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REVIEW ARTICLE

Natural disasters in India with special reference to Tamil Nadu

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Abstract

Natural disasters in India, many of them related to the climate of India, cause massive losses of Indian life and property. Droughts, flash floods, cyclones, avalanches, landslides brought on by torrential rains and snowstorms pose the greatest threats. Landslides are common in the Lower Himalayas. Parts of the Western Ghats also suffer from low-intensity landslides. Floods are the most common natural disaster in India. The heavy southwest monsoon rains cause the Brahmaputra and other rivers to distend their banks, often flooding surrounding areas. Though they provide rice paddy farmers with a largely dependable source of natural irrigation and fertilization, the floods can kill thousands and displace millions. Excess, erratic, or untimely monsoon rainfall may also wash away or otherwise ruin crops. Almost all of India is flood-prone, and extreme precipitation events, such as flash floods and torrential rains, have become increasingly common in central India over the past several decades, coinciding with rising temperatures. Mean annual precipitation totals have remained steady due to the declining frequency of weather systems that generate moderate amounts of rain. A natural disaster might be caused by earthquakes, flooding, volcanic eruption, landslide, hurricanes etc. In order to be classified as a disaster it will have profound environmental effect and/or human loss and frequently incurs financial loss. This review elucidates the natural disasters of Tamil Nadu and its possible cause as well as the preventive/mitigation measures.

Keywords: Natural disasters, droughts, flash floods, cyclones, avalanches, landslides, hurricanes.

Introduction

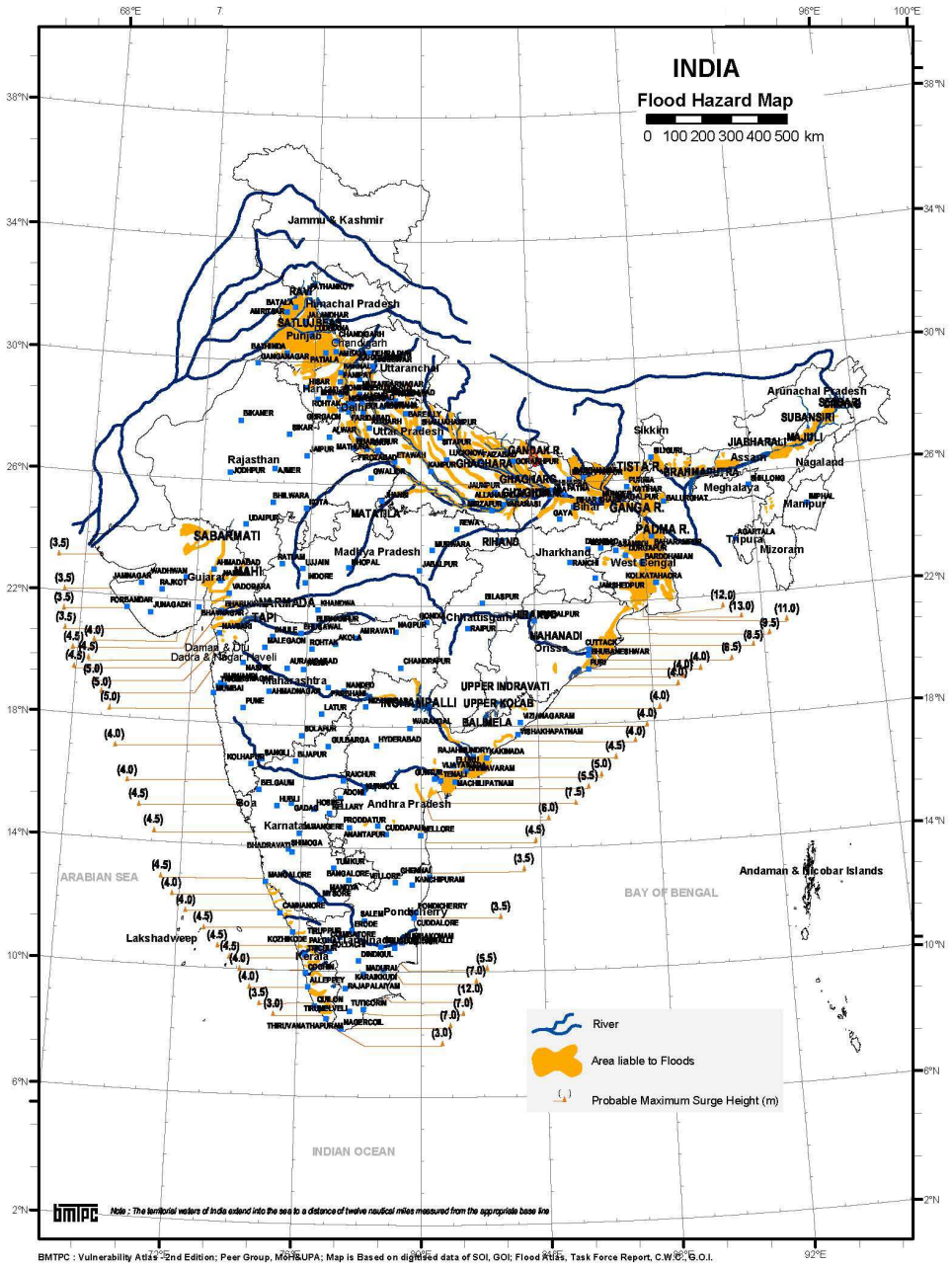
At the global level, there has been considerable concern over natural disasters. Many natural disasters in India have caused havoc to the life and property of citizens and nature as a whole from time to time. Because of this, United Nations General Assembly, in 1989, declared the decade 1990-2000 as the *International Decade for Natural Disaster Reduction* with the objective to reduce loss of lives and property and restrict socio-economic damage through concerted international action for appropriate management strategies, especially in the developing countries. These disasters include cyclones, floods, earthquakes, volcanic eruptions, famines, drought, landslides etc. Amongst all the ones mentioned floods and earthquakes are the most common in India. India is no exception as it has been traditionally vulnerable to natural disasters on account of its unique geo-climatic conditions. Floods, droughts, cyclones, earthquakes and landslides have been recurrent phenomena in India due to large population growth, and migration into urban areas (De *et al*., 2005). Tamil Nadu has witnessed havoc caused by cyclones and storm surge in the coastal regions, earthquakes, monsoon floods, landslides, and recently the Tsunami. Increase in urban population coupled with the construction of man-made structures often poorly built and maintained subject cities to greater levels of risk to life and property in the event of earthquakes and other natural hazards.

India is an area of 3,287,263 square kilometers and a coastline of 7516 km, with the last official census in 2001 showing a population 1.028 billion people (MIB, 2009). Tamil Nadu covers an area of 130, 0582 kms and has a coastline of about 1,076 kms which is about 15% of the coastline of India (Byravan *et al*., 2011). More than 40% of the fisher population lives within 1km of coast and 50% of them live within 2 km of the coast. The geographical setting of Tamil Nadu makes the state vulnerable to natural disasters such as cyclones (Mascarenhas and Jayakumar 2007) floods and earthquake-induced tsunami. About 8% of the state is affected by five to six cyclones every year, of which two to three are severe. Cyclonic activities on the east coast are more severe than on the west coast, and occur mainly between April-May and October-November (Kuppusamy and Rajarathnam, 2009).

Floods

Floods are high stream flow that overflows the natural banks of the rivers and most of the times become calamitous. India is the most flood affected nation after Bangladesh. Out of total deaths by Floods in the world, (1/5) are from India. The main causes of floods are excessive rains in river catchments, poor natural drainage, Change of river course, Landslide restricting river flow, cyclone and very intense rainfall (Fig. 1). Over that past few years the rise in population is forcing large settlements along the river banks, making the country

Fig. 1. Flood hazard map of India.



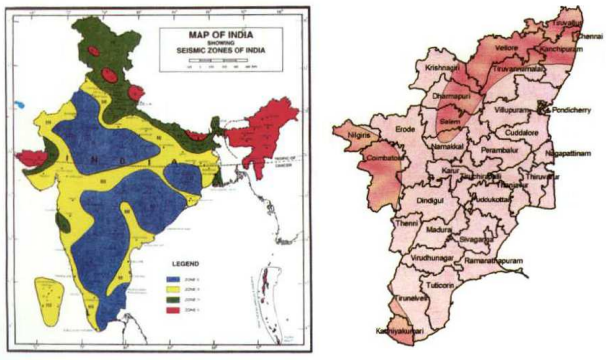
highly vulnerable to Floods. The most vulnerable states of India are Uttar Pradesh, Bihar, Assam, West Bengal, Gujarat, Orissa, Andhra Pradesh, Madhya Pradesh, Maharashtra, Punjab and Jammu and Kashmir. In 1994, a major flood killed 147 people in Kerala, 138 in Gujarat and marooned 10000 in Madhya Pradesh. In 1995, the states of Uttar Pradesh, Haryana and Arunachal Pradesh were severely hit by flood causing huge casualties. In the year 1996, a fierce flood literally paralyzed India, Thousands of people died, got homeless, were marooned in the states of Rajasthan, Andhra Pradesh, Jammu and Kashmir also affecting many other parts of the country. In short, nearly every year one or the other part of the country is severely hit by Floods and creating a shameful history for India. It is high time that the policies and measures for various preventions and disaster management activities are properly implemented. From the flood hazard map of India (Fig. 1), it is seen that no area in Tamil Nadu falls in the risk zone. But within a local body area, particularly with reference to an area's proximity to a major drainage system like rivers, canals, and also water bodies like lakes, and further with reference to contour levels/low-lying areas, flood prone area mapping has to be done. Tamil Nadu is also subjected to annual flooding, including flash floods, cloudburst floods, monsoon floods of single and multiple events, cyclonic floods, and those due to dam bursts or failure. Every year, on average thousands of people are affected, a few hundred lives are lost, thousands are rendered homeless and several hectares of crops are damaged. Every year, Flooding in India affects Tamil Nadu and the other Indian states of Assam, Bihar, West Bengal, Gujarat, Orissa, Uttaranchal, and Maharashtra (Kuppusamy and Rajarathnam, 2009). Floods are the most frequent and often the most devastating. The cause of flood is mainly the peculiarities of rainfall in North east monsoon period in the state. Out of the total annual rainfall in the state, 90% is concentrated over short monsoon season of three months. As a result, heavy discharges from the rivers during this period causing widespread floods in the delta regions. Floods occur mainly in the coastal districts basin that carries 100% of the state total river flows (Ponnuraj, 2006).

Cyclones

Cyclone refers to a whirl in the atmosphere with very strong winds circulating around it in anti-clockwise direction in the Northern Hemisphere and clockwise in the Southern Hemisphere. Cyclones are intense low pressure areas with pressure increasing outwards. Cyclones can be hazardous as Cyclones are normally associated with strong winds. A storm surge is an abnormal rise of sea level near the coast caused by a

severe tropical cyclone; as a result, sea water inundates low lying areas of coastal regions drowning human beings and lives-stock, eroding beaches and embankments, destroying vegetation and reducing soil fertility.

Fig. 2. TN: Hazard Map-Earthquake, Floods and Cyclone (After Ponnuraj, 2006).



Apart from strong winds, cyclones can result in heavy rains causing floods. However, the most destructive factor associated with the cyclones is the storm surge. The worst and the oldest cyclone in India was in 1737, in Calcutta that took 300000 lives respectively. For cyclone forecast and advance warning, the Government has strengthened the Meteorological Department, by providing Cyclone Surveillance Radars at Calcutta, Paradeep, Visakhapatnam, Machilipatnam, Madras and Karaikal in the east coast and at Cochin, Goa, Bombay and Bhuj in the west coast. As India has a vast coastline it is extremely vulnerable to cyclone. In India, nearly 150 million people are prone to natural hazard in coastal areas (Ertuna, 1995; 1999). Bay of Bengal is one of the five cyclone prone areas of the world. The coastal regions surrounding this bay are frequently affected by flooding from the sea as well as from the rivers due to tropical cyclones and related storm surges and heavy rainfall. In Tamil Nadu during the years 1990 to 1995, and 2006 the damages caused to property were worth 5800 million rupees (US$ 170 M) and the loss of human lives were more than 500 (Ramesh, 2007).

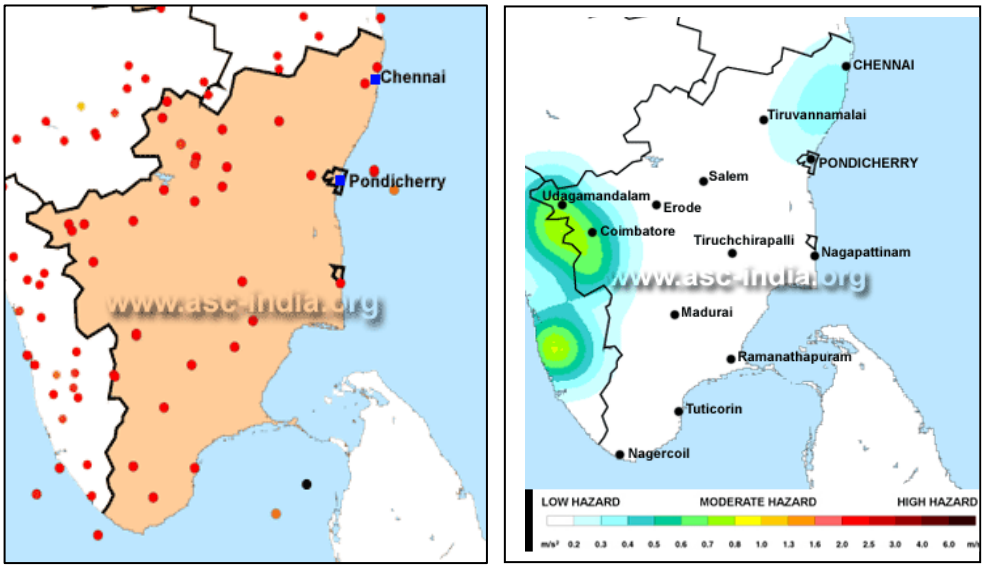
Tamil Nadu lies in the southern part of Indian peninsula and has a long east coast. The east coast is more vulnerable to cyclones and floods. Tamil Nadu has a very long coastline of about 1076km with 591 coastal villages, which is exposed to tropical cyclone arising in the Bay of Bengal and has seasonal character to Tamil Nadu. In 2005, 9 cyclonic storms crossed Tamil Nadu and Andhra coast in a three month period (Fig. 2). The coast line starts from Pulicat along the east coast and extends up to Erayamanthurai in Kanniyakumari District and consists of Estuaries of ecological importance, Major and Minor ports, Fishing harbours, Monuments of international heritage, Tourist locations, Pilgrimage centers, etc.

Earthquakes

Earthquakes are powerful manifestations of sudden releases of strain energy accumulated within the crust and propagated as seismic waves. The need to understand and study the phenomenon of earthquake is for a simple reason, that it is the most disastrous natural calamity for mankind. The Himalayan Frontal arc in India is amongst the most seismically active regions of the world. Even the Peninsular Stretch is extremely susceptible to Earthquakes. The Runn of Kutch Earthquake of 1918 is one of the largest interplate events in the world. The first Seismological observatory in India was established in the year 1898 in the city of Calcutta. Over the years the department has been exponentially expanded by the Meteorological Department of India. Tamil Nadu is not as seismically active as states in the northern and western parts of the country, small to moderate earthquakes have occurred in the state of Tamil Nadu. The frequency of earthquakes is low i.e. the gap between moderate sized events is fairly long. Seismic activity in the recent past has occurred in clusters (Dasgupta *et al*., 2000) along the borders with Andhra Pradesh, Karnataka and Kerala.

Several faults have been identified in this region out of which many show evidence of movement (Dasgupta *et al*., 2000) during the Holocene period. The east-west trending Cauvery Fault, Tirukkavilur-Puducherry Fault and Vaigai River Fault and the north-south trending Comorin-Point Calimere Fault and Rajapatnam-Devipatnam Fault are some of them and run close to major urban centres like Coimbatore, Madurai, Nagapattinam, Thanjavur and Puducherry.

Fig. 3. Seismic hazard map of TN (After Amateur Seismic Centre, 2012).



However, it must be stated that proximity to faults does not necessarily translate into a higher hazard as compared to areas located further away, as damage from earthquakes depends on numerous factors such as subsurface geology as well as adherence to the building codes.

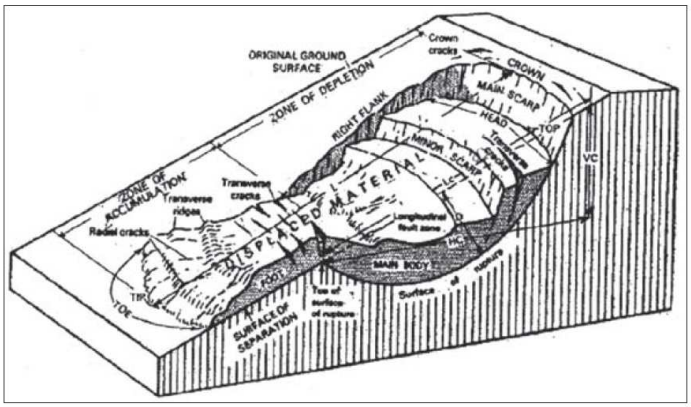
The seismic hazard map of India was updated in 2000 by the Bureau of Indian Standards (BIS). According to the new map more areas of Tamil Nadu are susceptible to damage from earthquakes than previously thought (Fig. 3). The city of Chennai, formerly in Zone II now lies in Zone III. Districts in the western part of the state, that lie along the border with Kerala also lie in Zone III, along with districts along the border of Andhra Pradesh and a section of the border with Karnataka. The maximum intensity expected in these areas would be around MSK VII. The rest of the state lies in Zone II. Since the earthquake database in India is still incomplete, especially with regards to earthquakes prior to the historical period (before 1800 A.D.), these zones offer a rough guide of the earthquake hazard in any particular region and need to be regularly updated (Parthasarathy and Rajendrakumar, 2011).

According to GSHAP data, the state of Tamil Nadu falls mostly in a region of low seismic hazard with the exception of western border areas that lie in a low to moderate hazard zone. Puducherry lies in a low hazard region. As per the 2002 Bureau of Indian Standards (BIS) map, Tamil Nadu and Puducherry fall in Zones II and III. Historically, parts of this region have experienced seismic activity in the M5.0 range. Tamil Nadu is also prone to very severe damaging earthquakes. Its people feel much more vulnerable to earthquake-induced tsunamis since the 2004 Indian Ocean tsunami, which affected the coast of Tamil Nadu destroying much of the marine biology and severely damaging the ecosystem (Government of Tamil Nadu, 2008). Crops, settlements, trees, birds, fishes, wildlife, and properties were destroyed. Precious coral reefs and mangrove areas were crushed by the huge tsunami waves that devastated South India, an environmental and economic setback that could take years to reverse. Power and communications were totally disrupted. The damage to humans, especially women and children, and animal life, was tremendous, resulting in emotional and mental trauma (Kumar *et al*., 2007). Largest Instrumented Earthquake occurred in Tamil Nadu and Puducherry on 26th September 2001(11.984 N, 80.225 E, D=010.0 kms, OT=14:56:55 UTC). A moderate earthquake occurred in the Bay of Bengal, off the coast of the union territory of Puducherry, on 25 September 2001 at 20:26 PM local time resulting in three deaths and minor damage to property in Puducherry and coastal Tamil Nadu. It had a magnitude of Mw=5.5.

Landslides

Landslides are mass movement of rocks and debris that usually follow a cyclone, volcano or earthquake under the influence of gravity (Nemcok *et al.*, 1972; Varnes, 1978; Hutchinson, 1988; WP/WLI, 1990; Cruden, 1991; Cruden and Varnes, 1996). In the hilly areas of India, the sliding of huge masses of land has been a common natural disaster causing havoc to life and property. One of the worst and most disastrous landslides has been recorded in the year 1998 in the state of Uttarakhand, when nearly 380 people were killed. As a measure of concern many committees and other measures have been taken to protect from this natural havoc in India. In India, the regions of Himalayas and the Western Ghats are the most vulnerable to these land-slides.

Fig. 4. Block diagram of a landslide (Varnes, 1974).



The main causes of landslides are weak, weathered materials, physical property variation, Ground Uplift, erosion, Earthquake, Volcanic eruptions etc. The general and simple mitigation that are adopted or should be adopted are drainage correction, proper land-utilization, reforestation and spreading of awareness. Landslides have represented 4.89% of the total natural disasters that occurred worldwide during the years 1990 - 2005 (www.em-dat.net). Landslide is one of the major natural hazards that are commonly experienced in hilly terrains all over the world. Landslides are affect at least 15 per cent of the land area of India—an area which exceeds 0.49 million km^2. In India the incidence of landslides in Himalayas and other hill ranges is an annual and recurring phenomenon. There is a variation in the degree of landslide incidences in various hill ranges (Table 1).

Table 1. Incidences of landslides in India.

Region	Incidences of landslides
Himalayas	High to very high
North-eastern Hills	High
Western Ghats and the Nilgiris	Moderate to high
Eastern Ghats and Vindhayachal	Low

For example, the landslide incidences are high to very high in Himalayas, high in Northeastern hill ranges, high to moderate in Western Ghats and Nilgiris and low in the hill ranges of Eastern Ghats and Vindhyas. The landslide hazard zonation atlas of India published by Building Materials and Technology Promotion Council (BMTPC), Government of India reveals that the Nilgiris district of Tamil Nadu state is one of the severe to very high landslide hazard prone areas of India.

Unprecedented rains triggered about a hundred landslides within an area of 250 sq.kms in the district during 1978. Nearly 200 landslides were recorded during 1979 and causing loss of life and severe damage to property. Though the Nilgiri and other mountainous areas are known to be susceptible to landslides, occurrences of such magnitude were unknown earlier. A total of 28 landslides of medium to large size occurred on 14 November, 2006 along NH67 between Kallar and Pudukkadu villages and along Mountain Railway track between Adderley and Barliyar stations. In the recent times casualities and damage due to landslides have increased in the Nilgiri Hills. More than 110 landslides were reported within five days from 10 to 15 November, 2009, and taken away about 80 human lives, also the vast damage reported on houses, roads and railway lines. This taught the lesson for the need and urgency of landslide planning in Nilgiris among the scientific community and planners (Ganapathy *et al*., 2010).

Some of the major landslides of Nilgiris

23rd October 1865: Worst Storm on record occurred around Ooty and Coonoor. Coonoor Railway station was covered with water up to 5 feet deep. In Ooty Lake rose up to top of willow bound and threatened to breach it.

November 1891: Storm caused many landslips on the Coonoor Ghat, and did great damage to the Kotagiri Metuppalayam road.

December 1902: Twenty one inches of rain (three times the average amount) fell in that month in Coonoor, and at Kotagiri 24 inches (six times the average amount) was received, of which 8.45 inches fell in a single night. The Coonoor railway was blocked for a month the old and new Coonoor railway was blocked for a month the old and new Coonoor ghat roads for nearly as long; and all the traffic of the eastern side of the plateau was thrown upon the Kotagiri ghat, which was itself in a perilous condition slips having occurred throughout and being serious in six places out of its twenty one miles length.

4th October 1905: 6.8 inches of rain fell at Coonoor in three hours and the Coonoor river and its effluents came down in heavy and sudden floods, the former sweeping right over the parapet of the bridge near the railwaystation. The families of the station staff had to be rescued by breaking open the back windows of their quarters with crowbars.

5th November 1978: 323mm of rain was recorded at Ooty of which 243 MM was during the night between 5.00 pm of 4th and 8.00 am of 5th. Many people were killed in Ooty on account of houses collapses, landslides and drowning. Reports were also received regarding the causalities due to landslides and floods in Kookalthorai; Madithorai; Adashola and Kallatti areas of Uthagamandalam Taluk and Manthada of Coonoor Taluk.

November 1979: Heavy rainfall started from 12th November 1979 and the highest rain fall was 114.5mm at Kodanad. On 13th it was 149.4 mm at Coonoor and 169.9 mm at Kodanad. On the 15th night heavy landslide had occurred at Doddacombai, on 16th night there was heavy rain at Coonoor resulting in washing away of one woman and 2 Children. The rainfall recorded at Coonoor and Kodanad was 145.2 mm and 142.2 mm respectively. On 19th there was heavy landslide of 100 yards in width and about 1.00 km in length in Selas of Ketti Village of Coonoor Taluk resulting in filling up of a Valley of 30'- 50'. The heaviest rainfall of the day was 187.6 mm at Coonoor. On 20.11.1979 also, there was heavy rain of 102.2 mm at Coonoor and a heavy landslide at Selas in which a house was completely buried in the debris along with 2 women and 3 children. The rainfall recorded on that day at Kotagiri, Kodanad and Kundah was 90.4 mm, 99.8 mm and 78.0 mm respectively. There was heavy rainfall of 71.0 mm at Devala on 21st. On 28.11.79 also there was heavy rain of 144.2 mm at Coonoor.

25th October 1990: The North East Monsoon was heavy and there was a 'cloud burst'. More than 35 families were buried alive in a place called Geddai.

November 1993: There was another 'cloud burst' on 11-11-1993 in the upper reach of Marappalam of Coonoor Taluk, about 18 huts situated below the road and washing away Coonoor MTP ghat Road for about 1½ km. The Road traffic was suspended for more than a fort night. 12 persons lost their live and 15 persons missing. It is laid that 21 passengers were washed away with two buses. An important highway, sheared stretched of rail road for about 300 m.

11th December 1998: Due to continuous rain fall, one big boulder weighing about 20 m tones fell on the Coonoor Mettupalayam main road and the road was closed for traffic, the rock was blasted and earth slips were removed and traffic was resumed from 14.12.98.

December 2001: Due to continuous rainfall, two massive landslides occurred near pudukadu on the Coonoor-Mettupalayam high way damaging two bridges resulting in the complete closure of traffic. In addition a closer damage was also caused to the railway track between Coonoor and Mettupalayam. Bridge no 55 near hill grove railway station was completely damaged and Bridge No 56 was also damaged.

November 2006: Consequent upon continuous heavy rains in the Nilgiri Hills, numerous landslides were reported to have occurred at the early hours on 14.11.2006 killing one and injuring three persons and disrupting traffic in NH 67 and blocking of Mountain Rail track between Mettupalayam and Coonoor (nilgiris.nic.in; Ganapathy *et al*., 2010).

Drought

Drought is a temporary aberration unlike aridity, which is a permanent feature of climate. It is a normal, recurrent feature of climate and occurs in all climatic regimes and is usually characterized in terms of its spatial extension, intensity and duration. Conditions of drought appear when the rainfall is deficient in relation to the statistical multi-year average for a region, over an extended period of a season or year, or even more (Manual for drought management, 2009). There are three types of droughts; *Meteorological drought* is when the actual rainfall is much less than the climatologically mean of the area.

The country as a whole may have a normal monsoon, but different meteorological districts and sub-divisions can have below normal rainfall. The rainfall categories for smaller areas are defined by their deviation from a meteorological area's normal rainfall (Table 2).

Table 2. Rainfall categories.

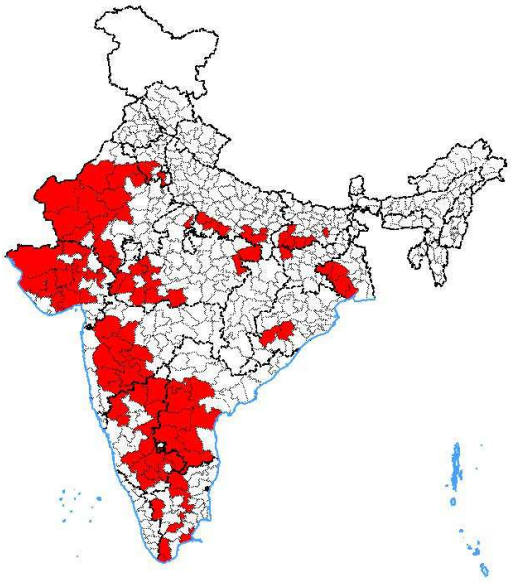
Category	Deviation
Excess	20% or more above normal
Normal	19% above normal-19% below normal
Deficient	20% below normal-59% below normal
Scanty	60% or more below normal

Meteorological history of droughts in India

During 1871-2002, there were 22 major drought years, defined as years with All India Summer Monsoon Rainfall (AISMR) less than one standard deviation below the mean (i.e. anomaly below-10%): 1873, 1877, 1899, 1901, 1904, 1905, 1911 , 1918, 1920, 1941, 195 1, 1965, 1966, 1968, 1972, 1974, 1979, 1982, 1985, 1986, 1987, 2002. The frequency of drought has varied over the decades. From 1899 to 1920, there were 7 drought years. The incidence of drought came down between 1941 and 1965 when the country witnessed just three drought years. Again, during 1965-87, of the 21 years, 10 were drought years and the increased frequency was attributed to the EI Nino Southern Oscillation (ENSO). Among the drought years, the 1987 drought was one of the worst droughts of the century, with an overall rainfall deficiency of 19%. It affected 59-60% of the crop area and a population of 285 million. In 2002 too, the overall rainfall deficiency for the country as a whole was 19%. Over 300 million people spread over 18 States were affected by drought in varying degrees. Around 150 million cattle were affected due to lack of fodder and water. Food grains production registered the steepest fall of 29 million tonnes. No other drought in the past had caused reduction in food grain production to this extent (Samra, 2004).

Hydrological drought results from the depletion of surface water causing very low stream flow and drying of lakes, rivers and reservoirs and *Agricultural drought* resulting from depletion of soil moisture resulting in acute crop stress and fall in agricultural productivity. India has been severely affected by droughts over the past years claiming millions of lives. The agriculture in India is totally dependent on rains, which when is not adequate results in poor yielding of crops. This is particularly true of major drought-prone regions such as southern and eastern Maharashtra, northern Karnataka, Andhra Pradesh, Orissa, Gujarat, and Rajasthan (Fig. 5). In India there is also a history of droughts leading to famines. During the major drought of 2000-2001, a total of eight states had fallen short of crops. Government policies and preventions play the most significant role in coping up with these environmental disasters.

Fig. 5. Map of drought prone districts of India (Drought prone areas are in red).



Drought is a normal, recurrent feature of climate. It occurs almost everywhere, although its features vary from region to region. Defining drought is therefore difficult; it depends on differences in regions, needs, and disciplinary perspectives. Based on the many definitions that have appeared in the literature, for example, we might define drought in Libya as occurring when annual rainfall is less than 180 mm, but in Bali, drought might be considered to occur after a period of only 6 days without rain! In the most general sense, drought originates from a deficiency of precipitation over an extended period of time, resulting in a water shortage for some activity, group, or environmental sector. Whatever the definition, it is clear that drought cannot be viewed solely as a physical phenomenon. Drought is a perennial feature in some parts of the Tamil Nadu (Table 3). In fact drought is a significant environmental problem too as it is caused by rainfall less than the average of the year and no/ less rainfall extending over a long period of time.

Experts in the field are of the conviction that drought can no more be considered a natural disaster. Rather it is manmade. If only the requisite awareness were to be generated among the people as to the need to save rain water, droughts can be mitigated. Agricultural activities can be sustained throughout the year with the available rainfall in Tamil Nadu. In the year 1995, there had been acute water scarcity and severe drought for the State of Tamil Nadu due to failure of North East monsoon. About 17 districts were fully affected and 14 Taluks in other 5 districts were declared drought affected areas. The Government sanctioned a sum of Rs. 62.69 crores for providing drinking water supply besides Rs. 35 crores from Calamity Relief Fund (CRF) for road works in the districts Ramanathapuram, Perambalur, Tiruvallur,

Thanjavur and Nagapattinam. Scarcity of drinking water continued to be felt in 19 districts in 1996 also. The Government sanctioned a sum of Rs.11.79 crores from CRF to combat drinking water scarcity. In the year 1997 scarcity of drinking water continued in 15 districts. The Government sanctioned a sum of Rs.26.44 crores from CRF to combat drinking water scarcity. In the year 2000, a sum of Rs.3 crores was sanctioned by the Government from CRF to meet the expenditure in connection with the drought situation which prevailed in the districts of Ramanathapuram, Thoothukkudi, Vellore and Tiruvannamalai for providing sinking borewells, flushing of borewells, providing ring wells, construction of open wells, replacement of motor and for transportation of water.

Table 3. Administrative districts chronically affected by drought conditions (After Nagarajan, 2003).

State	Districts
Andhra Pradesh	Anantpur, Chittoor, Cuddapah, Hyderabad, Kurnool, Mehboobnagar, Nalgonda, Prakasam.
Bihar	Munger, Nawadah, Rohtas, Bhojpur, Aurangabad, Gaya.
Gujarat	Ahmedabad, Amreli, Banaskantha, Bhavnagar, Bharuch, Jamnagar, Kheda, Kutch, Mehsana, Panchmahal, Rajkot, Surendranagar.
Haryana	Bhiwani, Gurgaon, Mahendranagar, Rohtak.
Jammu and Kashmir	Doda, Udhampur.
Karnataka	Bangalore, Belgaum, Bellry, Bijapur, Chitradurga, Chickmagalur, Dharwad, Gulbarga, Hassan, Kolar, Mandya, Mysore, Raichur, Tumkur.
Madhya Pradesh	Betul, Datia, Dewas, Dhar, Jhabua, Khandak, Shahdol, Shahjapur, Sidhi, Ujjain.
Maharashtra	Ahmednagar, Aurangabad, Beed, Nanded, Nashik, Osmanabad, Pune, Parbhani, Sangli, Satara, Solapur.
Orissa	Phulbani, Kalahandi, Bolangir, Kendrapada.
Rajasthan	Ajmer, Banswada, Barmer, Churu, Dungarpur, Jaisalmer, Jalore, Jhunjunu, Jodhpur, Nagaur, Pali, Udaipur.
Tamil Nadu	**Coimbatore, Dharmapuri, Madurai, Ramanathapuram, Salem, Tiruchirapali, Tirunelveli, Kanyakumari.**
Uttar Pradesh	Allahabad, Banda, Hamirpuf, Jalana, Mirzapur, Varanasi.
West Bengal	Bankura, Midnapore, Purulia.
Jharkhand	Palamau.
Chhattisgarh	Khargaon.

In the year 2001 a sum of Rs.75 crores was sanctioned under CRF by the Government to Chennai Metropolitan Water Supply and Sewerage Board to meet the expenditure for tackling the drinking water scarcity in Chennai City by way of transportation of water through rail wagons and Lorries. Another sum of Rs.1.36 cores was sanctioned to mitigate the drinking water problem in 15 Municipalities and nearly 45 Town Panchayats and Village Panchayats in 9 districts. Totally a sum of Rs.76.36 crores has been sanctioned from CRF to mitigate the drinking water problem in Chennai City and other 9 districts. The State of Tamil Nadu experienced a major disaster, an unprecedented drought, in all the districts of Tamil Nadu during the year 2002-2003. In the year 2002, 19 districts out of 29 districts received deficit rainfall, the departure from the normal ranging from 21%–52%. The major reservoirs in the State had less than 10% of their storage capacity and more than 95% of the tanks and ponds had gone dry. The Mettur Reservoir which provides water to delta areas, the rice bowl of the State received the lowest inflow since 1935. The Government responded to the situation by monitoring the situation closely, getting information from different sources and providing timely and adequate assistance especially in respect of drinking water. Two Central Teams visited the drought affected areas during the year. A memorandum was sent in Aug 2002 and an additional memorandum in Jan/Feb 2003 seeking Government of India's assistance to tackle the drought situation. A number of steps were also taken to alleviate the condition of small and marginal farmers and agricultural labourers notable among which was the provision of food security through the mechanism of the noon-meal programme.

Policies contributing to climate change mitigation in TN

As in many other countries, India has a number of policies that, while not driven by climate concerns, contribute to climate mitigation by reducing or avoiding Green House Gas (GHG) emissions (Specific estimates of the emission impacts of the policies described below are in most cases not available). However, a recent analysis by The Energy and Resources Institute (TERI) concluded that in the absence of a number of energy policies that are currently being implemented, CO_2 emissions would be nearly 20% higher compared to business as usual scenarios in both 2021 and 2031 (TERI, 2008). The forests in Tamil Nadu are managed with the enhancing tree cover outside forests for livelihood security and climate change mitigation. As per the Intergovernmental Panel on Climate Change (IPCC)'s recent report, India's monsoons will undergo significant change, increasing in intensity while decreasing in duration. That change is predicted to negatively impact India's farmers, 60 percent of whom are smallholders. In Tamil Nadu, southern India, villagers have revived ancient systems of storing surface and groundwater that are putting them in a good position to contend with today's changing climate. The Electricity Act, 2003, requires State Electricity Regulatory Commissions to specify a percentage of electricity that the electricity distribution companies must procure from renewable sources. Several Commissions have already

operationalized this mandate, and also notified preferential prices for electricity from renewables. This has contributed to acceleration in renewable-electricity capacity addition, and over the past three years, about 2,000 MW of renewable-electricity capacity has been added in India every year, bringing the total installed renewable capacity to over 11,000 MW. Of this, a little over 7,000 MW is based on wind power; India now has the fourth largest installed wind capacity in the world. The National Hydro Energy Policy has resulted in the accelerated addition of hydropower in India, which is now over 35,000 MW. An Energy Conservation Building Code (ECBC) was launched in May, 2007, which addresses the design of new, large commercial buildings to optimize the building's energy demand. Commercial buildings are one of the fastest growing sectors of the Indian economy, reflecting the increasing share of the services sector in the economy. Nearly one hundred buildings are already following the Code, and compliance with it has also been incorporated into the Environmental Impact Assessment requirements for large buildings. The National Environment Policy, 2006, provides the basis for the integration of environmental considerations in the policies of various sectors.

The policy statement for Abatement of Pollution, 1992, stresses the prevention of pollution at the source based on the "polluter pays" principle. The Forest Policy, 1988, highlights environmental protection through preservation and restoration of the ecological balance. The policy seeks to substantially increase the forest cover in the country through afforestation programmes. The statutory framework for the environment and energy efficiency includes the Indian Forests Act, 1927, the Water (Prevention and Control of Pollution) Act, 1974, the Air (Prevention and Control of Pollution) Act, 1981, the Forest (Conservation) Act, 1980, and the Environment (Protection) Act, 1986. Other enactments include the Public Liability Insurance Act, 1991, the National Environment Tribunal Act, 1995, the National Environment Appellate Authority Act, 1997, the Energy Conservation Act, 2001, and the Electricity Act, 2003.

The courts have also elaborated on the concepts relating to sustainable development, and the 'polluter pays' and 'precautionary' principles. In India, matters of public interest, particularly pertaining to the environment, are articulated effectively through a vigilant media, an active NGO community, and through the judicial process which has recognized the citizen's right to a clean environment as a component of the right to life and liberty (Bureau of Energy Efficiency, 2007). India should regard the issue of climate-change mitigation as a diplomatic challenge of getting the right terms, not as a bugbear to be feared and shunned (Joshi and Patel, 2003).

Conclusion

Tamil Nadu State Government will formulate an action plan on the lines of National Action Plan on Climate Change in which solar energy will get due significance. In National action plan 8 national missions were mentioned to mitigate climate change. They are National Solar Mission, National Mission for Enhanced Energy Efficiency, National Mission on Sustainable Habitat, National Water Mission, National Mission for Sustaining the Himalayan Ecosystem, National Mission for a "Green India", National Mission for Sustainable Agriculture and National Mission on Strategic Knowledge for Climate Change (Prime minister's council on climate change. 2010). If the same missions persuaded in the state action plan, then it may achieve great success. It is strongly felt that a comprehensive vulnerability assessment of the various natural hazards of Tamil Nadu needs to be undertaken. It must integrate the climate change considerations into all the developmental activities happening in the region.

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