	0.000
River Basins to the South of Cauvery Basin	-0.950	-0.333

Source: Jain and Kumar (2012).

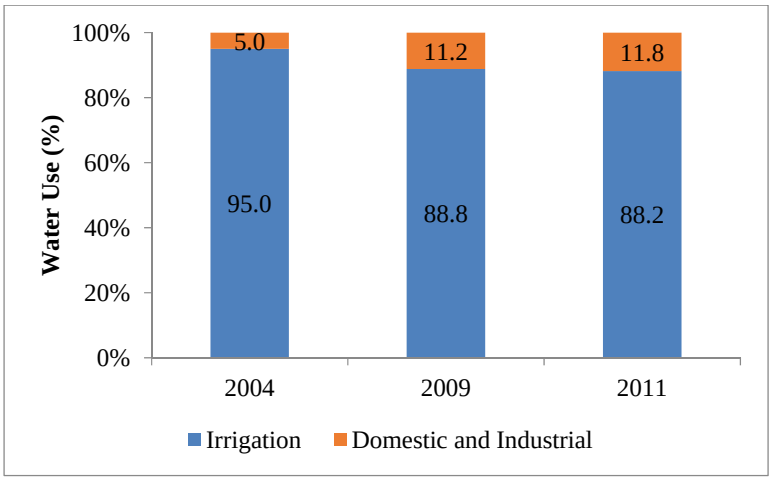
While the normal onset of south west monsoon over Tamil Nadu is 1st June, over the past 30 odd years (1981 to 2011), the onset date has advanced by a day. The north east monsoon on the other hand sets over Tamil Nadu on 20th October. Based on data over the period 1901 to 2000, it has been observed that the onset date varies between 13th October to 27th October. However, studies also indicate that early or late onset has relatively less bearing on the monsoon performance, and hence overall water supply in the state.

10.1.2 *Domestic, Industrial and Agricultural Water Use in Tamil Nadu – Trend*

Groundwater is used for various domestic, industrial and agricultural practices. Most of the annual groundwater draft is due to irrigation use (88 per cent in 2011). Water use for drinking purpose and industry accounts for nearly 12 per cent of the total annual demand. There have been significant changes in the use of groundwater resources with increasing domestic and industrial demand (see Figure 10.2). The total annual groundwater draft in 2011 due to irrigation was 13.2 bcm (88 per cent) of the net compared to 16.8 bcm (95 per cent) in 2004 (CGWB, 2014). Some of the studies have pointed out that most of the groundwater is exploited through the construction of millions of private wells (World Bank, 2010). In Tamil

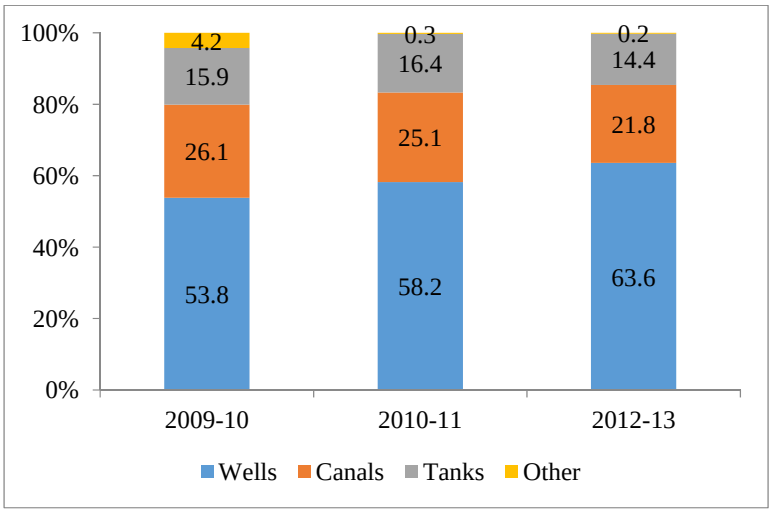
Nadu, significant amount of the irrigation activities depend on groundwater extracted from wells and not so much on canals or tanks. Further the use of ground water for irrigation purpose is showing increasing trend over years (see Figure 10.3).

However, as shown in Figure 10.4 there is substantial spatial difference in the pattern of use of ground water across Tamil Nadu. Some of the districts including Thanjavur, Perambalur, Viluppuram, Dindigul indicate more than 95 per cent of their groundwater use owing to irrigation. Districts such as Ramanathapuram, Thiruvallur, Nilgiris and Cuddalore, however, show less than 60 per cent of water use to irrigation.



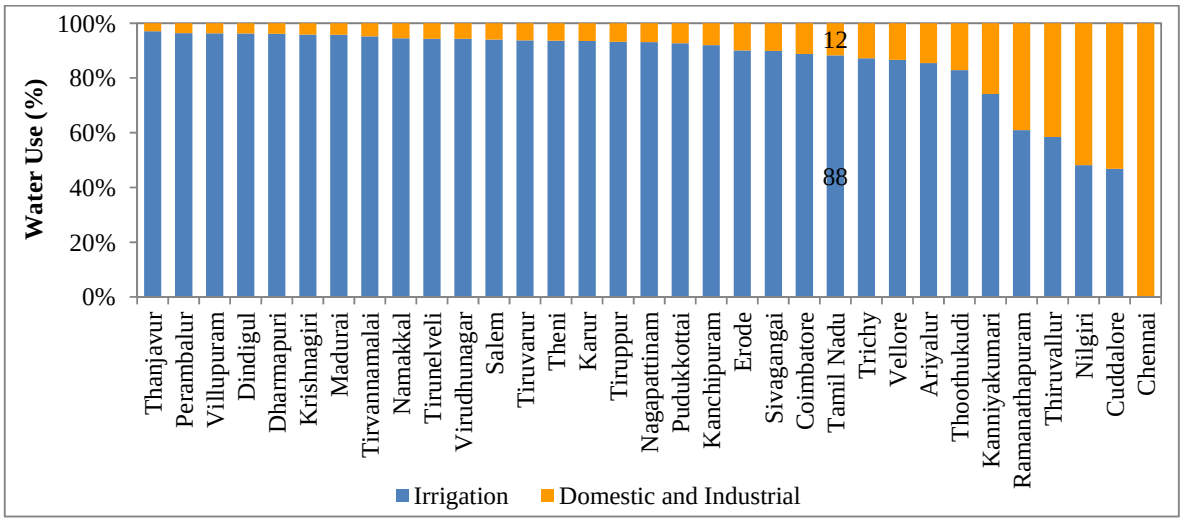
Source: CGWB (2014).

Figure 10.2: Changes in Sector-Wise Ground Water Use in Tamil Nadu



Source: DEAR (2013-14).

Figure 10.3: Gross Irrigated Area by Source of Water in Tamil Nadu



Source: DEAR (2013-14).

Figure 10.4: District-wise Groundwater Use by Sector in Tamil Nadu in 2011

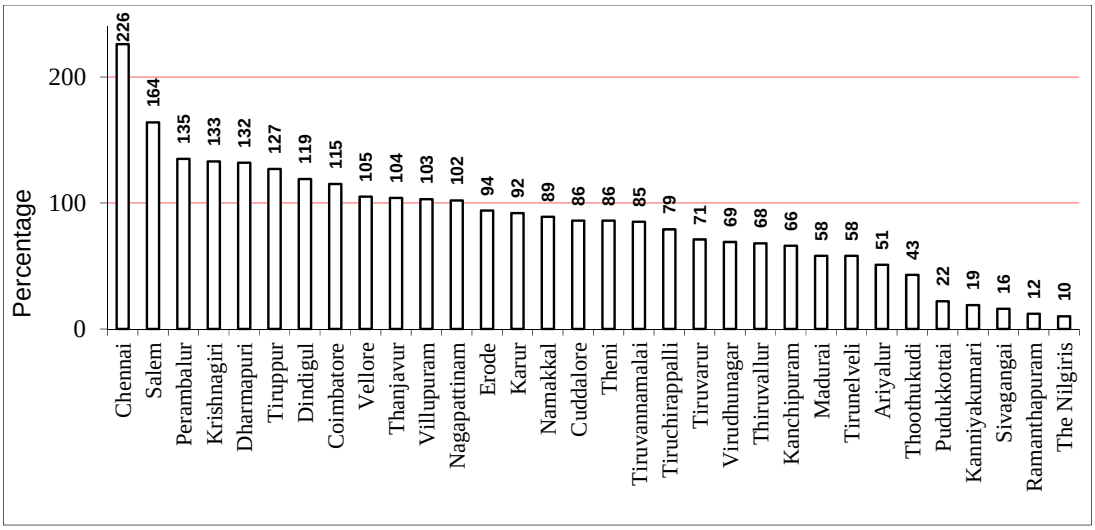
10.2 Status of Water Availability

10.2.1 *Quantity – Ground-water Tables – Spatial and Temporal Trends*

The Institute of Water Studies has prepared water resource plan of Tamil Nadu for the period 1994 and 2044. Of the annual water potential of 46540 million cubic meters (MCM), surface flows account for about half. Most of the surface water has already been tapped, primarily for irrigation. About 24 lakh hectares are irrigated by surface water through major, medium and minor schemes. The utilization of surface water for irrigation is about 90 per cent. Despite need for bringing more area under surface irrigation, inadequate and improper maintenance of irrigation facilities coupled with inefficient use of irrigation water (both in terms of quantum and timing of application) are widely considered as limiting factors. Also, poor drainage facilities in several irrigation facilities are considered to be responsible for continuation of water intensive paddy crop, which can withstand water stagnation, even during the water scarce conditions.

On the other hand, the utilizable ground water recharge in Tamil Nadu is 22423 MCM. The utilization expressed as net ground water draft of 13558 MCM has increased from about 60 per cent of the available recharge in 1993 to 64 per cent in 2003. While much of the ground water is used for drinking water purposes – for instance, in 2001 about 80 per cent of annual drinking water demand was met through ground water, increasingly ground water is also tapped for irrigation purposes. The state of ground water conditions in Coimbatore

district exemplifies the situation that prevails over most parts of Tamil Nadu. Between 1960-61 and 2004-05, the number of wells tapping ground water has doubled from about 1.09 lakhs to 2.42 lakhs. Such indiscriminate tapping of the resource fuelled by free power supply for irrigation pump sets has also resulted in significant number of 'failed' wells. According to Central Groundwater Board statistics the number of districts which record more than 20 cm fall in groundwater table per year has increased from 15 during 1980-2000 to 27 during 1995-2004 in Tamil Nadu. Figure 10.5 shows district-wise groundwater development stage and it clearly highlights the seriousness of overexploitation in few areas that is not evident from the state-level average data.



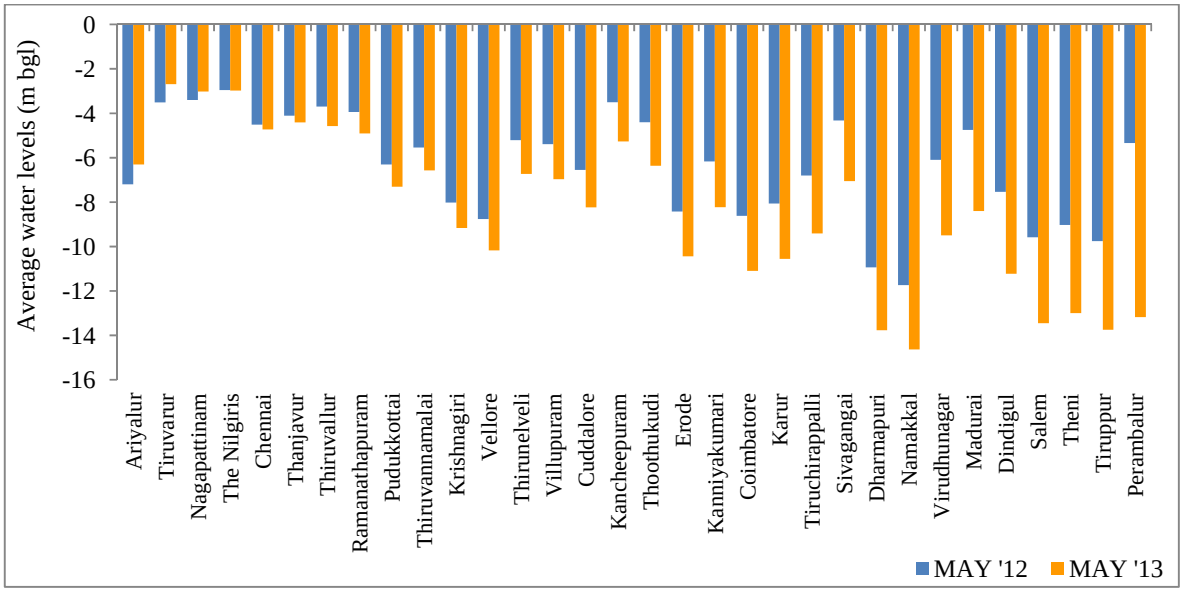
Source: CGWB(2014).

Figure 10.5: District-wise Stage of Ground Water Development in Tamil Nadu – 2011 (in %)

In the pre-monsoon period of 2013, the depth to water level in Tamil Nadu varied from 1.05 m below ground level (bgl) to 35.69 m bgl. Nearly 41 per cent of the wells have water levels in the range of 5-10 m bgl. In the pre-Monsoon period of 2012, 82 per cent of the wells showed a decline in water level compared to 18 per cent wells which showed an increase in the water level during pre-Monsoon period of 2013. Within the wells showing fall in water levels, 43 per cent, 20 per cent and 19 per cent of wells have shown a fall in the range of 0 to 2 m bgl, 2 to 4 m bgl, and more than 4 m bgl.

Examination of the groundwater levels across districts suggests barring three districts, *viz*., Ariyalur, Thiruvarur and Nagapattinam, all other districts in the state showed a decline in the levels during the pre-Monsoon (May) of 2012 and 2013. Owing to a poor monsoon during 2012-13, significant declines in groundwater level was witnessed by districts such as

Kanniyakumari, Coimbatore, Karur, Tiruchirappalli, Sivagangai, Dharmapuri, Namakkal, Virudhunagar, Madurai, Dindigul, Salem, Theni, Tiruppur, and Perambalur. Perambalur district had the maximum decline in the groundwater levels (7.84 meters) with level of groundwater at 13.2 m bgl (see Figure 10.6).



Source: DoWR (2013).

Figure 10.6: District-Wise Average Groundwater Level – Pre-monsoon (May), 2012-13

One of the immediate manifestations of ground water exploitation can be perceived in the availability of drinking water. Over the period 1998 to 2009, the percentage of safe blocks has remained stable around 35 per cent despite dropping to 25.2 per cent in 2003. Correspondingly the status of semi-critical blocks also remained same during 1998 to 2009 (see Table10.2). Over-exploitation has already occurred in more than a third of the blocks while 11 blocks have turned saline by 2009. The water level data reveals that the depths of the wells range from an average of 0.93 meters in Pudukottai district to 43.43 meters in Erode.

Vaidynathan (2006) points out yet another ramification of the ground water exploitation for irrigation purposes. He argues that since digging bore wells is typically capital intensive activity, it is mainly the rich farmers who have had capacity to avail the option, leaving the poor farmers to depend on shallow wells with reduced resource. Thus, ground water exploitation could have long-term socio-economic implications in terms of increasing social tensions.

Table 10.2: Block-wise Ground Water Status in Tamil Nadu – 1998 to 2009

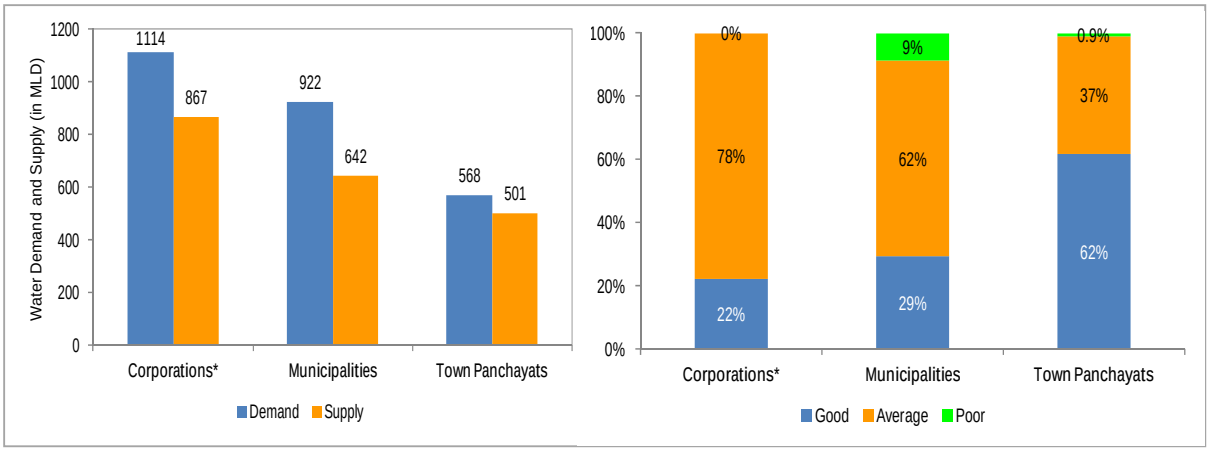
Status	No. of blocks as on Jan. 1998	Percentage	No. of blocks as on Jan. 2003	Percentage	No. of blocks as on Mar. 2009	Percentage
Safe	137	35.6	97	25.2	136	35.2
Semi-critical	70	18.2	105	27.3	67	17.4
Critical	35	9.1	37	9.6	33	8.5
Over-exploited	135	35	138	35.8	139	36.0
Saline	8	2.1	8	2.1	11	2.8
Total	385	100	385	100	386	100

Source: CGWB (1998, 2004, 2011).

10.2.2 *Urban Water Supply*

Increasing population pressure brings challenges for the provision of amenities such as drinking water, lighting, etc. in urban areas. The urban local bodies therefore face significant challenges to meet the present day water requirements. As of 2013-14, a total of 2010 MLD of water was supplied against the demand of 2604 MLD – a shortfall of 29.5 per cent across urban areas in the state. The largest short-fall was in the municipalities (44 per cent) and the municipal corporations (28 per cent). Assessment of the coverage of water supply in urban areas reveals that 22 per cent of the Corporations (excluding Chennai corporation), 29 per cent of the municipalities, and 62 per cent of the town panchayats fully adhere to the norm ("good") prescribed in water supply (Figure 10.7) (DEAR, 2013-14).

The Chennai corporation, operating on an area of 184 square kilometers, supplied 682 MLD of water for 47.6 million population as of 2010-11. However, an addition of 242 sq. km. in 2012-13 to the existing operational area has increased the need for higher water supply by 2013-14 to its present 68.28 inhabitants. Average time spent to fetch drinking water from sources outside the premise is an indicator of the water scarcity situation in urban areas. The recent study based on the NSS 69th round reveals that, at par with the all-India average figure, the average time taken in a day by a household member to fetch drinking water from outside the premises in urban areas of Tamil Nadu to be 15 minutes.



Source: DEAR (2013-14); TNPCB (2014). * Excluding Chennai.

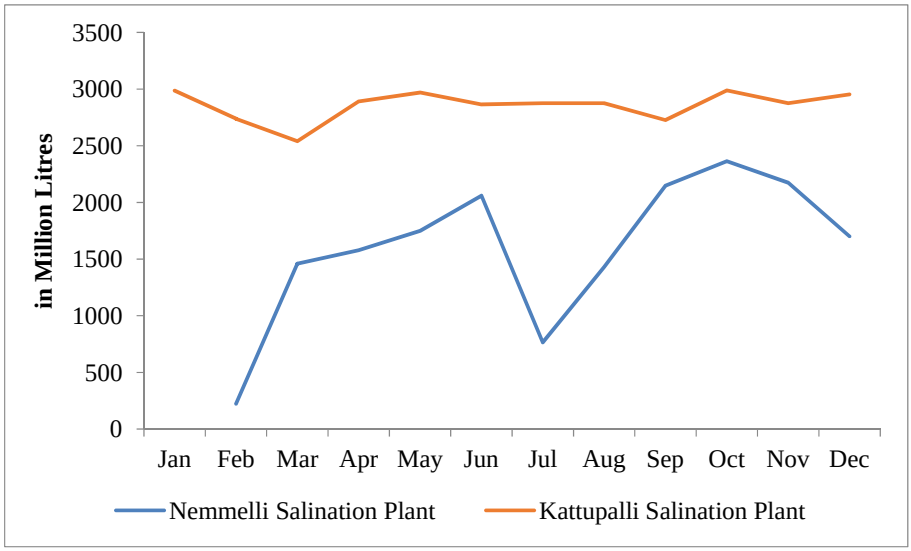
Figure 10.7: Demand-Supply Situation of Drinking Water in Urban Areas

10.3 Response Strategies

10.3.1 *Desalination Plants*

Given various pressures on water availability, desalination of water is important to ensure water security, particularly that of drinking water. Tamil Nadu has currently two desalination plants established to meet the water requirements in Chennai. Three more desalination plants, one to the South of Chennai at Perur along the East Coast Road (ECR) and one each in Thoothukudi and Ramanathapuram districts have been planned.

The desalination plant commissioned at Kattupali, Minjur was initiated on a Public Private Partnership basis with a capacity of 100 MLD (million litres per day). In the year 2013, about 34,398 ML (million litres) of water was pumped from the desal plant. The desalination plant at Nemmeli with a capacity of 100 MLD was commissioned in February, 2013. A total of 17653 MLD of water has been supplied to Chennai through this plant (CMWSSB, 2014) (see Figure 10.8).



Source: CMWSSB (2014).

Figure10.8: Water Supply from Desalination Plants - 2013

10.3.2 *Rainwater Harvesting*

In Tamil Nadu, the Rainwater Harvesting (RWH) program with the objective of improving groundwater recharge was launched in 2001. Through amendments made in the Tamil Nadu Districts Municipalities Act, 1920 and Building Rules, 1973 it has now been made mandatory to incorporate rainwater harvesting structures in all new buildings. The state has made provision for a Special Rain Water Harvesting Cell to offer guidance to the residents in the installation of RWH structures and its maintenance. As of 2012-13, a total of 8 lakh rainwater harvesting structures have been created in the state. An awareness campaign by CMWSSB was organized in 2012-13 that ascertained an increase in the proper maintenance of RWH structures from 40 per cent before the campaign to 90 per cent after the campaign. By 2013-14, out of the total number of 23,92,457 buildings in Town Panchayats, 22,94,342 buildings (96 per cent) are provided with RWH facilities (MAWSD, 2014).

10.3.3 *Drip and Sprinkler Irrigation*

Irrigation water being the main source of groundwater demand suggests that alternative systems of irrigation that are efficient may be viewed as effective strategies for sustainable water management. The National Mission on Micro Irrigation (NMMI) recognizes the importance of water management, given the predominantly agrarian nature of the economy. The 2023 vision for Tamil Nadu has the objective of achieving at least 50 per cent of net irrigated area under micro irrigation facilities such as drip and sprinklers. The Tamil Nadu

Horticulture Development Agency (TANHODA) is mainly responsible for the implementation of schemes under NMMI in the state through registered and empanelled Micro Irrigation Firms.

The total area covered under drop and sprinkler irrigation system in Tamil Nadu for the year 2010-11 and 2011-12 (upto January) stands at 26,153 ha and 14,228 ha respectively. In the past three years (till 2013-14), a total of 93,868 ha.of crops has been covered under micro irrigation (DoA, 2014). From 2014-15, the NMMI will be brought under the National Mission for Sustainable Agriculture (NMSA) as On Farm Water Management (OFWM) (DoA, 2014). The upscaling of micro irrigation system is also done through Irrigated Agriculture Modernisation and Water bodies Restoration and Management (IAMWARM) Project funded by the World Bank. Under this project, 41,918 ha.of cropping area has been covered under micro irrigation systems by the year 2013-14. Further, the state has made provision of 100 per cent subsidy for small- and medium farmers and 75 per cent for other farmers in order to promote micro irrigation in the state. In the year 2014-15, micro-irrigation will be adopted in 37,850 HA for various agricultural crops such as Sugarcane, Pulses, Cotton and Coconut (DoA, 2014).

10.3.4 ***Cropping Pattern - Promotion of Low Water Intensive Crops***

The necessity for smarter and precision technologies for irrigation and farming practices arises given the erratic monsoon, recurring droughts and competing demands for water from various sources. The government of Tamil Nadu has taken steps by focusing on knowledge based precision irrigation – optimum utilization of inputs while controlling both the volume and timing of water applied to crops. Moreover, the state government has systematically taken steps towards crop production intensifications system, e.g., System of Rice Intensification (SRI), System of Pulses Intensification on a whole village basis, promotion of transplanted red gram and intensification of millets along with precision farming and micro irrigation. Thus, an important strategy that followed is crop specific technologies in irrigation management to increase water use efficiency of crops. In adoption of sustainable crop production intensification, smallholder farmers are particularly encouraged, given their inability to significantly improve upon their farming practices.

10.3.5 *Watershed programs*

Creation of sustainable water resources by conserving water in watershed areas following a multi-tier approach is one of the objectives of the Integrated Watershed Management Programme (IWMP) that was initiated in 2008-09 by the Government of India. The IWMP integrates the older programmes such as Integrated Wastelands Development Programme (IWDP), Drought Prone Areas Programme (DPAP), Desert Development Programme (DDP). By the year 2013-14, the IWMP is implemented in 24 districts of Tamil Nadu covering 2413 watersheds. Local level governance (village panchayats) is mainly responsible for the implementation of these programmes. The various developmental activities carried out under this programme include Percolation pond, Formation of New Tank / Oorani, Farm Pond, Desilting of Existing Tanks and Supply Channels. Till the year 2013-14 a total of 3.68 lakh ha. of land has been treated under the IWMP (DoA, 2014).

10.3.6 *Water Use Charges*

Table 10.3shows the prevailing water rates for flow irrigation being applied in the canal commands across the states in India. As can be seen the rates in most states are too low to play both the efficiency and cost recovery functions of water pricing policy. Although many states (e.g., Andhra Pradesh, Karnataka, and Tamil Nadu) have recently revised water rates up to three times, water rates cover not even a fraction of the working expenses. The percentage of the recovery of working expenses varies from 78 per cent in Gujarat to about 5 per cent in the case of most other states (CWC, 2009). The present level and method of fixing water rates are unable to play the dual roles of cost recovery and resource use efficiency. These dual roles cannot be expected unless water pricing policy forms part of an institutional and technical arrangement needed for facilitating canal modernization, volumetric distribution, group-based allocation, and local management (GOI, 1992; Saleth, 1996). Although urban water rates are far higher than the water rates in canal regions, the general problems of cost recovery and use inefficiency also loom large in urban water sector.

Table 10.3: Water Rates for Flow Irrigation across States

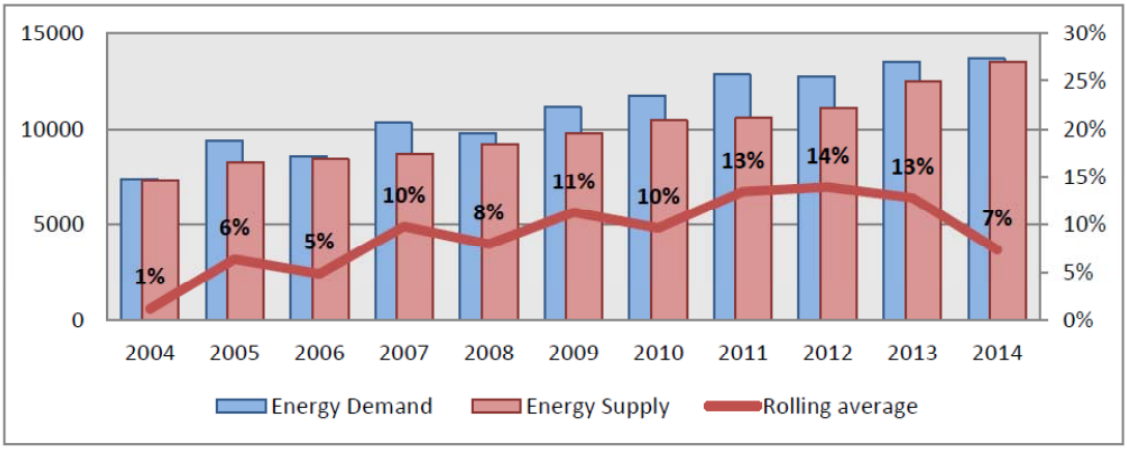
Sl. No.	States/UT	For irrigation purposes (Rate INR/ha)	Date since applicable	Status as on
1	Andhra Pradesh	148.20 to 1235.00	1.7.1996	23.4.03
2	Arunachal Pradesh	No water rates		25.2.02
3	Assam	150.00 to 751.00	30.3.2000	09.5.01
4	Bihar	74.10 to 370.50	1995/2001	28.02.03
5	Chhattisgarh	123.50 to 741.00	15.6.1999	Feb.04
6	Delhi	22.23 to 711.36	1951/1979	Nov.03
7	Goa	60.00 to 300.00	2.1.1998	24.3.06
8	Gujarat	70.00 to 2750.00	16.2.2001	1.3.06
9	Haryana	86.45 to 197.60	27.7.2000	29.11.05
10	Himachal Pradesh	21.23	1.6.2006	1.10.05
11	Jammu & Kashmir	49.42 to 247.10	1.4.2005	3.7.07
12	Jharkhand	74.10 to 370.50	26.11.2001	25.11.03
13	Karnataka	37.05 to 988.45	13.7.2000	24.10.05
14	Kerala	37.00 to 99.00	18.9.1974	18.3.06
15	Madhya Pradesh	50.00 to 960.00	1.11.2005	1.11.05
16	Maharashtra	238.00 to 6297.00	1.7.2003	25.10.05
17	Manipur	45.00 to 150.00	8.3.2007	8.3.07
18	Meghalaya	No water rates (100 proposed to be fixed)	-	28.2.06
19	Mizoram	No water rates	-	4.8.03
20	Nagaland	No water rates	-	12.4.06
21	Orissa	28.00 to 930.00	5.4.2002	1.3.06
22	Punjab	Abolished	14.2.1977	27.8.02
23	Rajasthan	29.64 to 607.62	24.5.1999	24.10.05
24	Sikkim	10.00 to 250.00	2002	10.3.06
25	Tamil Nadu	2.77 to 61.78	1.7.1962	4.3.02
26	Tripura	312.5	N.A.	26.10.05
27	Uttaranchal	60.00 to 948.00	18.9.1995	8.12.03
28	Uttar Pradesh	30.00 to 474.00	18.9.1995	Apr.02
29	West Bengal	37.05 to 123.50	6.4.1997	16.5.03
30	A & N Islands	No water rates	-	6.2.04
31	Chandigarh	No water rates	-	12.6.01
32	Dadra & Nagar Haveli	110.00 to 830.00	29.1.1996	31.8.05
33	Daman & Diu	200	1980	3.1.02
34	Lakshadweep	No water rates	-	8.3.06
35	Pondicherry	12.50 to 37.00		

Source: CWC (2009).

Chapter 11: Energy

11.1 Status of Energy – Tamil Nadu

Tamil Nadu, like many other states in India, faces significant power/energy deficit. An analysis of energy demand and supply over the past decade suggests that the deficit ranged between 1 percent (in 2004) and 14 percent (in 2012). As shown in Figure 11.1, the deficits are showing declining trend in the recent years, with the deficit in 2014 standing at 7 percent. Tamil Nadu also had success with decentralized generation as against grid expansion. As a result Tamil Nadu was one of the first states in India to achieve full electrification.



Source: Berger (2015)

Figure 11.1: Energy Deficit in Tamil Nadu – 2004 to 2014

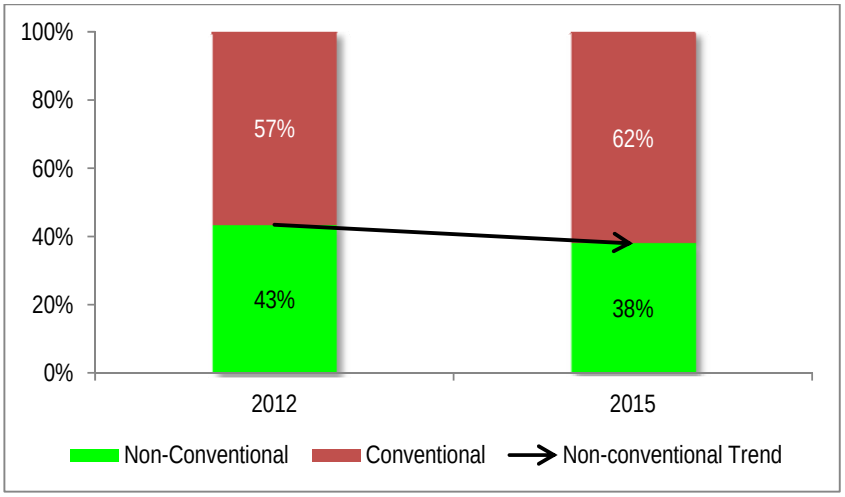
As discussed in Chapter 1, the total installed capacity of electricity generation in 2014-15 in Tamil Nadu is 21701 MW. The installed capacity increased by about 37 percent over the period 2009-10 to 2014-15. The share of renewable energy in the total installed capacity remained impressive at about 39 percent in 2014-15, though it declined from a high value of 42.5 percent in 2011-12. As of 2015, the energy mix in Tamil Nadu consisted 50 percent of thermal, 36 percent of renewable sources, 10 percent of hydro and 4 percent of nuclear. Tamil Nadu remains one of the 'frontrunners' in the country when it comes to non-conventional energy sources. Policies which aim at tapping the potential sources of renewable energy have set benchmarks for other states in the country to follow.

In promoting clean energy a number of challenges arise. Amount of energy generation from non-conventional sources are not on par with that generated from conventional sources (DEAR, 2013-14). Recent years have seen a declining trend in the share of renewable energy in the total installed capacity (see Table 11.1 and Figure 11.2).

Table 11.1: Energy mix in Installed Capacity for Electricity Generation (MW)

Source	2012[a]		2015[b]	
Conventional	10,364	57%	13,941	62%
Non-Conventional	7971	43%	8,533	38%
Total	18,335	100%	22,475	100%

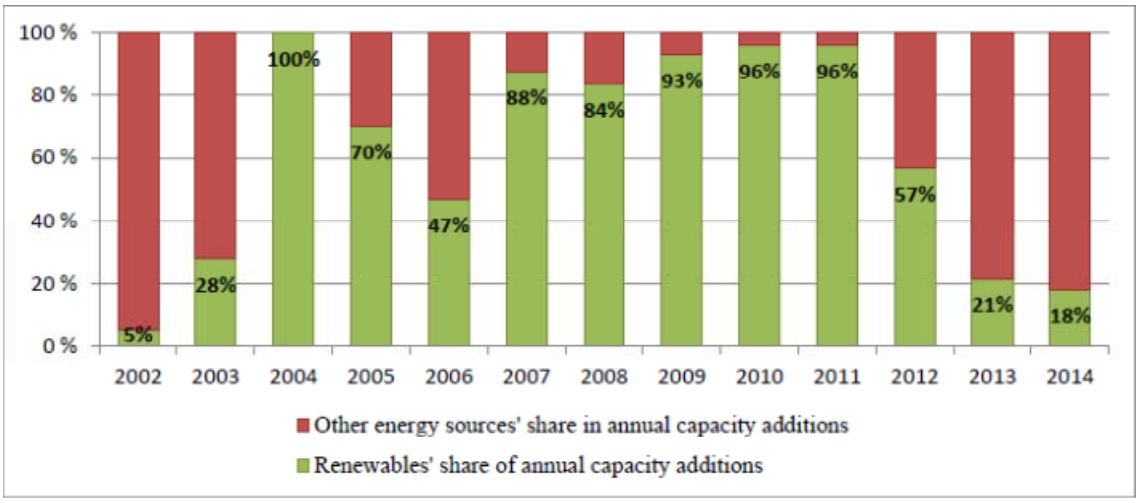
Source: a. 12th Plan Document, Tamil Nadu (reported in SAPCC, p. 9)
b. Policy Note, 2015-16 – Energy Department (GoTN)



Source: See Table 11.1 above.

Figure 11.2: Share of Energy-mix in Installed Capacity for Electricity Generation

As shown in Figure 11.3, the renewable's share of annual addition has declined since 2011 (Berger, 2015). The absolute annual addition to the installed capacity of renewable energy has been much slower compared to the target set forth for the State's 12th plan period. Particularly, the laggard pace in the promotion of solar energy is alarming: compared to the set objectives in the Tamil Nadu Solar Energy Policy (2012) of achieving 3000 MW of installed capacity only 173 MW (0.05% of the target) has been possible by August, 2015. This has endangered the overarching objective of sustaining the energy system via increasing its future dependence non-conventional energy sources.



Source: Berger (2015)

Figure 11.3: Share of Renewables in Annual Additions of Power Generating Capacity (2002-2014)

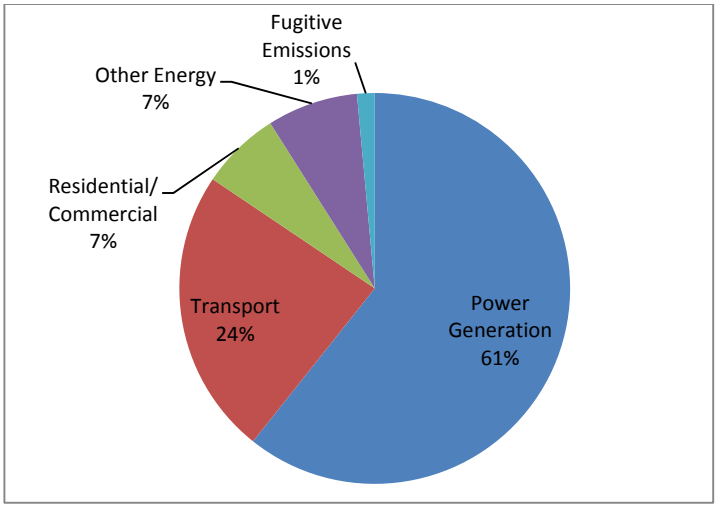
Further, the emphasis of the state policy on wind energy has not paid off in reality, given especially the low actual generation of this source of energy (DEAR, 2013-14). In fact, the state's leading position in the country in wind energy has been on a decline in the past few years.[1] Despite the recognition of higher solar energy potential of the state than its potential in the more volatile wind energy source, the State's Climate Change Action Plan (SAPCC) has highlighted greater emphasis on wind energy through more capacity addition in wind than solar energy during 12th and 13th Five year plan period (p. 181, SAPCC, 2015). The role of weather conditions in driving the supply of non-conventional energy also remains underemphasized. Although the SAPCC recognizes the importance of promoting non-conventional energy sources to deal with climate change, it doesn't factor in the possible future course of geopolitical discussion on climate change that could mount pressure on the country's renewable energy policy to address climate change. In promoting alternative sources of energy (e.g., nuclear), the state has not been able to generate sufficient public support in the past. This stands as an important obstacle to sustaining the future demand for energy.

[1] http://www.business-standard.com/article/companies/tamil-nadu-may-lose-its-leadership-position-in-wind-energy-113062400497_1.html

11.2 Greenhouse Gas Emissions from Energy Sector

Electricity generation from eight TNEB power plants – Ennore Thermal Power Station, Tuticorin Thermal Power Station, Mettur Thermal Power Station, North Chennai Thermal Power Station, Basin Bridge Gas Thermal Power Station, Kuttalam Gas Thermal Power Station, Valuthur Gas Thermal Power Station, and Thirumakottai Gas Thermal Power Station; Neyveli Lignite Corporation; captive power plants and independent power producers has been considered in estimating the GHG emissions. Total GHG emissions from electricity generation were estimated as 51.4 million tons of CO_2eq for the year 2009-10.

Considering roadways and railways as main constituents of GHG emissions from the transport sector, CII (2012) estimated the total emissions for 2009-10 as 20.9 million tons of CO_2eq, with the roadways contributing to almost 90 per cent of these emissions. The emissions from the aviation and navigation sector have not been included in the transport sector emissions due to difficulty in attribution. At the residential level, greenhouse gas emissions are mainly due to cooking and lighting fuels consumed namely kerosene and LPG. Total GHG emissions attributed to this sector for 2009-10 stands at 5.5 million tons of CO_2eq. Overall, the total GHG emissions from the energy sector are estimated as 84.72 million tons of CO_2eq. Figure 11.4 shows the distribution of GHG emissions from the energy sector.

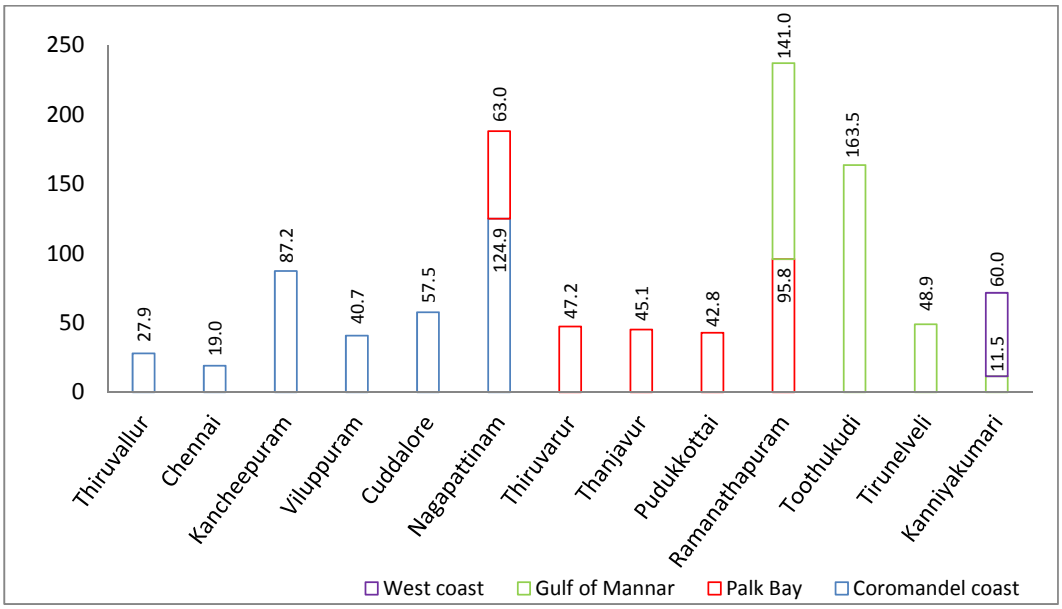


Source: CII (2012).

Figure 11.4: GHG Emissions from Energy Sector in Tamil Nadu

Chapter 12: Coastal Resources

Tamil Nadu is situated on the South-Eastern coast of India. It has a coastal length of approximately 1,076 kilometres, which accounts for more than 13 per cent of India's total coastline (DADF, 2014). Tamil Nadu has the second largest coastline in comparison to other coastal States located on the Indian mainland. Its coast stretches from Thiruvallur district in the north to Kanniyakumari district in the south along the Bay of Bengal and Indian Ocean. There are a total of 13 coastal districts in Tamil Nadu (see Figure 12.1) with Ramanathapuram having the longest coastal length (237 km) and Chennai having the shortest (19 km). The Tamil Nadu coast comprises of the Coromandel coast between Chennai and Point Calimere (357 km in length), Palk Bay (294 km), Gulf of Mannar (365 km) and the West coast between Kanniyakumari and Neerody (60 km).



Source: DoE (2006).

Figure 12.1: District-Wise Coastal Length of Tamil Nadu (in Kilometres)

Tamil Nadu is endowed with a variety of coastal and marine ecosystems, which are ecologically sensitive regions of extraordinary biological productivity and high accessibility. They include mangroves, coral reefs, seagrass beds, sand beaches and dunes, mudflats, salt marshes, estuaries and marine waters. Coastal ecosystems provide a host of services that are of vital importance to human well-being, health, livelihoods and survival. Some of these services include the provision of food, water and raw materials ('provisioning services'), coastal protection and carbon sequestration ('regulating services'), recreation and spiritual fulfilment ('tourism and cultural services'), and the provision of genetic diversity and nursery services ('habitat services'). The area under key coastal ecosystems in Tamil Nadu is given in Table 12.1. In particular, the Tamil Nadu coast is home to the ecologically important sites given in Table 12.2. Figure 12.2 presents the location of these coastal ecosystems.

Table 12.1: Area under Coastal Ecosystems in Tamil Nadu (in Square Kilometres)

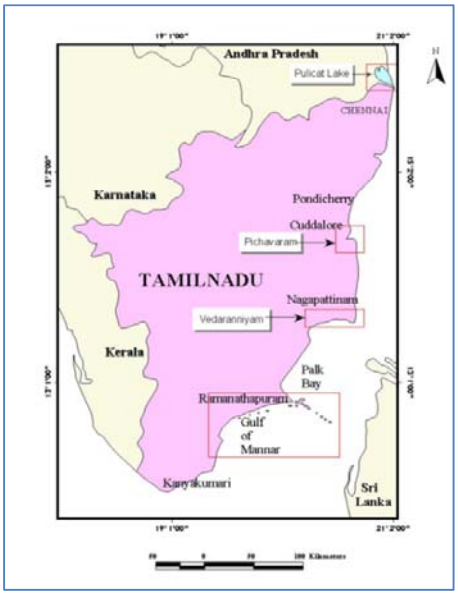
Coastal Ecosystems	**Area**
Estuaries	179
Mudflats	223
Mangroves	65
Salt Marshes	138
Coral Reefs	70
Sand beaches and dunes	579
Seagrass Beds (Gulf of Mannar)	86
Total	**1340**

Source: ISRO (2012); Seagrass Beds – IOM (2008). Note- estuaries include creeks and lagoons.

Table 12.2: Ecologically Important Sites in Tamil Nadu

S. No.	Site	Ecological Importance	District	Area (km^2)
1.	Pulicat Lake	Lagoon	Thiruvallur	252.04
2.	Pichavaram	Mangroves	Cuddalore	10.61
3.	Vedaranyam, Muthupet	Mangroves	Nagapattinam	24.53
4.	Gulf of Mannar (21 Islands)	Coral Reefs, Seagrass Beds	Ramanathapuram	63.22

Source: IOM (2008).



Source: IOM (2008).

Figure 12.2: Location of Ecologically Important Sites in Tamil Nadu

Pulicat Lake is the second largest brackish water lagoon in India that is situated on the Coromandel coast. The mixing of freshwater with sea water makes this wetland ecosystem an ideal habitat for marine fauna including exotic migratory birds such as the flamingo and pelican and several species of fish. The rich flora and fauna diversity of the lagoon supports active commercial fisheries (shrimp, crab and finfish) and is also an important tourist destination.

Pichavaram is known for its mangrove forest that is located between two estuaries; the Vellar estuary in the north and the Coleroon estuary in the south. The extent of mangrove area in Pichavaram is 8.79 square kilometres, mangroves with scrub cover an area of 1.82 square kilometres and tidal flats account for 1.44 square kilometres (IOM, 2008). The Pichavaram mangrove ecosystem contains a wealth of biological diversity including aquatic flora such as seaweeds, seagrasses and certain types of rare mangrove species like *Avicennia*

and *Rhizophora*, and aquatic fauna such as oysters, commercially important crustaceans and fin-fish, Olive Ridley turtles, otters and a variety of resident and migratory waterfowl and other birds. The Pichavaram mangroves support commercial fisheries (shrimps, crabs and mullets mainly) and it is also a tourist attraction owing to the unique natural beauty of the mangroves themselves as well as the two rivers and their backwaters that offer abundant scope for boating and water sports.

Vedaranyam is an important coastal wetland in Tamil Nadu and it is also one of the six major Wildlife Sanctuaries in India. It comprises of a range of coastal ecosystems including mangroves and salt marshes spread over 24.53 square kilometres each, reserved forests covering an area of 19.58 square kilometres, and tidal flats and salt pans spanning an area of 97.95 and 37.70 square kilometres respectively (IOM, 2008). Several thousand migratory birds and waterfowl visit this site each year (including flamingos, herons, storks, kites, eagles etc.) and it is also home to rare reptile and mammal species including the Blackbuck.

The Muthupet mangrove wetland that is part of the larger Vedaranyam swamp is located at the Southern most end of the Cauvery delta. The Muthupet lagoon has an area of 13.32 square kilometres. The density of Muthupet mangroves is very high, but its mangrove species diversity is low when compared to the mangroves of Pichavaram since 95 per cent of the total mangrove population is dominated by a single species namely, *Avicennia Marina* (ICMAM, 2005). Several species of seagrasses and seaweeds are found in the lagoon. The aquatic fauna comprise of commercially important finfish, shrimps and crabs. Birds such as herons and egrets have also been spotted in the area. Other than the fishing activity that takes place in the lagoon, the saltpans are used to produce salts for the manufacture of industrial chemicals.

The Gulf of Mannar is a large shallow bay in the Indian Ocean that lies along the south-eastern tip of Tamil Nadu extending from Rameswaram in the north to Kanniyakumari in the south. The Gulf of Mannar Biosphere Reserve was set up in 1989 jointly by the Government of India and the Government of Tamil Nadu with a view of protecting marine wildlife and coastal ecosystems that inhabit the 10,500 square kilometres of the reserve. The Gulf of Mannar Marine National Park is a protected area, which is part of the Biosphere Reserve that extends from Rameswaram to Tuticorin. It consists of 21 small islands varying in size from about 0.5 hectares to 125 hectares and adjacent coral reefs spread over an area of 560 square kilometres. It is one of the world's richest regions of marine biodiversity

containing diverse ecosystems such as estuaries, mudflats, beaches, salt marshes, mangroves, coral reefs, seagrasses and algal communities. Several species of mangroves, corals, seagrasses and seaweed are found in this biosphere that support numerous species of crustaceans, molluscs, finfish and ornamental fish in addition to marine mammals like whales, dolphins, porpoises, turtles and *Dugong dugong*, as well as seabirds and sea snakes. The Gulf of Mannar is famous for its chank and pearl fisheries – there are about 10 pearl banks in the region. It supports the finfish, shellfish and aquaculture industries. It is also rich in mineral resources. Public access to the islands in this region is prohibited and tourism is restricted to glass-bottomed boat rides.

12.1 Pressures on Coastal Ecosystems

A considerable amount of economic activity takes place along the coast of Tamil Nadu including fishing and allied activities (e.g. seafood processing, marketing and export), maritime trade, agriculture, and industrial activities that benefit from their proximity to the sea in one way or another (e.g. nuclear and thermal power plants, refineries, fertiliser and chemical plants, desalination plants, sand mining etc.). Increasing human population and urbanisation in the coastal areas of Tamil Nadu coupled with accelerated economic activities can exert significant pressure on coastal ecosystems and the services they provide. This section explores the anthropogenic pressures on fragile coastal environments in Tamil Nadu.

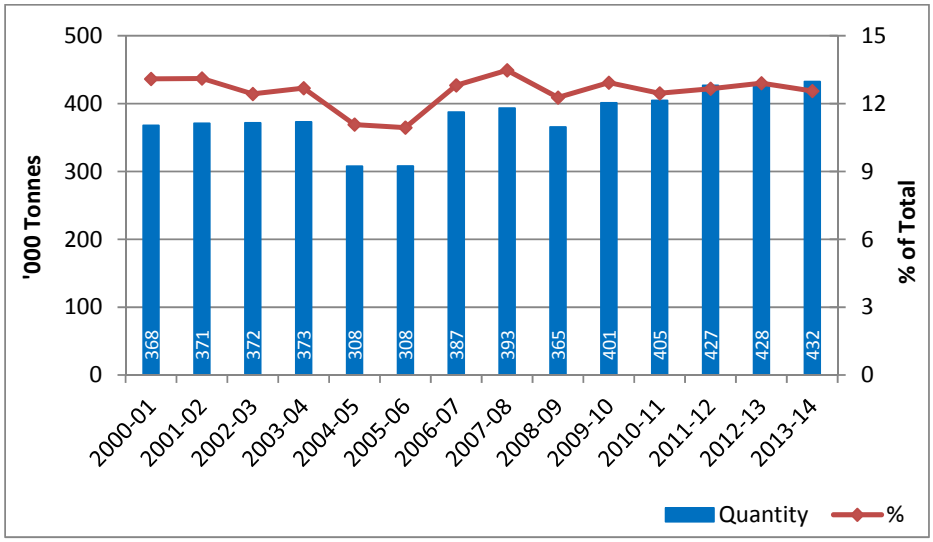
12.1.1 *Commercial Fishing*

Tamil Nadu is endowed with rich coastal biodiversity and abundant endemic fish species and thus it has one of the largest fisheries in India. Tamil Nadu has a continental shelf area of 41 thousand square kilometres. It has 34 fish landing centres, 254 fish landing points, 11 fishing ports (including the Chennai, Cuddalore, Nagapattinam, Pazhayar, Poompuhar, Mallipattinam, Thoothukudi, Chinnamuttom, Colochel, Muttom and Thengapattinam fishing harbours), 608 marine fishing villages and a fisher folk population of 9.23 lakh persons (Fisheries Department, GoTN[1]).

Marine fish production has been gradually increasing over the past decade or so in Tamil Nadu, except for the period 2004-06, when fish production fell (see Figure 12.3). The average annual marine fish production over the past 14 years has been about 380 tonnes, which accounts for approximately 12.5 per cent of total annual marine fish production in India. Tamil Nadu's annual percentage contribution to total fish production has been more or

[1] Fisheries Department, GoTN (personal communication through ENVIS Centre, Chennai).

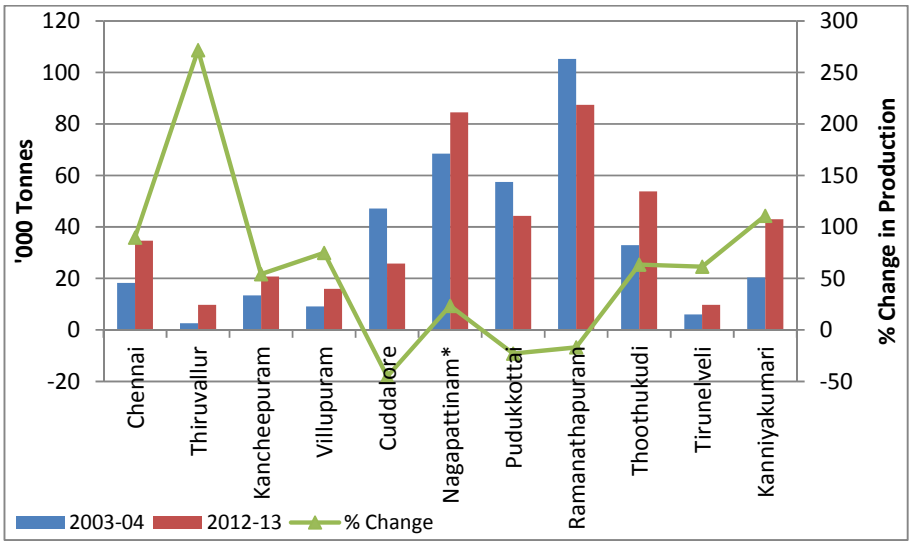
less steady over the years. It was the fifth largest marine fish producer in the country in 2013-14 (DADF, 2014).



Source: DADF (2014).

Figure 12.3: Fish Production in Tamil Nadu from 2000-01 to 2013-14 (in '000 Tonnes and as a % of Total All-India Production)

District-wise marine fish production over the time period 2003-04 to 2012-13 is presented in Figure 12.4. Over this past decade, marine fish production has fallen in Cuddalore, Pudukkottai and Ramanathapuram and the same has increased in all other coastal districts of Tamil Nadu. Despite its fall in marine fish production over time, Ramanathapuram continues to be the highest producer among all coastal districts of Tamil Nadu in 2012-13, followed by Nagapattiman (including Thanjavur and Thiruvarur) that is the second highest producer of marine fish. Between them they contributed roughly 40 per cent to total fish production of the State in 2012-13. Marine fish production increased by over 75 per cent in Chennai, Thiruvallur, Villupuram and Kanniyakumari between 2003-04 and 2012-13. The quantity of fish production is the lowest in Tirunelveli and Thiruvallur, each contributing about 2 per cent to the State total in 2012-13.



Note: *Nagapattinam includes Thanjavur and Thiruvarur. Source: DEAR (2005-06); DoES (2014).

Figure 12.4: District-Wise Marine Fish Production in 2003-04 & 2012-13

District-wise percentage of marine fish production by type of fishing crafts for the years 2003-04 and 2012-13 are presented in Figure 12.5. The general trend across the districts over time is that a higher percentage of fish production was undertaken by mechanised and/or motorised fishing craft (e.g. trawlers, gillnetters, ring seiners, boats with outboard motors) in 2012-13 compared to 2003-04. In other words traditional fishing methods like non-motorised boats or shore seine crafts were used to produce a lower percentage of districts' fish output in 2012-13 as opposed to 2003-04. This is particularly apparent in Chennai, Cuddalore, Nagapattinam and Kanniyakumari where the shift has been towards increased fish production via mechanical fishing crafts, and Kancheepuram where the shift has been towards fish production via motorised fishing crafts in more recent time periods. In both cases, this has largely been at the expense of fish production via more traditional methods. In Tirunelveli and Villupuram, however, the percentage share of fish production via traditional methods increased over time (by about 20 per cent and 5 per cent respectively), which was mainly at the expense of the decline in fish production via motorised crafts. Having said that, a larger percentage of fish production is still undertaken by motorised crafts in these two districts. In Thoothukudi, fish production by traditional means also increased by 5 per cent, which was largely due to the fall in fish production via motorised crafts, although fish production via mechanised crafts still dominates in this district. In Pudukkottai and Ramanathapuram, there has been an increase in the share of fish production via motorised crafts at the expense of

mechanised crafts over time although mechanised crafts are used to undertake a majority of the fish production in these districts.

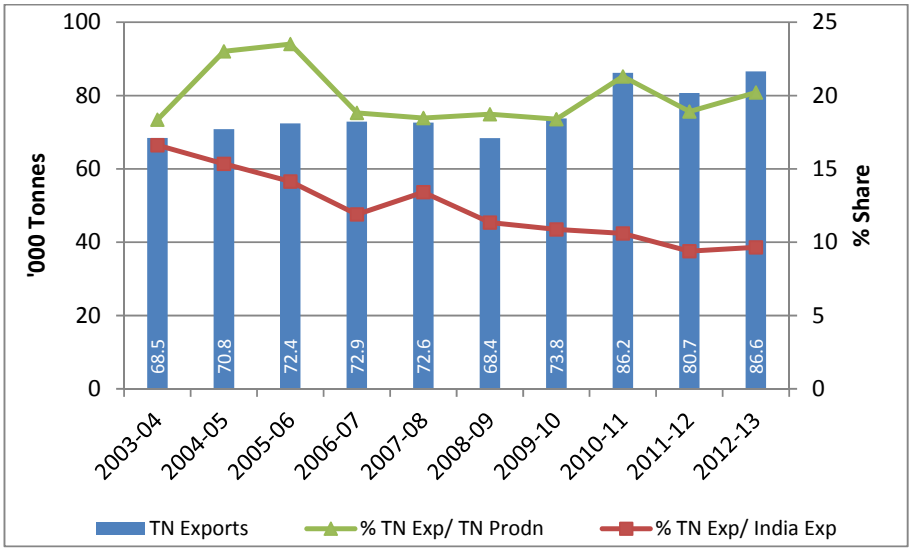
Note: *Nagapattinam includes Thanjavur and Thiruvarur. Source: DEAR (2005-06); DoES (2014).

Figure 12.5: District-Wise Percentage Share of Marine Fish Production by Fishing Crafts in 2003-04 & 2012-13

The fall in fish production in Pudukkottai and Ramanathapuram in 2012-13 compared to 2003-04 (Figure 12.4) may be explained by the huge decline in the share of fish production via mechanised means compared to other crafts over that time period. In Cuddalore, despite the increase in fish production via mechanical means, total fish production still fell in 2012-13 compared to 2003-04. This is primarily due to the fact that fish production via motorised and non-motorised crafts drastically declined over that period.

Exports of marine products from Tamil Nadu exhibit an increasing trend over the period 2003-04 to 2012-13 (Figure 12.6). The percentage share of marine fish exports to

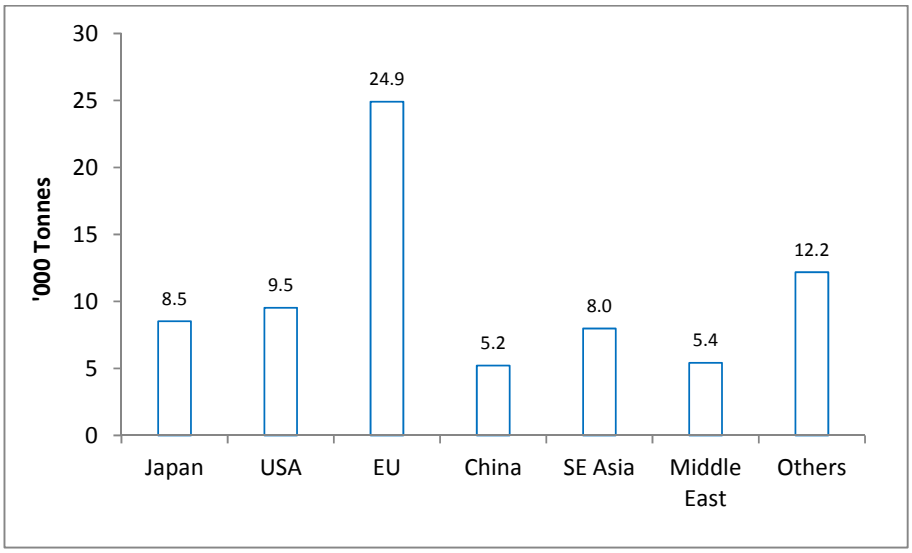
marine fish production in Tamil Nadu has also been increasing over the past decade. This implies that marine fish production is increasingly catering to demand from the international market rather than the domestic market. The share of Tamil Nadu's exports to total all-India exports, however, has been declining consistently over time.



Note: TN Exports are based on port-wise exports from Tuticorin and Chennai.
Source: DADF (2008, 2014).

Figure 12.6: Exports of Marine Products from Tamil Nadu and Percentage Shares from 2003-04 to 2012-13

In 2009-10, 34 per cent of total marine products exported from Tamil Nadu catered to demand from the European Union (Figure 12.7). Roughly 12 per cent was supplied to each of USA, Japan and South East Asia. The Figure shows that there is a fairly large and widespread international demand for marine products exported from Tamil Nadu. Of all the marine products exported, frozen shrimp has the highest international demand accounting for more than 50 per cent of the total quantity exported and almost 70 per cent of the total value of exports in Tamil Nadu in 2009-10.The bulk of frozen shrimp was supplied to Japan, USA, EU and the Middle East; frozen cuttlefish to EU; live items to China; and dried items to South East Asia in 2009-10.



Source: MPEDA (2009-10).

Figure 12.7: Export of Marine Products from Tamil Nadu by International Market in 2009-10 (in '000 Tonnes)

To sum up, fish production and marine exports have increased in Tamil Nadu over time. Also more recently, there has been a shift towards mechanised and motorised means of fishing as opposed to traditional methods. Together, increased fish production and the increased use of trawlers etc. can exert pressure on fishery resources as well as the marine environment in Tamil Nadu.

12.1.2 *Domestic and Industrial Pollution*

The main cause of coastal pollution in Tamil Nadu is the discharge and disposal of untreated industrial and domestic effluents into the sea and the adjoining coast. Moreover the development of infrastructure in coastal areas for domestic and industrial use has serious repercussions for maintaining the health of coastal and marine ecosystems.

Domestic and municipal wastes from coastal cities in Tamil Nadu are often untreated and mostly discharged directly into the sea. In 2008, there were four Class-I cities (having a population greater than 1 Lakh) including the metropolitan city of Chennai and eight Class-II towns (having a population between 50 thousand and 1 Lakh) situated along the coast of Tamil Nadu (CPCB, 2009-10). Pondicherry, although a Union Territory, is a Class-I city that is also situated along the Tamil Nadu coast. In per capita terms, sewage generation was the highest in the cities of Chennai, Cuddalore and Nagarcoil (81 litres per capita per day in each) although it was even higher in Pondicherry (112 litres per capita per day) in 2008 (Table 12.3). Chennai generated roughly 447 million litres of sewage per day in 2008, only half of which was treated. Sewage generated from all other coastal cities and towns was untreated during that year. The quantity of sewage generated per day across all coastal habitations was roughly 524 litres in 2008. Population has been steadily rising across coastal Tamil Nadu – currently more than 8.5 million people reside in the urban metropolitan city of Chennai alone (Census, 2011), thus sewage generation and disposal is expected to rise in the future placing considerable stress on the coastal environment.

Table 12.3: Sewage Generation in Class-I Cities and Class-II Towns of Coastal Areas in Tamil Nadu in 2008

S. No.	City/ Town	Sewage Generation (MLD)	Per Capita Sewage Generation (LPCD)	Treatment Capacity (MLD)
	Class-I			
1.	Cuddalore	16.8	81.0	-
2.	Chennai	447.4	81.0	264.0
3.	Nagarcoil	22.1	81.0	-
4.	Tuticorin	11.5	43.9	-
	Total	**497.8**	**79.5**	**264.0**
	Class-II			
5.	Chengalpattu	4.0	52.0	-
6.	Chidambaram	4.0	56.0	-
7.	Mayiaduthurai	4.1	44.0	-
8.	Nagapattinam	3.8	44.1	-
9.	Pantruti	4.5	66.3	-
10.	Ramanathpuram	1.2	15.9	-
11.	Tindivanam	3.1	37.7	-
12.	Tiruchendur	1.2	43.9	-
	Total	**25.9**	**44.6**	**-**
13.	*Pondicherry*	28.43	111.99	-

Units: MLD- Million Litres per Day; LPCD- Litres Per Capita per Day.

Source: CPCB (2009-10).

The main sources of industrial pollution on the Tamil Nadu coast are petroleum refineries, thermal power plants, tanneries, pulp and paper industries, chemical industries and non-metallic mineral industries that discharge heavy metals and other pollutants either directly into water bodies that connect to the sea or indirectly into land and air that are transported to the coast via rainfall runoff and wind. The heavy metals commonly found in the coastal waters of Tamil Nadu are cadmium, copper, lead, mercury, nickel and zinc. Further, pesticide pollution from agricultural runoff and increased levels of nutrients including nitrogen, phosphorous and high quantities of suspended solids and particulate organic matter in the waste water released form aquaculture farms add to coastal pollution (IOM, 2008). Close to 8000 hectares of brackish water area was under shrimp and scampi culture in 2012-13 in Tamil Nadu (DADF, 2014) and there are approximately 1200 aquaculture farms in Tamil Nadu (IOM, 2008). The nuclear power plants in Kalpakkam and Koodankulam in Tamil Nadu use seawater as a condenser cooling mechanism. The seawater is then discharged back into the sea at high temperatures, which can adversely impact flora and fauna in the condenser outfall area and on the adjacent shores. Seawater is also used for industrial cooling purposes of thermal power plants located along the coast such as those in Tuticorin and Ennore.

Various activities are also responsible for oil pollution in coastal Tamil Nadu including oil exploration, refining and production, oil transportation and associated spills and leakages from ships and fishing trawlers and the production of petro chemicals as detailed in Table 12.4. According to IOM (2008), the dissolved petroleum hydrocarbons in the Pichavaram mangrove waters (Parangipettai) ranged from 5 – 15 µg/l and in Kodiakkarai (Point Calimere) from 8 – 20 µg/l. In Chennai, values ranged from 4 – 108 µg/l in the water and from 1.5 – 3.5 µg/g in dry weight of sediments. The report notes that the values recorded along the Tamil Nadu coast are slightly lower than those recorded in other parts of the world however intensification of any or all of the activities mentioned in the table below will pose a threat to marine life.

Table 12.4: Activities Causing Oil Pollution in Coastal Tamil Nadu

S. No.	Activity	Area	Other Details
1.	Oil exploration (drilling wastes, production wastes and sanitary wastes)	Cauvery delta, Palk bay	Offshore and near shore
2.	Oil production (same as above and free emulsion tank bottom sludge etc.)	Koilkalapai, Narimanam, Bhuvanagiri	25000 to 30000 bbl/ d
3.	Oil transport (ship wastes, tank washings, spills etc.)	Chennai, Tuticorin	3 X 106 t/yr
4.	Oil refining (oil leaks, spills, effluents tank draw-off etc.)	Chennai	5 X 106 t/yr
5.	Petro chemical production (by product production and industrial wastes)	Chennai, Gulf of Mannar	75000 – 1 lakh t/yr

Source: IOM (2008); reference period not specified.

There are other commercial activities that directly extract coastal resources for human use thereby degrading the coastal environment through pollution resulting from such activities and/or depleting the coastal resource altogether as a result of over extraction. Other than fishing (discussed in the previous section), these activities include seaweed production, beach sand mining, the mining of coastal minerals, salt production and the production of freshwater by desalinating sea water.

Coastal minerals found on the Tamil Nadu coast and their production in 2010-11 is shown in Table 12.5. In 2010-11, the production of coastal minerals was a small percentage of reserves (less than 1 per cent), except in the case of Garnet where production was about 6 per cent of remaining reserves and Monazite that was not produced during that year. Mining of coastal minerals not only destroys/ depletes coastal sands and associated biodiversity, it

also causes erosion. The mining of coastal sands for construction purposes is also prevalent in Tamil Nadu, which similarly degrades the coastal environment.

Table 12.5: Reserves and Production of Coastal Minerals in Tamil Nadu in 2010-11 and 2011-12

Coastal Minerals	Reserves (Mt)	Production (Mt)	
		2010-11	2011-12 (p)
Ilmenite (incl. Leucoxene)	61.48	0.3400	0.476
Rutile	5.31	0.0120	0.003
Garnet	33.82	1.9500	1.740
Sillimanite	17.95	0.0001	-
Zircon	9.46	0.0160	-
Monazite	2.16	-	-

Notes: Mt- Million tonnes; (p)- provisional estimate.
Source: IBM (2012).

More recent data from the Department of Geology and Mining[2] indicates that Tamil Nadu is the leading producer of Garnet (abrasive) in India. In 2013-14, Garnet production in Tamil Nadu was 1,973,200 tonnes. The department also notes that reserves of Garnet, Ilmenite, Rutile and Ziron are 28.35, 108.02, 8.76 and 0.2 million tonnes respectively.

Tamil Nadu was the second highest producer of coastal salt in India in 2012-13, with a production of approximately 2.7 million tonnes, which accounted for roughly 12 per cent of total salt production (MoCI, 2013-14).There are two State owned desalination plants in operation in Chennai, one located in Kattupalli village (a northern suburb of Chennai) and the other located at Nemmeli (south Chennai)- both situated along the East coast. Both plants convert marine water from the Bay of Bengal to freshwater and each plant has the capacity to produce 100 million litres of drinking water per day. Water pollution from desalination plants is caused by the disposal of hot saline brine into the sea. This affects sea salinity and turbidity and causes water currents, as well as increases the temperature of seawater.

[2] Department of Geology and Mining, GoTN (personal communication through ENVIS Centre, Chennai).

Seaweeds grow abundantly along the Tamil Nadu coast especially commercially important species that are used to produce agar and sodium alginate, which are mainly found in the areas between Vedaranyam and Kanniyakumari. Table 12.6 gives an indication of the annual yield of seaweed production from the Tamil Nadu coast (although the studies are dated).

Table 12.6: Annual Seaweed Production in Coastal Tamil Nadu by Various Sources

Area	Annual Yield (tonnes fresh weight)	Source
Cape Comorin to Colachel	5	Koshy and John (1948)
Calimere to Cape Comorin	66,000	Chacko and Malu Pillai (1958)
Pamban	1,000	Varma and Rao (1964)
Palk Bay	900	Umamaheshwara Rao (1968)
South East coast	20,535	Subbaramaiah et al., (1977)
Entire coast	22,044	Subbaramaiah et al., (1977)

Source: Krishnan and Narayana Kumar (2010).

12.1.3 *Ports and Harbours*

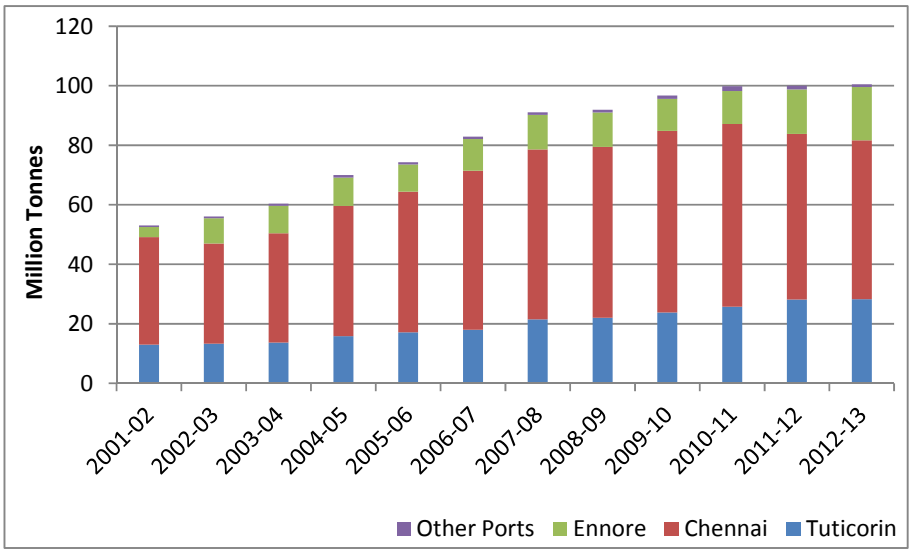
There are three major ports and fifteen non-major or minor ports in Tamil Nadu, of which all major ports and only six minor ports handled cargo traffic in 2011-12 (see Table 12.7).

Table 12.7: Ports in Tamil Nadu and Total Cargo Handled in 2011-12 and 2012-13

S. No.	Name of the Port	Cargo Handled ('000 tonnes) 2012-13	2011-12
	A. Major Ports:		
1.	Chennai	53404	55707
2.	Tuticorin	28260	28105
3.	Ennore Port Limited	17885	14956
	B. Minor Ports:		
4.	Cuddalore	246	230
5.	Nagapattinam	372	630
6.	Ennore Minor Port	29	46
7.	PY-3 Oil Field	-	59
8.	Thirukkadaiyur	274	235
9.	Kattupalli	12	10

Source: MoS (2012-13).

Figure 12.8 shows that cargo traffic in Tamil Nadu ports has been increasing over the past decade or so and that the major ports handle more than 99 per cent of the total traffic. Total quantity of cargo handled by all Tamil Nadu ports in 2012-13 was almost 90 per cent higher than the same in 2001-02. The potential environmental impacts of port and harbour development are coastal erosion and accretion and coastal pollution due to shipping activities.

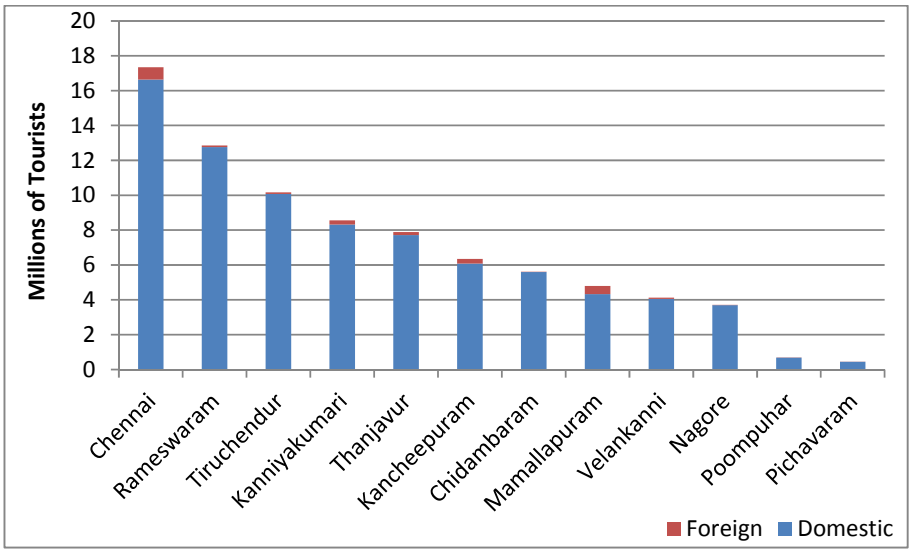


Source: MoS (2012-13).

Figure 12.8: Cargo Traffic in Tamil Nadu Ports over Time (in Million Tonnes)

12.1.4 *Coastal Tourism*

Tamil Nadu is a popular tourist destination with millions of visitors flocking to its historic temples, beaches, hill stations, forests/ sanctuaries and for its festivals of music, dance, art and culture each year. Coastal destinations of Tamil Nadu are popular for their wide sandy beaches (e.g. Chennai, Mamallapuram, Kanniyakumari), temples and places of pilgrimage (e.g. Kancheepuram, Thanjavur) and places of natural beauty (e.g. Pichavaram). In 2012, the coastal destinations of Tamil Nadu received almost 83 million visitors, of which 80 million were domestic tourists and the remaining, foreign tourists. Roughly 44 per cent of all domestic tourists to Tamil Nadu visited coastal destinations and 60 per cent of all foreign tourists visiting Tamil Nadu arrived in coastal destinations. 44 per cent of all tourists (both domestic and foreign) to Tamil Nadu arrived at coastal destinations during 2012. The number of tourist arrivals to coastal destinations in Tamil Nadu in 2012 is presented in Figure 12.9. Chennai, Rameswaram and Tiruchendur were the top three coastal destinations in Tamil Nadu with more than 10 million tourist arrivals in each of these destinations in 2012. Total tourist arrivals to Tamil Nadu (including arrivals to coastal destinations) have increased significantly by over 660 per cent between 2001 and 2012. This increasing trend is likely to continue in the future, which implies a considerable amount of pressure on the coastal environment.



Source: DoES (2014).

Figure 12.9: Number of Tourist Arrivals to Coastal Destinations in Tamil Nadu in 2012

The major beach tourist locations in Tamil Nadu include Chennai (Marina Beach, Besant Nagar Beach and beaches along the East Coast Road), Mamallapuram, Mudaliar Kuppam, Marakkanam, Cuddalore, Velankanni, Sirzhali, Kodiyakkarai, Vedaranyam, Mannargudi, Tranquebar, Poompuhar, Rameswaram, Kanniyakumari, Thiruchendur, Thondi, Devipattinam and Manapadu.

12.1.5 *Climate Change – Sea Level Rise*

Over the period 1891 to 2007, Tamil Nadu was hit by as many as 91 cyclonic storms. Table 12.8 shows the decadal break-up of the frequency of cyclonic storms crossing the northern and southern coasts of Tamil Nadu. The season-wise frequency of cyclonic storms crossing the northern and southern coasts of Tamil Nadu are shown in Table 12.9. The North-East monsoon period (October to December) brings maximum number of cyclones to both northern and southern coasts.

Table 12.8: Frequency of Cyclonic Storms in Tamil Nadu

Period	Tamil Nadu North	Tamil Nadu South
1891-1900	3	0
1901-10	4	1
1911-20	4	1
1921-30	9	2
1931-40	12	0
1941-50	10	1
1951-60	8	1
1961-70	10	2
1971-80	3	3
1981-90	2	2
1991-2000	9	3
2001-07	1	0
Total (1891-2007)	75	16

Source: IMD (2008).

Table 12.9: Season-wise Frequency of Cyclonic Storms in Tamil Nadu

	No. of Cyclonic Storms (1891-2007)	
Season	Tamil Nadu North	Tamil Nadu South
CWP	2 (2.67)	1 (6.67)
HWP	9 (12)	1 (6.67)
SWM	0 (0)	0 (6)
NEM	64 (85.33)	13 (86.67)
Total	75 (100)	15 (100)

Note: Figures in parentheses are percentages; CWP → Cold weather period (January – February); HWP → Hot weather period (March – May); SWM → South-west monsoon (June – September); NEM → North-east monsoon (October – December).

Source: IMD (2008).

Out of the 91 cyclonic storms that hit Tamil Nadu between the years 1891 to 2007, 30 were severe cyclonic storms. There have been 8 severe cyclonic storms having the highest intensity during their crossing from sea to land in the past 30 years in Tamil Nadu (IMD, 2011). Based on this, the annual probability of occurrence of severe cyclonic storms in Tamil Nadu is estimated as 27 per cent, which is considerably large and only slightly lower than that of one other Indian State (i.e. Andhra Pradesh with an annual probability of 30 per cent). Moreover, the widespread destruction to ecosystems, property, infrastructure and loss of human lives due to the 2004 Tsunami demonstrates the vulnerability of the Tamil Nadu coast to natural disasters and extreme weather events.

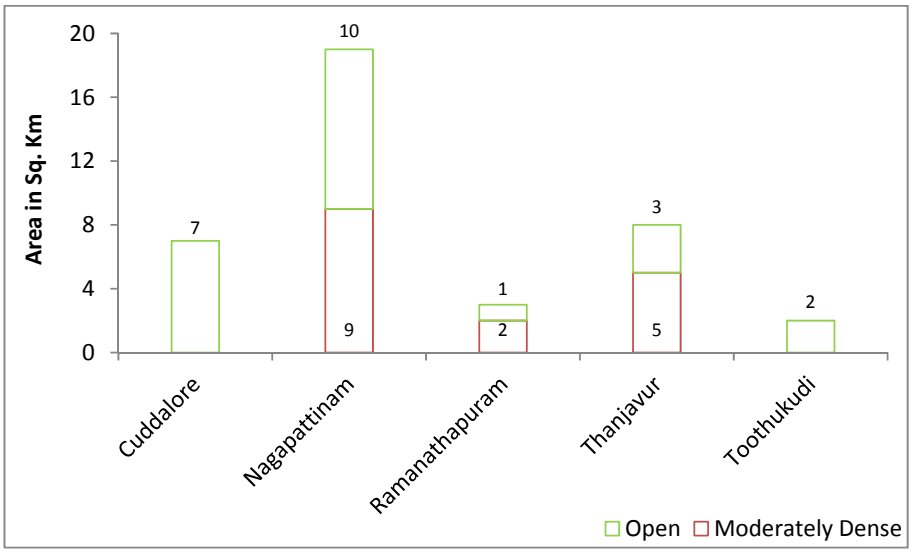
Based on data over the period 1916 to 2008 it has been estimated that the sea level is rising at an average rate of 0.32 mm/year along the Chennai coast. The Intergovernmental Panel on Climate Change projects a sea level rise of about 0.5 metres in the Bay of Bengal by 2100 from a 2006 base level (IPCC, 2013). Sea level rise as a result of anthropogenic climate change is likely to have the following impacts on the coast of Tamil Nadu: inundation, flooding and storm damage; wetland loss; beach erosion; saltwater intrusion and rising water tables impeding drainage.

12.2 State and Impacts – Coastal Ecosystems

This section looks at the current status of coastal ecosystems and ecosystem services in Tamil Nadu and also explores the possible impacts due to changes in coastal ecosystems.

12.2.1 *Mangroves*

As per the most recent State of Forest Report (FSI, 2013), total mangrove area in Tamil Nadu is 39 square kilometres, which includes 16 square kilometres of moderately dense mangrove forests (having a canopy density of 40 – 70 per cent) and 23 square kilometres of open mangrove forests (having a canopy density of 10 – 40 per cent). Mangrove area with a canopy density of more than 70 per cent ('very dense' category) has not been recorded in the State. Mangroves are present in five districts in Tamil Nadu, out of which Nagapattinam has the highest mangrove cover (Figure 12.10).

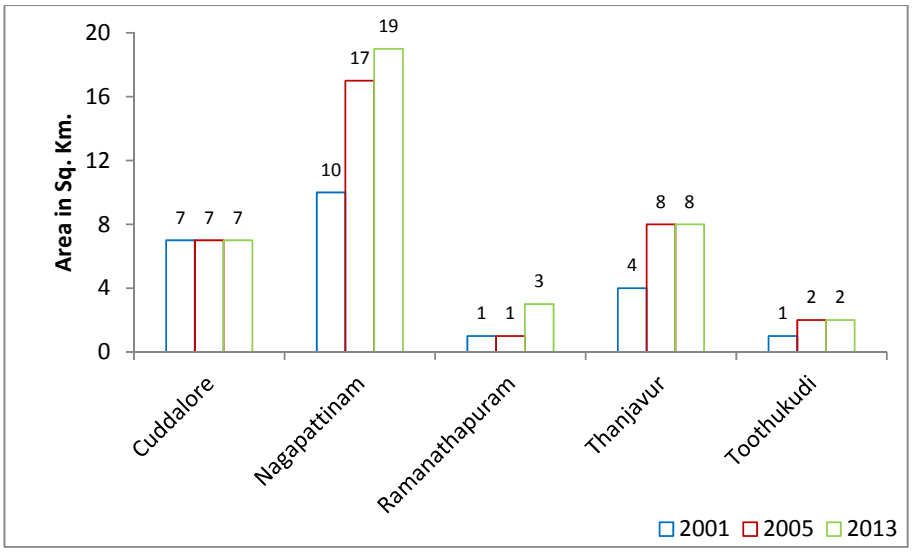


Source: FSI (2013).

Figure 12.10: District-Wise Area under Mangrove Cover by Density in Tamil Nadu in 2013 (in Square Kilometres)

Figure 12.11 shows that the total area under mangrove cover has increased in: Nagapattinam between 2001 and 2013; Ramanathapuram between 2005 and 2013; and, Thanjavur and Toothukudi between 2001 and 2005. Although the area under mangrove cover has remained the same in Cuddalore over the past decade or so, 5 square kilometres of mangrove area have shifted from the moderately dense category to the open mangroves

category implying a decline in mangrove density between 2005 and 2013 in this district. In Nagapattinam, Ramanathapuram and Thanjavur there has been a 1 square kilometre increase in moderately dense mangroves between 2005 and 2013 in each of these districts.



Source: FSI (2001, 2005, 2013).

Figure 12.11: District-Wise Total Area under Mangrove Cover in Tamil Nadu over Time (in Square Kilometres)

Tamil Nadu has two major mangrove forests namely the Pichavaram mangrove forest (in Cuddalore) that covers an area of 1,100 hectares and the Muthupet mangrove forest (in Nagapattinam) which is spread over an area of 6,800 hectares, only 77.2 hectares of which are occupied by well grown mangroves (IOM, 2008). In addition the Gulf of Mannar also has mangroves although these are not uniformly spread and occur in patches along the periphery of the islands. The species of mangroves found in Pichavaram, Muthupet and the Gulf of Mannar are presented in Table 12.10 along with their status based on the IUCN red list of threatened species. A vast majority of the mangrove species in Pichavaram and the Gulf of Mannar are either endangered or critically endangered.

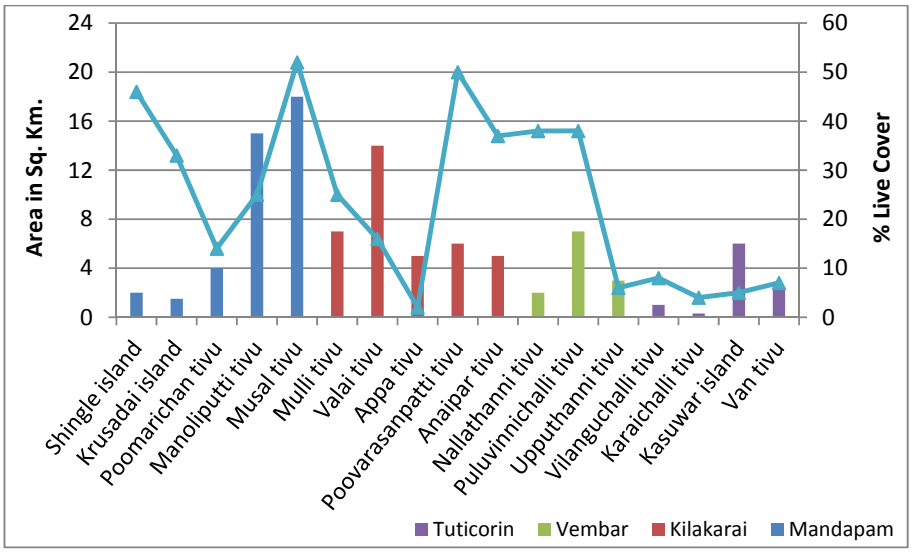
Table 12.10: Mangrove Species in Pichavaram, Muthupet and Gulf of Mannar and their IUCN Status

Species Name	***IUCN Status***	***Species Name***	***IUCN Status***
Pichavaram		***Muthupet***	
Aegiceros corniculatum	Endangered	Avicennia marina	-
Acanthus ilicifolius	Endangered	Exocaeria agallocha	-
Avicennia marina	Endangered	Aegicerus corniculatum	-
Avicennia officinalis	Endangered	Acanthus ilicifolius	-
Bruguiera cylindrical	Endangered	Suaeda maritime	-
Ceriops decandra	Endangered	Suaeda monica	-
Lumnitzera racemosa	Endangered		
Rhizophora apiculata	Endangered		
Suaeda maritime	Endangered	***Gulf of Mannar***	
Suaeda monica	Endangered	Aegiceras corniculatum	Critically endangered
Anthrocnemum indicum	Vulnerable	Avicennia marina	Vulnerable, stunted growth in all islands
Excoecaria agallocha	Vulnerable	Bruguiera cylindrica	Endangered
Rhizophora mucronata	Vulnerable	Exocoecaria agallocha	Critically endangered
Salicornia brachiata	Lower risk nearly threatened	Lumnitzera racemosa	Endangered
Rhizophora annamalayana	-	Rhizophora apiculata	Critically endangered
Sonneratia apetala	-	Rhizophora mucronata	Endangered
Xylocarpus granatum	-		

Source: IOM (2008).

12.2.2 *Coral Reefs*

In Tamil Nadu, coral reefs (mainly fringing reefs) are found along the Gulf of Mannar and Palk Bay, and at restricted places in Chennai and Cuddalore. The estimate of total coral reef area in Tamil Nadu is 94.3 square kilometres, of which reef flats make up 64.9 square kilometres and the remaining area includes reef vegetation, sand over reef etc. The major coral genera include *Acropora, Pocillopora, Montipoora, Turbinaria, Echinopora, Favia, Favites, Goniastrea, Leptastrea, Leptoria, Platygyra, Goniopora, Porites, Merulina, Symphyllia, Galaxea, Pavona, Coscinaria, Psammacora etc.* (IOM, 2008). Coral reef area and percentage of live coral cover in the Gulf of Mannar Islands is shown in Figure 12.12. The Mandapam group of islands have the largest combined coral reef area (41 square kilometres) followed by the Kilakarai group of islands (37 square kilometres). The island of Musal *tivu* has the highest reef area (18 square kilometres) as well as the highest live coral coverage over that area (52 per cent).



Note: Manoliputti tivu includes Manoli tivu, Valai tivu includes Thalaiyari tivu, Poovarasanpatti tivu includes Vallimunai tivu and Poomarichan tivu includes Pullivasal tivu.

Source: IOM (2008); reference period not specified.

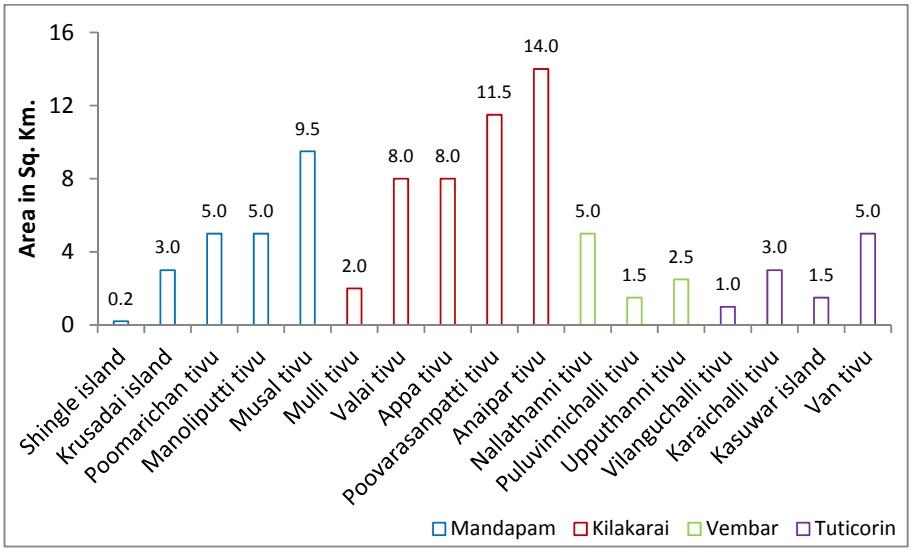
Figure 12.12: Coral Reef Area and Percentage of Live Corals in the Gulf of Mannar Islands

12.2.3 *Seagrasses and Seaweeds*

In Tamil Nadu, 11 species of seagrasses are recorded in the Palk Bay and 13 species of seagreasses occur in the Gulf of Mannar region including *Enhalusacaroides, Halophila ovalis, Halophila ovata, Halophila beccari, Halophilastipulacea, Thalassia hemprichii, Cymodocea serrulata, Cymodocea rotundata, Halodule uninervis, Syringodium isoetifolium* etc. In the Palk Bay *Cymodocea serrulata*, *Halophila ovalis*, *Halodule pinifolia* and *Syringodium isoetifolium* are predominantly distributed and *Halodule wrightii* occur only in Akkalmadam in Rameswaram (IOM, 2008). The total area under seagrasses in the Gulf of Mannar is 86 square kilometres. The Kilakarai group of islands has the largest area under seagrasses (44 square kilometres) followed by the Mandapam islands (23 square kilometres) (see Figure 12.13).

In addition to seagrasses, the Gulf of Mannar islands have several economically important species of seaweeds including *Gelidiella acerosa, Gracilaria edulis, G. follifera, Gracilaria sp., Hypnea sp. Acanthophora , Sargassum sp., Turbinaria sp., Cystoseira trinodis* and *Hormophysatriquetra*, *Ulva sp., Enteromorpha, Caulerpa, Codium, Hydroclathrus, Halimeda, Padina, Chondrococcus* and *Laurencia* (IOM, 2008). A total of 302 species of seaweeds are found along the coast of Tamil Nadu and 147 seaweed species occur in the Gulf of Mannar alone. Agar yielding seaweeds are harvested from the Gulf of Mannar, along the

coastline from Rameswaram to Tuticorin, and from the Sethubavachatram area in the Palk Bay (IOM, 2008).



Note: Same as Figure 4.12; Source: IOM (2008); reference period not specified.

Figure 12.13: Areal Extent of Seagrasses in the Gulf of Mannar Islands (in Square Kilometres)

12.2.4 *Estuaries*

The river Cauvery forms the major estuary in Tamil Nadu and minor estuaries include Vellar, Pazhayar, Adyar etc. Chakraborty et al. (2014) have undertaken an assessment of trace/heavy metal contamination levels in estuarine sediments of major rivers in India, including that of the Cauvery estuary. Using data on trace metal concentrations in estuarine sediments from the literature they estimated the contamination factor (CF), pollution load index (PLI) and geoaccumulation index (I_{geo}) for all estuaries in India. CF is used to express the level of contamination by each metal in the sediment and it was estimated such that: CF < 1 reflects low contamination by a metal; 1 ≤ CF ≤ 3 reflects moderate contamination; 3 ≤ CF ≤ 6 reflects considerable contamination; and, CF > 6 reflects high contamination. PLI is used to assess the level of contamination and pollution in coastal and estuarine sediments and it was estimated such that: PLI = 0 indicates no pollution; PLI = 1 indicates that only baseline levels of pollutants are present; and, PLI > 1 indicates progressive deterioration of estuarine quality. I_{geo} is also used to assess the contamination levels in river sediments and it was estimated such that: I_{geo}< 0 reflects the estuary is unpolluted; 0 < I_{geo}< 1 reflects it is unpolluted to moderately polluted; ; 1 < I_{geo}< 2 reflects it is moderately polluted ; 2 < I_{geo}< 3 reflects it is moderately to heavily polluted; 3 < I_{geo}< 4 reflects it is heavily polluted; 4 < I_{geo}< 5 reflects it is heavily to extremely polluted; and I_{geo}> 5 reflects it is extremely polluted. Note that all three indices were computed by using the concentrations of upper continental crust as a proxy for pre-industrial levels of trace/ heavy metals (due to lack of data on the latter) in order to make comparisons between the same and the actual levels of metals in estuarine sediments. CF, PLI and I_{geo} values for the Cauvery estuary computed by Chakraborty et al. (2014) from studies conducted over the period 1987 – 2013 are presented in Table 12.11.

The CF and I_{geo} values indicate that although Chromium and Nickel contamination was high in the estuarine sediments of the Cauvery during 1987-1989, it declined drastically by 2013. However, Cadmium contamination was high in 1987-1989 and remained relatively high in 1999. PLI values in the estuarine sediments from Cauvery estuary gradually decreased from 3.47 in 1987 to 0.50 in 2013, which indicates a significant improvement in estuarine sediment quality (with respect to metal loading) over time. Pollution indices based on the most recent study (Dhanakumar et al., 2013) indicate that the quality of estuarine sediments from the Cauvery estuary is in a good state.

Table 12.11: CF, PLI and I_{geo} Values of the Cauvery Estuarine Sediments over Time (1987 – 2013)

Contamination Factor (CF)	References	Cr	Ni	Cu	Zn	Pb	Cd	Mn	Fe	Co	As
	Srealathan (1987) and Seralathan and Seetaramaswamy (1987)	7.13	6.04	3.78	1.67	3.05		5.17		1.40	
	Ramanathan et al. (1988)	1.95	3.97	0.87				1.01	1.02	4.61	
	Subramanian et al. (1989)	6.54	18.95	1.32	1.06	1.90	18.88	2.18	0.96	0.00	
	Ramanathan et al. (1993)	1.23		0.78	0.36	1.52	2.24	0.95	0.47		
	Ramesh et al. (1999)	2.10	1.71		0.70	0.76	7.45			0.95	0.23
	Dhanakumar et al. (2013)	1.41	0.68	1.18	0.42	0.43		0.27	0.15		
Pollution Load Index (PLI)	**References**	**PLI**									
	Srealathan (1987) and Seralathan and Seetaramaswamy (1987)	3.47									
	Ramanathan et al. (1988)	1.78									
	Subramanian et al. (1989)	3.27									
	Ramanathan et al. (1993)	0.91									
	Ramesh et al. (1999)	1.18									
	Dhanakumar et al. (2013)	0.50									
Geo-accumulation Index (I_{geo})	**References**	**Cr**	**Ni**	**Cu**	**Zn**	**Pb**	**Cd**	**Mn**	**Fe**	**Co**	**As**
	Seralathan (1987) and Seralathan and Seetaramaswamy (1987)	2.25	2.01	1.33	0.16	1.02		1.78		-0.10	
	Ramanathan et al. (1988)	0.38	1.40	-0.79				-0.57	-0.56	1.62	
	Subramanian et al. (1989)	2.12	3.66	-0.18	-0.51	0.34	3.65	0.54	-0.65		
	Ramanathan et al. (1993)	-0.29		-0.94	-2.07	0.01	0.58	-0.67	-1.69		
	Ramesh et al. (1999)	0.48	0.19		-1.11	-0.99	2.31			-0.66	-2.68
	Dhanakumar et al. (2013)	-0.08	-1.15	-0.35	-1.83	-1.82		-2.49	-3.33		

Note: Cr = Chromium, Ni = Nickel, Cu = Copper, Zn = Zinc, Pb = Lead, Cd = Cadmium, Mn = Manganese, Fe = Iron, Co = Cobalt, As = Arsenic.

Colour Key: CF- red = high contamination, green = low contamination; I_{geo}- red = heavily polluted, green = unpolluted.

Source: Chakraborty et al. (2014). See this source for references mentioned in the table.

12.2.5 *Sand Beaches and Dunes*

Development activities as well as the recurrence of extreme weather events have led to coastal erosion and accretion along various locations on the coast of Tamil Nadu since the 1970s/1980s. The erosion of land mass has led to narrower and shorter beaches and the disappearance of sand dunes and islands. Table 12.12 shows the extent of erosion along the Tamil Nadu coast. High erosion zones include the coasts of Kanniyakumari, Thiruvarur, Nagapattinam, Villupuram and Kancheepuram, which have been protected by seawalls (artificial coast). However, it is important to note that although seawalls prevent sand erosion and dune removal along their lengths, erosion tends to increases beyond the walls' ends.

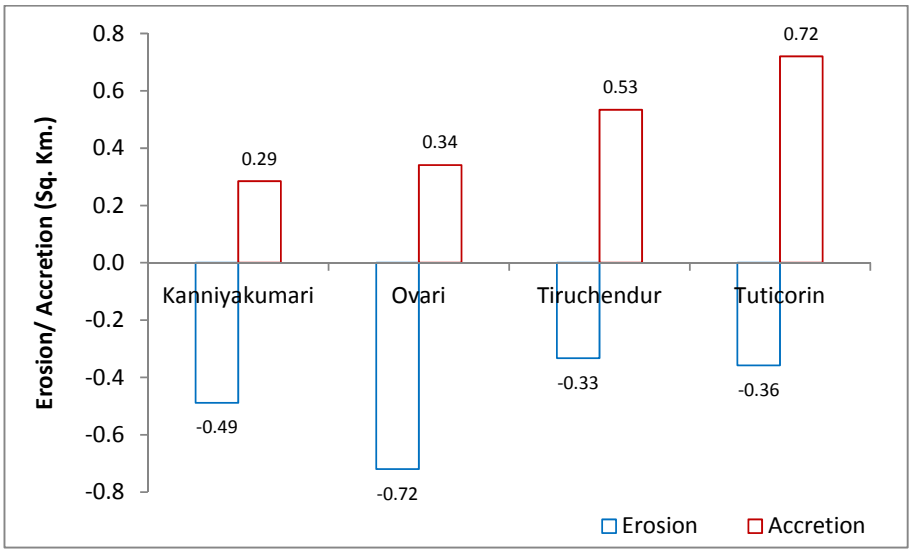
Table 12.12: Extent of Erosion along the TN Coast

District	*Extent (Km)*	*Per cent of Coast*
Kanniyakumari	AC	P
Tuticorin	2.02	1.73
Ramanathapuram	2.86	1.08
Pudukkotai	3.49	8.10
Thanjavur	0.92	2.20
Thiruvarur	AC	P
Nagapattinam	AC	P
Cuddalore	0.69	1.64
Villupuram	AC	P
Kancheepuram	AC	P
Chennai	0.40	0.92
Thiruvallur	0.31	2.69

Note: High erosion zones are protected (P) by an artificial coast (AC), i.e. seawalls.

Source: GoTN (2013).

Mujabar and Chandrasekar (2013) analysed the extent of coastal erosion and accretion along the southern coast of Tamil Nadu (over a distance of 160 kilometres between Kanniyakumari and Tuticorin) using remote sensing and GIS. They divided this region into four coastal zones namely, Kanniyakumari, Ovari, Tiruchendur and Tuticorin on the basis of the geological, hydrological and environmental conditions prevailing in these zones. Their results indicate that during the period 1999 – 2006, a net erosion of 0.204 and 0.379 square kilometres occurred in the coastal zones of Kanniyakumari and Ovari respectively, which translates into an annual rate of erosion of 29,142 square metres for Kanniyakumari and 54,143 square metres for Ovari. On the other hand, the coastal zones of Tiruchendur and Tuticorin experienced a net accretion of 0.201 and 0.362 square kilometres respectively, which translates into an annual rate of accretion of 28,713 square metres for Tiruchendur and 51,714 square metres for Tuticorin over the period 1999 – 2006 (see Figure 12.14).

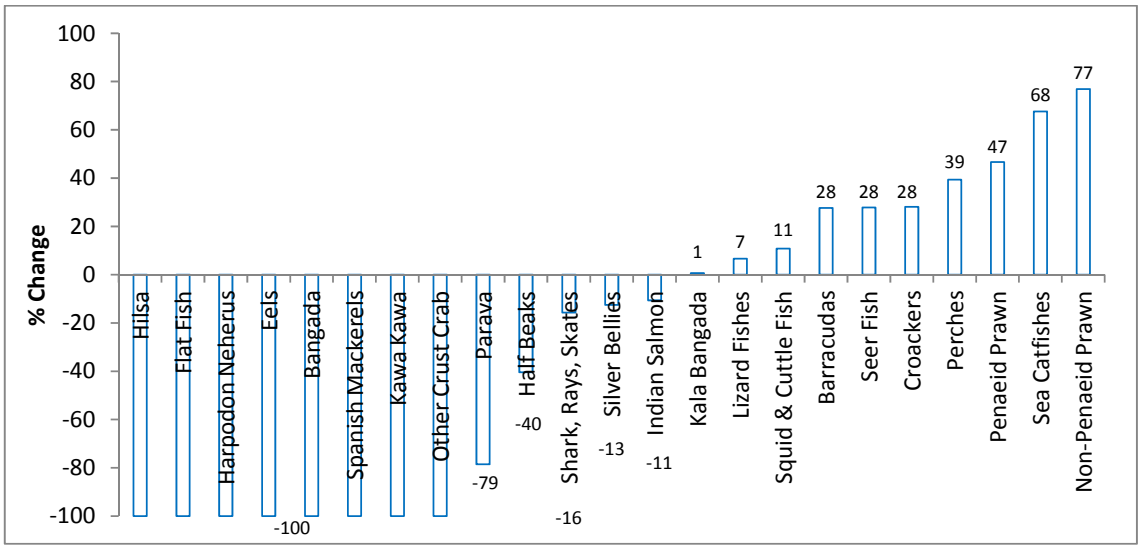


Source: Mujabar and Chandrasekar (2013).

Figure 12.14: Extent of Erosion and Accretion on the South Coast of TN during 1999 – 2006 (in Square Kilometres)

12.2.6 *Fish Species*

Over the period 2007 to 2012, there have been significant changes in the species composition of marine fish production in Tamil Nadu. Figure 12.15 shows the percentage change in production of fish species over that time period. A 100 per cent change in fish production implies that the production of that particular species of fish fell to zero in 2012 compared to 2007. A few species of fish including *Hilsa*, *Flat Fish*, *Eels*, *Bangada*, *Spanish Mackerels*, *Kawa Kawa* etc. witnessed such declines.

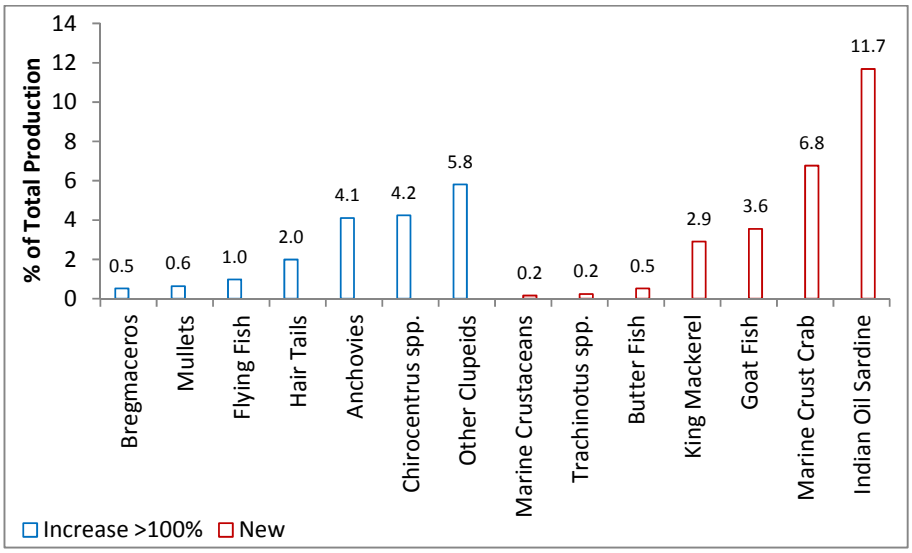


Source: DADF (2014).

Figure 12.15: Percentage Change in Production of Fish Species by Type from 2007 to 2012 in Tamil Nadu

In addition, certain species of fish that were produced in Tamil Nadu in 2003 including *Unicorn Cod*, *Bombay Duck*, *Big Jawed Jumper*, *Threadfins*, *Wolf Herrings*, *Ribbon Fish* and *Little Tuna* registered no production in either 2007 or 2012 (DADF, 2008). Moreover, production of certain other fish species including *Parava*, *Half Beaks*, *Sharks, Rays and Skates*, *Silver Bellies* and *Indian Salmon* declined by about 10 – 80per cent between 2007 and 2012. On the other hand, several fish species registered an increase in production (by between 1 – 100 per cent) over that time period including *Prawns*, *Catfishes*, *Perches* etc. The fall in production of certain species of fish could either be due to declining fish stocks or due to the change in consumption patterns of consumers.

Figure 12.16 shows the percentage share of fish production to total fish production in 2012 of those species of fish that either recorded an increase in production over 100 per cent compared to 2007 levels or that were produced for the first time in 2012. Fish species such as *Bregmaceros*, *Mullets*, *Flying Fish*, *Hair Tails*, *Anchovies* etc. fall into the first category, whereas *Butter Fish*, *King Mackerel*, *Goat Fish*, *Marine Crust Crabs* and *Indian Oil Sardines* fall into the second category. Of all fish species produced in 2012, *Indian Oil Sardines* accounted for the highest share (close to 12 per cent) of total production in 2012, followed by *Penaeid Prawns* and *Silver Bellies* that accounted for about 8 per cent each of total production in 2012.



Source: DADF (2014).

Figure 12.16: Percentage Share of Production to Total Fish Production by Type in Tamil Nadu in 2012

12.2.7 *Olive Ridley Turtles*

Olive Ridley turtles nest all along the coast of Tamil Nadu between the months of December and April each year. The three most important nesting locations on the Tamil Nadu coast are Chennai, Mamallapuram – Pondicherry and Nagapattinam (WWF-India, 2013). Although exact numbers of nests set up and eggs laid along the Tamil Nadu coast are unavailable, they are roughly in the thousands each year[3]. However, only a fraction of these survive as marine turtles face serious threats from human activities including-

a. sand mining that leads to sand erosion and the subsequent loss of nesting grounds;
b. coastal development (residential, tourism, ports and harbours) that leads to the loss of nesting grounds, increased human encroachment on nesting sites, and lighting that disorients both adult turtles and hatchling;
c. coastal fishing that leads to higher turtle mortality as a result of incidental catch in mechanised fisheries and fishing nets;
d. construction of coastal protection barriers and windmills that limit turtles' access to nesting grounds; and,
e. foraging for turtle eggs and meat by humans and feral animals that leads to higher turtle mortality.

[3] See- http://seaturtlesofindia.org/?page_id=191

Newspapers[4] report the deaths of hundreds of Olive Ridley turtles each year due to commercial fishing activities, i.e. turtles get caught in trawl nets and suffer internal injuries from hooks or external injuries from entanglement, strangulation or amputation. Although a complete ban on the use of mechanised fishing techniques within 20 kilometres of the coast has not yet been enforced in the State (as in Odisha[5], however a partial fishing ban exists, see Section 12.3.6), in January, 2015[6], NGOs, the State Fisheries department and the Coast Guard jointly organised a turtle awareness programme for mechanised boat owners, as well as a demonstration of turtle excluder devices that boat owners were advised to install in their nets, in order to protect Olive Ridley turtles.

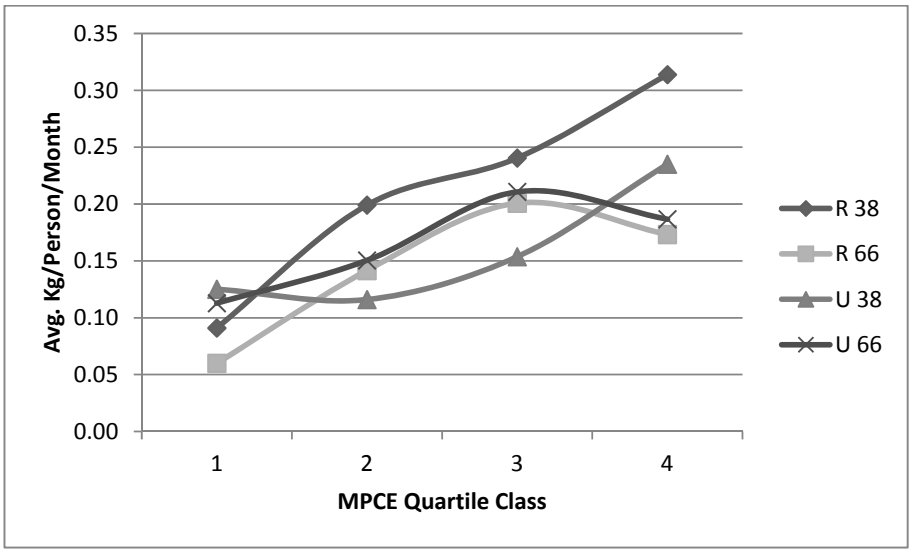
12.2.8 *Decline in Fish Consumption*

A comparison of the mean monthly per capita quantity of fish consumption in Tamil Nadu over the period 1983 (NSS 38th round) to 2009-10 (NSS 66th round) across monthly per capita expenditure (MPCE) quartiles and separately for the rural and urban sectors is presented in Figure 12.17.

[4] See- http://www.newindianexpress.com/cities/chennai/Fisherfolk-Advised-to-Use-Turtle-Excluders/2015/01/21/article2628450.ece; http://www.thehindu.com/news/cities/chennai/more-turtles-die-in-fishing-nets/article6870129.ece; http://www.thehindu.com/news/cities/chennai/operation-olivia-to-save-turtles/article7059818.ece; etc.

[5] http://www.saconenvis.nic.in/e_bulletin_april_2015_files%5CTurtle.htm

[6] http://www.thehindu.com/news/cities/chennai/fishermen-get-tips-on-saving-turtles/article6786835.ece



Source: Ravikanth and Kavi Kumar (2015).

Figure 12.17: Mean Monthly Per Capita Quantity of Fish Consumption in Tamil Nadu in 1983 and 2009-10 (in Kg/Person/Month)

The results indicate that for the rural population in Tamil Nadu, per capita fish consumption declined by 34, 29, 17 and 45 per cent each within the 1st, 2nd, 3rd and 4th quartile classes respectively over the past 30 years or so. This translates into a fall in mean per capita fish consumption for the total rural population from 0.202 kilograms per person per month in 1983 to 0.153 kilograms per person per month in 2009-10. For the urban population, per capita fish consumption declined in the 1st and 4th quartile classes by 10 and 21 per cent respectively, whereas, it increased in the 2nd and 3rd quartile classes by 30 and 37 per cent respectively. Mean per capita fish consumption increased marginally for the total urban population of Tamil Nadu from 0.153 kilograms per person per month in 1983 to 0.167 kilograms per person per month in 2009-10. Note that the NSS data does not distinguish between marine and inland fish consumption. Having said that people from south India (including Tamil Nadu) prefer marine fish and thus depend on capture fisheries, therefore it is reasonable to assume that the NSS fish consumption data for Tamil Nadu largely reflects marine fish consumption. Given that marine fish production in Tamil Nadu has been increasing over time (see Section 12.1), this decline in fish consumption in Tamil Nadu can largely be explained by the increase in marine fish exports over time (Ravikanth and Kavi Kumar, 2015), but it could also be a result of the decrease in the production of certain types of fish (see Section 12.2.6) and changes in consumers' tastes and preferences over time.

12.2.9 *Impacts due to Sea Level Rise*

A study conducted by Byravan et al. (2010) estimated the monetary losses associated with damages to major infrastructure (ports, power plants and roads), wetlands (mangrove ecosystems) and land located along the coast of Tamil Nadu that are at risk if sea level were to rise by 1 metre by the year 2050. District-wise estimates of the replacement value of major infrastructure, the present value of ecosystem services associated with damage to wetlands and the market value of land with a 1 metre sea level rise are given Table 12.13. The loss of land as a result of sea level rise is the biggest component of the total damage estimated and it ranges from about 74 – 97 per cent of total minimum and maximum values across all districts respectively. Monetary damages as a result of sea level rise are the highest in the coastal districts of Nagapattinam, Kancheepuram, Thiruvallur and Chennai. Total losses for the Tamil Nadu state as a whole range between Rs. 369 – 6,184 thousand crores. Note that these results are indicative rather than comprehensive owing to data constraints faced while conducting the analysis.

Table 12.13: Estimates of Losses from 1 metre Sea Level Rise by 2050 in Tamil Nadu

Districts	Ports		Power Plants		Mangroves		Roads		Land	
	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
Thiruvallur	9,106	9,794	13,814	13,814	0	0	0	0	33,939	9,24,130
Chennai	7,639	9,786	0	0	0	0	6	16	2,29,976	4,59,951
Kancheepuram	500	500	0	0	0	0	63	173	7,882	14,30,749
Villupuram	400	830	0	0	0	0	24	65	5,277	63,871
Cuddalore	3,825	3,825	0	0	710	2,894	64	176	7,615	4,64,531
Nagapattinam	1,873	1,873	0	0	2,421	9,871	374	1,029	7,120	22,33,596
Thiruvarur	0	0	0	0	0	0	57	157	4,347	2,08,356
Thanjavur	0	0	0	0	0	0	122	336	1,860	94,547
Pudukottai	0	0	0	0	0	0	117	321	874	10,930
Ramanathapuram	0	0	0	0	452	1,842	301	827	17,344	44,226
Tuticorin	8,585	9,456	0	0	0	0	16	44	1,149	86,151
Thirunelveli	532	532	0	0	0	0	0	0	33	7,160
Kanyakumari	0	0	0	0	0	0	0	0	246	1,479
TOTAL	**32,460**	**36,595**	**13,814**	**13,814**	**3,583**	**14,608**	**1,144**	**3,145**	**3,17,661**	**61,15,471**

Source: Byravan et al. (2010).

12.3 Responses

This section deals with the policy initiatives undertaken by the government to protect and conserve the coastal environment.

12.3.1 *Integrated Coastal Zone Management (ICZM) Plan*

The Ministry of Environment and Forests (MoEF) has issued a Coastal Regulation Zone (CRZ) notification in 2011 to protect all coastal areas of India that fall within 500 metres of

the of the high tide line (MoEF, 2011). This notification sets out in detail the economic activities that are prohibited within this zone and lays out regulations for permissible activities including environmental clearance procedures to be followed by project proponents. The notification also places the onus on the State Governments for the preparation of State-level Coastal Zone Management Plans (CZMPs) and for enforcing and monitoring this notification within their respective States. For the purpose of conserving and protecting the coastal areas and marine waters, the CRZ has been classified into-

a. CRZ-I, which includes ecologically sensitive areas that play an important role in maintaining the integrity of the coast such as mangroves, coral reefs, national parks, turtle nesting habitats etc.;
b. CRZ-II, which includes areas that have been developed up to or close to the shoreline;
c. CRZ-III, which includes relatively undisturbed areas that have not been substantially built up and those that do not belong to either CRZ-I or II;
d. CRZ-IV, which includes the water area from the low tide line to 12 nautical miles on the seaward side; and
e. Areas requiring special consideration for protecting critical coastal environment and difficulties faced by local communities, e.g. CRZ area of Greater Mumbai, Sunderbans region of West Bengal etc.

A draft Integrated Coastal Zone Management (ICZM) plan has been prepared for Tamil Nadu in order to minimise conflicts of interest between competing economic activities undertaken on the coast (such as industry, tourism, fishing etc.) and to simultaneously maintain the ecological integrity of the coast (GoTN, 2013). The key elements of the draft plan are briefly described in Table 12.14.


TREE
FOUNDATION

Table 12.14: Proposed ICZM Activities for Tamil Nadu

S. No.	Activities Proposed	Description
1.	Development of an enabling environment for decision making	a. Develop an integrated GIS-based coastal database for TN, which involves data collection and preparation of maps relating to land use, river discharge, sewage discharge from industry and households, estuaries, saline intrusion areas, energy availability etc. b. Communication, education, public awareness and capacity building. c. Develop an ICZM website. d. Set up a State management unit to oversee the implementation of ICZM plans and policies.
2.	ICZM demonstration projects	a. To be undertaken along the coastline of Cuddalore, Tarangambadi and Manakudy to understand the sedimentation process of the coast.
3.	Conservation and rehabilitation activities	a. Shoreline management for shoreline protection and land use planning including erosion mapping and the demonstration of remedial measures to mitigate erosion at Kanniyakumari. b. Biodiversity conservation and rehabilitation (including assessment and monitoring) of ecologically sensitive areas such as mangroves (Muthupet, Pichavaram, Manakudy and Punnakayal), wetlands (Point Calimere, Pallikarnai Marsh, Pulicat Lake), coral reefs and seagrasses (Gulf of Mannar and Palk Bay), and forests along the coastal zone. c. Controlling coastal pollution including solid waste management for urban settlements (Cuddalore Town, Thiruvanmiyur and Nagapattinam) and tourist areas (Marina Beach, Elliots Beach, Rameswaram, Mamallapuram, Velankanni and Nagore), and industrial effluent management (at Cuddalore Town, Kilakarai district, Mandapam, SIPCOT). d. Livelihood improvement plans including identification of alternative livelihood options, training and support for alternative livelihoods for those dependent on coastal livelihoods and thus vulnerable to climate change and extreme weather events. e. Improving potable water availability and access to energy including setting up of desalination plants in Nagapattinam and Tuticorin, generating energy through algal culture, and harnessing offshore wind energy. f. Improving fishery resources including the creation of artificial reefs at various locations, undertaking hatchery production of ecologically sensitive and commercially important fish species, encouraging pen and cage culture, and capacity building for the utilisation of eco-friendly fishing techniques. g. Development of eco-tourism in coastal areas including Pichavaram, Muthupet, Rameswaram, Mamallapuram, Manakudy, Tuticorin and Kanniyakumari town. h. Disaster preparedness and management including coastal vulnerability assessment and preparation of maps (relating to erosion, flooding, SLR etc.), early warning systems for coastal communities, and evacuation strategies and awareness and training thereof. i. Preparation of Decision Support System for disaster management to identify the average inundation area for cyclones of varying intensities that hit the TN coast along Cuddalore and Nagapattinam, and assess implications of climate change and SLR.

Source: GoTN (2013).

12.3.2 *National Centre for Sustainable Coastal Management (NCSCM)*

The National Centre for Sustainable Coastal Management is an autonomous centre of MoEF that was established within the Anna University Campus, Chennai in June 2010. It is dedicated to promoting the sustainability of the coast and coastal livelihoods through increased partnerships, conservation practices and scientific knowledge and research. Since coastal issues are both diverse and complex, this Centre works as a consortium drawing on expertise from 14 member institutions located in the different coastal states of India, including the Madras School of Economics (MSE) and M. S. Swaminathan Research Foundation (MSSRF) in Tamil Nadu, in order to strengthen its capacity and enhance research and management of the coastal environment. NCSCM has seven research divisions, each addressing a different aspect of coastal sustainability including geospatial sciences, integrated social sciences and economics, coastal environmental impact assessment, conservation of coastal and marine resources, knowledge, governance and policy, and futuristic research that includes the integrated island management unit. Further details of research activities undertaken by NCSCM and their outputs in terms of publications, policy briefs and management plans are available online at www.ncscm.org.

12.3.3 *In-Situ Conservation*

In-situ conservation and management of coastal and marine habitats and ecosystems is undertaken via the establishment of wildlife sanctuaries, national parks and biosphere reserves. In coastal Tamil Nadu, these include-

a. The Gulf of Mannar Biosphere Reserve (established in 1989) that extends from Rameswaram to Kanniyakumari and the Gulf of Mannar National Park that is contained within the biosphere reserve, which is one of the world's richest regions of marine biodiversity;
b. The Point Calimere Wildlife and Bird Sanctuary (established in 1967) that is located at the south-eastern tip of Nagapattinam district, which is home to the near threatened blackbuck antelope among other animals and marine birds; and
c. The Pulicat Lake Bird Sanctuary that is located in Thiruvallur district and is most noted for greater flamingos and other migratory birds.

12.3.4 *Mangrove Restoration*

Joint Mangrove Management (JMM) was introduced by MSSRF in partnership with the Forest Department of Tamil Nadu in Pichavaram and Muthupet mangrove wetlands in 1997.

The main aim of this programme was to enhance the capacity of the local community, forest department and other interested parties to restore, conserve and sustain mangrove wetlands through participatory analysis and action (Selvam et al., 2010). This programme was implemented in eight hamlets of Tamil Nadu (4 in Pichavaram and 4 in Muthupet) till May 2003 and covered both traditional and non-traditional fishing and farming communities. A total mangrove area of 675 hectares was restored, and healthy mangroves in 2,720 hectares are being protected by village-level institutions that were formed to implement JMM and socio-economic development programmes. In addition, a number of self-help groups and micro-enterprises were initiated as part of the programme.

12.3.5 *Tsunami Rehabilitation*

The 2004 Tsunami wreaked havoc on the East-Coast of India severely affecting all 13 coastal districts of Tamil Nadu. Damage to people, cattle, property and livelihoods was extensive-close to 11 lakh people were affected, almost 8000 human lives were lost and 850 people went missing; more than 16,000 cattle died; 1.2 lakh houses/huts were damaged; close to 9000 hectares of agricultural and horticultural land was damaged, and close to 40,000 boats were damaged in coastal Tamil Nadu[7]. In addition, ecological changes took place along the coast of Tamil Nadu as a result of the tsunami such as, changes in inter-tidal and sub-tidal faunal assemblages, changes in seafloor topography and shoreline, saltwater intrusion in agricultural lands and some damage to mangroves and other coastal plantations (DoE, 2006). The Government of India, several NGOs and international aid agencies like the World Bank and United Nations provided relief and rescue operations immediately after the event took place and also put in place long-term rehabilitation measures for those affected by the tsunami. Table 12.15 sets out the post-tsunami reconstruction and rehabilitation assistance provided by different agencies for Tamil Nadu.

[7] See http://www.tn.gov.in/tsunami/Tsunami2004/Damages%20Incurred.html

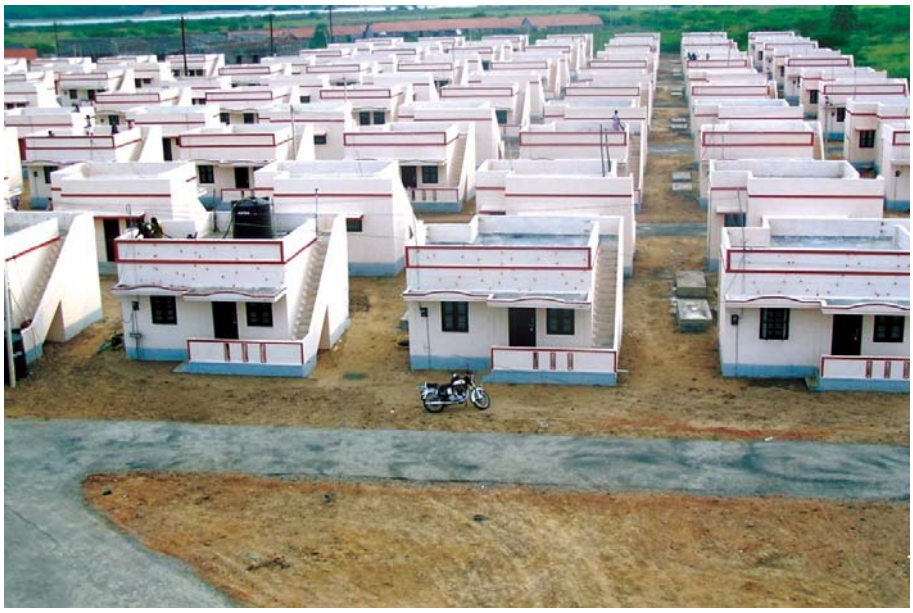


Table 12.15: Post-Tsunami Reconstruction and Rehabilitation Assistance for Tamil Nadu

S. No.	Agency/ Institution	Assistance Provided
1.	Prime Minister's National Relief Fund	a. Child education assistance scheme (Rs. 8.74 crores); scholarship scheme (Rs. 300 per month for tsunami affected children in classes I to X) b. Social infrastructure support scheme- trauma care cum recreation centres (Rs. 1.9 crores); first aid boxes (Rs. 9.4 crores) c. Waiver of loan to fishermen (Rs. 22.92 crores) d. Universal health insurance scheme (Rs. 7.77 crores)
2.	Rajiv Gandhi Rehabilitation Package aided by Government of India	a. Construction of houses (Rs. 807.11 crores) b. Repair, reconstruction and restoration of fishing boats and gear (Rs. 152.15 crores) c. Relief materials for fishermen- heavy duty bicycles, rechargeable lanterns, life jackets, insulated ice boxes, nets (Rs. 110.36 crores) d. Seamless communication network for fishermen (Rs. 7.73 crores) e. Restoration of drinking water- power pumps (Rs. 14.25 crores) f. Assistance to orphans, education etc. (Rs. 45.08 crores) g. Proposed fish landing centres (Rs. 50 crores)
3.	World Bank	I. Emergency Tsunami Reconstruction Project Phase I & II (Rs. 1852.74 crores) a. Providing multi-hazard resistant housing b. Reclaiming and restoring agricultural and horticultural lands c. Restoring and strengthening fisheries and animal husbandry infrastructure d. Restoring and strengthening public infrastructure (roads, bridges, water supply, schools, health centres) and social and economic infrastructure e. Creating green shelter belts f. Studying coastal ecology for disaster management plans
4.	Asian Development Bank	I. Tsunami Emergency Assistance Project (Rs. 629.93 crores) a. Restoration of livelihoods b. Reconstruction of transport infrastructure (roads, bridges, ports, harbours) c. Reconstruction of rural and municipal infrastructure (water supply, sanitation etc.) d. Capacity building and implementation assistance II. Japan Fund for Poverty Reduction (Rs. 16.704 crores) a. Various relief and rehabilitation works
5.	United Nations (including International Fund for Agricultural Development)	a. Hazard risk management, health services, primary education b. livelihood rehabilitation in affected coastal fisheries
6.	NGOs	a. Reconstruction of houses and restoration of boats

Source: Tsunami Rehabilitation Programme, Government of Tamil Nadu (www.tn.gov.in/tsunami/).

12.3.6 *Fishing Bans*

Each year, the Government of Tamil Nadu imposes a fishing ban in its territorial waters in order to conserve its marine resources and facilitate fish breeding. The annual 45 day ban is imposed on mechanised fishing boats and trawlers in the months of April/May (April 15th to May 29th in 2015). Traditional fishing crafts are exempt from this ban. Since the fishing ban results in a loss of livelihood and income for fishermen using mechanised crafts (during the ban period), a compensatory relief assistance package is sanctioned for these fishermen each year. In 2015, relief assistance of Rs. 1,000 – 2,000 per marine fishing family was sanctioned by the government, which amounted to a total of roughly Rs. 33 crores[8].

[8] See GoTN Order - http://cms.tn.gov.in/sites/default/files/gos/ahf_e_77_2015.pdf

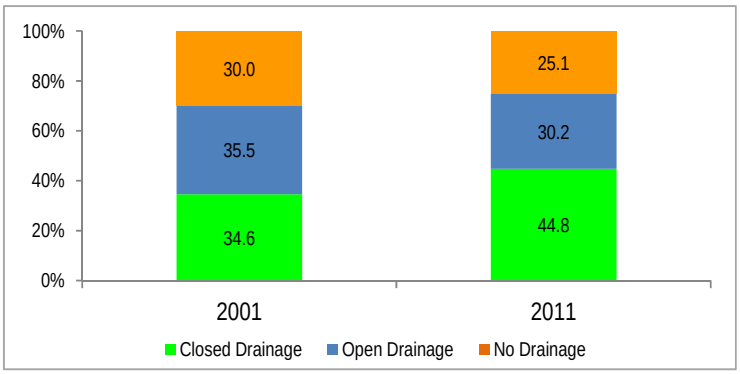
Chapter 13: Environment and Health

13.1 Environment and Health Linkages

The adverse environmental conditions outlined in previous chapters would in principle have effects on human, plant and animal health. While some of these effects have already been discussed in the context of air, water and solid waste, this chapter focusses on sewage, sanitation and other living conditions along with the possible response strategies to improved these conditions.

13.1.1 *Drainage*

In terms of waste water disposal, nearly 75 per cent of the urban households in Tamil Nadu had drainage connections in 2011, while 25 per cent of the households disposed waste water in open places (DEAR, 2013-14). Around 44.8 per cent of the households were having closed drainage facility and 30 per cent having open drainage (see Figure 13.1). Across districts, the share of urban households having no drainage facilities varies between 3 per cent for Chennai to 51 per cent in Ariyalur.



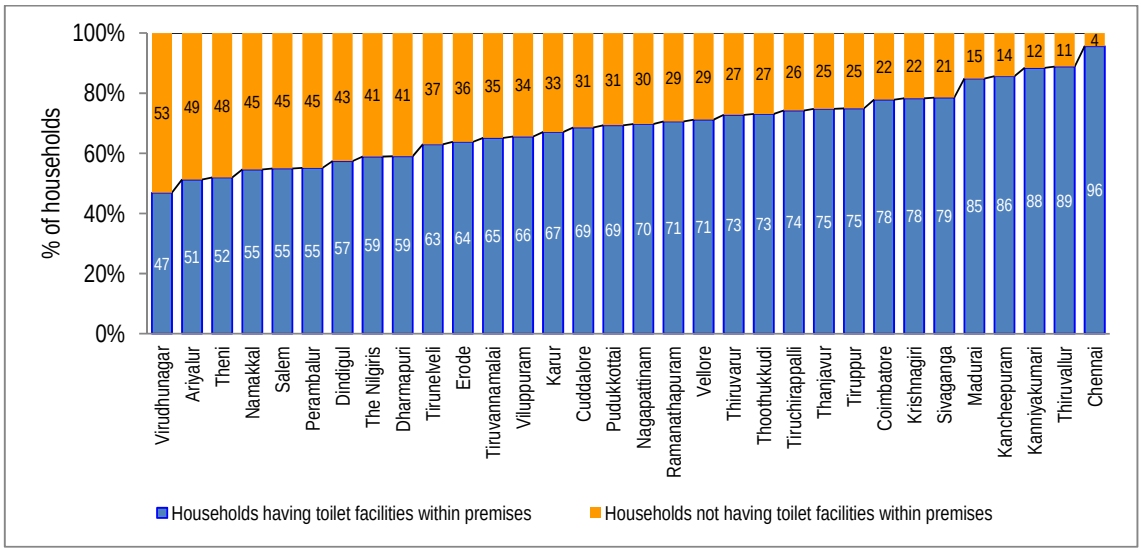
Source: DEAR (2013-14); Census (2011b).

Figure13.1: Types of Household Drainage System in Urban Areas

13.1.2 *Sanitation*

The percentage of urban households having toilet facilities has increased to 75 per cent in 2011 compared to 64 per cent in 2001 (DEAR, 2013-14). Share of urban households having toilet facilities shows significant variation across districts. As of 2011, share of urban households not having toilet facilities within premises varies from 53 per cent in case of Virudhunagar to 4 per cent in case of Chennai (see Figure 13.2). Share of households using public toilets and open defecation stands at 8.6 per cent and 16.2 per cent respectively

(DEAR, 2013-14). Within households with no toilet within premises, the share of households adhering open defecation varies significantly across districts in a range of 13.4 per cent for Chennai to 92.7 per cent in Thiruvannamalai (see Table 13.1).



Source: Census (2011a).

Figure 13.2: Toilet Facilities in Urban Households, 2011

Table 13.1: Urban Sanitation across Districts of Tamil Nadu

District	No. of Urban Households	HHs without Toilet Facilities within premises (%)	Alternative sources for HHs without toilet facility	
			Public latrine	Open
Ariyalur	21288	48.7	9.4	90.6
Chennai	1106567	4.4	86.6	13.4
Coimbatore	708788	22.1	51.6	48.4
Cuddalore	212231	31.4	9.5	90.5
Dharmapuri	65361	41.0	14.8	85.2
Dindigul	210415	42.6	33.2	66.8
Erode	334637	36.2	34.7	65.3
Kancheepuram	639333	14.4	14.5	85.5
Kanniyakumari	402811	11.6	44.6	55.4
Karur	119018	32.9	31.2	68.8
Krishnagiri	105255	21.7	24.7	75.3
Madurai	478813	15.2	42.4	57.6
Nagapattinam	89316	30.3	18.2	81.8
Namakkal	193601	45.4	54.3	45.7
Perambalur	24982	44.8	20.1	79.9
Pudukkottai	77760	30.7	11.2	88.8
Ramanathapuram	96808	29.4	18.2	81.8
Salem	463935	45.1	39.1	60.9
Sivaganga	105023	21.5	15.6	84.4
Thanjavur	213883	25.2	27.9	72.1
The Nilgiris	114556	41.1	35.3	64.7
Theni	182758	48.0	53.9	46.1
Thiruvallur	613024	11.2	20.7	79.3
Thiruvarur	65292	27.2	19.8	80.2
Thoothukkudi	225287	26.9	21.7	78.3
Tiruchirappalli	342041	25.8	49.6	50.4
Tirunelveli	397730	37.1	37.0	63.0
Tiruppur	417566	25.0	35.4	64.6
Tiruvannamalai	116158	34.9	7.3	92.7
Vellore	390296	28.8	13.3	86.7
Viluppuram	121321	34.4	10.8	89.2
Virudhunagar	273250	53.1	46.6	53.4
Tamil Nadu	**8929104**	**24.9**	**34.8**	**65.2**

Source: Census (2011a).

13.1.3 *Slum Population*

Faster development in urban areas attracts more population movement from rural areas to towns or cities. However, with limits existing in the provision of basic amenities in these towns/cities, increasing inflow of population results in growth in slums in the urban areas. The challenges associated with slums is two-fold: (a) increasing slums and slum population poses challenge for authorities in urban areas to provide basic amenities that are at par with those provided to the rest of the urban population; (b) rising slum population leads to certain environmental and health issues for people living in slums and their neighborhoods that may be difficult to deal without appropriate actions or measures.

As per the 2011 census, total population living in slums across 2613 towns reached 65.5 million. Tamil Nadu accounts for nearly 9 per cent of the slum population of the country. In 2011, the total slum population of the state was nearly 6 million. This amounts to nearly 17 per cent of total urban population of the state. The slum population is reported in 507 towns out of a total 1097 towns across the state. The five major cities/municipal corporations *viz*., Chennai, Madurai, Tiruppur, Trichy and Coimbatore accounted for one-third of the total slum population in the state (see Table 13.2).

Table 13.2: Slum Population in Selected Cities of Tamil Nadu

City/Municipal Corporation	Total City Population (lakhs)	Slum Population (lakhs)	Slum Population (%)
Chennai	69.6	26.8	38.5
Madurai	10.2	2.8	27.4
Tiruppur	4.4	0.7	15.9
Tiruchirappalli	8.5	2.3	27.0
Coimbatore	10.5	1.3	12.4

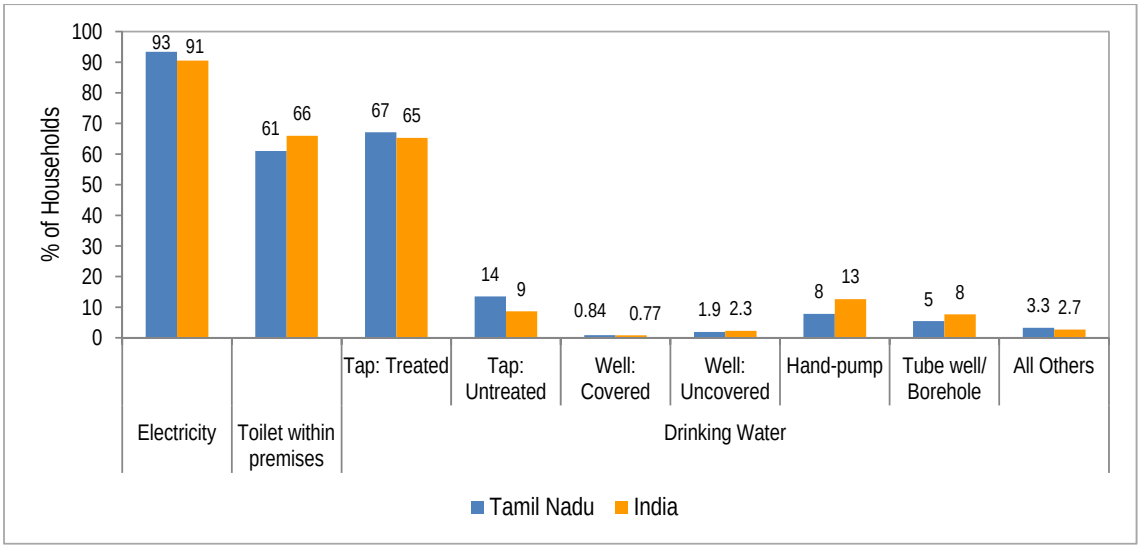
Source: Census (2011b) (correspondence with Directorate of Census Operations, Tamil Nadu via ENVIS Centre, Chennai).

A brief survey of the household amenities of the slum household reveals that more than 90 per cent of the households have access to electricity (see Table 13.3). With respect to toilet facilities, however, nearly 40 per cent of the slum households do not have toilet facilities within premises. Of these, 16 per cent of total slum households using public toilet facilities and 23 per cent adheres to open defecation. With regard to drinking water, 67 per cent of slum households have access to safe drinking water (tap water from treated sources), compared to 65 per cent for All-India (see Figure13.3).

Table 13.3: Household Amenities of Slum Households, 2011

Households	Total Households	Elec-tricity	Toilet	Drinking Water						
				Tap		Well		Hand-pump	Tube well/ Borehole	All Others
				Treated	Un-treated	Covered	Un-covered			
Number (lakhs)	14.52	13.56	8.86	9.74	1.96	0.12	0.28	1.14	0.79	0.48
Percentage	100.00	93.41	61.01	67.12	13.51	0.84	1.95	7.85	5.47	3.27

Source: Census (2011b).



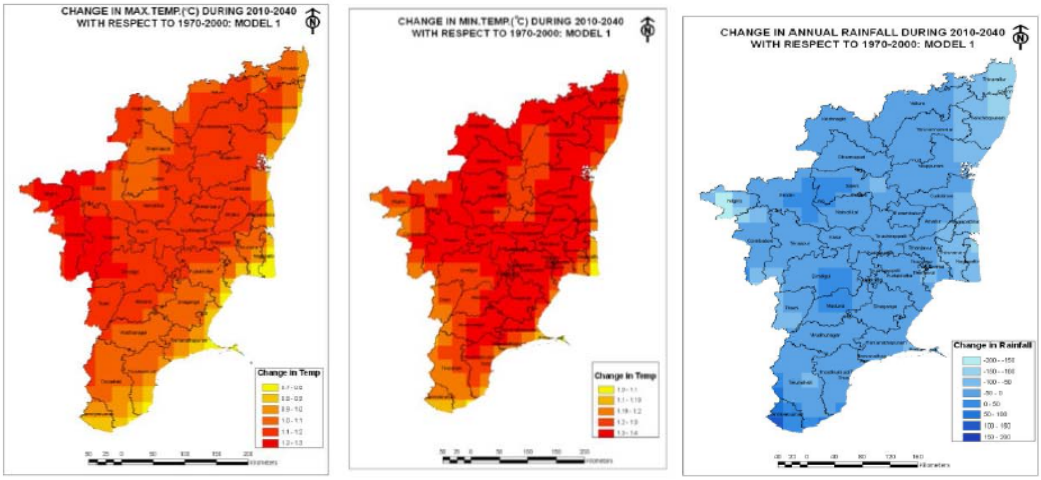
Source: Census (2011a).

Figure 13.3: Slum Household Amenities – Tamil Nadu and India (2011)

13.1.4 *Climate Change*

The climate change projections made using the UK Met Office Hadley centre regional climate model, PRECIS driven by the IPCC A1B SRES emissions scenario suggest that the maximum temperature would increase (compared to the average climate observed over the

period 1970 to 2000) by 1.1°C, 2.0°C, and 3.4°C in the years 2040, 2070 and 2100 respectively, whereas the corresponding increase in the minimum temperature are projected as 1.1°C, 2.2°C, and 3.4°C respectively for the same future years. The annual rainfall has been projected to rise by 7 cm over the period 2040 to 2070 compared to the mean annual rainfall observed over the period 1970-2000. Figure 13.4 shows the projected maximum temperature, minimum temperature and annual rainfall for the year 2040 for Tamil Nadu.



Source: GoTN (2015).

Figure 13.4: Projected Changes in Maximum Temperature, Minimum Temperature and Annual Rainfall over Tamil Nadu – 2040

The changes in climatic conditions may lead to several adverse health outcomes including, heat related morbidity and mortality, respiratory allergies and bronchial diseases, vector borne diseases, water borne diseases, and neurological diseases. Changes in climate can affect the potential transmission of vector borne diseases. Climate conditions affect quality and availability of water, and thus can cause water borne diseases. Timings and intensity of rainfall can affect the transport of disease causing organism into the water supply systems. Flooding and natural disasters may cause sudden outbreak of diseases. There is very little empirical evidence so far on the linkages between climate change and health effects. In addition to human health, plant and animal health may also be adversely affected by the changing climatic conditions.

13.2 Response Strategies

13.2.1 *Urban Planning*

Tamil Nadu has been progressive with respect to urban reforms and has been the first State to implement accrual accounting in all ULBs even before this was announced as a mandatory

reform measure under JnNURM. Except for Stamp duty rationalization to 5 per cent, most of the mandatory / optional reforms at the state and ULB level have already been implemented during the 11th plan period. Most ULBs allocate 25 per cent of the earmarked municipal budget shown as separate head on delivery of services to Urban Poor on ULB revenue are in line with the reform commitments under JnNURM and UIDSSMT.

The Public works department in coordination with the Tamil Nadu Slum Clearance Board (TNSCB) has attempted to rehabilitate the slum households. The Urban Development Vision 2023 of the state aims at rehabilitation of 1.5 million households living in slums in the state. The 12th Plan of the state also aims to achieve a "slum-free" cities in Tamil Nadu. For instance, 92272 tenements are being constructed in Chennai, Madurai and Coimbatore under JnNURM aimed at 2015 completion for making urban areas slum-free (DEAR, 2013-14).

The absence of adequate number of toilets linked to underground sewerage scheme, absence of sufficient and well maintained public/community toilets and the age old practice of open defecation are posing serious sanitation problems and health hazards. Recognising this, the State has formulated two strategies in the sanitation sector: coverage of all towns by Under Ground Sewerage System and total elimination of Open Defecation by 2015. Under the integrated Urban Development Mission (IUDM) of the state for the year 2012-13, 83 ULBs were undertaking construction of toilets towards eradication of open defecation.

Tamil Nadu is one of the few States that has come out with a comprehensive program for providing a sewerage network in Chennai city and all district headquarters with sustainable financing and user charges for sewerage connections. At present 99 per cent of the core areas of Chennai city have been covered with sewerage facilities. However, the existing treatment capacity (526 MLD) is insufficient to meet wastewater requirements by 2026, which are projected to 1490 MLD.

Rapid urbanisation and change in the lifestyle, there is a considerable increase in the quantity of waste as well as variations in the characteristics of waste. The ULBs in the State have already taken many good initiatives to bring about improvements in the Solid Waste Management services. For example, the Corporations of Madurai, Coimbatore, Salem and Namakkal Municipality have established waste processing and disposal facilities through the PPP mode under the JnNURM and other sources of funding.

Given the increasing population pressure on the City's existing infrastructure and environment, the Chennai Metropolitan Development Authority (CMDA) has put forth the

Second Master Plan. The plan envisages to make Chennai one of the most livable, economically vibrant, environmentally sustainable, and with better assets for the future generations. Its aim is planning of the city such that it would be able to accommodate 66 lakh population by 2026 in the Metropolitan area.

13.2.2 *Responses to Climate Change*

Tamil Nadu has prepared State Action Plan on Climate Change (TNSAPCC) and it has been approved by the Ministry of Environment, Forests and Climate Change recently in April 2015. The Action Plan has identified clear strategies for tackling climate change concerns in various sectors. The proposed Tamil Nadu State Climate Change Cell will serve as the nodal body in the state for coordinating and overseeing all operational aspects of TNSAPCC implementation. Housed in the Department of Environment, the Climate Change Cell will be guided by a Board headed by the Chief Secretary who in turn is assisted by an Executive Committee comprising Principal Secretaries of relevant line departments. Table 13.4 provides an overview of departments identified for actions under TNSAPCC.

A number of existing initiatives in the state for pollution control, resource conservation and livelihoods improvements would also qualify as response strategies geared towards climate change. These initiatives typically would have climate change co-benefits. Srivastava et al. (2014) have argued in favour of designing various fiscal instruments that would go long way in not only addressing the local and regional environmental concerns of Tamil Nadu but also reduce the carbon footprint of the state.

Table 13.4: TNSAPCC Implementation – Identified Departments

Sector	Identified Departments
Sustainable Agriculture	CC Cell: Commissioner of Agriculture; Agriculture and Marketing, Animal husbandry, Fisheries, Forest Department (Farm forestry, agro forestry),Agricultural Engineering, Seri culture, Horticulture, Rural development, PWD, Tamil Nadu Agricultural University, Institute for Forest Genetics and Tree Breeding (IFGTB), M. S. Swaminathan Research Foundation, DHAN Foundation
Water Resources	CC Cell: Institute of Water Studies, Ground Water; TWAD, Rural Development, Fisheries, Public Works Department, Chennai Metro Water Supply and Sewerage Board, Tamil Nadu Water Supply and Drainage Board, Meteorology Department, Central Ground Water Board, IIT, Centre for Water Resources, Anna University, DHAN
Forest and Biodiversity	CC Cell: Department of Forests, Department of Environment, National Biodiversity Authority, State Biodiversity Board, Agriculture Department, TNAU-Forest College and Research Institute, Institute for Forest Genetics and Tree Breeding, M. S. Swaminathan Research Foundation
Coastal Area management	CC Cell: Department of Environment, Revenue Department, Tamil Nadu Electricity Board, Rural Development, Chennai Metropolitan Development Authority, Directorate of Town and Country Planning, Forest Department, Pollution Control Board, Maritime Board, Town Panchayat, Municipal Administration, Fisheries, GoMBRT, Public Works Department, Central Ground Water Board, Department of Revenue Administration-Disaster Management, Institute of Hydraulics and Hydrology, Department of Ocean Development, Indian Coast Guard, IIT,

	Centre for Environmental Studies, IRS, CCCAR, Anna University, Institute for Ocean Management, SDMRI, Centre for advanced studies in Marine biology, Central Marine Fisheries Research Institute, MSSRF
Energy Efficiency, Renewable Energy & Solar Mission	CC Cell: Tamil Nadu Generation and Distribution Corporation (TNEB)Tamil Nadu Electricity Board, Tamil Nadu Energy Development Agency, Transport Department, Centre for Wind Technology, Institute for Energy Studies, Anna University; TNAU, Confederation of Indian Industry
Sustainable Habitat	CC Cell: Chennai Metro Water Supply and Sewerage Board Revenue Dept., Tamil Nadu Electricity Board, Rural Development, Chennai Metropolitan Development Authority, Directorate of Town and Country Planning, Pollution Control Board, Town Panchayat, Municipal Administration, Transport Department, Housing Board, Slum Clearance Board, Chennai Metro Water Supply and Sewerage Board, Tamil Nadu Water Supply and Drainage Board, Medical Education, Public Health Department, School of Architecture and Planning, Anna University
Knowledge Management	CC Cell: Department of Environment, Centre for Climate Change and Adaptation Research, Anna University and others appointed as and when required

Source: GoTN (2015).

Chapter 14: Environmental Hotspots

While the detailed information provided in the previous chapters with regard to the core and cross-cutting environmental themes highlights the response strategies that the government can initiate in general in short, medium and long-run, the state of environment reports are also typically expected to highlight the hotspot areas that require urgent attention. It is this aspect that the present chapter focusses on.

Mukherjee and Kathuria (2006) compared the economic growth in major states of India against the observed environmental degradation. The environmental quality is captured through integration of some fourteen indicators and the environmental degradation in each state is assessed in terms of the change in the environmental quality over 1990s.The study observed that along with West Bengal and Karnataka, Tamil Nadu registered higher economic growth during 1990s at the cost of environmental quality. While the detailed sectoral analysis presented in the previous chapters provides useful inputs for shaping appropriate policies, there is also a need for identifying issues and regions that need attention immediately. It is possible to identify issues and regions in such manner by aggregating different indicators to generate a single index. Though the intention of this study is not to aggregate various indicators to arrive at a comprehensive indices such as environmental performance index, or environmental sustainability index of a region, an attempt will be made in this section to briefly summarize the findings from such exercises carried out recently for Tamil Nadu.

While most of the discussion below focusses on geographical regions that are threatened by environmental degradation, environmental hotspots could also include focus on threatened species. As highlighted in Chapter 2, several medicinal species, and fauna are red listed and require attention for conservation. As many as 230 medicinal species, 126 fish species, 56 amphibian species, 77 reptile species, 32 bird species, and 40 mammals are under the red-list category in Tamil Nadu.

14.1 Environmental Hotspots – Tamil Nadu

The Blacksmith Institute of New York started an initiative to identify the worst polluted places of the world in 2006. The top ten worst polluted places are selected on the basis of size of affected population, severity of the toxin involved, impact on children's health and development, evidence of a clear pathway of contamination, and existing and

reliable evidence of health impact. In the 2006 report, Ranipet in Tamil Nadu featured among the top ten worst polluted places (Blacksmith Institute, 2006). While the state government has ordered the closure of Tamil Nadu Chromates and Chemicals Limited a decade ago, the legacy of the same still continues with no solution still in sight for the safe disposal of 1,500,000 tons of solid waste generated by the factory over two decades before its closure. Blacksmith Institute and Asian Development Bank estimate 3.5 million people as potentially affected people due to ground and surface water contamination. Within five kilometer distance around 68 tanneries operate in Dindigul leading to severe ground water pollution. Tannery-effluents reported to have left only 16 out of 56 wells in Kamatchipuram village uncontaminated forcing people to walk long distances for water. The water and soil pollution from the tannery effluents has the potential to affect about 450,000 people.

As highlighted in Chapter 5, the Ministry of Environment, Forests and Climate Change, Government of India vide office memorandum dated 13.01.2010 imposed temporary restriction on consideration of developmental projects in 43 industrial clusters in the country whose Comprehensive Environmental Pollution Index (CEPI) score was above 70. As far Tamil Nadu is concerned 4 industrial clusters, *viz.*, Vellore- Ranipet SIPCOT Industrial Complex; Cuddalore – SIPCOT Industrial Complex Phase I & II; Manali – Manali Industrial area; Coimbatore – Kurichi Industrial Cluster come under the category of CEPI score above 70. Based on the action plan and its implementation progress, the MoEF had lifted the moratorium on three industrial clusters – SIPCOT Industrial Complex Phase I & II; Manali Industrial area; and Kurichi Industrial Cluster. In respect of Ranipet SIPCOT Industrial Complex, the main cause for increase of CEPI score is due to the storage of chromium bearing hazardous waste in an unscientific manner by the unit of M/s. Tamilnadu Chromates and Chemicals Limited which is a defunct unit for past twenty five years. The storage of hazardous sludge pollutes the groundwater in the vicinity. For remediation of this contaminated site, MoEF has included this site for funding under the National Clean Energy Fund. The MoEF has engaged M/s. ERM India Pvt. Ltd as consultant to prepare detailed project report to carryout remediation. The consultant is in the process of preparing DPR. Once the site gets remediated, there are chances for reducing CEPI score and for lifting moratorium.

14.1.1 *Vulnerability to Climate Extremes*

Hossain and Singh (2002) used geographical information system based approach to categorize the coastal areas across India into low, moderate, high and extreme vulnerable categories based on their exposure to cyclonic storms. Table 14.1 shows the summary statistics of their analysis for Tamil Nadu. Large proportion of coastal population in the state is either highly or extremely vulnerable and the state also constitutes a large percentage of the India's total vulnerable population.

Table14.1: Vulnerability to Cyclonic Storms – Summary Statistics

Vulnerability Level	Percentage of State Coastal Population	Percentage of All India Vulnerable Population
Moderate	4.5	1.15
High	71.1	16.6
Extremely	24.4	28.9

Source: Hossain and Singh (2002).

Kumar and Tholkappian (2006) analysed district level vulnerability to cyclonic storms in Tamil Nadu. For the purpose of index calculation, vulnerability is hypothesized to be a function of *impact* on the district, and *resistance* and *resilience* of the district in responding to the impact it experiences. District specific data on the following parameters (which are considered to be influencing vulnerability) is assembled.

- **Demographic**: (a) Population density based on 2001 census; (b) Annual growth rate of population.
- **Physical**: (a) Coast length; (b) Insularity (defined as ratio of coastal length to the area of the district); (c) Frequency of cyclones (weighted to account for cyclones of different intensities) based on historic data; (d) Probable maximum surge height; (e) Area at risk of inundation due to sea level rise; (f) Vulnerable houses – both at the risk of damage and collapse (based on 1991 census).
- **Economic**: (a) Agricultural dependency (expressed in terms of population dependent on agriculture and other primary sectors); (b) Income.
- **Social**: Literacy rate.

While most of the above indicators capture the *impact* characteristic of vulnerability, the indicators listed under the headings 'economic' and 'social' indicate the ability of districts to *resist* and *bounce back*. The composite index is calculated by taking average of all the

standardized observations of each district over all the components. The averaging procedure implies that equal weights are assigned to each component. The procedure is similar to that followed in the construction of Human Development Index by the UNDP. The index computations are made for a range of combinations of the parameters listed above. Table 14.2 shows the vulnerability index and vulnerability rank (across the coastal districts in India). The vulnerability rankings are relatively robust independent of the specification and the results highlight significant disparity across coastal regions in terms of their vulnerability to cyclones.

Table 14.2: Vulnerability to Cyclonic Storms – Tamil Nadu Districts

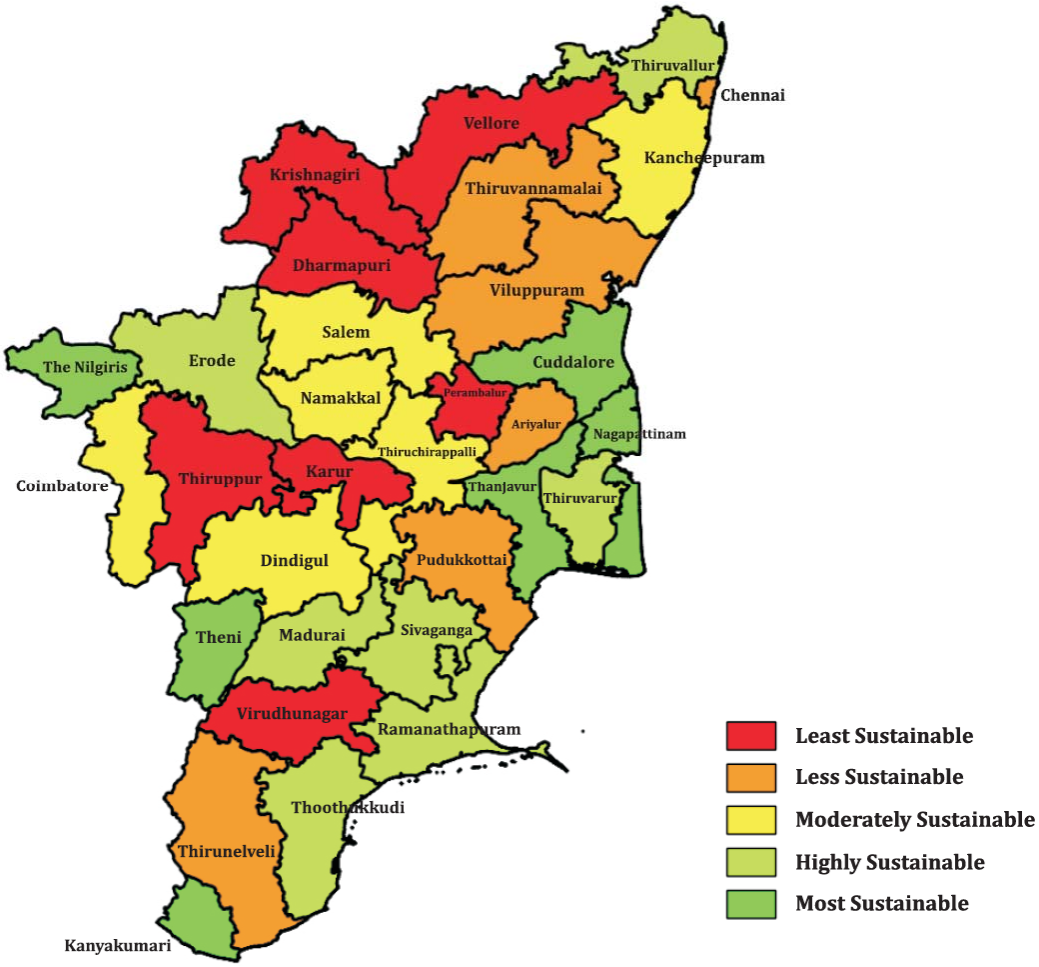
Sl. No.	District	*V1*	V1 Rank	*V2*	V2 Rank	*V3*	V3 Rank
1	Chengalpattu	0.4063	7	0.3802	8	0.4533	7
2	Kanniyakumari	0.2894	26	0.2611	28	0.3645	21
3	Chennai	0.5349	4	0.5042	4	0.5578	4
4	Ramanathapuram	0.3853	11	0.3443	13	0.4518	8
5	South Arcot	0.2942	22	0.2719	21	0.3622	23
6	Thanjavur	0.3957	8	0.3680	9	0.4466	9
7	Tirunelveli	0.2760	32	0.2609	29	0.3408	37

Note: (a) It may be noted that some of the districts are clubbed for data consistency; (b) V1 is estimated using Insularity, Population density, Population growth, Population in agriculture, Literate Population, Vulnerable houses (Total), Probable Max surge height and Cyclone frequency as indicators; V2 and V3 are estimated using all the indicators used in the computation of V1 and income as vulnerability indicator and resilience indicator, respectively.

Source: Kumar and Tholkappian (2006).

14.1.2 *Environmental Sustainability Index*

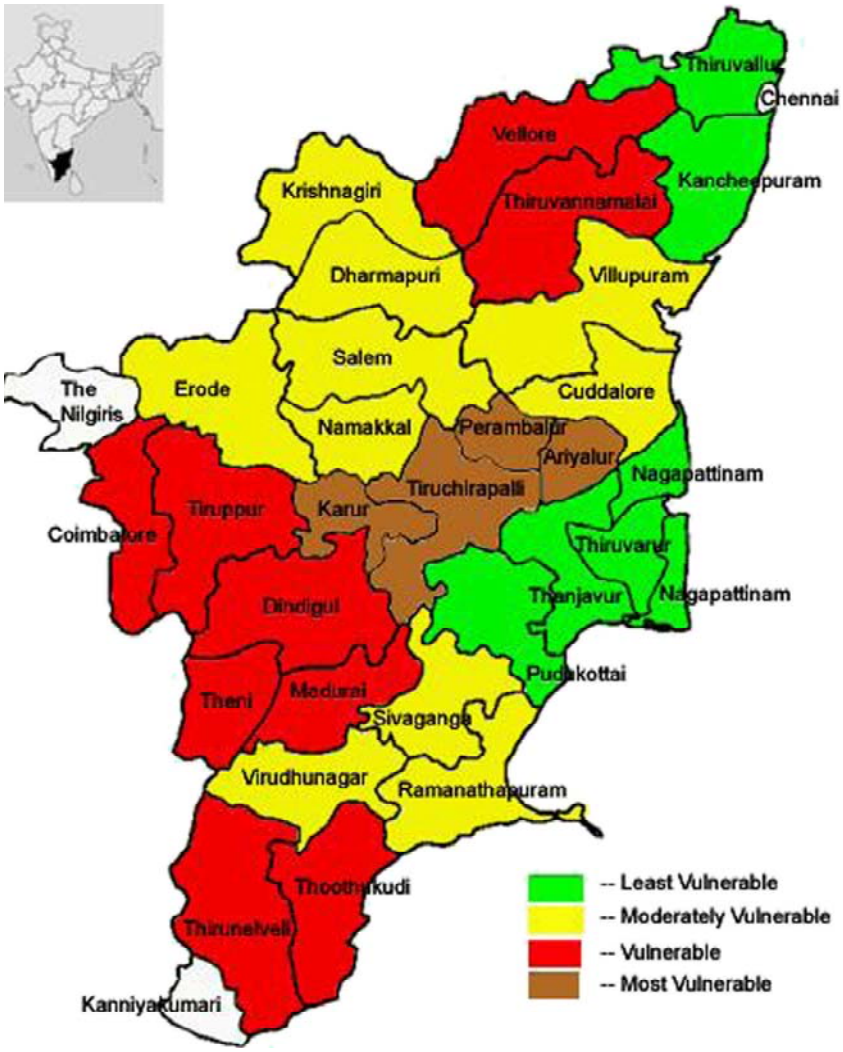
Recently, Shivaranjani and Venkataramani (2015) constructed environmental sustainability index (ESI) for the districts of Tamil Nadu using 2011-12 as the baseline year. The ESI consists of 45 indicators spread across nine thematic areas including, population, land-use, agriculture, transport, water, forests, solid waste, energy, and output. Figure 14.1 shows the environmental sustainability index assessed by the study for the districts of Tamil Nadu. The study identified Vellore, Karur, Perambalur, Virudhunagar, Krishnagiri, Dharmapuri and Tiruppur as the least sustainable districts.



Source: Shivaranjani and Venkataramani (2015).

Figure 14.1: Environmental Sustainability Index for Tamil Nadu Districts in 2011-12

In another recent study, Varadan and Kumar (2015) assess the agricultural vulnerability of the districts of Tamil Nadu to climate change. The study chooses the growth and instability of certain performance indicators to capture the relative vulnerability of the districts of Tamil Nadu. The agricultural vulnerability index (AVI) has been estimated as a weighted index based on growth and instability in south west and north east monsoon; growth in crop diversification; growth in net cultivated area; and growth in crop intensity. Figure 14.2 shows the estimated AVI across districts of Tamil Nadu based on data over the period 1980-81 to 2010-11. Due to changes in the district boundaries over the study period, the AVI has been reported for sixteen parent districts of Tamil Nadu. Tiruchirappalli, Karur, Perambalur and Ariyalur have been identified as agriculturally most vulnerable districts of Tamil Nadu from climate change perspective.



Source: Varadan and Kumar (2015).

Figure 14.2: Agricultural Vulnerability to Climate Change – Tamil Nadu Districts

If one juxtaposes the above two studies and relative ranking of the districts of Tamil Nadu, it is possible to identify the districts that are currently least sustainable from environmental perspective and are also identified as most vulnerable to climate change (albeit with focus on single sector namely, agriculture). Such an exercise reveals that Karur and Perambalur are two most important districts that need urgent policy attention.

Chapter 15: Conclusions

Article 21 of the constitution, relating to the fundamental rights, states that, 'No person shall be deprived of his life or personal liberty except according to procedure established by law'. This article has been repeatedly interpreted by the Supreme Court as ensuring 'right for clean environment' – arguing that right for life is not feasible without protection and preservation of natures' gift. Any disturbance to the basic environment elements, namely, air, water, and soil necessary for life, could thus be interpreted as hazardous to life within the meaning of Article 21 of the Constitution.

Article 47 of the Constitution requires the State to improve the standard of living and public health. To fulfill this constitutional goal, it is necessary that the State should provide among other things a pollution free environment. The United Nations Conference on Environment held at Stockholm in 1972 placed the protection of biosphere at the centre of international policy and law. India through its participation in the Stockholm convention and explicit statement has committed itself to the protection of the environment. Relevant constitutional changes were brought about through the 42nd Amendment Act in 1976 relating to articles 48 and 51.

- *Directive Principles of State Policy*: Article 48 A – 'The State shall endeavour to protect and improve the environment and to safeguard the forest and wildlife of the country'
- *Fundamental Duty*: Article 51-A (g) – 'It shall be the duty of every citizen of India to protect and improve the natural environment including forests, lakes, rivers and wildlife and to have compassion for living creatures'

Amendments to the Constitution were also made to accelerate the pace for environmental protection through changes in the Seventh, Eleventh, and Twelfth Schedules of the Constitution. Under the constitution, three important subjects concerning environment, namely, water, land, and gas and gas-works are placed in the State List of the Seventh Schedule of the Constitution as items 17, 18, and 25. Forests are placed in the Concurrent List.

The State of Environment studies being stock-taking in nature facilitate the concerned stakeholders, including the government departments and agencies to identify the critical areas needing immediate intervention and provide crucial insights about the efficacy of the ongoing programs in ensuring maintenance of life-supporting ecological functions and environmental

quality. This study with its focus on all environmentally relevant sectors of Tamil Nadu attempted to summarize the pressures acting on the environment, the status of the environment, the impacts due to environmental degradation and the responses being initiated by the state government in addressing the environmental concerns.

15.1 State of Environment in Tamil Nadu – Summary

As discussed in the introduction chapter, population growth, rapid urbanization, changing life styles, and the development goals outlined in the Visions 2023 act as drivers to exert pressure on the environment in Tamil Nadu. In the backdrop of these overall drivers, this report examined the state of environment in Tamil Nadu by analysing the sector specific indicators of pressure, state, impact and responses. In addition to key environmental issues namely, forests & wildlife, biodiversity, land degradation, air pollution, water pollution, noise pollution and solid waste, the report also analysed several cross-cutting environmental issues with focus on sectors such as agriculture and allied sectors, water resources, energy, coastal resources, and human health. Both temporal and spatial (across districts) patterns of various indicators have been analysed using the latest available data. Table 15.1 provides an overview of the various indicators used for the analysis in different environmental issues.

Table 15.1: Issue/Topic-specific Pressure-State-Impact-Response Indicators

Topic	Indicators
Forests, Wildlife and Biodiversity	Pressure: Demand for forest produce and firewood; Demand Supply Gap for wood; Growth in tourist population; Forest fires State: Forest Cover; Wetlands; Status of endangered animals Impact: Human animal conflicts Responses: Forest certification; Eco-tourism; Reserved and protected forests; Joint forest management; Biosphere reserves; National parks; Wildlife and bird sanctuaries
Land Degradation and Solid Waste	Pressure: Agricultural practices; Land conversion for non-agricultural use; Waste generation; Mining activities State/Impact: Wastelands; Fallow lands Responses: Organic farming; Environmental clearance for mining projects; Sustainable mining practices; Waste management; Compliance with MSW2000 Rules
Air and Noise Pollution	Pressure: Motor vehicle density; Road density and connectivity; Industrial growth; Use of solid fuels for cooking; Burning of agricultural and solid waste State/Impact: Air pollution levels in major cities; Indoor air pollution levels; Greenhouse Gas Emissions; Health Impacts Responses: Air pollution monitoring network; Growth of public transport; penetration of clean cooking fuels; Integrated Transport system
Water Resources and Water Pollution	Pressure: Rainfall anomaly; Fertilizer and pesticide use; Domestic, industrial and agricultural water effluents State: Quantity and quality of water Impact: Incidence and spread of water borne diseases; Water conflicts Responses: Desalination plants; Rainwater harvesting Water treatment plants; Drip and sprinkler irrigation; Promotion of low water intensive crops; Watershed programs; Water use charges
Agriculture and Allied Sectors	Pressure: Dependence on Agriculture; Climate Change State: Declining Production and Widening Yield Gap. Impact: Implications of Food Insecurity. Responses: Universal Public Distribution System; Organic Farming; Bio-fertilizers; Vermi-composting; Performance of PDS and ICDS, and Amma Canteen.
Energy	Penetration of Renewable Energy Sources in Energy-mix; Greenhouse Gas Emissions from Energy Sector
Coastal Resources	Pressure: Commercial Fishing; Domestic and Industrial Pollution; Ports and Harbours; Coastal Tourism. State / Impact: Mangroves; Coral Reefs; Seagrasses and Seaweeds; Estuaries; Sand Beaches and Dunes; Fish Species; Olive Ridley Turtles. Responses: Integrated Coastal Zone Management (ICZM) Plan; Institutional Changes; Tsunami Rehabilitation; Mangrove Restoration; In-Situ Conservation; and Fishing Bans.

The study could not provide comprehensive status of some critical issues such as sand mining and the associated environmental implications due to paucity of reliable data. Besides direct pollution effects, the agricultural lands are also affected by the sand querying for construction activities and mining of top soil among other things for brick manufacturing. Sand querying has received particularly wide attention in both river beds and coastal areas. The boom in construction activities in the urban areas appears to be triggering the indiscriminate mining of sand. Despite Government Order in 2002 regulating the sand mining activity, the activity is continuing in several river basins. The sand mining in river basins is considered responsible for impairment of water flow, bed erosion, collapse of banks and mix-up of sewerage flows with river water. In coastal areas unscientific methods of sand mining are considered responsible for loss of valuable silicon sand. It also leads to conflict of interest between sand miners and fishing community. The high-level committee constituted by the Government of Tamil Nadu has recommended a 'single' agency to oversee the issuance of permits for sand mining as against the practice involving several departments (e.g., geology and mining, revenue and public works).

Pressure from urbanization has not only resulted in competition for scarce resources like land and water but also affected their quality. For instance, increasing demand for bricks has resulted in removal of top-soil in the fertile agricultural lands prompting the farmers to apply chemical fertilizers in an attempt to replenish the loss of nutrient. Farm level studies have indicated that removal of top-soil have resulted in loss of major nutrients like phosphorous (20 per cent) and nitrogen (35 per cent), along with micro nutrients. However it is often difficult to replenish the loss of micro nutrients and as a result the productivity loss due to top-soil removal is rather permanent.

15.2 Government Initiatives and Environmental Linkages

What have been the response strategies in Tamil Nadu so far? Were they adequate? What kind of proactive strategies the state should adopt to improve the state of environment? Table 15.2 provides a comprehensive summary of various programs/initiatives of the Tamil Nadu government and their environmental linkages. The response strategies can be seen through three broad categories: (a) strategies towards reducing the pressure; (b) strategies aimed at restoring the state of the environment; and (c) strategies targeted towards the amelioration of impacts caused by the environmental degradation.

15.2.1 Strategies towards reducing pressure:

Several air, water and solid waste control acts were primarily aimed at reducing the pressure through reduction of pollution. Some of the policies have also attempted to control the driving forces that create pressure. But on the whole such policies have at best been inadequate. For instance while there have been several measures to reduce vehicular emission through adoption of stricter control norms, little effort is going towards control of increase in the number of vehicles. Improvement in public transport facilities can go long way in reducing the pressure on the environment with the added benefit of easing the traffic congestion. This essentially calls for a more integrated approach in designing the response strategies.

15.2.2 Strategies towards restoring the state:

Regular monitoring of the ambient environment has been a feature of the policies aimed at restoring the state of the environment. However, often the deterioration of environmental goods is not correlated with the potential driving forces. Awareness is important but may not be sufficient to galvanize required changes. As far as the policies aimed at physical restoration of environmental goods are concerned, the typical approach has been to deal with the 'hot-spot' area in an isolated manner. While such an approach is useful for the manageability of the situation, it may also create a 'special' status for the environmental good under consideration and hence may not work towards avoidance of recurring deterioration.

15.2.3 Strategies towards amelioration of impacts:

The polluter-pays principle has been effectively enforced in the case of compensation awarded to the victims of tannery pollution by the Loss of Ecology Authority. Besides this, however, the policies aimed at reducing the impacts caused by the environmental degradation have largely been in the form of compensation given by the state. For instance, in the case of climate extremes there has been little effort towards encouraging the potential victims to participate in insurance schemes. In case of agriculture, the new initiatives in the micro-finance sector undertaken by non-governmental organizations like Dhan-foundation and BASIX deserve more attention.

15.3 Fiscal Instruments for Environmental Management in Tamil Nadu

In addition to various government initiatives discussed in the previous section, there is an important role for fiscal instruments for effective environmental management. This section looks at possible fiscal interventions that Tamil Nadu government can consider for addressing

environmental concerns in the state. Broadly, the two sets of fiscal instruments used for environmental management are environmental taxes and environmental subsidies. Both are indirect instruments that operate by affecting the market prices. Taxes increase the price while subsidies reduce these. There are a number of critical differences in these two instruments. Some of these are mentioned below.

- Taxes work as disincentives while subsidies provide incentives;
- Taxes raise revenues while subsidies draw upon fiscal resources;
- Taxes can generally be broad based; subsidies allow fine distinctions to be made. Although the more refined the target, the costlier it is to administer a subsidy. Very fine distinctions in tax rates according to different attributes of goods lead to a variety of classification disputes. In general, there is a preference for common tax rates for all goods and services or very broad distinctions.
- Both taxes and subsidies require additional administrative costs.
- Viewed individually, in the case of taxes, the costs (reduced output, reduced employment) and benefits (environmental benefits, revenue benefits) may both be spread over a long period of time requiring detailed cost-benefit analysis. In the case of subsidies, generally costs are front-loaded (support for purchase of new machinery) and benefits (better environment) are spread over time. By using the two instruments jointly, some of the associated assessment risks can be minimized if not altogether neutralized.

With a view to maximizing their impact, a recent study by Srivastava et al. (2014) proposed a number of two part fiscal instruments. The first part is a tax and the second part is a subsidy. This strategy addresses several aspects of the design simultaneously. The basic features are as follows:

15.3.1 Maximizing Environmental Impact

Taxation has a disincentive effect and it acts as a disincentive to an environment damaging activity. But taxation raises revenue, which may become part of the general budget of the government. In order to ensure that this revenue is also used for promoting environment, we develop a counterpart of the tax instrument so that a subsidy can promote environment. This two-part strategy will therefore have maximum positive impact on environment both by introducing a disincentive and an incentive.

In India, two of the most significant contributors to pollution are coal and iron and steel. Both of these are part of a list under the central sales tax act (CST Act) called 'declared goods' and referred to as goods of special importance. States cannot increase the tax beyond the limit prescribed by the central government under the CST Act. This limit was fixed at 4 per cent[1], which has recently been increased to 5 per cent. At the same time unless these inputs are taxed relatively more heavily and alongside the use of substitutes for producing energy in the case of coal and shift in the usage of iron and steel to substitutes like cleaner plastics is encouraged, a tangible dent on pollution cannot be made. The options available for this purpose are discussed in further detail later in this chapter.

15.3.2 Financing of Subsidy

One of the major problems in using environmental subsidies is to ensure its financing. Generally, if it is to be financed by the general budgetary resources, it gets under financed and the funding is also not ensured. In the suggestions given in this study, the subsidy is financed automatically from within the sector by raising additional revenue from the environmental tax within the sector. It also ensures sectoral fairness as the funding for the subsidy comes from within the sector. This is not to suggest that general budgetary sources should not be relied on for financing environmental subsidies.

15.3.3 Endogenizing Administrative Costs

Another important aspect is that there are additional administrative costs of administering both a tax and a subsidy that requires to be provided for. In the suggestions that are made here, a part of the additional tax revenue is earmarked for meeting additional administrative costs so that this cost is also met by design.

15.3.4 Minimising Revenue Risks

The success of an environmental fiscal intervention depends on the decision making authority agreeing to assessments of additional revenues that can be raised in the case of taxation. In all such assessments, there are revenue risks as revenues depend on market conditions. However, if programs can be designed such that the revenue risks are minimized, it is easier for decision-makers to accept such decisions. A variety of strategies can be used to minimize revenue risks. Thus, a subsidy program can be scaled down in economic slow-down years

[1] The rate was increased from 4 to 5 per cent in the Union Budget of 2011-12. The relevant notes on clause 74 runs as: "Clause 74 of the bill seeks to amend section 15 of Central Sales Tax Act, 1956, so as to increase the ceiling imposed through the Central sales tax on the power of the States to levy VAT on the "declared goods" from 4 per cent to 5 per cent."

when revenues fall; a separate fund can be created to neutralize cyclical variations in revenue; and suitable borrowing strategies can be put in place where the subsidy program requires a lumpy investment in the beginning.

In the Indian federal context, environmental taxes can be divided into two groups: Group A consisting of state taxes where the relevant central provisions may have to be taken into account; and Group B, where the fiscal instrument can be decided by the state government. In the context of the instruments under Group A, account has also to be taken of present transitional position where efforts are being made to move to a comprehensive Goods and Services Tax (GST) regime from the present system of domestic indirect taxes consisting of cenvat, state vat and service tax. For example, the following instruments can be considered as belonging to Group A or B.

1. A sales tax or excise tax can be levied by a state at the first point of sale. Under the present constitutional arrangements, states can levy a sales tax or state vat on all goods including polluting goods. For such a tax to have any effect, it should not be rebated at a later stage. However, this is subject to considerations like whether the good belongs to the list of declared goods, which is a central provision.
2. The following two, however, are examples of instruments that belong to Group B instruments: (a) a cess or a surcharge, which can be levied on an existing tax but on selected polluting goods only and (b) local levies like property tax and congestion tax.

In the present system of state vat, taxes paid on inputs are rebated at later stages of sales. Any excise duty or additional sales tax on polluting goods can only be effective if it is not rebated at later stages of sales. An excise is relevant if the pollution is at the production stage. A cess is relevant if the government wants to earmark the revenues for environmental purposes specific to industries. A surcharge can be used more generally.

In addition, there is now a move toward direct taxation of pollution such as the carbon tax or SO_2 tax etc. These taxes are now being used extensively in many countries but in India such taxes are not specified in the Constitution and state governments cannot levy such taxes. The central government can levy a tax like this under its residuary powers.

From a longer term perspective, as already mentioned, there is a now a move to subsume a number of central and state taxes on goods and services in a comprehensive GST. The GST may involve constitutional changes affecting the powers and flexibility of the states in using the tax instrument for environmental purposes. It is important for the states to have

autonomy in levying cesses and surcharges or differentially higher rates for identified polluting goods and services. In a GST framework, the idea is to tax all goods and services in a rate structure that has either just a single rate or few rates. Scope for differentiation for environmental purposes will need to be separately provided for.

Apart from taxation, subsidies can also be used to promote environment. One example is subsidy for clean energy that is energy that is produced by relatively less polluting inputs. These subsidies can be used to encourage introduction of new technology or substitution of polluting inputs by cleaner inputs. Subsidies can be of two types: input focused and technology focused. There can be consumption focused subsidies to encourage consumption of cleaner fuels like ethanol or products like the CFL bulbs.

A summary of suggested environmental instruments aimed at interventions meant for the Tamil Nadu economy along with their basic features is described in Table 15.3. The primary objective of these environmental instruments is to address local environmental problems including air, water and land pollution, and conservation of biodiversity. The greenhouse gas emission reductions could be seen as co-benefits of these interventions.

Table 15.2: Description of Various Government Schemes/Initiatives and their Environmental Linkages

Sl. No.	Scheme/Initiative	Description	Concerned Department(s)	Environment/Resource Linkage	Remarks
1	Afforestation Programmes	Providing saplings for afforestation, incentives to tribals in Forest Operation	Adi Dravidar and Tribal Welfare Department	Increase in forest cover	**Strategy towards Restoring State** Beneficiaries: SC/ST; Valid to: Dec 31, 2016
2	Afforestation schemes providing incentives and providing employment to tribals in Forest Operation.	Afforestation schemes providing incentives and providing employment to tribals in Forest Operation. Tribal forest areas.	Adi Dravidar and Tribal Welfare Department	Increase in forest cover; Optimum utilisation of human resources leading to less destruction of natural resources	**Strategy towards Restoring State** Beneficiaries: Unemployed; Valid to: Dec 31, 2020
3	Assistance to farmers for improving the soil health-Soil and Water Sample Analysis	It's a subsidy providing a supply of mini kits – 5000 mini kits each worth 140/- containing 5 Kg of Urea, 1 kg of Pleurotus and a technical Pamphlet are given at free of cost.	Agriculture Department	Optimal utilisation of natural resources and technical guidance for sustainable farming practices	**Strategy towards Ameliorating Impacts** Beneficiaries: Farmers; Valid to: Dec 31, 2016
4	Assistance to farmers for improving the soil health-Vermicomposting of Agricultural Waste	Organizing Demonstration and Training – 1200/- is provided as subsidy for organizing a demonstration. 50/- per farmer towards incidental charges for training 50 farmers per batch.	Agriculture Department	Capacity building of farmers towards efficient agricultural waste management; sustainable practices and reduction in greenhouse gas emissions	**Strategy towards Ameliorating Impacts** Beneficiaries: Farmers; Valid to: Dec 31, 2016
5	Abatement of pollution in the rivers under National River Conservation Plan (NRCP)	Under National River Conservation Plan (NRCP), the sewage outfall from the towns into the rivers Cauvery, Vaigai and Tamiraparani has been diverted, collected and	Environment Management Agency of Tamil Nadu	Sewage treatment Plans and cleaning up of the state's rivers	**Strategy towards Reducing Pressure** Cauvery Stretch: Implemented since 1996-97. Cost- Rs. 380 crores. Activities worth Rs. 332 crores implemented

		treated in Sewage Treatment Plants.			including core activities- Sewage treatment plants implemented by the TN Water Supply and Drainage Board and non core activities- construction of low cost sanitation, crematoria and river front development done by local bodies. River Vaigai: Out of overall project cost of Rs.165.00 crores (207) Rs. 114 crores are spent (2014) involving establishment of Pumping stations work taken by Chennai Metro Water Supply and Sewerage Board, the Interception & Diversion works and Construction of Sewage Treatment Plant is being implemented by Madurai Corporation. River Tamiraparani: Solid Waste Management work-completed (Rs. 0.76 crore) by local bodies and Underground Sewerage Scheme carried out by the TN Water Supply and Drainage at cost of Rs. 54 crores.

6	Chennai City River Conservation Project (CCRCP)	A project which aims for the upgradation of the sewerage system and prevention of the entry of raw/partially treated sewage into the Chennai City waterways.	Environment Management Agency of Tamil Nadu	Sewage treatment Plans and cleaning up of the states rivers	**Strategy towards Reducing Pressure** Implemented by Chennai Metropolitan Water Supply and Sewerage Board.
7	National Lake Conservation Plan (NLCP)	Revival of Kodaikanal Lake, Ooty Lake and Yercuad Lake	Environment Management Agency of Tamil Nadu	Revival of rivers and maintenance of proper drainage systems in the state	**Strategy towards Restoring State** The Government of India sanctioned Rs.1.75 crores for revival of Ooty Lake; During 2007, as per the revised Detailed Project Report, a sum of Rs.10.42 crores was sanctioned for the revival of Kodaikanal Lake; Detailed Project Report for the revival of Yercaud lake in Salem district has been prepared by Tamil Nadu Water Supply and Drainage Board for Rs.8.46 crores
8	National Green Corps Programme	The main objectives of the programme is to sensitize students about environment and related issues and involving students in action based programmes related to environment such as tree planting, environmental awareness rallies, vermi composting, enviro-expo, enviro	Ministry of Environment, Forest and Climate Change	Increases environmental awareness and helps in applying sustainable practices towards a better present as well as future.	**Strategy towards Reducing Pressure** Beneficiaries - students and youth

		competitions, anti-plastic campaign, cultural programmes, nature camps and celebration of at least six green days in their surroundings.			
9	Coastal Regulation Zone Notification under Environment (Protection) Act, 1986	To protect the coastal environment and to regulate development activities along the coastal areas, thereby aiming to ensure livelihood security to the fishing communities, other local communities living in the coastal areas, to conserve and protect the coastal stretches, to promote sustainable development in the coastal areas.	Ministry of Environment, Forest and Climate Change	To protect the coast line and its resources and regulate development of the coastal stakeholders	**Strategy towards Restoring State** As per this 14 notification, the coastal areas have been classified into four zones- CRZ-I (ecologically sensitive), CRZ-II (built-up area), CRZ-III (Rural area) and CRZ-IV (water area which includes the water areas up to 12 Nautical mile of the territorial waters and the tidal influenced water bodies.) CRZ area includes the land area from High Tide Line (HTL) to 500mts on the landward side along the sea front, the land area between HTL to 100 mts. or width of the creek, water bodies etc. whichever is less.
10	Preparation of Integrated Coastal Zone Management Plan (ICZMP) under the Emergency Tsunami Reconstruction Project (ETRP)	The objective is to provide information, which will be the base for taking appropriate action in deciding any developments to be undertaken along the	Forests Department	Accessible information regarding coastal resources helps in better decision making towards development as well as conservation.	**Strategy towards Reducing Pressure** The Integrated Coastal Management Plan has been prepared for the coastline of Tamil Nadu at a cost of

		coast and the different layers of information can be used to assess the damage and plan for remedial measures at times of coastal hazard.			Rs.4.84 crores during 2013-14
11	Tamil Nadu Biodiversity Conservation and Greening Project	This project focuses on biodiversity conservation through forest protection and socio-economic development of forest fringe villagers and tribal communities. Increase in tree cover outside forest.	State Forests Department	Increase in tree cultivation in private lands; forest protection initiative and community development.	**Strategy towards Restoring State** Beneficiaries : forest fringe villagers and tribal communities. Rs. 686 crores is under implementation from 2011-12, which will continue till 2018-19. During 2013-14, the project was implemented at an outlay of Rs.96.80 crores. This scheme is being continued in 2014-15 with an outlay of Rs.143.69 crores.
12	Tamil Nadu Afforestation Project (Phase-II)	To restore degradation of forests through the participation of the dependant and poorer sections of the society.	State Forests Department	Conservation of forest resources	**Strategy towards Restoring State** Beneficiaries: Forest dependent communities; From 2005-06 to 2012-13, afforestation works were taken up over an extent of 1,77,500 hectares of degraded forests besides carrying out developmental works in 800 forest fringe villages including 150 tribal villages.

13	Massive Trees Planting Programme	To make tree planting a massive people oriented exercise as well as to increase green cover in the State.	State Forests Department	Increase in green cover of the State	**Strategy towards Restoring State** 65 lakh seedlings were planted in 32 districts from 2012-13 to 2014-15. The Government has accorded sanction for a sum of Rs.49.18 crores for a period of three years from 2013-14 to 2015-16 towards the implementation.
14	Raising teak plantations on padugai lands	To create timber resources in the State, to increase tree cover outside the Reserve Forests and to prevent soil erosion in the canal banks.	State Forests Department	Maintaining a balanced tree cover even outside the Reserved Forests and prevent soil erosion near the canal banks	**Strategy towards Restoring State** During 2013-14, teak plantations were raised over an area of 8,863 ha. besides carrying out maintenance works in the padugais of Thanjavur, Tiruvarur, Trichy, Dindigul and Villupuram districts from the sanctioned amount of Rs.13.41 crores. This scheme will be continued during 2014-15.
15	13 th Finance Commission	Sanction of Rs.142.48 crores under Grants in-aid for maintenance of forests for the period from 2010-11 to 2014-15 for Tamil Nadu to provide fiscal resources in support of State's commitment in forest and bio-diversity	Forests Department	Financial assistance towards forest and bio-diversity conservation of Tamil Nadu's Forest areas.	**Strategy towards Restoring State** During 2013-14, this scheme was implemented with an outlay of Rs.35.62 crores. It is proposed to implement the scheme at an outlay of Rs.35.62 crores during 2014-15 also.

		conservation.			
16	Replanting in Thane cyclone affected areas	Restocking of affected coastal areas of Cuddalore and Villupuram during the Thane cyclone with tree species like teak, casuarina, eucalyptus etc.	State Forests Department	Rebuilding disaster affected areas and communities	**Strategy towards Ameliorating Impacts** Beneficiaries: Communities affected by the Thane cyclone; the maintenance work continues in 2014-15 after implementation cost of Rs. 14.96 crores and expenditure till date being Rs. 11.11 crores (2014).
17	Water conservation and canopy improvement project	Main objectives of the scheme are to improve the soil moisture regime, to recharge ground water aquifer and to increase the availability of water for cultivation activities	State Forests Department with funding assistance from NBARD	Increase availability of water resources and maintain a hydrological balance in the selected districts	**Strategy towards Restoring State** This scheme has been implemented in 10 districts of Tamil Nadu viz. Coimbatore, Dharmapuri, Dindigul, Kanniyakumari, Madurai, Namakkal, Salem, Tiruvallur, Vellore and Villupuram. It is proposed to continue this scheme at an outlay of Rs.50 crores during 2014-15.
18	Nature Conservation	Improvement of existing enclosures in Guindy National Park, construction of compound wall for protection of forests and wildlife, establishment of fodder plot for herbivores, etc. in Tamil Nadu Forestry Training College	State Forests Department	Encourage and protect man-made environmental products; Encouraging eco-tourism	**Strategy towards Reducing Pressure** The sanctioned amount in 2013-14 of Rs 67 lakh was utilised towards maintenance of Guindy National Park, improving eco-tourism. An outlay of Rs. 1.38 crores was

		at Vaigai Dam.			proposed for implementation during 2014-15
19	Pallikaranai Marshland	The scheme was initiated in order to preserve the marshland to discharge its ecological functions, focusing on various restoration activities like habitat improvement, protection, research, monitoring, publicity, awareness, etc.	State Forests Department	Protection and conservation of marshland ecosystem of Pallikaranai	**Strategy towards Restoring State** Set up of Conservation Authority of Pallikaranai Marshland for restoration work. Implementation from 2011-12 to 2015-16, where Rs. 7.09 crores out of Rs. 15.75 crores have been utilised towards implementation till 2014-15.
20	Gulf of Mannar Biosphere Reserve Trust	Objective is to reduce the biotic pressure on the marine ecosystem, creation of alternate livelihood options for the local people who are directly dependent on the marine resources, eco-development works, protection and conservation of natural resources, education and awareness programme, etc.	Forests Department (Central and State)	Protection of marine organisms, coastal and marine species (flora and fauna)	**Strategy towards Restoring State** Transferred from UNDP to The Tamil Nadu Government for funding getting a sanctioned amount of 10 crores from 2013-14 to 2016-17. During 2013-14, research activities, awareness creation, training programmes and eco-development activities were undertaken at an outlay of Rs.2.50 crores
21	Intensification of Forest Management Scheme	Aiming to protect the forests resources by-protection and conservation of sacred groves, conservation and	Forests Department (Central and State)	Better functioning towards sustainable forestry management	**Strategy towards Restoring State** The scheme brings about outcomes that indicate regularised functioning of

		restoration of unique vegetation and ecosystems, control and eradication of forest invasive species and preparedness for meeting challenges of bamboo flowering and improving management of bamboo forests, working plans for scientific management of forest divisions, strengthening protection measures for controlling forest fires, survey and demarcation of the forest boundaries to prevent encroachments by constructing the cairns, improvement of roads, etc.			the state forest department and other agencies in protecting the forests on a daily basis. Rs. 4.20 crores was proposed towards tis scheme for 2014-15.
22	Green India Mission	It is one of the eight missions announced under the National Action Plan on Climate Change (NAPCC) recognising that climate change phenomenon will distribution and quality of natural resources. The Green India Mission is implemented in Kolli hills landscape of Namakkal Forest Division.	Forests Department (Central and State)	Helps in developing and strengthening skills, instincts, abilities, processes and resources towards a sustainable livelihood	**Strategy towards Ameliorating Impacts** The scheme cost is Rs. 72 lakh out of which Rs. 70 Lakh has been utilised for implementation till date, making the target area aware, conscious and encouraging sustainable practices.
23	Rain Water Harvesting and Runoff Management Programme	Objectives- To harvest rain water for potential use in the watershed and for	Tamil Nadu Agriculture Department	Water and soil conservation and optimal utilisation of the natural	**Strategy towards Reducing Pressure** Beneficiaries- All the

		ground water recharge; to increase the soil moisture regime of the watersheds; to prevent soil erosion.		resources.	farmers in the selected watersheds in selected 31 districts of Tamil Nadu.
24	Soil and Water Conservation in the catchments of River Valley Project	Objectives: Prevention of soil loss from the catchments to reduce siltation of multipurpose reservoirs; prevention of land degradation and watershed management in the catchment areas; improvement of land capability and moisture regime in the watersheds; promotion of land use to match land capability.	Tamil Nadu Agriculture Department	Prevention of soil loss and better watershed management	**Strategy towards Reducing Pressure** Beneficiaries - Farmers of all districts of Tamil Nadu
25	Soil and Water Conservation under Western Ghats Development Programme	Objective: To ensure eco-restoration, eco-development and eco-protection of Western Ghats areas; to maintain ecological balance by controlling soil erosion; to create awareness of the necessity for protecting and developing the eco system among the farmers and economical upliftment of the local people	Tamil Nadu Agriculture Department	Protection, development and conservation of the Western Ghats region, while increasing eco-tourism, awareness and upliftment of livelihood.	**Strategy towards Restoring State** Beneficiaries - Farmers of Coimbatore, Dindigul, Madurai, Theni, Tiruppur, Virudhunagar, Kanniyakumari and Thirunelveli districts of Tamil Nadu. Implementation of the scheme involved work in the following areas- Staggered contour trenching, Gabion structure, Drainage line treatment works, Check dams, Village ponds, Farm ponds, Land shaping,

					Percolation pond, Water harvesting structures, etc.
26	Technology Development Fund for evolving cleaner and / or energy efficient or IT enabled technologies for Micro, Small & Medium Manufacturing Sector.	To provide subsidy to manufacturers (small/medium/large enterprises) to use cleaner or energy efficient technology to encourage sustainable business practices.	Tamil Nadu Agriculture Department	Reduction in carbon emissions and to provide cleaner technology for sustainable development.	**Strategy towards Reducing Pressure** Beneficiaries - Manufacturers (small/medium/large enterprises) of all districts of Tamil Nadu
27	Soil and Water Conservation under Hill Area Development Programme	Objectives: to maintain and restore the ecology of the Nilgiris district; control soil erosion; improve the socio economic condition of the local people; create public awareness on the benefits of the soil conservation works; prevention of landslides	Tamil Nadu Agriculture Department	Restoration of the ecology of Nigliris district by soil conservation, resource management, prevention of landslides, etc.	**Strategy towards Restoring State** Beneficiaries: All the farmers whose lands are covered in the selected watersheds of the Nilgiri district. Implementation of the scheme included- construction and establishment of drainage line treatment, bench terracing, collection walls, terrace support works, water harvesting structures, landslide treatment works and stream support works.

Source: Compiled from policy notes, performance budgets and citizen charters of various departments of the Government of Tamil Nadu, 2014. See www.tn.gov.in.

Table 15.3: Proposed Fiscal Instruments for Environmental Management in Tamil Nadu

	Instrument	Counterpart	Implemented by
Group-A	Uplifting to higher State VAT rates of identified polluting goods	Applying lower State VAT rates to environment promoting goods	State government (under statevat regime)
Group-A	Alternate under GST Non-rebatable excise/cess on identified polluting goods	Placing under exempt category identified environment promoting goods and services	State government (under GST Regime)
Group-B	Cess on electricity duty for generation of electricity using polluting inputs (coal)	Subsidy to electricity producers using non-conventional inputs	State government
Group-B	Congestion tax on traffic in identified cities (city-centres; specified hours)	Inner city road development fund	Local government
Group-B	Property tax concession on green commercial buildings	Property tax cess on conventional commercial buildings	Local government
Group-B	Green motor vehicle tax	Augmenting financing of road building and maintenance using green materials	State government

Source: Srivastava et al. (2014).

15.4 Policy Recommendations

The previous section provided a comprehensive summary of various programs/initiatives of the Tamil Nadu government and their environmental linkages. A large majority of responses (over 55 per cent out of 27 programs and initiatives analyzed) are aimed at restoring the state of the environment, whereas the responses aimed at reducing the pressure on the environment (about 30 per cent) and the responses aimed at ameliorating the impacts due to environmental degradation (about 15 per cent) are given relatively lower importance so far. The policies aimed at reducing impacts caused by environmental degradation have largely been in the form of compensation given by the State. With the exception of the Loss of Ecology Authority, which awarded compensation to the victims of tannery pollution, there has been relatively less emphasis on polluter-pays principle and internalization of environmental externalities in private decisions. This is one of the policy priorities for facilitating sustainable development in the state.

15.4.1 Municipal Solid Waste Management

The solid waste management in Tamil Nadu faces similar challenges as faced in other Indian states (cities) – including, inadequate segregation of waste at source, and improper disposal in land fill site leading to serious environmental challenges. In the midst of growing despair on solid waste management, the case of Namakkal stands tall and provides optimism that if properly addressed with people's involvement these issues can be solved with considerable ease. Namakkal is the first municipality in the country involved in privatisation of all components in solid waste management. By institutionalisation of door-to-door collection with segregation at source, manufacturing of vermi-compost from organic waste and sale of recyclable from inorganic waste, Namakkal has the distinction of becoming the only zero garbage town in the country. Several recommendations given by CAG Environmental Report on Waste Management are still applicable to waste management in Tamil Nadu.

- State governments should make the segregation of wastes mandatory and municipalities could be authorized to levy fines if segregated waste is not made available to the municipalities for collection;
- Waste processing should be made mandatory and sufficient funding should be provided by MoEF/MoUD to set up waste processing infrastructure/technology in each municipality;
- Existing dumpsites should be made more sanitary and aesthetic, dumpsites in residential areas and near water sources/ water bodies should be closed down and dumpsites should be periodically monitored to prevent environmental contamination;
- Each municipality should identify land for setting up of landfills on a priority basis and landfilling should be restricted to non-biodegradable/inorganic waste;
- Both existing and new hospitals should have a treatment/disposal facility or join a common treatment facility, failing which they should not be allowed to continue their operations;
- Surprise checks should be conducted to verify vendors' compliance with plastic waste rules;
- PCB should maintain a database of manufacturers of plastic carry bags/containers to ensure that manufacture of the same does not occur without prior consent.
- In addition to the above recommendations, there is an overall need for better monitoring by the State PCB of waste disposal facilities like compost plants, incinerators, dumping grounds etc. For this purpose the state government should make

provisions in the budget for waste management activities and moreover the state government and PCB should assess their manpower requirements and accordingly hire staff dedicated to the implementation and monitoring of waste management activities.

15.4.2 Environment and Forest Department and Pollution Control Board

- The ongoing afforestation programs/schemes of the state should continue to increase forest cover as well as tree cover in private lands. A more coordinated approach among various ongoing programs/schemes – for example, TN Biodiversity Conservation and Greening Project, TN Afforestation Project, Massive Tree Planting Programme etc., all under State Forest Department; and Afforestation Programme and Afforestation Schemes under Adi Dravidar and Tribal Welfare Department – could achieve not only better targets but also ensure efficient utilization of resources. This would contribute towards additional carbon sink creation targeted in India's recently announced Intended Nationally Determined Contributions (INDCs).
- The operational activities of the Department of Environment and Forests are reported to have slowed down due to the lack of sufficient man power as the sanctioned staff strength is not fully placed in action. Around 25 per cent of the sanctioned posts are vacant in the Tamil Nadu Environment and Forest Department. Forty per cent of these vacant posts are meant for technical/ scientific personnel[2]. One of the world's richest marine biodiversity regions – the Gulf of Mannar Marine National Park, is facing a shortage of skilled manpower in the posts of rangers, foresters and watchers[3]. There is only one ranger as against the required strength of four rangers to carry out the duty. At present, 215 Forester posts and 496 Forest Guard posts are vacant (including promotional posts) in the Forest Department.
- The Tamil Nadu Pollution Control Board (TNPCB) laboratories are also facing severe staff shortages that could be hampering their operations. A total of 35 key environmental scientist posts have been lying vacant for more than two years. The TNPCB operates five advanced environmental laboratories and 10 district environmental laboratories. The laboratory branch is headed by the deputy director (labs), who is assisted by the scientific officers at different levels. The role of environmental scientists is pivotal for the functioning of these labs. It is the

[2] Environmental Resources Management, MoEF.
[3] The Hindu, 18th October, 2015

environmental scientist who actually does the field level monitoring of pollution including sample collection and analysis. It is reported that there are only 23 environmental scientists currently doing this job, who account for 58 per cent of the personnel strength needed for this activity[4]. By the year 2022 many of the senior scientists are due to retire which is likely to place considerable stain on the monitoring and regulating activities of the board.

- It is recommended that the posts, particularly of staff involved in the monitoring of pollution and the environment, be filled to full capacity in order that these activities may be carried out efficiently and effectively.
- As a percentage of the total plan outlay of the central and state governments, the allocation to the Environment and Forestry Sector is less than one per cent. Many of the schemes have allocations that are too small to make any real impact. This leads to a thin spread of scarce resources across various activities and the ensuing strain on the limited administrative capacity. The twelfth plan outlay allocated to the forest sector in Tamil Nadu is less than one per cent (Rs. 2146 crore) of the total outlay and for the ecology and environment sector it is around 0.1 per cent (Rs. 237 crores) despite its vast coverage[5]. Despite the increase in the budget allocation for forest protection under various schemes in the five years plans from 3 per cent to 6 per cent over the 12th and 13th finance commission, more financial allocation is required for this sector in order to overcome its administrative barriers.
- Presently there is no separate eco-tourism wing in Forest Department. In order to organize, direct and ensure an effective implementation and management of ecotourism objectives and principles in the State, a separate eco-tourism Board or an Authority should be established.

15.4.3 Renewable Energy

Tamil Nadu remains one of the 'frontrunners' in the country when it comes to non-conventional energy sources. Policies which aim at tapping the potential sources of renewable energy have set benchmarks for other states in the country to follow. For instance, recent reports highlight that the state has outperformed all its peers in rooftop solar installations. As of October 2015, with credible performance in industrial, commercial and residential sectors, Tamil Nadu topped the rooftop solar capacity addition in the country with

[4] Deccan chronicle, 20th April, 2015
[5] Twelfth Five Year Plan Tamil Nadu 2012-2017 Overview, State Planning Commission. http://www.spc.tn.gov.in//fiveyearplans/TN_XII_fyp_overview.pdf

a total installed capacity of 76 MW against the all India capacity of 525 MW. The state policies, however, need to be evaluated keeping in mind their potential to contribute towards future energy needs of its population, the evolution of geo-political discussions surrounding existing and emerging threats such as climate change. They also acquire importance in the context of India's recently announced INDCs that target to reduce emission intensity by 33 to 35 percent below 2005 level by 2030, primarily by installing 175 GW of renewable power capacity. In this context the following suggestions are made:

- The declining share of renewable energy in the energy mix in installed capacity[6] for electricity generation in the state should be addressed on priority basis;
- Given the greater potential for solar energy in the state compared to wind energy potential, as well as factoring in the more volatile nature of wind energy, appropriate policy to achieve the right mix of the two non-conventional energy sources must be promoted;
- Capacity of existing institutions must be enhanced to handle volatile nature of renewable energy generation with emphasis on creating flexible systems;
- Following example set by Gujarat and Maharashtra, feeder separation should be done on priority basis to not only increase reliability of power supply to the rural households but also minimize the losses to the state electricity board and avoid wasteful electricity consumption;
- Again, following the lead taken by Gujarat, the state could adopt a cess on electricity generation from conventional sources to facilitate more rapid expansion of renewable sources; and
- Mandate solar power generation and use for common lightings in all the new commercial and residential structures/complexes.

15.4.4. Transport Sector

Operation of integrated public transit modes (including bus and rail transport) as one seamless entity such that they meet the needs of the passengers (comfort, convenience, reduced travel time and costs etc.), increase patronage of public transport, reduce pollution and congestion levels and provide last mile connectivity. To this effect, the following recommendations may be considered:

[6] The share of renewable energy in the total installed capacity has declined from 43% in 2012 to 38% in 2015.

- A well networked metro rail system in all major cities of Tamil Nadu with good connectivity to bus routes. The recently inaugurated Chennai metro rail needs to be extended to the rapidly growing suburbs of Chennai city;

- Giving priorities to non-motorized transport, for instance through the undertaking of a public cycling sharing system wherein cycles may be hired to commute across the city. Delhi metro launched a public bicycle sharing scheme as per which commuters can rent cycles from residential areas and travel to the nearest metro and back[7]. There is also a need for designated cycling and walking tracks along arterial roads to ensure safety of pedestrians and cyclists;

- Putting in place a parking policy. The creation of designated parking spaces (including state of the art multi-level parking facilities like the recently inaugurated facility at Wallace Garden in Chennai) especially in highly congested areas like tourist and shopping destinations and outside hospitals, along with appropriate parking charges would reduce road and traffic congestion to a considerable extent. Chennai's parking charges are on average about 50 times lower than those of most developed countries', thus a revision of the same is recommended in the face of growing vehicular traffic;

- Levy of congestion charges and green taxes on motor vehicles. The recent environmental compensation charge on commercial vehicles entering Delhi is a case in point. An extra charge of Rs. 700 is to be levied on light duty vehicles and vehicles with 2 axles (taxis and small trucks) and Rs. 1,300 would be charged for those vehicles with three axles and above (large truck-trailers) starting from 1st November 2015 to 29th February 2016 on an experimental basis[8]. Tamil Nadu could introduce similar charges for commercial vehicles entering the state; and

- Similarly green motor vehicle tax to discourage use of older vehicles (and thus reduce pressure on the environment), and congestion tax in selected cities (for specific locations and for specified hours) to address the twin issues of traffic management and environmental management could be considered by the state.

[7] See http://www.delhimetrorail.com/press_reldetails.aspx?id=C0KYrggV5Fslld

[8] See http://indianexpress.com/article/cities/delhi/vehicles-entering-delhi-to-pay-environment-charge-from-november-supreme-court/

References

Chapter 1

Adriaanse, A. (1993), 'Environmental Policy Performance Indicators: A Study of the Development of Indicators for Environmental Policy in the Netherlands', The Hague, SDU Publishers.

Adriaanse, A., Bryant, D., Hammond, A.L., Rodeburg, E. and Woodward, R. (1995), 'Environmental Indicators: ASystematic Approach to Measuring and Reporting on Environmental Policy Performance in the Context of Sustainable Development', Washington D.C., World Resources Institute.

Agarwal, Bina (1995), 'Gender, Environment and Poverty Interlinks in Rural India: Regional Variations and Temporal Shifts, 1971-1991', Discussion Paper No. 62, Switzerland, United Nations Research Institute for Social Development.

Amarnath, J. S. and S. Krishnamoorthy (2001), 'Study on Relationship between Productivity, Inputs and Environmental Quality in Tannery Effluent Affected Farms of Tamil Nadu', *Water Resources Management*, 15: 1–15.

Arrow, K., P. Dasgupta, L. H. Goulder, K. J. Mumford, K. Oleson (2010), 'Sustainability and the Measurement of Wealth', NBER Working Paper, No. 16599.

Balamurugan, J., &Ravichandran, M. (2014), 'Environmental Sanitation Index for the State of Tamilnadu, India', *International Research Journal of Environment Sciences*, Vol. 3(5), 54-59.

Centre for Development Finance (2011), *Environmental Sustainability Index for Indian States 2011: Informing Environmental Action*, Centre for Development Finance, Institute for Financial Management and Research, Chennai.

Census (2011a), Primary Census Abstract – Data Highlights Tamil Nadu Series 34, Directorate of Census Operations, Tamil Nadu.

Census (2011b) Census of India 2011, Office of the Registrar General and Census Commissioner, Ministry of Home Affairs, Government of India. Available online at – http://censusindia.gov.in/

Chandrasekaran, I. R.,Senthil Kumar, Sinha Raghunathan and Shweta Chandrasekaran, (2013), 'Construction of Environmental Performance Index and Ranking of States', *Current Science*, 104(4), 25: 435-439.

Dasgupta, Partha (2001), 'Human Well-Being and the Natural Environment', New Delhi, Oxford University Press.

DEAR (2013-14) Tamil Nadu – An Economic Appraisal, Department of Evaluation and Applied Research, Government of Tamil Nadu. Available online at – http://www.tn.gov.in/dear/.

DoES (2014) Statistical Handbook of Tamil Nadu, Department of Economics and Statistics, Government of Tamil Nadu.

Emerson, J., D. C. Esty, M. A. Levy, C. H. Kim, V. Mara, A. de Sherbinin, and T. Srebotnjak. (2010), *2010 Environmental Performance Index*. New Haven: Yale Center for Environmental Law and Policy.

Environmental Management & Policy Research Institute (2012), 'State of Environment Report of Karnataka', Department of Forest, Ecology and Environment, Government of Karnataka, Bangaluru.

Esty, D.C., Levy, M., Srebotnjak, T. and de Sherbinin, A. (2005), '2005 Environmental Sustainability Index: Benchmarking National Environmental Stewardship', New Haven, Yale Center for Environmental Law & Policy.

Government of India (2009), 'State of Environment Report India', Environmental Information System, Ministry of Environment and Forests, Government of India, New Delhi.

Government of India (2012), 'Press Note on Poverty Estimates, 2009-10', Planning Commission, Government of India, New Delhi.

Government of National Capital Territory of Delhi (2010), 'State of Environment Report for Delhi', Department of Environment and Forests, Government of NCT of Delhi, New Delhi.

Government of Tamil Nadu (2012) Vision Tamil Nadu 2023: Strategic Plan for Infrastructure Development in Tamil Nadu, Government of Tamil Nadu.

Jones, L., Fredricksen, L. and Wates, T. (2002), 'Environmental indicators', Fifth Edition, The Fraser Institute, available at http://www.fraserinstitute.ca/shared/readmore.asp?snav=pb&id=314.

Mukherjee, S. and P. Nelliyat (2006) 'Ground Water Pollution and Emerging Environmental Challenges of Industrial Effluent Irrigation: A Case Study of Mettupalayam Taluk, Tamil Nadu', Working Paper No. 7/2006, Madras School of Economics, Chennai.

Mukherjee, S., D. Chakraborty, and S. Sikdar (2014), 'Three Decades of Human Development across Indian States: Inclusive Growth or Perpetual Disparity?', Working Paper No. 2014-139, National Institute of Public Finance and Policy, New Delhi.

NABARD (2014), 'Agricultural Land Holding Pattern in India', NABARD Rural Pulse, Issue 1, Department of Economic Analysis and Research, NABARD, Mumbai.

Nadkarni, M.V. (2000), 'Poverty, Environment, Development: A Many Patterned Nexus', Economic and Political Weekly, April 1, 1184-90.

Perman, R., Y. Ma, J. McGilvray, M. Common (1999), *Natural Resource and Environmental Economics*, Pearson Education Ltd., England.

RIVM/UNEP: undated, 'Global Environment Outlook (GEO-3)', Bilthoven, The Netherlands, National Institute of Public Health and the Environment (RIVM), UNEP, available at http://arch.rivm.nl/env/int/geo

Rogers, Peter, Jalal, Kazi F., Lohani, Bindu N., Owens, Gene M., Yu, Chang-Chung, Christia, M. and Dufournaud, Jun B. (1997), 'Measuring Environmental Quality in Asia', London, U.K., Harvard University Press and ADB.

Solow, M. Robert. (1986), 'On the Intergenerational Allocation of Natural Resources', *The Scandinavian Journal of Economics*, 141-149.

Srivastava, D. K., K. R. Shanmugam, K. S. Kavi Kumar, M. Saripalle (2014), 'Fiscal Instruments for Climate Friendly Industrial Development in Tamil Nadu', Monograph 28/2014, Madras School of Economics, Chennai.

State of Environment Report Tamil Nadu (SoERTN) (2006): *State of Environment Report Tamil Nadu*, Department of Environment, Government of Tamil Nadu.

Stavins, R. N., A. F. Wagner, G. Wagner (2003), 'Interpreting Sustainability in Economic Terms: Dynamic Efficiency plus Intergenerational Equity', *Economics Letters*, 79: 339–343.

Wackernagel, M. and W. Rees (1996), *Our Ecological Footprint: Reducing Human Impact on the Earth*, New Society Publishers, Gabriola Island. See also http://www.footprintnetwork.org.

World Wildlife Fund (2002), 'WWF's Living Planet Report 2002', Switzerland, WWF International. Available at - www.panda.org/news_facts /publications/general/livingplanet/lpr02.cfm.

Chapter 2

Census (2011) Census of India 2011, Office of the Registrar General and Census Commissioner, Ministry of Home Affairs, Government of India. Available online at – http://censusindia.gov.in/

DEAR (2005-06, 2013-14) Tamil Nadu – An Economic Appraisal, Department of Evaluation and Applied Research, Government of Tamil Nadu. Available online at – http://www.tn.gov.in/dear/

DoE (2006) State of Environment Report Tamil Nadu – 2005, Department of Environment, Government of Tamil Nadu, Chennai.

DoES (2014) Statistical Handbook of Tamil Nadu 2014, Department of Economics and Statistics, Government of Tamil Nadu. Available online at – http://www.tn.gov.in/deptst/

FSI (2005, 2013) India State of Forest Report, Forest Survey of India, Ministry of Environment and Forests, Government of India, Dehradun.

GoTN (2015), 'State Action Plan on Climate Change', Government of Tamil Nadu (draft).

Kavi Kumar, K. S., Viswanathan, B. and Begum I, Z. (2013) Estimation and Forecast of Wood Demand and Supply in Tamil Nadu, Monograph 24/2013, Madras School of Economics, Chennai.

MoSPI (2013) Compendium of Environment Statistics India 2013, Social Statistics Division, Central Statistics Office, Ministry of Statistics and Programme Implementation, Government of India, New Delhi.

NSSO (2009-10) India – Household Consumer Expenditure Survey, NSS 66th Round, Type-1: July 2009 – June 2010, National Sample Survey Office, Ministry of Statistics and Programme Implementation, Government of India.

Sekar, T. (2013) Dimensions of Human Wildlife Conflict in Tamil Nadu, *The Indian Forester*, 139(10).

Chapter 3

DEAR (2005-06, 2013-14) Tamil Nadu – An Economic Appraisal, Department of Evaluation and Applied Research, Government of Tamil Nadu. Available online at – http://www.tn.gov.in/dear/

DoES (2014) Statistical Handbook of Tamil Nadu 2014, Department of Economics and Statistics, Government of Tamil Nadu. Available online at – http://www.tn.gov.in/deptst/

GoTN (2015), 'State Action Plan on Climate Change', Government of Tamil Nadu (draft).

SAC (2011) National Wetland Atlas, Space Applications Centre, Indian Space Research Organisation, Ahmedabad, Sponsored by Ministry of Environment and Forests, Government of India.

Chapter 4

Amarnath, J.S. and Velmurugan, S. (2015): An Environmental Impact Assessment of Soil Salinity in Tamil Nadu. Research Journal of Agricultural and Environmental Sciences 2(3): 34-42.

Dasgupta, S., Hossain, Md. M., Huq, M. and Wheeler, D. (2014): Climate Change, Soil Salinity, and the Economics of High-Yield Rice Production in Coastal Bangladesh. Policy Research Working Paper 7140, The World Bank, Washington D.C.

DEAR (2003-04) Tamil Nadu – An Economic Appraisal, Department of Evaluation and Applied Research, Government of Tamil Nadu. Available online at – http://www.tn.gov.in/dear/

DoES (2013-14) Season and Crop Report – Tamil Nadu, Department of Economics and Statistics, Chennai.

DoLR and NRSC (2011) Wastelands Atlas of India 2011, Department of Land Resources, Ministry of Rural Development, Government of India, New Delhi, and National Remote Sensing Centre, Indian Space Research Organisation, Department of Space, Government of India, Hyderabad.

Gore, P. G., B.A. Roy, and H. R. Hatwar (2011), 'Impact of Climate Change on Land Degradation over India', Research Report 1/2011, National Climate Centre, India Meteorological Department, Pune.

MoM (2011) Sustainable Development Framework (SDF) for Indian Mining Sector, Final Report, 30 November 2011, Ministry of Mines, Government of India.

MoM (2014-15) Annual Report 2014-15, Ministry of Mines, Government of India.

Chapter 5

Balakrishnan, K., V. Ramasubramanian, and K. Srividya (2001), 'Economic Valuation of Health Damage in North Chennai using a Comparative Risk Assessment Framework', Environmental Economics Research Committee Project Report, IGIDR, Mumbai.

Census (2011) Census of India 2011, Office of the Registrar General and Census Commissioner, Ministry of Home Affairs, Government of India. Available online at – http://censusindia.gov.in/

Confederation of Indian Industry (2012), 'Estimation of Tamil Nadu's Carbon Footprint', CII-Sohrabji Green Business Centre, Confederation of Indian Industry, Hyderabad.

DEAR (2009-10, 2013-14) Tamil Nadu – An Economic Appraisal, Department of Evaluation and Applied Research, Government of Tamil Nadu. Available online at – http://www.tn.gov.in/dear/

DoE (2014) Air Pollution Database in Tamil Nadu, Department of Environment, ENVIS Centre, Government of Tamil Nadu.

DoES (2014) Statistical Handbook of Tamil Nadu 2014, Department of Economics and Statistics, Government of Tamil Nadu. Available online at – http://www.tn.gov.in/deptst/

IARI (2012) Crop Residues Management with Conservation Agriculture: Potential, Constraints and Policy Needs, Indian Agricultural Research Institute, Indian Institute of Agricultural Research, New Delhi.

IIPS (2008) National Family Health Survey (NFHS-3) India, 2005-06: Tamil Nadu, Indian Institute for Population Sciences, Mumbai.

Kumar, K.S. Kavi and B. Viswanathan (2013), 'Household Level Pollution in India: Patterns and Projections', *Climate and Development*, 5(4), 288-304.

Mariappan, V.E.N., P. Mohana, and C.A. Murrugesan (2013), 'Spatio-Temporal Assessment of Air Pollution from Thermal Stations and Vehicular Pollution from Urban Places in Tamil Nadu', *International Journal of ChemTech Research*, 5(1), 172-179.

MoSPI (2013) Compendium of Environment Statistics India 2013, Social Statistics Division, Central Statistics Office, Ministry of Statistics and Programme Implementation, Government of India, New Delhi.

Ramachandra, T. V., Aithal, B. H., &Sreejith, K. (2015).GHG footprint of major cities in India. *Renewable and Sustainable Energy Reviews*, *44*, 473-495.

SPC (2012) Twelfth Five Year Plan Tamil Nadu 2012-17, State Planning Commission, Government of Tamil Nadu.

Chapter 6

Amarnath, J.S. and S. Krishnamoorthy (2001): "Study on Relationship between Productivity, Inputs and Environmental Quality in Tannery Effluent Affected Farms of Tamil Nadu", *Water Resources Management*, 15: 1–15.

Blacksmith Institute (2006), *The World's Worst Polluted Places*, Blacksmith Institute, New York.

Census (2011) Census of India 2011, Office of the Registrar General and Census Commissioner, Ministry of Home Affairs, Government of India. Available online at – http://censusindia.gov.in/

DEAR (2009-10, 2013-14). Tamil Nadu – An Economic Appraisal, Department of Evaluation and Applied Research, Government of Tamil Nadu. Available online at – http://www.tn.gov.in/dear/

DoES (2008) Statistical Handbook of Tamil Nadu 2008, Department of Economics and Statistics, Government of Tamil Nadu.

DoES (2014) Statistical Handbook of Tamil Nadu 2014, Department of Economics and Statistics, Government of Tamil Nadu. Available online at – http://www.tn.gov.in/deptst/

Mukherjee S. and P.Nelliyat (2006): *Ground Water Pollution and Emerging Environmental Challenges of Industrial Effluent Irrigation: A Case Study of Mettupalayam Taluk, Tamil Nadu*, Working Paper No. 7/2006, Madras School of Economics, Chennai.

Planning Commission (2012).12th Plan document.Planning Commission.Government of Tamil Nadu, Chennai.

TNPCB (2014).Pollution Database for Tamil Nadu, Tamil Nadu Pollution Control Board, Chennai.

Chapter 7

CPCB (2014) Ambient Air Quality and Noise Levels, Deepawali Festival Report, Central Pollution Control Board, Delhi.

Rodgers, W.H. (1977), *Handbook on Environmental Law*, St. Paul: West Publishing Company.

Chapter 8

Census (2001, 2011) Town Amenities. District Census Handbook for Tamil Nadu, Census of India, Office of the Registrar General & Census Commissioner, Ministry of Home Affairs, Government of India. http://www.censusindia.gov.in/2011census/dchb/DCHB.html

DoE (2014) Pollution Database for Tamil Nadu, April 2014, ENVIS Centre, Department of Environment, Government of Tamil Nadu, Chennai.

Planning Commission (2012) 12th Plan document, Planning Commission, Government of Tamil Nadu, Chennai.

TNPCB Annual Report (2013-14). Municipal Solid Waste Management and Handling, Annual Report, Tamil Nadu Pollution Control Board. http://www.tnpcb.gov.in/pdf_2014/MSW_AnnualRptt20132014.pdf

TNPCB (2014) A Summary Statement on Progress Made by Municipal Authorities in Respect of Implementation of Schedule I, II, III and IV, Tamil Nadu Pollution Control Board, Government of Tamil Nadu.

Chapter 9

DEAR (2003-04, 2013-14) Tamil Nadu – An Economic Appraisal, Department of Evaluation and Applied Research, Government of Tamil Nadu. Available online at – http://www.tn.gov.in/dear/

DLHS (2014). District Level Household and Facility Survey 4. State and District Fact Sheets, Ministry of Health and Family Welfare.Govt. of India.

DoA (2014). Policy Note, 2014-15, Department of Agriculture, Government of Tamil Nadu, Chennai.

DoES (2004-05, 2005-06, 2013-14) Season and Crop Report – Tamil Nadu, Department of Economics and Statistics, Chennai.

DoES (2014) Statistical Handbook of Tamil Nadu 2014, Department of Economics and Statistics, Government of Tamil Nadu. Available online at – http://www.tn.gov.in/deptst/

DoH (2014-15). Policy Note, 2014-15. Department of Health, Government of Tamil Nadu, Chennai.

NCOF (2013).Organic Farming Statistics.*National Centre of Organic Farming*, Department of Agriculture and Cooperation, Ministry of Agriculture, Govt.Of India.

NSSO (2014). Nutritional Intake in India, 2011-12, NSS 68th Round: July 2011-June 2012, Ministry of Statistics and Program Implementation.

Planning Commission (2012) 12th Plan document, Planning Commission, Government of Tamil Nadu, Chennai.

Saravanakumar (2015), 'Impact of Climate Change on Yield of Major Food Crops in Tamil Nadu, India', Working Paper 91-15, South Asian Network for Development and Environmental Economics, Kathmandu.

Chapter 10

CGWB (1998, 2004, 2011, 2014). Dynamic Ground Water Resources of India, Central Ground Water Board, Fraidabad.

CMWSSB (2014). Quantity of Water Pumped from Desalination Plants in 2013. See http://www.chennaimetrowater.tn.nic.in.

Central Water Commission (CWC) (2009) *Water and Related Statistics*, New Delhi.

DEAR (2013-14). Tamil Nadu – An Economic Appraisal, Department of Evaluation and Applied Research, Government of Tamil Nadu. Available online at – http://www.tn.gov.in/dear/

DoA (2014). Policy Note, 2014-15, Department of Agriculture, Government of Tamil Nadu, Chennai.

DoWR (2013).Monthly Water Availability Reports, Water Resources Department, Government of Tamil Nadu.http://groundwatertnpwd.org.in/water_level_status.htm

GOI (1992): *Report of the Committee on Pricing Irrigation Water*, Planning Commission, New Delhi.

Jain, S. K. and V. Kumar (2012), 'Trend and Analysis of Rainfall and Temperature Data for India', *Current Science*, 102 (1), 37-49.

MAWSD (2014).Policy Note, 2014-15, Municipal Administration and Water Supply Department, Government of Tamil Nadu, Chennai.

Saleth, R. M. (1996)*Water Institutions in India: Economics, Law, and Policy*, Commonwealth Publishers, New Delhi.

State of Environment Report Tamil Nadu (SoERTN) (2006)*State of Environment Report Tamil Nadu*, Department of Environment, Government of Tamil Nadu.

TNPCB (2014). Pollution Database for Tamil Nadu: Water Pollution. Tamil Nadu Pollution Control Board.

Vaidyanathan, A. (2006): "Farmers' Suicides and the Agrarian Crisis", *Economic and Political Weekly*, September 23.

World Bank (2010) *Deep wells and prudence: towards pragmatic action for addressing groundwater overexploitation in India*. Washington, DC: World Bank. http://documents.worldbank.org/curated/en/2010/01/11899840/deep-wells-prudence-towards-pragmatic-action-addressing-groundwater-overexploitation-india

Chapter 11

Berger, S. S. (2015). Transitions to Renewable Energy in Industrializing Countries: A Comprehensive Case Study of the Indian States Maharashtra and Tamil Nadu, Fridtjof Nansen Institute, Report Number 6/2015.

Confederation of Indian Industry (2012), 'Estimation of Tamil Nadu's Carbon Footprint', CII-Sohrabji Green Business Centre, Confederation of Indian Industry, Hyderabad.

DEAR (2013-14) Tamil Nadu – An Economic Appraisal, Department of Evaluation and Applied Research, Government of Tamil Nadu. Available online at http://www.tn.gov.in/dear/.

DoE (2015). Policy Note, 2015-16, Department of Environment, Government of Tamil Nadu, Chennai

SAPCC (2015). Tamil Nadu State Action Plan on Climate Change. Available online at http://www.moef.gov.in/sites/default/files/Tamilnadu%20Final%20report.pdf

Chapter 12

Byravan, S., Chella Rajan, S. and Rangarajan, R. (2010) Sea Level Rise: Impact on Major Infrastructure, Land and Ecosystems Along the Tamil Nadu Coast, Institute for Financial Management and Research, Chennai and Indian Institute of Technology Madras.

Census (2011) Census of India, Office of the Registrar General and Census Commissioner, Ministry of Home Affairs, Government of India. Available online at – http://censusindia.gov.in/

Chakraborty, P., Ramteke, D., Chakraborty, S. and Nagender Nath, B. (2014) Changes in Metal Contamination Levels in Esuarine Sediments around India – An Assessment, *Marine Pollution Bulletin*, 78: 15-25pp.

CPCB (2009-10) Status of Water Supply, Wastewater Generation and Treatment in Class-I Cities and Class-II Towns of India, Central Pollution Control Board, Ministry of Environment and Forests, Government of India.

DADF (2008, 2014) Handbook on Fisheries Statistics, Department of Animal Husbandry, Dairying and Fisheries, Ministry of Agriculture, Government of India. Available online at – http://www.dahd.nic.in/dahd/handbook-on-fisheries-statistics-2014.aspx

DEAR (2005-06) Tamil Nadu – An Economic Appraisal, Department of Evaluation and Applied Research, Government of Tamil Nadu. Available online at – http://www.tn.gov.in/dear/

Dhanakumar, S., Murthy, K.R., Solaraj, G. and Mohanraj, R. (2013) Heavy-Metal Fractionation in Surface Sediments of the Cauvery River Estuarine Region,

Southeastern Coast of India. *Archives of Environmental Contamination and Toxicology*, 65: 14–23pp.

DoE (2006) State of Environment Report Tamil Nadu – 2005, Department of Environment, Government of Tamil Nadu, Chennai.

DoES (2014) Statistical Handbook of Tamil Nadu 2014, Department of Economics and Statistics, Government of Tamil Nadu. Available online at – http://www.tn.gov.in/deptst/.

FSI (2001, 2005, 2013) India State of Forest Report, Forest Survey of India, Ministry of Environment and Forests, Government of India.

GoTN (2013) State Action Plan on Climate Change, Government of Tamil Nadu.

IBM (2012) Indian Minerals Yearbook, Indian Bureau of Mines, Ministry of Mines, Government of India.

ICMAM (2005) Ecosystem Modelling for Muthupet Lagoon Along Vedaranyam Coast (Tamil Nadu), Integrated Coastal and Marine Area Management, Department of Ocean Development, Government of India.

IMD (Web Version 2.0/ 2011) Cyclone eAtlas, Tracks of Cyclones and Depressions over North Indian Ocean 1981 – 2013, Indian Meteorological Department, Government of India.

India Meteorological Department (2008), Electronic Atlas of Tracks of Cyclones and Depressions in the Bay of Bengal and the Arabian Sea, Version 1.0/2008" CD Rom, India Meteorological Department, Chennai.

IOM (2008) Database on Coastal Information of Tamil Nadu, Prepared by Ramesh, R., Nammalwar, P. and Gowri, V. S., Institute for Ocean Management, Anna University, Chennai.

IPCC (2013) *Climate Change 2013: The Physical Science Basis,* Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)], Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 1535 pp.

ISRO (2012) Coastal Zones of India, Space Applications Centre, ISRO, Ahmedabad, India.

Krishnan, M. and Narayana Kumar, R. (2010) Socio-Economic Dimensions of Seaweed Farming in India, CMFRI Special Publication No. 104, Central Marine Fisheries Research Institute, Kochi.

MoCI (2013-14) Annual Report 2013-14, Salt Department, Ministry of Commerce and Industry, Government of India.

MoS (2012-13) Basic Port Statistics of India 2012-13, Transport Research Wing, Ministry of Shipping, Government of India.

MPEDA (2009-10) Item-Wise Export of Marine Products from Port of Tamil Nadu, The Marine Products Export Development Authority, Ministry of Commerce and Industry, Government of India. Available online at – http://seai.in/filecategory/statistics/.

Mujabar, P. S. and Chandrasekar, N. (2013) Coastal Erosion Hazard and Vulnerability Assessment for Southern Coastal Tamil Nadu of India by using Remote Sensing and GIS, *Natural Hazards*, 69: 1295-1314pp.

Ravikanth, L. and Kavi Kumar, K. S. (2015) Caught in the 'Net': Fish Consumption Patterns of Coastal Regions in India, Working Paper 110, Madras School of Economics, Chennai. Available at - http://www.mse.ac.in/pub/Working%20Paper%20110.pdf.

Selvam, V., Ravichandaran, K. K., Karunakaran, V. M., Mani, K. G., Evanjalin Jessie Beula and Gnanappazham, L. (2010) Pichavaram Mangrove Wetlands: Situation Analysis, MSSRF for MFF, Chennai, 39 pp.

WWF-India (2013) Marine Turtles along the Indian Coast – Distribution, Status, Threats and Management Implications, World Wildlife Fund for Nature- India, New Delhi.

Chapter 13

Census (2011a) Census of India, Office of the Registrar General and Census Commissioner, Ministry of Home Affairs, Government of India. Available online at – http://censusindia.gov.in/

Census (2011b). Town Amenities. District Census Handbook for Tamil Nadu, Census of India, Office of the Registrar General & Census Commissioner, Ministry of Home Affairs, Government of India. http://www.censusindia.gov.in/2011census/dchb/DCHB.html

DEAR (2003-04, 2013-14) Tamil Nadu – An Economic Appraisal, Department of Evaluation and Applied Research, Government of Tamil Nadu. Available online at – http://www.tn.gov.in/dear/

GoTN (2015), 'State Action Plan on Climate Change: Executive Summary', Government of Tamil Nadu (draft).

Srivastava, D. K., K. R. Shanmugam, K. S. Kavi Kumar, and M. Saripalle (2014), 'Fiscal Instruments for Climate Friendly Industrial Development in Tamil Nadu', Monograph 28/2014, Madras School of Economics, Chennai.

Chapter 14

Blacksmith Institute (2006), *The World's Worst Polluted Places– 2006*, Blacksmith Institute, New York.

Hossain, S. M. N. and A. Singh (2002): *Application of GIS for Assessing Human Vulnerability to Cyclone in India*, http://gis2.esri.com/library/userconf/proc02/pap0701/p0701.htm

Kumar, K. S. Kavi and S. Tholkappian (2006): "Relative Vulnerability of Indian Coastal Districts to Sea Level Rise and Climate Extremes", *International Review of Environmental Strategies*, Vol. 6, No.1.

Mukherjee, S. and V. Kathuria (2006), "Is Economic Growth Sustainable? Environmental Quality of Indian States Post 1991", Working Paper 6/2006, Madras School of Economics, Chennai.

Shivaranjani, V. and V. Venkataramani (2015), *Environmental Sustainability Index for the Districts of Tamil Nadu: A Baseline for 2011-12*, Centre for Development Finance, IFMR, Chennai.

Varadan, R. J. and P. Kumar (2015), ‘Mapping Agricultural Vulnerability of Tamil Nadu, India to Climate Change: A Dynamic Approach to take forward the Vulnerability Assessment Methodology’, *Climatic Change*, 129: 159-181.

Chapter 15

Srivastava, D. K., K. R. Shanmugam, K. S. Kavi Kumar, and M. Saripalle (2014), ‘Fiscal Instruments for Climate Friendly Industrial Development in Tamil Nadu’, Monograph 28/2014, Madras School of Economics, Chennai.

Core Research Team:

Dr. K. S. Kavi Kumar, Professor, Madras School of Economics, Chennai

Dr. Lavanya Ravikanth Anneboina, Consultant, Madras School of Economics, Chennai

Mr. Anubhab Pattanayak, Lecturer, Madras School of Economics, Chennai

Dr. A. Balasubramanian, Research Associate, Madras School of Economics, Chennai

Research Assistance:

Ms. Swati Sheshadri

Ms. Megha Nath

Mr. Abhijith Sharan

Secretarial Assistance:

Ms. Saraswathi, MSE, Chennai

Ms. Geetha, MSE, Chennai

Acknowledgements:

The research team would like to sincerely thank Shri Hans Raj Verma, Principal Secretary, Environment and Forest Department, GoTN for giving the opportunity to prepare the SoE report for Tamil Nadu. The research team is grateful to the Advisory Committee and in particular to valuable comments given by Shri Hans Raj Verma and Shri Skandan, Chairman, TNPCB. The immense support extended by Dr. H. Malleshappa, Director and Dr. M. Jayanthi, Additional Director, Department of Environment is also gratefully acknowledged. Dr. J.D. Marcus Knight and Ms. S. Indra Devi of ENVIS Centre at the Department of Environment has provided excellent support throughout the study period. The research team would also like to acknowledge the help extended by various departments, Government of Tamil Nadu in the preparation of the report. The research team would like to acknowledge Shri M.P. Johnson, Advisor, MoEF&CC and all other participants representing various Government Agencies for their valuable comments on the draft report at the brainstorming meeting held on 22nd June 2015 and at the Advisory Committee meeting held on 19th October 2015. The research team would also like to acknowledge the suggestion made by the MoEF&CC to restructure the report as per the prescribed format approved in the Experts meeting held in January 2014.

The research team would like to gratefully acknowledge the support extended by the Chairman and Director, Madras School of Economics throughout the study period.

The authors acknowledge the excellent research assistance provided by Ms. Swati Sheshadri, Ms. Megha Nath, and Mr. Abhijith Sharan. The team would also like to thank Mr. Vivek Venkataramani and Ms. Shivaranjani of IFMR for valuable discussions.