सत्यमेव जयते

INDIA DISASTER REPORT
2018



nidm
Resilient India - Disaster Free India

National Institute of Disaster Management
(Ministry of Home Affairs, Government of India)



Ministry of Home Affairs
Government of India

India Disaster Report 2018

National Institute of Disaster Management (NIDM)
(Ministry of Home Affairs, Government of India)

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India Disaster Report 2018

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Editor

Dr. Amir Ali Khan, NIDM

Maj Gen Manoj Kumar Bindal, VSM, NIDM

Contributor

Ms. Safia Khatoon (Intern, 2019)

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Resilient India - Disaster Free India

Maj Gen Manoj Kumar Bindal
VSM

Executive Director

सत्यमेव जयते

राष्ट्रीय आपदा प्रबंधन संस्थान
(गृह मंत्रालय, भारत सरकार)
National Institute of Disaster Management
Ministry of Home Affairs, Govt. of India
A-wing, 4th Floor, NDCC-II, Jai Singh Road,
New Delhi-110001

FOREWORD



The National Institute of Disaster Management was established under the Disaster Management Act 2005 with a vision to play the role of a premier institute for capacity building in the area of disaster risk reduction. It has been entrusted with the responsibility of human resource development, training and capacity building, research, documentation and policy advocacy in the area of specialization.

NIDM initiated compilation of the India Disaster Report (IDR) since 2011 to stimulate improved data collection and process of management of disaster events that had taken place in a particular year. These yearly disaster reports compile all the important database of the past disasters in a document form.

The year 2018 was an extraordinary year in context of natural and human-induced disasters. The IDR-2018 focuses on major as well as minor disasters of the year putting more emphasis on Kerala Floods-2018. These floods left a substantial impact on the country with its severity and proved to be a great lesson for disaster managers at national level. A substantial loss of life and property was witnessed during the calamity. This report accommodates a detailed account of useful information associated with the floods. Besides Kerala floods, other floods in different parts of the country have also been covered.

The country faced four cyclonic storms over the eastern and western coasts during the year. Other disasters which took place during the year include biological disasters like Nipah Virus outbreak in the state of Kerala, forest fires, building fires, road and rail accidents, etc. All these disaster events have also been listed briefly in the Report.

The past disaster events illustrate that certain lessons need to be learnt for correcting future course of action and to manage such events in a better and coordinated manner. It is expected that this compilation of data would provide a valuable source of information to all stakeholders including researchers and practicing disaster managers and help in improving the overall disaster management at national level. It is also expected that the Report brings out much needed awareness among the vulnerable population and many useful lessons are extracted and applied in future scenarios.

MKBindal

(Major General Manoj Kumar Bindal, VSM)
Executive Director,
National Institute of Disaster Management (NIDM)
New Delhi, India

ACKNOWLEDGEMENT

India is a highly disaster prone country. Every year country faces disasters of unprecedented nature leading to damage to life and property. These recurring disaster events teach certain lessons, which may be of use in mitigating the impact of future disasters. The documentation of disaster events provides an opportunity to learn lessons from specific events. Through India Disaster Report, NIDM makes an attempt to document the events that have taken place during a specific year. The IDR series of the Institute was started in 2011 compiling information, data and other relevant information of all disaster events that had taken place in the country with lessons learnt. The IDR-2018 is an attempt to compile the information of some of the events that had impacted the nation during the year.

The IDR-2018 was compiled with the active assistance of the NIDM Summer Intern-2018 over a period of eight weeks. The Report is primarily based on the secondary data sources. However, an attempt has been made to use data mostly from government sources.

It is a pleasure to express thanks to all who have contributed towards this effort. Special thanks to Major General Manoj Kumar Bindal, Executive Director, NIDM for his constant support, encouragement and guidance in compiling this Report. Well-deserved thanks to Director General, National Disaster Response Force (NDRF) and his team for providing useful information. Special thanks to the reviewers of the IDR-2018 Prof. Vinod K Sharma, Shri Anil Sinha and Maj. Gen. Dr. V K Naik for going through the draft report and sharing useful insights. The team of officials at the Disaster Management Division, Ministry of Home Affairs (MHA), particularly Om Prakash ji, was supportive and provided useful insights also. Last but not the least thanks to NIDM summer intern Ms. Safia Khatoon for her dedicated hard work in compilation of the Report and NIDM Team including Shri S. K. Tiwari, Ms. Sonali Jain and Ms. Yogita Garbyal their useful assistance in finalizing the report.



(Amir Ali Khan)
Assistant Professor

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LIST OF ABBREVIATIONS

ASDMA	Assam State Disaster Management Authority
CBRN	Chemical, Biological, Radiological& Nuclear
CHC	Community Health Centre
CNN	Cable News Network
CRED	Centre for Research on the Epidemiology of Disasters
CRPF	Central Reserve Police Force
CS	Cyclonic Storm
CWC	Central Water Commission
DD	Deep Depression
ETF	Engineer Task Forces
ETR	Extra Tropical Cyclones
FRL	Full Reservoir Level
HFL	Highest Flood Level
IAF	Indian Air Force
IDR	India Disaster Report
IMD	Indian Meteorological Department
KWA	Kerala Water Authority
LPA	Low Pressure Area
MCM	Million Cubic Meters
MSW	Maximum Surface Wind
NDMA	National Disaster Management Authority
NDRF	National Disaster Response Force
ODRAF	Odisha State Rapid Action Force
PDNA	Post Disaster Needs Assessment
PHC	Primary Health Centre

RAMT	Rapid Action Medical Team
RSMC	Regional Specialized Meteorological Centre
SANDRP	South Asian Network on Dams River and People
SCS	Severe Cyclonic Storm
SDRF	State Disaster Response Force
SHOC	Strategic Health Operation Centre
SNC	Southern Naval Command
TLM	Teaching Learning Material
UN	United Nations
UNDP	United Nations Development Programme
UNISDR	United Nations International Strategy for Disaster Reduction
VSCS	Very Severe Cyclonic Storm
WASH	Water Sanitation and Hygiene
WHO	World Health Organization
WMO	World Meteorological Organization

1 INTRODUCTION

1.1 GENERAL PROFILE OF INDIA

India has a unique geophysical setting which separates it from the rest of Asia. Being the seventh-largest country in the world, it covers an area of 32, 87,263 sq. km, extending from the snow-covered Himalayan heights to the tropical rain forests of the south[1]. The country is surrounded by three huge water bodies; Bay of Bengal to the east, Arabian Sea to the west and Indian Ocean to its south which gives the country a distinct geographical entity.

As per the socio-economic profile, India has experienced tremendous growth of population since the advent of the industrial revolution and now contains about 1,210,193,422 people as per the provisional results of the 2011 census. The sex ratio in the country stands at 940 females per 1000 males, and the literacy rate at 74.04%[2].

1.2 HAZARD/VULNERABILITY PROFILE OF INDIA

Due to its unique geo-climatic conditions, topography, environmental degradation, processes of urbanization, industrialization and other human-induced factors, India has been quite prone and vulnerable to various natural and human induced disasters. Natural disasters like floods, droughts, cyclones, tsunami, earthquakes, landslides, avalanches, heat and cold waves, forest fires, etc. have been recurrent. To be precise, about 58.6% of the region is prone to earthquakes of varying intensities; over 12% of the land is exposed to floods and erosion; 8% to cyclones and 68% is vulnerable to droughts[3]. Besides, the hilly areas are at risk of landslides and avalanches.

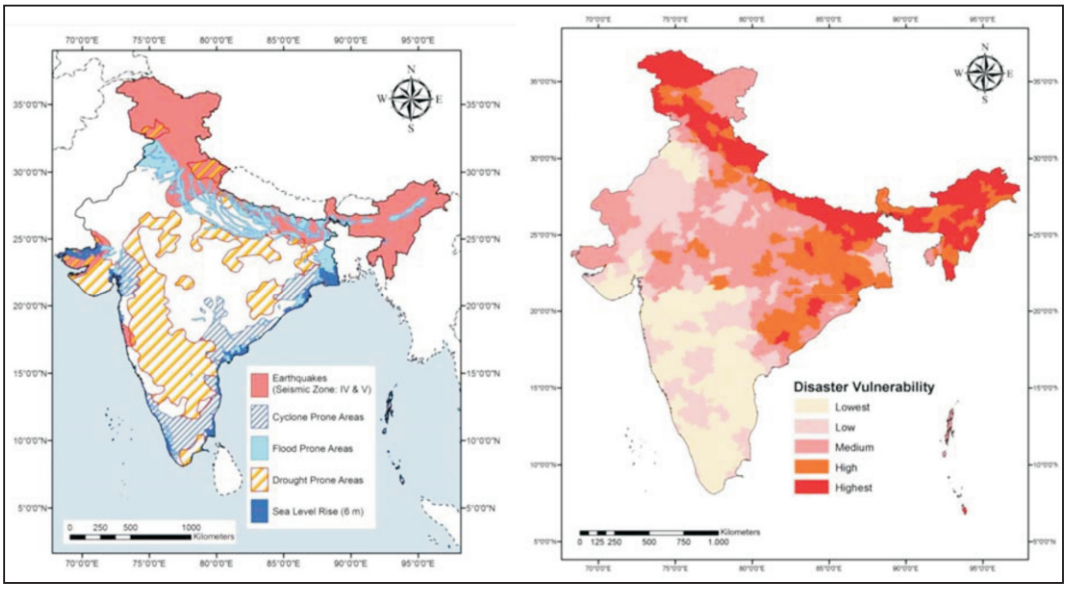
The country also witnesses CBRN (Chemical, Biological, Radiological and Nuclear) disasters; examples being gas tragedies, industrial disasters, several kinds of virus outbreaks and disasters due to technical failures, etc. The frequency and intensity of the disasters in the country have been increasing in recent years as witnessed.

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[1] National Portal of India, https://www.india.gov.in/india-glance/profile.
[2] Census 2011 from censusindia.gov.in
[3] National Institute of Disaster Management. "India", accessed from https://nidm.gov.in/easindia2014/err/pdf/country-profile/India.pdf on June 26, 2019.

Hazard and vulnerability map (Map 1) shows the hazard and vulnerability profile of India; one classifies the country based on high to low vulnerability to disasters and another portrays hazard profile with various disaster types recurrent in the country. It can be observed that the highest vulnerability to disasters is found in the northern part and some portions of eastern coastal areas, whereas the lowest proneness is observed in its southern parts. However, the northern part is highly exposed to earthquakes, landslides, and floods while most of the southern part is exposed to cyclones (mainly eastern parts) and droughts (mainly west part).

Map 1: Hazard and vulnerability map of india



Source:- Chakraborty, Anusheema & K. Joshi, P. (2016). Mapping disaster vulnerability in India using analytical hierarchy process, retrieved on July 5, 2019 from Research gate. net

1.3 DISASTERS - SCENARIO OF 2018

Year 2018 witnessed many dreadful disasters viz. floods, cyclones, landslides, droughts, heat/cold waves, fires, and other human-induced ones. Some of them viciously influenced the socio-economic conditions of the areas where they befell. Table 1.1 provides an overview of the major disasters occurred in 2018. It can be observed that India has the highest number of people affected by various disasters; the most devastating one was the Kerala floods.

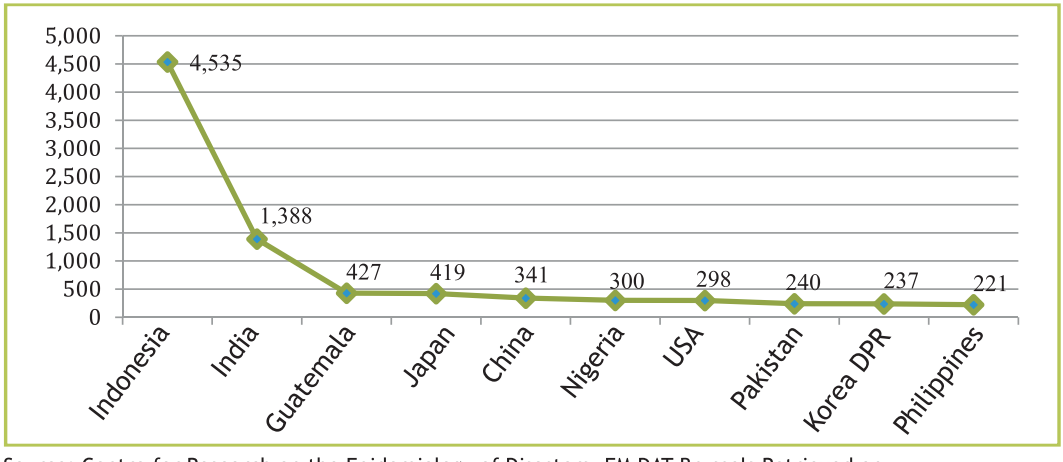
Disasters bring with them huge distress, not only in terms of physical damage and loss of human lives, but also mental, social and economic damages. Every year, hundreds of million people are affected owing to these events. Figure 1.1 gives a profile of countries with the highest number of deaths caused by various disasters in 2018.

Table 1.1: Top 10 countries with number of people affected by various disasters in 2018

COUNTRY	NUMBER OF PEOPLE AFFECTED
India	23,900,348
Philippines	6,490,216
China	6,415,024
Nigeria	3,938,204
Guatemala	3,291,359
Kenya	3,211,188
Afghanistan	2,206,750
USA	1,762,103
Japan	1,599,497
Madagascar	1,472,190

Source: Centre for Research on the Epidemiology of disasters (CRED), EM-DAT Brussels. Retrieved on June 26, 2019.

Figure 1.1: Top 10 countries by number of deaths in 2018



Source: Centre for Research on the Epidemiology of Disasters, EM DAT Brussels Retrieved on June 26, 2019 from https://cred.be/sites/default/files/PressReleaseReview2019.pdf

1.4 DISASTERS IN INDIA-2018

The year 2018 witnessed Kerala Floods as a major disaster which makes it the third wettest year in the last 118 years (1901-2018) after 1924 (wettest) and 1961 (second wettest)[4]. Other disasters include a series of four cyclones on the eastern coast of India and some moderate ones like forest fire in Tamil Nadu, heat wave and drought in Maharashtra, storms and thunderstorms in Uttar Pradesh and Rajasthan, floods in Karnataka, North-East India and West Bengal, road accidents and urban fires etc. in several parts of the country.

Such disaster occurrences in India have been documented in India Disaster Report (IDR) - 2018. The concept of IDR was initiated in 2011 with an objective to document the yearly events taking place at national level and to build an aware and resilient society.

1.5 OBJECTIVES OF THE IDR - 2018

IDR 2018 is documented considering the following objectives:

- To gather information and data about the disaster events witnessed by India in 2018; and
- To outline possible causes, impacts, with rescue relief operations undertaken for the respective disasters.

1.6 METHODOLOGY AND DATA BASE

1.6.1 Database

The data used in this report is secondary in nature and has been obtained from the following sources:

- Ministry of Home Affairs;
- Memorandums submitted by State Governments to Government of India;
- Post Disaster Needs Assessment Reports;
- Disaster Management Authorities of respective states;
- EM-DAT, the International Disaster Database;
- NDRF Sources;
- Different International and National Disaster websites (UNDP, SANDRP, UNISDR, NDMA etc.);
- Several published reports and articles in public domain (including Newspapers etc.);
- Others.

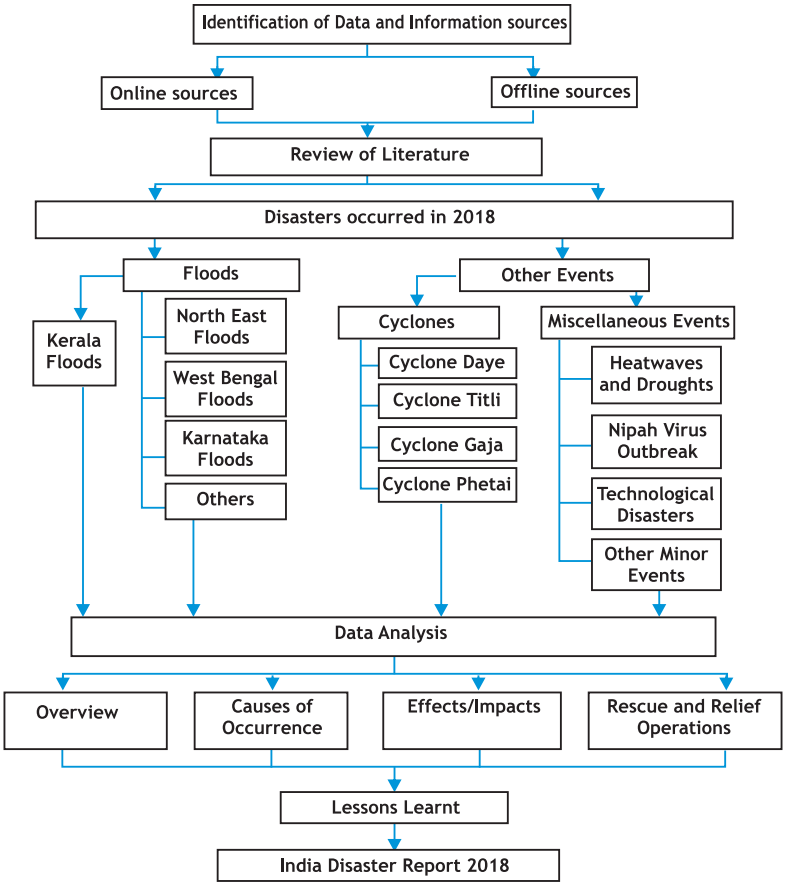
[4]Prasad,R.(2018,September21).ArareconfluenceofeventsledtofloodinginKerala,saysstudy.RetrievedJuly2,2019, from https://www.thehindu.com/news/national/kerala/a-rare-confluence-of-events-led-to-flooding-in-kerala-says-study/article25005984.ece

1.6.2 Methodology

The data and information derived for the report was divided into two major sources; offline sources and online sources. After analyzing the sources, different disastrous events were outlined. The major causes of the disasters, their overall impacts and consequences along with the rescue and relief operations held by different international and national organizations have been included in the report. Based on this information, some lessons are also extracted from different disaster events.

Flow chart depicting the methodology adopted for compiling the India Disaster Report 2018 has been placed at figure 1.2.

Figure 1.2: Methodology flow chart



1.7 LIMITATIONS

The compilation of this report has following limitations:

- The source and data used in this report are secondary; and
- Limited access to several official websites and documents
- Pressing timeline (of about two months) to compile the initial draft report.

2 FLOODS

The year 2018 was a year of enduring floods. During the south west Monsoon season, sizably capacious parts of the country suffered from heavily ponderous to extreme precipitative events that led to extreme flood surges and landslides, etc. Floods in many parts have impacted the country severely; and resulted in about 504 deaths[5]. These events affected not only the lifestyle of the population but also caused a lot of physical, economic and mental distress.

Table 2.1 shows the distribution of several flood events occurred in different parts of the country in the year 2018; maximum flood occurrence was observed in the north-eastern region with Assam, Tripura, Mizoram and Manipur being the most affected. However, the most disastrous event witnessed in this year was the Kerala floods that made 2018 the third wettest year after 1924 and 1961. It can be observed from the table below that from the month of May to August, the monsoon season, many flood events were observed in most parts of the country including even parts of Rajasthan.

Table 2.1: Floods in India in 2018

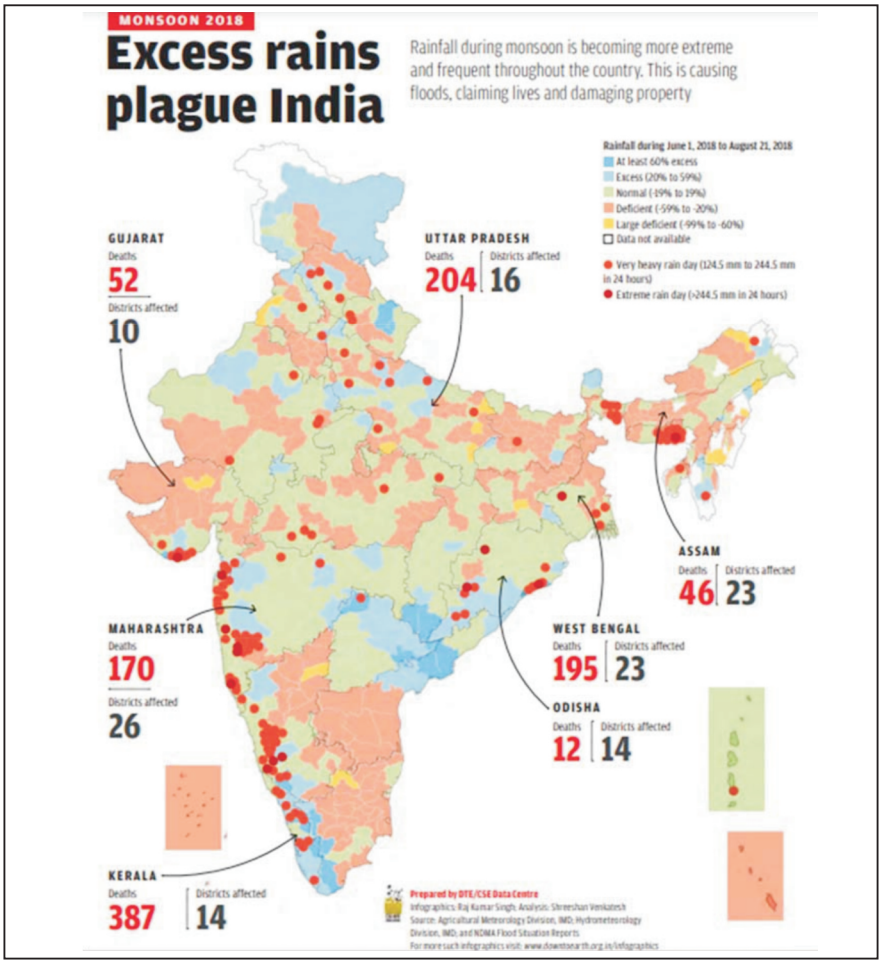
LOCATION	PERIOD
Kerala Floods	June 1-August 19, 2018
Tripura Flash Floods	May 17-May 20, 2018
Karnataka Floods	May 29-May 31, 2018
Assam, Maharashtra, Gujarat	June 22-July 7,2018
Odisha	July 20-July 23, 2018
Uttar Pradesh, Rajasthan	July 26-July 28, 2018
Assam and West Bengal	August 2-August 6, 2018
Flash Floods in Kerala, West Bengal, Odisha, Assam, Maharashtra, UP, MP.	August 7-August 20, 2018

Source: - EM-DAT Brussels and Situation reports by DM Division, MHA, 2018.

[5]EM-DAT Brussels, International Disaster database

Figure 2.1 depicts that most parts of the country experienced floods in 2018. According to the map, Kerala had the highest number of deaths followed by Uttar Pradesh, West Bengal and Maharashtra due to the monsoon rains that resulted in flooding and extreme loss of lives and property. Other affected states were Gujarat, Assam, Odisha and Karnataka. Number of districts affected can also be observed in figure 2.1.

Figure 2.1: Monsoon rains in India - 2018



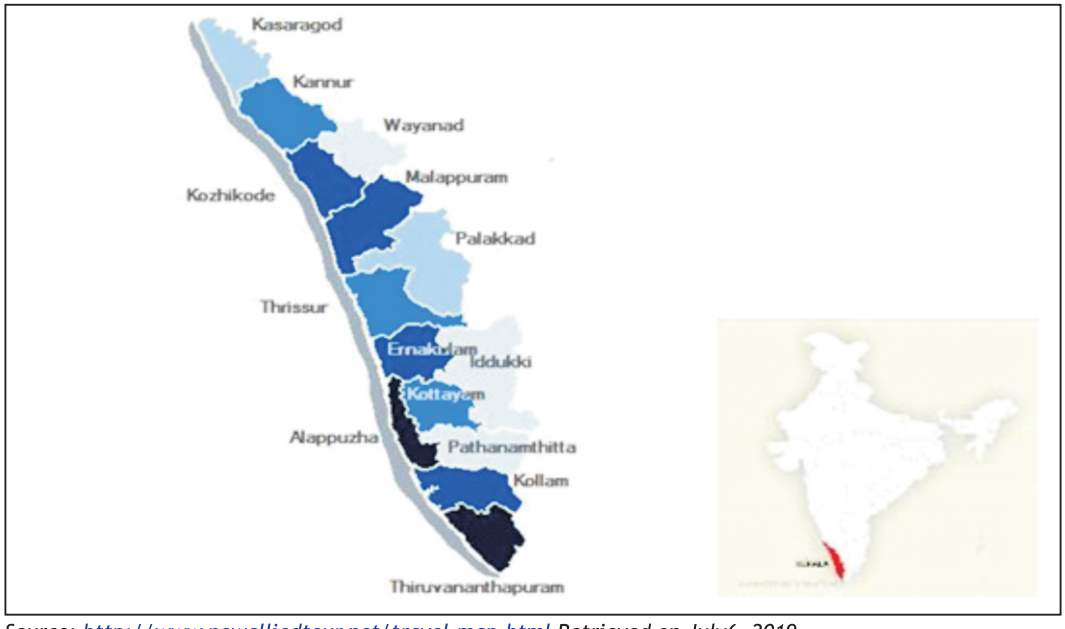
Source: https://www.downtoearth.org.in/news/natural-disasters/monsoon-2018-destructive-yes-distributive-no-61465,, Retrieved on July 20, 2019.

2.1 KERALA FLOODS

2.1.1 General Profile of Kerala

Kerala lies in the south western region of India, located at 8˚18` and 12˚48` North and 74˚52` and 77˚22` East. It covers an area of about 3, 88, 863 sq. km which is 1.18% of the total area of India. It is surrounded by Arabian Sea on the west and Western Ghats on the east and may be divided into three geographical regions; high land, mid land and low land. The high land slopes down from the Western Ghats, rising to an average height of 900 m, with numerous peaks over 1,800 m in height. The mid land lies between the mountains and the low lands near the coastal areas. In short it is made up of undulating hills and valleys[6].

Figure 2.2: Location of Kerala and its districts



Source: http://www.newalliedtour.net/travel-map.html Retrieved on July6, 2019.

The 'Western Ghats' with their rich primeval forests having a high degree of rainfall, form the eastern boundary of the State and extend upto Kanyakumari in the south. The entire western border is caressed by the Arabian Sea[7]. The State has a population of about 3.48 crores (Census 2011) which is 3.43% of the total population of India. It has the highest literacy rate in the country standing at 94%.

[6]MSME-DI, S. (2015, March). State profile of Kerala 2014-15 (Publication). Retrieved July 5, 2019, http://dcmsme.gov.in/dips/state_wise_dips/state profile 08-07-15 combined dc.pdf

[7]Ibid6

The sex ratio of 1084 females per thousand males is also much higher than the national average.

2.1.2 Hazard/Vulnerability Profile of Kerala

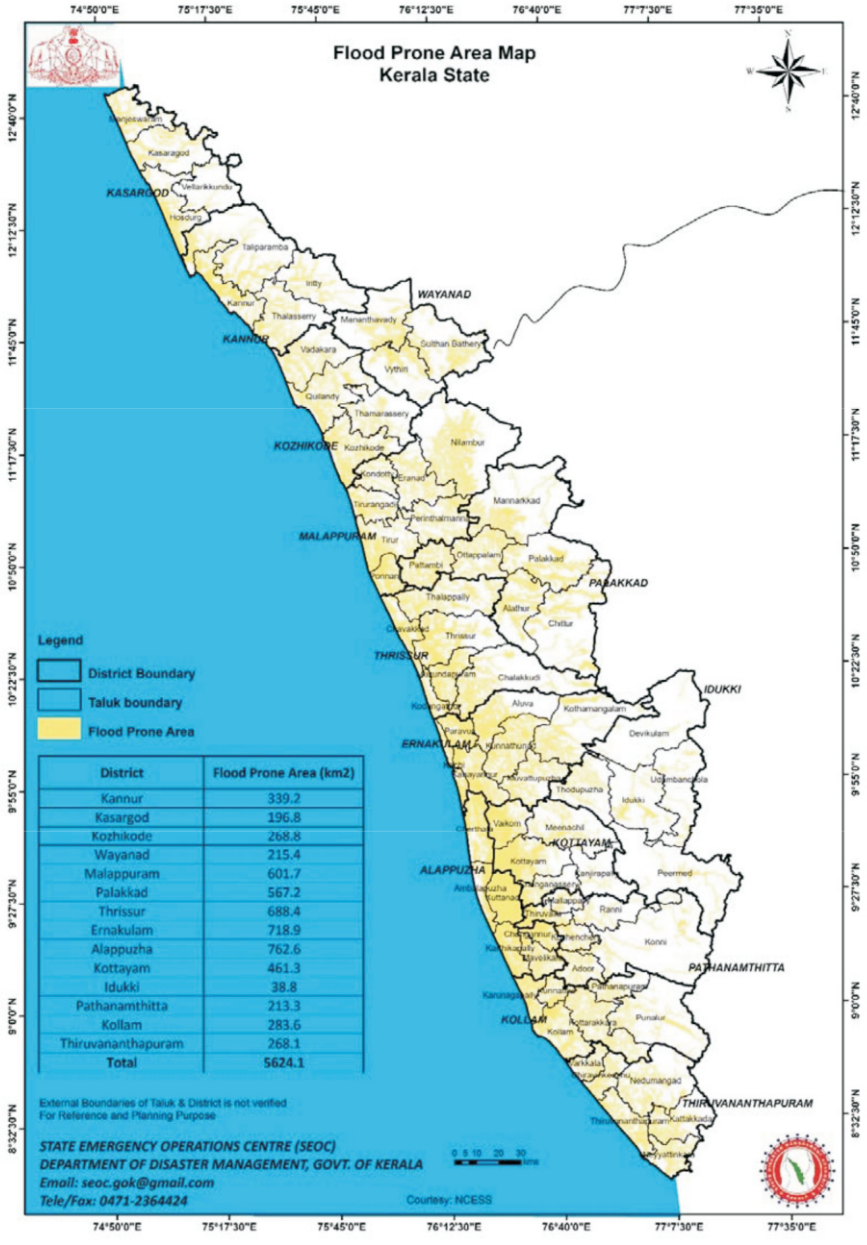
Kerala experiences a lot of disasters every year due to its geographical location and weather patterns ranging from natural to human induced ones, which make it a 'multi- hazard prone state'. In Kerala floods, landslides, and lightning are the most common natural hazards; it is estimated that about 70 people die every year due to lightning; 14.8% of the state is prone to flooding, and the mountain regions of the state experience several landslides during the monsoon season[8]. It undergoes heavy rainfall in monsoon season especially south-west monsoons, and in contrast to this, drought conditions have also been prevalent which usually occur in the pre-monsoon season, and at times of failure of south-west monsoon or north-east monsoon. Before the Kerala floods of this year, the state was already coping with the drought during the month of March. Districts Kannur, Alappuzha, Idukki, Kasaragod, Kozhikode, Malappuram, Palakkad, Thrissur and Waynad were worst affected.

The State is prone to cyclones and tsunamis due to its proximity to the Arabian Sea. The coastal regions had experienced a major tsunami induced disaster in the year 2004 and due to rising water levels, coastal erosion is also becoming more prevalent. Impact of changing climatic conditions are visible with rapid shift of the weather conditions causing situations leading to drought and floods[9]. Flood prone areas of Kerala are shown in Map 2. Kerala falls under zone III and zone II as per earthquake hazard zoning map of India.

[8]Kerala State Disaster Management Plan Profile, Government of Kerala retrieved on July 5, 2019

[9]Aravind, I. (2019, March 23). After deluge, drought sets in Kerala. Retrieved July 5, 2019, from https://economictimes.indiatimes.com/news/politics-and-nation/after-deluge-drought-sets-in-kerala/articleshow/68540606.cms?from=mdr

Map 2: Flood prone areas of Kerala



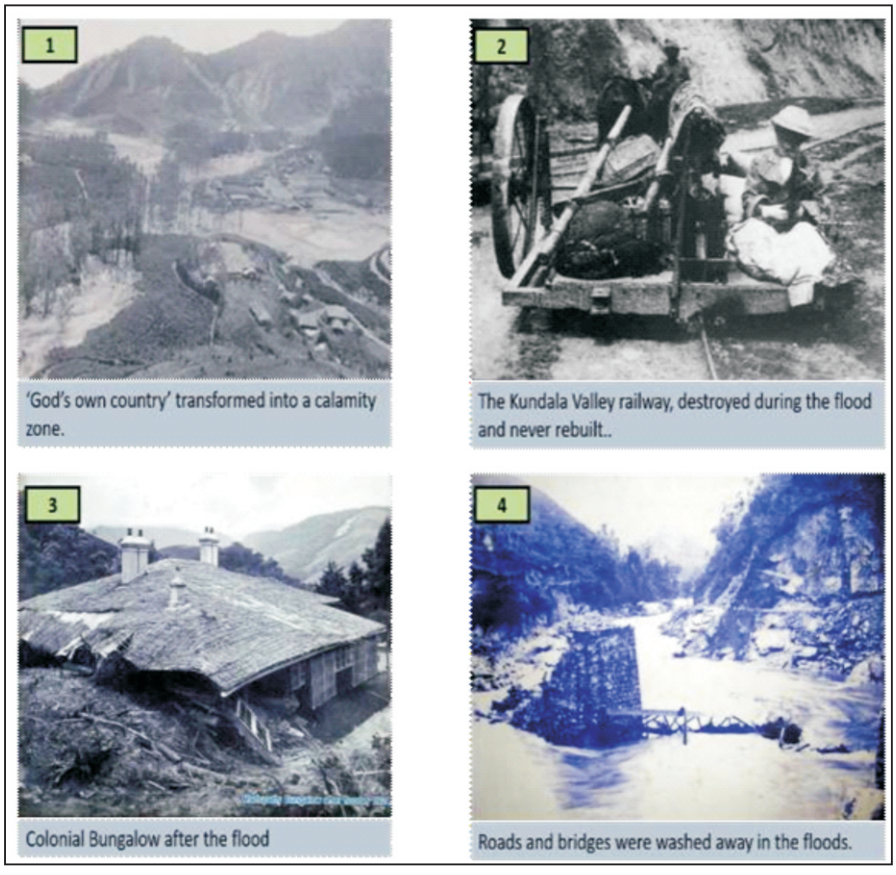
District	Flood Prone Area (km2)
Kannur	339.2
Kasargod	196.8
Kozhikode	268.8
Wayanad	215.4
Malappuram	601.7
Palakkad	567.2
Thrissur	688.4
Ernakulam	718.9
Alappuzha	762.6
Kottayam	461.3
Idukki	38.8
Pathanamthitta	213.3
Kollam	283.6
Thiruvananthapuram	268.1
Total	**5624.1**

Source: Kerala Disaster Management Authority. Retrieved on July 5, 2019 from https://sdma.kerala.gov.in.

2.1.3 Floods in Kerala- A Flashback

Kerala has come across three major floods before the floods of 2018; the most disastrous one was the 1924 flood, which claimed thousands of lives and loss of property along with the destruction of the natural landscape. It was the biggest ever flood recorded in 100 years; 4 lac cubic ft. /sec water was discharged through Aluva (Kochi) into the Periyar River. The second biggest flood occurred in 1961, when 2.5ft./sec of water was discharged into the same river[10]. Figure 2.3 illustrates pictures of the previous floods occurred in the State.

Figure 2.3: July 1924 flood of Year1099 ME in the malayalam calendar (Kollam Era) known as "the great flood of 99"



Source: Pic 1 Flickr/ Benjamin Weber, Pic 2 Wikimedia Commons, Pic 3 & 4 Onmanorama.

[10]Retrieved on July 5, 2019 from https://economictimes.indiatimes.com/news/politics-and-nation/kerala-floods-a-snapshot/articleshow/65455262.cms?from=mdr

2.1.4 Kerala Floods -2018

The Kerala Flood of 2018 was the third biggest flood in its history wherein 1.48 lac cubic ft./sec water[11] was discharged into the Periyar River. The flood occurred with the commencement of south-west monsoon with a heavy downpour, beginning from June 1, 2018[12] and continued till August 19, 2018. The first onset of flooding occurred towards the end of July.

Figure 2.4: Flooded Periyar, 2018



Source: Ajith K Joseph, Manorama news. Retrieved on July 5, 2019

2.1.4.1 Causes

There were several causes for the extreme flooding. Though most of the attention is being given to heavy precipitation, reasons such as poor dam management, lack of attention and inefficient reservoir operations may also need consideration. This study identifies the following causes:

2.1.4.1.1 Heavy to Extreme Precipitation

According to IMD, Kerala received heavy precipitation from June 1, 2018 till the end of July and an extreme precipitation afterwards till August 19, 2018. Table 2.2

[11]Ibid 6
[12]Earth System Science Organization, IMD. (August 19, 2018) Retrieved on July 5, 2019

gives an overview of month wise actual and normal rainfall including the percentage departure from normal. It can be observed that the state began to perceive abnormal rainfall starting from June itself where the departure recorded was 15%, which rose to 18% in July and as high as 164% in August when the state was exposed to extremely heavy precipitation.

Table 2.2: Rainfall in Kerala during the monsoon season, 2018

PERIOD	NORMAL RAINFALL (mm)	ACTUAL RAINFALL (mm)	DEPARTURE FROM NORMAL (%)
June	649.8	749.6	15
July	726.1	857.4	18
1-19 August	287.6	758.6	164
Total	**1663.5**	**2365.6**	**42**

Source: Earth System Science Organization, Ministry of Earth Sciences, IMD. (August 19, 2018) retrieved on July 6, 2019.

District wise rainfall (June 1 – August 22, 2018)

The monsoon season in Kerala experienced an unprecedented extreme precipitation which had deviated largely (42%) from the average and expected normal rainfall in the State. Statistics given in table 2.3 shows that Idukki was the most affected district with a total rainfall of 3555.5 mm, which was higher than the average annual rainfall of the district. While the normal and expected rain was 1851.7 mm; the district witnessed a deviation of 92%. The Kozhikode district experienced the second highest rainfall of 2898 mm that is deviated by 29% from the normal. The third district was Wayanad which registered about 2884.5 mm rainfall and a departure of 26% from the normal figure. The highest deviation was observed in Idukki district (92%), followed by Palakkad (73%), Kollam (52%) and Kottayam (51%) districts

Table 2.3: District wise rainfall in Kerala during monsoon season, 2018

DISTRICTS	NORMAL RAINFALL (mm)	ACTUAL RAINFALL (mm)	DEPARTURE FROM NORMAL (%)	
Kerala State	1701.4	2394.1	41	Excess
Alappuzha	1380.6	1784	29	Excess
Kannur	2333.2	2573.3	10	Normal
Ernakulum	1680.4	2477.8	47	Excess
Idukki	1851.7	3555.5	92	Large Excess

DISTRICTS	NORMAL RAINFALL (mm)	ACTUAL RAINFALL (mm)	DEPARTURE FROM NORMAL (%)	
Kasaragode	2609.8	2287.1	-12	Normal
Kollam	1038.9	1579.3	52	Excess
Kottayam	1531.1	2307	51	Excess
Kozhikode	2250.4	2898	29	Excess
Malappuram	1761.9	2637.2	50	Excess
Palakkad	1321.7	2285.6	73	Large Excess
Pathanamthitta	1357.5	1968	45	Excess
Thiruvananthapuram	672.1	966.7	44	Excess
Thrissur	1824.2	2077.6	14	Normal
Wayanad	2281.3	2884.5	26	Excess

Source: Hydrological Studies Organization, CWC (September, 2018).

Map 3: Rainfall departures for the month of July (left) and August (right), 2018

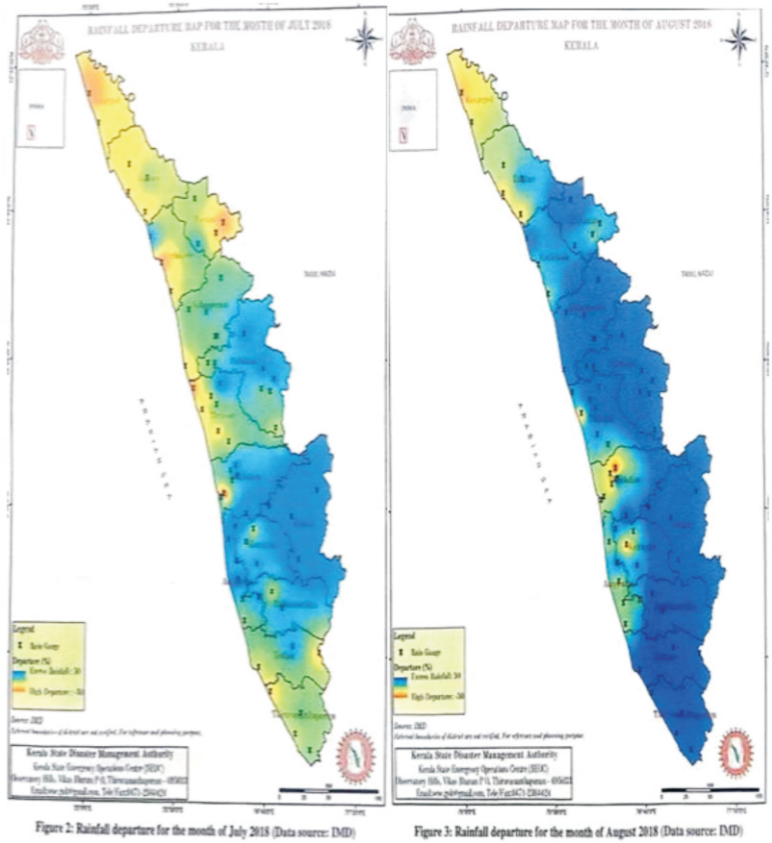


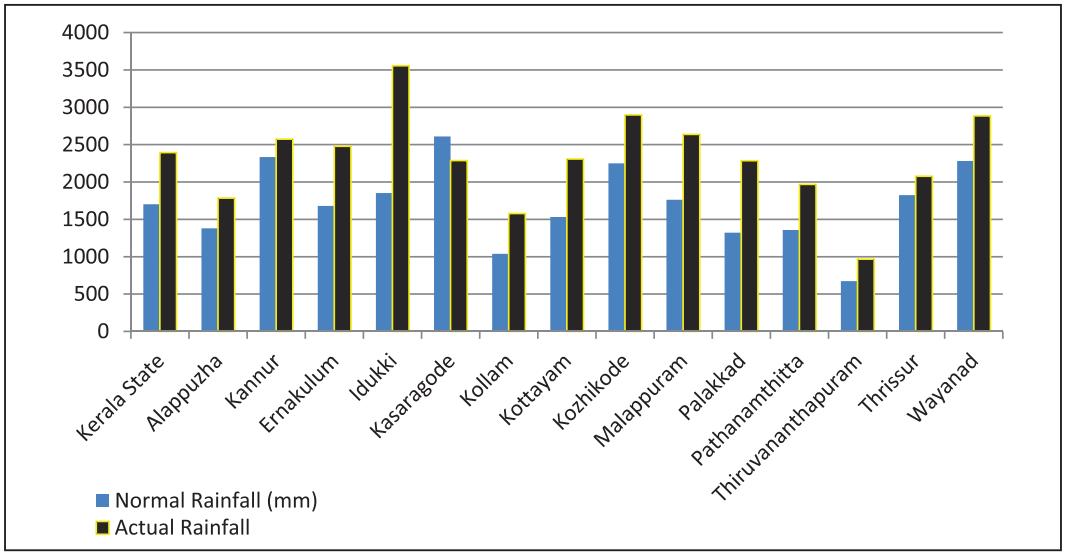
Figure 2: Rainfall departure for the month of July 2018 (Data source: IMD)

Figure 3: Rainfall departure for the month of August 2018 (Data source: IMD)

Source: Additional Memorandum (August 1 – August 30, 2018), State Government, Kerala

Although, the first two months, June and July witnessed rainfall slightly above normal, the state experienced an extremely abnormal rainfall beginning from August 1. Within the first two weeks, about 500 mm of rain over and above normal of about 290 mm was registered; from August 9 to August 17, 75% of the rain was observed[13].

Figure 2.5: District wise normal and actual rainfall in the monsoon period, 2018



Source: Hydrological Studies Organization, CWC. (September 2018)

Table 2.4 provides an assessment of the rainfall from August 1-August 30, 2018 when Kerala got exposed to extreme precipitation. It received an excess of 96% rainfall during August, and 42% excess rainfall during the entire monsoon period.

Table 2.4: District wise monsoon rainfall assessment (August 1 – 30, 2018)

DISTRICT	ACTUAL RAINFALL (mm)	NORMAL RAINFALL (mm)	PERCENTAGE DEPARTURE	
Thiruvananthapuram	373.8	142	163	Large Excess
Kollam	644.1	258.7	149	Large Excess
Pathanamthitta	764.9	352.7	117	Large Excess
Alappuzha	608.2	343.1	77	Large Excess
Kottayam	619.2	386	60	Large Excess
Idukki	1478.9	527.3	180	Large Excess

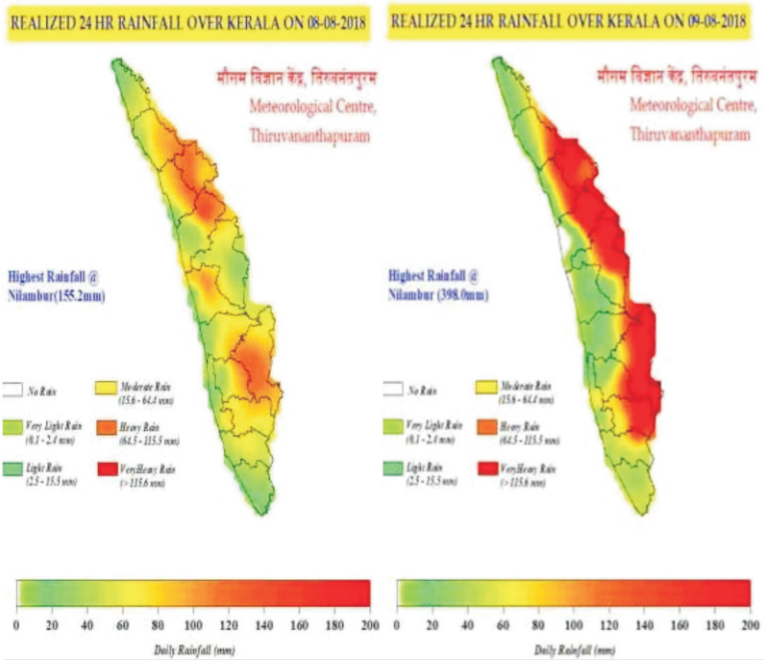
[13]Venkatesh, S. (2018, September 12). "This is why Kerala floods were the worst in a century". Retrieved July 6, 2019, from https://www.downtoearth.org.in/coverage/climate-change/this-is-why-kerala-floods-were-the-worst-in-a-century-61491

DISTRICT	ACTUAL RAINFALL (mm)	NORMAL RAINFALL (mm)	PERCENTAGE DEPARTURE	
Ernakulam	648.3	401.3	62	Large Excess
Thrissur	734.7	440.1	67	Large Excess
Palakkad	848.8	333.8	154	Large Excess
Malappuram	913.7	395.3	131	Large Excess
Kozhikode	836	500.9	67	Large Excess
Wayanad	1053.5	592.9	78	Large Excess
Kannur	665.3	540.9	23	Excess
Kasaragode	636.9	636.3	0	Normal

Source: Additional Memorandum (August 1 – August 30, 2018), State Government, Kerala.

According to IMD, there were two consecutive active invocations of rainfall peaking around June 14, 2018 and June 20, 2018 respectively but after a halt, another abnormal activity of rainfall was observed on July 20, 2018[14]. However, with the onset of August, floods gained momentum with a fresh spell of rainfall that commenced on 8th day of the month which continued up to 16th day of the month. This can be observed from the following maps (Map 4 and 5).

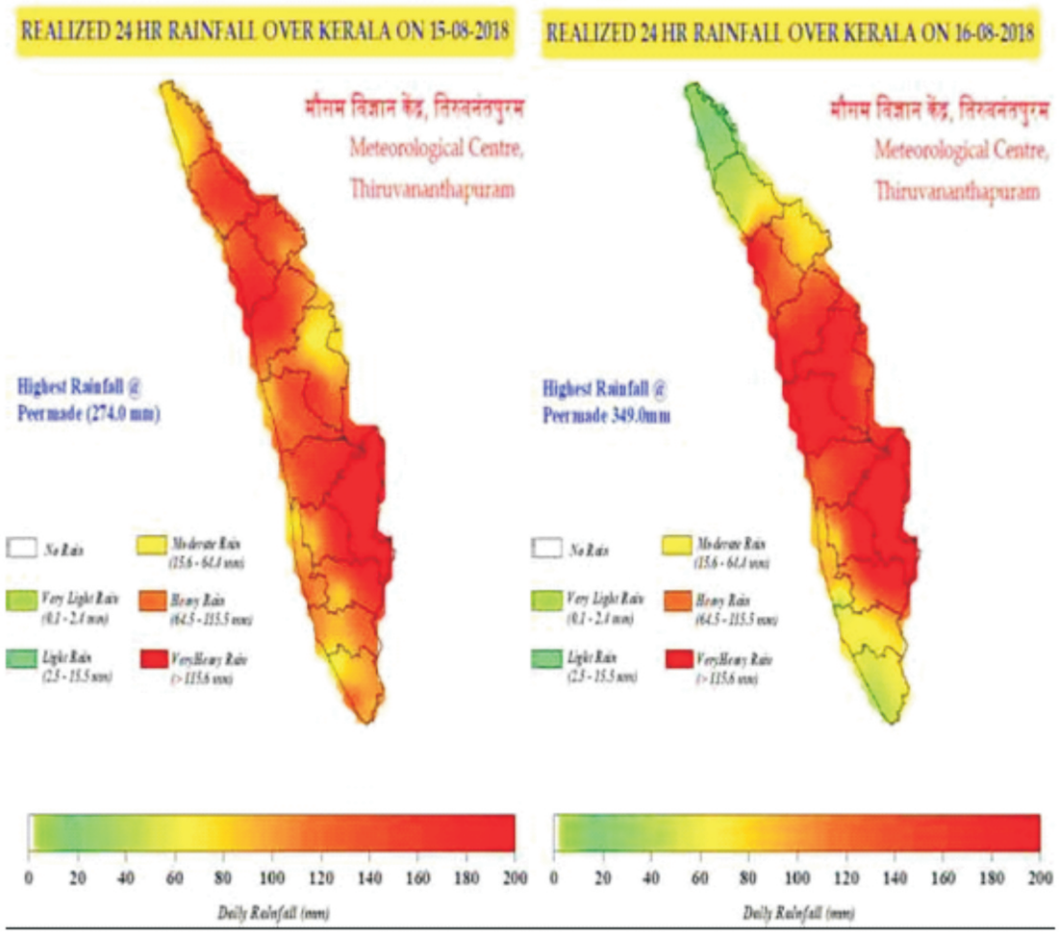
Map 4: Daily rainfall maps of Kerala during the monsoon season (August 8 and 9, 2018).



Source: IMD

[14]Ibid 13

Map 5: Daily rainfall maps of Kerala during the monsoon season (August 15 to 16, 2018).

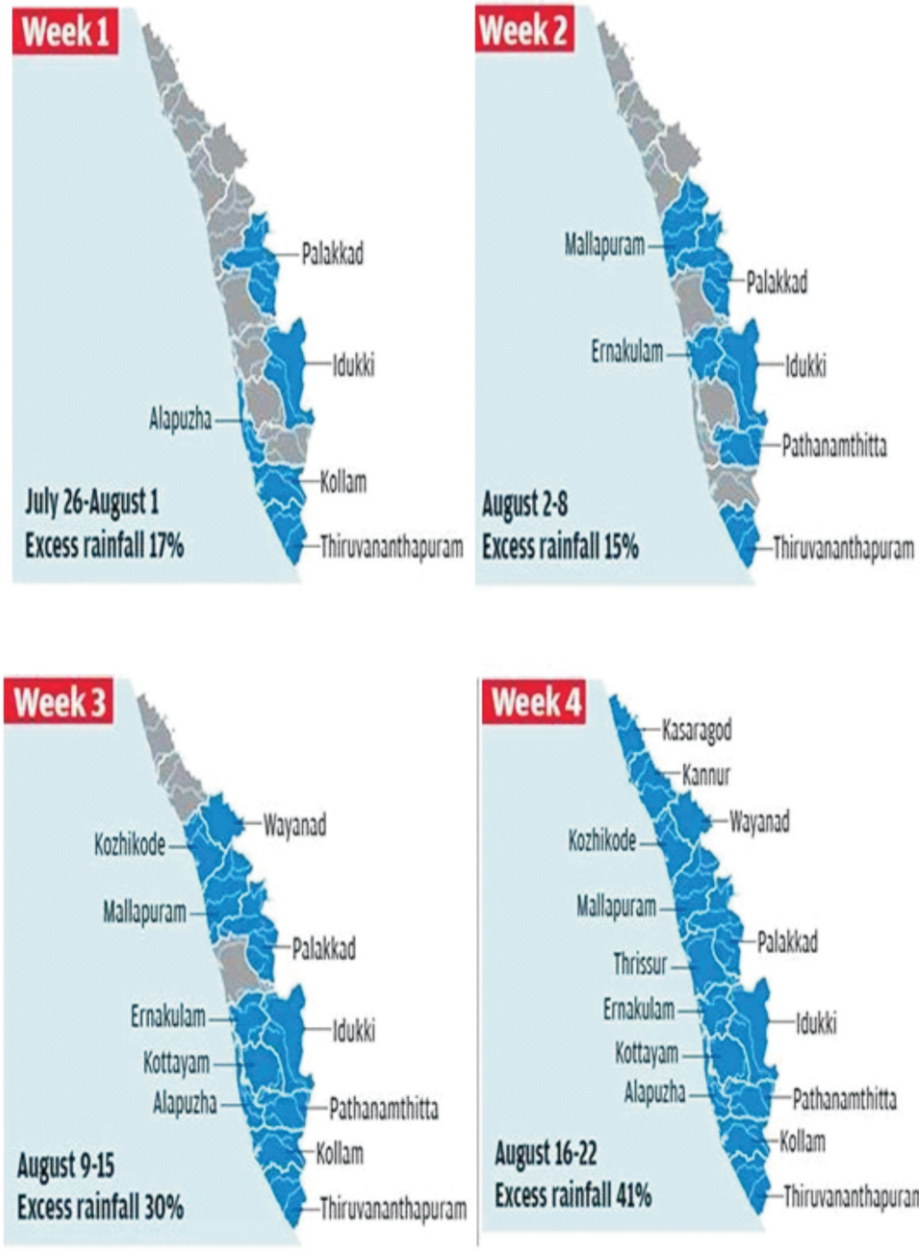


Source: IMD

District wise weekly rainfall assessment

As discussed earlier, extreme rainfall started towards the end of July and continued until the end of August affecting more and more districts on daily basis. Weekly rainfall assessment can be done by observing map 6, which shows the district wise rainfall in Kerala for the first 2 weeks. In the first week, the spell of precipitation was limited to Palakkad, Idukki, Alappuzha, Kollam and Thiruvananthapuram with Idukki being the most affected. In the second week, the rainfall extended to Malappuram, Ernakulum and Pathanamthitta, with Idukki still being under severe spell. By the fourth week, the rainfall had spread all over Kerala.

Map 6: District wise rainfall (July-August, 2018)



Source: Venkatesh, S. (September, 2018). This is why Kerala floods were the worst in a century. (2018, September 12). Retrieved July 6, 2019, from https://www.downtoearth.org.in/coverage/climate-change/this-is-why-kerala-floods-were-the-worst-in-a-century-61491.

A study by Shreeshan Venkatesh discusses statistics that reveal the actual location of the monsoons in Kerala; it says that the coastal regions of the State received more rainfall especially in the northern part rather than the Western Ghats and this is precisely the reason that submerged the State under the flood waters.[15]

2.1.4.1.2 Reservoir Storage

A reservoir can be defined as a man-made lake where water is stored by building dams across rivers which control and confine the amount of water level. Though it can also be formed from a natural lake that has been dammed to control the water.

There are a total of 53 reservoirs and 19 dams in Kerala[16]. The largest one is the Idukki reservoir having an area of 6160 hectares which is constructed on the Periyar River. Out of these, there are seven major reservoirs in the State with a live storage capacity of more than 0.20 bcm(billion cubic meter). They constitute about 74% of the total live storage in Kerala[17].

Table 2.5: Major reservoirs in Kerala

S.N.	NAME OF RESERVOIR	AREA (ha)	LIVE STORAGE CAPACITY (mcm)
1	Idukki	6160	1460
2	Edamalayar	350	1018
3	Kallada	2590	488
4	Kakki	1800	447
5	Parambikulam	2092	380
6	Mullaperiyar	400	271
7	Malampuzha	2313	227

Source: Hydrological Studies Organization, CWC (September, 2018).

Kerala received an unprecedented rainfall during the monsoon season especially in August. Before the extreme rainfall events could occur, six of the seven major reservoirs were almost full (90%)[18]. As the water level began to rise beyond the reservoir's carrying capacity, the water that was stored had to be released at once, which made the reservoirs a huge contributor to severe flooding in the state.

A report by 'The Hindu' states that during the monsoon period, the catchment

[15]Ibid 13

[16]ENVIS Centre, reservoirs in Kerala. Retrieved on July 8, 2019 from http://www.kerenvis.nic.in/Database/Reservoirs_1635.aspx

[17]CWC, (2018, September). Study report Kerala floods of August 2018 (Publication). Retrieved July 6, 2019, from Central Water Commission website: https://reliefweb.int/report/india/study-report-kerala-floods-august-2018-september-2018

[18]The Hindu, A rare confluence of events led to flooding in Kerala, says study , retrieved from https://www.thehindu.com/news/national/kerala/a-rare-confluence-of-events-led-to-flooding-in-kerala-saysstudy

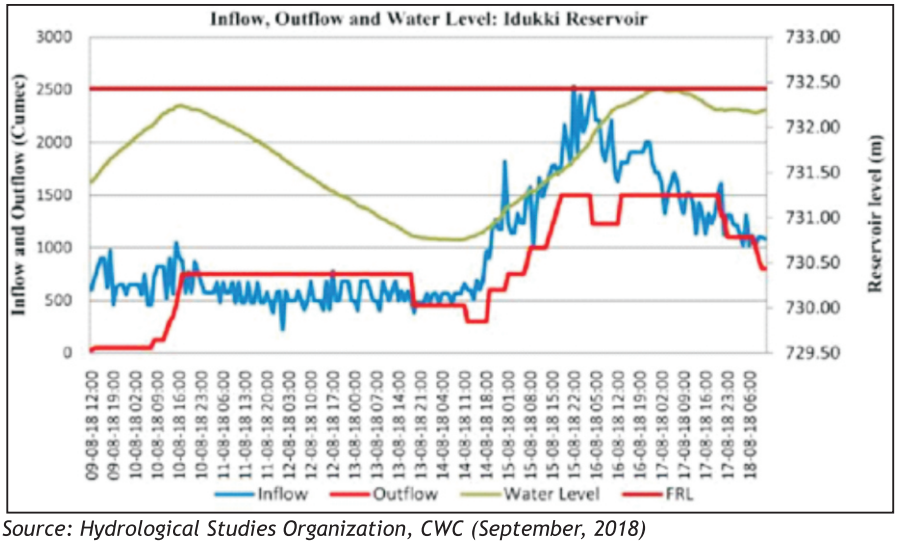
upstream of Idukki, Kakki and Periyar reservoirs received unprecedented rainfall of 279%, 700% and 420% respectively[19] which was among the major causes of overflow of water in the reservoirs. The most affected one was the Idukki located on the Periyar River.

The Idukki reservoir

The Periyar River basin on which the Idukki reservoir is located has experienced the most severe flood. On August 10, 2018 when the extreme precipitation took place, the water level in the Idukki dam was 731.82 m which was only 0.61 m below the Full Reservoir Level (FRL). At that time, the inflow into the reservoir was about 649 cumecs (cubic meter per second) and spill was 50 cumecs. The storage was already full, and due to the inflow, the water level kept rising which became a major cause of the flooding.

It can be observed from the figure 2.6 that the reservoir level touched 732.16 m at noon of August 10, 2018 which was above FRL. In order to contain the water level within the limit, spill was increased to 750 cumecs, in addition to 118 cumecs power house release[19a]. On August 15, 2018, it received extremely heavy rainfall all over yet again. The inflow of water reached to 25.32 cumecs into the dam with a corresponding release of 1614 cumecs (1500 cumecs spill+114 cumecs power house release). FRL was reached again on August 17, 2018[20].

Figure 2.6: The inflow, outflow and water level of Idukki reservoir, August 2018



Source: Hydrological Studies Organization, CWC (September, 2018)

[19]Ibid18
[19a]Ibid17
[20]Ibid 18

A similar recent study[21] on Kerala floods also considered the modeled inflow, modeled storage and observed storage from India-WRIS, and the maximum capacity of the Idukki reservoir. According to the study, the observed reservoir storage reached its maximum capacity by August 16, 2018. The modeled reservoir inflow in an end-of-century Representative Concentration Pathway (RCP) 8.5 climate has also been shown and it has been predicted that occurrence of such an event in RCP 8.5 climate would be even more catastrophic.

Full Reservoir Level (FRL)

Full Reservoir Level can be defined as the highest reservoir level which includes both active and inactive storage along with the flood storage. It has been said that most of the major reservoirs in Kerala had reached their Full Reservoir Level, even before it received extreme rainfall. It might be because they already had so much water stored in it, and then the heavy rainfall events started at the advent of monsoon which made it almost 90% full[22]. Table 2.6 outlines the FRL of major dams/reservoirs of the State.

Table 2.6: Full reservoir level of major dams and reservoirs of Kerala

SL	NAME OF DAM/ RESERVOIR	RIVER	FULL RESERVOIR LEVEL
1	Idukki	Periyar	2403 ft.
2	Malampuzha	Bharathapuzha	114.6 m
3	Mullappriyar	Periyar	136.10 ft.
4	Vazhani	Wadakkancherry	62.48 m
5	Banasura Sagar	Kaanapuzha	775.60 m
6	Edamalayar	Edamalayar	169 m
7	Meenkara	Meenkara	156.63 m
8	Chulliyar	Meenkara	154.08 m
9	Kanjirapuzha	Kanjirapuzha	97.53 m
10	Pothundi	Meenichiladipuzha and Padipuzha	108.20 m

Source: Adapted from "Role of NDRF in Kerala floods-2018", NDRF, Government of India.

Mr. Himanshu Thakkar, an expert working on reservoir management, gave his opinion that better dam management could have avoided the situation and halved the impacts of floods. The water release level of the reservoirs is approximately

[21]Hunt, K.M. and Menon, A. 2020. "The 2018 Kerala floods: a climate change perspective", springer retrieved July 25, 2020 from https://link.springer.com/article/10.1007/s00382-020-05123-7
[22]Ibid 18

68% to 70% before reaching to which the water cannot be released, but the other dams could be moderated in order to compensate the additional flow and the situation could have been controlled[23].

The Mullaperiyar Reservoir

The Mullaperiyar reservoir was one of those reservoirs that had reached its almost full storage before the heavy precipitation took place, the sole recourse was to release the water through the power house before it reached 70%[24]. One of the units of the power house was already 'out of service' since July of the previous year, and another went out of operation on June 26, 2018 for annual maintenance; release of water through the power house, thus, was a major decision especially having monsoon season around. During July, when the state was experiencing heavy rainfall, it was decided to release water through the gates which were not operational since the last 26 years. Due to reduction in the rainfall intensity, leading to decreased water inflow to the reservoir, gates were not opened.

The heavy precipitation returned again on August 9, 2018, forcing the administration to open the gates of the reservoir, ultimately leading to uncontrolled flooding. On the night of August 14, 2018, the Highest Flood Level (HFL), ever achieved, was crossed by 3.5 meters and remained at this level for 4 days.

Figure 2.7: Mullaperiyar (left) and Idukki (right) reservoirs during the monsoon season, 2018



Source: Ghosal, A. (2018, August 25) https://www.news18.com/news/india/mullaperiyar-dam-999-year-lease-at-the-heart-of-acrimony-between-tamil-nadu-and-kerala-1856279.html.

[23]Himanshu Thakkar. Coordinator, South Asia network on Dams, River and People. Retrieved from "NIDM Lecture series- Reservoirs operations in the context of Flood Risk Management" on July 17, 2019.
[24]Ibid 23

The Chalakudy River Basin

The district of Thrissur and Ernakulam have six dams. All dams were almost full except the Parambikulam dam. Even when the dams were full, the water was still coming from the upper and lower Nirar dams (Periyar) to Chalakudy Dam.[25] A letter was sent from Dr. Madhusoodhan (IITB) to the district collectors of Thrissur and Ernakulam regarding the Chalakudy basin on July 18 and July 20, 2018. The letters pointed this out, and warned them about a major disaster at any time. It included the following warnings:

- Alarming water levels in Chalakudy dam;
- Eminent possibility of dam induced floods and;
- Suggestion about what needs to be done.

Figure 2.8: Water spilling over the gates of Poringalkuthu reservoir, Chalakuddy river, Kerala



Source: SANDRP, role of dams in Kerala's 2018 floods. (October 4, 2018).

As such no reasonable action could be taken to reduce the risk[26]. Similarly, with Idukki Reservoir, water could have been released before-hand following the warning; and when the rainfall occurred again on August 9, 2018, the water had to be released that ultimately caused floods. However, the officials of the State Government of Kerala stated that the severity of the floods was due to a once-in-a-century rainfall that could not have been reasonably prepared for, neglecting the impact of spilling water from the dams.

[25]Ibid 23

[26]SANDRP. "Role of dams in Kerala's 2018 floods". (October 4, 2018).

Rule Curves

According to Mr. Himanshu Thakkar, there were no rule curves available in Kerala at the time of floods, which became another contributory factor. Rule curves are important for the proper management and operation of the reservoirs. In order to have proper dam and disaster management, one needs to look from a whole perspective; from rainfall forecasts to flood and upstream-downstream forecasts and every little thing for working on a better disaster management plan[27].

Rule curve: A rule curve is a proposal for the water abundance periods (such as the monsoon season) necessary to develop techniques that improve the operation of the reservoir.

2.1.4.2 Impacts/Effects

The Kerala flood was one of the major and worst disasters of the century so far. The flood not only took lives of hundreds of people but also destroyed natural landscape and infrastructure facilities like houses, roads, railways, bridges, electricity poles, communication network lines and power supplies etc. Its impacts and effects were felt on a large scale leading to physical, social, psychological and most importantly economic consequences. The floods affected about 23 million people and led to a large number of property losses leaving people homeless[28]. Post flood scenario of the State was highly dominated by numerous health issues in form of communicable diseases. The issues like water scarcity and drought after the floods also raised multiple problems.

Table 2.7: Overall flood damage assessment

Districts affected	Kannur, Kollam, Kasaragode, Alappuzha, Thrissur, Kozhikode, Palakkad, Malappuram, Pathanamthitta, Ernakulam, Kottayam, Idukki, Thiruvananthapuram & Wayanad.
Number of villages affected	776
Area affected	7.351 million hectares
Population affected	5411712
Human lives lost	477
Number of missing	15
Number of injured	140

[27]Thakkar, H. September 2018, NIDM lecture series- Reservoirs operations in the context of Flood Risk Management.

[28]Centre for Research on the Epidemiology of Disasters, EM DAT Brussels, retrieved on June 26, 2019 https://cred.be/sites/default/files/PressReleaseReview2018.pdf

Houses damaged	Fully: 10758 Partially: 11663
Animal deaths	46867 (Goat, Buffalo, cow)
Total crop area affected (in hectares)	43727.73 Cash Crops: (83 (in number) Trees uprooted: 4920 (in number) Plantation trees with fruit: 17,517 (in number) Plantation trees without fruit: 15,000 (in number)

Source: Adapted from NDRF, Government of India. "Role of NDRF in Keralafloods 2018" original source of which is memorandum issued by Kerala Government (June-August, 2018)

2.1.4.2.1 Human Fatalities

The total number of fatalities according to the Government of Kerala[29] during the monsoon period (May to August) was 477; 138 deaths were recorded between May 29, 2018 to July 31, 2018, whereas 339 deaths were registered in August 2018. Table 2.8 indicates that the highest number of deaths were witnessed by Kozhikode district from May to July, with a record of highest rainfall in this period (1742.3mm) which was 18 % above normal. However, during August, the highest number of deaths were recorded by Thrissur district falling at 72, followed by Ernakulam and Idukki.

Table 2.8: District wise human fatalities recorded during the monsoon period-2018

DISTRICT	MAY 29 - JULY 31, 2018	AUGUST 1 - AUGUST 30, 2018
Thiruvananthapuram	7	11
Kollam	3	5
Pathanamthitta	8	3
Alappuzha	12	43
Kottayam	9	14
Idukki	5	54
Ernakulam	6	58
Thrissur	11	72
Palakkad	4	20
Malappuram	13	30
Kozhikode	21	16
Wayanad	5	6
Kannur	22	6
Kasaragode	12	1
Total	**138**	**339**

Source: Memorandum by State Government of Kerala (May 29- August 1, 2018).

[29] Memorandum (May 29-August 1, 2018), State Government, Kerala.

2.1.4.2.2 Damages to Primary Sector

Agriculture Sector

Heavy rainfall causes havoc to the nature in several ways, especially destroying the agricultural landscape. Agriculture of a country or a region is a very important indicator of economic growth. Kerala is one of those States that flourish in agricultural activities which have a large share in the state's economy. A developing country like India whose economy is mostly agrarian has a larger overall impact at times of such calamities. The floods of 2018 have gravely impacted the agricultural land and practices including the livestock. Some of the details about the destruction in agricultural sector such as damages to the fields, crop loss, damage to agricultural outlets and fully and partially submerged areas in the affected regions are given below.

District wise Agricultural Damage

About 52% of Kerala's population lives in rural areas and nearly 17.15% depends on agricultural sector[30]; so, an unimaginable damage to this sector was faced by the state during the floods. All of the districts suffered crop loss. However, looking at the statistics given in table 2.9; it can be noticed that the losses were more evident in the month of August apparently because of the extreme rainfall. Highest loss of crops per hectare was witnessed by Alappuzha district followed by Pathanamthitta and Kottayam.

Table 2.9: District wise crop loss (in hectares)

DISTRICT	CROP LOSS EXTENT (ha)		
	29 May to 31 July	1 August to 30 August	Total Loss (HA)
Thiruvananthapuram	325.59	1356.96	1682.55
Kollam	354.87	869.73	1224.6
Pathanamthitta	91.53	12085.05	12176.58
Alappuzha	13087.75	12095.55	25183.3
Kottayam	5103.46	7170.71	12274.17
Idukki	2608.17	5745.97	8354.14
Ernakulam	589.72	1296.66	1886.38
Thrissur	812.82	3569.25	4382.07

[30]Agriculture Census 2011, Department of Economics and Statistics, Government of Kerala, www.ecostat.kerala.gov.in, 2013.

DISTRICT	CROP LOSS EXTENT (ha)		
	29 May to 31 July	1 August to 30 August	Total Loss (HA)
Palakkad	2140.57	6250.43	8391
Malappuram	1020.5	5275.4	6295.9
Kozhikode	278.17	627.04	905.21
Wayanad	541.04	1876.8	2417.84
Kannur	294.87	926.53	1221.4
Kasaragode	110.08	199.29	309.37
Total	**27359.14**	**59345.37**	**86704.51**

Source: Memorandum by State Government of Kerala (May 29th- August 1, 2018).

Table 2.10: Number of agricultural outlets damaged

DISTRICT	EMBANKMENTS	PUMPS	POLDERS
Alappuzha	350	802	115
Thrissur	100	50	5
Kottayam	48	21	3
Pathanamthitta	25	18	4
Total	**523**	**891**	**127**

Source: Additional memorandum (1 August-30 August), State Government, Kerala.

Figure 2.9: Fully submerged areas of Kerala during the flood, 2018



Source: Saberin, Z. (2018, August 31). Kerala officials estimate post-floods rebuilding will cost $3.7bn. Retrieved on July 5, 2019 from Aljazeera.com.

Fisheries

The damage to fishery sector and its infrastructure, assets and stocks resulted in huge but temporary deterioration of livelihood, export, disruption in transportation, fishery related employment and post disaster government expenditure. Several small and large boats and nets were damaged. Table 2.11

gives a brief description of fully and partially damaged boats and nets in the districts during the flood.

Table 2.11: Damage to fisheries sector

DISTRICT	BOATS		NETS		Total
	FD	PD	FD	PD	
Thiruvananthapuram	7	7	6	3	23
Kollam	20	14	80	2	116
Pathanamthitta	36	24	269	20	349
Alappuzha	26	19	171	7	223
Kottayam	10	1088	968	1217	3283
Idukki	23	7	76	3	109
Ernakulam	98	65	213	348	724
Thrissur	18	17	132	276	443
Palakkad	0	4	71	2	77
Malappuram	34	9	19	4	66
Kozhikode	7	13	40	0	60
Wayanad	0	0	0	0	0
Kannur	4	33	3	1	41
Kasaragode	2	0	1	0	3
Total	**285**	**1300**	**2049**	**1883**	**5517**
FD= Fully Damaged, PD=Partially Damaged					

Source: Memorandum by State Government, Kerala (May 29, 2018-August 30, 2018).

Figure 2.10: Damaged boat of a fisherman



Source: https://edition.cnn.com/2018/08/20/asia/india-kerala-floods-fishermen-intl/index.html.

2.1.4.2.3 Impacts on Social and Physical Infrastructure

One of the most severe damages caused by the floods was on infrastructural facilities including houses, roads, railways, bridges, electricity and communication lines, water supply, medical and educational institutions etc. Roads, especially, were so damaged and filled up with water that it was hard to differentiate between roads and rivers. Tables and figures in following sections depict the damages in several infrastructural sectors and facilities that contributed in making the situation worse. Figure 2.11, for instance shows severely damaged roads due to spurting water going all through and around it.

Figure 2.11: Damaged road due to the flood



Source: Onmanorama. (2018, August 27). Kerala: Rebuilding damaged roads, bridges to take 18 months, cost Rs 5,815 cr. Retrieved from https://www.theweek.in/news/india/2018/08/27/kerala%20rebuilding-damaged-roads-bridges-18-months-cost-5815-crore.html.

Houses damaged

A large number of houses were damaged either fully or partially during the floods. Table 2.12 gives an account of the district wise damaged houses and also the loss it caused.

Figure 2.12: Damaged houses



Source: CNBC TV 18. August 16, 2018 retrieved on July 15, 2019.

Table 2.12: District wise houses damaged due to floods

DISTRICT	FULLY DAMAGED	PARTIALLY DAMAGED	SEVERELY DAMAGED	TOTAL
Thiruvananthapuram	161	1269	2940	4370
Kollam	117	766	1338	2221
Pathanamthitta	765	1520	32775	35060
Alappuzha	2100	594	18990	21684
Kottayam	83	774	656	1513
Idukki	1200	821	1445	3466
Ernakulam	640	506	1684	2830
Thrissur	2917	310	18241	21468
Palakkad	1141	504	3604	5249
Malappuram	532	570	3731	4833
Kozhikode	183	2442	1338	3963
Wayanad	719	413	9250	10382
Kannur	152	934	3216	4302
Kasaragode	48	240	74	362
Total	**10758**	**11663**	**99282**	**121703**

Source: Memorandum by State Government, Kerala (May 29, 2018-August 30, 2018)

Education and Educational Infrastructure

Out of all the infrastructural amenities, educational institutions hold paramount importance. If anything happens to them, education gets affected. During the floods, lots of schools including aanganwadis were damaged; from the buildings to every material in the schools such as desks, boards, lockers, play grounds, important documents and children's creative works etc. were severely destroyed. Following are the estimates of the extent of damage to schools according to a report by UN:

- About 1219 aanganwadis[31] were left wrecked by the floods. The walls, roofs and floors were all damaged. In addition, there was a disruption to kitchen items that hindered the regular service of the center besides affecting the pre-school education of children.
- Overall 1613 schools were found influenced by the great calamity, about 1148 toilets and 842 urinal facilities and about 34,251 compound walls were damaged. Mid-day meal services were hindered.
- Districts that stood affected the most were Alappuzha, Ernakulam, Pathanamthitta, Thrissur, Wayanad, Idukki, and Kottayam.

[31]Kerala Post Disaster Needs Assessment, Floods and Landslides-August 2018. (October, 2018) by UNDP. Retrieved on July 10, 2019.

- In context of higher education, 52 consortium for Educational Communication (CECs) were fully destroyed in addition to 100 CECs partially destroyed resulting in tremendous loss including the loss of important documents such as learning materials, certificates, examination papers and ICT equipment's etc.[32]

Besides dealing with the destroyed infrastructure, there were a number of other hazards that were prevailing in the flood affected areas; threat of toxic pollution due to seeping chemicals; damaged and exposed electrical wiring and building structures were also weakened.

Table 2.13: Damage to educational infrastructure

DAMAGE TO INFRASTRUCTURE AND ASSETS	DESCRIPTION	PUBLIC DAMAGE (IN CRORES)
Classrooms and offices	Classrooms: 1420 CEC classrooms: 152 Office rooms: 193	128.28
Uniforms	71,927 meters	0.93
Teaching and Learning Materials(TLM)	Pre-school learning materials, Lesson plans, notebooks etc.	1.94
Computer Laboratories	1853 laptops and desktops 203 LCD projectors 387 printers 775 UPS 313 batteries 256 network switches 927 computer tables	13.61
Science Laboratories	2653 laboratories in schools were damaged	0.26
Sports equipment's	33,171 sports equipment's	0.35
Furniture	Desks, Benches, Almirahs, chairs and tables etc.	7.38
Playground and boundary walls	3,68,731 m sq. of playground 34,251 m of boundary walls	12.17
Kitchen materials	13,978 m^2 of school kitchen, 5542 m^2 of dining hall along with utensils, food grains, and gas cylinders damaged	4.46
Water, sanitation and hygiene facilities	1148 school toilets were damaged. 842 school Urinals were damaged. Toilets in CECs and CCIs were damaged.	4.50
Total		**179.48**
Note: Privately run educational institutions (35%) excluded.		

Source: UNDP (October, 2018). Post Disaster Needs Assessment, Kerala. Accessed on July 8, 2019

[32]Ibid 31

Figure 2.13: A flooded school



Source: CNBC India.

Health and Health Related Infrastructure

Health infrastructural amenities like hospitals, medical centers, PHCs (Primary Health Centers) and CHCs (Community Health Centers), etc. were one of the critical infrastructures which need to be functional all the time, especially when such calamities occur.

The floods in general, destroy the medical infrastructure influencing various medical amenities like health centres, laboratories, blood banks, warehouses, furniture, equipment, medicines, drugs and consumables, ambulance services and nutrition services etc. Destruction and losses to health facilities become a reason of great distress at such times. The worst affected district was Wayanad where 15 hospital buildings were fully damaged and 64 were partially damaged.

Amidst the great loss of health infrastructures, the state saw 1,617 cases of chicken pox with one death in August, against zero cases in all of 2017. Also, Hepatitis A infected 1,044 and killed four this August in comparison of only 988 cases in 2017.

Table 2.14: Damage to health sector (in crore)

CATEGORIES	DAMAGE	LOSS	PUBLIC	PRIVATE	RECOVERY NEEDS
Infrastructure	272.62	4.25	276.87	33.68	421.29
Service delivery	0	5.21	5.21	0	6.25
Governance	0	13.09	13.09	0	15.71
Risks	0	2.95	2.95	0	3.55
Total	**272.62**	**25.50**	**298.12**	**33.68**	**446.80**

Source: UNDP (October, 2018). Post Disaster Needs Assessment, Kerala. Accessed on July 8, 2019

Table 2.15: Damaged hospital buildings

DISTRICTS	FULLY DAMAGED	PARTIALLY DAMAGED
Wayanad	15	64
Alappuzha	7	76
Kottayam	5	35
Kannur	4	4
Palakkad	3	8
Thrissur	2	60
Ernakulam	2	66
Pathanamthitta	1	34
Kozhikode	1	4
Idukki	1	16
Malappuram	0	42
Trivandrum	0	1
Kollam	0	1
Total	**41**	**411**

Source: UNDP (October, 2018). Post Disaster Needs Assessment, Kerala. Accessed on July 8, 2019

Transportation

Transportation networks are the first thing that get impacted by the floods. Roads, bridges and other means of transportation are severely affected by floods as they were submerged during the process. In fourteen districts, the road network was damaged. In Idukki, the major district roads were affected, while in Thrissur the state highways were severely impacted. The highest number of bridges that were affected were seen at Kottayam district.

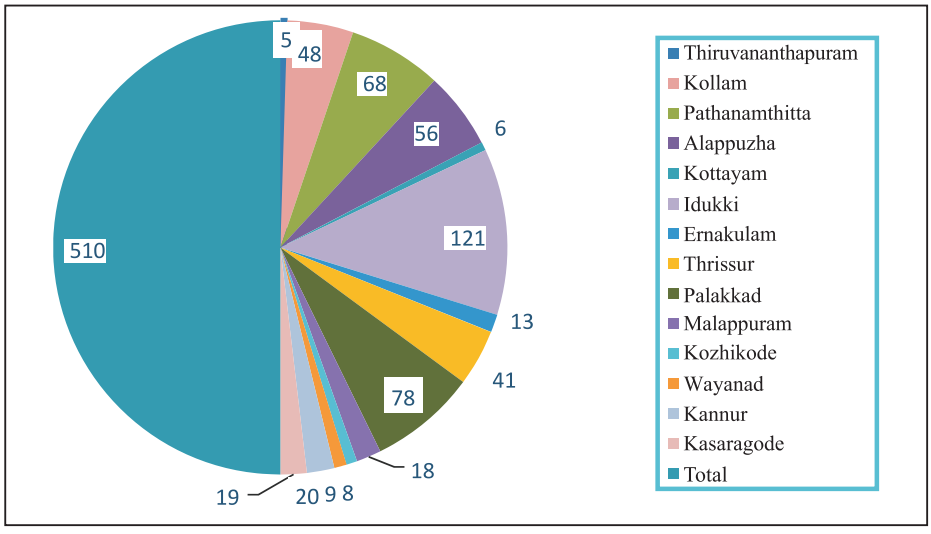
Table 2.16: District wise lengths of roads affected (in km)

DISTRICT	LIGHTLY AFFECTED		SEVERELY AFFECTED	
	Major District Road	State Highway	Major District Road	State Highway
Alappuzha	173.51	13.05	260.26	0
Ernakulam	1167.83	120.78	780.85	71.43
Idukki	401.44	469.56	1798.28	158.78
Kannur	783.58	13.7	126.75	45.92
Kasaragode	320.62	42	92.75	48.14
Kollam	413.61	5.3	285.05	8.3
Kottayam	528.22	62.63	571.97	65.63
Kozhikode	495	0	486.98	16.02

DISTRICT	LIGHTLY AFFECTED		SEVERELY AFFECTED	
	Major District Road	State Highway	Major District Road	State Highway
Malappuram	427.16	192.76	299.41	28.04
Palakkad	691.79	137.77	466.32	4.5
Pathanamthitta	299.67	0	227.17	8.2
Thiruvananthapuram	274.48	14	355.3	33.7
Thris sur	505	18.6	227	171.35
Wayanad	44.74	0	485.39	74.33
Total	**6526.66**	**1090.15**	**6463.48**	**734.34**

Source: UNDP (October, 2018). Post Disaster Needs Assessment, Kerala. Accessed on July 8, 2019

Figure 2.14: Number of bridges affected



Source: Memorandum by State Government of Kerala (May 29 - August 1, 2018).

Impacts on Emergency Services

Availability of drinking water, sanitation, hygiene, communication services, and electricity, etc. are some critical requirements at times of calamities. Obliterations of these necessities make the situation worse. Damage to WASH sector (Water, sanitation, and Hygiene) was very much significant; however, the water supply was the most desirable necessity because all the freshwater sources were destroyed, contaminated and thus, people were left with destroyed structures and muddy water everywhere[33].

[33]UNDP (October, 2018). Post Disaster Needs Assessment, Kerala. Accessed on July 8, 2019

Table 2.17: Damage to water supply, sanitation and solid waste management

CATEGORIES	NUMBER	COST OF DAMAGE (INR IN CRORES)
KWA schemes	480	81.63
Jalanidhi water scheme	583	30.24
Damaged shallow wells	3,17,003	380.40
Sub -total water supply	318066	492.27
Damaged household latrines	95,146	146.52
Sub -total sanitation	95146	146.52
Damaged SWM units at household level	2,68,088	188.54
Damaged SWM units at community level	349	28.35
Damaged SWM units at institutional level	6,848	34.24
Sub -total SWM	275285	251.13
WASH Damage Total	6,88,497	890

Source: UNDP (October, 2018). Post Disaster Needs Assessment, Kerala. Accessed on July 8, 2019

Damages to Power Sector

There was significant damage recorded in the power sector. Several power stations and substations, including hydroelectric stations, were affected. Many transformer towers tumbled down, resulting into destruction of major transmission corridors. In seven districts, the power distribution in 300 odd electrical sections was shattered and about 16,158 distribution transformers were disrupted. Damage to the power sector is given in table 2.18.

Table 2.18: Damage recorded in power sector

ITEMS	NUMBER
Major hydro generation stations	5
Small hydel station	14
Substations	22
Major power transformers	10
Major transmission corridors	10
Damaged distribution transformers	1700
Distribution substations switched off	10,000
Consumers affected	2560000

Source: UNDP (October, 2018). Post Disaster Needs Assessment, Kerala. Accessed on July 8, 2019

2.1.4.2.4 Landslides

Besides other physical damages and losses, landslides have been recurrent since the advent of floods. The floods and rainwater weakened and loosened the rocks

and ended up disintegrating them which became the cause of several landslides in various parts of the state. Landslides also became the cause of road destruction and blockages which affected the transportation systems.

Table 2.19: Number of landslide during the monsoon period

DISTRICT	NUMBER OF EVENTS
Kollam	2
Pathanamthitta	8
Kottayam	29
Idukki	143
Thrissur	26
Palakkad	20
Malappuram	30
Kozhikode	9
Wayanad	17
Kannur	17
Total	**331**

Source: Commissionerate of Land and Revenue. Retrieved from Memorandum by State Government, Kerala.

2.1.4.3 Rescue and Relief operations

In response to the disastrous event in Kerala, several rescue and relief operations were conducted by various agencies including International, National/ Governmental and Non-Governmental Organizations. In addition to formal systems, role of fishermen in evacuating and rescuing the victims of the floods was of utmost importance. Overall, about 4500 responders of central agencies were engaged during the flood management. The state government responded promptly by mobilizing its national/state rescue forces:

- Kerala Fire and Rescue Services: 4100 individuals and entire rescue equipment
- NDRF: 58 teams with 207 boats
- Army: 23 columns with 104 boats
- Navy: 94 rescue teams with one medical team, 9 helicopters and 94 boats
- Coast Guard: 36 teams, 49 boats, 2 helicopters, 2 fixed wings and 27 hired boats
- Air Force: 22 helicopters and 23 fixed wing aircrafts
- CRPF: 10 teams
- Border Security Force: Two companies and one water vehicle team[34]

[34]NDRF, September 2018. "Role of NDRF in Kerala floods 2018".

To ensure effective coordination of emergency management (including search, rescue and relief operations), an Emergency Operation Centre at State level and Disaster Management Control Rooms at District levels were set up.

2.1.4.3.1 National Disaster Response Force

The NDRF had made its highest ever deployment in a single state by raising and deputing 58 teams for fighting flood rage in the worst affected areas. A large chunk of the teams was deployed in the districts which were severely affected such as Pathanamthitta, Idukki, Alappuzha, Wayanad, Kottayam, Ernakulam, Thrissur, Kozhikode, Trivandrum and Malappuram. Most of the deployment was from Arrakkonam, Pune, Vijaywada, Ghaziabad, Patna, Bhatinda, Odisha, and Gandhinagar, etc. When the floods were at their extreme, the teams were called for help. The heavy rainfall results in landslides which in turn creates roadblocks at several places, with endangering weather conditions and difficult terrain making the rescue-relief operations challenging. Despite all odds, NDRF successfully rescued 535 and evacuated 24690 people along with 119 livestock. In addition NDRF also provided medical assistance and relief material to the victims[35].

2.1.4.3.2 Indian Army

The Indian Army was called for help due to increasing adversity in the State on August 9, 2018. The Indian Army provided aid to 10 districts of Kerala by deploying 10 flood relief columns, each having an approximate strength of 65 personnel. Besides, 10 Engineer Task Forces (ETF), having the strength of 40 personnel, were equipped for action. The Indian Army deployed military boats, a total of 53 in number for evacuation procedures[35a].

Table 2.20: Engineer Task Forces (ETF) deployments in Kerala by Indian Army

SERIAL NO.	COLUMN NUMBER	PLACE OF DEPLOYMENT	DATE OF DEPLOYMENT
1	ETF 1	Munnar, Idukki	09 Aug 2018
2	ETF 2	Ernakulam	09 Aug 2018
3	ETF 3	Pathanamthitta	11 Aug 2018
4	ETF 4,5,6	Thrissur	16 Aug 2018
5	ETF 7,8,9	Trivandrum	16-17 Aug 2018
6	ETF 10	Kozhikode	17 Aug 2018

Source: Press Information Bureau, Ministry of Defence, Government of India.

[35]Ibid 34

[35a]col. Aman Anand PRO (Army) Press Information Bureau, Ministry of Defence, Government of India posted on 17 August, 2018 by PIB Delhi

The Indian Army successfully rescued a total of 3627 personnel, including 22 foreign nationals. They achieved their goals by constructing temporary footbridges, bunds and finding out alternate routes; 13 temporary bridges were constructed to reconnect 38 remote areas.

2.1.4.3.3 Operation KARUNA by the Indian Air Force

Due to heavy rainfall and resultant extreme floods and landslides, many parts of Northern Kerala were completely isolated. For this, the Government of Kerala called Indian Air Force (IAF) for help, which provided immediate assistance by introducing Operation 'KARUNA' and through launching a Humanitarian Assistance Disaster Relief (HADR) mission. The IAF delivered aid by deploying transport aircrafts on August 9, 2018. With the help of IAF Aircrafts, tons of supplies including food, clothing, and water, etc. were provided everyday including medicinal help with doctors on board. On the first day alone, 300 kg of relief material was dropped followed by 9 tons of relief material on August 16, 2018. Till August 20, 663 people were rescued, and 974 tons of material was airlifted to the state[36].

Figure 2.15: Operation KARUNA by IAF



Source: OPERATION KARUNA: Indian Air Force: Government of India. (2018). Retrieved on July 10, 2018 from , http://indianairforce.nic.in/content/operation-karuna.

Medical Assistance

Continuous medical assistance was provided by IAF with the help of Rapid Action Medical Teams (RAMT). Out of all, 3 RAMTs continued providing medical care till September 14, 2018. Overall 7300[37] patients were provided treatment by the teams of the IAF.

[36]Operation Karuna, 2018. Retrieved on July 12, 2019 from http://indianairforce.nic.in
[37]Ibid 36

2.1.4.3.4 Operation "MADAD" by the Indian Navy

Southern Naval Command (SNC) launched operation 'MADAD'[38] with effect from August 9, 2018, to undertake the disaster relief operations. On August 9 and 10, with the help of Gemini inflatable boats, it commenced relief operations at Kalpatta, Wayanad, and Panmarum where they evacuated 55 stranded people. Several fully equipped diving teams were also deployed in various districts including four teams at Wayanad district and five at Aluva district. The Indian Navy was ready to render any medical assistance as required.

Figure 2.16: Indian navy in operation



Source: Operation 'MADAD' by Southern Naval Command. (2018). Retrieved on July 11, 2019 from https://www.indiannavy.nic.in/content/operation-madad-southern-naval-command.

[38]MADAD here is the name of the rescue operation, the literal meaning of which is "Help"

In all, the Indian Navy rescued a total of 16,843 people, of which 1,173 were airlifted while 15,670 were rescued by teams using Gemini boats[39].

2.1.4.3.5 Role of Central Reserve Police Force (CRPF)

The Central Paramilitary Force deployed 350 troops in addition to 200 troops from Rapid Action Force (RAF) from Palakkad and Thrissur districts. The CRPF helped by launching "Operation Sahayata" to rehabilitate those who were displaced starting from Mala village of Thrissur. In the same region, medical camps, with five medical officers and 20 paramedics were also setup to provide basic care.

2.1.4.3.6 Role of Community

The role of community such as local people, fishermen, religious communities and NGOs has the utmost significance, as they all lend helping hands in such a deluge. Several NGOs such as RAHI-"Rise against Hunger", a renowned international organization in close association with several others like Arshabharath, Hope Foundation, and the Times Foundation contributed a lot in make-shift relief camps. Others like "Reach World Wide" also contributed to relief activities.

The role of fishermen in rescuing the victims from swirling flood waters was exemplary. From August 15 to August 18, 2018, they organized themselves as rescue service teams during the flash floods. They used their wooden boats to rescue men, women, and children taking them to safer places; there were about 1500 fishermen who joined the rescue operations from coastal Cochin, Quilon, Aleppy, and Trivandrum.

A team from Trivandrum carried their boats on lorries to the disaster affected areas in central Kerala; they organized 130 boats manned by 500 fishermen[40]. During the rescue operations, many of the fisherman's boat got damaged. According to a report by CNN[41], the government announced compensation of 3,000 rupees to each volunteer fisherman plus the costs to repair damaged boats.

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[39]Indian Navy rescued 17,000 people from Kerala floods retrieved from https://www.indiatoday.in/india/kerala/story/indian-navy-rescued-17-000-people-from-kerala-floods-1324270-2018-08-27on July 12, 2019.

[40]Devasia, T. (2018, August 27). Indian fishermen become heroes of Kerala flood. Retrieved July 10, 2019, from https://www.ucanews.com/news/indian-fishermen-become-heroes-of-kerala-flood/83155

[41]Gupta, S. (2018, August 21). Kerala floods: some fishermen recruited for rescues say survivors insulted them" retrieved July 1, 2019 from https://edition.cnn.com/2018/08/20/asia/india-kerala-floods-fishermen-intl/index.html

2.1.5 Lessons learnt

The destructive Kerala flood of 2018 teaches us plentiful lessons. Following are few of the lessons that can be derived from the disaster.

- The 2018 floods in Kerala were unprecedented in nature. IMD had issued adequate forecasts and sufficient information was available about impending rainfall and imminent floods. In light of available information efforts could have been made to lessen the impacts of the floods.
- Flood forecasts and early warning need to be strengthened. There is a need for better information dissemination to the local people.
- A need for better dam and reservoir management was realized during the floods. As stated earlier, the major reservoirs were already (almost) full before the extreme rainfall took place. Continuous checks and balances on dams and reservoirs should be done; the power houses and dam gates etc. should be taken care of. During the floods, two of the power houses of Idukki dam/reservoir were not in operation that added to the adversity.
- Better evacuation plans must be developed; evacuation should be done in advance of the flooding keeping in mind the climatic conditions and the forecasts. There are examples available at international level where advance evacuation has been done keeping the forecasts in mind. For example Oroville Dam in USA is a decent example; 2 lac people were removed in advance from the river impact zone when it was realized that the spill was getting damaged and that it could fail. Lessons of effective evacuation management can be learned from Odisha as to how it managed to lessen the impacts of sever cyclonic storm "Phailin 2013" by evacuating as many as 983,553 people, limiting the death toll to 21people.
- People in remote areas should be evacuated first, where there are threats of landslides and rock falls which make the rescue operation difficult.
- Downstream inundation maps for different releases must be developed and necessary awareness must be generated among the masses.
- Strengthening of infrastructures facilities needs to be taken up on priority, especially health and education related facilities.
- Strengthening the local communities for dealing the impending disasters, as the role of fishermen during floods is of utmost importance.
- Comprehensive disaster management plans must be prepared keeping in mind the topography, environmental and climatic conditions. For preparation in advance, adequate preparedness and an effective management strategy are essential for better management of disasters.

2.2 NORTH EAST FLOODS

North East India faces heavy spell of rainfall during the monsoon season due to its geo- climatic location. The continuous rainfall along with floods and flash floods in the region accompanied by numerous landslides and rock falls affect millions of people every year and result in destruction of natural landscape as well as human built infrastructure. The year 2018 was not much different as heavy rainfall approached North Eastern region of India carrying with it floods and landslides.

According to reports by Assam State Disaster Management Authority (ASDMA)[42], over 4 lakh people in Assam, Manipur, Mizoram and Tripura had been affected by the second week of June. The most affected states of the region included Assam, Mizoram, Manipur and Tripura.

Figure 2.17: North east floods, 2018



Source: DownToEarth.org retrieved on July 26, 2019 from https://www.downtoearth.org.in/news/climate-change/as-india-endures-unusual-dust-storms-northeast-india-gets-flooded-before-monsoon-arrives-60840.

[42]Situation reports (2018). ASDMA. Retrieved on July 26, 2019.

Heavy to very heavy rainfall in Assam and the river catchments increased the level of various rivers in Assam that caused flooding in the State. Heavy precipitation started in Assam in the month of June and continued up to the month of August taking several breaks in between, triggering flash floods in various districts of both upper and lower Assam leaving millions of people in great distress.

Severe Flood Situation occurs where water level is within the danger and highest flood levels. - Central Water Commission

During the month of July, the high-risk situation continued. On July 5, 2018, Central Water Commission issued Orange bulletin (Severe Flood Situation) for several states including Assam. The bulletin included river Brahmaputra, Jiabharali and Puthimari . Till July 2, 2018, the floods killed about 32 people in Assam[43].

Another fresh spell of flooding occurred in the month of August, precisely from August 2, 2018[44]. Flooding in Assam left 30 out of 33 districts submerged and about 4 million people affected. This event had taken about 50 lives; 42 in floods and 8 in landslides. Assam received a total of 935.60 mm rainfall till the month of August affecting a total of 25 districts according to the situation reports by Ministry of Home Affairs[45].

Mizoram also received heavy rainfall as well as flooding of rivers that caused several deadly landslides in the region. Due to continuous heavy rainfall, the water level of Khwathangtuipui River continued to rise submerging hundreds of houses in various villages. Most affected districts were Lunglei and Aizawl that constitute 38% of the total area of Mizoram; several landslides occurred in these districts that became the cause of many deaths. First incident of landslide occurred on June 4, 2018 in which one building collapsed killing 10 people including 5 minors and leaving 4 injured[46]. Mizoram also suffered huge infrastructural damage and loss of human lives due to landslides and floods resulting from heavy rainfall. Between June 1 and June 12, Mizoram received 59 % more than normal rain[47].

[43]Sangomla, A. (July 16, 2019) retrieved on July 26, 2019 from https://www.downtoearth.org.in/news/environment/north-east-reels-under-floods-despite-recording-highest-rain-deficit-in-the-country-61130

[44]Davis, R. August 2018. Relief web.int

[45]Situation reports by MHA.

[46]Retrieved on July 26, 2019 from Disaster Management and Rehabilitation Centre, Mizoram.

[47]Sangomla, A. June 13, 2018. Retrieved from https://www.downtoearth.org.in/news/climate-change/as-india-endures- unusual-dust-storms-northeast-india-gets-flooded-before-monsoon-arrives-60840

Figure 2.18: Glimpses of heavy rain and landslides in Mizoram, 2018





Source: https://www.indiatoday.in/india/story/landslides-and-floods-plague-mizoram-1258130-2018-06-12.

2.2.1 Impacts

The North-Eastern states of India especially Assam, Mizoram, Manipur and Tripura faced a lot of damages owing to incessant rainfall along with numerous landslides that damaged their natural and man-made landscape. Blocked routes, destroyed infrastructure including houses and inundation affected the livelihoods to a large extent. Apart from this, many people lost their lives while others were severely affected. Table 2.21 gives an account of the overall damages witnessed by Assam, Manipur and Tripura during the south west monsoon. Among the affected states, Assam experienced the most damages.

Table 2.21: Overall damages caused by the event

DAMAGES/IMPACTS	ASSAM	TRIPURA	MANIPUR
Human lives lost	50	21	09
Number of districts affected	25	8	11
Number of villages affected	1472	-	164
Population affected	11,48,485	-	1,26,511
Number of animals affected	Big -136 Small -56	5	400
Houses damaged	Fully -986 Partially -5204	Fully-490 Partially-5845 Severely-1258	17,846
Infrastructural damage	Roads, bridges and embankments	Roads, Trees, electric poles, power lines etc.	-

Source: Situation Reports, 2018. Natural Emergency Response Centre, MHA.

2.2.2 Rescue and Relief

Table 2.22 and 2.23 give an account of the relief and rescue operations in three states viz. Assam, Tripura and Manipur according to the situation reports issued by National Emergency Response Centre, MHA.

Table 2.22: Relief operations

	ASSAM	TRIPURA	MANIPUR
No. of persons evacuated	41,472	-	22,789
No. of relief camps opened	359	332	86
Inmates in relief camps	2,45,965	64,705	15,563
Relief material distributed	Rice-23451.98 Q Dal -5566.67 Q Salt-1430.20 Q Oil -19100.97 L	Food items and daily need items	Food items and daily need items

Source: Situation Reports, 2018. National Emergency Response Centre, MHA.

Table 2.23: Rescue operations

	ASSAM	TRIPURA	MANIPUR
NDRF	13 teams consisting of 368 personnel with 37 boats	3 teams consisting of 67 rescuers with 9 boats	-
Armed Forces	Deployed in Cachar District	-	J&K Rifle Army, CRPF, 14 Sikh regiment and 38 AR were deployed
SDRF, Local Police/Fire/ Boats	Teams deployed in 30 locations	Deployed in several locations	Deployed in several locations

Source: Situation Reports, 2018. National Emergency Response Centre, MHA.

2.3 KARNATAKA FLOODS

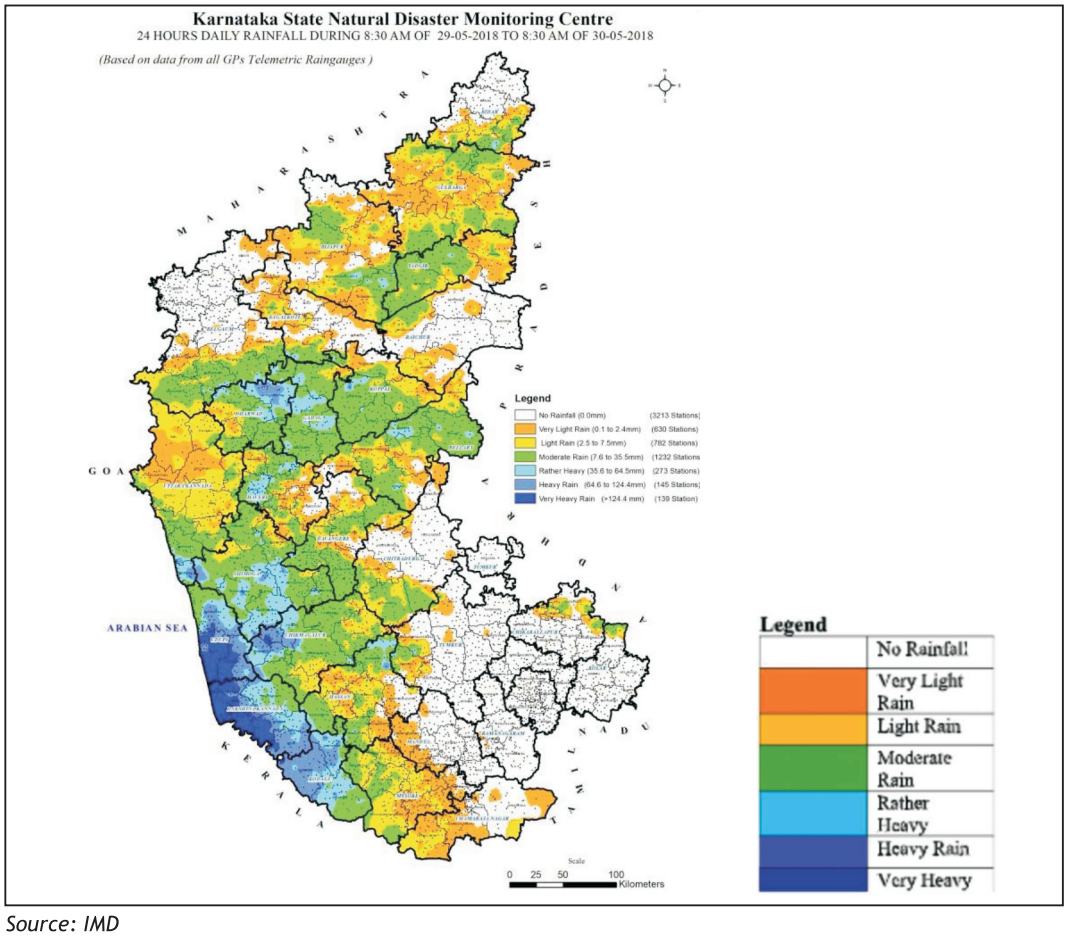
"Some parts of Karnataka such as Kodagu, Uduppi, and Dakshin Kannada suffered from record breaking rainfall in 2018 which led to severe flooding in these areas. The deluge affected thousands of people along with destroying natural and man-made landscape. The rainfall received by the state in the monsoon season of the year was way more than normal; which can be observed from table 2.24.

Table 2.24: Rainfall statistics in Karnataka during monsoon season, 2018

District	MAY		JUNE		JULY		AUGUST	
	Normal	Actual	Normal	Actual	Normal	Actual	Normal	Actual
Dakshin Kannada	169	375	940	1142	1281	1177	685	962
UDUPPI	168	357	1127	1229	1457	1247	804	986
KODAGU	156	302	622	891	905	1117	474	922

Source: Memorandum by Department of Revenue (Disaster Management), Government of Kerala, September 2018

Figure 2.19: Daily rainfall in various parts of Karnataka from May 29 to 30, 2018.



Source: IMD

Figure 2.20: Heavy rains and floods in Karnataka, 2018



Source: https://www.indiatoday.in/india/story/flood-alert-in-karnataka-as-heavy-rain-lash-coastal-districts-1315581-2018-08-16.

Table 2.25: Damage caused as on May 30, 2018

ITEMS	NUMBERS
Number of Deaths	12
Number of People Affected	4945
Houses Damaged	989
Animal Deaths	16
Cost Incurred	2500 lakh (In US$)

Source: EM-DAT Brussels and Situation reports by DM Division, MHA (2018)

Table 2.26: Overall damage occured during the monsoon season, 2018

ITEMS	NUMBERS
Number of Districts Affected	11
Number of Villages Affected	275
Population Affected	3,50,000
Human Lives Lost	170
Number of Missing	3
Number of Injured	4
Houses Damaged	14485
Crop Area Affected	3521.65 Hectares
Animals Affected	739
Number of Persons Evacuated	13951

Source: Situation report by Ministry of Home Affairs (August 31, 2018).

2.3.1 Rescue and Relief

Rescue and relief operations were arranged by several organizations due to the extreme situation in Karnataka. The Armed Forces were deployed and relief materials were continuously provided along with the evacuation procedures. Rescue and relief operations have been summarized in table 2.27 and table 2.28 as per the reports by Disaster Management Division of Home Ministry[48].

Figure 2.21: Rescue forces in operation



Source: http://floodlist.com/asia/india-record-rainfall-floods-karnataka-may-2018.

Table 2.27: Operations held by several rescue organizations during the floods in Karnataka, 2018

RESCUE OPERATIONS	
NDRF	2 teams having 65 personnel along with 5 boats.
Armed Forces	1 column, 1 ETF and 1 QRMT deployed in Kodagu district. Rescued 504 persons and constructed 2 temporary bridges
SDRF	Deployed in affected districts

Source: Situation report by MHA (August 31, 2018).

Table 2.28: Relief operations held during the floods in Karnataka, 2018

RELIEF OPERATIONS	
Number of Relief Camps opened	124
Inmates in Relief camps	5839
Relief material distributed	Food, water and medicines

Source: Situation report by MHA (August 31, 2018).

[48]Situation reports, National Emergency Response Centre, Ministry of Home Affairs retrieved in July 2019

2.4 WEST BENGAL FLOODS

Large parts of western West Bengal were inundated owing to heavy rains and water release from dams in Jharkhand as reported by the New Indian Express[49]. The report also mentioned that rainfall received by some of the districts such as Bankura was about 354 mm in one day which was also thought to be one of the causes of rising levels of the rivers that in turn led to flood like conditions.

Talking about the damages, from August 2 to August 6, 2018, 3 people were registered dead and 25,000 were affected as per the EM-DAT Brussels database. However, throughout the monsoon season, huge destructions and damage were witnessed by the state which is mentioned in the table 2.29.

Table 2.29: Overall damages suffered by West Bengal in the monsoon season-2018

DAMAGES	TILL AUGUST 31, 2018	TILL SEPTEMBER 30, 2018
Number of Districts Affected	23	23
Number of Villages affected	2201	3205
Population affected	228023	320827
Human lives lost	210	266
Number of missing	05	05
Number of injured	35	44
Houses Damaged	Fully -1279 Partially -11244	Fully - 2228 Partially - 21212
Animals affected	25	93
Number of people evacuated	-	84

Source: Situation reports -by National Emergency Response Centre, Ministry of Home Affairs.

For the rescue operations, 9 teams of NDRF consisting of 280 personnel along with 18 boats were deployed. About 84 victims were evacuated by the teams. Besides, relief material along with medicinal items was also provided.

[49]New Indian Express. (2018, August 6). Flood-like situation in western West Bengal. Retrieved July 27, 2019, from http://www.newindianexpress.com/nation/2018/aug/06/flood-like-situation-in-western-west-bengal-1854159.html

2.5 OTHER FLOODS OF 2018

Table 2.30 Some other floods

June 22 - July 24, 2018	Maharashtra
	• Rainfall received: 107.6mm • Human Lives lost: 100 (57 till June 22) including deaths by lightning • Number of Injured:67 • Animals affected:61 • NDRF teams deployed: 3 consisting of 101 rescuers and 8 boats
	Gujarat
	• Rainfall received till July 29, 2018: 449.94mm • No. of Districts affected:10 • No. of Villages affected:213 • Human Lives lost: 52 • No. of Injured:13 • Houses Damaged: Fully -1502 Partially -1722 • Animals affected:336 • People evacuated:15912 • NDRF teams: 9 with 271 personnel and 18 boats • SDRF: 11 teams on stand by
July 20 - 23, 2018	Odisha
	• Floods caused by two heavy spells of rain; First one occurred on July 15 and 16, 2018 while another one on July 20 reaching up to July 23. • No. of districts affected:20 • Human lives lost; 20 (5 died due to heavy rains and 15 in flood related incidents) • Houses Damaged: 8,286[50]
July 22 - 28, 2018	Uttar Pradesh
	• Rainfall received: 171.1mm • Districts affected: Faizabad[51], Agra, Muzaffarnagar, Mainpuri and Kasganj[52] • No. of population affected:329 • Human lives lost: 70 (including 21 due to building collapse on July 28) • No. of Injured:68

[50]Press Trust of India. 2018. Retrieved from https://www.business-standard.com/article/current-affairs/incessant-rains-floods-claim-20-lives-in-odisha-over-300-000-affected-118072501658_1.html
[51]As per Situation Reports by National Emergency Response Centre, Disaster Management Division, MHA.
[52]Garda World, July 29, 2018. Retrieved from https://www.garda.com/crisis24/news-alerts/140631/india-flooding-kills-at-least-64-in-uttar-pradesh-july-26-29-update-7

July 22-28, 2018	Uttar Pradesh
	• Houses damaged:272 • Animals affected:17 • NDRF Teams: 7 consisting of 215 personnel along with 16 boats.
September 23-24, 2018	Punjab
	• Rainfall received: 487.44 (till September 30,2018) • No. of Districts affected:11 • No. of Villages affected:2 • Human lives lost: 14 • No. of injured:10 • Houses Damaged: 232 • Animals affected:29 • Total affected Crop area: 54296acres • NDRF Teams: 3 teams with 68 personnel along with 6 boats.
September 1-October 6, 2018	Uttar Pradesh
	• Rainfall received: 860.4 mm (till October 6,2018) • No. of districts affected:29 • Number of Villages affected:923 • Population affected:545429 • Human lives lost: 299 • No. of missing:14 • No. of Injured:204 • Houses Damaged:7902 • Animals affected:219 • Total damaged crop area: 87587.28 hectares • NDRF: 5 teams consisting of 154 personnel along with 21 boats. • SDRF: 1team • State Police: 7 teams

Source: Situation reports by National Emergency Response Centre, MHA and EM-DAT Brussels

3 CYCLONES

A cyclone is a large system of winds circulating inward around a low-pressure area caused by atmospheric disturbances. World Meteorological Organization (1976) defines Tropical Cyclones as weather systems in which winds exceed "Gale Force" (34 knots or 63kmph)[53]. India experiences several severe to moderate tropical cyclones almost every year. According to the wind speed and damage capacity, cyclones are categorized as indicated in table 3.1.

Table 3.1: Category of cyclones

CATEGORY	WIND SPEED IN KM/H	DAMAGE CAPACITY
1	120-150	Minimal
2	150-180	Moderate
3	180-210	Extensive
4	210-250	Extreme
5	250 and above	Catastrophic

Source: National Disaster Management Authority, "Cyclones". Retrieved on July 13, 2019.

Gale Force: A Gale Force is a sustained strong wind force ranging from 45 to 90 kilometers per hour

One knot is equal to 1.85 km/h.

Tropical Cyclones in India are mostly generated in the Bay of Bengal, affecting the eastern coastal areas. These cyclones bring with them huge risks of damage and destruction owing to severe winds touching hundreds of kilometer per hour, heavy rainfall, storm surges and floods. The effects and impacts are mostly felt in areas near wide and shallow bays exposed to cyclones, e.g. northern Bay of Bengal. The Indian subcontinent is one of the worst cyclone affected regions of the world; it experiences approximately 10% of the world's tropical cyclones. It witnesses almost five to six cyclones every year, out of which two or three are of severe nature. Though most of them originate in the Bay of Bengal, the Arabian Sea also generates few of them. As per the data provided by IMD[54] about the frequency of cyclones on the eastern and western coasts of India between 1891 and 1990, the

[53]NDMA, Cyclones. Retrieved on July 13, 2019 from https://ndma.gov.in/en/2013-05-03-08-06-02/disaster/natural-disaster/cyclones.html

[54]Regional Specialized Meteorological Centre, IMD. Retrieved on July 13, 2019 from http://www.rsmcnewdelhi.imd.gov.in/index.php?option=com_content&view=article&id=55&Itemid=203&lang=en.

number of cyclones witnessed so far on the eastern coast is nearly 262 out of which 92 were severe, whereas 33 cyclone incidences have been noticed on the western coast out of which 19 were found to be of severe nature[55]. Besides the Indian mainland, the islands of Andaman & Nicobar and Lakshadweep also are highly prone to cyclonic storms due to exposure of water all around them. IMD has classified the Tropical Cyclones (low-pressure systems) in the Bay of Bengal and the Arabian Sea based on the Wind Speed and their damage capacity as shown by table 3.2.

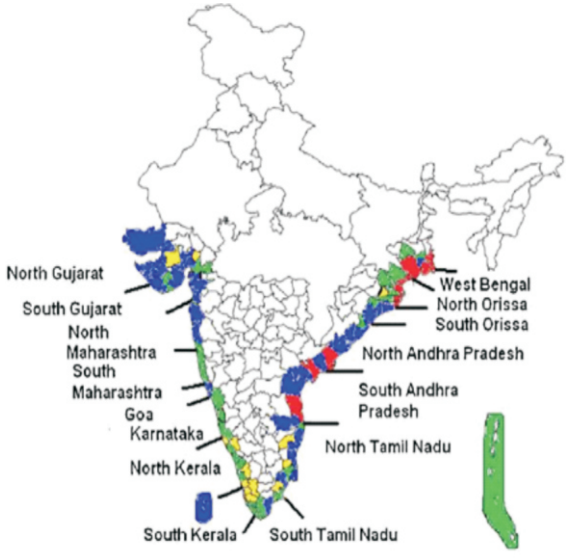
Table 3.2: Classification of tropical cyclones by IMD

TYPE OF DISTURBANCES	WIND SPEED (KM/H)	WIND SPEED (IN KNOTS)
Low Pressure	Less than 31	Less than 17
Depression	31-49	17-27
Deep Depression	49-61	27-33
Cyclonic Storm	61-88	33-47
Severe Cyclonic Storm	88-118	48-63
Very Severe Cyclonic Storm	119-221	64-119
Super Cyclone	More than 221	More than 120

Source: National Disaster Management Authority, "Cyclones" retrieved on July 13, 2019.

Map 7 shows the cyclone prone districts of India with vulnerability ranging from very highly prone regions to less prone regions. It can be observed that very highly prone regions are on the eastern coast of India, e.g. West Bengal, Odisha, Tamil Nadu and Andhra Pradesh etc. whereas less prone areas include some portions of central southern region and parts of Gujarat.

Map 7: Cyclone hazard/vulnerability map of India



Source: https://www.researchgate.net/figure/Cyclone-hazard-prone-districts-of-India-based-on-frequency-of-total-cyclones-totalfig3 _276101628 retrieved on July 2019

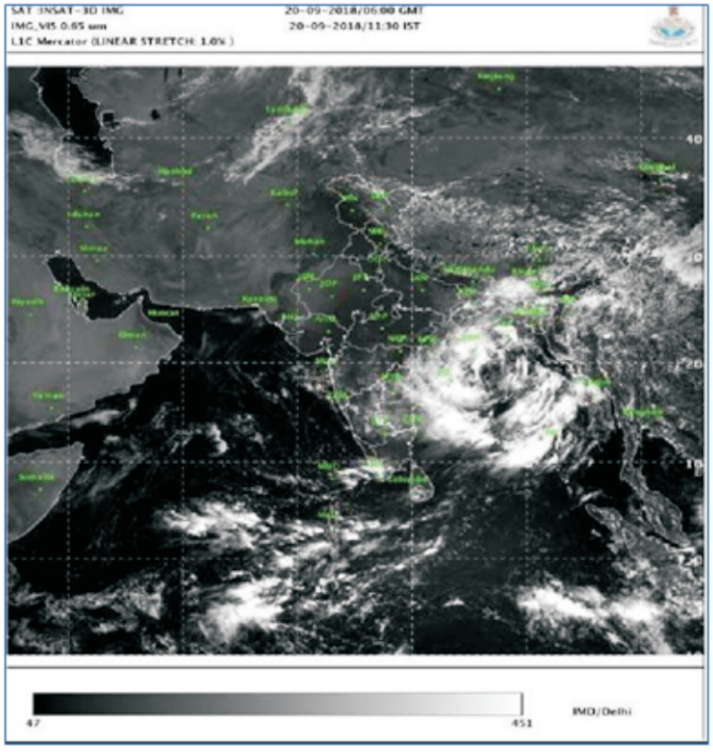
[55] Ibid 54

During the year 2018, India experienced a series of four cyclones; Cyclone Daye (September 19, 2018) in Odisha and West Bengal, Cyclone Titli (October 6, 2018) in Odisha, Cyclone Gaja (November 5, 2018) in Tamil Nadu, and Cyclone Phetai (December 13, 2018) in Andhra Pradesh.

3.1 CYCLONES DAYE

Cyclone Daye was the first Cyclonic Storm (CS) to develop over North Indian Ocean[56] and also the first Cyclone of 2018 that made occurrence in September. It originated over the east central Bay of Bengal from a Low-Pressure Area (LPA) observed in the afternoon of September 18, 2018. Map 8 shows the captured INSAT image of Cyclone Daye transforming into a deep depression on September 20, 2018.

Map 8: Cyclone daye



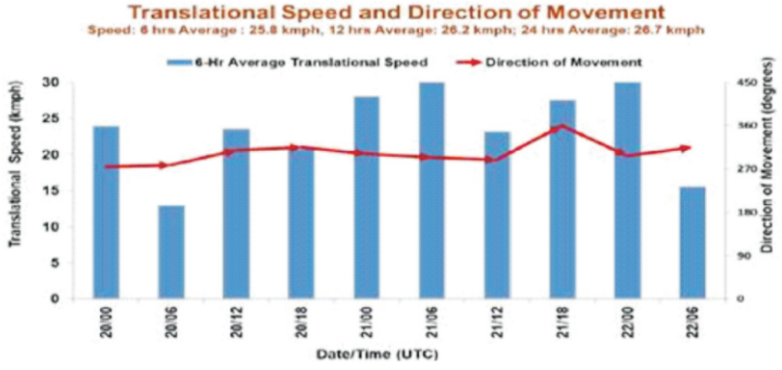
Source: Ministry of Earth Sciences, IMD. "Cyclonic Storm, 'DAYE' over the Bay of Bengal (19 – 22 September 2018): A Report".

[56] Ministry of Earth Sciences, IMD (January 2019). "Cyclonic Storm, 'DAYE' over the Bay of Bengal (19 – 22 September 2018): A Report" retrieved on July 13, 2019.

The calculated average period of the cyclone was 87 hours (3 days and 15 hours); however, the intensification remained only for 6 hours. The average translational speed of the cyclone was 26.2 kmph which was higher than the average speed of LPA of 13.7 kmph over North Indian Ocean, whereas the Maximum Sustained Surface Wind Speed and lowest estimated central pressure was 60-70kmph gusting to 80 kmph and 992 hpa respectively[57].

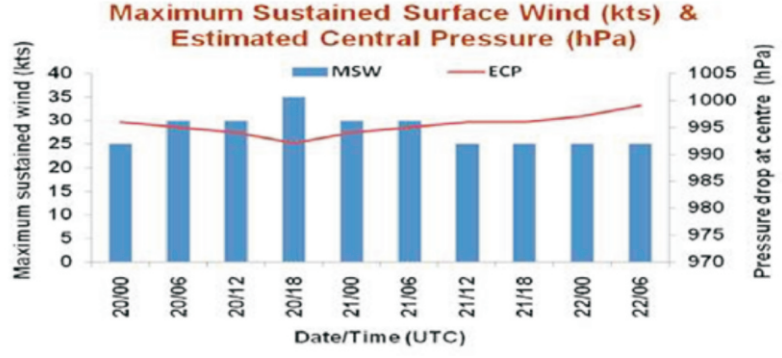
Figure 3.1 shows the translational speed and direction of movement of the cyclone. The 12-hour average speed of the cyclone was about 26 kmph which indicates its furious nature. Whereas figure 3.2 depicts the Maximum Sustained Surface Wind and the pressure observed during the cyclone.

Figure 3.1: Translational speed and direction of movement of Cyclone Daye-2018



Source: Ministry of Earth Sciences, IMD. (January 2019).

Figure 3.2: Maximum sustained surface wind and estimated central pressure of Cyclone Daye-2018



Source: Ministry of Earth Sciences, IMD. (January 2019).

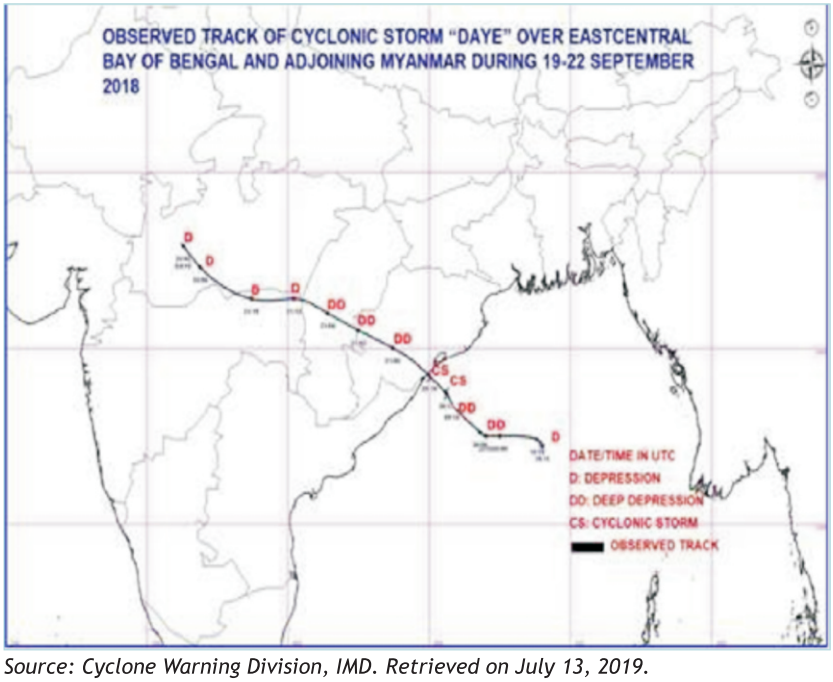
[57] Ibid 56

3.1.1 Formation and Track

The cyclonic storm was recorded by the Indian Meteorological Department and Regional Specialized Meteorological Centre (RSMC), New Delhi even before its genesis. It was observed as a depression over east central Bay of Bengal on September 18, 2018 which was 530 km south-east of Kalingapatnam (coastal Andhra Pradesh) and about 440 km south-west of Puri (Odisha); this low-pressure area went on to become a well-marked low-pressure area on the next day and to a Deep Depression (DD) on September 20, 2018 over west central Bay of Bengal moving north-westwards.

On the same day (September 20, 2018) at 2030 hours, the Deep Depression over west central Bay of Bengal moved north-westwards and intensified into the cyclonic storm "Daye". It was only 90 km south-east of Gopalpur, Odisha and about 160 km north-east of Kalingapatnam[58]. The forecast issued red message for Odisha, coastal Andhra Pradesh and Telangana and Orange and Yellow warnings for adjoining regions. This track of cyclone can be observed in Map 9 which shows the development, intensification and transformation of the cyclone Daye.

Map 9: Observed track of cyclone daye



Source: Cyclone Warning Division, IMD. Retrieved on July 13, 2019.

[58] Ibid 56

On September 21, 2018, the Cyclone Daye weakened and turned into a Deep Depression moving north-westwards with a speed of 23 kmph, crossing Southern Odisha and adjoining North Andhra Pradesh turning to in a Depression in the evening of the same day. Table 3.3 shows the Observed Position, Wind Speed and Category of the cyclone as per its life period starting from September 20, 2018 to September 22, 2018.

Table 3.3: Observed characteristics of cyclone daye

DATE/TIME	POSITION (LAT. 0N/ LONG. 0 E)	MAXIMUM SUSTAINED SURFACE WIND SPEED (KMPH)	CATEGORY OF CYCLONIC DISTURBANCE
20.09.18/1730	18.5/85.4	60-70 gusting to 80	Cyclonic Storm
21.09.18/0530	19.9/82.6	50-60 gusting to 70	Deep depression
21.09.18/1730	21.5/80.0	40-50 gusting to 60	Depression
21.09.18/0000	20.0/83.7	55-65 gusting to 75	Deep Depression
21.09.181200	21.0/80.0	40-50 gusting to 60	Depression
22.09.18/0530	22.8/77.5	30-40 gusting to 50	Depression

Source: Earth System Science Organization, Retrieved on July 13, 2019.IMD (January 2019).

3.1.2 Associated Weather

Cyclonic storm Daye was associated with bad weather and caused heavy rainfall in some parts of Odisha and Andhra Pradesh affecting several other adjoining regions. The forecasts were being issued with three hourly intervals for the tropical cyclone and extreme Gale winds associated with rainfall. However, no noteworthy damage was reported due to this cyclonic storm.

3.1.3 Role of IMD and RSMC

The role of IMD and RSMC in tracking, monitoring, forecasting and issuing warnings for the cyclone right after the initial signs require appreciation. The probability of the intensification of the Cyclone was issued about 54 hours in advance of formation of LPA and 84 hours in advance of formation of Depression. In addition, there was a continuous modelling of the observed and forecasted cyclone track along with the calculated wind speed, and the warnings were simultaneously updated. Some of the bulletins issued by the Cyclone Warning Division, New Delhi were:

- Track, intensity and landfall forecast
- Cyclone structure forecast for shipping and coastal hazard management
- Adverse weather warning bulletins
- Warning graphics

- Warning and advisory through social media; through various WhatsApp groups
- Press release and press briefing
- Advisory for International Civil Aviation
- Diagnostic and prognostic features of cyclone
- Four Stage warning - from formation of a Depression, to Deep Depression and Cyclonic storm to Very Severe Cyclonic Storm.
- Warnings and advisory for marine community
- In addition, they were also issuing the national bulletins and hourly bulletin.

Despite this, warnings through SMS and social media and WhatsApp were also being sent including the press releases and press briefings.

3.2 CYCLONE TITLI

Odisha, lying on the eastern coast of Indian subcontinent is very vulnerable to Tropical Cyclones; in 2018 alone, it experienced two cyclones, "Cyclone Daye" in September and "Cyclone Titli" in October. Odisha was hit by a Super Cyclone in 1999 that ravaged large parts of the state, since then it faces continuous threats to post monsoon tropical cyclones. Cyclone Daye did not affect the state much but Cyclone Tilti brought with it huge destruction resulting in loss of lives affecting 16 out of 30 districts[59].

The associated phenomenon has been called by IMD as "rarest of the rare occurrences" as a similar cyclone called "Luban" was noticed in the Arabian Sea 45 hours before the onset of Titli; the movement of these cyclones was termed as unique. The incidence of two similar Very Severe Cyclonic Storms (VSCS) was last noticed in the year 1977: Super Cyclonic Storm over Bay of Bengal (November 14-20) and another VSCS over Bay of Bengal as well (November 9-23).

Cyclone Titli was the most destructive cyclone witnessed in 2018. The maximum surface wind speed recorded was 140-150 kmph gusting to165 kmph (80 Knots), and the lowest pressure recorded was 927 hpa between October 10 and 11, 2018. However, one of the reasons of its uniqueness was the life period of this cyclone which was 117 hours (4 days and 21 hours) as compared to the 1999 Cyclone whose life period was 114 hours[60].

[59]Mahapatra, B. (2018, October 17). India: Cyclones buffet Odisha as temperatures rise. Retrieved July 14, 2019.
[60] Indian Meteorological Depatment, R. (n.d.). Very Severe Cyclonic Storm "Titli" over east central Bay of Bengal (08-13 October 2018): Summary (Publication). Retrieved July 14, 2019, from Regional Specialized Meteorological Centre website: http://www.rsmcnewdelhi.imd.gov.in/images/pdf/publications/preliminary-report/titli.pdf

3.2.1 Formation and Track

Cyclone Titli originated from a Low-Pressure Area formed over south-east Bay of Bengal and adjoining north Andaman Sea in the morning of October 7, 2018 as reported by IMD[61]. The LPA turned into a well-marked LPA on the same evening over the same region. It was predicted by IMD that it was likely to turn into a depression during the next 24 hours and move in north-west direction towards Odisha in the next 72hours.

On October 8, 2018 it was informed that the area is likely to intensify further into a deep depression in the next 24 hours and into a cyclonic storm during subsequent 24 hours. On October 10, 2018, IMD issued a red message for intensification of Titli as a Severe Cyclonic Storm (SCS) and forecasted its intensification as a VSCS with a wind speed of 120-1130 kmph. The forecast by IMD was as shown in table 3.4.

Table 3.4: Forecast of cyclone Titli by IMD

DATE	TIME (IST)	MAX. SUSTAINED SURFACE WIND SPEED (KMPH)	CATEGORY OF CYCLONIC DISTURBANCE
08.10.18	0830	40-50 gusting to 60	Depression
08.10.18	1730	45-55 gusting to 65	Depression
09.10.18	0530	50-60 gusting to 70	Deep Depression
09.10.18	1730	55-65 gusting to 75	Deep Depression
10.10.18	0530	60-70 gusting to 80	Cyclonic Storm
10.10.18	1730	65-75 gusting to 85	Cyclonic Storm
11.10.18	0530	70-80 gusting to 90	Cyclonic Storm
12.10.18	0530	56-60 gusting to 70	Deep Depression

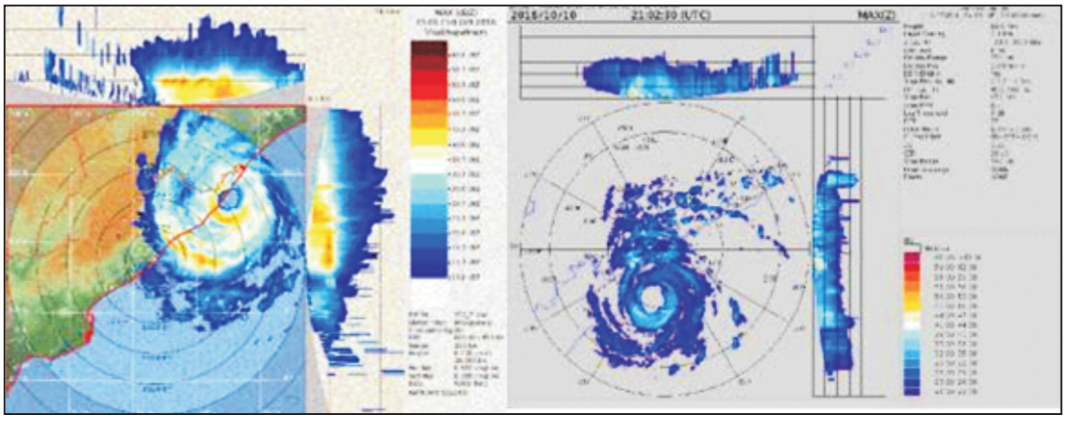
Source: IMD

Landfall

The cyclonic storm Titli made landfall as a Very Severe Cyclonic Storm on October 11, 2018 at 0430 hour between North Andhra Pradesh and South Odisha. The Surface Wind Speed reported at Gopalpur (Centre of the state) was 102 kmph. It weakened into a severe cyclonic storm after entering into the Gajapati district which is 18 km away from the coastline and continued the path with gradual weakening.

[61] Ibid 60

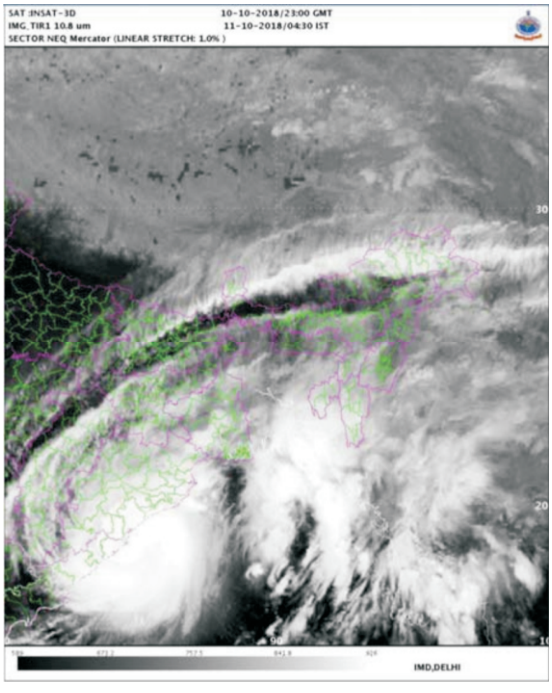
Map 10: Typical radar imagery from DWR Vishakhapatnam & Gopalpur for VSCS titli over bay of Bengal near landfall time.



Source: Regional Specialized Meteorological Centre, IMD (January 2019).

The cyclone re-curved its path and entered into Gangetic West Bengal on October 13, 2018 passing through Nayagarh, Cuttack, Dhenkanal, Jajpur, Bhadrak, Balasore and Mayurbhanj districts of Odisha causing heavy rainfall in the adjoining districts.

Map 11: Satellite image of cyclone titli during its landfall on 11.10.2018 at 4.30 am.

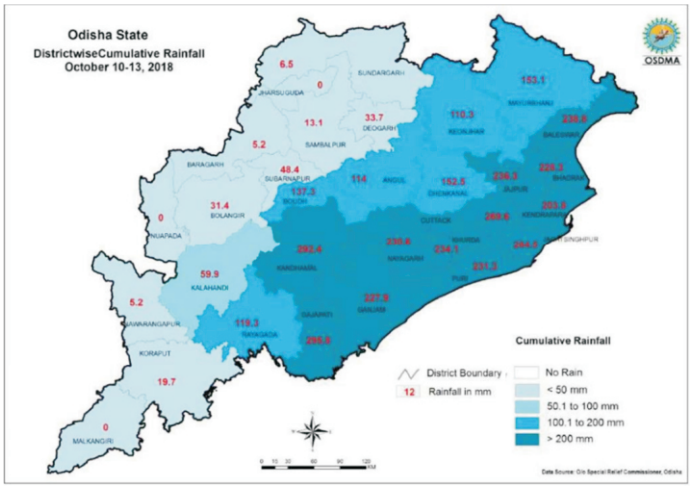


Source: IMD, Retrieved from Final Memorandum (Oct 2018) of Special Relief Commissioner, Revenue and Disaster Management Department

3.2.2 *Associated weather:*

Due to the cyclone, the coastal and adjoining districts of the state experienced heavy rainfall from October 11, 2018 to October 13, 2018. Map 12 gives a profile of rainfall recorded during the cyclonic storm:

Map 12: District wise cumulative rainfall during october 10-13, 2018



Source: Preliminary Memorandum, State Government, Odisha.

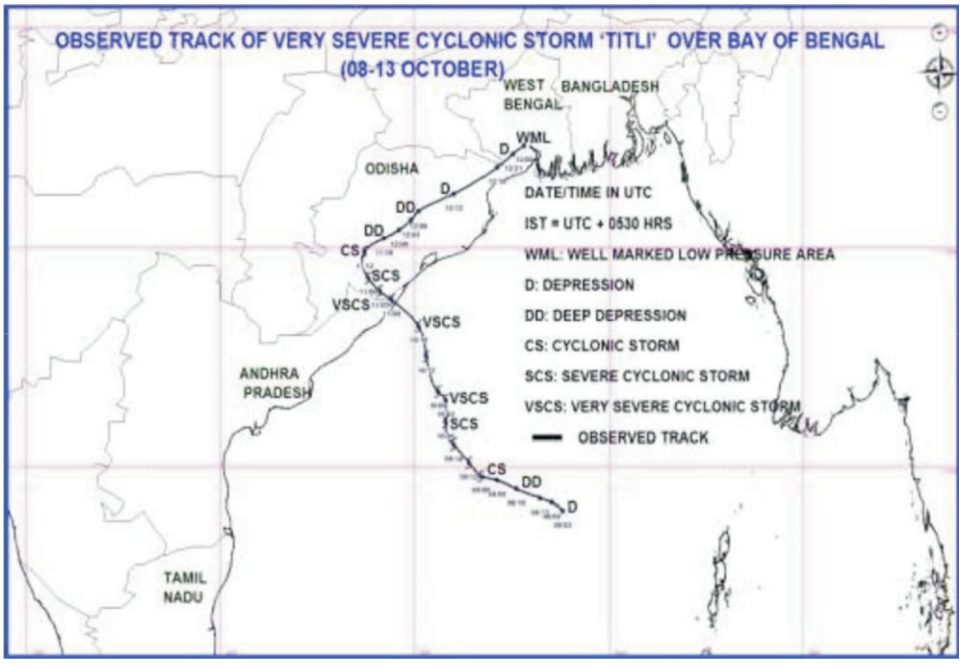
Figure 3.3: Cyclone Titli makes landfall in Odisha, October 11, 2018



Source: - Das, S. (2018, October 11). Cyclone Titli Makes Landfall In Odisha, Crosses Coast. Retrieved July 16, 2019, from https://english.kolkata 24x7.com/cyclone-titli-makes-landfall-in-odisha-crosses-coast.html/.

Cyclone Titli severely affected Gajapati and Kandhamal districts of Odisha along with Srikakulum and Vizianagaram districts of the Andhra Pradesh. It caused heavy rainfall leading to flood conditions in its aftermath. The cyclone got weakened around October 13th into a well-marked low-pressure area over Gangetic West Bengal and adjoining Bangladesh and North Bay of Bengal.

Map 13: Observed track of cyclone titli



Source: Regional Specialized Meteorological Centre, IMD.

3.2.3 Impact

Cyclone Titli was the most severe cyclone of 2018 that destroyed infrastructure and property and created havoc with accompanied heavy rainfall and flood surges. Many of the districts received rainfall more than 100 mm and about 5.7 million people across 7,402 villages were affected according to a report issued by Odisha's Special Relief Commissioner's Office[62]. The heavy rainfall caused several landslides

[62]Sangomla, A (2018, October 11366). IMD calls Titli, Luban cyclones "rarest of rare" occurrences. Retrieved July 14, 2019, from https://www.downtoearth.org.in/news/natural-disasters/imd-calls-titli-luban-cyclones-rarest-of-rare-occurrences-619000

as well; the situation reports from Odisha registers 18 deaths[63]. Besides this, damages to the primary sectors were also of immense significance; fishing sector registered damages to boats, nets, fish ponds, fish seed farms, etc.

Figure 3.4: Floods caused by Cyclone Titli



Source: Preliminary Memorandum, Government of Odisha.

Damage to Agriculture:

The state suffered a huge loss in the agricultural sector. The damaged crops and crop areas had no chance of revival because sowing of Rabi crops was already over in the month of October. About 2.63 lakh hectares of crops were affected in most parts of the state. Table 3.5 gives a detailed account of agriculture damage caused by the cyclone.

Table 3.5: Agricultural area damaged by the cyclone

DISTRICT	AGRICULTURE CROP AREA DAMAGED (ha)		
	PADDY	NON-PADDY	TOTAL
Gajapati	12215	26908	39123
Ganjam	85612	0	85612
Rayagada	2964	25833	28797

[63]Source: Preliminary Memorandum, Government of Odisha (October, 2018). "Very Severe Cyclonic Storm "Titli" and Subsequent Floods".

DISTRICT	AGRICULTURE CROP AREA DAMAGED (ha)		
	PADDY	NON-PADDY	TOTAL
Kandhamal	8067	10850	18917
Balasore	13718	70	13788
Khordha	7329	257	7586
Mayurbhanj	6540	258	6798
Cuttack	13742	944	14686
Puri	2760	0	2760
Nayagarh	1852	169	2021
Jagatsinghpur	13982	0	13982
Keonjhar	136	0	136
Bhadrak	29160	0	29160
TOTAL	**198077**	**65289**	**263366**

Source: Preliminary Memorandum, Government of Odisha.

Figure 3.5 Damaged agricultural areas due to the cyclone



Source: https://watchers.news/2018/10/14/cyclone-titli-andra-pradesh-odisha-india-october-2018/ on July 15, 2019.

Damage to Fisheries Sector

Due to the cyclone and subsequent floods, a large number of fishery infrastructure got damaged, e.g. boats, nets, fish ponds and fish farms etc. According to the memorandum submitted by Odisha Government, about 312 boats (37 fully damaged and 275 partly damaged), 552 nets (160 fully damaged and 362 partly damaged), 616 fish ponds covering 434.870 hectares and about 94 private fish seed farms and 5 government seed farms covering an area of about 56.01 and 14.66 hectares respectively were impacted by the cyclone.

Figure 3.6: Fishermen boats destroyed during the disaster



Source: Vaishnavi, H. (2018, November 5), Retrieved on July 16, 2019 from https://www.thenewsminute.com/article/cyclone-titli-aftermath-month-andhra-fishing-communities-continue-struggle-91092.

Damage to Drinking Water Sources

Immense damage to the rural and urban water supply systems were caused due to the cyclone and floods. Several pipelines and tube wells etc. were destroyed and many were submerged underwater, hence severely impairing the access of people to drinking water sources. District wise damage to the water sources are given in table 3.6.

Table 3.6 Number of damaged drinking water sources

DISTRICT	PIPED WATER SUPPLY/TUBE WELLS
Gajapati	1070
Ganjam	1357
Kandhamal	137
Rayagada	100
Khordha	47
Dhenkanal	68
Bharak	70
Balasore	68
Mayubhanj	93
Bayagarh	69
Cuttack	49
Angul	64
Puri	65
Jajpur	103
Total	**3360**

Source: Preliminary Memorandum, Government of Odisha.

Damage to Educational Institutions

About 2322 schools were damaged in total as reported by Odisha Government. The maximum number of school buildings were destroyed in Gajapati district followed by Ganjam and then Rayagada district. The total estimated cost for repair was 3482.63 lakhs. Table 3.7 gives an account of district wise damage to school buildings.

Table 3.7: Number of damaged educational buildings

DISTRICT	NUMBER OF DAMAGED SCHOOLS	NUMBER OF DAMAGED AANGANWADIS
Gajapati	829	777
Ganjam	722	223
Kandhamal	15	27
Rayagada	530	60
Dhenkanal	106	-
Khordha	-	14
Balasore	22	-
Mayubhanj	5	-
Nayagarh	81	13
Cuttack	12	-
Total	**2322**	**1114**

Source: Preliminary Memorandum, Government of Odisha.

Damage to Health Institutions

The damages to health institutions such as hospitals, primary and community health centres are shown in table 3.8 according to the data presented by the Odisha government in preliminary memorandum. There were four districts that have recorded most damages to health sector viz. Ganjam that recorded the highest, Rayagada, Gajapati and Balasore districts.

Table 3.8: Number of damaged health institutions district wise

DISTRICT	NUMBER OF PHCs/CHCs/SUB CENTRE/DDH/SDH DAMAGED
Ganjam	101
Rayagada	6
Gajapati	46
Balasore	1
Total	**154**

Source: Preliminary memorandum, Government of Odisha.

The infrastructural damages due to the storm were also huge leading to immense and long-term economic losses. It damaged around 50,000 houses including destruction of several bridges, embankments and roads in the state[64]. The overall damages and losses caused by Cyclone Titli are shown with the help of table 3.9.

Table 3.9: Details of overall losses in Andhra Pradesh & Odisha

LOSSES	ANDHRA PRADESH	ODISHA
Number of Districts affected	02	17
Human lives	16	71
Cattle Loss	5823	4692
Agricultural Area affected	1.40 Lac Hectares	3.9 Lakh Hectares
Houses destroyed	50265	62373
Boats damaged	638 Fully 182 Partially	308 Fully 37 Partially
Roads	1084 Km	2486 Km
NDRF Deployment	04 Teams deployed 11 Teams Standby	12 Teams deployed 06 Teams on Stand by
Electricity Pole	13407	16586

Source: Disaster Management Division, Ministry of Home Affairs. Retrieved on July 16, 2019.

Figure 3.7: Damaged infrastructure and landscape caused by Cyclone Titli



Source: IANS, https://weather.com/en-IN/india/monsoon/news/2018-10-09-cyclone-titli-to-hit-east-coast-on-thursday.

[64] Ibid 63

3.2.4 Response

Cyclone Titli received very well coordinated response by various organizations like NDRF and ODRAF (Odisha Disaster Rapid Action Force) etc. besides warnings and forecasting from IMD and RSMC.

3.2.4.1 Role of IMD and RSMC

IMD was monitoring and tracking the cyclone along with issuing the warnings and guidelines for the same that were shared with key state level officers, collectors and media. Information was being disseminated through use of various media sources. Similarly, the public address systems were used for broadcast at local level. Fishermen were also warned.

Based upon the forecasts, about 3 lakh people were shifted to safer places before the landfall of the cyclone and free kitchen services were made available for them.

3.2.4.2 Deployments of the Response Forces:

Odisha Disaster Rapid Action Force (ODRAF) and National Disaster Response Force (NDRF) deployed several teams for the rescue and relief operations. 26 teams from ODRAF and 14 teams from NDRF (45 personnel each) were positioned in 16 districts of the state for the search, and providing rescue and relief in the affected areas[65].

Food and other utilities and amenities were distributed to the needy such as rice, jaggery and dry food, candles, matchboxes, kerosene and other materials. People of affected districts were given relief materials for 15 days. For delivering the materials, two helicopters of Indian Navy were requisitioned which airdropped the materials to inaccessible and remote areas of the state such as Aska, Purusottampur and Patrapur blocks of Ganjam district; 2120 packets of dry food were airdropped[66]. District wise deployment of the disaster response forces is given at Table 3.10.

[65]Preliminary memorandum, Government of Odisha. (October 2018). Retrieved on July 15, 2019
[66]Ibid 65

Figure 3.8 Relief material distribution by the response forces



Source: Preliminary memorandum, Government of Odisha.

Table 3.10: District wise deployment of the response forces

SN.	DISTRICT	NDRF TEAMS	ODRAF TEAMS
1	Ganjam	4	4
2	Gajapati	2	2
3	Puri	2	-
4	Kendrapara	1	-
5	Nayagarh	-	-
6	Bhadrak	1	-
7	Jagatsinghpur	1	3
8	Jajpur	1	-
9	Khordha	-	3
10	Cuttack	-	1
11	Balasore	1	3
12	Mayurbhanj	-	3
13	Kalahandi	-	2
14	Boudh	-	2
15	Samblapur	1	-
16	Rayagada	-	3
	Total	**14**	**26**

Source: Preliminary Memorandum, Government of Odisha, October 2018.

3.2.4.3 Medical Assistance

Prior to the occurrence of cyclone, medicinal stock was stored in the district headquarters which in addition to essential drugs and other medicinal help was rushed to all the affected districts. Besides, medical teams were also deployed. Table 3.11 shows the medical assistance provided at the time of the cyclone:

Table 3.11 Medical Assistance provided to the affected areas

ITEMS	NUMBERS
Medical Relief Centres	193
Mobile teams	70
ORS packs distributed	1230000
Halogen tablets distributed	5070000
Minor Ailment treated	428
Injections supplied	2500
Fluids supplied	80000
Cleaning activities conducted	157 villages

Source: Preliminary Memorandum, Government of Odisha (October 2018).

In addition to the medical and rescue operations for people, animals were also attended. About 38099 animals were vaccinated and 39878 treated with the help of veterinary doctors engaged in about 614 camps.

3.3 CYCLONE GAJA

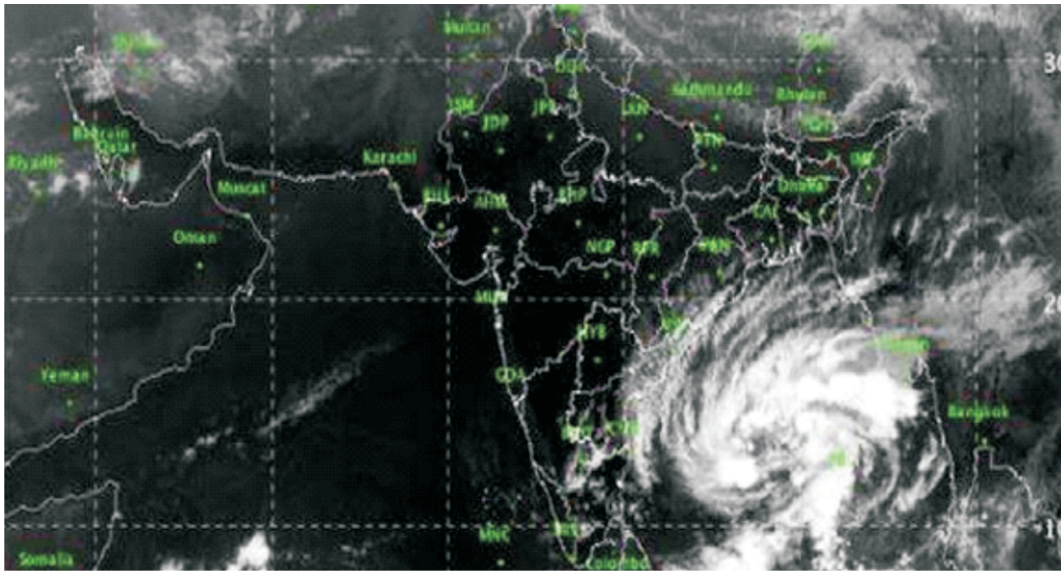
Cyclone Gaja was the first looping cyclone after 1996 over Bay of Bengal with one of the longest track lengths of 3418 km. It was the sixth cyclone over north Indian Ocean in 2018. The cyclone was identified as a Low-Pressure Area formed over Gulf of Thailand and adjoining Malay Peninsula in the morning of November 8, 2018. Some characteristic features of Cyclonic Storm Gaja are provided in the Table 3.12.

Table 3.12: Characteristic features of cyclonic storm Gaja

ITEMS	NUMBERS
Track length	3418 Km
Maximum Surface Wind Speed	130 kmph gusting to 145 kmph
Lowest Central Pressure	975 hPa
Life Period	219 hours (9 days and 3 hours) against the long period average of 98 hours for SCS category over Bay of Bengal
Velocity Flux	9.4×10^2 Knots
Accumulated Cyclone Energy	4.35 x 104 knots [2]
Power Dissipation Index	2.1 x 10 Knots[3]

Source: Regional Specialized Meteorological Centre, IMD.

Map 14: Satellite Image of cyclone Gaja



Source: Retrieved on July 16, 2019 from.https://www.thehindubusinessline.com/news/cyclone-gaja-may-cross-chennai-nagapattinam-coast-on-thursday article25473175.ece

3.3.1 Formation and track

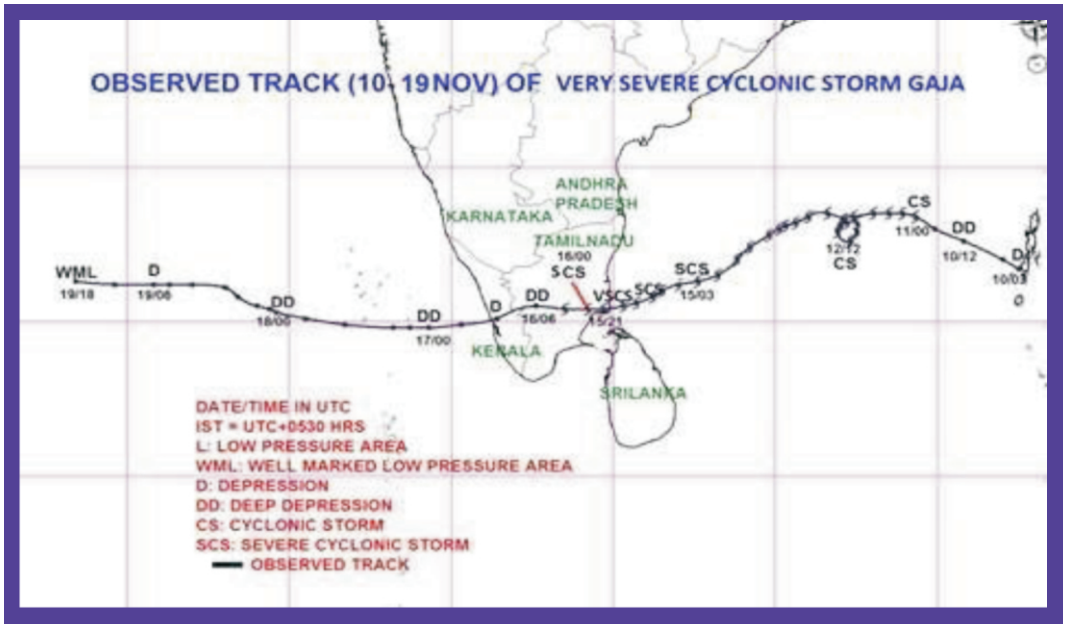
According to the Regional Specialized Meteorological Centre (RSMC)[67], Cyclone Gaja was categorized to be a Very Severe Cyclonic Storm (VSCS) originating from a low-pressure area turning into a well-marked low-pressure area in the evening of November 9, 2018 over North Andaman Sea and adjoining region. It concentrated into a Depression in the morning of November 10, and into a Deep Depression (DD) in the evening of the same day over south-east and Central Bay of Bengal. Turning into a Cyclonic Storm (CS) on November 11. It shifted its track towards west concentrating into a Severe Cyclonic Storm afterwards. Shifting again in the south-south west direction, it followed an anticlockwise looping track till the morning of November 13, 2018. Cyclone Gaja turned into a VSCS making landfall on November 15, 2018 crossing Tamil Nadu and Puducherry coast with a wind speed of 130 kmph gusting to 145 kmph on the next day.

[67]Regional Specialized Meteorological Centre, IMD, "Very Severe Cyclonic Storm "Gaja" over east central Bay of Bengal (10-19 November): Summary" retrieved o July 16, 2019.

Thereafter, moving nearly westwards, it weakened into a CS in the morning, and a Deep Depression (DD) in the forenoon over interior Tamil Nadu on November 16, 2018 and simultaneously got weakened into a Depression in the same evening over central Kerala and moved towards south east Arabian Sea in the same midnight. Making an entrance into the south east Arabian Sea, it again intensified into a DD in the early morning of November 17, 2018.

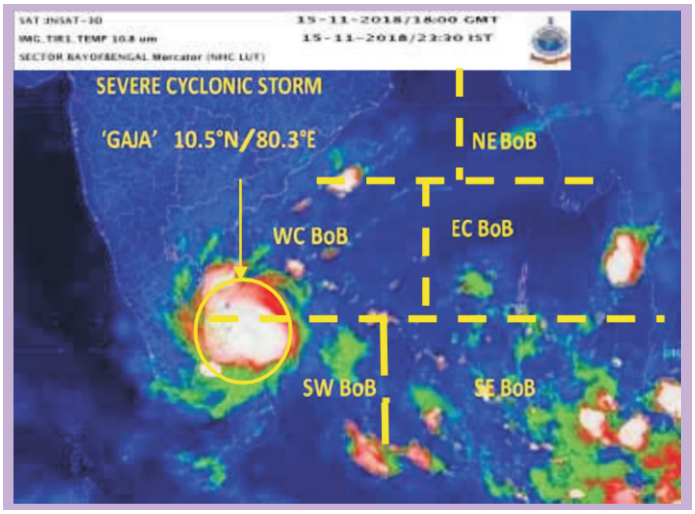
The cyclone crossed Lakshadweep Islands in the afternoon of November 17, 2018 as a DD. Gradually dying; it lay as a Low-Pressure Area (LPA) over southwest Arabian Sea on November 21, 2018 and became less marked over the same region on November 22, 2018. The observed track of Cyclone Gaja is shown with the help of the Map 15.

Map 15: Observed track of cyclone Gaja



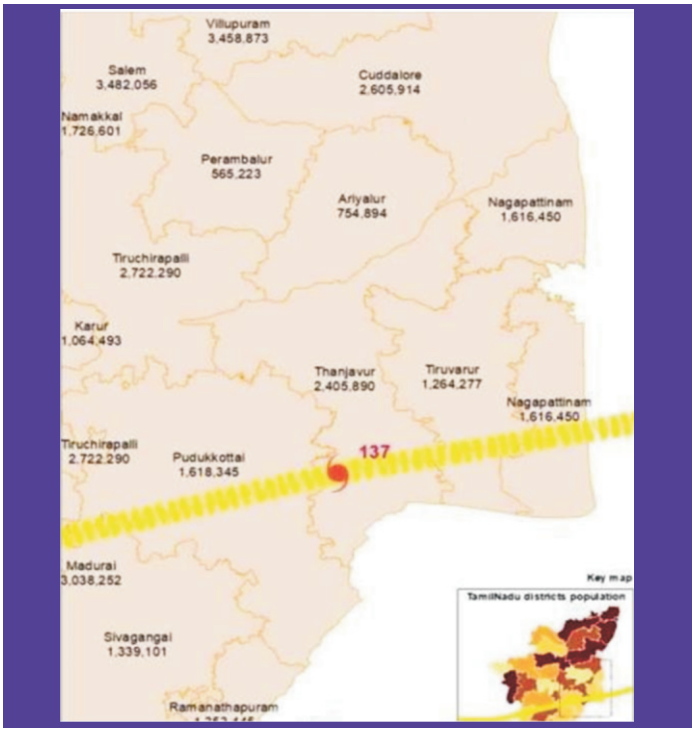
Source: Regional Specialized Meteorological Centre, IMD.

Map 16 Typical satellite imagery of cyclone Gaja making landfall on November 15, 2018.



Source: Regional Specialized Meteorological Centre, IMD

Figure 3.9: Districts affected by cyclone Gaja, 2018



Source: NDMA. September, 2019. "Study report on Gaja cyclone 2018" retrieved on July 25, 2020

3.3.2 Associated Weather

Rainfall was experienced by Tamil Nadu and the adjoining regions from November 15, 2018. Rainfall at most places and heavy rainfall at isolated places was witnessed in Tamil Nadu with moderate rainfall over Kerala, south coastal Andhra Pradesh, Rayalaseema and south interior Karnataka[68]. Next day, heavy to extremely heavy rainfall was observed in Kerala and isolated heavy rainfall over coastal Andhra Pradesh. Besides, a storm surge of about 1 meter above astronomical tide inundated low lying areas up to 1km from the coast near landfall point.

Figure 3.10: Onset of heavy rainfall



Source: https://www.indiatoday.in/india/story/cyclone-gaja-pounds-tamil-nadu-strong-wind-heavy-rain-1389560-2018-11-16 retrieved on July 17, 2019.

3.2.3 Impacts

The cyclonic storm Gaja was a severe one whose impacts were felt over a large region especially in Tamil Nadu and Puducherry whereas Tamil Nadu faced greater damage. It impacted about 80,000 people in Tamil Nadu and 63 people were killed. However, Puducherry had lesser impacts. Table 3.13 provides a general overview of the damage caused by Cyclone Gaja.

[68]Regional Specialized Meteorological Centre, IMD, "Very Severe Cyclonic Storm "Gaja" over east central Bay of Bengal (10-19 November): Summary" retrieved o July 16, 2019.

Table 3.13: Overall impacts of cyclone Gaja

ITEMS	TAMIL NADU	PUDUCHERRY
Number of districts affected	Severely affected - 05 Moderately affected - 07	02
Number of villages affected	465	-
Population Affected	81948	-
Human Fatalities	63	NIL
Number of missing people	-	NIL
Number of injured	259	02
Houses Damaged	Fully damaged huts -64978 Partially damaged huts -30354 Pucca/kutcha houses damaged-43729	Fully - 02 Partially - 19 Severely - 318 Huts -1106
Animals Lost	324	-
Number of people Evacuated	81948	4857
Number of Relief Camps opened	816	57
Inmates in relief camps	454132	5358
Relief material distributed	Food Packets	Yes
Affected crop area (ha)	559562	-
Infrastructure damaged	EB Poles (L) - 98868 Damaged distribution: 846 Transformers and trees fallen-170454	Tress uprooted - 2200 Electric Poles - 152 Electric Line - 15

Source: Disaster Management Division, Ministry of Home Affairs

A summary of bulletins issued by ACWC Chennai and CWWC Thiruvananthapuram (TRV) has been given in table 3.14.

Table 3.14: Statistics of bulletins issued by ACWC Chennai and CWWC Thiruvananthapuram

TYPE OF BULLETIN	NUMBER OF BULLETINS ISSUED	
	ACWC CHENNAI	MC TRV
Sea Area Bulletins	13	NIL
Coastal Weather Bulletins	13	NIL
Fisherman warnings issued	26	72
Port warnings	8	17
Heavy rainfall warnings	16	7
Gale Wind Warning	35	NIL
Information and Warning issued to State Government and other Agencies	35	52
Special weather Bulletins	35	NIL
SMS	1200	15 times

Source: Regional Specialized Meteorological Centre-Tropical Cyclones, IMD.

3.4 CYCLONE PHETAI

Cyclone Phetai was categorized as a Severe Cyclonic Storm (SCS) being the seventh cyclone over North Indian Ocean during 2018. Cyclone Phetai had a re-curving path that moved north-eastward during and after the landfall having a track length of 1525 km. The maximum surface wind speed attained by the cyclone was100-110 kmph gusting to120 kmph (55 knots) having a translational speed of 13.5 kmph. The lowest estimated central pressure of this cyclone was calculated as 992hpa[69].

3.4.1 Formation and Track

The SCS Phetai was observed to be originated from a low-pressure area formed over Equatorial Indian Ocean and central parts of south Bay of Bengal on December 9, 2018 that turned into a well-marked low-pressure area on December 11, 2018. Due to the favorable environmental conditions prevailing, it transformed into a DD over the same region on December 13, 2018 and intensified afterwards on the same evening while moving north and north-westward. The storm was named "Cyclone Phetai" when it intensified into a CS in the evening of December 15, 2018 while turning into a SCS on the very next day. Maintaining the intensity of a SCS till December 17, 2018, it got weakened into a SC crossing Andhra Pradesh after making the landfall on the same day with a Maximum Sustained Wind Speed of 75-85 kmph and gusting of 95kmph.

Figure 3.11: Onset of Cyclone Phetai, 2018



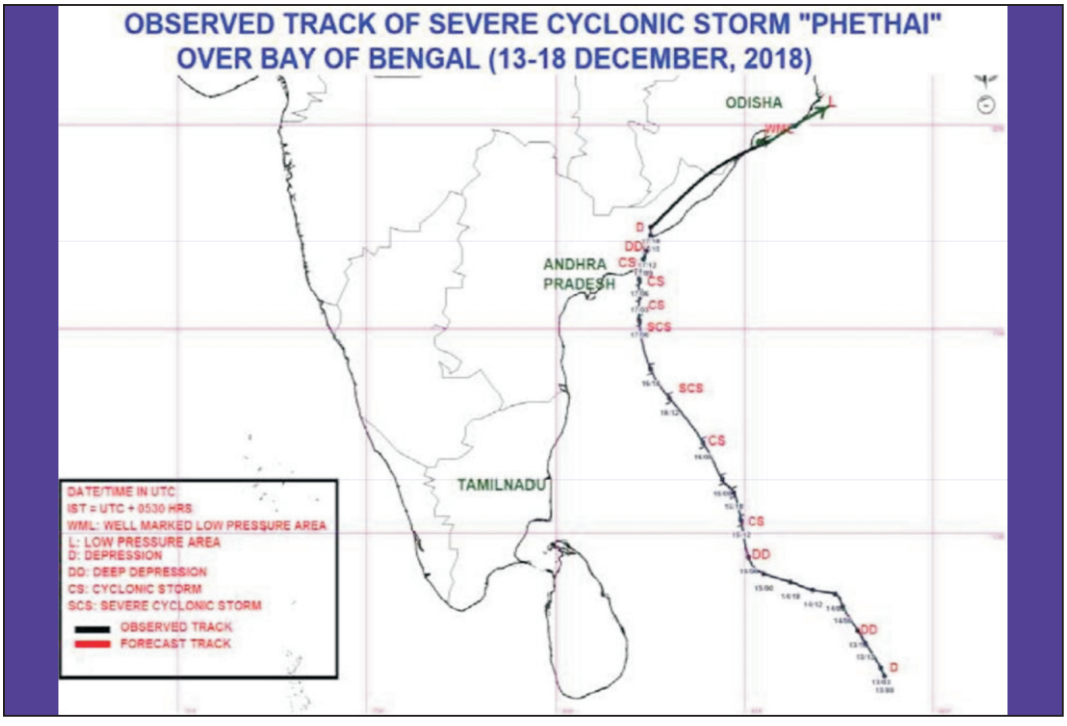
Source: Livemint (December 17, 2018). Retrieved on July 17, 2019 from https://www.livemint.com/Politics/775Tjh5CecUagSLZacxUxN/Cyclonic-storm-Phethai-to-trigger-heavy-rainfall-in-Odisha.html

[69]Ministry of Earth Sciences, IMD (January 2019). "Severe Cyclonic Storm, 'PHETHAI' over southeast Bay of Bengal (13 – 18 December 2018): A Report" retrieved on July 17, 2019.

After making landfall, it changed its direction towards north-northeast swiftly abating into a DD over west central Bay of Bengal. Crossing Andhra Pradesh coast again; it gradually washed-out by turning into a Depression in the midnight of December 17, 2018. LPA was attained by Phetai over northwest Bay of Bengal and Odisha in the morning of December 18, 2018.

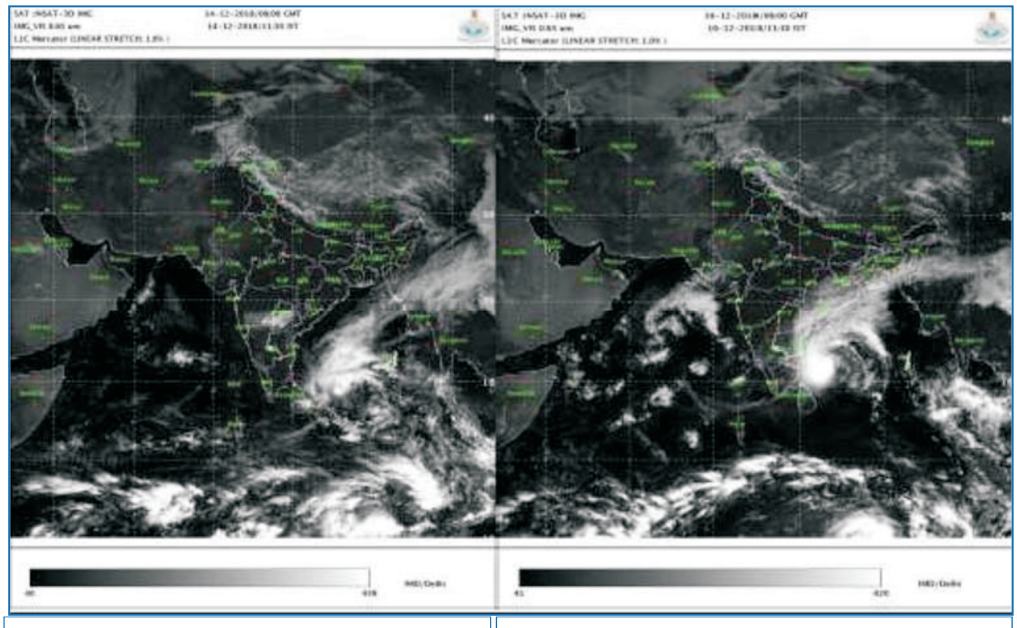
Map 17 shows the observed track of the Severe Cyclonic Storm Phetai by the India Meteorological Department from December 13, 2018 to December 18, 2018 over Bay of Bengal.

Map 17 Observed track of Cyclone Phetai (December 13 – 18, 2018).

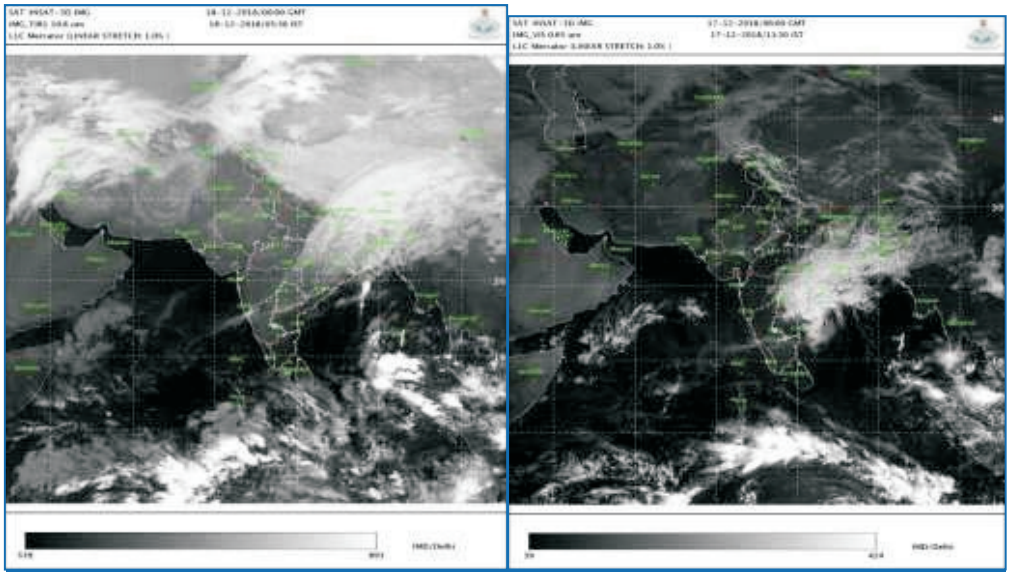


Source: Ministry of Earth Sciences, IMD (January 2019)"Ministry of Earth Sciences, IMD (January 2019). "Severe Cyclonic Storm, 'PHETHAI' over southeast Bay of Bengal (13 – 18 December 2018): A Report" retrieved on July 17, 2019.

Map 18: Satellite images of the Cyclone Phetai over Bay of Bengal and adjoining areas



December 14, 2018 | December 16, 2018



December 17, 2018 | December 18, 2018

Source: Earth System Science Organization, IMD. (January 2019)

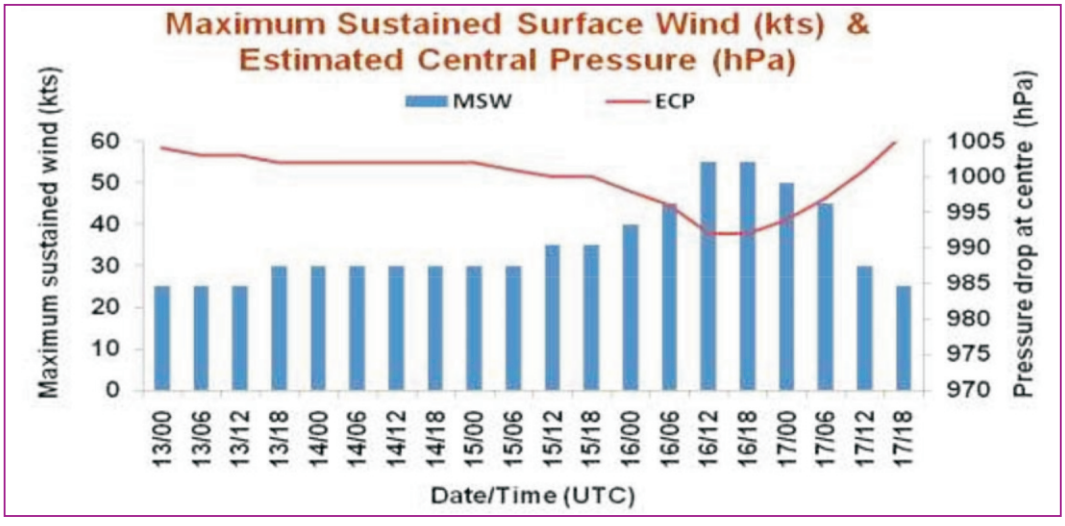
3.4.2 Associated Weather

The cyclonic system caused heavy to very heavy rainfall at several places e.g. over central parts of south Bay of Bengal during December 13 to December 15, 2018; over southwest Bay of Bengal on December 16, 2018 and over Coastal Andhra Pradesh on December 17, 2018. Heavy to very heavy rainfall occurred at isolated places over north coastal Andhra Pradesh and heavy rainfall at isolated places over Telangana from December 16 till December17, 2018. In addition, heavy to very heavy rainfall occurred at a few places over north coastal Andhra Pradesh and heavy rainfall at a few places over Odisha and isolated places over Jharkhand ending at December 18, 2018.

3.4.3 Central Pressure and Wind

According to IMD, the lowest estimated central pressure and the maximum sustained wind speed was 992 hpa and 55 knots respectively recorded on December 16, 2018. Whereas, at the time of landfall, the estimated central pressure was 997 hpa while the MSW was 45 knots, during the second landfall, the pressure went on to1001 hpa and MSW decreased to 30 knots.

Figure 3.12: Surface wind and central pressure for Cyclone Phetai



Source: Earth System Science Organization, IMD. (January 2019).

3.4.4 Impacts

Cyclonic Phetai was categorized as a Severe Cyclonic Storm that impacted the coastal areas of Andhra Pradesh and Odisha before and after making landfall. The

total population affected by the cyclone was around 80,000; however, no loss of human and animal lives was reported. Table below provides general information of the total losses caused by the cyclone.

Table 3.15: Overall damages caused by Cyclone Phetai

ITEMS	NUMBERS
Number of Districts affected	6 (Krishna, West Godavari, East Godavari, Vishakhapatnam, Guntur & Vizianagram)
Number of Mandals affected	174 Mandals
Population affected	796408
Human lives lost	-
Number of Missing	-
Number of Injured	-
Houses damaged	Fully -205
Animals affected	-
Number of persons evacuated	31232 evacuated, 04 boats and 26 fishermen rescued by Coast guard & Navy.
Number of relief camps opened	280 relief camps and 131492 persons were benefitted
Number of Medical and Health camps organized and treated	476
Relief material distributed	241841 food packets and 1541479 water packets supplied to all the people in relief camps
Total crop area affected (hectares)	(Agriculture - 55,8111.50 lakh ha and 82539 farmers were affected). Horticulture - 7033.68 hectare and 12516 farmers were affected
Infrastructure damage	**Electricity-** 52 33KV feeders, 326 11KV feeders, 80 33/11KV substations, 34 33 KVpoles, 223 LT poles, 387 DTRs, 17km LT lines, 3.21 km 33Kv lines and 10.6 km 11KV lines. **Roads-** 519.61 km

Source: Situation Reports, National Emergency Response Centre, Disaster Management Division, Ministry of Home Affairs. Retrieved in July 2019

3.4.5 Rescue and Relief Operations

Rescue and relief operations were organized by several SDRF an NDRF teams. These teams were deployed in advance in the coastal districts of Guntur, Krishna,

West Godavari, East Godavari and Vishakhapatnam. According to the SDRF Authority Director, 2 teams of SDRF containing 80 personnel and 2 teams of NDRF having 60 personnel were deployed with all the necessary and emergency equipment for evacuation and rescue purposes[70].

In addition, 16 teams of Andhra Pradesh Disaster Response and Fire Services were kept on reserve at Rajamahendravam while nine of them each having 5 members were positioned in West Godavari district for road clearance[71]. Fishermen were also warned. The Odisha government had asked the district collectors to take steps to protect paddy from the unreasonable rain. Farmers were recommended to reap the paddy in their field and bring it to a safe place.

[70] Thomas, S. (2018, December 16). Cyclone Phethai: Andhra Pradesh on high alert, NDRF teams deployed in coastal districts; heavy rainfall to hit Odisha over next two days. Retrieved July 18, 2019, from https://www.indiatvnews.com/news/india- cyclone-phethai-andhra-pradesh-odisha-met-department-sdrf-teams-ndrf-teams-government-evacuation-relief-operations- latest-updates-493240

[71] Ibid 70

OTHER EVENTS 4

4.1 TAMIL NADU FOREST FIRE

Forests are one of the major natural resource. They play an important role in maintaining environmental balance. As per the assessment of the India State of Forest Report (ISFR), the forest cover of the state is 26,281 sq.km, which amounts to 20.21% of the geographical area of the State[72].

A forest fire may be defined as unclosed and freely spreading combustion that consumes the natural fuels.

Every year about 5 billion hectares of forest land gets damaged worldwide due to forest fire. Forest fires are viewed as a potential hazard with biological, ecological, and environmental consequences. Its occurrence is frequent in regions such as tropical countries, particularly in the dry and hot seasons, causing serious damage to the forest resources and agricultural production[73].

4.1.1 Forest Fire Hazards in Tamil Nadu

The state of Tamil Nadu has witnessed more than one fourth of annual average fire incidents, of the last decade, in the 15 forest divisions of the State viz. Kodaikanal, Vellore, Theni, Mudumali Tiger Reserve, Hosur, Sathyamangalam Tiger Reserve, Kanyakumari, Anamalai Tiger Reserve, Tirupattur, Nilgiris (N), Tiruvallur, Dindigul, Kallakurichi, and Megamalai WLS divisions[74].

Table 4.1: Total affected area and number of reported fire incidents in Tamil Nadu

S.N.	YEAR	NO. OF REPORTED FIRE INCIDENTS	TOTAL AFFECTED AREA IN (ha)
1.	2012	470	1202.020
2.	2013	310	943.329
3.	2014	661	1356.740
4.	2015	406	855.732
5.	2016	916	1527.426

Source: EM-DAT Brussels and Situation reports by DM Division, MHA, 2018.

[72]Tamil Nadu State of Forest Report. 2017, ISFR 2017

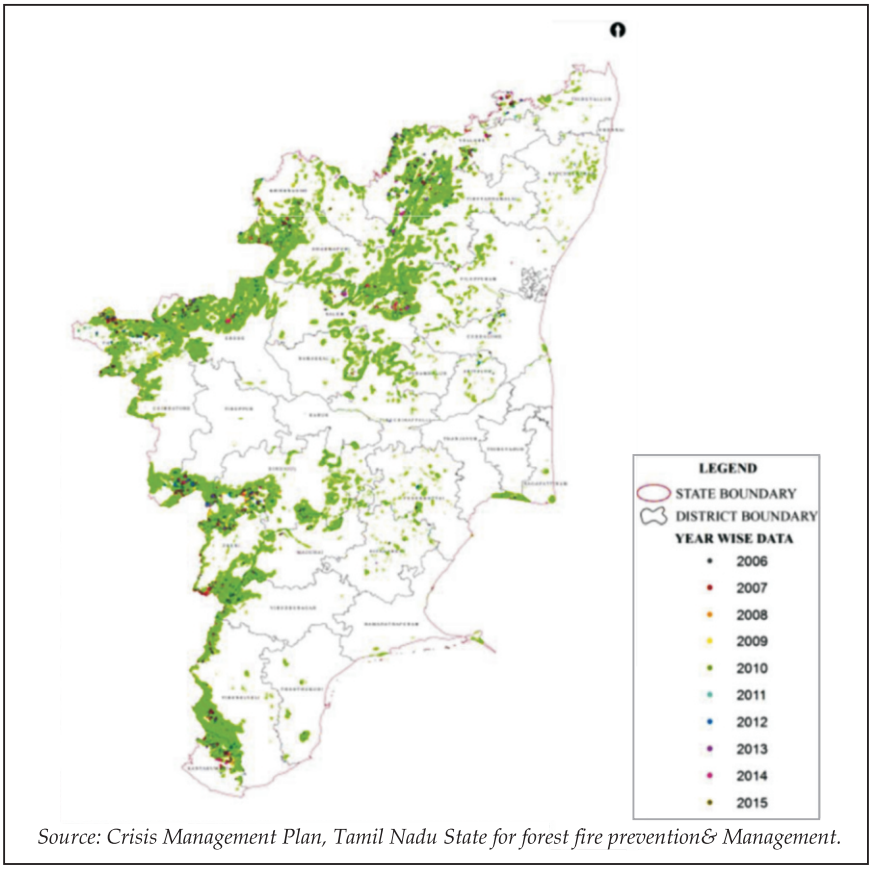
[73]Assessing forest fire prone area in Kurangani, Tamil Nadu using remote sensing & GIS, International Journal of Applied Engineering Research ISSN 0973-4562 Volume 13, Number 7 (2018) pp. 264-269 © Research India Publications. http://www.ripublication.com

[74]Crisis Management Plan, Tamil Nadu State for Forest Fire Prevention and Mitigation, 2016-2017.

The state has seen two-fold growth of reported fire incidents from nearly 470 reported forest fire incidents in the year 2012 to 916 reported forest fires in 2016. During the decade 2006-2015, 8649 fire incidents were detected within the geographical area of the state of Tamil Nadu. These 3272 fire incidents were detected within the notified forests of the state. At an average, 327 fire incidents in 74 fire days per annum were detected during the period 2006 to 2015, with maximum fire incidents during the year 2009.

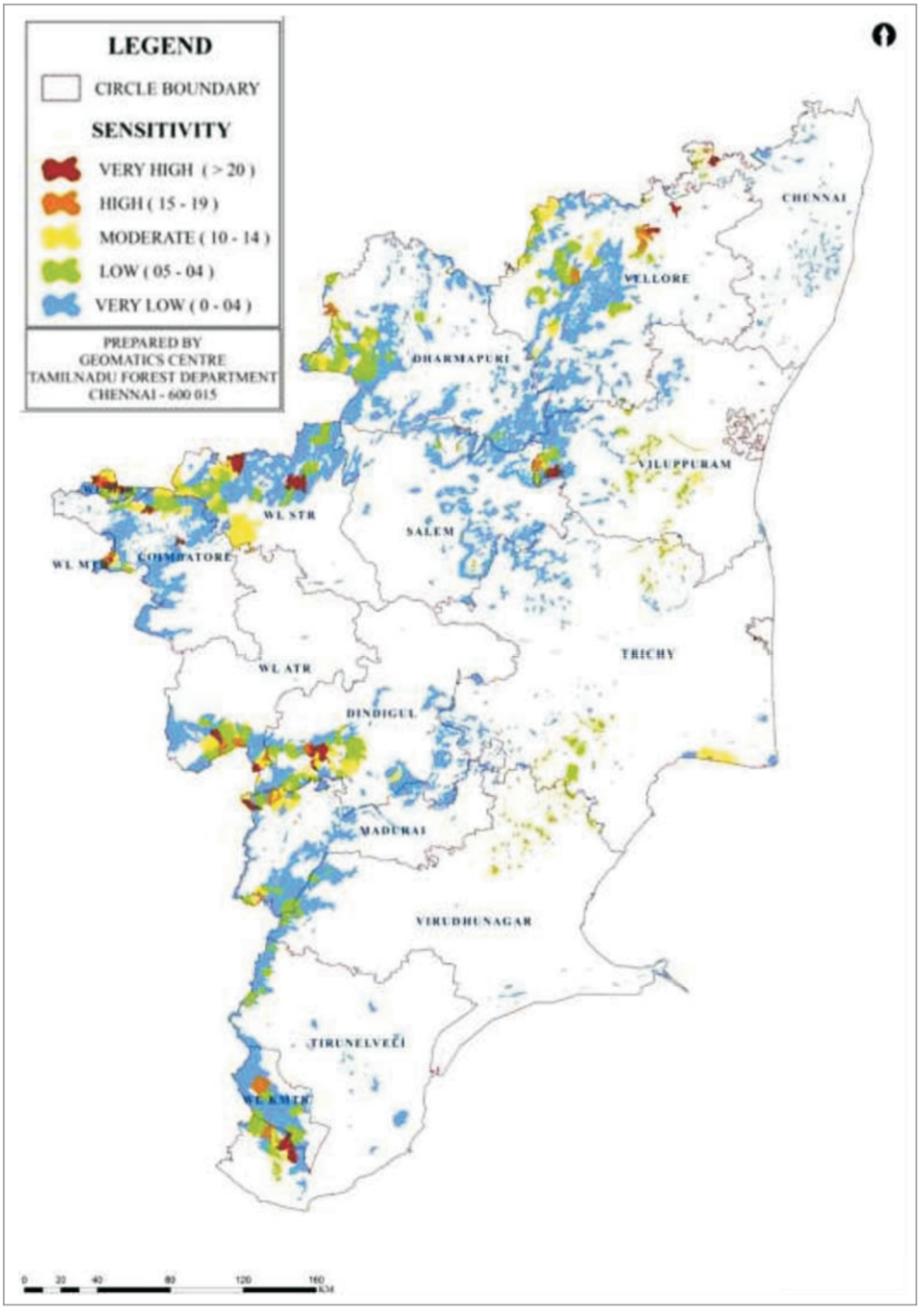
The state of Tamil Nadu has a mix of moderately dense moist, dry and deciduous forests, which are located on both the Western and Eastern Ghats of India. 56% of forest fires were detected in the Western Ghats and around 39% in the Eastern Ghats of the State. Hence, both the Eastern and Western Ghats are highly vulnerable to forest fire. Map 19 and Map 20 represent forest fire incidents and fire risk zones respectively in notified forest areas.

Map 19: Year wise forest fire incidents in notified forests



Source: Crisis Management Plan, Tamil Nadu State for forest fire prevention& Management.

Map 20: Tamil Nadu state fire risk zone



Source: Crisis Management Plan, Tamil Nadu State for forest fire prevention& Management.

4.1.2 Forest Fire of 2018

On March 10, 2018, a forest fire was reported at the Southern part of the state. The fire initially started at Kurangiri Hills in Theni district. The area has lost about 205 hectares of its land, around 98 forest fires were registered till then. It registered about 8 fires in 2018. The fires took the lives of many trekkers and injured others who were on their way to Kurangiri hills. It was reported by The Hindu, that two teams went for trekking in the hills, one consisting of 24 members from Chennai trekking club and another of 12 members from Erode and Tirupur. They were caught by the fire as they were on the way to Kurangiri hills from Kozhukkumalai. The cause of the fire outbreak was attributed to the dried grasses, due to which the fire spread rather rapidly and quickly. About 17 people, including 9 students lost their lives, and the rest were rescued and admitted to a nearby hospital.

Table 4.2: Tamil Nadu forest fire inventory- 2018

ITEMS	DESCRIPTION
Date	**March 10, 2018**
Location	Kurangiri hills, Theni, Tamil Nadu
Number of Dead	17
Rescue operation	Locals, IAF and others

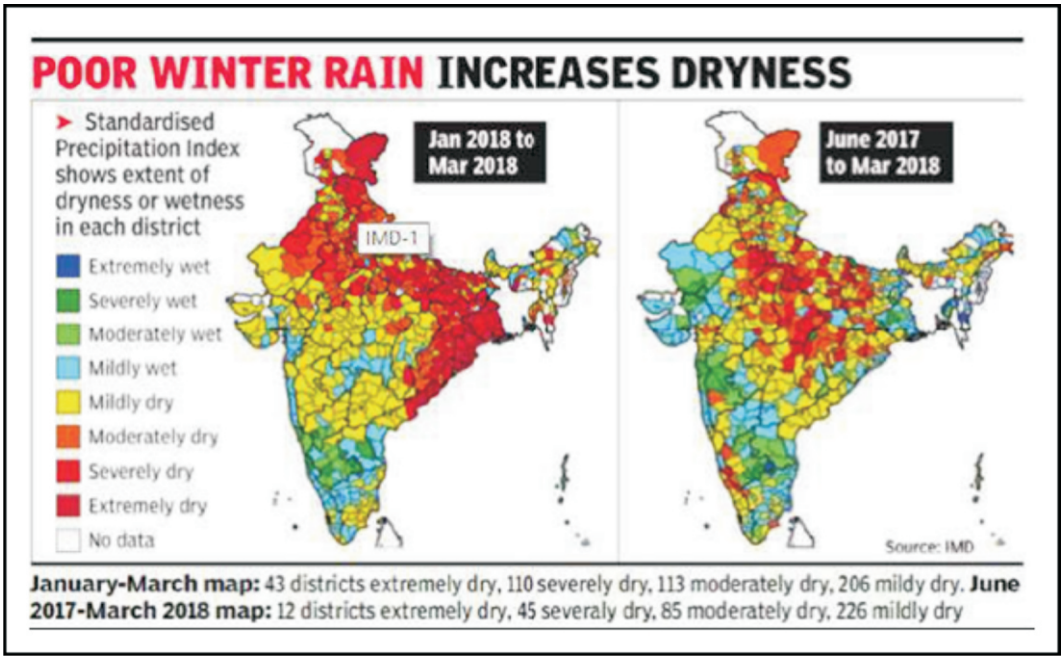
Source: B.A.K. (2018, March 18), The Hindu.

Immediate rescue operations were organized by the local community; subsequently help came from State and Central Governments. A total of 4 Indian Air Force Choppers were deployed for fire fighting roles. In addition, one team of Kerala Police was also sent to the Theni district. The State Government launched Comprehensive Tamil Nadu Forests and Wildfire Areas Rules (2018) for more efficient regulation of trekking activities.

4.2. DROUGHT SITUATION IN INDIA

The India Meteorological Department forecasted 97% of the long period rainfall (average of 89 centimeters) during the 2018 South-West monsoon season. The actual rainfall received was 91% of the quantum, which led to extreme soil moisture deficit in many states and many parts of the country. Figure 4.1 shows the Standardized Precipitation Index of dryness or wetness in the districts of India.

Figure 4.1: Standardized Precipitation Index (SPI) showing extent of dryness or wetness in the districts of India



Source: Drought and Heat Wave Situation in India- 1-3rd May, 2018, Sphere India.

Maharashtra and Karnataka faced severe drought in the year 2018. According to data from the Ministry of Agriculture, 80% of the districts in Karnataka and 72% of the districts in Maharashtra were suffering with water scarcity and crop failure. Apart from the two states, Andhra Pradesh, Jharkhand, Gujarat, and Rajasthan also reported drought. A total of around 1.96 crore hectares of land was affected and the state governments sought Rs.16,773 crore in aid from the Centre to tackle the situation as shown in table 4.3.

The worst affected state was Maharashtra with an area of around 85.76 lakh hectares, which had a direct impact on over 82 lakh farmers in Maharashtra. Farmers did not plant Rabi (spring) crop in the Beed district of Maharashtra due to water shortage. Around 75% of the crops in Beed were destroyed due to water shortage. The state government asked for Rs.7,522 crore in aid stating that more districts could be added to the list of drought-affected ones.

The erstwhile Ministry of Drinking Water and Sanitation also provided relief measures for restoration of drinking water supply in drought-hit areas, the funds were drawn from the flexi funds as per National Rural Drinking Water Programme (NRDWP) provisions, under which the states could utilize up to 25% of NRDWP funds, in case of a natural calamity.

Table 4.3 Drought affected states

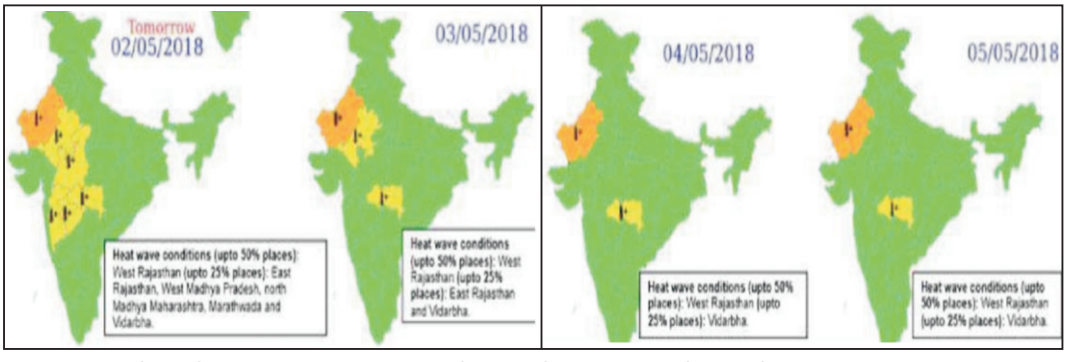
STATES	AFFECTED DISTRICTS	AREA AFFECTED (IN ha)	ASSISTANCE SOUGHT (INR Cr.)
Maharashtra	26	8576367.00	7,522.26
Karnataka	24	3712432.00	2,434
Andhra Pradesh	9	1361531.54	1,401.54
Jharkhand	18	359304.90	818.938
Gujarat	11	2093238.00	1,777.54
Rajasthan	9	3496574.00	2,819.58
Total	**97**	**1,95,99,447.44**	**16,773.86**

Source: Union Ministry of Agriculture

4.3 HEAT-WAVE SITUATION IN INDIA

A Heat Wave is a period of abnormally high temperatures, more than the normal maximum temperature that occurs during the summer season in the North-Western parts of India. The India Meteorological Department (IMD) issued heat wave warnings in West Rajasthan (up to 25% places), East Rajasthan, West Madhya Pradesh, north Madhya Maharashtra, Marathwada and Vidarbha regions. Figure 4.2 shows the heat wave alerts generated between 2- 5th May, 2018 in India.

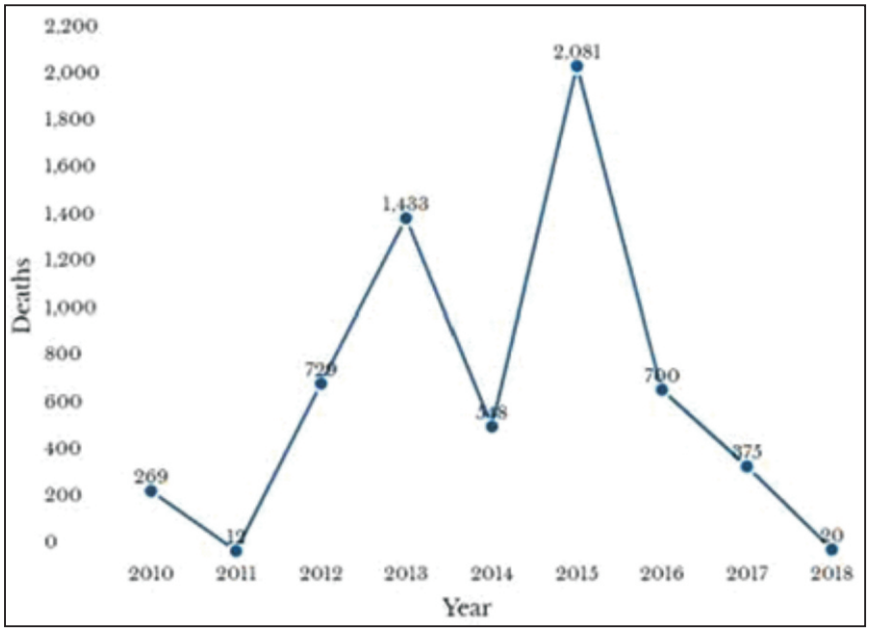
Figure 4.2 Heat waves alerts in India



Source: Drought and Heat Wave Situation in India- 1-3rd May, 2018, Sphere India

On May 22, parts of the national capital recorded its highest temperature of the year, 46°C, joining Rajasthan, Andhra Pradesh, and Telangana in getting scorched. Figure 4.3 represents heat wave deaths during the period 2010-2018. With heat-wave conditions affecting regions across India, 6,167 heat-related deaths were reported between 2010 and 2018. The year 2015 reported the most fatalities, around 2,081 deaths. The numbers got reduced from 2,081 in 2015 to 700 in 2016 and 375 in 2017 as heat-related illnesses fell sharply. Twenty people were reported dead due to heat-wave in 2018.

Figure 4.3: Deaths caused by heat wave from 2010 to 2018



Source: Chaitanya Mallapur, India Spend, Mumbai, Last Updated on April 4, 2019, Business Standard

4.4 NIPAH VIRUS OUTBREAK IN KERALA

Nipah Virus is a zoonotic virus which is transmitted through contaminated food or from person to person; usually the transmission occurs from animals to humans. It is an emerging infectious disease in the South-East Asia region; named after a Malaysian village[75] where it was first discovered.

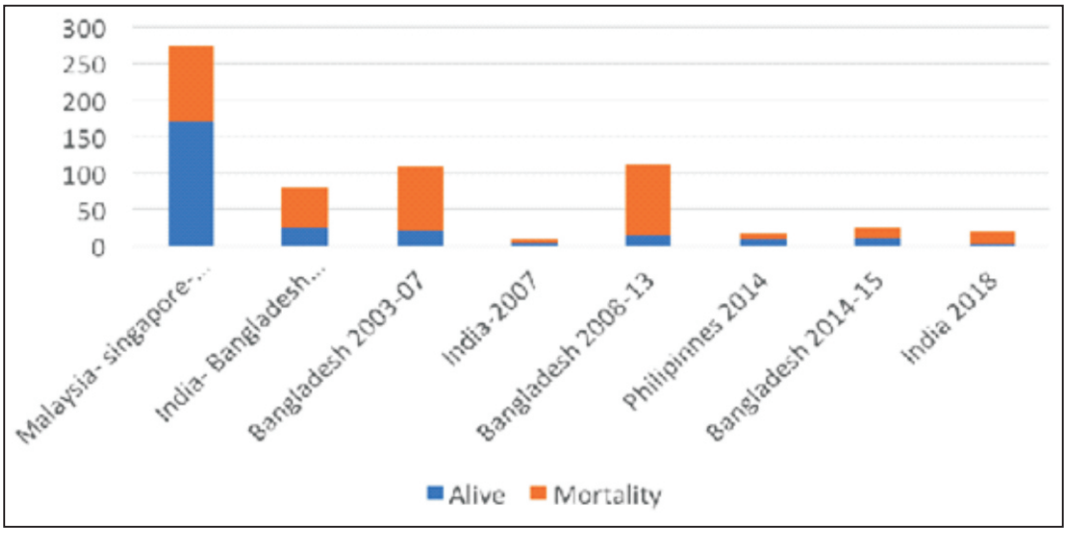
[75] Anno. (1999). Outbreak of Hendra-like virus – Malaysia and Singapore, 1998-99. Morb. Mort. Weekly Rep., 48 (13), 265-269.

Pteropus fruit bats have been identified as natural reservoirs of this virus[76] and as these bats are known to be migratory, this virus is likely to return to the countries affected. The case fatality of Nipah Virus ranges from 40%-70% though it has 100% impact in some outbreaks; since 1998, it has infected around 477 and killed 252 people[77].

4.4.1 A brief history

Usually the mode of transmission is through infected bats that during their excretion and secretion contaminate the food items and other things humans get into contact with. A large outbreak in Malaysia in 1999 recognized transmissions through pigs as a predominant mode as 90% of the farmers who were infected used to be in regular contact with pigs. In 2001, there were evidences of Nipah outbreak in Bangladesh and India which was attributed to fruit bats, and transmitted to humans. There are evidences of human to human transmission also in 2001 when 33 health workers and hospital visitors became ill due to exposure with the patients.

Figure 4.4 Timeline of Nipah virus outbreak across the world with total number of cases registered

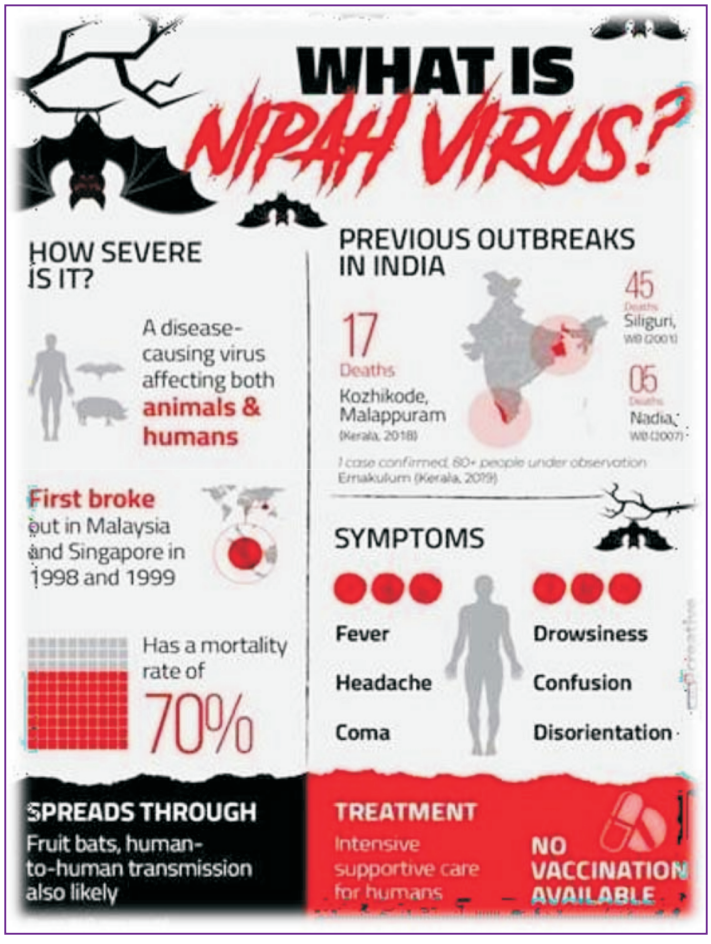


Source: retrieved on July 27, 2019 from https://www.researchgate.net/figure/Timeline-of-Nipah-Virus-outbreaks-across-the-world-with- total-number-of-cases-reported-in_fig1_330745881

[76]Nipah virus infection, WHO. May 30, 2018 retrieved I July 2019 from https://www.who.int/csr/disease/nipah/en/

[77]Ibid 76

Figure 4.5: NIPAH virus outbreak in India and other information



Source: Two Suspected Cases of Nipah Virus Reported from Karnataka. (2018, May 23). Retrieved July 27, 2019, from https://www.news18.com/news/india/two-suspected-cases-of-nipah-virus-reported-from-Karnataka-1757177.html

4.4.2 Nipah outbreaks in India so far

An outbreak of Nipah Virus was witnessed in Kerala in May, 2018 which is attributed to be transmitted from infectious bats to humans taking lives of many and affecting others. It was first identified on May 17, 2018 when a patient was admitted to a hospital in Kozhikode district of Kerala; test samples declared emergence of Nipah virus linking it to Pteropus bats which was confirmed by

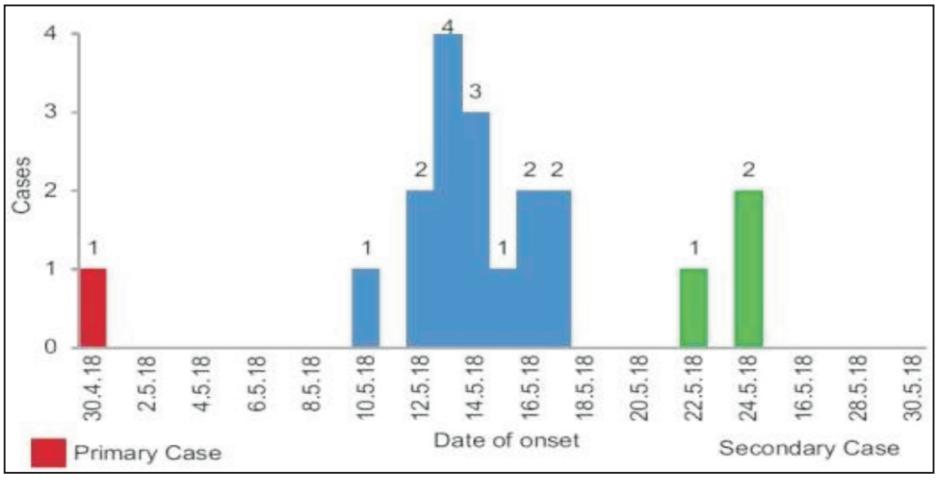
NIV/ICMR with 19.2% of the bats testing positive[78]. It was the first outbreak in Kerala and third in India. Till July 19, 2018, a total of 19 cases were reported out of which 17 deaths were confirmed[79]; rest of the patients recovered completely. Two districts namely Kozhikode and Malappuram were reported to have witnessed the virus.

Table 4.4: Nipah outbreaks in India

MONTH/YEAR	LOCATION	NUMBER OF CASES	NUMBER OF DEATHS	CASE FATALITY RATE
February 2001	Siliguri, West Bengal	66	45	68%
April 2007	Nadia, West Bengal	5	5	100%
May 2018	Kerala	14	12	86%

Source: World Health Organization.

Figure 4.6: Epidemic curve of Nipah virus outbreak, 2018



Source: Thomas, B. et al. 2019. "Nipah Virus Infection in Kozhikode, Kerala, South India, in 2018: Epidemiology of an Outbreak of an Emerging Disease", Indian Journal of Community Medicine. Retrieved from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6881878/

4.4.3 Efforts made to control the spread of virus

Several teams from the National Centre for Disease Control were sent to work along with state government officials in response to the outbreak. During the

[78]Sadanadan, R. et al. (2018, November 01). Towards global health security: Response to the May 2018 Nipah virus outbreak linked to Pteropus bats in Kerala, India. Retrieved July, 2019, from https://gh.bmj.com/content/3/6/e001086

[79]WHO (August 7, 2018). "Nipah Virus-India"

[80]Ibid 79

investigation, more than 2600 contacts were identified, and all were tested for Nipah according to a report by WHO[80]. The teams were provided with guidelines and material for identification and prevention. Besides this, guidelines to hospitals and local people were also issued in addition to Syndromic Surveillance enhancement in the state.

The response to the outbreak included the following:

- Training and capacity building of health care personnel
- Sample collection and safe transportation
- Safe disposal of dead bodies
- Contact tracing
- Hospital waste management, infection control and prevention
- Monitoring of the outbreak through Strategic Health Operation Centre (SHOC) at the National Centre for Disease Control.

In addition to the state government efforts, the World Health Organization also contributed through providing technical material and guidance on the virus to the Ministry of Health & Family Welfare and Kerala health authorities.

4.5 TECHNOLOGICAL DISASTERS

Technological disasters include those which occur due to some human error or caused by the malfunction of a technological system. These disasters include road and rail accidents, air crashes, building and factory fires, industrial accidents etc. The year 2018 witnessed numerous technological disasters that were severe to moderate in nature. They are listed below in the following tables:

Table 4.5: Road/rail accidents

DATE	LOCATION	DISASTER TYPE	NUMBER OF DEATHS	NUMBER OF AFFECTED PEOPLE
March 6, 2018	Bhavnagar, Gujarat	Road Accident	30	-
April 9, 2018	Nurpur, Himachal Pradesh	Bus Accident	30	12
April 10, 2018	Khandala, Maharashtra	Road Accident	18	15
May 26, 2018	Uttar Pradesh	Road Accident	13	5
July 19, 2018	Uttrakhand	Bus falls into a ravine	14	17
September 11, 2018	Jagtial,Telangana	Bus Accident	50	-

[80]Ibid 79

DATE	LOCATION	DISASTER TYPE	NUMBER OF DEATHS	NUMBER OF AFFECTED PEOPLE
October 19, 2018	Amritsar, Punjab	Rail Accident	59	90
November 24, 2018	Mandya, Karnataka	Road Accident	28	-
December 8, 2018	Poonch, Kashmir	Road Accident	13	13

Source: EM-DAT Brussels (International Disaster Database).

Table 4.6: Fire incidents

DATE	LOCATION	DISASTER TYPE	NUMBER OF DEATHS	NUMBER OF AFFECTED PEOPLE
January 4, 2018	Marol, Mumbai	Fire in a building	4	5
January 6, 2018	Kanjurmarg, Mumbai	Fire at Cine Vista Film Studio	1	-
January 8, 2018	Mumbai,Maharashtra	Fire at sessions Court	-	-
January 20, 2018	Bawana, New Delhi	Industrial Accident: Fire in a Plastic factory	17	-
January 22, 2018	Andheri, Mumbai	Fire in Industrial Area	2 firemen injured	-
February 7, 2018	Goregaon, Mumbai	Fire in Cloth Mill	No Casualties	
February 16, 2018	Beawar/Ajmer, Rajasthan	Explosion in a hotel	18	5
March 3, 2018	Asalfa village, Ghatkopar, Mumbai	Fire inside a chemical factory	-	-
May 27, 2018	Goregaon, Mumbai	Fire	4	9
May 30, 2018	Goregaon, Mumbai	Fire in a building	4	1
June 10, 2018	Kothari Mansion, Mumbai	Fire in a residential building	No casualties	-
June 19, 2018	Charbagh, Lucknow	Viraat Hotel	5	5
July 4, 2018	Warangal, Telangana	Fire in a Cracker factory	10	-
August 9, 2018	Chembur, Mumbai	BPCL Factory	43 severely Injured	-
December 1, 2018	Mumbai	Fire in a shop leading to collapse	12	-
December 17, 2018	Mumbai	Fire in a public hospital (ESICKamgar Hospital)	8	150
December 18, 2018	Saki Naka, Mumbai	Fire in a Snack shop	12	-

Source: News Articles and EM-DAT.

Table 4.7: Miscellaneous incidents

DATE	LOCATION	DISASTER TYPE	NUMBER OF DEATHS	NUMBER OF AFFECTED PEOPLE
May 15, 2018	Varanasi, Uttar Pradesh	Flyover Collapse	15	11 injured, dozens trapped
28 June, 2018	Mumbai	Aircraft crash	5	No survivor
September 5, 2018	Kolkata, West Bengal	Majerhat bridge collapse	1	24 injured
December 28, 2018	Dehradun, Uttarakhand	100-year-old bridge collapsed	2	2 injured

Source: EMDAT Brussels and from different News Articles and reports.

Disclaimer: Some of the information is derived from various news articles and reports due to unavailability of data sources, whereas most of them are derived from International Disaster Database (EM-DAT Brussels).

4.6 OTHER MINOR EVENTS

Table 4.8: Natural hazard causing minor events

DATE	LOCATION	DISASTER TYPE	NUMBER OF DEATHS	NUMBER OF PEOPLE AFFECTED	LOSSES INCURRED (IN US$)
January 1, 2018	New Delhi	Cold Wave associated with Fog, temperature dips to 4.2℃	40	-	-
CONVECTIVE STORMS					
April 1, 2018	Uttar Pradesh and Rajasthan	Storm	42	200	-
May1 -10,2018	Rajasthan and Uttar Pradesh	Storm	143	200	
May 13-16, 2018	Uttar Pradesh, West Bengal, Bihar, Andhra Pradesh	Storm with winds gusting to 100 kmph	95		
May 6-9, 2018	Uttar Pradesh, West Bengal, Tripura	Storm	32	21000	50,000
May 28, 2018	Uttar Pradesh, Jharkhand, Bihar,	Storm	54	-	25,000

DATE	LOCATION	DISASTER TY PE	NUMBER OF DEATHS	NUMBER OF PEOPLE AFFECTED	LOSSES INCURRED (IN US$)
June 1-6,2018	Uttar Pradesh, Kerala, Maharashtra, Mizoram, Rajasthan	Storm with winds gusting to 100 kmph leading to land and mudslides.	42		
June 8-12, 2018	Uttar Pradesh, West Bengal, Assam, Tripura, Manipur, Mizoram	Convective storm leading to landslides and floods	61		50,000

Source: International Disaster Database, EM-DAT Brussels

LESSON LEARNT AND WAY FORWARD 5

The India Disaster Report 2018 (IDR-2018) has attempted to compile and analyze the major disasters which impacted the country during 2018. In 2018 India witnessed the largest number of people affected from various disasters around the globe. Given the fact that the frequency, intensity, and unpredictability of natural disasters is expected to increase as a result of climate change, it is more important than ever that one must learn from the past events in a holistic perspective.

The year 2018 witnessed one of its major floods in the State of Kerala. The Kerala floods clearly highlight the need for a change in perspective for controlling floods and creating necessary awareness both at the government and the local community level. Another issue requiring attention is non-availability of reliable real time flood warning mechanism in the state.

Effectiveness of dam management in controlling the floods in the state was debated at length. Use of technological support including artificial intelligence needs to be promoted for effective management of dams. Apart from the appropriate generation of warning, its effective dissemination to stakeholders present in the affected area is equally important. There is a need to strengthen the mechanism of effective early warning dissemination. Moreover, long term measures for flood risk mitigation in the vulnerable areas like land use planning etc. need to be implemented on a war footing to prevent the disaster from eroding the developmental gains year after year. Involvement of local community in search, rescue and relief operations made the post disaster response operation very effective. Promoting the development of human resources who can play a major role in making the society more resilient, is of utmost importance.

The vast improvement in cyclone early warning and forecast has resulted in improvement in planning the evacuation and preparation to face the cyclones. The events of 2018, once again, showed how different stakeholders involved in cyclone risk mitigation and management could coordinate to cope with recurring cyclonic events. Incidences of forest fires, heat-waves and droughts are becoming a common phenomenon in India in recent years with an increasing trend. Obvious reasons of enhanced frequency and intensity of hydro-meteorological disasters may be the changing climatic conditions along with high population growth, rapid

urbanization, and environmental degradation. Thus investing in climate change adaptation is the key to reduce the risk of disasters.

An integrated approach with emphasis on prevention, mitigation and preparedness will ultimately help in conserving developmental gains in long run as also minimize losses of lives, livelihoods and property. It is always better to have proactive approach for risk reduction at national level.

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National Institute of Disaster Management
(Ministry of Home Affairs, Government of India)
A-Wing, 4th Floor, NDCC-II Building, Jai Singh Road, New Delhi-110001
Phone: 011-23438286, Fax: 011-23438285
Email: ed.nidm@nic.in | Website: www.nidm.gov.in

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