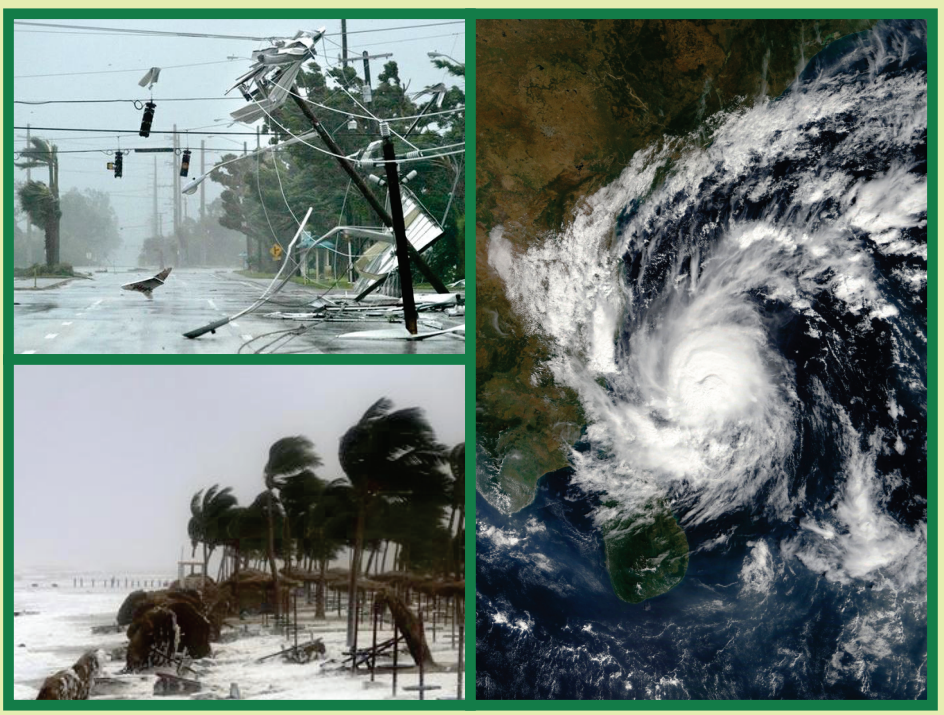
सत्यमेव जयते

STUDY REPORT ON
GAJA CYCLONE 2018



September 2019

NATIONAL DISASTER MANAGEMENT AUTHORITY
MINISTRY OF HOME AFFAIRS
GOVERNMENT OF INDIA

Study Report on
Gaja Cyclone 2018

Study Report on Gaja Cyclone 2018

A publication of:
National Disaster Management Authority
Ministry of Home Affairs
Government of India
NDMA Bhawan
A-1, Safdarjung Enclave
New Delhi - 110029

September 2019

Study Report on Gaja Cyclone 2018

National Disaster Management Authority
Ministry of Home Affairs
Government of India

Table of Content

राष्ट्रीय आपदा प्रबंधन प्राधिकरण
National Disaster Management Authority
भारत सरकार
Government of India

सत्यमेव जयते

FOREWORD

In India, tropical cyclones are one of the common hydro-meteorological hazards. Owing to its long coastline, high density of population and large number of urban centers along the coast, tropical cyclones over the time are having a greater impact on the community and damage the infrastructure. Secondly, the climate change is warming up oceans to increase both the intensity and frequency of cyclones. Hence, it is important to garner all the information and critically assess the impact and manangement of the cyclones.

Cyclone Gaja was one of the major cyclones to hit the Tamil Nadu coast in November 2018. It lfeft a devastating tale of destruction on the cyclone path damaging houses, critical infrastructure for essential services, uprooting trees, affecting livelihoods etc in its trail. However, the loss of life was limited. This has been achieved over time with targeted mitigation, better preparedness, swift response and community awareness.

This report documents the actions taken by the state government of Tamil Nadu in order to cap the number of mortality and efforts put in place for faster restoration of essential services and infrastructure. It also critically analyses these efforts to identify gaps for making a cyclone-resilient society. Finally, it draws upon the best practices and lessons learnt to suggest the future course of action.

We acknowledge the support and cooperation extended by the government of Tamil Nadu in our efforts to document the best practices adopted during the Cyclone Gaja. We are hopeful that this study will help other state Governments in cyclone mitigation, preparedness and response.

Kamal Kishore
Member, NDMA

Dr. D.N. Sharma
Member, NDMA

Lt. Gen. N.C. Marwah
Member, NDMA

G.V.V. Sarma
Member Secretary, NDMA

एन.डी.एम.ए. भवन, ए-1, सफदरजंग एन्कलेव, नई दिल्ली-110029/ NDMA Bhawan, A-1, Safdarjung Enclave, New Delhi-110 029
दूरभाष/Tel.: +91 11 26701700 फैक्स/Fax : +91 11 26701831

Acknowledgement

Cyclone is one of the most common and frequent disasters, and affects a large number of people in India. Our cyclone management system, which has come a long way since the Super cyclone struck Odisha in 1999, has lately drawn praise from across the world. An important aspect of preparedness is to study each event to learn lessons, identify gaps and document best practices so that future events are handled in an even more efficient manner.

We would like to express our gratitude to the Government of Tamil Nadu for extending all possible help and cooperation in conducting this study.

We thank Dr. K. Satyagopal, Additional Chief Secretary, Govt. of Tamil Nadu, and his staff for facilitating this study. We also thank the District Collectors of Thanjavur and Nagapattinam along with the entire staff of these districts for their detailed interactions with us.

Shri G. V. V. Sarma, Member Secretary, NDMA; Lt. Gen. N. C. Marwah (Retd.), Dr. D. N. Sharma and Shri Kamal Kishore, Members, NDMA, and Dr. Pradeep Kumar, the then Secretary in-charge, NDMA, wholeheartedly supported this study tour and the writing of this document.

Dr. V. Thiruppugazh, Joint Secretary (Policy and Plan), NDMA, led the team that visited Tamil Nadu for this study. His insights, suggestions and guidance have played a key role in preparing and finalising this report. Other Members of the team included Dr. Pavan Kumar Singh (Joint Advisor, Operations), Shri Nawal Prakash (Senior Research Officer, NDMA) and Shri Anuj Tiwari (Senior Consultant, Policy, Plan and Mainstreaming). Besides this team, Dr. Swati Sulangna (Senior Consultant, Climate Change) has contributed to the writing of this report.

The staff of the Policy and Plan Division, NDMA, has provided institutional support.

Executive Summary

Tamil Nadu is historically one of the most vulnerable States to tropical cyclone. The total geographical area of Tamil Nadu is 13 Million hectares and it has a coastline of 1,076 km which is about 15% of the coastline of India. The State is multi-hazard prone, the major natural hazards being Cyclonic storms, Urban and Rural floods, and periodic Droughts. Some of the tropical cyclones that hit Tamil Nadu are Gaja (2018), Ockhi (2017), Vardha (2016), Nilam (2012), Thane (2011), Jal (2010) and Nisha (2008).

Severe Cyclonic Storm Gaja originated as a low-pressure system over the Gulf of Thailand. The weak system intensified into a depression over the Bay of Bengal on November 10 and further intensified to a cyclonic storm on November 11, being classified 'Gaja'. Cyclone Gaja made landfall in South India, at Vedaranyam, Tamil Nadu. At the time of landfall of the cyclone, 100-120 kmph speed was experienced. The highest sustained speed was recorded in Adhirampattinam at 165 kmph and 160 kmph at Muthupet. The cyclone Gaja affected 08 districts of Tamil Nadu, namely, Nagapattinam, Thanjavur, Thiruvarur, Pudukottai, Karaikal, Cuddalore, Trichy and Ramanathapuram.

To build upon the learning of Cyclone “Gaja” and to document the lessons learnt and best practices, the present study was undertaken with the following objectives:

Objectives

The objectives of this study were as follows:

- To critically analyze the role of disaster managers in the management of Cyclone Gaja with special reference to early warning, preparedness, impact, response, and community preparedness.
- To assess the impact of Cyclone Gaja on the infrastructure, services, and communities.
- To study the measures undertaken by the Central Government, State Governments and District Administrations to reduce the mortality and impact of cyclones in the State of Tamil Nadu.
- To document the best practices undertaken during the management of Cyclone Gaja.
- Suggest evidence-based recommendations for better management of Cyclones in the future.

Approach

An assessment framework was developed to learn the impact and response of the Cyclone Gaja in Tamil Nadu. The present study was conducted from 12 to 15 February 2019 in consultation with Government of Tamil Nadu and District Administration of affected Districts. Two worst affected districts were also visited during the period. An interview schedule was prepared in advance (Annexure I) for different stakeholders namely government officials, civil society and local communities. In-depth interviews were held with government officials at the state and district level like Additional Chief Secretary/ State Relief Commissioner, Officials of line Departments like Electricity, Animal Husbandry, Agriculture, PWD, etc. A number of focused group discussions were held with civil society organizations and affected communities. In addition, a team of NDMA for direct observation in the field visited two of the districts affected.

Layout of the Report

Chapter I sets the context and purpose of the report beginning briefly with background and prominent studies on various aspects of cyclone. The chapter also highlights the major cyclone in India. The study design in terms of objective, methodology and limitations of the study are detailed herein.

Chapter II focuses on various aspects of Cyclone Gaja including formation, forecast, Landfall, physical and climatologically characteristics and early warning.

Chapter III highlights the preparedness measures undertaken by state government.

Chapter IV brings out the impact of Cyclone Gaja on population, livelihood and infrastructure.

Chapter V collates all the responses geared towards management of Cyclone Gaja by the Central Government, State Government and other stakeholders.

Chapter VI critically examines various aspects of Cyclone Gaja like early warning, preparedness, impact and response to identify gaps for improvement of disaster management in case of future cyclones.

Chapter VII highlights the best practices undertaken for management of Cyclone Gaja

Chapter VIII tries to bring out the major lessons learnt in case of the Cyclone Gaja and recommendations for future strategies for cyclone management and planning.

Analysis

Preparedness plays a significant role in disaster risk reduction and critical for preventing loss of lives. Various measures have been undertaken at the institutional level in order to manage

disaster risks like designing and maintaining Incident Response Systems, Inter-Departmental Teams, Disaster Response Guards, mobile teams as an effective monitoring mechanism, etc. A number of mitigation measures have been undertaken in order to address the cyclone risk. Early Warning Systems and information dissemination systems like Tamil Nadu System for Multi-Hazard Impact Assessment, Alert and Emergency Response Planning and Tracking (TNSMART) have played a major role in reducing the number of deaths.

Loss and damage due to the impact of the cyclone were very high. The reported number of deaths accounted to 52 persons and 259 persons were injured. Almost 5.6 lakh persons were directly affected, losing their livelihoods, clothes or utensils. A large number of pucca and kutcha houses were partially or fully damaged. Maximum brunt was borne by coconut farmers and people dependent on primary livelihoods.

Pre-disaster response like prepositioning of Disaster Response Teams, Evacuation by the local administration, preparation of cyclone shelters, mobilization of relief material, etc. were initiated on receipt of early warning from IMD. Actions like Search and Rescue, Emergency Helpline, Relief distribution were carried out the post-disaster strike. Cyclone Gaja led to extensive damages of infrastructure in different sectors. As a part of disaster response, the temporary restoration of these infrastructural damages was addressed on a war footing to restore essential services.

Based on the analysis certain best practices, lessons learnt and a set of recommendations have been developed for future planning and informed decision making. Highest level of preparedness and monitoring mechanism, vulnerability mapping and analysis, pool of trained volunteers as Disaster Response Guards, better inter-departmental coordination, web-GIS based mobile application TNSMART, strengthened TNSDRF, animal shelters are some of the best practices followed in Tamil Nadu for management of Gaja cyclone.

Recommendations

Important recommendations, based on the analysis, include HRVA for all districts, strengthening of TNSDRF, Fire Services and other agencies engaged in response and rescue, trained team of community volunteers, including women with specialised skills, a supply chain mechanism, list of geographical coordinates of identified rescue and relief points, alternate livelihood, cyclone resistant building designs and multi-purpose cyclone shelters.

1 Introduction

1.1 Background

1.1.1 India is vulnerable, in varying degrees, to a large number of natural as well as man-made disasters. 58.6 per cent of the landmass is prone to earthquakes of moderate to very high intensity; over 40 million hectares (12 per cent of land) is prone to floods and river erosion; of the 7,516 km long coastline, close to 5,700 km is prone to cyclones and tsunamis; 68 per cent of the cultivable area is vulnerable to drought and hilly areas are at risk from landslides and avalanches. Further, the recent scientific researches' are pointing towards a plausible connection in the increase of frequency and intensity of cyclones in the Bay of Bengal due to climate change.

1.2 Vulnerability to Cyclone

1.2.1 There are 13 coastal States/ UTs encompassing 84 coastal districts which are affected by cyclones. Four States (Andhra Pradesh, Odisha, Tamil Nadu and West Bengal) and one UT (Pondicherry) on the East Coast and One State (Gujarat) on the West Coast are more vulnerable to cyclone disasters. 40% of the total population lives within 100 km of coastline. Analyzed data for the period 1980-2000 shows that on an average, annually 370 million people are exposed to cyclones in India. Cyclones occur in the month of May-June and October-November, with a primary peak in November and secondary peak in May.

1.3 Tropical Cyclones

1.3.1 Tropical Cyclones (TCs) are one of the natural hazards that affect India almost every year causing huge losses of lives and property. The term 'Cyclone' is used globally to cover tropical weather systems (World Meteorological Organisation (WMO), 2009), in which winds equal or exceed the minimum of 34 knot (62 kmph). These are intense low-pressure systems of the earth atmosphere system which may develop into extreme weather events of the tropics. TCs are known by many names the world over like cyclones, typhoons, hurricanes, etc. Though TCs differ by name across regions, they are primarily classified according to associated maximum sustained surface wind speed (MSW). The

classification, however, varies from region to region. These low pressure systems with varying intensity of depression are known as cyclonic disturbances (Mohapatra, 2015).

1.3.2 Tropical disturbances are classified into different nomenclature as adopted by Regional Specialised Meteorological Centre (RSMC) – Tropical Cyclones, New Delhi. The classification of disturbances is shown in the following Table – 1.

Table 1: Classification of Low-Pressure Systems at RSMC – Tropical Cyclones, New Delhi

Sl. No.	Maximum Sustained Surface Wind Speed in knot (kmph)	Nomenclature
1.	Less than 17 (< 31)	Low Pressure Area (L)
2.	17 to 27 (31-49)	Depression (D)
3.	28 to 33 (50-61)	Deep Depression (DD)
4.	34 to 47 (62-88)	Cyclonic Storm (CS)
5.	48 to 63 (89-117)	Severe Cyclonic Storm (SCS)
6.	64 to 89 (118-166)	Very Extremely Cyclonic Storm (VSCS)
7.	90 to 119 (167-221)	Extremely Severe Cyclonic Storm (ESCS)
8.	120 and above (≥ 222)	Super Cyclonic Storm (SuCS)

Source: Annual Review, WMO-ESCAP, 2015

1.4 Literature Review

Tropical Cyclones and Damaging Factors

1.4.1 Tropical Cyclones are the most frequent natural disaster in India. The consequences of the tropical cyclones are Storm surge, flood, high winds, inundation, and erosion etc. along with loss of life, casualties, and damages to the properties causing socio-economic loss (Nair et al, 2018).

1.4.2 Any cyclone, in principle, carries the potential to be severe, but those associated with high storm surge and resulting coastal inundation are indeed deadly. In the north Indian Ocean basin, the phenomenon of Cyclone is recurring, however, not all of them produce significant storm surge and coastal inundation. The role of storm surge in the increasing death toll is widely documented (Dube et al 2009; Shaji et al 2014). Following Table shows, some of the major cyclonic disasters in India and Bangladesh characterised with high storm surge and corresponding death tolls.

Table 2: Historic major Cyclones in India and Bangladesh

Year	Name of the Country	No. of Deaths	Storm Surge (Height in ft)
1737	Hooghli, West Bengal, India	3,00,000	40
1876	Backerganj, Bangladesh	25,000	10-40
1885	False Point, Orissa, India	5,000	22
1960	Bangladesh	5,490	19
1961	Bangladesh	11,468	16
1970	Bangladesh	2,00,000	13-17
1971	Paradeep, Orissa, India	10,000	13-17
1977	Chirala, Andhra Pradesh, India	10,000	16-18
1990	Andhra Pradesh, India	990	13-17
1991	Bangladesh	1,38,000	7-20
1998	Kandla, India	1,173	--
1999	Paradeep, Orissa, India	9,885	30

Source: De et al, 2005.

1.4.3 The role of the tidal surge in causing death and destruction is further highlighted in the case of cyclones during recent times (Table 3). Hurricane Katrina, in the United States (US) recorded a maximum of 27.8 ft storm surge (Knabb et al, 2005), while cyclone Sidr, generated a 20 ft surge in Bangladesh (Paul, 2009). Super cyclone Gonu, 2007 that affected Oman and Iran had a storm surge height of 5 metres (Fritz et al, 2010). Similarly, Nargis 2008, one of the deadliest cyclones to hit Myanmar reported a maximum storm surge height of 5.60 m (Fritz et al, 2009). Haiyan that hit the Philippines in 2013 had a surge height of 15 ft-20 ft (Lagmay et al, 2015). In comparison, cyclone Phailin 2013 recorded storm surge height of 2-2.5 m (6.5-8.2 ft) (IMD, 2013: 20) and Hudhud 2014 reported 1.4 m (4.5 ft) (IMD, 2014:1). Clearly as far as storm surge height is concerned, both Phailin and Hudhud were of less magnitude.

Table 3: Recent Catastrophic (Tropical) Cyclones and Storm Surge Height

Name of Tropical Cyclone	Year and Country Affected	Human Deaths	Storm Surge-Maximum Height (ft)
Katrina	2005, US	1,833	27.8
Sidr	2007, Bangladesh	3,406	16.67-20
Gonu	2007, Oman and Iran	72	5 m (16.40)
Nargis	2008, Myanmar	1,38,000	5.60 m (18.37)
Haiyan	2013, Philippines	6,300 (excluding 1,061 missing)	15-20

1.4.4 In addition to the height of storm surge, speed and force of surge, the number of times it occurs and duration are important factors in determining mortalities (Paul, 2009: 300).

1.4.5 Moreover, the topography of landfall location plays a crucial role in determining the extent of inundation, though this particular aspect remains far less explored. For example, in the case of super cyclone Gonu 2007, coastal inundation was limited largely due to steep bathymetry though the surge height was 5 m (Fritz et al 2009: 106). When a high storm surge combines with low lying coastal areas, it results in massive inundation (Dube et al 1997). Penetration can sometimes be deep inland, for example, it was up to 50 km in the case of cyclone Nargis in Myanmar (Fritz et al 2009), and up to 20 km during the Orissa super cyclone of 1999 (Dash 2002). Inundation up to 9 km was along bays and rivers (Knabb et al 2005: 9). Again to compare, Phailin caused inundation limited up to 1 km (IMD 2013: 1), while Hudhud even lesser, up to 500 m.

Evacuation for Minimizing the Deaths

1.4.6 Evacuation, in general, and that for a tropical cyclone in particular, is among the most investigated problems in disaster studies (Perry 1979; Lindell and Perry 1991; Sorensen, 1991). Tropical cyclone related evacuation has been studied in a number of country settings, for example, in the USA (Baker, 1979 and 1991; Galdwin et al 2001: Horney et al, 2010; Riad and Noris, 1998), Bahamas (Westgate, 1978), Mexico (Aguirre 1991), Australia (Yates and Anderson-Berry, 2004), Bangladesh (Paul, 2009) and India (Sharma et al, 2009).

1.4.7 To explain differential public response to tropical cyclone warning, a number of factors have been identified such as safety of one's house (Baker 1979 and 1991; Aguirre, 1991; Galdwin et al 2001; King et al 2006); risk of looting when away from home, inconveniences of various kinds at public shelters (Haque, 1995; Paul and Rahman, 2006; Zhai and Ikeda, 2006); role of local government in evacuation such as nature of engagement, formof warning, kind of provision (Westgate, 1978; Baker 1991; Riad and Norris, 1998), social context, for example role of friends, relatives and one's past experience (Lindell et al, 2005; Christensen and Ruch 1980) and physical environment context (Westgate, 1978; Dash, 2014).

1.4.8 Public evacuation can be spontaneous and/ or planned. It is broadly categorised into three types; voluntary, recommended and mandatory (Wolshon et al, 2001). Further, different evacuation approaches have been identified, for example, preventive, vertical, shelter-in-place (in situ) or a combination of them (Kolen and Helsloot 2012; Kolen et al 2013; Velotti et al 2013). In vertical evacuation, people are directed to specially designed buildings within the impact zone (Salmon, 1984).

Recent Major Cyclones and Cyclone-prone Districts in India

1.4.8 Ninety-six districts including 72 districts touching the coast and 24 districts not touching the coast, but lying within 100 km from the coast have been classified based on their proneness. Out of 96 districts, 12 are veryhighly prone, 41 are highly prone, 30 are moderately prone, and the remaining 13 areless prone. Twelve very highly prone districts include South and North 24 Praganas, Medinipur, and Kolkata of West Bengal, Balasore, Bhadrak, Kendrapara, and Jagat singhpur districts of Odisha, Nellore, Krishna, and East Godavari districts of Andhra Pradesh and Yanam of Puducherry. The remaining districts of Odisha and Andhra Pradesh, which touch the coast, are highly prone districts. The north Tamil Nadu coastal districts are more prone than the south Tamil Nadu districts (south of about 10□N Latitude). Most of the coastal districts of Gujarat and north Konkan are also highly prone districts. The remaining districts on the west coast and south Tamil Nadu are either moderately prone or less prone districts (Mohapatra, 2015).

1.4.10 Based on the incidences of cyclones, strength of wind speed, Probable Maximum Storm Surge (PMSS), Probable Maximum Precipitation (PMP), the proneness of cyclones in various districts of India has been categorized (Mohapatra, 2015). Table 3 below clearly shows that Nagapattinam District of Tamil Nadu falls under category P2, whereas, Thanjavur District falls under category P3. These two districts were the worst affected by Cyclone Gaja.

Table 4: Cyclone prone districts of India touching the coast based on the frequency of total cyclones and severe cyclones; strength of actual/estimated wind speed with rating of 2, 4, 7 and 10, PMSS and PMP for all districts

Ratings based on								
State	Districts	No. of severe cyclones	Total no. of cyclones	Strength of wind speed	PMSS	PMP	Mean rating	Category of proneness
AP	Nellore	7	10	10	7	7	8.2	P1
AP	East Godavari	5	10	10	7	7	7.8	P1
AP	Krishna	5	7	10	7	7	7.2	P1
Odisha	Balasore	5	10	7	10	7	7.8	P1
Odisha	Kendrapara	5	10	10	10	7	8.4	P1
Odisha	Jagatsingh pur	5	10	10	10	7	8.4	P1
Odisha	Bhadrak	5	10	7	10	7	7.8	P1
Puducherry	Yanam	5	10	10	7	7	7.8	P1
West Bengal	South 24-Pragana	10	10	10	10	7	9.4	P1
West Bengal	Medinipur	7	10	10	10	7	8.8	P1
AP	Srikakulam	5	7	10	5	7	6.8	P2
AP	Guntur	3	3	10	10	7	6.6	P2
AP	Visakhapatnam	5	5	10	5	7	6.4	P2
AP	West Godavari	3	5	10	7	7	6.4	P2
AP	Prakasam	3	3	10	7	7	6	P2
AP	Vizianagaram	3	3	10	5	7	5.6	P2
Daman & Diu	Diu	5	5	7	5	10	6.4	P2
Daman & Diu	Daman	3	3	4	7	10	5.4	P2
Goa	North Goa	3	3	4	7	10	5.4	P2
Goa	South Goa	3	3	4	7	10	5.4	P2
Gujarat	Junagadh	5	5	7	5	10	6.4	P2
Gujarat	Ahmedabad	3	3	7	7	7	5.4	P2
Gujarat	Kachchh	5	5	7	5	7	5.4	P2
Gujarat	Bhavnagar	3	3	7	7	7	5.4	P2
Gujarat	Jamnagar	3	5	7	5	10	6.0	P2

Gujarat	Anand	3	3	7	7	7	5.4	P2
Gujarat	Navsari	0	3	7	7	10	5.4	P2
Gujarat	Surat	0	3	7	7	10	5.4	P2
Gujarat	Bharuch	0	3	7	7	10	5.4	P2
Gujarat	Valsad	3	3	4	7	10	5.4	P2
Gujarat	Rajkot	3	3	7	5	10	5.6	P2
Gujarat	Porbandar	3	3	7	5	10	5.6	P2
Lakshadweep	Lakshadweep	5	5	7	0	10	5.4	P2
Maharashtra	Thane	3	3	4	7	10	5.4	P2
Maharashtra	Mumbai suburban	3	3	4	7	10	5.4	P2
Maharashtra	Raigarh	3	3	4	7	10	5.4	P2
Odisha	Ganjam	5	7	10	5	5	6.4	P2
Odisha	Puri	3	5	10	5	7	6	P2
Odisha	Khordha	3	3	10	5	7	5.6	P2
Puducherry	Karaikal	3	5	7	7	7	5.8	P2
Puducherry	Puducherry	3	3	7	5	10	5.6	P2
Tamil Nadu	Pudukkottai	3	3	4	10	7	5.4	P2
Tamil Nadu	Cuddalore	5	5	7	5	10	6.4	P2
Tamil Nadu	Kanchipuram	7	7	4	5	10	6.6	P2
Tamil Nadu	Tiruvarur	3	5	7	7	7	5.8	P2
Tamil Nadu	Nagappattinam	3	5	7	7	10	6.4	P2
Tamil Nadu	Chennai	3	3	10	5	7	5.6	P2
Tamil Nadu	Thoothukudi	3	3	4	10	7	5.4	P2
Tamil Nadu	Viluppuram	3	3	7	5	10	5.6	P2
A & N Island	A & N Islands	3	5	7	-	-	5	P3
Gujarat	Vadodara	3	3	2	7	10	5	P3
Gujarat	Amreli	3	3	7	5	7	5	P3
Karnataka	Udupi	0	3	2	7	10	4.4	P3
Karnataka	Uttar Kannada	0	3	2	7	10	4.4	P3
Karnataka	Dakshin Kannada	0	3	2	7	10	4.4	P3

Kerala	Kozhikode	3	3	4	7	7	4.8	P3
Kerala	Malappuram	3	3	2	7	7	4.4	P3
Kerala	Thrissur	0	3	2	7	7	3.8	P3
Kerala	Kannur	3	3	2	5	7	4	P3
Kerala	Kollam	0	3	4	5	5	3.4	P3
Kerala	Alappuzha	3	3	4	5	3	3.6	P3
Kerala	Thiruvanantha puram	3	3	4	5	5	4.0	P3
Maharashtra	Ratnagiri	3	3	4	5	10	5	P3
Maharashtra	Sindhudurg	3	3	4	5	10	5	P3
Puducherry	Mahe	3	3	4	7	7	4.8	P3
Tamil Nadu	Ramanatha puram	3	3	4	10	5	5	P3
Tamil Nadu	Tirunelveli	3	3	4	10	5	5	P3
Tamil Nadu	Thanjavur	3	3	7	7	5	5	P3
Tamil Nadu	Tiruvallur	3	3	7	5	7	5	P3
Tamil Nadu	Kanyakumari	3	3	4	5	3	3.6	P3
Kerala	Kasargod	0	3	2	5	5	3	P4
Kerala	Ernakulam	0	3	2	5	5	3	P4
	Total	72						

Cyclone Vulnerability of Tamil Nadu

1.4.11 Tamil Nadu is multi hazard prone and faces the brunt of the Cyclonic storms during the Northeast Monsoon periods. In addition, Tamil Nadu also faces spells of heavy downpours and cloud bursts resulting in damages due to floods (G.O (Ms) No. 481, 10.12.2018, Government of Tamil Nadu).

1.4.12 The total geographical area of Tamil Nadu is 13 Million hectares and it has a coastline of 1,076 kms which is about 15% of the coastline of India. The State is multi-hazard prone, the major natural hazards being cyclonic storms, Urban and Rural floods and periodic droughts. The State is also prone to Landslides, Sea Erosion and Sea Water Incursion in specific pockets. The State is also exposed to the risk of Tsunami. The State has witnessed natural disasters of severe intensity since the beginning of the current century. The large scale loss of lives and colossal damages to the infrastructure

during Tsunami 2004, battering of Districts of Cuddalore, Nagapattinam, Chennai and its surroundings during 2015 Floods, extensive damages in several districts during cyclones Nisha, Jal, Thane, Nilam and Vardah, severe damages in Kanyakumari during Ockhi cyclone's and crippling of the entire state due to the severe drought 2016-2017, unknown to the recorded history in Tamil Nadu, are some of the major disasters that impacted Tamil Nadu already during the current century.

1.4.13 Among the coastal disasters tropical cyclones followed by storm surges are one of the catastrophic natural disasters occurring in India. Some of the deadliest tropical cyclone hit in the country are Ockhi (2017), Vardha (2016), Hudhud (2014), Phailin (2013), Nilam (2012), Thane (2011), Jal (2010), Nisha (2008), Fanoos (2005), Sidr (2007), Super Cyclone (1999), Bhola (1970) (Nair and Annadurai, 2018). Almost all the cyclonic storms or storms with higher intensity were accompanied by storm surges, high speed winds, heavy precipitation resulting in the inundation of low lying areas followed by flooding situations.

1.4.14 Two cyclonic storms "Phailin" and "Hudhud" struck the east coast of India in successive years, 2013 and 2014 respectively, both making landfall on 12th October and both categorized as "very severe" by the India Meteorological Department. Phailin was detected as a low pressure system on 6th October 2013, which developed into a severe cyclonic storm by 10th October and eventually crossed the coast near Gopalpur, Ganjam district in Odisha on 12th October around 10.30 pm. Hudhud was identified as a low pressure system on 7th October 2014, that became a "very severe" cyclonic storm by the afternoon of 10th October and made landfall over Vishakhapatnam City in Andhra Pradesh between 12 noon and 1 pm of 12th October 2014 (Dash, 2016).

1.4.15 In the run up of these two cyclonic landfalls, large-scale public evacuation was carried out in the states of Odisha and Andhra Pradesh, minimising casualties to 44 in the case of Phailin and 26 for Hudhud (Dash, 2016).

1.4.16 Thane Cyclone (2011) mainly affected the areas of Cuddalore, Puducherry, Villupuram, Kanchipuram, Thiruvallur, Chennai, Nagapattinam, Thiruvarur and Thanjavur districts of Tamil Nadu. It also severely affected the Union Territory of Puducherry. Thane crossed the Tamil Nadu coast and caused extensive damages to Cuddalore and the neighbouring Union Territory of Puducherry which remained cut-off from the nearby districts of the State. With wind speed of 140 kmph, cyclone Thane uprooted hundreds of trees, electric poles, traffic signal poles and mobile phone tower and damaged standing crops across the coastal districts of Tamil Nadu and Puducherry. 46 human lives have been reported to be lost alongwithlarge number of livestock. Around 6,000 people living in low lying areas in Kanchipuram, Cuddalore, Tiruvallur, Nagapattinam, Villupuram and Chennai were shifted to safer places.

1.5 Scope of the Study

1.5.1 To build upon the learning of Cyclone "Gaja" and to document the lessons learnt and best practices, the present study was undertaken with the following objectives:

1.6 Objectives

1.6.1 The objectives of this study were as follows:

- To critically analyze the role of disaster managers in the management of Cyclone Gaja with special reference to early warning, preparedness, impact, response, and community preparedness.
- To evaluate the impact of Cyclone Gaja on the infrastructure, services, and communities.
- To study the measures undertaken by the Central Government, State Governments and District Administrations to reduce the mortality and impact of cyclones in the State of Tamil Nadu.
- To document the best practices undertaken during the management of Cyclone Gaja.
- Suggest evidence-based recommendations for better management of Cyclones in the future.

1.7 Methodology

1.7.1 An assessment framework was developed to learn the impact and response of the Cyclone Gaja in Tamil Nadu. The present study was conducted from 12 to 15 February 2019 in consultation with Government of Tamil Nadu and District Administration of affected Districts. Two worst affected districts of Nagapattinam and Thanjavur were also visited during the period. An interview schedule was prepared in advance (Annexure I) for different stakeholders namely government officials, civil society and local communities. In-depth interviews were held with government officials at the state and district level like Additional Chief Secretary/ State Relief Commissioner, Officials of line Departments like Electricity, Animal Husbandry, Agriculture, PWD, etc. A number of focused group discussions were held with civil society organizations and affected communities. Also, two of the districts affected were visited by team of NDMA for direct observation in the field.

1.7.2 Thus, the data used in this study includes both primary and secondary data. Primary data was generated from the field through direct observation and in-depth focused

discussions. The secondary data was sourced from a memorandum issued by the state government, government reports and articles from the newspaper, journals, etc.

1.8 Limitations

1.8.1 The main aim of the study was to gauge the impact of the cyclone and evaluate the level of preparedness and response to Cyclone Gaja. The study is based on secondary data and observations from the affected areas. Hence, this study relies mostly on secondary source of data, mostly from the government sources. Since, post disaster reconstruction and recovery process had already begun; the observation of real damage may be negatively biased.

2 Cyclone Gaja

2.1 Formation

2.1.1 Severe Cyclonic Storm Gaja was the fifth named cyclone of the 2018 North Indian Ocean cyclone season, after cyclones Sagar, Mekunu, Luban and Titli. Forming on 5th November 2018 as a low pressure system over the Gulf of Thailand, the system crossed through Southern Thailand and the Malay Peninsula and eventually crossed into the Andaman Sea. The weak system intensified into a depression over the Bay of Bengal on 10th November 2018 and further intensified to a cyclonic storm on 11th November 2018, being classified 'Gaja'. After tracking west-south-westward for a number of days in the Bay of Bengal, Gaja made landfall in South India, shifted through Vedaranyam, Voimedu, Muthupet, and Adirampattinam. The storm survived its crossing into the Arabian Sea; however, it dissipated in hostile conditions only a few days later.

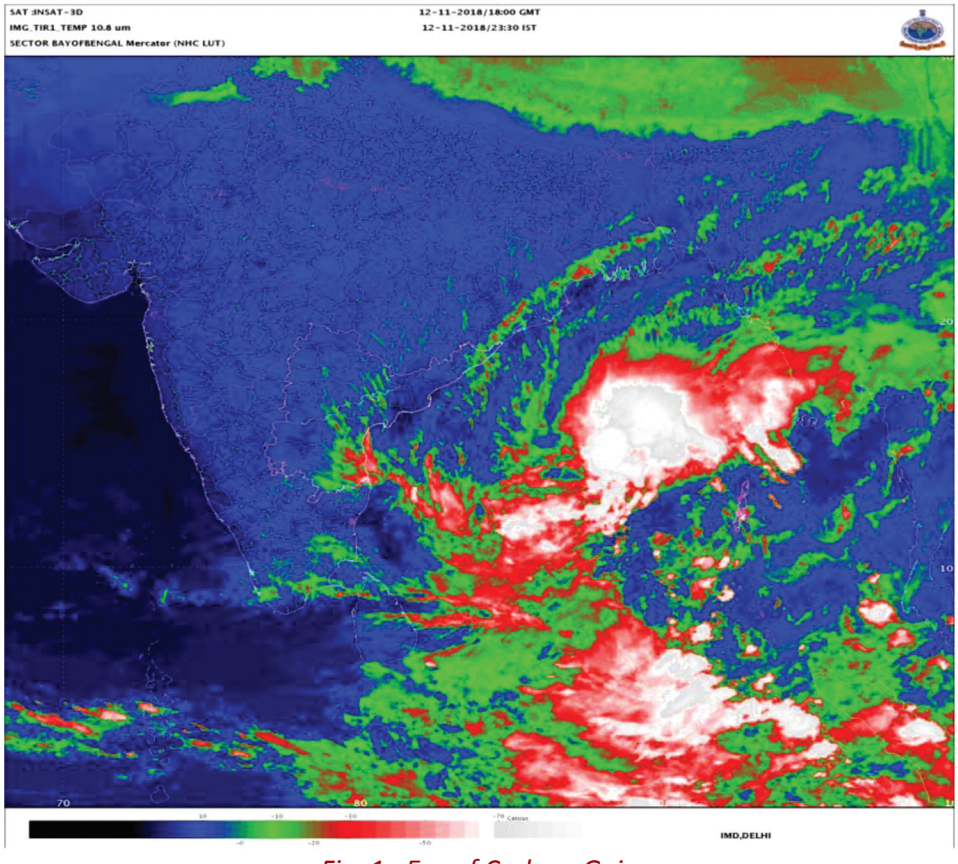


Fig. 1 : Eye of Cyclone Gaja

2.2 Forecast & Path

Forecast track and intensity are given in the following table:

Table: 5

Date/Time(IST)	Position (Lat. ˚N/ long. ˚E)	Maximum sustained surface wind speed (Kmph)	Category of cyclonic disturbance
12.11.18/2330	13.2/87.5	75-85 gusting to 95	Cyclonic Storm
13.11.18/0530	13.1/87.0	80-90 gusting to 100	Cyclonic Storm
13.11.18/1130	12.6/86.4	85-95 gusting to 105	Cyclonic Storm
13.11.18/1730	12.0/85.5	90-100 gusting to 110	Severe Cyclonic Storm
13.11.18/2330	11.4/84.3	100-110 gusting to 125	Severe Cyclonic Storm
14.11.18/1130	10.9/82.6	95-105 gusting to 120	Severe Cyclonic Storm
14.11.18/2330	10.5/80.9	85-95 gusting to 105	Cyclonic Storm
15.11.18/1130	10.1/79.2	80-90 gusting to 100	Cyclonic Storm
15.11.18/2330	9.9/77.3	50-60 gusting to 70	Deep Depression
16.11.18/1130	9.7/75.3	35-45 gusting to 55	Depression
16.11.18/1730	9.6/74.3	20-30 gusting to 40	Low

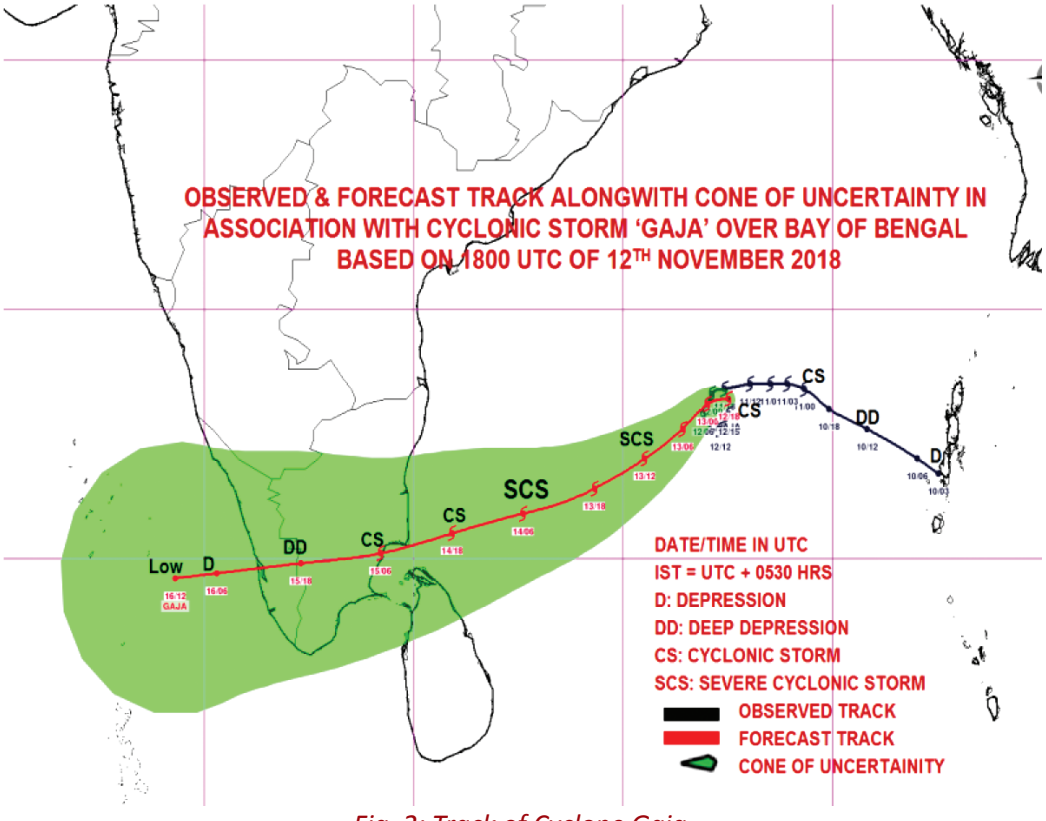


Fig. 2: Track of Cyclone Gaja

2.3 Landfall & Expansion/ Area of Impact

2.1.3 At the time of landfall of the cyclone, heavy winds of about 100-120 kmph speed were experienced. The highest sustained speed was recorded in Adhirampattinam at 165 kmph and 160 kmph at Muthupet recorded. Regions of Karaikal and Nagapattinam also experienced 100 kmph winds. The cyclone Gaja affected districts of Nagapattinam, Thanjavur, Thiruvarur, Pudukottai, Karaikal, Cuddalore, Trichy and Ramanathapuram.

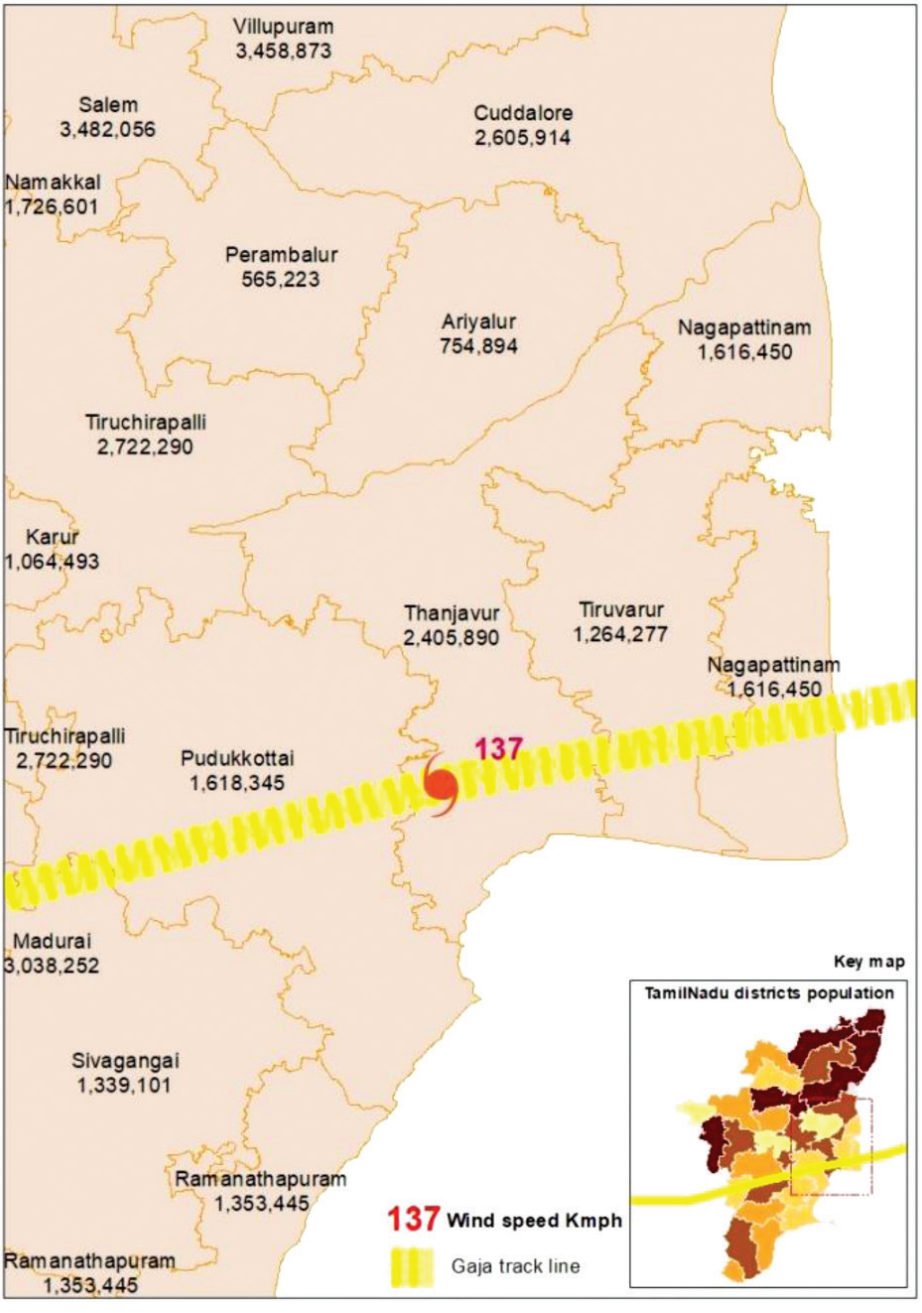


Fig. 3: Districts along the path of Cyclone Gaja

2.4 Physical & Climatic Characteristics

Table: 6

S No	Physical Parameters	Cyclone Gaja
1.	Type of storm	Very severe cyclonic storm
2.	Wind speed	117 kmph
3.	Rainfall	Extremely heavy falls (≥ 20 cm)89.54 mm

2.5 Early Warning from IMD

2.5.1 IMD issued the specific warning for the system on 12th November 2019. Following are the excerpts of the Warning:

Wind Warning

2.5.1.1 It was predicted that gale (wind speed reaching 70-80 kmph gusting to 85 kmph) would prevail over Southeast and adjoining Central & Southwest Bay of Bengal. The speed was very likely to gradually increase to 90-100 kmph gusting upto 110 kmph over southwest & adjoining west-central and southeast Bay of Bengal from the evening of 13th November 2018.

2.5.1.2 Moreover, squally wind with a speed reaching 45-55 kmph gusting upto 65 kmph was likely to commence along & off north Tamil Nadu & Puducherry and adjoining south Andhra Pradesh coasts from 14th November morning. The speed was very likely to gradually increase and turn into a gale (wind speed 80-90 kmph gusting upto 100 kmph) along & off north Tamil Nadu & Puducherry coasts from 14th November night onwards.

Sea Condition

2.5.1.3 The warning mentioned sea condition as 'high' over Southeast and adjoining Central & Southwest Bay of Bengal and that it would become 'very high' over southwest and adjoining west-central and the south-east Bay of Bengal from 13th evening to 14th night and high over the southwest Bay of Bengal on 15th November. It was very likely to be rough to very rough along and off Tamil Nadu-south Andhra Pradesh coasts from 14th November morning and high from 14th November night.

Storm Surge Warning

2.5.1.4 According to the warning, a storm surge of about 1.0 meter above astronomical tide was very likely to inundate low-lying areas of Nagapattinam, Thanjavur, Pudukkottai and Ramanathapuram districts of Tamil Nadu and Karaikal district of Puducherry at the time of landfall.

Damage Expected

2.5.1.5 The cyclone was expected to cause destruction in Cuddalore, Nagapattinam, Tiruvarur, Thanjavur, Pudukkottai and Ramanathapuram districts of Tamil Nadu and Karaikal district of Puducherry. Major damage to thatched huts/ houses and roof tops was expected. Flying metal sheets were identified as a hazard that could do considerable damage. Damage to power and communication lines, major damage to Kutch & minor damage to Pucca roads, breaking of tree branches and uprooting of large avenue trees was expected along with damage to paddy crops, banana, papaya trees and orchards. It was also expected that low-lying areas would face sea water inundation after erosion of Kutcha embankments.

Advisory issued by IMD:

2.5.1.6 IMD advisory requested total suspension of fishing operations along & off north Tamil Nadu & Puducherry and adjoining south Andhra Pradesh coasts during 13-15th November. The fishermen were advised not to venture into central parts of south and central Bay of Bengal on 13th November and into southwest & adjoining west central Bay of Bengal during 13-15th November.

- The fishermen, who were in deep sea, were advised to return to the coast.
- Coastal hut dwellers were advised to move to safer places.
- Other people in the affected areas were asked to remain indoors.

2.6 Early Actions taken by the State Government

2.6.1 Due to the possibility of adverse effects in the coastal regions of Tamil Nadu and Puducherry, early steps were taken by the state governments. In areas likely to be affected, people were evacuated and moved to relief camps. Holidays were also announced in the coastal districts of Tamil Nadu as well as Puducherry. People were advised to stay indoors as the cyclone would cause high-speed winds. Preventative measures were communicated through print, electronic and social media.

3 Preparedness

3.1 Pre-disaster Preparedness for Northeast Monsoon/ Tropical cyclones

3.1.1 Essentially disaster preparedness plays a significant role in reducing the loss of human and cattle lives and to a certain extent it lessens the economic loss. Learning from each disaster can strengthen preparedness and enhance disaster risk reduction

3.1.2 Recent preparedness efforts in Tamil Nadu towards disasters sought guidance from Government of Tamil Nadu State Disaster Management Policy in the year 2004 which was later updated in the year 2013. It gives a overall picture of Disaster Management in the State. Secondly, the State Disaster Management Plan in 2016 lays down the vision "To build a safe and disaster resistant Tamil Nadu through systems approach, inclusive development and mainstreaming disaster risk concerns into the development ethos of the State" for the disaster management in Tamil Nadu. Further, the State Disaster Management Perspective Plan 2018-2030, sets the priorities, lists out the strategic action plans and shows the way forward in accordance with the priorities of Sendai Framework for risk reduction.

3.1.3 The Relief Commissioner, Commissionerate of Revenue Administration supervises the efforts for Northeast Monsoon preparedness keeping in mind the probable disasters during the period such as cyclones, extremely heavy rainfall, storm surges, drought etc.

3.2 Pre-disaster efforts for preparedness

3.2.1 Based on the legacy data and maps, assessment of risk was undertaken and 4,399 vulnerable areas were identified and classified into 4 categories based on the intensity of risks. Hazard Risk Vulnerability Mapping was also done with 3 vulnerable areas in each map at Firka (Rural areas) and at Ward (Urban areas) level incorporating vulnerability analysis, details of escape routes and relief centers.

3.3 Institutional Mechanism for preparedness

3.3.1 Hazard Risk Vulnerability Assessment (HRVA) is an important and foremost step that lays down the foundation for effective preparedness. Government of Tamil

Nadu initiated HRVA for cyclone affected districts and also conducted some studies pertaining to it. :

3.3.2 The Government of Tamil Nadu took planned and immediate response measures on the lines of Incident Response System (IRS) in the State. The same was supported by the deployment of nine teams of the National Disaster Response Force (NDRF) and seven units of the Tamil Nadu Disaster Response Force (TNDRF) ahead of the cyclonic storm Gaja.

3.3.3 A team of trained volunteers played an important role in awareness generation on preparedness aspects for the cyclone. First responders from the community also helped in information dissemination and evacuation.

3.4 Strengthening Disaster Risk Governance to manage Disaster Risks

Incident Response System

3.4.1 The Chief Secretary to the Government of Tamil Nadu is designated as the Responsible Officer. The Chief Secretary is assisted by the Revenue & Disaster Management Department at Government level. The State Relief Commissioner & Additional Chief Secretary/ Commissioner Revenue Administration is designated as the Incident Commander, assisted by the Commissioner, Disaster Management.

3.4.2 A similar arrangement is in place at the district level, IRS headed by the District Collector who is assisted by the Superintendent of Police, District Revenue Officer, District level Officers of different departments. Similarly, by assigning the Sub-Divisional Officers at the Sub-Divisional level and Tahsildars at Taluk level.

Inter-Departmental Teams

3.4.3 Inter-Departmental team's main role and responsibility includes pre-inspection and monitoring of all disaster preparedness measures. Inter-Departmental Zonal Teams are in place headed by an officer from Revenue Department for a group of vulnerable areas. Village Administrative Officers at Village level are also trained in disaster management. 662 Inter departmental Zonal Teams led by Revenue Authority have been constituted by drawing members from Police, Fire services, Rural Development, Agriculture Departments etc.

Disaster Response Guards

3.4.4 Volunteers from Civil Societies who are already well trained in search and evacuation operations have been enrolled as Disaster Response Guards. Volunteers from Satya Sai Trust and Red Cross Society have been enrolled in 2018.

Community Participation

3.4.5 Community Participation is an essential component of any disaster management strategy, recognizing the same volunteers who are able bodied and having swimming and climbing skills have identified and built their capacity to act as First Responders. Totally 30,759 Volunteers from the community were identified as First Responders of which 9162 are women volunteers. Additionally, 8624 volunteers interested in animal welfare were identified as First Responders exclusively for protecting animals.

Constitution of mobile teams and an effective monitoring mechanism

3.4.6 Mobile teams of first responders which includes even Snake catchers were formed at Block/ Taluk/ Sub-Divisional and District levels for need-based deployment. Senior IAS Officers, assisted by Senior IPS Officers in all Districts were appointed to monitor the preparedness measures and inter departmental coordination.

3.4.7 Summary of Preparedness measures taken by Government of Tamil Nadu is placed in the following Table:

Table: 7

Sl. No	Details	Values (in Numbers or km)
1	No. of Vulnerable areas	4399
2	No. of Inter Departmental Zonal Teams	662
3	No. of First Responders including women first responders	30,759
4	No. of Women First Responders	9,162
5	No. of Encroachments removed in water bodies	25,246
6	No. of Bridges cleaned	10,500
7	No. of Culverts cleaned	1,62,524
8	No. of Pipe culverts converted of Box culverts	2,807
9	No. of Bridges where additional vents provided	248
10	No. of Recharge wells created	5,764
11	No. of defunct bore wells converted as recharge pits	11,635
12	No. of Check dams created	10,773

13	No. of percolation Ponds created	6,500
14	No. of Tanks / Ponds deepened	19,184
15	No. of Households where Rainwater Harvesting structure installed	67,02,903
16	No. of Institutions where Rainwater Harvesting structure installed	5,88,490
17	No. of Tanks / Supply Channels Desilted	25,855

3.5 Investing in disaster risk reduction

3.5.1 Preparedness was strengthened by investing in disaster risk reduction through permanent mitigation measures as well as annual maintenance works prior to monsoon. Water ways and bodies, irrigation canals in vulnerable areas were de-silted. 7.2 crore cubic metre of silt was removed from 30,783 tanks during 2017 and 2018 as a flood mitigation measure. Several encroachments in water bodies were removed. Blockages under Bridges and Culverts were cleared. Defunct bore-wells were converted into recharge structures. Mitigation measures were also undertaken under CSR initiatives.

Permanent Mitigation Measures

3.5.2 State Government has taken a number of permanent mitigation measures after the lessons learnt from the Vardha Cyclone and Chennai Floods. Some of the measures taken are as follows:

- Rehabilitation and restoration of the flood damaged Adayar River and its tributaries.
- Rehabilitation and restoration of the flood damaged Vegavathy River.
- Special package for Public Works department of Cuddalore District.
- Removal of 25,246 encroachments from the water bodies.
- Construction of 5,764 Recharge Wells.
- Conversion of 11,635 defunct bore-wells into Recharge Pits.
- Under Coastal DRR Project of Central Government, multi-purpose evacuation shelters were constructed to accommodate about 2000 people.

Temporary Mitigation Measures

3.5.3 Some of the temporary mitigation measures taken by the State Government are as follows:

- Removal of 10,500 blockages from under the bridges.
- Removal of blockages from 1, 62,524 Culverts.
- 32,187 tanks were de-silted.
- 11,466 kms of Irrigation Canals, Channels, river courses and streams were de-silted.
- Fire & Rescue Services, Police Department and Fisheries Department were equipped with modern equipment.

3.5.4 Preparedness also focused on enhancing disaster preparedness for effective response and to build back better in recovery, rehabilitation, and reconstruction. Some of these activities are illustrated into the following Tables:

Table 8: Animals affected in Disaster

Sl. No	District	No. of First Responders	No. of Animal Cattle Shelters
1	Ariyalur	29	1
2	Chennai	NA	NA
3	Coimatore	20	6
4	Cuddalore	1,195	34
5	Dharmapuri	260	1
6	Dindigul	489	14
7	Erode	48	2
8	Kancheepuram	108	21
9	Kanyakumarai	10	4
10	Karur	77	37
11	Krishnagiri	177	2

12	Madurai	25	5
13	Nagappatinam	2,020	212
14	Namakkal	165	27
15	Nilgiris	50	26
16	Peramalur	31	44
17	Pudukottai	12	31
18	Ramanathapuram	121	39
19	Salem	23	26
20	Sivagangai	22	55
21	Thanjavur	195	36
22	Theni	14	14
23	Tiruvallur	141	54
24	Thiruvannamalai	477	71
25	Thiruvarur	424	11
26	Thoothukudi	360	36
27	Tirichirapalli	150	154
28	Thirunelveli	165	55
29	Thiruppur	114	7
30	Vellore	167	16
31	Vilupuram	1,260	60
32	Virudhunagar	275	78
	Total	8,624	1,179

Table 9: Relief Centre details

North East Monsoon Preparedness 2018															
Relief Centre Details															
Sl. No	District Name	No. of Relief Centres identified other than Multi Purpose Evacuation Shelters (MPES) constructed under CDRRP												No. of Multi Purpose Evacuation Shelters (MPES) cons tructed under CDRRP (Coastal)	Grand Total
		Schools			Colleges			Community Hall/ Thirumana Mandapams			Other Buildings			Sub Toal	
		Private	Govern ment	Total	Private	Govern ment	Total	Private	Govern ment	Total	Private	Govern ment	Total		
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1	Ariyalur	0	29	29	0	0	0	0	0	0	0	0	0	29	0	29
2	Chennai	22	112	134	0	1	1	14	12	26	4	11	15	176	0	176
3	Coimbatore	0	10	10	0	0	0	0	0	0	0	0	0	10	0	10
4	Cuddalore	77	212	289	22	12	34	29	68	97	0	0	0	420	14	434
5	Dharmapuri	2	55	57	1	0	1	6	4	10	0	0	0	68	0	68
6	Dindigul	4	52	56	0	0	0	5	0	5	0	0	0	61	0	61
7	Erode	8	65	73	0	0	0	21	0	21	1	0	1	95	0	95
8	Kancheepuram	74	99	173	27	67	94	47	56	103	3	14	17	387	5	392
9	Kanniyakumari	11	33	44	1	0	1	6	1	7	0	0	0	52	12	64
10	Karur	1	41	42	2	2	4	44	4	48	0	0	0	94	0	94
11	Krishnagiri	0	29	29	0	0	0	9	3	12	0	6	6	47	0	47
12	Madurai	22	12	34	9	2	11	1	0	1	0	0	0	46	0	46
13	Nagapattinam	80	203	283	19	2	21	162	15	177	0	21	21	502	9	511

14	Namakkal	15	29	44	7	2	9	33	3	36	0	0	0	89	0	89
15	Nilgiris	17	233	250	0	0	0	0	205	205	0	1	1	456	0	456
16	Perambalur	6	45	51	0	0	0	1	6	7	2	3	5	63	0	63
17	Pudukottai	0	41	41	0	1	1	0	3	3	0	11	11	56	10	66
18	Ramnathapuram	30	42	72	2	7	9	44	0	44	91	0	91	216	23	239
19	Salem	5	15	20	0	0	0	5	2	7	0	0	0	27	0	27
20	Sivagangai	3	24	27	0	0	0	13	28	41	0	0	0	68	0	68
21	Thanjavur	28	150	178	1	1	2	9	6	15	2	0	2	197	14	211
22	Theni	12	37	49	6	0	6	25	11	36	1	1	2	93	0	93
23	Tirunelveli	57	77	134	3	0	3	86	22	108	9	0	9	254	6	260
24	Tiruppur	1	31	32	0	1	1	10	1	11	0	0	0	44	0	44
25	Tiruvallur	94	311	405	25	0	25	136	50	186	7	5	12	628	5	633
26	Tiruvannamalai	4	68	72	0	0	0	0	3	3	0	0	0	75	0	75
27	Tiruvarur	12	199	211	0	2	2	10	7	17	0	13	13	243	6	249
28	Thoothukudi	36	10	46	0	1	1	12	11	23	2	2	4	74	5	79
29	Tiruchirapalli	28	89	117	4	0	4	19	12	31	4	0	4	156	0	156
30	Vellore	71	5	76	0	1	1	6	9	15	6	2	8	100	0	100
31	Villupuram	320	977	1297	29	8	37	280	89	369	0	38	38	1741	12	1753
32	Virudhunagar	15	48	63	1	0	1	6	53	59	0	1	1	124	0	124
	Total	1055	3383	4438	159	110	269	1039	684	1723	132	129	261	6691	121	6812

3.6 Preparedness for effective response and to build back better in Recovery, Rehabilitation, and Reconstruction

Early warning Systems

3.6.1 Government of Tamil Nadu has strengthened its State Emergency Operation Centre, District Emergency Operation Centres and has created new Emergency Operation Centre at Revenue Sub-Divisions in Coastal and Hill Districts.

Tamil Nadu System for Multi-Hazard Impact Assessment, Alert and Emergency Response Planning and Tracking (TNSMART)

3.6.2 A Web-GIS based mobile application was developed during 2018 as a decision support tool, which has been named as Tamil Nadu System for Multi-hazard Impact Assessment, Alert and Emergency Response Planning and Tracking (TNSMART). This decision support tool with 11 modules empower policy-makers, operational-users of Incident Response System, and communities with necessary early warning information for decision making during all the phases of Disaster Management. The unique alarm system built in TNSMART mobile application can save lives even if the lead time available is minimal for reaching to all stakeholders.

3.6.3 Disaster Warning Announcement System is a new system operationalized during the year 2018 in 142 locations in Coastal Districts through which messages can be conveyed from a central location based on alerts received from IMD/ INCOIS etc.

3.7 Some Other Measures Taken by Government of Tamil Nadu

Capacity Building

3.7.1 Some of the Capacity Building measures taken by the State Government are enlisted below:

- The first responders were trained by Fire services/ SDRF and Red Cross society.
- Multiple mock exercises were organized on different days including on International Disaster Reduction day.
- Telecast of Animation Films with Do's and Don'ts.
- Detailed circulars were issued to carry out activities in a time bound manner in vulnerable areas and at district level during cyclone, floods, tsunami etc.
- To sensitize the private institutions, series of meetings were organized at District/ State level with Hospitals, Educational Institutions, Communication Service providers and Oil Companies to ensure round the clock functioning of emergency services.

Preparedness for effective Disaster Response

3.7.2 Some of the measures taken by the State Government for effective and efficient response include delineation of Green corridors to facilitate quick movement of rescue teams and relief measures.

3.7.3 Previous experiences show that some of the first responders were also affected. They were not trained in tree cutting. In future, the first responders will also be trained in tree cutting and the strength of Disaster Response Guards will be enhanced by drawing volunteers from NCC, NSS etc.

3.8 Post-Warning Preparatory Measures

3.8.1 Following preparatory measures were ensured by the State Government:

- Prepositioning of men and materials in the vulnerable areas to ensure rescue and relief operations.
- Prepositioning of rescue teams and rescue equipment Boats etc. in areas identified as areas of Very High and High vulnerability.
- 6,812 Relief centers were identified (both Government and Private buildings). Additionally 507 relief centers with all basic amenities were opened and kept ready in 10 districts which were likely to be affected during the land fall.
- Instructions issued for special care for Children, pregnant women, lactating mother aged and differently-abled persons.
- Ensuring adequate stock of Food, Medicine, Milk Powder.
- Provision of protected Drinking Water.
- Constitution of stationary and mobile Health Teams.
- Strengthening of Ambulance Services.
- In affected districts warning was given well in time so fishermen did not go inside the sea.
- 1,151 JCBs and 1,650 Power saws were prepositioned and utilized for clearing operations.
- 7,000 electric poles were moved to districts in the path of cyclone to ensure immediate restoration in case of damages due to the cyclone.
- Over Head Tanks were filled to ensure water supply post landfall of cyclone, even if power is disrupted.

- On 15.11.2018, when it was forecasted by IMD that the probable area of the landfall of Cyclone GAJA will be around Nagapattinam, massive evacuation operation was carried out and lakhs of people took shelters in safe premises based on the advisory issued by the Government of Tamil Nadu. About 82,000 people took shelter in Government buildings and Multipurpose Evacuation Shelters in the affected districts mainly in Nagapattinam, Tiruvarur, Thanjavur and Padukottai.
- Water level in the reservoirs, tanks and dams was closely monitored.
- Animation film on Do's and Don'ts during cyclone were repeatedly telecast. As a measure of caution advisory messages and Do's and Don'ts during cyclones were also communicated through info graphics in Tamil and English both in visual and print media.
- As a precautionary measure Holiday was declared for Schools and Colleges on 15.11.2018 and 16.11.2018 in the coastal and other districts.
- Private Sector and commercial establishment were asked to declare holiday on 15.11.2018 afternoon.
- Cinema theatres were asked to stop screening of films from the evening on 15.11.2018.
- Transport of vehicles was stopped in coastal districts between 6 pm of 15.11.2018 to 6 am of 16.11.2018.
- Advisories/ warnings were given to fishermen, and it was ensured that all the fishermen returned to shore from high seas and berthed their vessels safely.
- Inter-agency Coordination between and amongst the concerned stakeholders was re-worked before the Landfall.
- Based on the forecast of GAJA cyclone, Hon'ble Chief Minister convened a meeting on 12.11.2018 and instructed Senior Officials to monitor the situation on hourly basis and move to the Districts likely to be severely affected. They were deputed to oversee the cyclone preparedness, coordinate and assist the District Administration.
- The Hon'ble Minister for Revenue and Disaster Management along with Additional Chief Secretary/Commissioner of Revenue Administration & State Relief Commissioner (ACS/CRA & SRC) and Principal Secretary to Government, Revenue and Disaster Management Department conducted a press meet at SEOC on 13.11.2018 and explained the preparedness measures that were taken up in the Coastal Districts for 'GAJA' Cyclone.

- The Chief Secretary to Government conducted a special meeting on the status of preparedness for 'GAJA' Cyclone with Senior IAS officers heading the Line Departments and also Central-Agencies viz., Coast Guard, Navy, Air Force on 12.11.2018 and various instructions were issued to them. The Central Agencies were advised to be in a state of high preparedness and proactively reach out to the disaster victims. The Indian Coast Guards were asked to closely monitor movement of Multi day fishing vessels and alert them to reach safe locations. All the Multi day fishing vessels reached shore safely. Army, Navy and Air force were asked to be available in standby mode.

- A Special meeting through Video conference was conducted on 12.11.2018 by Additional Chief Secretary/ Commissioner of Revenue Administration & State Relief Commissioner (ACS/ CRA & SRC) with all Coastal District Collectors to review the status of Preparedness for 'GAJA' Cyclone based on the instruction issued in circulars 1) Preparedness for Northeast Monsoon 2) Preparedness for Cyclones 3) Check list.

- The ACS/ CRA conducted a meeting with the Public Sector Undertaking Oil Companies and Mobile Service providers on 13.11.2018 to review the action taken on the minutes of the NEM 2018 Preparedness meeting held on 07.09.2018 and issued instructions on preparedness measures to be taken for 'GAJA' Cyclone. Mobile service providers were advised to position "Cell Tower on Wheels" (COW) in Nagapattinam in anticipation of damages to power infrastructure.

- The situation was continuously monitored by the Hon'ble Minister for Revenue and Disaster management and the Additional Chief Secretary/ Commissioner of Revenue Administration & State Relief Commissioner from the SEOC on a continuous basis. All the District Collectors were personally alerted by the ACS/ CRA taking into account the changing direction of Gaja and prediction of very heavy rains with winds gusting upto 110 kmph and possible impact the cyclone can have in non-coastal areas of the State that are in the path of the Cyclone.

- Senior IAS officers who were appointed as Monitoring officers of coastal districts and non-coastal districts were directed to camp in their districts and to monitor the situation from 13.11.2018 onwards. The Hon'ble Ministers in charge of Districts camped in their Districts on 15.11.2018 to supervise the works along with Monitoring Officers both in coastal and non-coastal districts.

- The State Relief Commissioner prepositioned 7 teams of NDRF and 4 teams of TNSDRF were positioned in the coastal districts of Cuddalore, Ramanathapuram, Nagapattinam and Chennai districts.

- Inter-Departmental zonal Teams, NDRF, SDRF, Disaster Response Guards and First responders and essential commodities were prepositioned.

3.8.2 The SEOC was manned through the day and night of 15th November 2018 by the Hon'ble Minister for Revenue and Disaster Management & ACS/ CRA and provided updates and explained about measures to be taken to the general public through electronic, print and social media.

4 Impact of the Gaja Cyclone

4.1 Major Affected Areas

4.1.1 Prior to the landfall, advisory issued by National Emergency Operation Centre, based on the Warning of IMD, cautioned for very heavy rainfall at isolated places over south interior Tamil Nadu and heavy rainfall at isolated places over north interior Tamil Nadu. Eventually, upon landfall, nearly 20,927 sq.km of area in Nagapattinam, Cuddalore, Thiruvarur, Thanjavur, Pudukkottai and Ramanathapuram districts were severely affected by Cyclone Gaja.

4.2 Coastal Inundation and Run-up

4.2.1 One of the major factors that lead to loss of lives and property in a severe cyclonic storm is coastal inundation associated with extreme sea levels. Post-cyclone, the State government conducted a field survey wherein run-ups were measured using the water marks on the walls of houses in Kodikkarai village, Nagapattinam. With the help of field measurements and eye witness reports, the maximum run up and inundation were measured. The measured run up value was 1.8 m above MSL and the inundation was extended up to 2 kilometers from the shoreline. Similarly, a run up of 1.6m above MSL and a 500m of inundation were measured at Karaikal Beach. The run up was inferred from the colour variation between younger and older beach sediments. Ripples marks formed away from the normal shoreline also evidences' the run up. Inland intrusion of water had partially silted the canals that supply tidal water to the mangroves.

4.3 Loss of Flora & Fauna

4.3.1 Cyclone Gaja uprooted a large numbers of trees. The coastal sacred groves of Nagapattinam were also affected. According to a report by M.S. Swaminathan Research Foundation, a large number of trees that lined the shoreline in the groves at Muthupetwere uprooted.

4.3.2 An article in the New Indian Express on Cyclone Gaja's impact on wildlife in the Kodiyakarai sanctuary reported the death of a herd of deer. The herd, which had escaped from the sanctuary, was found dead on the shores. Bleeding noses indicated a possible heart failure.

4.4 Impact on Human Settlements

4.4.1 A total of 52 persons died and 259 persons were injured. Almost 5.6 lakh persons were directly affected, losing their livelihoods, clothes or utensils.

Housing

4.4.2 A large number of pucca and kutcha houses were partially or fully damaged. The number of pucca houses damaged partially (15% or more damage) stood at 2.2 lakhs. In Thanjavur and Pudukkottai, 1,877 pucca houses were fully damaged.

4.4.3 Similarly, a large number of huts were partially or fully damaged. In Tiruvarur, total 56,613 huts were damaged. Fully damaged huts numbered at 77,796 in Nagapattinam, 47,182 in Thanjavur and 7,148 in Tiruvarur.

Animal Husbandry

4.4.4 Cyclone Gaja severely affected milch animals, draught animals and poultry. The maximum damage to cattle was observed in Nagapattinam whereas Thanjavur lost a large number of poultry.

Agriculture

4.4.5 Total agricultural area where crop loss was more than 33% stood at 1,22,063 hectares. Coconut trees spread over 69,358.41 hectares were uprooted.

Fisheries

4.4.6 One of the sectors that invariably bear the brunt of a cyclone is fisheries. All fishing activities remain suspended during a cyclone. As boats and fishing gears are highly cost intensive, the economic damage for fishermen is quite high due to the cyclone.

4.4.7 A total of 1,429 mechanized boats were partially damaged and another 195 were fully damaged. Cyclone Gaja also damaged 10,648 nets. Moreover, the Fishing Harbour and the Fish Landing Center Infrastructure were also damaged.

Infrastructure

4.4.8 A total of 2,168 government buildings were damaged. Similarly, 284 culverts were damaged across the affected districts. The power sector is highly vulnerable to cyclones and any damage has severe financial implications. A total of 3,31,772 poles, 1,655 distribution transformers and 31,824 kms of conductor were damaged.

4.5 Nagapattinam District

4.5.1 Nagapattinam district was severely impacted due to Cyclone ‘Gaja’, especially affecting the fishing community residing close to the seashore. More than 400 boats

were damaged by the inundation in and around Kodiyakkarai. An approximately 10,000 hectares of coconut plantation was uprooted in Vedharanyam, Puspavanam and Pappakovil. Settlements and residential areas were also damaged such as the Vedharanyam town, a school in Kodiyakkadu, residential buildings in Kodiyakkarai and Vettaikaraniruppu, and commercial buildings in Ayakkaranbulam and Karuvelangadai. Around 6,000 kutcha roofs, 12,000 metal roofs, 5,000 asbestos roofs and 5,000 huts were reported damaged. More than 40,000 electric poles were uprooted throughout the district. The district reported 08 deaths, the highest number of causalities reported from any affected district.

4.6 Thanjavur District

4.6.1 Thanjavur is one of the most important deltaic districts involved in cultivation of crops like paddy. It also boasts of coconut, mango and banana trees, and other vegetation. Plantation was severely affected in areas such as Aandarkaadu, Thiruvonam, Karambayam, Veppankadu, Eanathi, Nallvazhikollai, Chettiyakadu, Naduvikaadu, Anaikadu, Thokkalaikadu, Gangatharapuram and Kottaikadu. Settlements were damaged in Pandipalamavikadu, Uranipuram, Nambivayal, Karikadu, Bilal nagar and Uthangaadu. Approximately 13,000 metal roofs, 6,000 asbestos roofs, 8,000 huts and 7,000 kutcha roofs were damaged in the district. Around 100 boats were destroyed by the gale winds. More than 18,000 hectares of coconut plantation was damaged in the district with Pattukkottai and Peravurani suffering maximum damage. Over 1,000 hectares of banana plantation was damaged in Orathanadu.

5 Response

5.1 Response from Central Government

5.1.1 Nine teams of National Disaster Response Force consisting of 237 rescuers with 19 boats were deployed in Tamil Nadu. Indian Coast Guard (ICG) was on high alert and high state of preparedness. Indian Coast Guard Remote Operating Centres broadcasted weather warning alerts in local languages along the coast. Around 74 ship days and 10 air sorties were pressed into action; special community interaction programmes were conducted at 11 places for fishermen and coastal population for taking safety measures. ICG assisting in shifting of 1,500 fishing boats south of Pamban, thereby ensuring their safety and protecting their livelihood. Relief materials and lifesaving equipment from available resources were pooled in coordination with State/ UT Administration for mobilization and further distribution.

5.1.2 One helicopter sortie was made from INS Parundu to assess the effect of Cyclone Gaja damages in and around Ramanathapuram. The Indian Navy had positioned a Dornier Detachment at Arrakkonam to facilitate damage assessment and any other assistance that may be needed.

5.2 Response from State Government

Disaster Response Teams

5.2.1 The Tamil Nadu government deployed nine teams of the National Disaster Response Force and seven units of the State Disaster Response Force ahead of cyclonic storm Gaja's landfall. The teams were stationed in the coastal districts of Nagapattinam, Cuddalore, Thanjavur, Pudukkottai, Ramanathapuram and Tuticorin.

Evacuation and Cyclone Shelters

5.2.2 In the districts likely to be affected by cyclone Gaja, 28 cyclone shelters, 14 multipurpose evacuation centres and 191 temporary shelters were set up. At Cuddalore, the district administration had set up 19 inter-departmental zones and made arrangements to evacuate people living in coastal areas to relief centres. According to Tamil Nadu

State Disaster Management Authority, as many as 76,290 people were evacuated from low lying areas and sheltered at over 300 relief centres in six districts, including Nagapattinam, Pudukottai, Ramanathapuram and Tiruvarur.

Search and Rescue

5.2.3 At least 3,124 first responders who are volunteers trained for search and rescue were mobilised to help people evacuate to safer locations.

5.2.4 Around 1,178 first respondents especially trained to rescue animals were moved to pre-marked 43 shelters designated for animals during the cyclone.

5.2.5 The state administration set up a 24-hour control room in Chennai and directed District Collectors to form rescue teams. As part of preparedness, Cyclone Management Committees had been formed in all the 2,559 vulnerable places. These committees were also asked to help in evacuation and post disaster management.

5.2.6 The State Government also mobilised 368 medical teams, 315 veterinary medical teams, motor pumps, swimmers and snake catchers to provide assistance of any event during or after the cyclone.

Communication

5.2.7 The State Disaster Management Authority had released an animated video aimed at creating awareness on the do's and don'ts during cyclone.

Post Disaster

Emergency Helpline

5.2.8 Helpline numbers 1070 (state-level) and 1077 (districts) functioned to provide help for those who may need assistance.

Relief Measures

5.2.9 The State Government organised totally 828 no. of relief centres for 1,22,754 families and provided them with temporary shelters, food, milk and essentials. Sanitary napkins and other materials as required to women were also provided.

5.2.10 Each house in the affected districts were provided with a set of relief articles to tide over the emergency situation.

Table 10: Relief articles distributed during Cyclone Gaja to each affected household

1	Bed sheet	1 No
2	Towel	2 Nos
3	Lungies	2 Nos
4	Umbrella	1 No
5	Nighty	1 No
6	Mosquito coil	1 No
7	Plastic Mug	1 No
8	Coconut oil 50 ml	1 No
9	Milk Bikis – 10/-	4 Nos
10	Kurunji Bath soap	2 Nos
11	Detergent soap	2 Nos
12	Ladies Napkin	2 Nos
13	Avin Milk Powder	1 No
14	Sugar 1 Kgs Pocket	2 Nos
15	ToorDhall 1 Kgs Pocket	2 Nos
16	Amma Powder Salt 1 Kgs	1 No
17	Naga Ravai 1 Kgs	2 Nos
18	Ooty Tea dust 100 grms	2 Nos
19	Tamrind 250 grms	1 No
20	SakthiSambar powder 100 grm	1 No
21	Match Box	2 Nos
22	Saree	2 Nos
23	Dhoties	2 Nos
24	Palm. Oil Pocket 1 ltr	2 Nos
25	Plastic Bucket	1 No
26	Tarpaulin (12x24) 120 gsm	1 No
27	Rice Bags 10 Kgs	1 No

Restoration of Critical Infrastructure & Essential Services:

5.3 Public Health

5.3.1 Public Health department immediately swung into action and organized Static & Mobile Health Camps to treat the persons accommodated in the relief camps. The department along with local bodies launched massive cleaning and sanitation measures to prevent the spread of epidemic diseases.

5.4 Temporary Restoration of Damaged Infrastructure

5.4.1 After the landfall of the Gaja cyclone, extensive damages to infrastructure in different sectors were observed. Temporary restoration of these damaged infrastructures was addressed on war footing to bring back normalcy in the affected districts. At institutional level, Senior Ministers and IAS, IPS officers were deputed to supervise these operations.

5.4.2 Due to prepositioning of manpower from different departments i.e., workers from urban and rural local bodies, Department of Highways, personnel from National Disaster Response Force and Tamil Nadu State Disaster Response Force & Fire Safety & Rescue Service Staff with assistance of Disaster Response Guards & First Responders were brought in, to restore the critical infrastructure as per the following details:

5.5 Roads

5.5.1 One of the major requirements was to remove the fallen trees, electric poles and other debris strewn around the arterial roads covering NH, State Highways and major district and rural roads. The prepositioned JCBs, Bulldozers and other Heavy machinery and Power saws were utilized, besides mobilizing additional manpower, machinery, power saws and other equipment from other unaffected districts were mobilised. Almost a whopping number of 13, 66,736 uprooted trees were removed. Due to these efforts within 24 hours of the cyclone major roads were operationalized.

5.6 Drinking water

5.6.1 Post-disaster, the Government accorded highest priority for ensuring supply of drinking water to all the habitations by mobilizing gensets for pumping water, supply of water through tankers and by drilling shallow bore wells. A large number of relief camps were made operational to ensure that people whose houses were damaged were provided with food and shelter. The safety and health needs of the inmates of the relief camps were also given priority.

5.7 Power

5.7.1 Power sector is one of the sectors which bear the brunt of cyclone's destructive power. According to State of Tamil Nadu the estimated damage to Tamil Nadu Generation and Distribution Corporation Limited (TANGEDCO) in Cyclone Gaja was Rs. 1,054.11 crores. The colossal damages caused to the power infrastructure required a massive mobilization of men and materials for restoration from within the state as well as from outside the state. The operations were carried out round the clock in spite of the risks involved by pressing into service 28,644 men and a large technical force. DISCOM workers from Andhra Pradesh, Karnataka and Kerala were mobilized for the restoration operations. Moreover adopting the principle of build back better, the lines in the fields have been shifted to the road side to make regular repairs and restoration much easier in future.

6 Analysis of Gaja Cyclone

6.1 Frequency, Intensity and Predictability

6.1.1 Cyclones are becoming more frequent, intense and difficult to predict. North Indian Ocean is the fertile ground for deadly cyclones. In 2018, a total of 13 depressions were formed over the Bay of Bengal and the Arabian Sea which is the highest number in the last 28 years. Since 2000, six major cyclones made their landfall in Tamil Nadu. In 2005, three cyclones namely Pyarr, Baaz, and Fanoos formed into one mega-cyclone and devastated Vedaranyam (place of Cyclone Gaja's Landfall). In 2008, Cyclone Nisha with a wind speed of 102 km/hr hit North of Karaikal and 189 lives were lost.

6.1.2 In 2011, Cuddalore and Puducherry withstood the forces of Cyclone Thane which not only killed of 38 people but also wiped out a large number of trees. Cyclone Nilam (2012) and Cyclone Vardah (2016) were no less, displacing lakhs of people and adding to a large number of deaths. Cyclone Ockhi in 2017 affected south Tamil Nadu mainly the district of Kanyakumar in which 42 deaths and 185 missing fishermen were construed as dead. Cyclone Gaja was one of the severe cyclones to hit the Tamil Nadu coast.

6.1.3 The cyclones in the North Indian Ocean are becoming more and more intense and harder to predict the path. The Cyclone Titli and Cyclone Luban two very severe cyclones developed on either side of the Indian subcontinent in 2018. The India Meteorological Department (IMD) referred to this as rarest of rare occurrences as their movement was unique (Down to Earth, 2019). Cyclone Titli hit Odisha coast after changing track multiple times and Cyclone Luban after travelling through the south-eastern Arabian Sea on the Gulf coast before making landfall in Yemen on October 14, 2018.

6.1.4 Interestingly since 2010, twelve cyclones have formed in this region, but very few reached the Arabian Peninsula with cyclone strength; they usually weakened to tropical storms as dry desert air and wind shear sap their energy. However, Cyclone Luban changed tracks multiple times with rapid intensification. Cyclone Titli too underwent rapid intensification, increasing its wind speed by 55 kmph within 24 hours.

6.1.5 The cyclone Ockhi in 2017 left IMD completely surprised. It took a convoluted route with rapid intensification in wind speeds making cyclone prediction difficult. On November

28, 2017, Ockhi developed near the south-eastern coast of Sri Lanka. The next day it started moving north-westwards before striking Lakshadweep on November 30. Then the cyclone stopped its north-ward movement and turned towards India's west coast. According to IMD, the last time such a movement was recorded was in 1912, when a cyclone originated near Sri Lanka and ended up in Maharashtra. Ockhi had also transformed from a depression to a very severe cyclone in less than 40 hours, as against the normal period of 72 hours.

6.1.6 Gaja was the sixth cyclone over the north Indian Ocean during 2018 against the normal frequency of about 4.5 cyclones per year during the satellite era (1961 onwards). It was the first ever looping track cyclone over the Bay of Bengal after 1996 and the system has one of the longest track lengths equal to 3,418 km. It made landfall much later than predicted and remained a severe cyclone despite IMD saying that it would transform into a cyclone just before making the landfall. The eye of the cyclone was elliptical and turbulent, and hence it took about three to four hours to complete its landfall. The system was so powerful that its gusty winds churned the sea violently, causing a huge quantum of marine ooze of slush and mud to be spewed up for a distance of one kilometre on the shore in many villages.

6.1.7 With an increasing surface temperature of the ocean, warming of the ocean, change in vertical shear of wind the intensification of tropical cyclones is becoming more common. This has an immense impact on early warning and prediction and challenges for preparedness measures. In-depth study in cyclogenesis needs to be undertaken and examined under the lens of climate change. This phenomenon needs to be explored further keeping in mind climate change.

6.2 Coastal Disaster Risk Reduction Project (CDRRP)

6.2.1 In order to address the vulnerability of the State towards coastal hazards a project named Coastal Disaster Risk Reduction Project (CDRRP) with financial assistance from the World Bank is being implemented in the State from 2013. The components of CDRRP are – Vulnerability Reduction, Sustainable Fisheries and Capacity Building in Disaster Risk Management. Some of the innovative works being undertaken in this project include construction of multi-hazard resistant permanent houses, multi-purpose evacuation shelters and underground electric cabling. In addition, the project also focuses on developing practices for sustainable fisheries.

6.3 Improved Early Warning

6.3.1 Early warning can make a huge difference in cyclone-related mortality. In recent years, IMD, the nodal agency of early warning for cyclones in India, has been successfully

providing the information. The warning is issued well in advance about the development of depressions into impending cyclones with five to six days lead time. This provides ample time to evacuate people and ultimately limit damage and casualties as witnessed in the case of cyclones Phailin in 2013, Hudhud in 2014 or Vardah in 2016.

6.3.2 Despite the warning issued about Ockhi cyclone on afternoon of 29thNovember, 35 country boat fishermen went for fishing on 30.11.2017 morning and were killed. However, during cyclone Gaja, fishermen followed the advisory seriously and none of them went for fishing thereby causality of fishermen was nil, which highlights the need for the community to heed to the advisories of Government agencies during disasters.

6.3.3 Early warning messages reaching the last mile are one of the key challenges in disaster management. First, there should be technological reach to take it to the last mile. This has been met by sending SMS alerts to mobile phones and by using television telecasts & radio broadcast. In case of Cyclone Gaja, large number of SMSs alerting about the cyclone were sent out. The Cuddalore district administration launched an FM radio (107.8) to ensure uninterrupted dissemination of information regarding cyclone. State

Fig. 4: Public Announcement System

Emergency Operation Centre (SEOC) conducted massive awareness campaign on the "Do's and Don'ts during cyclone" through electronic, print, social media and mobile app. Second, there should be awareness at community level to accept the warning and immediately act upon it.

6.3.4 Under the Coastal Disaster Risk Reduction Project (CDRRP), being implemented with the help of the World Bank, Disaster Early Warning Announcement Systems (DWASs) have been established at taluk level in the coastal district of the State. These DWASs proved very useful in disseminating the early warning to the inhabitations and alerting the people during the Gaja Cyclone.

Fig. 5: Disaster Early Warning Announcement Systems (DWASs)

6.4 Multi-purpose Cyclone Shelters

6.4.1 Cyclone shelters are one of the mainstays of cyclone risk mitigation and are considered first line of defence against high wind speed and flooding. Under CDRRP 121 multi-purpose cyclone shelters are being constructed in the coastal regions of the State.

Fig. 6: Multipurpose Cyclone Shelters

6.4.2 During Cyclone Gaja, 28 cyclone shelters, 14 multipurpose centres and 191 community centres and schools were used for accommodating people. Construction of cyclone shelters is expensive and it can accommodate only a limited number of people. It also involves maintenance during non-disaster times. Hence, construction of cyclone resilient houses for saving lives and reducing damages should be given priority.

6.5 Increased Affected Population – Reduced Mortality

6.5.1 The cyclone related deaths are declining in India over past decades. This reduction in disaster mortality has come through robust preparedness, effective early warning by IMD, people's readiness and swift response. Despite decrease in mortality, economic loss and the number of affected population is increasing. In the memorandum of loss submitted by Government of Tamil Nadu, the total projected loss is Rs. 16341 Cr. As per India's commitment to Sendai Framework, more focused approach is needed to address Target B of Sendai framework which aims at substantially reducing the number of affected people globally by 2030, aiming to lower average global figure per 100,000 in the decade 2020 -2030 compared to the period 2005-2015. Similarly focus should be on achieving Target C of SFDRR, which aims at reducing direct economic losses.

Table 11: Number of deaths due to cyclone in Tamil Nadu

Sl No.	Cyclone	Date	Number of Deaths
1.	Nisha (2008)	25-29th November 2008	186
2.	Thane (2011)	1-12th November 2010	57
3.	Vaardah (2016)	6-19th December 2016	22
4.	Ockhi (2017)	29th November – 6th December 2017	42
5.	Gaja (2018)	10 – 21st November 2018	52

6.5.2 However, despite decrease in number of deaths, number of people getting affected by disasters is increasing. Coastal areas are densely populated due to availability of variety of livelihood options, rapid economic growth and coastward migration. Most of the world's megacities are located in the coastal zone and many of these are situated in large deltas, where combinations of specific economic, geographic and historical conditions to date attract people and drive coastal migration. Thus, disasters in coastal areas impact more population and lead to greater economic loss.

6.5.3 Secondly, a large number of populations are involved in primary livelihoods which get more affected by coastal hazards like cyclone. For instance, fishermen in the coast are severely affected by the cyclones. The high speed winds often damage the boats kept at the shore and large quantity of fishing net either gets damaged or lost.

6.5.4 Thirdly, the time gap between the occurrences of cyclones is decreasing. Hence the ability of households as well as governments for post disaster recovery is hugely challenging.

6.6 Critical Analysis of Preparedness

6.6.1 Government of Tamil Nadu is concerned about preparedness for cyclones and other weather related disasters and has comprehensive plan for HRVA and other strategic actions in accordance with the Sendai Framework for Disaster Risk Reduction (2015-2030) and National Disaster Management Plan 2016. The Government of Tamil Nadu also initiated studies to analyse the Hazard, Risk and Vulnerability of various disasters. However, the HRVA has not been completed for the Cyclone Gaja affected districts. The HRVA study for Cuddalore District is still under progress.

6.6.2 The Government of Tamil Nadu mobilised its response in line with Incident Response System (IRS) and accordingly all stakeholders were geared up for immediate response to

protect people & their properties. NDRF and TN-SDRF were deployed at required places ahead of the cyclonic storm Gaja. With 19 inter-departmental zones in Cuddalore, the district administration made arrangements to evacuate people in coastal areas to relief centres. The government mobilised top administrative officials for better inter-agency coordination and preparedness that resulted into effective response and relief.

6.6.3 The first responders are local level volunteers in Tamil Nadu who were activated after receiving early warning information. They not only provided information about the impending cyclone but also helped in evacuation. Though Government of Tamil Nadu deployed volunteers trained in first aid and search & rescue and also for awareness generation, there is a need for more trained volunteers and first responders with specialised training in search & rescue, cutting of fallen trees etc.

6.6.4 Management of relief distribution is one of the most important aspects of disaster management. While providing food and shelter remains the focus of relief distribution, items like clothes, school uniform, cooking vessels and other essential items are also very relevant and important in post disaster situation.

6.6.5 There is a need to focus more aggressively and in organised manner for creating awareness at all levels among stakeholders including community. Use of IEC materials and appropriate media mix can be instrumental in awareness, sensitisation and dissemination of early warning.

6.6.6 Responsibilities were laid down clearly for all stakeholders including senior IAS officers and others concerned with management of cyclone Gaja and everyone took their responsibility and discharged their duties effectively.

6.6.7 Cyclones become so devastating due to high wind speeds and cause severe damage and fatalities. In the absence of any wind breaks in coastal areas, their impact is very high. Government should take special measures for plantation in coastal areas which will act as wind shields and protect houses, people and other establishments in coastal areas.

6.6.8 Enacting Coastal Zone Regulation could be very useful in demarcating 'no development zones' along the coastline and prevent unauthorised development in coastal areas. It will subsequently check environmental degradation and loss to property and lives.

6.6.9 In rural India agrarian economy still constitutes a sizeable share in providing livelihoods and contributes to India's GDP. Cyclones like 'Gaja' impact agriculture, fisheries and livestock leaving the affected community deprived of their basic livelihood in the absence of any alternate livelihood mechanism. This can be addressed by focusing on establishments of other industries or skill development programmes for creating more livelihood options, which can offer some means of survival for disaster affected population.

7 Best Practices

7.1 The Government of Tamil Nadu took various measures towards disaster preparedness and response keeping in minds all the coastal disasters floods, cyclones and tsunamis. These are some of the best practices that are noteworthy with reference to management of Cyclone Gaja:

- Preparedness at highest level – Hon'ble Chief Minister closely reviewed and monitored all preparedness measures pertaining to North East Monsoon. This was also accompanied by close watch on the situation by the Hon'ble Minister for Revenue and Disaster Management, Principal Secretary, Revenue and Disaster Management Department and Commissioner Revenue Administration/ State Relief Commissioner etc. The Principal Secretary/ Commissioner of Revenue Administration issued circulars with detailed instructions to the District Collectors and other Department officials of all Districts and conducted regular review/ advisory meetings regarding preparatory measures to be taken to face the North East Monsoon.
- Monitoring Mechanism - Senior IAS Officers were appointed by the Hon'ble Chief Minister of Tamil Nadu for all districts to monitor the preparedness measures and interdepartmental coordination.
- Mapping and Vulnerability Analysis – Total of 4,399 areas were identified in the State as vulnerable to disasters related to monsoon.
- Disaster Response Guards-Skilled Volunteers: A pool of volunteers who were adept in swimming and climbing were selected. 30,750 volunteers, including women, were trained as first responders. Primary task of first responders was to evacuate people and help in search & rescue. In addition, 8,500 first responders were also trained to protect animals.
- Better inter-departmental co-ordination: Inter Departmental Zonal Teams were constituted, which were responsible for 5–7 vulnerable areas. This helped in establishing effective coordination between different departments. These teams were led by Revenue Department officials and assisted by Police, Fire, RD, PWD etc. At district level DM and SDMs were involved. One Minister was in charge of every district, to supervise preparedness and evacuation.

- Co-ordination with private organizations - To sensitize the private institutions, to seek their support at the time of need, series of meetings were held at District and State level with Hospitals, Educational organizations, Communication Service providers and Oil Companies to develop institutional strategies and to ensure round the clock functioning of emergency services. Seamless Communication through multiple channels - Multiple channels such as newspapers, electronic news channels, social media, wireless systems were used to spread awareness among the community on the Do's and Don'ts during disasters.

- TNSMART: Tamil Nadu System for Multi-Hazard Impact Assessment, Alert and Emergency Response Planning and Tracking (TNSMART) is Web-GIS based mobile application and mobile application developed as a decision support tool. This decision support tool, with 11 modules, empowering policy-makers, operational-users of Incident Response System, and community with necessary early warning information for decision making during all the phases of Disaster Management, is first of its kind in India and elsewhere. The modules enable even the general public to take informed decisions since the alerts sent using the system are location and user specific. The unique alarm system built in TNSMART mobile application can save lives even if the lead time available is not much.

- Disaster Response - Tamil Nadu State Disaster Response Force (TNSDRF): Government of Tamil Nadu has strengthened its response mechanisms over a period of time, in order to ensure that people in vulnerable areas are evacuated safely, based on forecast and search & rescue operations are carried out swiftly as and when the disaster strikes. In order to strengthen the disaster response, Government of Tamil Nadu decided to raise an exclusive battalion as Tamil Nadu Disaster Response Force (TNSDRF) and also to procure equipment to strengthen different agencies involved in search & rescue operations.

- Capacity Building - Training to Revenue and Disaster Management Officials: In pursuance of the announcement made by the Hon'ble Minister for Revenue and Disaster Management on the floor of the Assembly on 10.07.2017, the Government has passed orders vide G.O. (Ms) No.282, Revenue and Disaster Management (DM- II) Department, dated 23.09.2017 for releasing an amount of Rs.73.55 Lakhs for providing training to Revenue and Disaster Management Officials. Out of this amount, a sum of Rs.13.55 lakhs was allotted for conducting Regional Level Disaster Preparedness Training Programme. Further, a sum of Rs.3.00 lakhs per Coastal and Hilly District and Rs.1.00 Lakh per Non-Coastal District, totaling a sum of Rs.60.00 lakh was sanctioned to all Districts to conduct the Mock Exercises at District Level.

- Coastal Disaster Risk Reduction Project (CDRRP) - On 15.05.2013, the then Hon'ble

Chief Minister of Tamil Nadu announced on the floor of Legislative Assembly that a special scheme called Coastal Disaster Risk Reduction Project (CDRRP) will be implemented with the assistance of World Bank at a cost of Rs.1,481.80 crore and the administrative sanction was accorded in the year 2014. 13 Coastal districts are covered under this project. The Commissioner, Disaster Management (DM) is the Project Director for the project and the Additional Chief Secretary/ Commissioner of Revenue Administration is the Project Coordinator. The core components of the project are: Vulnerability Reduction, Sustainable Fisheries, Capacity Building in Disaster Risk Management and Implementation Support.

- Animal Shelters: Animals are equally affected by cyclones. Government identified shelters in order to protect the animals. In Nagapattinam itself there are 2,200 first responders trained to protect animals and 212 shelters to house animals.
- Specific advisory: As precautionary measure, along with declaring holidays for schools and colleges, the private sector and commercial establishment were also asked to declare holidays during 15th - 16th November, 2018 afternoon onwards. Similarly, cinema theatres were asked to stop screening of films and transport of vehicles was stopped in coastal districts between 6 pm 15th November, 2018 to 6 am of 16th November, 2018.
- From Food Based Relief Measures to Need Based Relief Measures: Government of Tamil Nadu provided need based relief in place of only food based relief. It distributed 27 household items as gift hampers to the affected populations. These items included utensils, tarpaulins, mosquito coils, umbrella, bed-sheets, detergent soaps, milk powder, etc.

8 Lessons Learnt & Recommendations

8.1 Lessons Learnt

8.1.1 Every disaster response, if analysed, helps us to learn lessons to respond better in future. Some of the lessons learnt from Tamil Nadu Gaja cyclone are:

- State Governments should convene pre-monsoon meetings to review the preparedness for cyclones and other weather related disasters with defined roles and responsibilities of various stakeholders.
- Regular mock-exercises should be conducted, involving all stakeholders.
- TNSMART, the web-GIS based application should be operationalized for better results in management of cyclone and other disasters.
- Updation of resource inventory on India Disaster Resource Network (IDRN).
- Provision for underground cabling in coastal areas to prevent disruption of power supply.
- Training of community volunteers as first responders with specialized skills on search & rescue, evacuation, first aid, cutting of fallen trees etc.
- Proper documentation of learning from past and subsequent disasters for better preparedness and development of effective strategies for future.

8.2 Recommendations

8.2.1 Based on the study, following recommendations are provided for better management of cyclones not only in Tamil Nadu but also in all the cyclone prone coastal States/ UTs:

- HRVA needs to be done on priority basis for all the districts.
- Strengthening of SDRF, Fire Services and other agencies engaged in response and rescue.

- Community volunteers, including women, should be trained in specific skills for search & rescue, evacuation, first aid etc.
- A mechanism for supply chain management needs to be established for smoother procurement, transportation and distribution of relief supplies.
- As a matter of practice, the kit of relief articles to be distributed during disasters to affected households should be prepared in advance.
- List of Geographical Coordinates of identified strategic rescue and relief points to be included in the SDMPs/ DDMPs.
- Alternate livelihood opportunities for fishing and farming community.
- Utilizing labour under National Rural Employment Guarantee Scheme with provisioning of fund from State budget and Corporate Social Responsibility to maintain clean water bodies.
- Institutional mechanism and Standard Operating Procedures need to be formulated for seeking assistance from neighboring districts and states.
- Application of impact based forecast using socio-economic data up to village level.
- The State Disaster Management Plan (SDMP) should be periodically reviewed and updated, incorporating learning from subsequent disasters. All the districts should have their District Disaster Management Plan (DDMP) with periodic revision and updates.
- Should focus on Cyclone resistant building designs and construction to minimize economic losses.
- Business Continuity Planning for B2B and B2G may be encouraged for essential sectors.
- Need based relief measures should be promoted.
- A pool of Multi-skilled trained volunteers needs to be created at district and village level.
- Use of NCC, NSS, Industry and community volunteers for removal of trees from interior as well as main roads.
- Universal accessible designs need to be implemented in all Multi-Purpose Cyclone Shelters.

- Promoting solar systems for ensuring emergency electricity supply.
- Inter-departmental coordination needs to be ensured.
- Strategies should be developed based on the return period of cyclones, as well as increasing frequency of hydro-meteorological events due to changing climate.

References

- Aguirre, B (1991): "Evacuation in Cancun during Hurricane Gilbert," International Journal of Mass Emergency and Disaster, Vol 9, No 1, pp 31-45.
- Baker, E J (1979): "Predicting Responses to Hurricane Warnings: A Reanalysis of Data from Four Studies," Mass Emergencies, Vol 4, No 1, pp 9-24.
- Baker, E J (1991): "Hurricane Evacuation Behaviour," International Journal of Mass Emergencies and Disaster, Vol 4, No 2, pp2879-310.
- Christensen, L and C E Ruch (1980): "The Effect of Social Influence on Response to Hurricane Warnings," Disasters, Vol 4, No 2, pp 205-10.
- Dash, B, 2002; "Lessons to be Learned from Orissa Super Cyclone 1999," Economic & Political Weekly, Vol XXXVII, No 42, pp 4270-71.
- Dash, B (2014): "Public Understanding of Cyclone Warning in India: Can Wind Be Predicted?," Public Understanding of Science, Vol 15, No. 8.
- De, U S, SK Dube and U S P Rao (2005): "Extreme Weather Events in India over Last Hundred Years", Journal of Geo Physical Union, Vol 9, No. 3, pp173-187.
- Dube, S K, A D Rao, P C Sinha, T S Murty and N Bahulayan, (1997); "Storm Surge in the Bay of Bengal and Arabian Sea," Natural Hazards, Vol 51 No 1, pp 3-27.
- Dube, S.K., I. Jain, A D Rao and T S Murty (2009): "Storm Surge Modelling for the Bay of Bengal and Arabian Sea", Natural Hazards, Vol 51, No. 1, pp 3-27.
- Fritz H M, C D Blount, F B Albusaidi and A H M Al-Harthy (2010): "Cyclone Storm Surge in Oman," Estuarine, Coastal and Shelf Science, Vol 86, No 1 PP 102-06.
- Fritz H M, C D Blount, S Thwin, M K Thu ans N Chan, 2009; "Cyclone Storm Surge in Myanmar," Nature Geoscience, Vol 2, No July, pp 449.
- Gladwin, C H, H Gladwin and W G Peacock (2001): "Modelling Hurricane Evacuation Decision with Ethnographic Methods," International Journal of Mass Emergencies and Disaster, Vol 19, pp 117-43.
- Haque, C E (1995): "Climate Hazard Warning Process in Bangladesh: Experience of and Lessons from 1991 April Cyclone," Environmental Management, Vol 19, No 5, pp 719-34.

- Horney, J, P D M MacDonald, M V Willigen and P R Berke (2010): "Factors Associated with Evacuation from Hurricane Isabell in North Carolina," International Journal of Mass Emergency and Disaster, Vol 28, No 1, pp 33-58.
- IMD 2013:20- "Very Severe Cyclonic Storm, Phailin over the Bay of Bengal (8-14 October): A Report," New Delhi: India Meteorological Department, Government of India, http://www.imd.gov.in/section/nhac/dynamic/Phailin.pdf.
- IMD 2014: 1- "Very Severe Cyclonic Storm, Hudhud over the Bay of Bengal (7-14 October): A report," New Delhi: India Meteorolocial Department, Government of India, http://www.rsmc-newdelhi.imd.gov.in/images/pdf/publications/preliminary-report/hud.pdf.
- King, G, and T Dominey-Howes (2006): "Cyclone Knowledge and Household Preparation: Some Insights from Cyclone Larry," Australian Journal of Emergency Management, Vol 21, No 3.
- Knabb et al 2005 – "Tropical Cylone Report Hurricane Katrina," National Hurricane Centre US, http://www.nhc.noaa.gov/pdf/TCR-AL122005_Katrina.pdf, viewed on 15 March 2015.
- Kolen, B and I Helsloot (2012): "Time Needed to Evacuate the Netherlands in the Event of Large-scale Flooding: Strategies and Consequences," Disaster Vol 36, No 4, pp 700-22.
- Kolen, B, M Kok, I Helsloot and B Maaskant (2013): "EavcuAid: A Probabilistic Model to Determine the Expected Loss of Life for Different Mass Evacuation Strategies during Flood Threats," Risk Analysis, Vol 33, No 7, pp 1312-32.
- Lagmay, A M< R P Agaton, M A C Bahala, J L T Briones, K M C Cabacaba, C V C Caro et al, 2015; "Devastating Storm Surges of Typhoon Haiyan," International Journal of Disaster Risk Reduction, Vol 11, pp 1-12.
- Lindell, M K and R W Perry (1991): Evacuation Research: Theory and Applications," International Journal of Mass Emergency and Disaster, Vol 9, No 2, pp 133-36.
- Lindell, M K, L Jing-Chien and S P Carla (2005): "Household Decision Making to Evacuation in Response to Hurricane Lilli," Natural Hazards Review, Vol 6, No. 4, pp 171-79.
- Mohapatra, M., Journal of Earth System Science, 124, No. 3, April 2015, PP 515-526, Indian Academy of Sciences.
- Nair, Akhila. G., and Annadurai, R., International Journal of Pure and Applied Mathematics, Vol. 119, No. 14, 2018, Pg 589-595.
- Narain, S (2019): "Changing character of cyclones" Down to Earth, https://www.downtoearth.org.in/blog/climate-change/changing-character-of-cyclones-64496.

- NCRMP, 2019 https://ncrmp.gov.in/cyclones-their-impact-in-india.
- Paul 2009 – "Why Relatively Fewer People Died? The Case of Bangladesh's Cyclone Sidr," Natural Hazards, Vol 50, No 2, pp 289-304.
- Paul, A and M MRahman (2006): "Cyclone Mitigation Perspectives in the Islands of Bangladesh: A case of Sandwip and Hatia Islands," Coastal Management, Vol 34, No 2, pp 199-215.
- Perry, R W (1979): Evacuation Decision-making in Natural Disaster," Mass Emergencies, Vol 4, pp 25-38.
- Riad, J K and F H Norris (1998): Hurricane Threat and Evacuation Intentions: An Analysis of Risk Perception, Preparedness, Social Influence and Resources, Preliminary Paper#271, University of Delaware.
- Salmon, J D (1984): "Vertical Evacuation in Hurricanes: AN Urgent Policy Problem for Coastal Managers," Coastal Management Journal, Vol 12, No 2-3, pp 287-300.
- Shaji, C, S K Kar and T Vishal (2014): "Storm Surge Studies in the North Indian Ocean: A Review", Indian Journal of Geo-Marine Sciences, Vol 43, No. 2, pp 125-147
- Sharma, U, A Patwardhan and D Parthasarathy (2009): "Assessing Adaptive Capacity to Tropical Cyclone in the East Coast of India: A Pilot Study of Public Response to Cyclone Warning Information," Climatic Change, Vol 94, No 1-2, pp 189-209.
- Sorensen, J H (1991): "When Shall We Leave: Factors Affecting the Timing of Evacuation Departure," International Journal of Mass Emergencies and Disasters, Vol 9, No 2, pp 153-65.
- Velotti, L, J E Trainor and K Engel (2013): "Beyond Vertical Evacuation: Research Consideration for a Comprehensive Vertical Protection Strategy," International Journal of Mass Emergency and Disaster, Vol 31, No 1, pp 60-77.
- Westgate, K (1978): "Hurricane Response and Hurricane Perception in the Commonwealth of Bahamas," Mass Emergencies, Vol 3, pp 251-65.
- WMO 2009 Tropical Cyclone operational plan for the Bay of Bengal and the Arabian Sea; Tropical Cyclone Programme Report no. TCP-21, Edition 2009, WMO/TD No. 84.
- Wolshon, B, E Urbina and M Levitan (2001): "National Review of Hurricane Evacuation Plans and Policies," Baton Rogue: Louisiana State University Hurricane Centre.
- Yates, L and L Anderson-Berry (2004): "The Societal and Environmental Impacts of Cyclone Zoe and the Effectiveness of Tropical Cyclone Warning System in Tikopia and

Anuta Solomon Islands: December 26-29, 2002," Australian Journal of Emergency Management, Vol 19, No 1, pp 16-20.

- Zhai, G and S Ikeda (2006): "Flood Risk Acceptability and Economic Value of Evacuation," Risk Analysis, Vol 26, No 3, pp 6.

VPS Engineering Impex Pvt. Ltd.
B-4, Sector 60, Noida-201309
+91 120 4317109
e mail: marketingvps2013@gmail.com