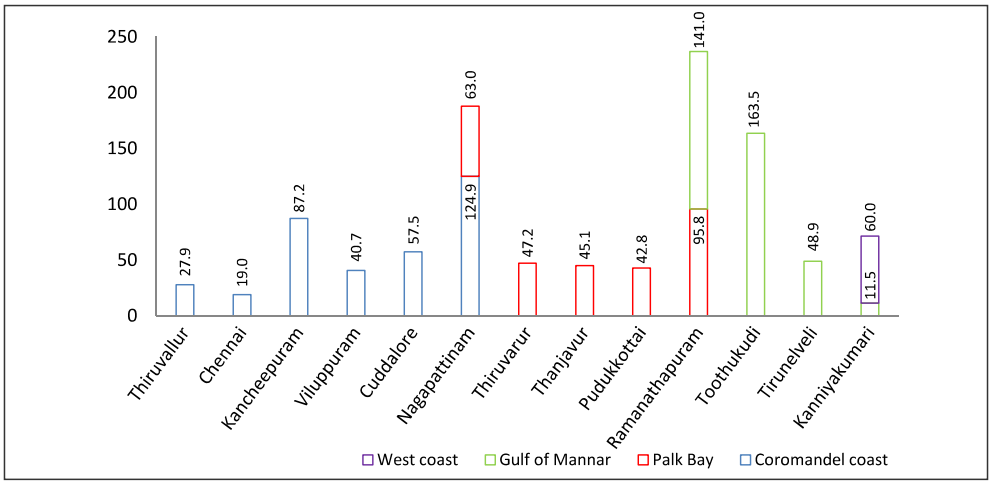
COASTAL RESOURCES

COASTAL RESOURCES 12

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).

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



Source : DoE (2006); see also district - wise cost length of Tamil Nadu at www.iomenvis.nic.in

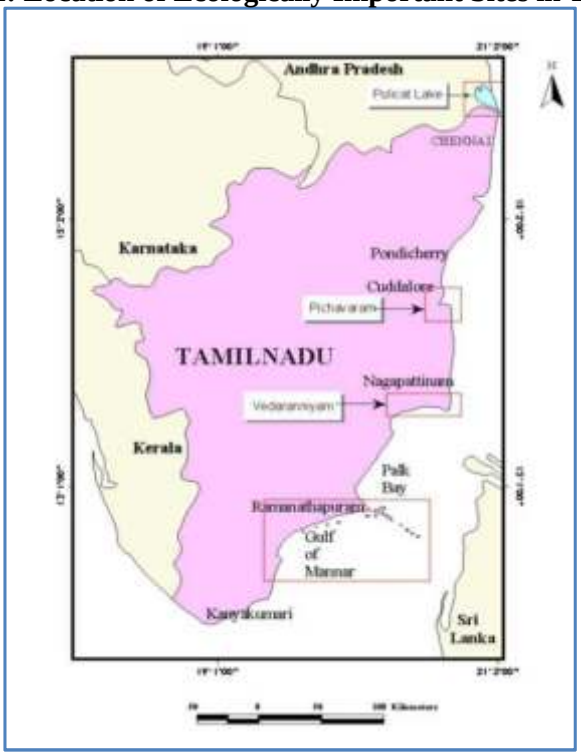
Tamil Nadu is endowed with a variety of coastal and marine ecosystems, which are ecologically sensitive regions of extraordinary biological productivity and high accessibility. They include mangroves, coral reefs, seagrass beds, sand dunes and beaches, mudflats, salt marshes, estuaries and marine waters. 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 serves as a 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.

Figure 12.2: Location of Ecologically Important Sites in Tamil Nadu



Source : IOM (2008).

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).

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 flamingos and pelicans, 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 sq.km. each, reserved forests covering an area of 19.58 sq.km. and tidal flats and salt pans spanning an area of 97.95 and 37.70 sq.km. 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 which 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 sq.km.. 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 this 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 seaweeds 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.

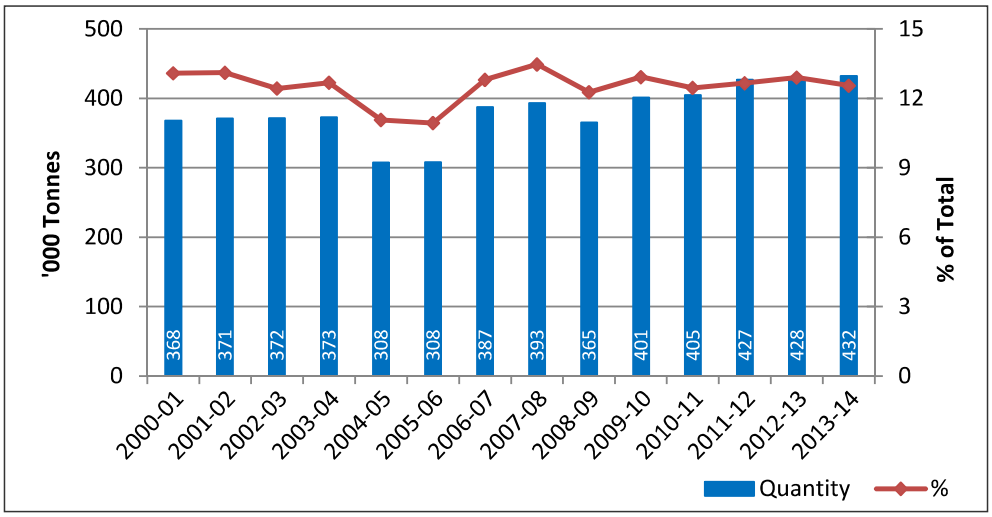
12.1.1 Commercial Fishing

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, during which fish production declined (Figure 12.3). The annual average marine fish production over the past 14 years has been about 380 thousand tonnes, which accounts for approximately 12.5 per cent of annual total marine fish production in India. Tamil Nadu's annual percentage contribution to total fish production has been more or less steady over the years. It was the fifth largest marine fish producer in the country in 2013-14 (DADF, 2014).

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

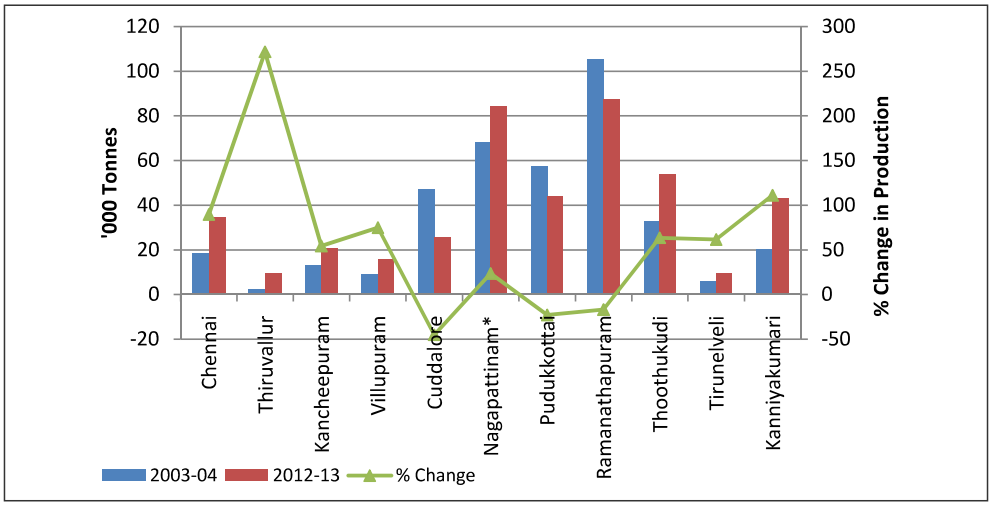
Figure 12.3: Fish Production in Tamil Nadu from 2000-01 to 2013-14 (in '000 Tonnes and as a % of Total All-India Production)



Source : DADF (2014).

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 of marine fish 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's total in 2012-13.

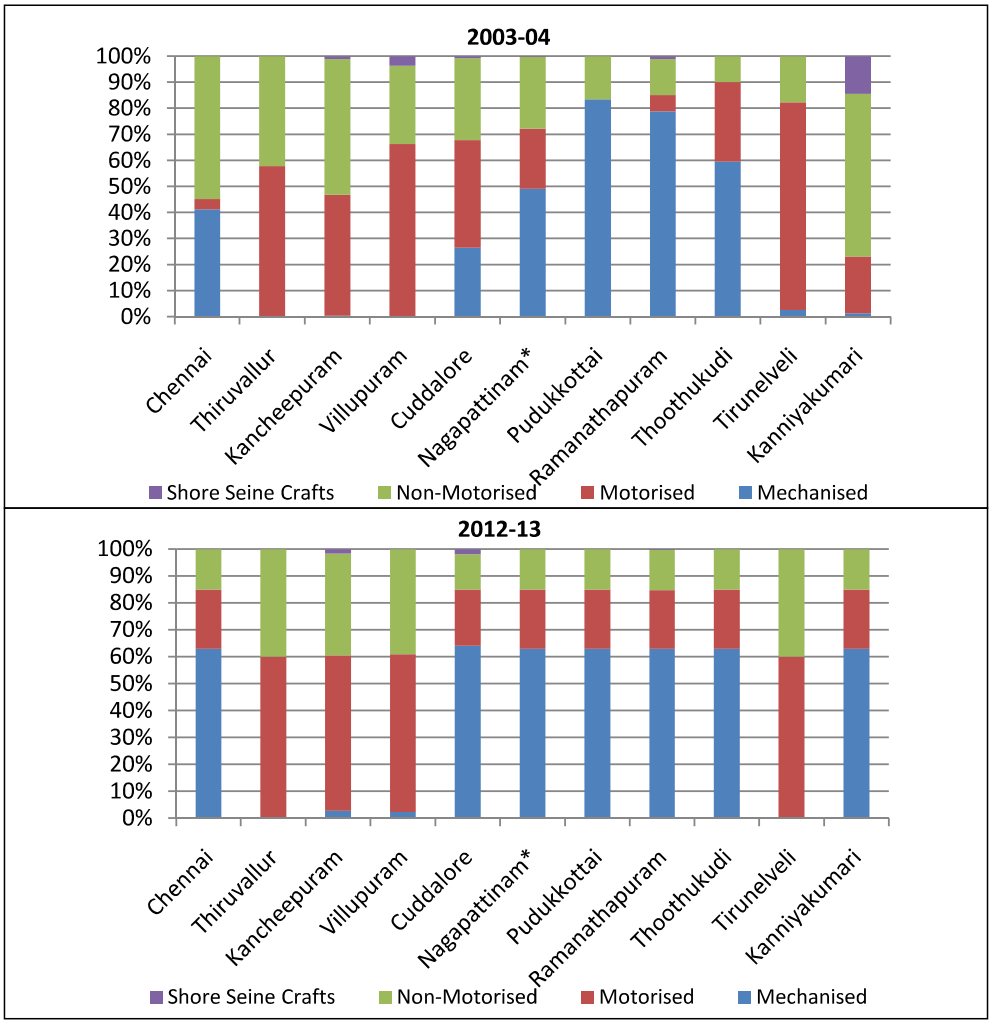
Figure 12.4: District-Wise Marine Fish Production in 2003-04 & 2012-13



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

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

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



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

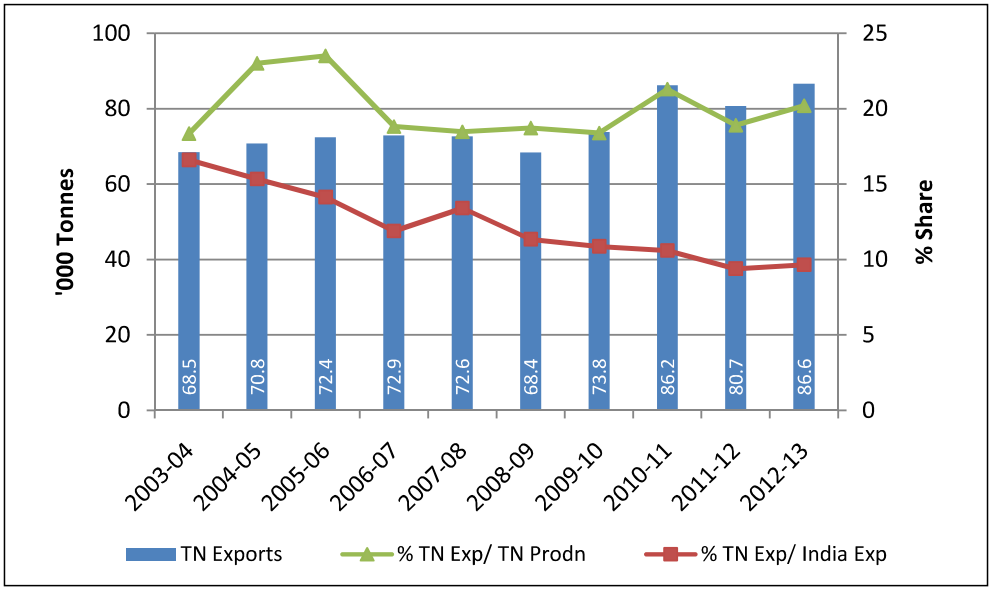
per cent respectively), which was mainly at the expense of the decline in fish production via motorised crafts. Having said that, a larger percentage of fish production is still undertaken by motorised crafts in these two districts. In Thoothukudi, fish production by traditional means also increased 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.

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.

In 2009-10, 34 percent 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

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

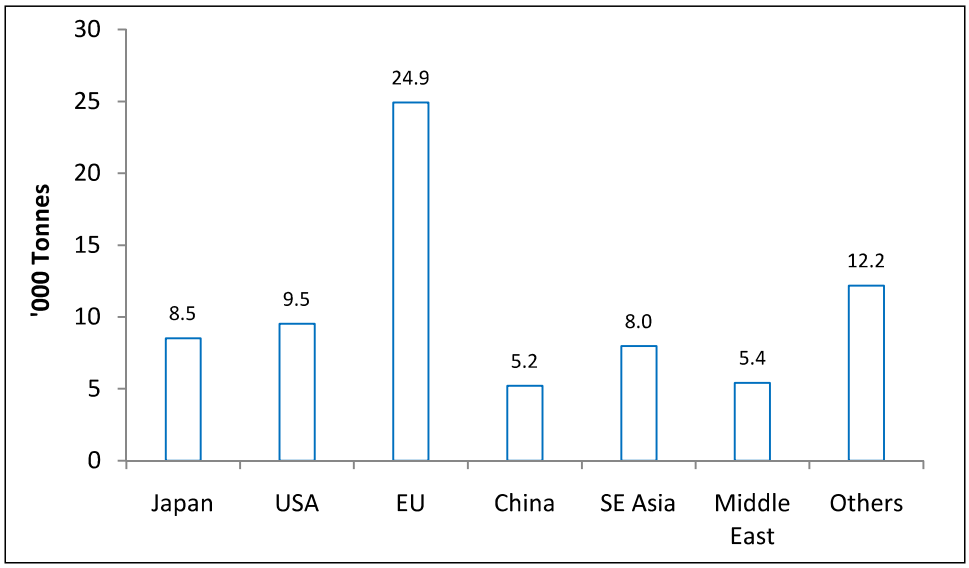


Note : TN Exports are based on port-wise exports from Tuticorin and Chennai.
Source : DADF (2008, 2014).

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.

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.

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



Source : MPEDA (2009-10).

Fishermen Offloading their Catch in Nagapattinam Harbour

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 fifty 50,000 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 Nagercoil (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, 2011a), 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.	Nagercoil	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.	Mayiladuthurai	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).

Coastal Pollution

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.

Units : bbl/d - 'barrels' per day
t/yr - tonnes / year

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 percent 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	-	-

Source : 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 19,73,200 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.

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

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.

Salt Pans

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 (Table 12.7).

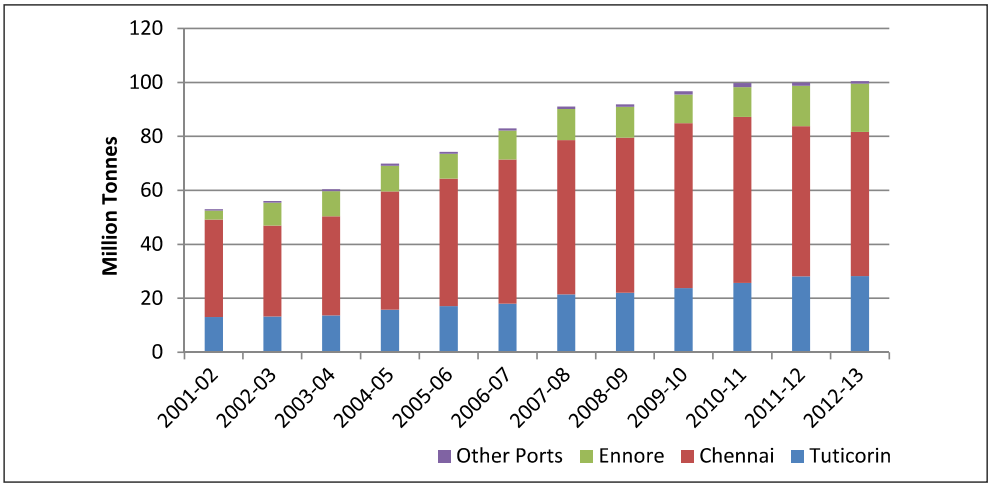
Table 12.7: Ports in Tamil Nadu and Total Cargo Handled in 2011-12 and 2012-13

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 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.

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



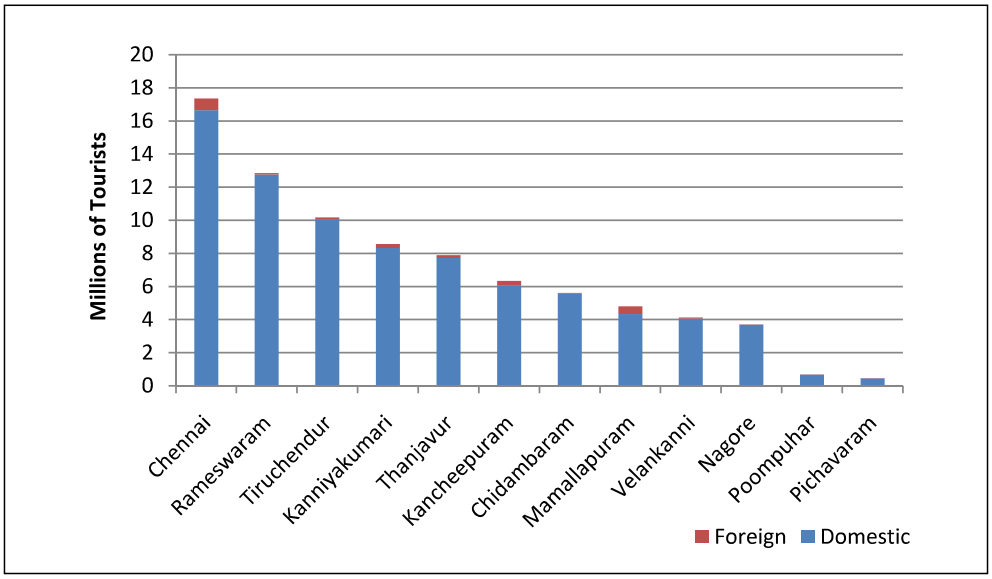
Source : MoS (2012-13).

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.

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



Source : DoES (2014).

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.

Shore Temple, Mahabalipuram

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

Season	No. of Cyclonic Storms (1891-2007)	
	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 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

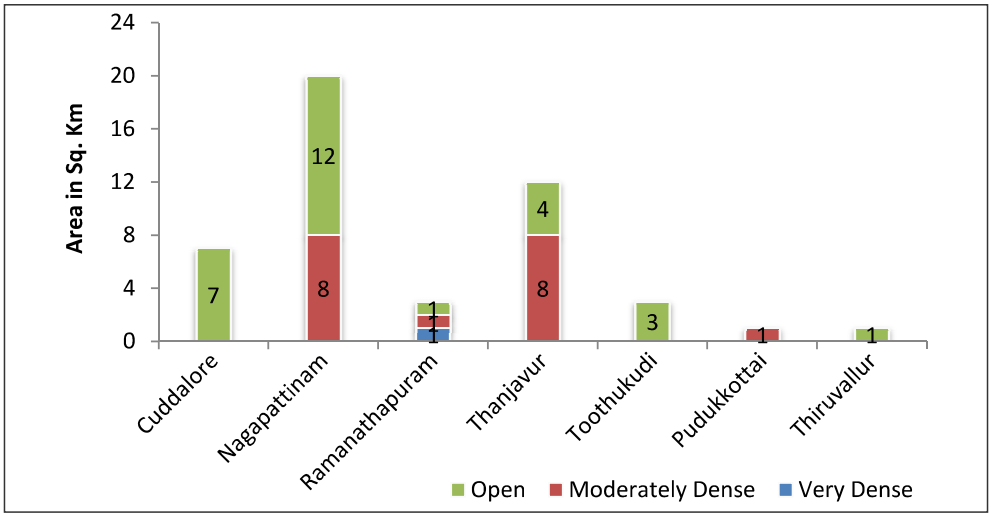
This section looks at the current status of coastal ecosystems and ecosystem services in Tamil Nadu and also explores the possible impacts due to changes in coastal ecosystems.

12.2.1 *Mangroves*

As per the most recent State of Forest Report (FSI, 2015), total mangrove area in Tamil Nadu is 47 square kilometres, which includes 1 sq.km. of very dense mangrove forests (having a canopy density of greater than 70 per cent), 18 sq.km. of moderately dense mangrove forests (having a canopy density of 40 – 70 per cent) and 28 sq.km. of open mangrove forests (having a canopy density of 10 – 40 per cent). Mangroves are present in seven districts in Tamil Nadu, out of which Nagapattinam has the highest mangrove cover (Figure 12.10).

Figure 12.11 shows that the total area under mangrove cover has increased in Nagapattinam, Thanjavur and Toothukudi between 2001 and 2015 and Ramanathapuram, Pudukkottai and Thiruvallur between 2005 and 2015. Although the area under mangrove cover has remained the same in Cuddalore

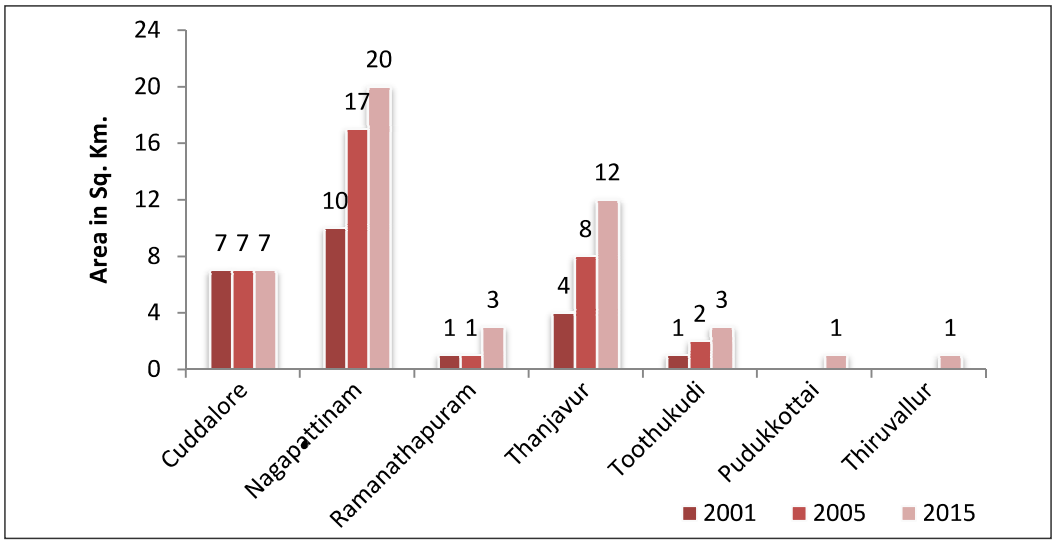
Figure 12.10: District-Wise Area under Mangrove Cover by Density in Tamil Nadu in 2015



Source : FSI (2015).

over the past decade or so, 5 sq.km. of mangrove area have shifted from the moderately dense category to the open mangroves category implying a decline in mangrove density between 2005 and 2015 in this district. In Ramanathapuram district there has been a 1 sq.km. increase each in very dense and open mangroves between 2005 and 2015. Ramanathapuram is the only district with very dense mangroves in the state. The increase in mangrove cover between 2005 and 2015 in Pudukkottai and Thanjavur is due to the increase in moderately dense mangroves, and in Nagapattinam and Thiruvallur the same is due to the increase in open mangroves over time.

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



Source : FSI (2001, 2005, 2015).

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.

Mangroves at Pichavaram

12.2.2 *Coral Reefs*

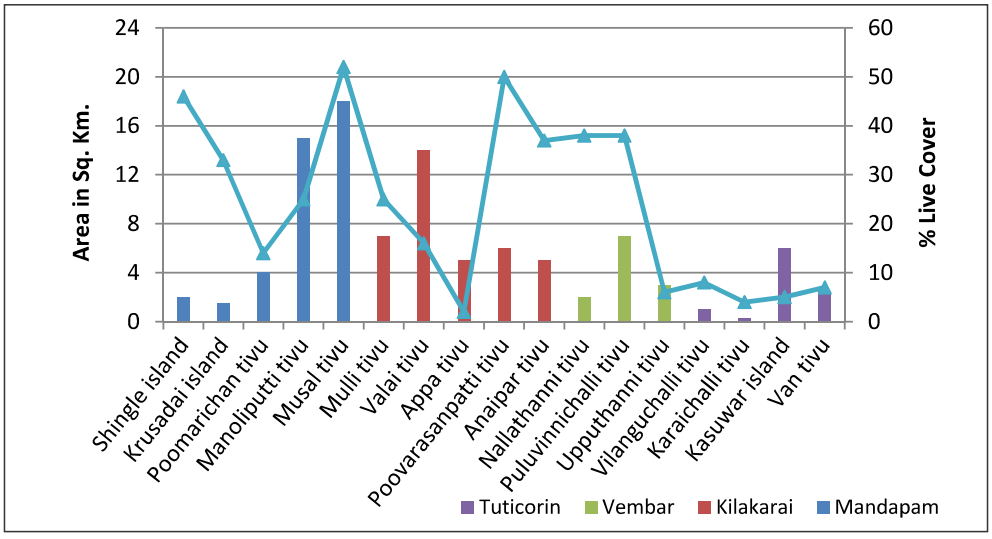
In Tamil Nadu, coral reefs (mainly fringing reefs) are found along the Gulf of Mannar and Palk Bay, and at restricted places in Chennai and Cuddalore. The estimate of total coral reef area in Tamil Nadu is 94.3 square kilometres, of which reef flats make up 64.9 sq.km. and the remaining area includes 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 sq.km.) followed by the Kilakarai group of islands (37 sq.km.). The island of Musal tivu has the highest reef area (18 sq.km.) as well as the highest live coral coverage over that area (52 per cent).

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).

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



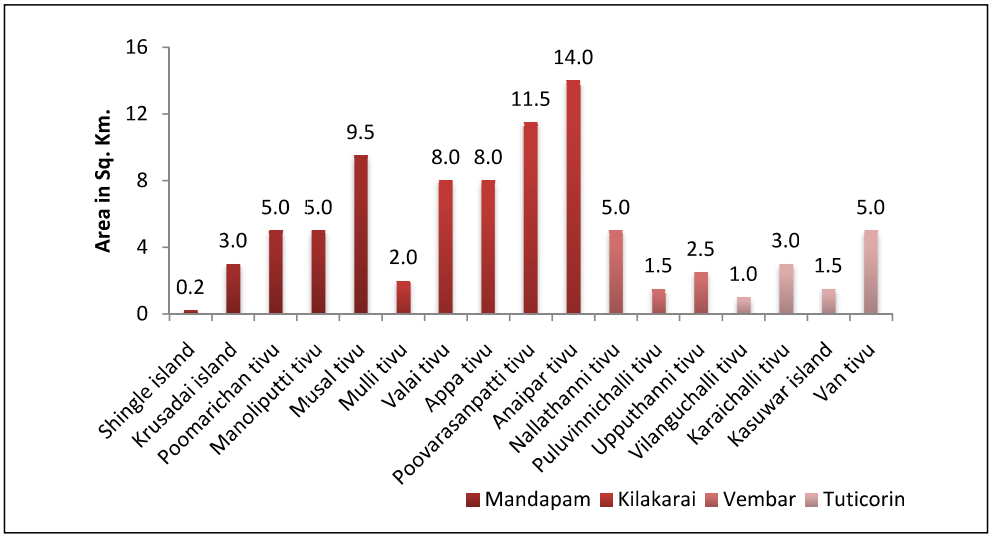
Note : Manoliputti tivu include Manoli tivu, Valai tivu includes Thalayari tivu, Poovarasanpatti tivu includes Vallimalai tivu and Poomarichan tivu includes Pullivasal tivu.
Source : IOM (2008); reference period not specified.

Coral Reefs at the Gulf of Mannar Marine National Park.

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 sq.km. The Kilakarai group of islands has the largest area under seagrasses (44 sq.km.) followed by the Mandapam islands (23 sq.km.) (Figure 12.13).

Figure 12.13: Areal Extent of Seagrasses in the Gulf of Mannar Islands



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

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).

12.2.4 *Estuaries*

The river Cauvery and its estuary, and the rivers Vellar, Pazhayar, Adyar and their estuaries are the main estuaries found in Tamil Nadu. 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 (Igeo) 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; $1 \leq CF \leq 3$ reflects moderate contamination; $3 \leq CF \leq 6$ 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. Igeo is also used to assess the contamination levels in river sediments and it was estimated such that: Igeo< 0 reflects the estuary is unpolluted; 0 < Igeo< 1 reflects it is unpolluted to moderately polluted;

1 < Igeo< 2 reflects it is moderately polluted ; 2 < Igeo< 3 reflects it is moderately to heavily polluted; 3 < Igeo< 4 reflects it is heavily polluted; 4 < Igeo< 5 reflects it is heavily to extremely polluted; and Igeo> 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 Igeo 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 Igeo 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.

12.2.5 *Sand Dunes and Beaches*

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 12.11: 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.

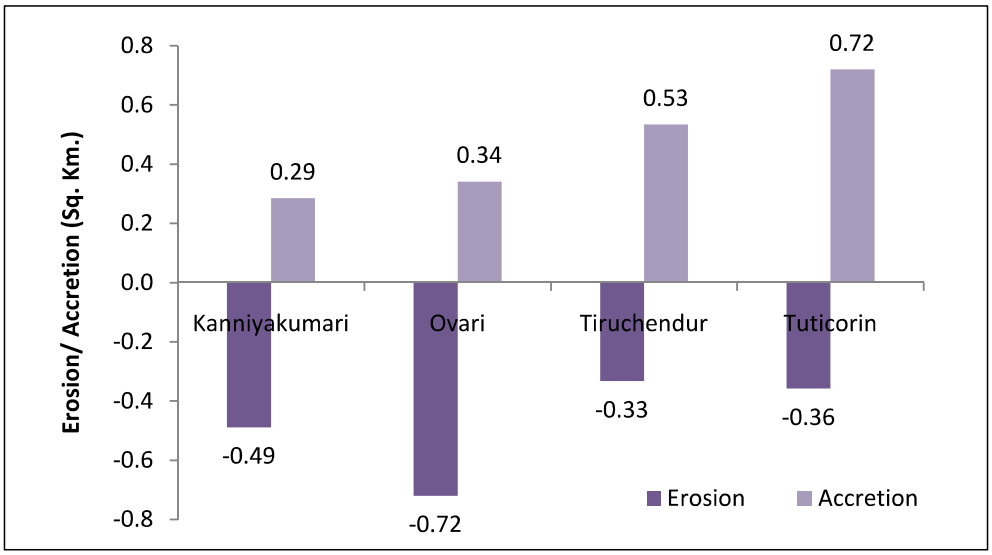
Table 12.12: Extent of Erosion along the TN Coast

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 km between Kanniyakumari and Tuticorin) using remote sensing and GIS techniques. 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 sq.km. occurred in the coastal zones of Kanniyakumari and Ovari respectively, which translates into an annual rate of erosion of 29,142 sq.m. for Kanniyakumari and 54,143 sq.m. for Ovari. On the other hand, the coastal zones of Tiruchendur and Tuticorin experienced a net accretion of 0.201 and 0.362 sq.km. respectively, which translates into an annual rate of accretion of 28,713 sq.m. for Tiruchendur and 51,714 sq.m. for Tuticorin over the period 1999 – 2006 (Figure 12.14).

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



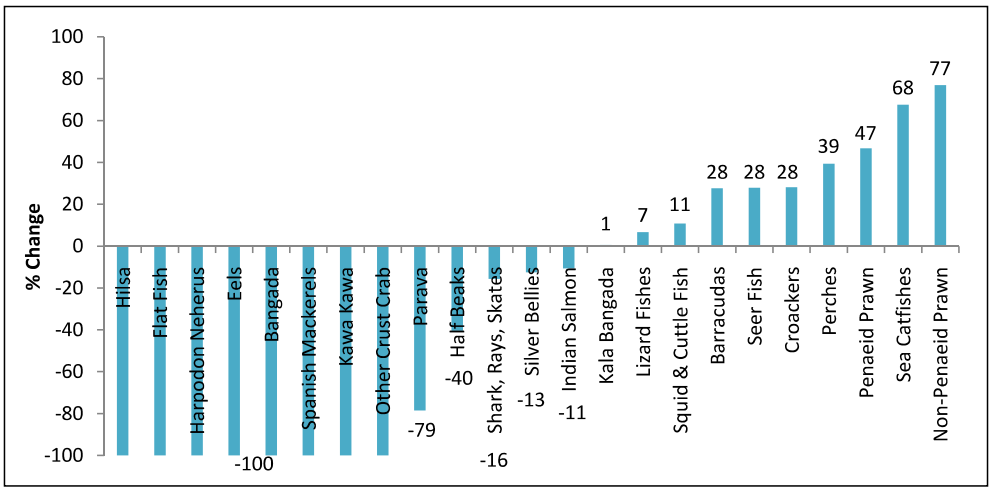
Source : Mujabar and Chandrasekar (2013).

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 reduced 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.

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

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

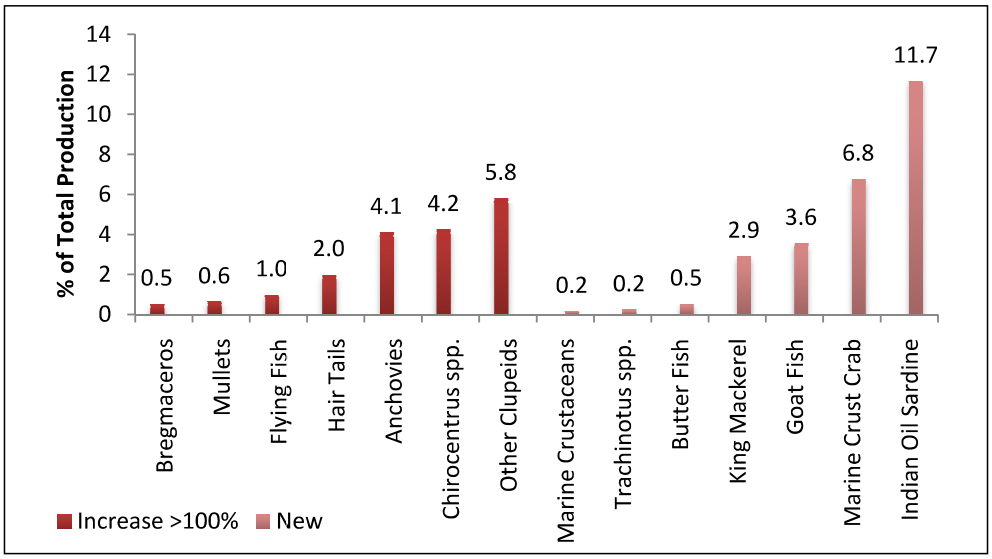


Source : DADF (2014).

species including Parava, Half Beaks, Sharks, Rays and Skates, Silver Bellies and Indian Salmon declined by about 10 – 80 per 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 percent each of total production in 2012.

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



Source : DADF (2014).

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-

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

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.

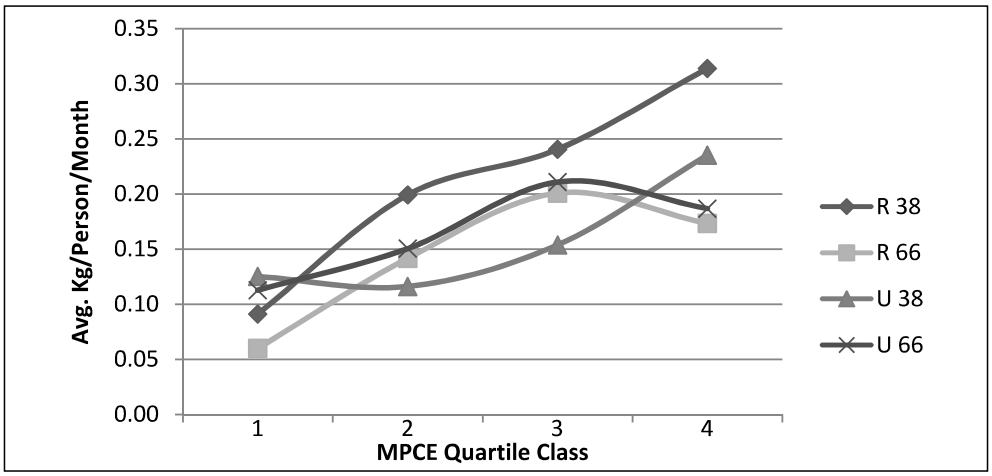
Newspapers[4] report the deaths of hundreds of Olive Ridley turtles each year due to commercial fishing activities, i.e. turtles get caught in trawl nets and suffer internal injuries from hooks or external injuries from entanglement, strangulation or amputation. Although a complete ban on the use of mechanised fishing techniques within 20 km. of the coast has not yet been enforced in the State (as in Odisha[5], however a partial fishing ban exists). 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

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



Source: Ravikanth and Kavi Kumar (2015).

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 kg per person per month in 1983 to 0.153 kg 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 percent 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 kg 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 (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 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 m 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 percent 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 (in Rs. Crores)

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 *Coastal Zone Management Plan (CZMP)*

The Ministry of Environment, Forests and Climate Change (MoEF&CC) 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. 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. CRZ-V, 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.

To augment this legislative response, 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.

Beach Cleaning Campaign

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

The National Centre for Sustainable Coastal Management is an autonomous centre of MoEF&CC, GoI. 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.

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, evacuation strategies, 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 to assess implications of climate change and SLR.

Source : GoTN (2013).

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).


Mangroove Restoration

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.

Tsunami Rehabilitation Homes

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].

[7] See - www.tn.gov.in/tsunami/Tsunami2004/Damages%20 incurred html.
[8] See - GoTN order - http://cms.tn.gov.in/sites/default/files/gos/anfe772015pdf.

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/).

ENVIRONMENT AND HEALTH

ENVIRONMENT AND HEALTH 13

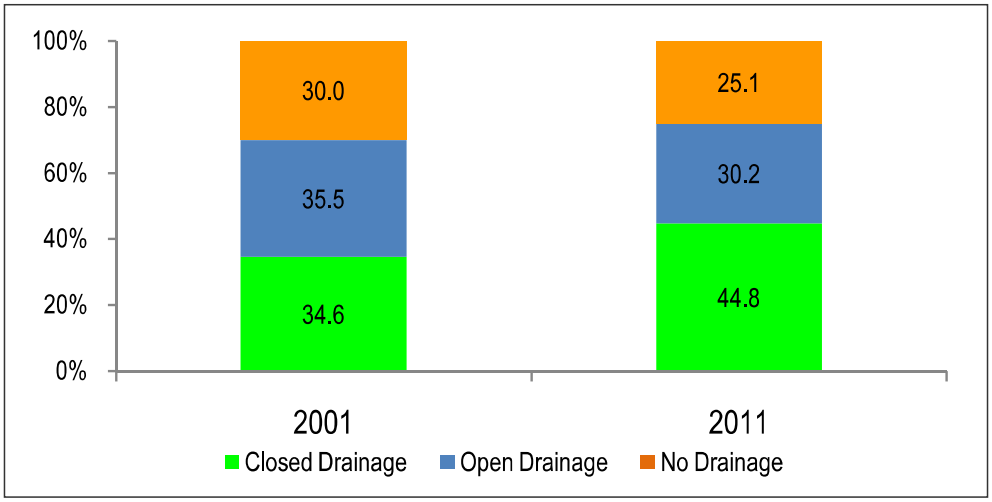
13.1 Environment and Health Linkages

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 improve 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 (Figure 13.1). Across districts, the share of urban households having no drainage facilities varies between 3 percent for Chennai to 51 per cent in Ariyalur.

Figure 13.1: Types of Household Drainage System in Urban Areas



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

13.1.2 *Sanitation*

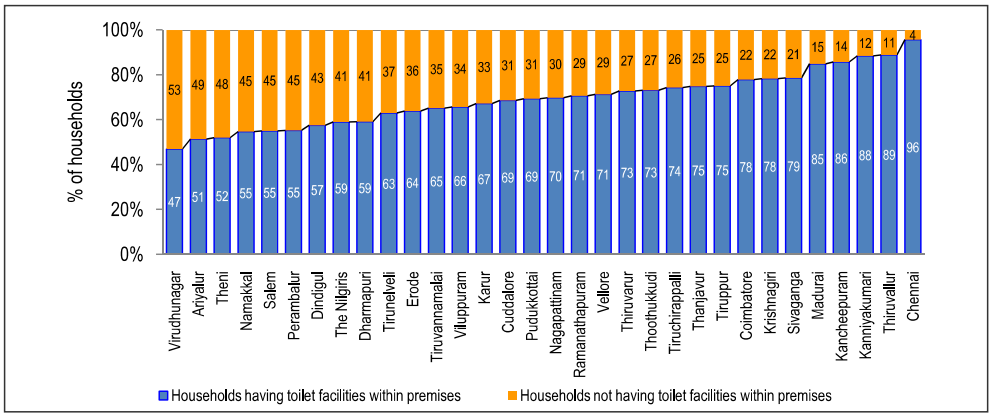
The percentage of urban households having toilet facilities has increased to 75 percent in 2011 compared to 64 per cent in 2001 (DEAR, 2013-14). Share of urban households having toilet facilities shows significant variation across districts. As of 2011, share of urban households not having toilet facilities within premises varies from 53 percent in case of Virudhunagar to 4 per cent in case of Chennai (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 to open defecation varies significantly across districts in the range of 13.4 per cent for Chennai to 92.7 per cent in Thiruvannamalai (Table 13.1).

Table 13.1: Urban Sanitation across Districts of Tamil Nadu

District	No. of Urban Households (HH)	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).

Figure 13.2: Toilet Facilities in Urban Households, 2011



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 neighbourhoods that may be difficult to deal with, 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, Tiruchirappalli and Coimbatore accounted for one-third of the total slum population in the state (Table 13.2).

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 (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 13.2: Slum Population in Selected Cities of Tamil Nadu

City/Municipal Corporation	Total City Population (lakhs)	Slum Population (lakhs)	Slum Population (%)
Chennai	46.5	13.4	28.9
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

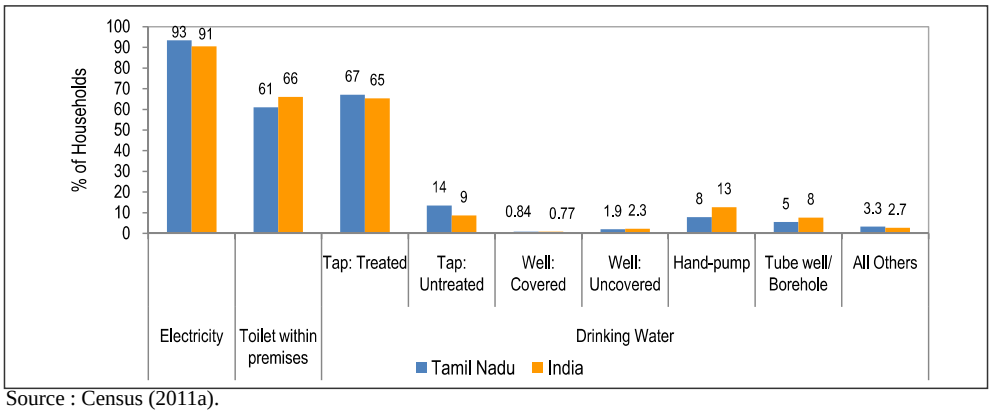
Source : Census (2011b)

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).

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

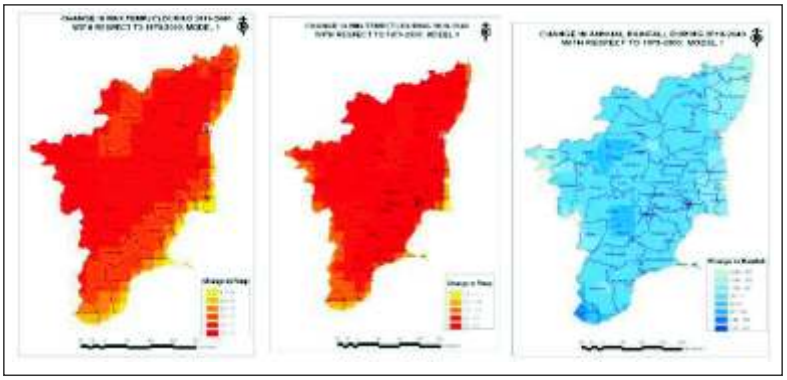


Source : Census (2011a).

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^{o}C, 2.0^{o}C, and 3.4^{o}C in the years 2040, 2070 and 2100 respectively, whereas the corresponding increase in the minimum temperature are projected as 1.1^{o}C, 2.2^{o}C and 3.4^{o}C respectively for the same future years. The annual rainfall has been projected to rise by 7 cm over the period from 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.

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



Source : GoTN (2015).

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 organisms 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 Urban Local Bodies (ULBs) even before this was announced as a mandatory reform measure under Jawaharlal Nehru National Urban Renewal Mission (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 (Urban Infrastructure Development Scheme for Small and Medium Towns).

The Public works department in coordination with the Tamil Nadu Slum Clearance Board (TNSCB) has attempted to rehabilitate the slum households. The Vision Tamil Nadu 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 “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 percent 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.

Houses Constructed at Perumbakkam, Chennai under JNNURM

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 and 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, GoI on 31st March 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. 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 livelihood improvement 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 a 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 Department
Sustainable Agriculture	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	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	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	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	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	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	Department of Environment, Centre for Climate Change and Adaptation Research, Anna University and others appointed as and when required

Source : GoTN (2015).

Beach Embankment

Sustainable Agriculture

ENVIRONMENTAL HOTSPOTS

ENVIRONMENTAL HOTSPOTS 14

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 focuses 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 a 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 comprehensive indices such as the 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 focuses 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 km 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 4,50,000 people.

As highlighted in Chapter 5, the MoEF&CC, GoI 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, MoEF&CC 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 the past twenty five years. The storage of hazardous sludge pollutes the groundwater in the vicinity. For remediation of this contaminated site, MoEF&CC has included this site for funding under the National Clean Energy Fund. MoEF&CC has engaged M/s. ERM India Pvt. Ltd as consultant to prepare a detailed project report (OPR) 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*

Tamil Nadu is vulnerable to climate extremes and slow-onset disasters, e.g., cyclonic storms, floods, droughts, sea-level rise, temperature and rainfall changes, salinization, etc. As noted in Chapter 12, northern Tamil Nadu experienced, on an average, 6 cyclones (including depression, cyclonic storms and severe cyclonic storms) in each decade over the period 1891-2007, whereas southern Tamil Nadu experienced, on an average, 1 cyclone over the same period. A higher percentage of cyclones occurred during the north-east monsoon season (i.e., October-December) and have significantly affected agricultural output. A study by Indian Network for Climate Change Assessment (INCCA) (2010) reports that the frequency of cyclonic storms will be higher during the post-monsoon season in the future (2071-2100) in comparison to the baseline scenario (1961-1990) in the Bay of Bengal region. Further, an expected rise in sea-level by 46-59 cm along the Indian coastline by 2100 will have a significant impact on the coastal districts of Tamil Nadu. From the Building Materials and Technology Promotion Council (BMTPC) vulnerability atlas, it is observed that the majority of coastal districts in Tamil Nadu have a high/ very high level of vulnerability (Mohapatra et al., 2012).

Since agriculture is one of most vulnerable sectors to climate extremes, extensive relief measures are periodically sanctioned by the state government in the wake of several climate extremes. Table 14.1 summarizes the loss of agricultural production due to climate extremes and relief measures provided by the state government over the period 2003-04 to 2012-13.

Hossain and Singh (2002) used a 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 14.2 shows the summary statistics of their analysis for Tamil Nadu. A 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.

Table 14.1 : Loss of Agricultural Production due to Natural Calamities and Relief Measures Provided – 2003-04 to 2012-13

Year	2003-04	2007-08	2008-09	2011-12	2012-13
Natural Calamity	Drought	Flood	Flood	Cyclone	Drought
Area Affected (in million ha)	1.481	0.514	0.577	0.188	1.001
Food Crop	0.269	0.459	0.529	0.165	0.868
Non-food crop	1.212	0.054	0.047	0.023	0.133
Value of Crop Loss (Rs. In million)		10121.40	20133.60	9687.30	34754.60
Food Crop		8265.50	18972.70	6673.90	27704.80
Non-food Crop		1855.90	1160.90	3013.40	7049.80
Relief Measures Sanctioned (Rs. in million)		2140.60	4044.10	1742.40	11432.60
Percentage of Loss Compensated (%)		21.1	20.1	17.98	32.89
Farmers Benefited (in million)		0.77	0.86	0.29	2.03
Food Crop				0.26	1.81
Non- food crop				0.04	0.23
Area benefited (in million ha)					
Food Crop				0.17	0.51
Non-food crop				0.02	0.13

Source : Various issues of Tamil Nadu - An Economic Appraisal, Department of Evaluation and Applied Research, Government of Tamil Nadu, Chennai.

Table 14.2: 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 an 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 the Human Development Index by the United Nations Development Programme (UNDP).

Table 14.3: 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).

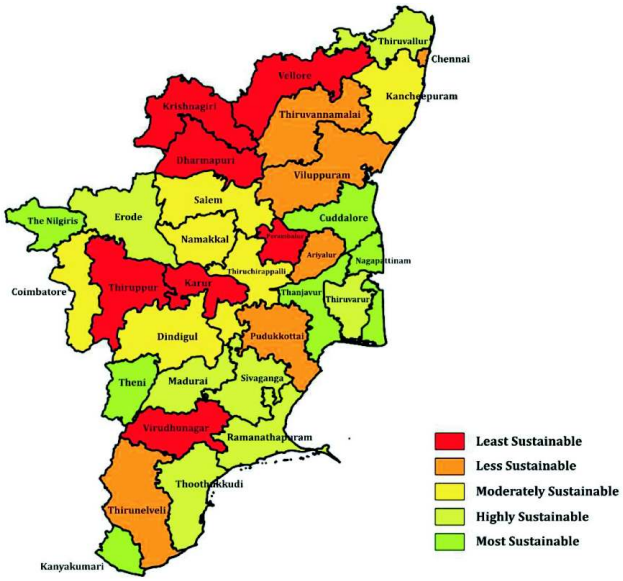
The index computations are made for a range of combinations of the parameters listed above. Table 14.3 shows the vulnerability index and vulnerability rank (across the coastal districts in India). The vulnerability rankings are relatively robust, independent of the specification and the results highlight a significant disparity across coastal regions in terms of their vulnerability to cyclones.

Box 14.1 gives an account of the vulnerability of cities to natural disasters by presenting the case of the recent floods in Chennai and surrounding areas during November-December 2015.

14.1.2 *Environmental Sustainability Index*

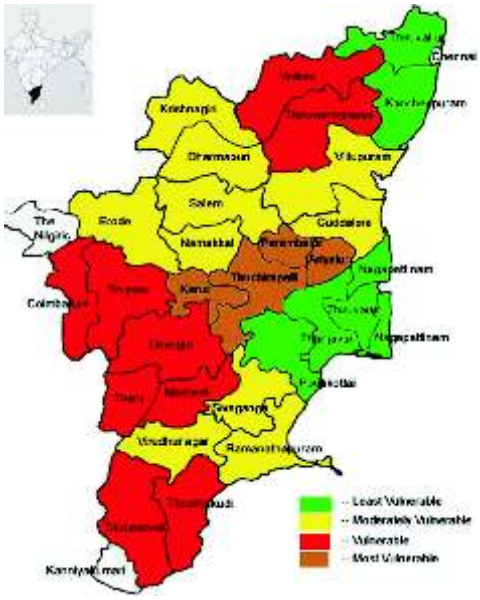
Recently, Shivaranjani and Venkataramani (2015) constructed an environmental sustainability index (ESI) for the districts of Tamil Nadu using 2011-12 as the baseline year. The ESI consists of 45 indicators spread across nine thematic areas including, population, land-use, agriculture, transport, water, 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.

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



Source : Shivaranjani and Venkatarmani (2015).

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



Source : Varadan and Kumar (2015).

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 the agriculturally most vulnerable districts of Tamil Nadu from a 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 an environmental perspective and are also identified as most vulnerable to climate change (albeit with a focus on a single sector namely, agriculture). Such an exercise reveals that Karur and Perambalur are two most important districts that need urgent policy attention.

Box 14.1 : Vulnerability to Natural Disasters: The Case of the Chennai Floods

Cities have become increasingly vulnerable towards natural calamities. The hazards hitting these urban centres have grown fiercer with time, directing the attention of the policymakers towards the surging threat of Climate Change to the cities. The urban sprawl has been mushrooming due to a rapidly growing population. Urban areas generally offer lucrative job opportunities and a better standard of living, leading to rural-urban migration. Rural migrants are poor, and because of the lack of institutional support, they end up being slum dwellers. The lure of urban attractiveness brings in unskilled labourers and they usually find themselves doing petty jobs in the informal sector. Slums are usually marked with poor sanitation, intermittent electricity supply, absence of access to purified water, uncertainty about their dwelling and a deplorable living standard. These urban poor are highly susceptible to adversities stimulated by disasters. Given the grave situation of cities against the wrath of the natural calamities like floods, cyclones and earthquakes, concerns have emerged regarding infusing resilience into a complex structure like a city so that it becomes well equipped to face such unpleasant situations. Adger (2003) views resilience in the light of the ability to withstand a shock and adapt against uncertain future events. In the event of a disaster, Norris et al. (2008) highlights that it is the adaptive capacities like economic prosperity, social capital, communication, information and community competence that together work as a shield.

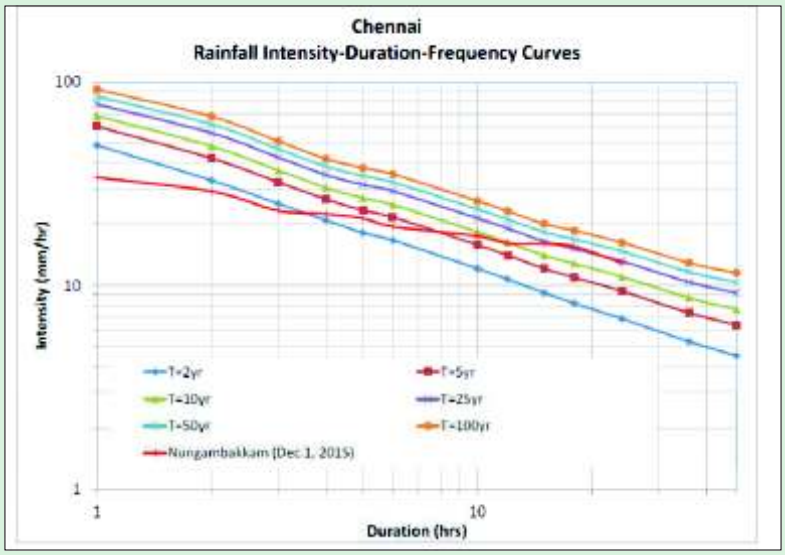
Recent floods during November-December 2015 in Chennai and surrounding areas are yet another reminder of the vulnerability of urban centres to natural disasters. The vulnerability of urban centres such as Chennai is very high as typically more is in harm's way and the developmental pressures add-on to the impact of natural disasters.

Extreme Rainfall

During November-December 2015, torrential rains thrashed the coastal districts of Chennai, Kancheepuram and Tiruvallur affecting more than 4 million people. While these districts recorded heavy rainfall on several days in November 2015, extremely heavy rain was reported during 1-2 December 2015. Tambaram in Kancheepuram district recorded the highest with 49 cm of rainfall, followed by 47 cm at Chembarambakkam and 42 cm at Marakkannam in Tiruvallur district. Chennai airport recorded 35 cm of rainfall, whereas several parts of the city received 28 to 30 cm of rainfall. Based on the intensity-duration-frequency plot based on 30 years of hourly rainfall data at Nungambakkam station (see Figure below), it appears that the 24 hour rainfall recorded at Nungambakkam on December 1, 2015 was like a 25-year storm. However, the rainfall recorded at Chembarambakkam on December 1, 2015 was considered more like a 100-year storm. Further, Narasimhan et al. (2016) report that based on a frequency analysis of the maximum 24-hour rainfall at Minambakkam station and IMD's grid point centred over Chennai city, the extreme rainfall recorded in 2015 in Chennai could be considered as rare with a return period close to 100 years.

In addition to the rainfall received, the release of water from various tanks (such as Chembarambakkam and Poondi) also contributed to the floods in December 2015 in Chennai. However, Narasimhan et al. (2016) argue that compared to reservoir release of about 800 cum/sec, the flood flow from parallel catchments (such as Manimangalam, Perungalathur, and Tambaram) could have contributed as much as 3000 cum/sec. Thus, the flood at its peak could have brought waster to the city which is twice the flood carrying capacity of the Adyar river. While it is widely reported in the media that unplanned release of water from the Chembarambakkam and Poondi reservoirs has led to the unprecedented floods in the city, it must be noted that these reservoirs are conservation reservoirs and not flood control reservoirs. Further as pointed out above, the deluge was largely contributed by the flow from parallel catchment areas that were not controlled by the reservoirs.

Rainfall Intensity-Duration-Frequency Curves for Various Return Periods at Nungabakkam, Chennai and Recorded Rainfall on 1st December 2015



Source : Narasimhan et al. (2016).

Impacts

The floods caused significant damage to life and property. As many as 347 people have reportedly died in Chennai and other parts of the state during the floods. The media reports suggested that over 18 lakh people were temporarily displaced due to floods. The re-insurance companies estimated the loss due to floods at $3 billion – making the Chennai floods as the eighth most expensive natural disaster in 2015. These estimated damages were however the most caused by floodwaters anywhere in the world in 2015.

Quoting various media reports, Narasimhan et al. (2016) estimate the total economic losses as Rs. 49,025 crores (Table below). These bottom-up estimates are more than double of that estimated by the re-insurance companies. It may be noted that even the bottom-up estimates do not account for the fiscal costs including the massive relief operations undertaken by the government in the wake of floods and also the almost universal flood relief grant given by the government to the city residents.

Estimated Economic Loss due to Chennai Floods

Sl. No.	*Damage Head*	*Amount (in Rs. Cr.)*	*Source*
1	Real Estate	30,000	http://www.dnaindia.com/india/report-chennairealty-market-faces-rs-30000-crore-loss-postfloods-2160122
2	Industrial Units	14,000	http://www.newindianexpress.com/cities/hennai/Flood-hit-Industrial-Belts-Clamour-for-Aid/2015/12/27/article3198021.ece
3	Insurance Companies	4,800	http://indianexpress.com/article/india/indianews-india/hennai-floods-insurance-cos-get-rs-4800-cr-claims/
4	Street Vendors	225	http://www.thehindu.com/news/cities/chennai/over-15-lakh-street-vendorsaffected/article8023454.ece
	Total	**49,025**	

Source : Narasimhan et al. (2016).

Potential Lessons

While the extreme rainfall contributed significantly to the devastating floods witnessed by Chennai city in December 2015, several other developmental factors including unprecedented land use change in several parts of the city over the past two decades and poor infrastructure facilities had an equal, if not a bigger, role to play in making the natural hazard into a virtual death trap.

Poor Drainage System : Chennai gets regularly flooded due to its poor drainage system. In addition to inadequate design capacity, the drainage system suffers from the usual suspects such as encroachments, poor connectivity between storm sewers with macro drainage facilities, indiscriminate dumping of solid waste and construction debris into the drains, and sand bar formation at the mouth of the rivers. It is striking that for a city with 6000 km length of road network (including the bus and interior roads), the length of storm water drain is only 1660 km (less than 30 per cent). This leaves many roads flooded even with medium rainfall events. It is imperative that the city must enhance its drainage facilities on war footing to ensure that the future vulnerability to flooding is reduced.

Rapid Land-use Change : Chennai is urbanizing very rapidly leading to significant land use change. The area covered by high density urban areas increased by four times between 1988 and 2014 (from 81.32 sq.km. in 1988 to 330.30 sq.km. in 2014). Several areas have witnessed rapid increase in built-up area leaving very little floodable area. The emerging theory of urban resilience to floods challenges the conventional wisdom that cities depend crucially on flood control. Liao (2012) proposes the percentage of floodable area as a proxy for assessing urban resilience to floods. As revealed by Google maps shown below, several areas in Chennai have reduced their floodable area, which has led to the erosion of resilience. Better urban planning with the development of peri-urban areas and stricter building norms are essential for enhancing the urban resilience to floods.

Land-use Change in Select Areas of Chennai – 2000 and 2015

Airport – 2000 | Airport – 2015

Porur – 2000 | Porur – 2015

Velachery – 2000 | Velachery – 2015

CONCLUSIONS

CONCLUSIONS 15

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 the 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 of 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 Tamil Nadu 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 a 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 aspects.

The study could not provide a 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, agricultural lands are also affected by sand quarrying for construction activities and mining of top soil among other things for brick manufacturing. 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 nutrients. 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.

Sand quarrying 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 the Government Order in 2002 regulating the sand mining activity, the activity is continuing in several river basins. 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 the 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).

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 should the state adopt to improve the state of environment? Table 15.2 provides a summary of some 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 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

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.

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 the control of an increase in the number of vehicles. Improvement in public transport facilities can go a 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 the 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 the possible fiscal interventions that the 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 the environment, we develop a counterpart of the tax instrument so that a subsidy can promote the environment. This two-part strategy will therefore have the maximum positive impact on the 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.

[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."

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 need 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 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 (Goods and Services Tax) 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 the 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 Compact Fluorescent Lamp (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	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

		been diverted, collected and treated in Sewage Treatment Plants.			crores implemented 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,	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

		enviro 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 coast and the different layers of information can be used to assess 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 Rs.4.84 crores during 2013-14

		damage and plan for remedial measures at times of coastal hazard.			
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	State Forests Department	Increase in green cover of the State	**Strategy towards Restoring State** 65 lakh seedlings were planted

		green cover in the State.			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 conservation.	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.
16	Replanting in Thane cyclone affected areas	Restocking of affected coastal areas of Cuddalore and Villupuram during the Thane cyclone with tree species like	State Forests Department	Rebuilding disaster affected areas and communities	**Strategy towards Ameliorating Impacts** Beneficiaries: Communities affected by the Thane cyclone;

		teak, casuarina, eucalyptus etc.			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 at Vaigai Dam.	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 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	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

		improvement, protection, research, monitoring, publicity, awareness, etc.			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 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	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 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.

		and demarcation of the forest boundaries to prevent encroachments by constructing the cairns, improvement of roads, etc.			
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 ground water recharge; to increase the soil moisture regime of the watersheds; to prevent soil erosion.	Tamil Nadu Agriculture Department	Water and soil conservation and optimal utilisation of the natural resources.	**Strategy towards Reducing Pressure** Beneficiaries- All the 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	Tamil Nadu Agriculture Department	Prevention of soil loss and better watershed management	**Strategy towards Reducing Pressure** Beneficiaries - Farmers of all districts of Tamil Nadu

		watersheds; promotion of land use to match land capability.			
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	Tamil Nadu Agriculture Department	Restoration of the ecology of Nigliris district by soil conservation, resource management, prevention	**Strategy towards Restoring State** Beneficiaries: All the farmers whose lands are covered in the selected watersheds of the

		local people; create public awareness on the benefits of the soil conservation works; prevention of landslides		of landslides, etc.	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 summary of some 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. In addition to this broad suggestion, the following sub-sections attempt to provide policy suggestions for specific line departments to foster sustainable development in Tamil Nadu.

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. They are reiterated here, though some are already implemented.

- 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&CC/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 continue to 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 filled-up. Around 25 percent 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 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 percent to 6 percent over the 12th and 13th finance commission, more financial allocation is required for this sector to facilitate the state's transition towards sustainable development.

[2] Environmental Resources Management, MoEF&CC.
[3] The Hindu, 18th October, 2015
[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

- Presently there is no separate eco-tourism wing in the 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 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:

- Efforts should be made to ensure prominent share of renewable energy in the energy mix in installed capacity[6] for electricity generation in the state;
- 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.

[6] Despite increase in absolute increase, the share of renewable energy in the total installed capacity has declined from 43% in 2012 to 38% in 2015.

15.4.4. *Transport Sector*

Integrated public transit modes (including bus and rail transport) as one seamless entity ensures 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[7]. There is also a need for designated cycling and walking tracks along arterial roads (as has been undertaken in some parts of Chennai city) 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/

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ABBREVATIONS

ADD	-	Acute Diarrheal Diseases
AVI	-	Agricultural Vulnerability Index
BFPUs	-	Bio-Fertilizer Production Units
CAAQMS	-	Continuous Ambient Air Quality Monitoring Stations
CBE	-	Coimbatore
CBOs	-	Community-based organizations
CCS&CP	-	Commissioner of Civil Supplies and Consumer Protection
CEPI	-	Comprehensive Environmental Pollution Index
CETP	-	Common Effluent Treatment Plan
CETPs	-	Common Effluent Treatment Plants
CFL	-	Compact Fluorescent Lamp
CMDA	-	Chennai Metropolitan Development Authority
CMWSSB	-	Chennai Metropolitan Water Supply and Sewage Board
COC	-	Chain of Custody certification
COPD	-	Chronic Obstructive Pulmonary Disorder
CPCB	-	Central Pollution Control Board
CPCB	-	Central Pollution Control Board
CPCB	-	Central Pollution Control Board
CRZ	-	Coastal Regulation Zone
CSD	-	Commission on Sustainable Development
CZMP	-	Coastal Zone Management Plan
DADF	-	Department of Animal Husbandry and Dairying
DBOOT	-	Design Build Own Operate and Transfer
DDP	-	Desert Development Programme
DoE	-	Department of Environment
DPAP	-	Drought Prone Areas Programme
DPSIR	-	Driver Pressure State Impact Response
DPSIR	-	Driver Pressure State Impact Response
DPSIR	-	Driving Force Pressure State Impact Response
DSR	-	Driving Force, State and Response
EACs	-	Expert Appraisal Committees
ECR	-	East Coast Road
EMPRI	-	Environment Management and Policy Research Institute
EPI	-	Environmental Performance Index
ESI	-	Environmental Sustainability Index
ETP	-	Effluent Treatment Plan
ETP	-	Effluent Treatment Plants
FMU	-	Forest Management Unit certification
FSC	-	Forest Stewardship Council
FSI	-	Forest Survey of India
GDP	-	Gross Domestic Product
GEMS	-	Global Environmental Monitoring System
GoI	-	Government of India
GSDP	-	Gross State Domestic Product

GSDP	-	Gross State Domestic Product
HDI	-	Human Development Index
IAMWARM	-	Irrigated Agriculture Modernisation and Water bodies Restoration and management
IARI	-	Indian Agricultural Research Institute
ICDS	-	Integrated Child Development Services
ICDS	-	Integrated Child Development Services
ICMAM	-	Integrated Coastal and Marine Area Management
ICZM	-	Integrated Coastal Zone Management
IFGTB	-	Institute for Forest Genetics and Tree Breeding
IIPS	-	International Institute for Population Sciences
INCCA	-	Indian Network for Climate Change Assessment.
INDCs	-	Intended Nationally Determined Contributions
IPCC	-	Intergovernmental Panel on Climate Change
IPCC	-	Intergovernmental Panel on Climate Change
IUDM	-	Integrated Urban Development Mission
IWDP	-	Integrated Wastelands Development Programme
IWMP	-	Integrated Watershed Management Programme
JFM	-	Joint Forest Management
JICA	-	Japan International Cooperation Agency
JMM	-	Joint Mangrove Management
JNNURM	-	Jawaharlal Nehru National Urban Renewal Mission
KUM	-	Kumbakonam
LPG	-	Liquid Petroleum Gas
MCM	-	Million Cubic Meters
MDU	-	Madurai
MINARS	-	Monitoring of Indian National Aquatic Resources
MLD	-	Millions of Litters per Day
MoCI	-	Ministry of Commerce and Industry
MoEF&CC	-	Ministry of Environment, Forests and Climate Change
MPCE	-	Monthly Per Capita Expenditure
MRTS	-	Mass-Rapid-Transit System
MSE	-	Madras School of Economics
MSME	-	Micro Small and Medium Enterprises
MSSRF	-	M. S. Swaminathan Research Foundation
MTA	-	Metric Tonnes per annum
MTC	-	Metropolitan Transport Corporation
NAAQS	-	National Ambient Air Quality Standards
NAMP	-	National Air Quality Monitoring Programme
NCSCM	-	National Centre for Sustainable Coastal Managemen
NFHS	-	National Family Health Survey
NGO	-	Non-Governmental Organization
NMMI	-	National Mission on Micro Irrigation
NMSA	-	National Mission for Sustainable Agriculture
NRSC	-	National Remote Sensing Centre
NSS	-	National Sample Survey

NSSO	-	National Sample Survey Office
OFWM	-	On Farm Water Management
PDS	-	Public Distribution System
PE	-	Potential Evapotranspiration
PNG	-	Pipeline Natural Gas
PSIR	-	Pressure State Impact Response
PTMGRNMP	-	Puratchi Thalaivar MGR Nutritious Meal Programme
RADP	-	Rainfed Area Development Programme
RMS	-	Reject Management System
RO	-	Reverse Osmosis
RSPM	-	Respirable Suspended Particulate Matter
RWH	-	Rainwater Harvesting
SDF	-	Sustainable Development Framework
SEEA	-	System of Integrated Environmental and Economic Accounting
SETC	-	State Express Transport Corporation Ltd.
SHGs	-	Self-Help Groups
SIDCO	-	Small Industries Development Corporations
SIPCOT	-	State Industries Promotion Corporation of Tamilnadu Ltd
SLM	-	Salem
SNA	-	System of National Accounts
SoE	-	State of Environment
SPCBs	-	State Pollution Control Boards
SPM	-	Suspended Particulate Matter
SRI	-	System of Rice Intensification
STPs	-	Sewage Treatment Plants
TANGEDCO	-	Tamil Nadu Generation and Distribution Corporation Ltd.
TANHODA	-	Tamil Nadu Horticulture Development Agency
TAP	-	Tamil Nadu Afforestation Programme
TNCSC	-	Tamil Nadu Civil Supplies Corporation
TNEB	-	Tamil Nadu Electricity Board
TNEB	-	Tamil Nadu Electricity Board
TNPCB	-	Tamil Nadu Pollution Control Board
TNPCB	-	Tamil Nadu Pollution Control Board
TNPL	-	Tamil Nadu Newsprint and Papers Limited
TNSCB	-	Tamil Nadu Slum Clearance Board
TNV	-	Tirunelveli
TSDF	-	Treatment Storage and Disposal Facility
UA	-	Urban Agglomerations
UIDSSMT	-	Urban Infrastructure Development Scheme for Small and Medium Towns
UNEP	-	United Nations Environment Programme
UTs	-	Union Territories
VPM	-	Villupuram
WWF	-	World Wildlife Fund
ZLD	-	Zero Liquid Discharge
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