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राजेन्द्र रत्नू, भा. प्र. से.
कार्यकारी निदेशक

Rajendra Ratnoo, IAS
Executive Director

सत्यमेव जयते

आज़ादी का अमृत महोत्सव

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Foreword

Floods are a frequent occurrence. Even while water is essential to existence, it brings about sadness when it floods. At times, it has yielded favorable outcomes and bestowed upon civilizations immense wealth and prosperity. The fertile great northern plains of India which produce nearly 60 percent of our food grains is result of sediments brought by the floods of Indus-Ganga-Brahmaputra and their tributaries. Parallely, floods have caused tremendous losses in different resources including economic resources and turned into great tragedy.

Now a days, the frequency of floods has increased and flash floods have also been taking place in the country irrespective of geographical locations and seasons. The flash flood is having casualities in many folds. Also have limited remedial measures to prevent such type of disasters. These days, floods lead all disasters in the number of people affected and in resultant economic losses, with these numbers rising at alarming rates.

Government is always supporting to public in all kinds whenever floods or disasters are taking place. Also, they are focussing on preparedness, warning, mitigation etc. to reduce the agony of every sufferer. Lots of efforts of Central Water Commission and other departments have been made for the forecasting floods by considering new inputs. Present thrust on effective and long-lasting strategy, involves combination of structural and non-structural measures along with the use of modern technology which can alleviate the problem of floods to a great degree and to make the country flood resillient.

One thing which every decision maker has to understand is that floods are not something which we have to prevent. It is the destruction of livelihood which has to be minimized by leaving the room of the river. Like any other natural entity, rivers have their own course and methods of operation and in order to minimize the loss and destruction, we have to develop a sustainable ecosystem wherein both humanity and nature can benefit from each other.

Keeping in view, the floods are taking place in each state & UT, the quantum of misery, havocness of floods, losses of human, cattle, other property, and total economic losses, the histoical socio-economically recorded for future references. These database would be of immense use to various departments for their specified purposes.

(Rajendra Ratnoo)

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Acknowledgement

This report is an archival record of the history of India's significant floods in different States and Union Territories from the year 2000 to 2021, which has been collected from various sources. It is perceived as a big opportunity to put forth the prepared archival report as a milestone for future use of commuters. To complete the report, different organisation reports like Central & State Govt., News sources, digital media etc. have been used to obtain the relevant information and are thankfully acknowledged.

The authors are thankful to those who have given ample support to complete the task. Heartfelt thanks are due to Shri Rajendra Ratnoo, IAS, Executive Director, NIDM for providing various kind of supports to prepare and publish the document. Thanks are due to Central Water Commission (CWC) for their various information which has given a good basis to prepare the report. Different Departments of State & Central Govt are also greatfully acknowledged for providing relevant information. Specially, Dr KVH Durga Rao, Group Head, Disaster Management Support Group, RSA, National Remote Sensing Centre (NRSC), ISRO, Hyderabad, Central Water Commission Experts, UP Irrigation Department Persons with whom valuable discussions were made, are thankfully acknowledged.

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Executive Summary

Each year, floods cause severe destruction in human life, infrastructure, livelihood, and resources etc. Owing to its recurrent nature, it is adding the misery of human and animals in many folds. Now a days, the flash flood gives mental agony to human civilization, further its impact make the public totally handicapped.

In India, each year intensity and spatial extents of floods are also increasing. Lot of modern technologies are now a days supporting to alleviate the problems of floods to a great degree. Hence, it is high time that we should formulate and implement sustainable prevention and mitigation measures by involving the combination of structural and non-structural measures.

In this regard, the archival record of floods can give insight of flood patterns, type, economic losses and the severity. Accordingly planning preparedness and warning may be taken to save human lives, economy and the environment. Thus, a study for archival records has been done for significant floods during last 22 years i.e. for the calendar year 2000 to 2021.

The report clearly indicates that the frequency of floods is more in riverine areas in Assam, Odisha, West Bengal, Andhra Pradesh, Bihar, Uttar Pradesh, Gujarat etc., compared to other parts of the country. The flood frequency and quantum in Bihar, Assam and Odisha does not show any trend, but intermittently severe floods have taken place in different places. The flash floods are very active in Maharashtra, Uttarakhand, Kerala, Himachal, Arunachal, J&K etc. Due to heavy rainfall, and flash flood with increased erosion/scouring action, the landslide prone areas viz. Uttarakhand and Kerala are also experiencing landslides in such a manner that causes severe casualties. Glacial Lake Outburst Floods (GLOF) are also presently rising phenomenon in Himalayan region. The coastal regions are also is experiencing multiple and big cyclones almost every year that result into floods. Such incidents may be linked with the climate change. The economic losses are more in urban areas as compared to sub-urban, peri-urban areas. The prepared database would be of immense use for those who are working on floods for different regions, as well as for decision makers, planners, policy makers and communities in flood affected areas.

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3.1.3	Andhra Pradesh	2009	Riverine
3.1.4	Andhra Pradesh	2008	Riverine
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3.2.2	Assam	2018	Riverine
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3.4.7	Bihar	2007	Riverine
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3.5.2	Gujarat	2017	Flash
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3.5.4	Gujarat	2013	Riverine

S. No.	State/UT	Year	Flood category
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3.5.6	Gujarat	2005	Cyclonic
3.5.7	Gujarat	2000	Riverine
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1. Context

India is flood prone country. Flood is recurring phenomenon and causes devastation of life and economic resources. Lot of serious events are happening during and after flood since times immemorial. After a generation gap, it would be difficult to know the severity of flood in a region. The context needs to investigate the incidences of flood disasters and how it affects can be accessed from the records that are available in the archive. To determine the relationship between flood disaster that took place and what records are available from the archives, an attempt has been made to study the disaster prevention measures adopted in the past; find out the disaster response and recovery plans implemented in the past; and make recommendations for effective disaster prevention and control measures for future flood risks.

An archive is a place where people can go to gather first hand facts, data, and evidence from letters, reports, notes, memos, photographs, and other primary sources. The benefits of archiving data are: reduced cost - data is typically stored on low performance, high capacity media with lower associated maintenance and operation costs. Better backup and restore performance - archiving removes data from backups, reducing their size and eliminating restoration of unnecessary files.

As floods cause greater economic damage and loss of human life than any other type of disaster. We urgently need better assessments of flood hazards to reduce the societal impact of extreme floods caused by the rapidly changing climate, among other factors. Hence, it is essential using archives of past floods to estimate future flood hazards for the relief of environment. Despite the wealth of flood archive data, it is still challenging to compare different data sets or integrate these data into risk assessments. To know the past flood variability, archival data (like historical document, instrumental data, tree rings, speleothemes, sediments, lacustrine fluvial, marine etc.) is essential. Thus, it is very much needed to prepare a report on archival records of flood of the country. In view of this, a report on above has been prepared for the Socio-economically significant floods in the country.

2. Introduction

2.1 Overview

Flood is the overflow of surface water that normally takes place on dry land. It is a low lying area which is not normally submerged under any body of water. Floods are the most frequent type of disasters and occur when an overflow of water submerges land where usually there is no impound of water. Floods are often caused by heavy rainfall, rapid snowmelt or a storm surge from a tropical cyclone or tsunami in coastal areas. It is as such not a purely hydrological notion but a geomorphological and water management one. It is the recurrent phenomenon taking place repeatedly in the country. It is age old phenomenon which imposes threats though, its damages could be minimized by proper flood management measures. Flood disaster management requires efficient planning measures, implementation and policy based decisions, applications of modern scientific and communication tools for smooth functioning of the system. The spatial extents of the flood affected area need immediate collaboration and co-ordinated decisions, relief & rescue measures on urgent basis. The flood inundation map could be created by geospatial technologies. Satellite remote sensing from their vantage position has unambiguously demonstrated their capability in providing unbiased and timely information upon the flood disaster related things. The flood prone maps as well as hazard zonation map of various regions in India can give the clue of floods. The decision support system for flood could be built up using the above clues and technologies.

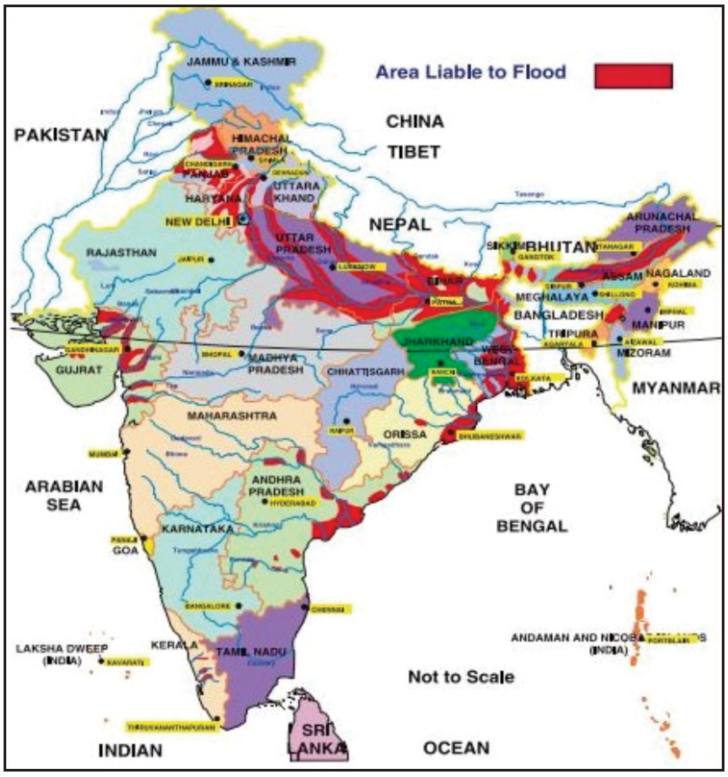


Figure 1: Area Liable to Flood, India, (NDMA - https://ndma.gov.in/Natural Hazards/Floods)

There are two basic types of floods: flash floods and the more widespread riverside floods. Flash floods generally cause greater loss of life and river floods generally cause greater loss of property. A good percentage of civilization has settled on the flood plains and the fertile great northern plain of India which produces major share of our food grains. It is result of sediments brought by the floods of Indus-Ganga-Brahmaputra and their tributaries. At the same time, flood is the cause of sorrow for the adversely affected communities. Day by day the disasters are increasing, among them flood is leading. The areas which are not traditionally prone to floods are evidencing severe inundation due to downpour and cloud bursting.

Urban flood is a common phenomenon in India. Urban areas like metros and cities such as Chennai, Mumbai, Hyderabad where chaotic urbanisation are giving trouble and need proper management of drainages system. Even in the present times floods, have emphasized as the lead disasters in the number of people affected and in resultant economic losses, with these numbers raising at alarming rates. The recent floods stressed on the need for proper management of floods and the drainage system.

Central Water Commission (CWC) and NITI Aayog are very much concerned about the causes of the floods and appropriate solutions for flood disaster. The effective and long lasting solutions for flood are adopted with combination of structural and non-structural measures along with the use of modern technology. Such strategies can alleviate the problem of floods to a great degree.

By bringing together oral, socio-economical and environmental history, we intend to develop 'sustainable flood memories' in which community share their experiences of local flood events. In the country, each year there might be hundreds of floods taking place but in the present report, only the significant socioeconomic floods have been considered.

By studying the flood, memories of people in the inundated regions of India, it will provide a long term perspective on memories and how they shape people's perceptions of environment and society. By aiming to rethink about the past flood events through lesser known images and photographs, we intend to provide a greater dimension to the existing historical records. The purpose of this archival report is to provide sustainable flood memories to the society. In the context of floods, images and visual representations play a vital role in understanding how these events were perceived and experienced by individuals and communities. With the same spirit, this report also considered to build 'conversational narratives' around flood memories.

2.2 Socio-economical aspects

Floods are the serious concerns for mental agony to mankind. Severe flood puts the risk of life, poverty and eco-environmental resources. Livelihoods are the prime concerns of human immediately after floods. The social impact deals with the vulnerability and resilience of the communities exposed to flood hazards. Flooding of areas used for socio-economic activities produces a variety of negative impacts. The magnitude of adverse impacts depends on the vulnerability of the activities and population as well as the frequency, intensity and extent of flooding.

Vulnerability and Resilience

Vulnerability is the attribute that the people have due to their conditions and weakness against a given hazard or set of hazards depending upon the degree of exposure. The vulnerability of the population depends on several social factors like- age, gender, economic status, social cohesion, population density, health status,

race/ethnicity, education, culture, lack of warning and preparedness of the affected community, are the main concerned. Areas with lowest socio-economic conditions show higher mortality rates. Frequent floods compel the population to migrate to safer places irrespective of leaving their important resources. Further migration to urban areas exerts pressures on all sorts of resources.

Flood disasters have adverse consequences of mortality, damage to properties, deterioration or environmental degradation and human health. Developed and developing countries both are facing similar incidences of flood disasters, with developed countries have better disaster management and advanced disaster warning systems to prevent the disaster impacts compared to developing nations that remain unprepared and un-informed thereby resulting in higher causalities. All those disasters are having mostly negative socio-economic impacts.

Resilience, the ability of a system to resist the perturbation or it is the speed the system recovers after being disturbed. An area is more resilient if its vulnerability, i.e. potential damage of flooding is lower. Resilient flood management is based on minimizing the impact on flooding rather than improving the existing flood defense constructions. The underlying idea is to foster the ability of areas to recover after they had been prone to flood which in a general sense represents the resilience of a system to persist and absorb changes and disturbances. This implies that in flood resilience policy, flood damages have to be minimized and normal life has to return as soon as possible after flood. In ecological systems, the rate of resilience is determined by many factors, like variability of populations, their capability to adjust to the environmental conditions and to repopulate, flood resilience touches a variety of sectors and measures as discussed below.

a) Loss of human lives, livestock and property

Floods are one of the most significant types of disasters in terms of human impacts and economic losses. The loss of human life is one of the most important consequences of floods and it is, therefore, important to take into account the loss of life. Destruction of crops, loss of human life, damage to property, loss of livestock, non-functioning of infrastructure facilities and deterioration of health condition owing to waterborne diseases are the prime concerns of flood disasters.

Flood gives serious damage to land through erosion, landslides, wash out of soil, loss of nutrients, also destroy critical agricultural assets and infrastructure etc. which gives severe impact on production of fodder, fiber, crop etc. As a result, it has a direct impact on livestock. In turn, this will lead to the livestock owners a serious crisis of meat, fish, eggs, milk and fibers. Indirect impacts of land being damaged in flood disaster relate to its loss of productivity. This is particularly relevant to agriculture and pastoral areas, where reduced productivity means reduced crop yield and reduced fodder available for stock. In the long run, the loss of productive capacity of the land is felt throughout and gives lower yield of fodder and fiber which will give impact on milk, egg, meat, fish etc. This has implications for the livelihoods of pastoral communities and for food security in areas with low-income and little connection to outside markets.

Examples of long-term impacts include the interruption to communication networks and critical infrastructure (such as power plants, roads, hospitals, etc.). Flash floods cause more deaths than slow-rising riverine floods. In case of flash floods which generally dissipate as quickly as they begin, the flood waters aren't always the only issue. Losses in terms of monetary values depend on the extent of damages caused by floods, depth and duration of flooding, and the velocities of flows in the flooded areas. It is also dependent on the vulnerabilities of economic activities and communities. The very nature of flash floods makes them fast and very difficult to

predict. Since they can occur without warning, it is no surprise that people can be seriously injured or killed by these disasters. Also, many flash floods occur at night while people are sleeping, thereby adding to the risk.

In addition to the force of the water, flash floods can carry large debris such as boulders. This combination can cause heavy structural damage to homes making them uninhabitable and can carry away large pieces of property such as vehicles.

Rooms, vehicles, and other property that came in contact with flood waters may not be salvageable. Homes that were flooded can be susceptible to harmful moulds. Vehicles that were submerged usually have irreparable water damage to the engine and other critical components.

b) Loss of Critical Infrastructure

Large debris and floodwaters can cause structural damage to bridges and roadways, making travel impossible. Power, telephone, and cable lines can also be taken out by flash floods. Flood waters can disrupt or contaminate ground water, making tap water unfit for consumption.

c) Deposited Sediment and Silt

Flood waters carry along with them sand, silt, and other debris as they travel. When the velocity of the flash flood slows, it begins depositing this debris. Floods can leave behind large amounts of silt and other debris that can make travel difficult and can be costly to remove.

d) Soil erosion

Rapid soil erosion can be a result of flash floods. Short-duration flash floods primarily affect the floodplain through sedimentation, causing little to no bedrock erosion or channel widening. Some wetland plants, like some types of rice, are prepared to withstand rapid flooding. However, floods can harm plants that grow well in drier environments because the excess water stresses the plants.

e) Economic Losses

Depending on the damage caused, it may prevent local businesses from opening or keep customers from getting to those businesses. The high cost of relief and recovery may adversely impact investment in infrastructure and other development activities in the area and in certain cases may cripple the frail economy of the region. Recurrent flooding in a region may discourage long-term investments by the government and private sector alike. Lack of livelihoods, combined with migration of skilled labourer and inflation may have a negative impact on a region's economic growth. Loss of resources can lead to high costs of goods and services, delaying its development programme.

- **Loss of livelihoods**

Due to ill effects of flood disasters, economic activities come to a standstill which compels dislocation and the dysfunction of normal life for an uncertain period. That's why the direct effect on production assets, be it in agriculture or industry, can inhibit regularly activity and lead to loss of livelihoods. Also the loss of livelihoods can be felt in business and commercial activities even in adjacent non-flooded areas.

- **Decreased purchasing and production power**

Loss of livelihoods, reduction in purchasing power and loss of land value in the flood plains lead to increased

vulnerabilities of communities living in the area. The additional cost of rehabilitation, relocation of people and removal of property from flood-affected areas can divert the capital required for maintaining production.

After a disaster, the private sector, non-governmental and faith-based organizations provide critical resources to communities that help save lives and protect property. Following a disaster, these organizations provide critical resources to help facilitate community and economic recovery.

f) Mass migration

Frequent flooding, resulting in loss of livelihoods, production and other prolonged economic impacts and types of suffering can trigger mass migration or population displacement. Migration to developed urban areas contributes to the overcrowding in the cities. These migrants swell the ranks of the urban poor and end up living in marginal lands or informal settlements that are prone to floods or other risks.

g) Psychosocial impacts

The huge psycho-social impacts on flood victims and their families can traumatize them for long periods of time. The loss of loved ones can generate deep impacts, especially on children. Displacement from one's home, loss of property, loss of memorabilia and livelihoods, decreased levels of security in the aftermath of floods and in temporary shelters, and disruption to business and social affairs can cause stress. The stress of overcoming these losses can be overwhelming and produce lasting psychological impacts.

h) Political implications

Ineffective response to relief operations during major flood events may lead to public discontent or loss of trust in the authorities or the state and national governments. Lack of development in flood-prone areas may cause social inequity and even social unrest posing threat to peace and stability in the region.

i) Adverse environmental effect

Floods have adverse effects on the built environment as well as the natural environment. It can have devastating effects and a wide variety of side effects, from infrastructure and building damage to effects on vegetation, human and animal life and livestock. In urban locations, the consequences are particularly challenging to define. To link the effects of flash floods with the underlying physical processes, researchers have used data sets from the Severe Hazards Analysis and Verification Experiment (SHAVE). This ought to make flash flood impact forecasting models more accurate.

j) Socio-Economic Impact due to Urban Flooding

Urban and metropolitan areas are developed as economic engines that contribute valuable GDP to the nation. Movements of urban development have witnessed migration from rural areas to urban areas, thus, sprawl of urban areas are serious concerns. These urban areas are somewhere developed and somewhere semi-developed facing severe crisis during flooding which is in turn giving the negative impact on economies.

k) Socio-Economic Impact due to storm surges and Tsunamis

Loss of income in the local economy and future losses from the destruction of infrastructure will be a problem for some time to come. The total financial cost of the last few cyclones storm surges and 2004 tsunami could be millions or even billions of rupees of damage to coastal structures and habitats. The damages and losses of

Infrastructure, economy and environment occur in addition to the fatalities of humans and animals as well as displacement/irrigation of affected population.

Flood waters gives health risks such as contaminated water and food supplies. Loss of shelter leaves people vulnerable to insect exposure, heat, and other environmental hazards. The majority of deaths associated with tsunamis are related to drowning, but traumatic injuries are also a primary concern.

3. Sequential Flood Events of India: Case Studies between 2000 and 2021

Flood is the most predominent and destructive disaster which devastates both life and economy to large extent. Floods are not relegated to the least developed nations, but it is also grasping and ravage the most economically advanced and industrialized nations. Over the years, the intensity of floods is increasing and associated destruction is also on high surge. This chapter elucidate each year flood events in India and the damages not have taken place. It will help the policy makers to understand the sequence of flood occurrences and post flood best practices adopted by the affected state governments and the communities. Starting from year 2021 and back upto year 2000, the summary of some major flood events of these years are briefly described.

3.1 State/UT: Andhra Pradesh

(Including Telengana)

Major Floods in 2015, 2014, 2009, 2008

3.1.1 Andhra Pradesh, 2015

a) Year/Time of event and its duration: In the year 2015, rainfall began to pour during monsoon in the places in the state. Also, on 4th December 2015, flood took place. At the start of December, Chittoor district recorded 65.1cm of rain over the second monsoon season (i.e. 9th to 16th November 2015).

b) Areas affected: Nellore, Chittor and Kadapa districts of AP flooded villages (Fig 2). Tirumala got a heavy rainfall of 309 mm^2 along with Tirupathi with 148 mm in 24 hours triggered a flood situation in Chittoor District.

Figure 2: Chittoor, Nellore and Kadapa districts bordering Tamil Nadu received heavy rains
(https://www.ndtv.com/andhra-pradesh-news/rains-pound-andhra-pradesh-districts-bordering-tamil-nadu-1250340)

c) Causes and factors: Thousands of lakes and ponds across the district overflowed, with breaches reported in some areas due to heavy rainfall generated by the annual northeast monsoon in November–December 2015.The season began on 9 November, with a depression hitting Tamil Nadu. Rainfall begin pour in the places of Nellore and Chittor district. Tirumala and Tirupathi in Chittoor District received a very heavy rainfall. Coastal places of Tada recorded 114 mm of rainfall on the same day. There were 3–4 good spells of rain between 9th and 15th November, 2015. Heavy rain of about 27 cm pounded the temple town of Tirupathi. At Sri Kalahasti, a pilgrimage centre in the region, the Swarnamukhi River was reported to be rising. This flood is Rivirine flood.

d) Consequences & Impacts: As on 4th December 2015, 81 people were reported to have been killed by flooding in the state, while over 14,000 people had been evacuated to relief camps in Nellore and Chittoor districts. Transport networks were disrupted. It was estimated that 500 km of roads had been damaged by flooding, with the Chennai-Kolkata highway damaged the previous day and stranding hundreds of vehicles and motorists. 3 people were swept away by floodwaters in Chittoor district. Roads were damaged in many parts of Nellore district, disrupting transport services. Basic necessities, including milk, water, and vegetables, were affected due to logistical difficulties. Horticulture farms at Pendlimerry, Chintakommadinne, Siddhavatam and Khajipet Mandals were also destroyed by the rain. Other heavy agricultural losses were reported in Rayalaseema, Nellore, Prakasam, East and West Godavari districts; Govt. asked agriculture department officials to drain fields at the earliest in order to save crops. There were heavy infrastructural losses in Nellore and Chittoor districts, with heavy agricultural losses in Godavari district; more than 500,000 acres of standing crops had been destroyed. The flood-related damage was estimated in the state included Rs. 12.5 billion (US$175 million) worth of agricultural-related damages and Rs. 10.25 billion (US$144 million) of damage to infrastructure; State Govt. requested central authorities to release Rs. 10 billion (US$140 million) for immediate relief efforts. Nellore district was the most seriously affected, reporting an estimated Rs. 13.95 billion (US$196 million) worth of losses, followed by Chittoor district, which reported losses of Rs. 8.18 billion (US$115 million). Kadapa district was also seriously affected, with extensive crop damage reported in East and West Godavari districts and a lesser scale of damage in Anantapur, Prakasam and Krishna districts. The aquaculture industry in Nellore district was catastrophically affected, with over 8000 hectares of fish and prawn ponds destroyed, at an estimated loss of Rs. 2.5 billion (US$35 million). Most hospitals in State had wholly or partially restored services by the end of December 2015.

e) Actions taken on pre, during, and post-events: Chief Minister Naidu directed district officials and health, water and sanitation officers to organise water purification and set up medical relief camps. On 4 December 2015, Andhra Pradesh Home Minister Nimmakayala Chinarajappa reported heavy infrastructural losses in Nellore and Chittoor districts, with heavy agricultural losses in Godavari district; he added that over 500,000 acres of standing crops had been destroyed, and that the state government had requested ₹37.5 billion (US$498 million) in immediate relief funds from the central government. At the start of December, Chittoor district recorded 65.1 cm of rain over the monsoonal season thus far, as opposed to a normal 16.1 cm of rainfall. The state government announced an initial ex-gratia payment of 500,000 (US$6,600) to the relatives of flood victims, while 140 relief camps were established in Nellore district, the worst affected. 20 million (US$265,600) of relief supplies were distributed to fishermen, weavers and local communities in the district; other organisations helped to distribute food packets and blankets. On 24 November, the central government stated it had released an initial 10.3 billion (US$137 million) towards relief efforts, with further funds possible following an assessment. In Chittoor district, 8,455 affected households were given a total of 42.9 million (US$570,000) in compensation, while 10,797 people were sheltering in rehabilitation camps. 4,714,000

(US$63,000) was sanctioned to compensate for livestock and poultry losses. On 3 December, one then Chief Minister Chandrababu Naidu offered support to Tamil Nadu, which had likewise been severely affected by the floods (2015 South India floods, n.d.).

f) Lessons learnt:

- A key lesson learnt from disasters over the last few years by various government departments/NGOs engaged in relief and recovery operations is the need to collaborate and coordinate among themselves for greater effectiveness and synergy. As soon as the depression formed over the Bay of Bengal, a warning was circulated to Inter Agency Group (IAG) members in AP and Tamil Nadu about the possibility of a cyclone or heavy rains. This helped all the partner agencies to quickly mobilise resources - both human resources and material to enable speedy response.
- Disaster also brought out the best - both from individuals and the corporate sector in terms of their contribution to the flood relief effort. Especially heartening was the spontaneous response of hospitality of ordinary citizens opening up their homes and kitchens for the stranded and needy. Schools, colleges and other institutions were opened up to provide temporary shelter to displaced people. Cooked food was provided for many days even after the flood waters receded. In essence, this kind of humanitarian response which transcended religion, caste, ethnicity and social status, truly reflected India's ethos and values.

3.1.2 Andhra Pradesh, 2014

a) Year/Time of event and its duration: 2nd week of June and last week of October, 2014; the state has faced floods.

b) Areas affected: Torrential rains and resultant deluge were reported in 6 districts of State - Adilabad, Khammam, Warangal, Karimnagar, East Godavari and West Godavari districts. One of the worst affected areas is the district of Karimnagar, where 40 villages were under water.

c) Causes and factors: A depression over Southwest Bay of Bengal brought torrential rains and resultant deluge. River Godavari dangerously flowing super actively (Fig 3). River levels were extremely high in Dowleswaram in East Godavari district, although they appeared to be falling slowly in Bhadrachalam. Cyclone Nivar had passed near the state that caused heavy rainfall and made the situation of flood.

Figure 3: Godavari River in spate in Andhra Pradesh, 3 districts is high alert (Source: News18.com, Dt. 18.07.18)

d) Consequences & Impacts: Last week of October 2014, left 53 persons dead and caused a loss of Rs 3,756 crore, but the situation returned to normal with floodwater receding. 200 villages under water across state and around 1,200 people were displaced in East Godavari district, having to move to higher ground during the floods (Fig 2). People from the

villages under threat in West Godavari district were also moved to higher ground. Agriculture had also suffered and about 100,000 hectares of farmland remains under water with soya and cotton crops badly damaged. The threat of floods in the Krishna basin which was so badly flooded in 2010, was lessened when authorities released around 80,000 cusecs of water released from the Almatti dam into the Jurala hydro power project, easing pressure on the dam and the river Krishna. (Andhra Pradesh Floods, India, July 2013, n.d.). This flood was rivirine flood.

e) Actions taken on pre, during, and post-events: Indian Air Force helicopters were needed to bring in food, water, medicine and other supplies. Khammam district was also badly hit and 3 rescue teams from the National Disaster Response Force (NDRF) were deployed there to carry out relief work. Special flood disaster centres were set up to monitor and co-ordinate rescue and relief work across the state.

f) Lessons learnt:

- Need to integrate the contributions of volunteers and non-governmental organizations in disaster response at the State level has been fact. This integration would have been best achieved at the district and local levels. NGOs should have been engaged in the planning process for their involvement in a joint response.
- Therefore, a clear identification of flood-prone areas, periodic maintenance of embankments, and proper and accurate flood forecasting data was the need of hour. Rather than a temporary solution, the government was expected look into a comprehensive and holistic approach to flood management. Integrated Flood Management, within the framework of Integrated Water Resource Management, has been a paradigm shift from flood control to flood management.

3.1.3 Andhra Pradesh, 2009

a) Year/Time of event and its duration: Intervening night of October 5 to 6, 2009

b) Areas affected: The massive flood in the Krishna River wreaked havoc in Kurnool, Krishna, Guntur and Nalgonda districts of Andhra Pradesh as certain reservoirs overflowed and inundated the neighbouring area.

c) Causes and factors: Heavy rains that lashed the coastal districts under the influence of the vigorous northeast monsoon. Heavy rainfall followed by release of enormous quantity of water from reservoir and dam were added the flood situation. In Kurnool, Krishna, Guntur and Nalgonda districts of Andhra Pradesh as enormous quantities of water were released from Nagarjunasagar dam and Vijayawada's Prakasam Barrage inundating about 400 villages, including all island habitations.

d) Consequences & Impacts: In view of the continuing heavy rains, discharge of water from reservoirs and swollen rivers, as many as 681 villages were likely to be submerged, according to a release from the Chief Minister's Office.Rainfall reached over 110 millimetres in parts of Hyderabad, with heavier rainfall amounts outside of the city. More than 37 people having lost their lives and 12 others were reported missing further, about 36,000 families were displaced (India: Andhra Pradesh Floods Situation Report, 05 Oct 2009, n.d.).

Sudden spells of heavy downpour, cloud bursts and flash floods over a week and especially on the intervening night of October 5 to 6, 2009, exposed the fragile and inefficient urban infrastructure of the capital of Telangana (M. Somasekhar). Some experts claimed that it has been a clear case of the impact of climate change causing extreme weather events. Others pointed out that it was an example of bad planning, encroachment of lakes and poor urban infrastructure and preparedness. This flood was Riverine flood.

e) Actions taken on pre, during, and post-events: Over 88,000 people were shifted to safer places in the districts of Srikakulam, Vizianagaram, East Godavari, West Godavari, Krishna, Guntur, Khammam, Adilabad, Warangal, Karimnagar, Nizamabad, Mahabubnagar and Rangareddy, according to officials of Disaster Management Department.

Figure 4 Roads and houses at Hafeez Baba Nagar in Hyderabad submerged in water Hyderabad (Source: Scroll.in, Photo)

(https://scroll.in/article/977569/hyderabad-floods-underline-the-need-for-a-climate-resilience-plan-for-indian-cities credit: Special arrangement)

The disaster management officials said the state, as a whole, the affected area has received 34 per cent excess rainfall. Chief Minister asked the district collectors to increase the number of medical camps in the rain-affected areas. He asked the officials to closely monitor the flood situation and take precautionary measures to prevent loss of lives and property and damage to crops.

The study from the Indian Space Research Organisation (ISRO) used Land Use Land Cover (LULC) imagery and conducted a dozen simulated, heavy rainfall events over the three southern states. The changes in LULC led to higher surface temperatures and a deeper and moist boundary layer. This in turn caused a relatively higher convective available potential energy and, consequently, heavier rainfall. The precipitation levels during heavy rainfall events have significantly increased from 2000 to 2017. Their findings were reported in the 'Quarterly Journal of Royal Meteorological Society' on May 18, 2020. According to India Meteorological Department (IMD), Hyderabad, the unusually heavy rainfall was due to two reasons. The deep depression in the Bay of Bengal that moved onto the land in Hyderabad (Fig 4). The second was the rain bearing clouds of the withdrawing Southwest monsoon also pouring out.

f) Lessons learnt:

- The areas affected by the disaster included many which had already been suffering from the highest levels of poverty and food insecurity and the people most severely affected were mainly small farmers and agricultural laborers in the state. Even the medium income group had been affected and their food security status changed to highly food insecure.
- The experiences of the recent floods revealed many deficiencies in flood forecasting, monitoring and management. Especially, the present flood forecasting system failed in capturing very accurately the extreme precipitation events like the recent flood. The current flood early warning system also was not widely disseminated down to communities. Where the early warning reached to communities, they were not well prepared, not willing to evacuate and lacked confidence in forecasts.
- A number of gaps were also reported in emergency response to the affected population. These included (a) local stocks (food and non-food) were not readily available in the affected areas and the affected communities (including women and children) were without food, water, medicines and shelter, (b) roads and communication networks got damaged due to floods and there were no

sufficient means of transport for the communities, (c) there were no designated escape points and/or camp sites as such most communities had to stay under open sky with their women and children, (d) where camps were arranged, these lacked facilities including toilets for women. In most areas, local NGOs and civil society was found to be more proactive despite limited resources in their hands.

3.1.4 Andhra Pradesh, 2009

a) Year/Time of event and its duration: August 2008

b) Areas affected: Widespread devastation was in Hyderabad and eight other districts in coastal Andhra and the Telangana region.

c) Causes and factors: Suddenly torrential rain in Andhra Pradesh on August caused flood situation and fatalities. Heavy rains and flash floods since 2 days had caused widespread devastation in AP.

d) Consequences and Impacts: Heavy rains had caused flash floods in the state. As many as 70 people died. About 31 people were feared dead when a truck they were riding to reach their village, was washed away in the flood waters in Guntur district. Four bodies were recovered from the stream on 10th August 2010 as reported by India Today. Hyderabad accounted for 14 deaths while 13 other people were killed in the Krishna district. Nine deaths were reported from Guntur. Seven people were killed in West Godavari, four in Nalgonda, three in Medak, two each in Visakhapatnam, Khammam and Warangal and one in Karimnagar district. More than 50 residential colonies in Hyderabad city and dozens of villages in the eight districts remained under water as several rivulets and water tanks were either overflowing or have breached. Normal life came to a grinding halt in the affected districts. With some roads under water, vehicular traffic between major towns remained paralysed. Hundreds of vehicles were stranded on the Hyderabad-Vijayawada and the Bhadrachalam-Vijayawada roads. Some places received more than 25 cm of rainfall. During the last two days, places like Hyderabad received 20 cm of rainfall. The water level in Vamsadhara and Nagavali rivers in Srikakulam district in north coastal Andhra was rising alarmingly due to heavy inflows from neighbouring Odisha.

The rains have damaged crops over 127,000 hectares of land. 811 tanks were breached in the affected districts (Andhra floods toll mounts to 70, officials say situation grim, n.d.). Hyderabad bore the brunt of this calamity with 14 people losing their lives, mostly due to house collapses. As many as 52 residential areas in and around the state capital were inundated. 20 tanks and several major storm waters drains over-flowed. Boats were pressed into service in the city on August 10, 2008 to rescue people from marooned areas (Fig 5 & 6). Although the rains receded since Saturday night, hundreds of houses remained under water. The water level in the Hussain Sagar in the heart of the city rose alarmingly due to heavy inflows.

Figure 5 Andhra Pradesh floods: Alert sounded in 18 villages of Chittoor over Rayala pond's rising water level (Indiatvnews.com Published on 23.11.21)
(https://www.indiatvnews.com/news/india/andhra-pradesh-heavy-rains-rayala-pond-water-level-rises-chittoor-villages-evacuated-tripura-govt-camp-746281)

Several areas along the outflow channel are faced the threat of inundation as the Greater Hyderabad Municipal Corp (GHMC) let out the water. Water was flowing over the bridges on the outflow channel, bringing traffic to a standstill. The water level in the Musi River, which flows through the city, was also on the rise. Fishermen were warned not to venture in to the sea.

Apart from Hyderabad and Krishna districts, deaths were reported from West Godavari (7 no.), Guntur (5 no.), Nalgonda (4 no.), Medak (3 no.), Visakhapatnam (2 no.) and Warangal (2 no.). More deaths were reported from different places. Most of the deaths were either due to house collapse or flood. This flood is Rivirine flood.

Figure 6 Hyderabad flood –Army DDRF join rescue & relief (Source: PTI/India tv news, updated on 14.10.20)

(https://www.indiatvnews.com/news/india/hyderabad-floods-death-toll-telangana-army-ndrf-join-rescue-relief-work-656956)

e) Actions taken on pre, during, and post-events:

A lorry carrying about 50 people was washed away in flash floods, in a rivulet in Guntur district as it was trying to negotiate the flood waters over a bridge. Out of those, 40 were missing on 10th August 2008 (rediff.com). The tragedy occurred when the toll in the continuing heavy rains and flood over the last two days had mounted to 59, 14 of them in the state capital Hyderabad and 13 in Krishna district. Transport Minister Kanna Lakshminarayana, who was among the first to reach the spot to oversee the rescue operations, said that while seven persons survived, three bodies have been recovered. The district administration was making all possible efforts to rescue the missing people. The state government had opened 85 relief camps across the state and was providing the evacuated people with food and drinking water.

f) Lessons learnt:

- Gaps between Government and Private Sector efforts were bridged. Private companies came forward, post-disaster, for repairing vehicles, re-phasing loans and personnel management.
- Meetings held at the district and state level to sensitize hospitals, educational and industrial organizations, communication service providers and Oil Companies etc. sensitizing them to be equipped with institutional strategies for immediate response during disasters. They were also sensitized to make back-up arrangements to ensure continuity of life saving services, especially in the hospitals.

3.2 State/UT: Assam

Major Floods in 2020, 2018, 2017, 2013, 2009, 2004, 2003, 2000

3.2.1 Assam, 2020

a) Year/Time of event and its duration: May – August 2020

b) Causes and factors: During the 2020 monsoon season, particularly high rainfall was experienced across central, north, and northeast India, with 15 centimeters more rainfall than usual by the middle of July. The reason for the excess rainfall was attributed to Madden-Julian oscillation, thereby causing prolonged break-monsoon conditions which decreased the rainfall in North West India and increased it in North East India. By 21 July, the meteorological subdivision of Assam and Meghalaya had received rainfall of 1,164 mm as compared to normal rainfall of 894 mm during the period, an excess of nearly 30%. The catchment areas of nearby states, Arunachal Pradesh and Sikkim also received excess rainfall nearly to the tune of 16% and 45% respectively aggravating the flood situation. All the floods were Riverine floods.

c) Areas affected: The flood waters had submerged 9,948 hectares of crop land of 219 villages in Nagaon, Morigaon, West Karbi Anglong, Dhemaji, Majuli, Sivasagar, Dibrugarh, Tinsukia and Lakhimpur district (Indiatoday.in, 2020)

d) Consequences & Impacts: Assam State Disaster Management Agency (ASDMA) reported 5.69 million people were affected during the season. Initial flooding started in May 2020 due to heavy rainfall affecting 30,000 persons and destroying crops across 5 districts. As of October 2020, the floods affected over five million people, claiming the lives of 149 people, with an additional 26 deaths due to landslides, 5474 villages were affected (2020 Assam floods, n.d.) and over one hundred and fifty thousand people found refuge in relief camps. It was also found that inundation was in 5,378 villages in 30 districts (Fig. 7) Appx. 113 flood-related fatalities were reported from 23 flood affected districts. Rainfall recorded 1223.60 millimetre. Permanently damaged houses appx was 10,063. and.46,490

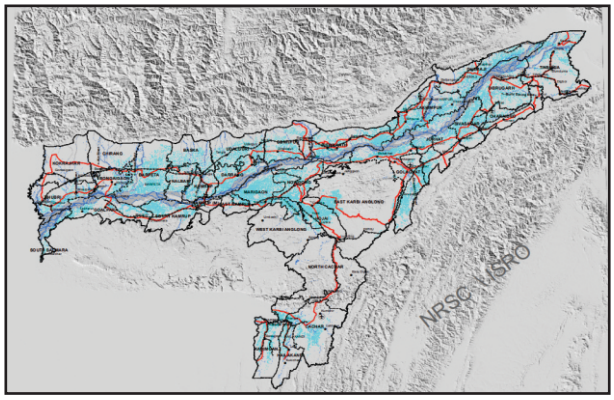


Figure 7 Flood inundation of Assam (Source: ISRO map, 30 July, 2020 TWC India)

(https://weather.com/en-IN/india/monsoon/news/2020-07-30-isro-releases-satellite-images-of-flood-hit-assam-and-bihar)

were partially impacted. The total cropped area affected by the floods was estimated to be approximately 0.26 million hectares. (Hindustan Times, 2020)

Flooding and subsequent landslides had caused damage to bridges, government buildings, roads, embankments and schools. Millions of people living in the flooded area relied on crops and livestock to provide for their families. The flooding began just before harvest and had caused destruction to more than 267,203 hectares of crops and more than 45,000 domesticated animals were forced to flee or be abandoned. Assam is home to important wildlife sanctuaries and World Heritage sites which were damaged by the flooding. Assam floods had a significant impact on humans and its wild animals. Pobitora Wildlife Sanctuary has India's highest population of rhinoceroses and at the height of the flooding, 90% was impacted by flood waters. Kaziranga National Park had also been affected with more than 150 wild animals rescued and 125 animals, including 12 rhinoceros had died (Placeholder1) (12 rhinos among 151 animals killed in Kaziranga due to floods, n.d.).

e) Actions taken on pre, during, and post-events:

The government had announced funding of 3.46 billion Indian Rupees ($42 million) for repairs and aid to the region. In addition to this aid, the central government, according to Chief Minister an ordinance to be set up by North East Water Management Authority, to address flood and erosion problems" with more permanent solutions as an attempt to stop future monsoon seasons from being so devastating.

Leadership in disaster management and relief operations was ensured by the partial leadership. As of 14 October 2020, a total 627 relief camps and 1662 relief distribution centers were set by up ASDMA, including hygiene and isolation measures for COVID-19 pandemic infected persons.

Post-disaster response by ASDMA included compensation schemes for homestead losses, infrastructure repair together with an Asian Development Bank and World Bank funded embankment and flood risk reduction program. Asian Development Bank (ADB) (7 December 2018). (Assam Integrated Flood and Riverbank Erosion Risk Management Investment Program - Project 2). Despite government efforts in disaster risk reduction, the dual effect of flooding and Covid-19 related job-losses increased distress and poverty of around 70% of the population, whose livelihoods were agriculture dependent and were not eligible for compensation without formal documentation or land rights.

f) Lessons learnt: As a result of the yearly monsoon related destruction, the South Asia Flash Flood Guidance System (South Asia FFGS) was launched on 23 October 2020 by the World Meteorological Organization. The system will strengthen coordination of disaster risk reduction and preparedness in India with 4 other South-Asia country through forecasts and early warnings of dangers related to flash floods with the hope of lessening the loss of life and damage to property (South Asia Flash Flood Guidance System Launched).

3.2.2 Assam, 2018

a) Year/Time of event and its duration: First week of June 2018

b) Areas affected: Districts of Karbi-Anglong West, Hojai, Karbi-Anglong East, Karimganj, Golaghat, Hallakandi and Cachar.

c) Causes and factors: Heavy rainfall in Assam and river catchments had increased river levels. Gharmura recorded 107 mm of rain in a 24-hour period to 12 June, and Lakhimpur 71.9 mm during the same period. On 13 June, Karimganj recorded 127.6 mm of rain and Goalpara 93.5 mm. Several rivers were at or above danger levels in the state, including the Dhansiri at Numaligarth in Golaghat, the Katakhal at Matizuri in Hailakandi and the Kushiyara at Karimganj. As of 15 June, the Kushiyara at Karimganj stood at 16.39 m; just

below its highest ever level of 16.57 m set in June 2018. CWC (Central Water Commission) predicted levels would rise further and the river to reach 16.5 metres in the coming days (Guwahati, India Today).

d) Consequences & Impacts: Flooding in the first week of June 2018 had affected appx 167,000 people in the districts of Karbi-Anglong West, Hojai, Karbi-Anglong East, Karimganj, Golaghat, Hallakandi and Cachar. Previous flooding in Biswanath district that had since receded, as per ASDMA. Urban flooding was also reported in Kamrup district, where 1 person died in flooding in Golaghat district. 23 persons lost their lives in the first wave of flood in the year, 2 more persons died in a landslide in the Mahur area of Dima Hasao district. Roads were damaged in all 7 affected districts. Over 1,376 hectares of crops were also damaged in total. The floods inundated 11,243 hectares of agricultural lands with standing crops in four districts. (Assam: Incessant rains wrecked havoc in Karbi Anglong, West Karbi Anglong, n.d.).

e) Actions taken on pre, during, and post-events: The Lakhimpur district administration had sounded a flood alert as NEEPCO (North Eastern Electric Power Corporation Ltd) in Arunachal Pradesh released water from its hydel power dam into Ranganadi river in Assam due to the rising water level. ASDMA informed that, 126 persons were evacuated in Lakhimpur. Nine relief camps were set up in Dhemaji and Lakhimpur, adding that 585 persons were taking shelter there. According to a Central Water Commission (CWC) report, rivers Dhansiri at Numaligarh in Golaghat; Jia Bharali at N T Road Crossing in Sonitpur; and Beki at Road Bridge in Barpeta were flowing above the danger level. The sources said around 25 metres of railway track was breached at Panitola Block Gaon in Dhemaji, affecting the movement of railway traffic. Roads (Ref. 11), bamboo bridges and culverts were also damaged in the affected districts. The National Disaster Response Force (NDRF) rescued around 400 people in Golaghat after flooding from the overflowing Dhansiri River. Around 100 people were also rescued in Shivsagar district.

f) Lessons learnt: In order to reduce flood damage in future, the effective way is to prevent development in flood prone lands. So, the best approach is zoning of such land, however the land use planning as discussed should be adopted so the land contains an outlined use. Zoning can be used to scale back damages from flooding and must be so flexible to acknowledge that different types of land use are compatible.

Table - 1 Major Flood Events of Last few Years

State	Year	Reason	Casualty losses	Population Affected	Property Damage / Economic Loses
Orissa	2000	Heavy Rainfall in state and upper catchment	17	14.32 lakh	1,68,905 Ha Crops
	2009	Heavy monsoon rains	57 and 10 missing	10 million	100 blocks: property 90,000 sqkm
	2011	Heavy rains Mahanadi catchment	68	4.5 million	2,900 km road
	2013	Cyclone Phailin		1.2 crore	Uncounted propert
	2017	Low pressure		65,000	
West Bengal	2015	Cyclone and rainfall	48	10,000 villages in 12 districts	38000 Houses
Tamil Nadu	2015	Heavy Rainfall	500	1.8 million	Rs 50000 Cr
Andhra Pradesh	2016	Long Term Heavy Rain	15	25000 people	50,000 hectares of crops.
Bihar	2000	Heavy Rainfall	-	1 million displaced	1,041,500 Villa-ges, 4,000 houses
	2002	Heavy Rainfall	351	15.44 million	372,009houses
	2004	Torrential rainfall in upper catchment	885	21.299 million	
	2007	Long Term Heavy Rain	1,287	2 million	8 distrts, 2 vill
	2008	Heavy monsoon rains		1.2 million	250,000 acres
	2013	Torrential rain	1201		
	2016	Heavy Rainfall	17	3.753 million.	
	2020	Heavy Rainfall	27	8.36 million	
Gujarat	2017	Extreme Rainfall	224	0.3 million	Rs 10 cr
Assam	2004	Incessant rain	46	8.826 million	**Rs. 771.00 Crores.**
	2009	Extreme rainfall		0.386 million	
	2013	Torrential Rainfall		60,000	
	2014	Heavy Rainfall	67	42 lakh	
	2017	Heavy Rainfall	85	5 lakh	
	2018	Heavy Rainfall	05	1.5 lakh	
	2020	Extreme rainfall	117	5.69 million	
Maharastra	2005	Heavy Rainfall	1087	20 million	Rs. 5.50 billion
	2020	Extreme rainfall	47	2 million	
	2021	Extreme rainfall	251 + 100 missing		

3.2.3 Assam, 2017

a) Year/Time of event and its duration: July 2017

b) Areas affected: Dhemaji, Lakhimpur, Biswanath, Sonitpur, Darrang, Nalbari, Barpeta, Bongaigaon, Chirang, Kokrajhar, Dhubri, South Salmara, Goalpara, Morigaon, Nagaon, Karbi Anglong, Jorhat, Golaghat, Majuli, Sivasagar, Dibrugarh, Charaideo, Cachar, Karimganj, Kamrup and Hailakandi districts.

c) Causes and factors: In Northeast India, floods in the year caused by overflowing of Brahmaputra River in the state in July 2017 affecting four Indian states: Assam, Arunachal Pradesh, Nagaland and Manipur. While natural topography and excessive rainfall are obvious causes, floods are also caused by human intervention—like encroachment of river banks and wetlands, lack of drainage, unplanned urban growth, hill cutting and deforestation.

The Brahmaputra, a trans-boundary river and among the mightiest rivers in Asia, is braided and unstable in its entire reach in Assam except for a few places. As per the Brahmaputra board's latest annual report, the obvious reasons behind the instability of the river & flood are high sedimentation, steep slopes and meteorological factor (high rainfall).

d) Consequences & impacts: Till July 2017, at least 85 people were deadas a result of the flooding (Fig.8) and 4 lakh people were affected and 5,00,000 became homeless (Assam floods: 85 dead, over 70 lakh people affected, n.d.). Nearly 60 animals, mostly deer and wild boars, perished in the floods. Kaziranga National Park was inundated and animals of park were also badly affected. More than 15 districts of state that includes Golaghat, Lakhimpur, Sivasagar, Jorhat, Cachar, Dhemaji, Karimganj etc were affected during 1st& 2nd phase of flood.

Figure 8 Floods in Majuli, Assam 13 July, 2017 (Source: Floodlist.com, 14 AUGUST, 2017 BY RICHARD DAVIES IN ASIA, NEWS)

(https://floodlist.com/asia/india-floods-landslides-assam-and-arunachal-pradesh-july-2017)

As per Assam State Disaster Management Authority, the flooding had hit more than 17.43 lakh people across 26 districts. It had also inundated large tracts of, Pobitora Wildlife Sanctuary and Nameri National Park.154 people died due to drowning, electrocution and diseases caused due to water contamination. After a short respite period during early August, heavy rain began to fall once again from 10 August onwards

The state government of Assam set up 128 relief camps under the surveillance of Assam Chief Minister for people displaced, and had planned for drinking water, food and medical teams and rescue goods. Thousands of people were once again forced to evacuate their homes after further flooding in Assam.

It was third wave of flooding in the state since the start of the 2017 monsoon. As of 06 August 2017, 85 people had lost their lives and 29 districts in the state had been affected by heavy rains and floods during this monsoon season.

Dozens of roads and bridges were damaged causing major transport problems. Over 140 boats were deployed for rescue teams. River embankments were damaged in 11 districts. Ever since Assam had witnessed flooding, the Central Government was closely and constantly monitoring the situation.

The Brahmaputra and its tributaries are flowing above danger levels after heavy rain in the state and in catchment areas upstream. On 10 August, India Meteorological Department (IMD) issued an Advisory Forecast for Rapid Rise in Water Levels of Rivers in Arunachal Pradesh, Assam, North Bengal, Sikkim, Meghalaya, Eastern UP and North Bihar.

e) Actions taken on pre, during and post events: The ASDMA added that 2,450 villages were under water in Assam that more than 86,000 hectares of crop areas had been inundated due the flooding. Across the state, 14,10,968 animals and poultry had been affected by the flood waters.

f) Lessons learnt:

- Identification of flood-prone areas, periodic maintenance of embankments, and proper and accurate flood forecasting data is the need of hour. Rather than a temporary solution, the government should look into a comprehensive and holistic approach to flood management. Integrated Flood Management, within the framework of Integrated Water Resource Management, is a paradigm shift from flood control to flood management. It has its genesis in the 2002 World Summit on Sustainable Development, Johannesburg, South Africa. Its main aim is to maximise the net benefits of flood plain and at the same time reduce loss of life. It also looks at the river basin as a dynamic system, where there is continuous interaction between land and water resources.
- While natural topography and heavy rainfall are obvious causes, floods also result from human interventions like encroachments in flood plain areas, lack of drainage, faulty agricultural practices and hill-cutting, which further increase flood frequency and intensity. Central and state government strategy involving flood control measures, based on engineering solutions such as construction of embankments, are ad hoc in nature and provide only uni-dimensional solutions.

3.2.4 Assam, 2013

a) Year/Time of event and its duration: 24th June, 2013; onwards during monsoon period.

b) Areas affected: Torential rain causedflooding in 12 districts (Bongaigaon, Chirang, Dhemaji, Golaghat, Jorhat, Kamrup, Karimganj, Lakhimpur, Morigaon, Nagaon, Sivasagar and Tinsukia) of Assam.

c) Causes and factors: Continuous rainfall on 24th June, North East India has resulted in severe flooding in 12 districts out of the 27 districts in the state were affected 6 districts of Assam.

d) Consequences & Impacts: Nearly 250,000 people had been forced to leave their homes because of flooding in the north-eastern Indian state of Assam. Till July, the floods along with landslides affected 1.6 million people in 22 districts of Assam and casualties rising to 33 (Brahmaputra floods, n.d.). Some 400 villages in 12 out of 27 districts were hit by floods. Over lakhs people were affected. Heavy monsoon rain in neighbouring Arunachal Pradesh state had caused major rivers in Assam, including the Brahmaputra, to burst their banks. Assam State Disaster Management Authority said, the Jiadhol River had risen most in the wake of torrential rain since 24th June, 2013, flooding Dhemaji district on Assam's border with Arunachal Pradesh. More than 35 villages in Dhemaji were completely submerged, forcing tens of thousands of people to move to higher ground (Fig 9). Many roads and bridges had been washed away, affecting road links between the district and the rest of the state. Floods had also damaged six roads and a bridge in Golaghat district and breached river embankments in Karimganj district. The region's main Brahmaputra River was flowing above the danger level in

Jorhat district, reports said. Many animals at Kaziranga national park, home to nearly two-thirds of the world's remaining one-horned rhinos, had fled to higher ground as flood waters have entered the area. Floods hit Assam almost every year, displacing tens of thousands of people and damaging crops and property.

e) Actions taken on pre, during, and post-events: Eight relief camps were set up in Dhemaji and Chirang districts where about 3,000 people were given shelter. The flood victims claimed there were no river embankments at various places or those breached by earlier floods were not repaired (Assam Floods)

Figure 9: Flood relief camp by Varsity (Source: Assam Times, Jesif Ahmed, Friday, Aug 26, 2016, (02:08 pm) (https://assamtimes.org/node/17592)

f) Lesson learnt::

- While natural topography and heavy rainfall were obvious causes, floods also resulted from human interventions like encroachments in flood plain areas, lack of drainage, faulty agricultural practices and hill-cutting, which further increase flood frequency and intensity. Central and state government strategies involving flood control measures, based on engineering solutions such as construction of embankments, were adhoc in nature and provide only uni-dimensional solutions. Such structural measures have only heightened the level of ecological imbalance, which limits the spread of river water, and in turn increases the thickness of the river bed. Over time, with continuous flow of water, embankments are weakened which eventually get breached and result in heavy floods along adjoining areas. To some extent, such an engineering approach, which amounts to flood control only, prolongs the next round of floods.
- Floods always have a severe impact on the lower basin. Brahmaputra floods have a devastating effect on the lower river streams, particularly in Bangladesh, which is highly vulnerable to flood hazards, being a lower riparian state. Uncoordinated flood management policies in an identical and geographically integrated region are not effective solutions. Therefore, along with the national and regional action plan, India should also play the role of a responsible upper riparian neighbour.
- Civilisations have historically prospered on flood plains that support agriculture and allied livelihood activities for which rivers provide the water for human settlements. Floods are, therefore, an integral part of nature, which is essential for creation and maintenance of an ecosystem. It helps to reinvigorate the farm lands, enhance fertility and increase agricultural productivity.

3.2.5 Assam, 2009

a) Year/Time of event and its duration: In the month of July 2009, flood took place.

b) Causes and factors: Torrential rains have triggered by heavy monsoon causes flash floods in Assam. Following heavy to very heavy rainfall in north-eastern states of India since end-June, the rising flood waters of the Brahmaputra River caused a breach in an embankment in Assam's Lakhimpur District, Dhakunakhata Gaon Panchayat on 1 July 2009. The 100 metre wide breach on the 5 km long embankment was caused due to the water levels rising to a breach height of 93.03 metres.

On 2 July, indicated that the situation has worsened with the release of water from the Kurishu dam in Bhutan at the pace of 698 cubic metres per second. Water was also released from Karbi Langpi Hydel Project in Assam.

c) Areas affected: Four districts of Lakhimpur, Dhemaji, Jorhat and Nagaon were hit by the current wave of flooding that has left about 2,00,000 people displaced in some 350-odd villages during the past two days," said Assam Revenue and Rehabilitation Minister Bhumidhar Barman

d) Consequences & impacts: The north-eastern states with multiple instances of landslides and flash floods were reported from the states of Mizoram, Manipur, Meghalaya, Tripura, Nagaland and Assam. Close to four lakh people were estimated to be stranded due to floods in Assam, (IANS reported). The Assam State Disaster Management Authority (ASDMA) stated a total of 3,86,570 people had been affected in the seven-flash flood-hit districts. Major findings were:

The flood waters have fully damaged 325 houses besides state and National Highways at different places, an ASDMA official informed, furthering that rainfall had also triggered landslides at Mahur, Harangajao, Maibang and Dima Hasao (Floods, rain and landslides batter northeast India; death toll touches 17, n.d.).

The landslides in Dima Hasao and on the Lumding-Badarpur hill section had also disrupted railway services to Assam's Barak Valley (Fig 10) and Tripura.

Brahmaputra at Nimatighat in Jorhat, Barak at AP Ghat in Cachar and Badarpurghat in Karimganj were above the danger marks in the state. It is, in general, true that villagers have become poor, marginalised, and more vulnerable to environmental as well as socioeconomic changes because of the impacts of floods and associated hazards over the years. Each year, floods leave them more susceptible to the next year's flood, creating a vicious cycle of impacts and vulnerability. Within a community or a site, however, communities or families were impacted in different ways depending on the environmental, socioeconomic, and cultural characteristics of the groups or families. There were a few households and individuals in state who did better than others in spite of the fact that they shared the same experiences of water stress and hazards.

Figure 10: Major landslip in Badarpur - Lumding Hill (Source: Barakbulletin.com, Updated 20.06.20)
(https://www.barakbulletin.com/en_US/major-landslip-in-badarpur-lumding-section-railway-services-to-remain-interrupted-for-2-3-days/)

e) Actions taken on pre, during, and post-events: Following the breach, the District Administration sounded a Red Alert in the affected areas. Official reports on 2 July 2009, mention almost 1 lakh people affected in the Dhakuakhana sub-division. The flood protection

measures of the Brahmaputra River had totally broken down. The situation was described as grim and deteriorating.

f) Lessons learnt:

- Flood control is a short-term approach to ensure that day-to-day living of people resident along the river are not affected; on the other hand, flood management is a comprehensive strategy that involves management of the ecology. There are many plans and programmes to reduce flood hazards. So, the main concern is to prepare a time-bound action plan to accelerate the completion of all the long-term river management projects. Strong political will at both national and state level, besides active participation of all stakeholders, is necessary to accomplish these objectives.
- Floods always have a severe impact on the lower basin. Brahmaputra floods have a devastating effect on the lower river streams, particularly in Bangladesh, which is highly vulnerable to flood hazards, being a lower riparian state. Uncoordinated flood management policies in an identical and geographically integrated region are not effective solutions. Therefore, along with the national and regional action plan, India should also play the role of a responsible upper riparian neighbour.
- Civilisations have historically prospered on flood plains that support agriculture and allied livelihood activities for which rivers provide the water for human settlements. Floods are therefore an integral part of nature, which is essential for creation and maintenance of an ecosystem. It helps to reinvigorate the farm lands, enhance fertility and increase agricultural productivity. Also, flooded areas ensure maintenance of ground water levels.

3.2.6 Assam, 2004

a) Year/Time of event of duration: last week of June, 2004 onwards in different phases.

b) Area affected: 25 affected districts were Tinsukia, Dibrugarh, Shivsagar, Jorhat, Golaghat, Nagoan, Morigaon, Kamrup, Kamrup Metro, Darrang, Sonitpur, Dhemaji, Lakhimpur, Nalbari, Berpetta, Bongaigaon, Kokrajhar, Goalpara, Dhubri, Chirang, Karbi Anglong, Karimganj Hailakhandi, Cachar and Udayguri but Kamrup and Nalbari, Darrang, Sonitpur, Dhemaji and Lakhimpur were the worst affected districts.

c) Causes and factors: Due to incessant rain since the last week of June the river Brahmaputra and its tributaries started swelling up. As a result of this, the State witnessed a devastating flood in Brahmaputra and Barak valleys. Overall situation in the state remained unchanged but the situation had worsened in the Guwahati city of Kamrup district as large scale landslides have taken place in the Guwahati city itself. Due to heavy down pour had resulted in these landslides. These fresh landslides had taken place at 5 points in Guwahati city killing 12 people and injuring 16 people. The land slides sites were at Shantipur, Fatasil, Kamakhya, Pub-sarahia and Birubari area. Search and rescue operations were on and the death toll may likely to increase.

d) Consequences & impacts: Karimganj Four revenue circles - Patherkandi, Nilambazar, Badapur and Karimganj were mainly affected by the current flood. Approximately 6010 hector area and 22000 people had been affected. Total crop area affected was about 5900 hectors. People had taken shelter in the temporary shelters made in schools.

Hailakandi Almost all the revenue circles have been affected by the flood. In Agalpur revenue circle, 22 no. of villages have got marooned.

Kamrup: The entire Rangia sub-division was flooded affecting around 0.0365 million people and 15650 cattle. 244 villages and land area of 0.8484 million hectares had been affected. Breach on the embankment of river

Puthimari had taken place at 10 places in the district of which, 6 were in the Rangia Sub-division alone Around 430 villages in different other revenue circles were affected. 300 students of Navodaya Vidyalaya were rescued by using IAF helicopter.

Nalbari: The entire district was under the grip of high flood and situation remains grim. Breach of embankments of Pagladiya river at 6 places had flooded the entire district affecting 350 villages and population of 0.035 million. The district had taken the shape of an island and there was no surface communication to the district.

Goalpara: The district was affected by flood water of river Brahmaputra causing large scale damages to villages and crop areas. Population affected was estimated to be more than 0.02 million. Flood water had entered the Municipal Town.

Sonitpur: The flood water or river Bordikarai caused extensive damage to Bordikarai Irrigation Dam and canals. There had been siltation on the paddy fields and the road connecting Assam and Arunachal Pradesh as flood water carried silt and timber logs. Gohpur sub-division of the district had also been affected by floods. River Brahmaputra and its tributaries were flowing above danger level in the district.

Barpeta: 525 villages and a population of 0.065 million was affected. The total area affected was 34,370 hectares. Two human lives had been lost. 500 houses had been fully damaged. 42 relief camps had been opened and the water levels of the river Brahmaputra as well as tributaries Manas and Beki were reported to be rising.

North Lakhimpur: The water level of river Brahmaputra was rising. Around 0.02 million people were estimated to have been affected.

Cachar: Out of five revenue circles, three were affected i.e Silchar, Udarbandh and Katigorah. Flood water had inundated few areas of Silchar town like Fatak Bazaar, Kalibari road, Janiganj People were taken to shelter in schools and other Govt. buildings.

Road communication in NH-53 Silchar-Imphal road had been disrupted due to overflowing of river Barak at several places.

Silchar: Kumbhirgram road (Airport road) was under water.. Railway route between Silchar-Badarpur- Lumding remains closed due to heavy landslide in the N. C .Hills.

The NH-44 i.e. Silchar-Guwahati road was closed due to heavy landslide in Sonapur area, Garo hills of Meghalaya. About 300 meters of the highway had been blocked. This was the only lifeline highway for entire Barak Valley, Tripura, Mizoram and Manipur too.

Darrang: The Lamabari Bridge was reported to have been washed away by the flood waters.

Dhemaji: 581 villages and 0.022 million population have been affected. Total Cropped area affected was 11,268 hectares and 2 lives were lost There had been a breach of 400 metres on National Highway-52 and it was reported to be widening due to soil erosion.

Marigaon: Total area affected was 39,421 hectares and 17,800 hectares of cropped area were affected. Population affected is 4.18 lakhs covering 319 villages

Jorhat: All communications (including ferry service) were disrupted in the river island (subdivision) of Majuli. 53 villages in Majuli subdivision and 41 villages in Jorhat subdivision had been affected.

Dhubri: All the three sub division, Hatsingmari (HSM), Bilashipara (BLP) and Dhubri (DBB) had been affected. 794 villages and a population of 1.192 million are reported to had been affected by the ongoing floods. 20,968 hectares of land had also been affected.

DAMAGE DETAILS:

No. of Districts affected -	25
No. of Talukas affected-	40
No. of villages affected-	6566
Loss of lives -	46 (India: Situation report - Assam floods, 16 Jul 2004)
	Bongaigaon-2, Dhemaji-2, Dararng-4, Kamrup (rural)-6, Naogoan-2, Sonitpur-3, Cachar-2, Kamrup metropolitan district-13, Berpetta-5, Morigaon-2, Lakhimpur- 4, Nalbari-1
Houses damaged -	4,00,000 partially and 19,000 fully
Total population affected-	8.826 million
Total crop area affected -	0.637 million hectares
Total area affected-	12.24 million hectares

e) Actions taken on pre, during and post events: The state government had issued guidelines to all districts for taking up Search & Rescue and Relief measures in war footing. Senior officials were assigned to carry forward the operation in a smoother way. Special arrangements were made for the procurement of food grains, medicines, cattle fodder, water purifying tablets, Oral Rehydration Solution (ORS), boats and vehicles.

- The State Control Room had functioning round the clock.
- Army and Air Force assistance had been utilized in rescue operation. 11 Air Force helicopters were engaged for rescue of marooned people of Kamrup, Nalbari and other lower Assam districts. Army speed boats were also utilized for rescue of the affected people. 3 composite flood relief columns were providing assistance in Nalbari with 6 boats; 6 composite flood relief columns and 7 boats in Kamrup; 1 composite flood relief column and 4 boats in Darrang; 1 composite flood relief column and 6 boats in Sonitpur and one composite flood relief column (was on stand by) in Kokrajhar district.
- At the request of the state Government, the Central Government had made available helicopters at Guwahati, Tejpur, Dibrugarh, Jorhat, Silchar and Tezpur.
- 1296 nos. of relief camps had been opened in the affected districts and 10,14,599 people were taken to shelter in these camps. Special measures were taken to prevent from breakdown of epidemics in the affected areas.
- Rs. 500 million had been released for carrying out the flood relief & rehabilitation work in the state. Gratuitous relief distribution: Rice-80,599 quintals, Dal-6453.56 Quintals, Salt-2448.77 Quintals, Bread - 50,000 packets, Jaggery 120 Quintals, Biscuits - 1 lakh packets and Chira- 665 Quintals
- The state government had requested the Railways for allotment of additional rakes of essential commodities, due to snapping of road communication at several places as well to reschedule some passenger trains and facilitated movements of the goods train.
- The government was monitoring the overall flood situation and coordinating with the neighboring states.

The State Government had requested the Central Government to provide 10 nos. of Satellite Phones, 300 rubber boats, 3 Bailley bridges, food items,. Medical aid (halogen and ORS tablets), polythene sheets, tents and other essential items such as candles and matches.

f) Lessons learnt :

- Dams, embankments, and such other structural flood management options have costs, impacts and limitations.
- Dams and embankments also lead to disasters when not maintained and operated properly
- Flood forecasting, flood preparedness, disaster risk reduction are some non structural flood management options.
- In the time of embankment breaches in certain rivers it has to be vigilant through Drone technology along with the past records.

3.2.7 Assam, 2004

a) Year/Time of event and its duration: June 2003; Assam had been experiencing severe flooding since 13 June.

b) Areas affected: The affected areas were low lying places in the districts Dhemaji, Nalbari, Haillakandi, parts of Kamrup, Kamrup (Metro), Karimganj, Darrang, Dhubri, Goalpara, Morigaon, Golaghat, Sonitpur, Jorhat, Sivasagar, Naigaon, Barpeta, Karbi Anglong North Lakhimpur Dibrugarh, Bongaigaon, Tinsukia and Kokrajhar.

c) Causes and factors: Heavy downpours, with the onset of the monsoon, had caused flooding in most low lying areas in the districts. The flood and erosion problem of Assam is singularly different from other states so far as extent and duration of flooding and magnitude of erosion is concerned and is probably the most acute and unique in the country. The flood prone area of the state as assessed by the Rastriya Barh Ayog (RBA) is 31.05 Lakh Hectares against the total area of state 78.523 Lakh Hectares i.e. about. 39.58 % of the total land area of Assam. This is about 9.40% of total flood prone area of the country. The flood problem of the state is further aggravated due to flash floods by the rivers flowing down from neighbouring states like Arunachal Pradesh and Meghalaya. During the year 2004 and 2014 the south bank tributaries of Brahmaputra in lower Assam, experienced flash floods of high magnitude due to cloud burst in the catchment areas in Meghalaya. During the month of August, 2011, due to cloud burst in the catchment area of Arunachal Pradesh the river Gainadi and Jiadhal also experienced flash flood of very high magnitude. These flash floods caused large scale devastation in vast areas including losses of human lives.

d) Consequences & impacts: This flood has caused widespread damage to human life and property, standing crops, existing Public Works Department (PWD), flood control embankments and other basic infrastructure. The total numbers of deaths occurred due to flood is 30. Karimganj district administration given a detail report and mentioned 40,000 population affected which was nil in previous reports IMD Reports that moderate rain occurred at most places.

Major findings are:

No. of Districts affected	:	22
No. of villages affected	:	5030
Population affected	:	5.1 million
Total crop area affected	:	215154 hectares
Total area affected	:	683526 hectares
House damaged	:	3666 (Fully) and 1015 (Partially)
Loss of Lives	:	27

The total number of SPT / RCC Bridge and approach damaged: 972 nos

Total road length damaged: 3184.84 kilometers.

As per Public Health and Engineering Department (PHED) the total cost of damage to assets in 16 districts: at Rs. 154.00 Cr (India: Flood situation report 21 Aug 2003, n.d.)

e) Actions taken on pre, during, and post-events: After the flash floods in Assam had displaced an estimated 200,000 people by state government sounding an alert as more than 300 villages were inundated. "Four districts of Lakhimpur, Dhemaji, Jorhat and Nagaon were hit by the current wave of flooding that had left about 200,000 people displaced in some 350-odd villages during the deluge.

f) Lesson learnt :

- The structural measures have only heightened the level of ecological imbalance, which limits the spread of river water, and in turn increases the thickness of the river bed? Over time, with continuous flow of water, embankments are weakened which eventually get breached and result in heavy floods along adjoining areas. To some extent, such an engineering approach, which amounts to flood control only, prolongs the next round of floods. But it is not flood management in the true sense.
- Flood control is a short-term approach to ensure that day-to-day living of people resident along the river are not affected; on the other hand, flood management is a comprehensive strategy that involves management of the ecology. There are many plans and programmes to reduce flood hazards. So, the main concern is to prepare a time-bound action plan to accelerate the completion of all the long-term river management projects.

3.2.8 Assam, 2000

a) Year/Time of event of duration: June last week of 2000

b) Areas affected: The affected districts are Tinsukia, Dibrugarh, Shivsagar, Jorhat, Golaghat, Nagoan, Morigaon, Kamrup, Kamrup Metro, Darrang, Sonitpur, Dhemaji, Lakhimpur, Nalbari, Berpetta, Bongaigaon, Kokrajhar, Goalpara, Dhubri, Nalbari, Darrang, Sonitpur, Dhemaji and Lakhimpur were the worst affected districts.

c) Causes and factors: Due to incessant rain since the last week of June, 2004, through out the State of Assam and catchments areas of Arunachal Pradesh, Meghalaya, Nagaland and Bhutan, the river Brahmaputra and its tributaries started swelling up. As a result of this, the State witnessed a devastating flood in Brahmaputra and Barak valleys.26 out of 27districts had been affected by floods

d) Consequences & impacts: In the worst-hit far eastern state of Assam, it is estimated that half of the 80 deaths were caused by water-born disease. In western Assam, the flood had left an estimated 2.5 million people homeless, and tens of thousands of stranded villages had been without food or medical supplies. The flooding, triggered by heavy rains that caused the Brahmapura River and its tributaries to burst their banks, inundating more than 2,000 villages, killed 26 people.

- Death toll: 46
- Flood affected population: 8.826 million
- Districts affected: 27
- Number of Villages affected: 7311
- No. of breaches formed: 944
- Houses Damaged: 4,00,000 partially and 19,000 fully

- Roads Networkrop loss: 0.637 million hectares (India: Situation report - Assam floods, 17 Jul 2004, n.d.)

e) Actions taken on pre, during, and post-events:

i) State level

The State Government has issued guidelines to all districts for taking up Search & Rescue and Relief measures in war footing. Senior officials had been assigned to carry forward the operation in a smoother way. Special arrangements were being made for the procurement of food grains, medicines, cattle fodder, and water purifying tablets, ORS, boats and vehicles.

- The State Control Room was functioning round the clock.
- Army and Air Force assistance had been utilized in rescue operation. 11 Air Force helicopters are engaged for rescue of marooned people of Kamrup, Nalbari and other lower Assam districts. Army speed boats are also utilized for rescue of the affected people. 3 composite flood relief columns are providing assistance in Nalbari with 6 boats; 6 composite flood relief columns and 7 boats in Kamrup; 1 composite flood relief column and 4 boats in Darrang; 1 composite flood relief column and 6 boats in Sonitpur and one composite flood relief column (was on stand by) in Kokrajhar district.
- 1368nos. of relief camps had been opened in the affected districts and 13,00,790 people had taken shelter in these camps. Special measures are being taken to prevent from breakdown of epidemics in the affected areas.
- Rs. 500 million had been released for carrying out the flood relief & rehabilitation work in the state. The state government has requested the Railways for allotment of additional rakes of essential commodities, due to snapping of road communication at several places as well to reschedule some passenger trains and facilitates movements of the goods train.
- The government was monitoring the overall flood situation and coordinating with the neighboring states.
- Additional amount had been sanctioned for distribution of relief materials like food stuff, drinking water, medicine, fodder, veterinary care to the cattle population.

ii) Central level

At the request of the state Government, the Central Government had made available helicopters at Guwahati, Tejpur, Dibrugarh, Jorhat and Silchar.

- The central Govt. had released Calamity relief fund of Rs. 462.6 million. In addition Rs. 550 million had been released from National Calamity Relief Contingency Fund (NCCF).
- Ministry of Petroleum had already released 4,00,000 liters of Kerosene Oil as additional allocation to the state of Assam.
- The Ministry of Health had been send a central team to the flood affected areas of Assam to advise the State on the action to be taken prevent outbreak of epidemics. National Institute of Communicable Diseases (NICD), National Vector Borne Disease Control Programme (NVBDCP) and the regional Directors for Health & family welfare at Patna and Guwahati had been kept on high alert to detect and disease outbreak at an early stage and contain it by ensuring proper surveillance mechanism in coordination with the State heath Authorities.

f) Lesson learnt:

- Flood control works, mainly anti-erosion works, are need to be planned with conducting any detailed and holistic hydrological and morphological studies, which led to execution of anti-erosion works repeatedly on the same/adjacent sites.
- Capacity Building for flood management by imparting training to the officers/staff are to be imparted. New technologies such as Digital Elevation Models, Very Small Aperture Terminal System for automatic receipt of online flood information, preparation of hazard zonations and inundation maps are requiped to be adopted.
- Adequate monitoring mechanism is needed to monitor the execution of flood control works as vital informations (such as progress of execution of ongoing works, structure wise details of executed works with initial costs, cost of subsequent modifications etc).

3.3 State/UT: North - East India

(Excluding Assam)

Major Floods in 2017, 2009, 2000

3.3.1 North - East India

a) Year/Time of event of duration: 2017

b) Consequences & impacts: Around 80 people died so far due flooding and landslides in the Northeast, the Centre said (16). The damage due to the flooding had been "unprecedented" and ISRO was roped in to assess the extent of destruction. Around 80 people have died so far in the Northeast due to floods and landslides said the Centre on 14th July 2017 termed "unprecedented". Jitendra Singh, Union minister of state for development of north eastern region (DoNER), who on 14th July, 2027 chaired a review meeting on the flooding in the Northeast, said that the devastation has hit 58 districts across Assam, Arunachal Pradesh and Manipur. Assam was the worst hit, with nearly 50 flood-related deaths so far in 26 districts. The state had also seen more than 17 lakh people getting affected as a result of the flooding. The Centre also planned to bring in experts from space technology and the Indian Space Research Organisation to assess the damage caused by floods and landslides in the Northeast. Northeast flooding Villagers used boat to cross flooded road in Assam's Morigaon (India Today, 2017).

Arunachal Pradesh had taken a major hit to its road infrastructure with capital Itanagar getting virtually cut off. Nagaland too was hit by flash floods after torrential rains swept the state. The Dimapur-Kohima National Highway-29 had been badly damaged near Kiruphema village (Fig 11).

Figure 11 Flash floods swept the Dimapur-Kohima National Highway-29 (nagalandpage.com, dt 09.07.18)

3.3.2 North - East India

a) Year/Time of event of and is duration: 28th July 2009;

b) Consequences & impacts: Multiple landslides had blocked vital transport routes, hindering the relief work in the affected states. Security forces comprising of paramilitary troops, state forces as well as the Army, had been deployed in carrying out the relief operations and required medical support in the affected states. The flood situation had deteriorated in Assam with four more deaths reported, taking the death toll to 17. Thousands of people had suffered the loss of livelihoods and a total of seven deaths had been reported in Manipur alone, news agency PTI reported. Multiple landslides had blocked vital transport routes, hindering the relief work in the affected states. Security forces comprising of paramilitary troops, as well as the Army, had been deployed in carrying out the relief operations and required medical support in the states of Tripura, Assam and Manipur. Official reports stated that the flash floods had destructed crops and plantations, and scores of livestock had swept away causing major loss of livelihoods for local population. The Indian Meteorological Department (IMD) attributed the heavy rainfall in northeast India to an upper air cyclonic circulation over south Assam and Meghalaya and neighbouring areas.

Manipur: Torrential rain on 28th July affected Manipur. Around 1.8 lakh people had been estimated to be affected by the flash floods in Manipur. One death reported from the West Imphal district pushed the death toll to seven on Saturday. Landslides had killed 21 people as of 3 August, 2015 (OCHA, 03/08/2015). The rainfall intensity had weakened in the state but the ground situation remains disrupted in the valley districts of Thoubal, Imphal West and Bishnupur, official sources informed. (Sphere India, 05/08/2015).The state government report mentioned 22,624 houses as damaged by the flood waters and landslides. Majority of the people living near the river had been evacuated

Meghalaya: The recurrent rains had caused landslides in different parts of the state. East Khasi Hills district in Meghalaya had witnessed landslide that had left commuters stranded on the roads, disrupting the transport facilities. Landslides incidents in the state obstrstracted the peoples to reach 'mandis' and other places due to the blocked roads.

Mizoram: Although no casualty had been reported from the southernmost state in the northeast, landslides had caused a serious paralysis of transport facilities in Mizoram and had left Lunglei district virtually cut off from the state capital Aizawl. The main road to Lengpui Aiport has been blocked by mudslides even as the clearance work was going on.

Normal life was badly affected in Aizawl and various other parts of Mizoram due to torrential rains. Many electric poles and trees were uprooted affecting supply of electricity.

Tripura: The flood situation in Tripura had made near to 40,000 people remain marooned in 189 relief camps across the state. At least 10,000 people were left homeless in two districts of Tripura due to floods caused by incessant rain. The displaced people had been forced to take shelter in relief camps. The personnel of the National Disaster Response Force (NDRF) and security forces of the state-rescued a number of stranded people from Khowai and West Tripura districts (Fig 12)

"Sufficient boats and rescued teams were kept in readiness to tackle the situation if it turns worse. District administration was looking to provide food and other relief materials to the flood-affected people," he added.

In West Tripura and Khowai districts, where temporary relief camps were opened by the administration, around 10,000 people had taken shelter in government buildings and local clubs.

Figure 12 Unikuti District of Tripura Collector and Superintendent of Police visit the flood-affected Area at a village, in Kailash (Source: envis.tropmet.res.in)

c) **Causes and factors:** From early July 2017, heavy monsoon rains and floods were reported across the north-east part of India, especially in the states of Assam and Manipur. These states were affected by three rounds of floods, with sporadic rainfall and raised flood water levels continuing until early September. Floods and erosions every year due to monsoon rainfall in the North Eastern states and its neighboring states, with its two main rivers - Brahmaputra and Barak - and their numerous tributaries and sub-tributaries flooding during the monsoon season. However, the deluge this year was one of the worst in 29 years. According to Assam's State Disaster Management Authority, as of July 2017, 75 people were killed and approximately 1.7 million people affected in 24 districts of the state (with 12 districts being the worst affected) as a result of flooding. Infrastructure was damaged and roads and bridges submerged, disrupting surface communication. Almost 75 per cent of Kaziranga National Park, a world heritage site, was inundated.

In Manipur, the rains that started after cyclone Mora during the last week of May 2017 caused floods across many parts of the state. Like in Assam, in Manipur too the flood levels this year were above normal and were referred to as once in a 30-year event by media reports. According to Manipur's State Department of Relief and Disaster Management, four districts were affected, with many low-lying areas in and around Imphal, the capital of Manipur, inundated by flood waters. The road network was cut off at many places due to landslides.

d) **Actions taken on pre, during, and post-events:** The floods of 2017 in the northeastern states including Arunachal Pradesh, Assam and Manipur, the government had taken the required steps in extending timely support to the state governments," told Minister of State for Home Affairs Sri Kiren Rijiju.

According to Home Ministry data, the loss of lives this year was more than in the 2015 and 2016 floods. While 124 people died in 2015 across Arunachal Pradesh, Assam, Manipur, Meghalaya, Nagaland, Sikkim and Tripura, the figure was 186 in 2016, with Assam alone recording 115 deaths. In 2017 however, the death toll had risen sharply to 191.

e) Lessons learnt:

- Water, sanitation and health are major issues in the aftermath of cyclones and floods, and a speedy response is crucial to prevent the spread of diseases (ACAPS 07/2011).
- Indirect losses, such as livelihood impact, are often much higher than direct damage (ECLAC 2003).
- Implementing an improved real-time flood and drought control warning system can reduce the damage caused by floods. Improved forecasting, early warning system, and preparedness measures have helped to reduce the number of lives lost and impact on livelihoods (WFP 19/20/2014, JNA ACAPS 04/2014).
- Drills should be regularly organised to inform people what to do if an alert is issued: locking up their homes, keeping their cattle in a safe place, and taking only few clothes and important documents with them (First Post 14/10/2013). Different means of communication have proved essential in reaching a large population: constant news coverage before and throughout the event (emails, fax, telephone, print media, online news networks, loudspeakers) to communicate warnings and alerts, as well as, the distribution of satellite phones to representatives of the most vulnerable districts, ensure that communications continue during the storm (UNEP 11/2013)

3.3.3 North - East India

a) Year/Time of event and its duration: 11th June, 2000;

b) Consequences & Impacts: On 11 June, 2000; Arunachal Pradesh experienced one of the worst devastations caused by flash flood following the bursting of an artificial lake caused by lanslides on Siang in Tibet. “And therefore, in order to take preventive measures, the general public was cautioned to refrain from venturing into Siang river or its periphery areas for collecting fire woods, fishing, swimming,” East Siang district magistrate Tamiyo Tatak said in the order. The vulnerable areas identified by the administration in East Siang were Jarku, Paglek, SS Mission, Jarkong, Bankskota, Berung, Jampani, Sigar, Ralling Borguli, Seram, Kongkul, Namsing, Mer and Gadum. It asked public to remain alert “without panic for any eventuality.”

Police stations and district disaster management authority had alerted about the possibility of disaster, and asked them to take all preventive measures for mitigation.

The administration also informed that due to the landslides in the Tibetan region water level of Upper Siang in Arunachal Pradesh showed decreasing trend. On August 29, the East Siang district administration also warned of flooding after Chinese government informed India of heavy rainfall and large quantity of water discharge from the Yarlung Zangbo. According to the Chinese government, the river discharged 9020 cumec water on August 29, which was one of the highest in 50 years, causing flood in the downstream of Siang in Arunachal Pradesh. Water gushed down Siang causing large waves in Arunachal Pradesh. Over 100 people had to be rescued by Air Force chopper from a island on Siang following the flood.

3.4 State/UT: Bihar

Major Floods in 2019, 2017, 2016, 2013, 2011, 2008, 2007, 2004, 2003, 2000

3.4.1 Bihar, 2019

a) Year/Time of event and its duration: 21st September 2019;

b) Areas affected: 28 districts including the capital city Patna were affected. The names of affected districts are Araria, Kishanganj, Madhubani, East Champaran, Sitamarhi, Sheohar, Supaul, Darbhanga, Muzaffarpur, Saharsa, Katihar, Purnea, West Champaran, Buxar, Bhojpur, Samastipur, Lakhisarai, Begusarai, Khagaria, Bhagalpur, Munger, Patna, Saran, Vaishali, Arwal, Jehanabad, Nalanda and Nawada.

Figure 13 Incessant rainfall in Bihar has hit normal life, capital city Patna under Knee-deep waters (Source: indiatoday.in, dt 30.09.19)
((https://www.indiatoday.in/diu/story/bihar-flood-satellite-images-flooding-1604831-2019-09-30)

c) Causes and factors: Flooding in the city appeared to had been caused by a choked, damaged and dysfunctional drainage system, and delayed activation of pumps at the sump houses (Fig 13).The flooding of north Bihar preceded extreme rainfall. The trigger for the deluge was the downpour in Nepal. Bihar shares its northern border with the country, from which a slew of Himalayan Rivers run down south. Rising water level in many of those wreaked havoc in 12 districts of north Bihar as floodwater breached embankments, snapped roads, washed away small bridges. Heavy rainfall ensued in Bihar as well and the sudden rise of water levels in Bihar due to an extreme weather event in Nepal

d) Consequences & Impacts: As per assessment, 40 slums were fully affected by the flood and 16825 families were the victims of flood. In most of the slums, water level was 3 feet and 4 slums had not been in accessible condition. The water resources were fully contaminated due to the situation, 66.52 % families were denied by safe drinking water too. This flood is Rivirine flood.

3. Flood in Patna impacted the shelter in slums in various ways. The impact ranges from complete collapse of houses to partial damages and minor damages. The slum dwellers need support to help them recover from the impact of flood. In many places, people who lost their homes were unable to return to their home and getting back to normalcy. 3.3% of the houses were completely collapsed and these houses would require reconstruction and major repair work. Shelter support should include options from provision of material and technical support to labour and cash. It was also observed that the families lost their homes were staying at relief camps.

4. As per the analysis the livelihood of both male and female were affected badly by the devastating floods. For female -Domestic works, wage labour, Households chores as domestic maids, Rag pickers, Tailoring labours were affected. For male's construction workers, self-employee, daily wages workers, rickshaw puller, street vendor's labours were affected. It indicates the incapacity of the community members to have proper nutritious food availability in their households.

Number of Villages affected	:	1846
Population affected	:	119 lakh
Number of People Evacuated	:	1.25 lakh
People dead	:	116 (Flood-Report.pdf-|NITIAayoghttp://www.niti.gov.in›sites› default›files›Fl...PDF, n.d.)

e) Actions taken on pre, during, and post-events: Residents in flooded areas were taken out in rescue boats. Municipal cranes were also used to rescue people. There was no power supply in Bihar since the last 3 days.

The release of 2.75 lakhs cusecs of water from Indrapuri barrage across the Sone river at the time of deluge, had worsened the situation in river Ganga which caused panic among people living in Patna. Other than that seven minor embankments of the water resources department were damaged in Nalanda and Jehanabad districts. IMD (India Meteorogical Department) had predicted heavy rainfall in Bihar region. The Meteorological Department stated that with the activation of the southwest monsoon, cyclonic circulation remains in the Bay of Bengal, due to which heavy rains are expected.

f) Lessons learnt:

In order to reduce flood damage in future the effective way is to prevent development in flood prone lands. So the best approach is zoning of such land. However, the land use planning as discussed should be adopted so the land contains an outlined use. Zoning can be used to scale back damages from flooding and must be so flexible to acknowledge that different types of land use are compatible.

The storm water drainage system is unknown to Patna; what exists in some parts is a sewage network that is meant to double as drainage. At the best of times, this network lies overburdened with unrelieved human effluence. Therefore, there is need for regulated development of the city. Funds to develop the proper sewerage and storm water drainage system in the city can be taken under Smart City Mission, National Mission for clean Ganga and AMRUT (Atal Mission for Rejuvenation and Urban Transformation).

Special drive to clean channels leading to water tanks is undertaken before the monsoon season.

All urban water bodies will be protected. Efforts will also be made to restore water bodies by de-silting and taking other measures. Efforts will also be made to revive water bodies that have been put to other uses. Water bodies will be an integral part of the storm water system.

3.4.2 Bihar, 2017

a) Year/Time of event and its duration: Between 12 and 20 August, 2017

b) Areas affected: 187 blocks of 19 districts of Northern Bihar had been affected in the flood. In Bihar, all the floods taken place during the specified years in the report were Riverine flood.

c) Causes and factors: Torrential rain in the foothill of the Himalaya in Nepal and adjoining areas in Bihar between August 12 and 20 led to flash flood in various rivers (Gandak, Burhi Gandak and Bagmati, Kamla, Kosi and Mahananda) due to heavy rain in the catchment areas of the major rivers of North Bihar in Nepal.

d) Consequences & Impacts: In the year 2017, Bihar was one of the worst affected states; rainfall patterns have seen a dramatic shift. The month of August saw very high rainfall this year, causing death of 514 people. Around 1.71 crore (17.1 million) people were hit by the floods (Times of India. 22 August 2017). Over 8.5 lakhs of people had lost their homes, with Araria district alone accounting for 2.2 lakh homeless people. 2017 Flood had broken 9-Year record of deaths in Bihar. Last year, however, rainfall in August was much lower than expected. The departure in rainfall from the expected amount was quite different this year and last year in the 19 flood hit districts of Bihar. While farmers in parts of north and eastern Bihar had lost their standing crops to heavy floods, in south and central Bihar, a lack of rainfall in August had left the farmers worried about timely irrigation.

Amid the pandemic, thousands of farmers across Bihar were facing a peculiar situation. While farmers in parts of north and eastern Bihar had lost their standing crops to heavy floods, in south and central Bihar, a lack of rainfall in August had left the farmers worried about timely irrigation.

e) Actions taken on pre, during, and post-events: Bihar Government sought a central assistance of Rs 7,636.51 crore for the post-flood repair and restoration work, which included Rs 1091.34 crore for crop compensation, a sum of Rs 2,900 crore has been sought to repair the 512 km damaged roads, among others. In October 2017, officials of an inter-ministerial team of the Centre Government held discussions in Bihar for assessing the damages caused by the floods in the state. On 29 August 2017, Bihar cabinet sanctioned Rs 1,935 crore under Bihar Contingency Fund for relief and restoration work in the flood-hit districts in the state.

f) Lessons learnt: Low-lying areas should be reserved for parks and other low-impact human activities, wherever unavoidable, buildings in low lying areas should be constructed on stilts above the High Flood Level (HFL)/ Full Tank Level (FTL),

For chronic flooding spots, alternate locations may be explored for accommodating people staying there; Buildings should be constructed on stilts after taking into account the stability of slopes.

The nallahs/drains/watercourses/flood plains should be clearly delineated and boundaries fixed in new developments. Those should be followed strictly.

3.4.3 Bihar, 2016

a) Year/Time of event and its duration: 21 August, 2016; flooding has affected the state

b) Areas affected: The districts of Patna, Vaishali, Buxar, Bhojpur, Saran, Begusarai, Samastipur, Lakhisarai, Khagaria, Munger and Katihar.

c) Causes and factors: In Bihar state, the Ganges and several other rivers had overflowed, affecting around 130,000 people over the last few days. It was found that the flood was mainly caused by rapid release of water from the Bansagar Dam on the Son from 18 to 20-Aug-2016, as a tropical storm traversed through its upper catchment. Contributions from the Ganga's Himalayan tributaries and upstream of the flooded area were negligible

d) Consequences & Impacts: According to a statement by the Bihar disaster management department of 21 August 2016, flooding has affected Over 15,000 people were sheltered in 82 relief camps after being evacuated from flood affected areas. Two fatalities had been reported in Vaishali and one person reported killed in Buxar. As many as 114 people had died as a result of floods in Bihar since 01 June (by Richard Davies in Asia, news,28 July, 2016). There were several other rivers flowing above the danger mark including the Sone river at Koilwar (Bhojpur district) and Maner (Patna district), the Ghaghra river at Gangpur-Siswan in Siwan and Saran districts, the Gandak river in Hajipur, the Kosi river at Baltara and Kursela in Katihar district and Burhi Gandak in Khagaria. Department of Disaster Management Bihar report as of 18 July, 31 villages in Araria and Supaul had been flooded. By 27 July, 2016, over 1,500 villages had been flooded in the eight affected districts: Kishanganj (543), Purnea (478), Araria (292), Supaul (106), Katihar (177), Bhagalpur (8), Madhepura (48) and Darbhanga (9). On 28 July, villages in the districts of Saharasa (7) and Gopaiganj (15) were also affected. By 02 August, the districts of Saharsa, Gopalganj, East Champaran, and Muzafferpur had also been affected. From 05 August, the districts of Saran and West Champaran were also affected. After a short respite where many were able to return to their homes, further flooding struck from 19 August, 2016 with the worst affected districts being Patna, Bhagalpur, Vaishali, Buxar, Bhojpur, Sonepur, Saran, Begusarai, Samastipur, Lakhisarai, Khagaria, Munger, Nalanda and Katihar. Fatalities: 60 people from July 15 to September 12, 2016, Evacuated: 641,707 July 12 to August 8, 2016 and Evacuated 715,158 persons from August 19 to August 30, 2016. After a short break from the rain where many were able to return to their homes, further flooding struck from 19 August. Affected 3.753 million from August 19 to August 23, 2016 mostly affecting Patna, Vaishali, Buxar, Bhojpur, Saran, Begusarai, Samastipur, Lakhisarai, Khagaria, Munger and Katihar (India - Bihar Floods Worsen Leaving 60 Dead and 380,000 Displaced, n.d.).

e) Actions taken on pre, during, and post-events: Bihar Chief Minister expressed concern that levels of the Ganges had increased after a release of water from the Farakka dam, and that the situation could worsen after a planned release of water from the Bansagar dam. Depth of Ganges had been reduced by siltation causing the river to overflow when levels increase. He appealed to the central government to prepare a policy on silt management.

f) Lessons learnt:

- The great need to put flood-affected people's priorities at the heart of flood response was most recently recommended by the people's commission on the floods, need to be in active with priority.
- Humanitarian agencies — private and public — time and again get into crisis situations in large numbers and often leave the communities they aim to assist undermined. There is tremendous need to do better by actually supporting and facilitating flood-affected communities' own relief and recovery efforts and working alongside government counterparts.

3.4.4 Bihar, 2013

a) Year/Time of event and its duration: 1st week of June 2013 experienced a terrific rain and storms in the State.

b) Areas affected: North Bihar districts were vulnerable to at least five major flood-causing rivers during monsoon - Mahananda River, Koshi River, Bagmati River, Burhi Gandak River and Gandak - which originate in Nepal. Some south Bihar districts had also become vulnerable to floods from Son, Punpun and Phalgu rivers.

c) Causes and factors: 201 people had died due to the flooding and 22 people had been reported killed by lightning strikes (2013 Bihar flood, n.d.). At the same time, there were also severe storms and lightning strikes in the neighbouring state of Uttar Pradesh where 13 people died. Over 20 districts had been affected by

the Flood. It was the most disastrous flood in the state after 2008 Bihar flood. The deluge affected over 5.9 million people in 3,768 villages in 20 districts of the state. Some more causes were -Major drainages viz Narayani, Bagmati, and Koshi rivers are coming from mountainous region of Nepal which gives thrust when heavy rains occur in the mountains of Nepal, the water flows into the major drainages of Narayani, Bagmati, and Koshi rivers. It was found that because of siltation, the Kosi river bed was in fact several feet higher than the adjoining land. Therefore, high and low lands separated by embankments had created a situation where the low lands had become permanently waterlogged.

Deforestation in the catchment area had led to increase in the silt content of the river flow.

- Farakka Barrage was constructed to maintain the dynamic equilibrium of the river hindering the natural oscillation of the river within its meandering belt. The meandering belt of Ganges in Malda and Murshidabad is 10 km wide. The water level of the Ganges rose about 8 m upstream of the Farakka barrage. Farakka barrage had led to following problems upstream of the barrage:
- Interception of the flow channel/ changed from straight to oblique
- Sedimentation (640 x106 metric tonnes/ year)
- Reduction of the cross-sectional area
- Declining slope of the long profile
- Widening of the river and increasing length
- Increase in flood frequency and magnitude

d) Actions taken on pre, during, and post-events: Bihar Chief Minister, Nitish Kumar himself supervised the Flood Relief Operations. The State Health Department started 306 Health Check up Camps and 128 Veterinary Camps in the Flood affected areas. 22,623 tonnes of solid food items and 25 Crores of Cash was distributed among the victims of Flood, according to a Statement released by Bihar Government. A total of 50,550 polythene sheets was distributed among the flood-affected people.

e) Lessons learnt:

- The great need to put flood-affected people's priorities at the heart of flood response were the following:
- Humanitarian agencies — private and public — time and again get into crisis situations in large numbers and often leave the communities they aim to assist undermined. There is tremendous need to do better by actually supporting and facilitating flood-affected communities' own relief and recovery efforts and working alongside government counterparts.
- The necessity for the Union government, with state and civil society organization support, to invest much more in risk reduction and preparedness at all time.
- Perhaps the time has come to consider establishing a voluntary or more formal certification and accreditation system for humanitarian aid actors. Sphere India, a leading Delhi-based network of humanitarian agencies, has done the basic groundwork in this respect. There are also those who believe that it's time to set up an effective inter-agency oversight mechanism that has the authority to provide performance feedback and measure improvements.

3.4.5 Bihar, 2011

a) Year/Time of event and its duration: 1st week, July 2011

b) Areas affected: West Champaran, Bhagalpur, Khagaria and Gopalganj districts. During second week of August, River Ganga at Colgong/Kahalgaon, Hathidah and Patna (Gandhighat), river Burhi Gandak at

Khagaria, river Kosi at Kursela, river Son at Maner and river Punpun were at moderate flood situation as per CWC reports

c) **Consequences & Impacts:** During first week of July 2011 parts of Darbhanga, West Champaran, Gopalganj, Muzaffarpur, Araria and Saharsa districts were reported to be affected due to heavy rainfall in the catchment areas of Gandak River. During first week of August, swelling waters of Gandak, Ganga, Kosi and Bagmati rivers were reported to be putting pressure on the embankments in above mentioned districts.

Several rivers that run through the state: Ganga, Sone, Punpun, Falgu, Karmanasa, Durgavati, Kosi, Gandak and the Ghaghara, to name a few. Nearly 85% of the state's land was under cultivation. Bihar also received heavy rainfall all through June to October. The state had been facing floods ever since, but the frequency of floods had become high in recent years. There had been floods almost every year from 1979 which caused extensive damage. Lakhs of people had lost their lives and their homes. The state had faced infrastructural losses worth crores of rupees.

The Kosi river system drains about 60,000 km^2 of eastern Nepal and southern Tibet before it enters Bihar. The basin includes almost half of the world's 8,000 m plus peaks. North of the India-Nepal border, it is known as the Sapt Kosi or "Seven Rivers" in reference to its seven tributaries: Indrawati, Sunkosi, Tambakosi, Lihku Khola, Dudhkosi, Arun and Tamur. Its three main tributaries i.e. Sunkosi, Arun and Tamur join the river at Tribeni (Fig 15). Downstream of the Tibreni, the Sapt Kosi flows through a narrow gauge of 11km, before spreading over the Gangetic plains. As a result of the sudden decrease in slope below the mouth of the gorge, an inland delta is formed. It is interesting to note that the river had shifted more than 100 km westward in the past 200 years. Hundreds of people in Bihar had been forced to abandon their homes as flood waters entered nearly 100 villages and rising levels of most rivers threatened to inundate many others, officials said on Saturday. All the inundated villages were in flood-prone districts of Muzaffarpur, Gopalganj, Purnia, Araria, Saharsa, Madhepura and Bagaha, official's said. As per water resource department official, water entered these villages after levels rose in all the major rivers following heavy rains in the state and the catchment areas of Nepal. According to the Central Water Commission, the water level in major rivers - Kosi, Mahananda, Gandak, Budhi Gandak, and Bagmati - had increased. Kosi and Bagmati are flowing above danger mark at some places. "All the rivers were in full spate following heavy rains. Some rivers may cross the red mark during that time. Officials said that after two consecutive years of drought (Fig 16), the fear of floods is back in Bihar with incessant rains and heavy water discharge into the Kosi River from Nepal.

What causes floods?

There had been increased conversion of forests to agricultural and pastural land in the middle hills of Nepal, which significantly contributes to the flood damage in India. There was an increase in the annual run off in the Sapt Kosi from the 1950s until the 1980s, but the rainfall also increased correspondingly at several stations in the basin.

Another reason for the flood damage is that people had been increasingly occupying the flood plains and had been assuming that the river volume increased to a great extent.

The state government had built about 3000 kms of embankments, but the flow of the river had grown 2.5 times resulting in the failure of embankments in every flood. So the big question is: is the state of Bihar prepared? The Disaster Management Department, Government of Bihar had come out with a number of schemes.

- Procurement of motor boats and other necessary accessories like life jackets, mahajals, tents, etc. for 28 flood-prone districts.

- To improve the response mechanism and tackle the impact of natural disasters effectively, a State Disaster Response Force (SDRF) is to be established on the similar pattern of National Disaster Response Force (NDRF).
- A number of warehouses will be constructed to store the relief and rescue materials and to keep them safe and secure.
- Establishment of Emergency Operation Centres (EOC) in all the districts to carry out rescue and relief work effectively.
- Since the communication system often becomes dysfunctional, procurement and proper maintenance of communication systems has been considered. Satellite phones, GPS instruments, hand packs, walkie – talkies will be procured.
- An Early Disaster Warning System is to be established.
- A plan has been prepared to generate awareness among the masses about the ways and means of mitigating the risk of disaster.

The budget for the above scheme crossed Rs. 5000 crores.

What more can be done?

A number of structural measures can be taken up in the state:

- Detention Basins: The state area has a number of depressions locally called chaurs which act as detention basins. These chaurs absorb a considerable amount of water of the first flood of the season. No man made detention basins or improvements in natural chaurs has been done.
- Embankments: All the rivers have been embanked in the state. River Kosi is embanked on both the sides. But there are few gaps in these embankments which reduce its effectiveness. The maintenance and repair of these embankments must be taken into account.
- Channel Improvement: It is not a usual practice.
- Hundreds of people in Bihar have been forced to abandon their homes as flood waters entered nearly 100 villages and rising levels of most rivers threatened to inundate many others, officials said on Saturday.
- All the inundated villages were in flood-prone districts of Muzaffarpur, Gopalganj, Purnia, Araria, Saharsa, Madhepura and Bagaha, officials said.
- "Water entered these villages after levels rose in all the major rivers following heavy rains in the state and the catchment areas of Nepal," a water resource department official said.
- According to the Central Water Commission, the water level in major rivers - Kosi, Mahananda, Gandak, Budhi Gandak, and Bagmati - has increased in that duration. Kosi and Bagmati are flowing above danger mark at some places. "All the rivers are in full spate following heavy rains. Some rivers may cross the red mark at that time. After two consecutive years of drought, the fear of floods wasback in Bihar with incessant rains and heavy water discharge into the Kosi River from Nepal.

d) Actions taken on pre, during, and post-events:

However, Bihar Water Resource Development Minister said that all embankments were safe and there was no need to panic. "The government is ready to face any eventuality if the river waters become a threat," he said. The government had taken prepatory measures to protect embankments, but conceded that several villages in flood prone districts faced a threat. Hundreds of people were shifted to safer places due to the rising Kosi waters. The state government has asked engineers and district officials to keep a 24-hour vigil.

3.4.6 Bihar, 2008

a) Year/Time of event and its duration: Torrential rain on 18th August, 2008 caused flood in the state

b) Causes and factors: Due to poor maintenance in the embankments, breaching took place in Kosi River and caused flood in the state. Huge water (appx. 3675 cubic metre/sec) passed through the breach and inundated many villages in north Bihar. During last few decades, >3000 km embankments were made but the intensity and frequency of flood is increased in many folds. It is difficult to manage the embankments protection in leau of deluge.

c) Consequences & Impacts: Heavy monsoon rains caused the river to break out of the channel during August. It started flowing through an old channel much further east, inundating cropland and towns and villages with 1.2 million inhabitants, mostly in Bihar.

The worst affected districts included Supaul, Madhepura, north Bhagalpur, Araria, Purnia (all by the Kosi) and West Champaran (by Gandak). It was not possible to assess the magnitude of deaths or destruction, because the affected areas were totally inaccessible. Even mobile phones had stopped working, because entrapped persons cannot get their batteries charged. 150 persons were washed away in a single incident. Another report says 42 people have died in the flood in Bihar (2008 Indian floods, n.d.). It was reported that the year 2008 was the worst flood in the area in 50 years, prompting the then Prime Minister to declare a "national calamity" on 28 August, 2008 (Wikiapedia & PreventionWeb.net). The government earmarked US$230 million in aid for the region. The Indian Army, National Disaster Response Force (NDRF) and non-governmental organizations operated the biggest flood rescue operation in India in more than 50 years. Death tolls rose from Indian floods as more than 65 people had been killed in monsoon rains. Supaul district was the worst-hit by floods and surging waters swamped 1,000 square kilometres (250,000 acres) of farmlands, destroying wheat and paddy crops.

d) Actions taken on pre, during, and post-events: The Prime Minister declared a "natural calamity" on 28 August and earmarked US$230 million in aid for the region (Wikipedia). Rescue operations were carried out by the Indian Army, National Disaster Response Force (NDRF) and non-government organisations. Indian Air Force helicopters dropped relief supplies in the worst-hit districts. Mumbai Fire Brigade sent a 22-member disaster management team to help in relief work.

Chief Minister requested a rehabilitation package of Rs. 145 billion from the central government for the flood ravaged Kosi region.

The Government of Bihar initiated Kosi Reconstruction and Rehabilitation Programme covering 30,000 affected families in Saharsa, Supaul and Madhepura district based on a pilot project implemented by ODR Collaborative, a network of organisations, supporting the Government and an owner driven reconstruction policy was formulated to support each family with Rs. 55,000 to construct their own house. After signing an agreement with the World Bank in January 2011, this programme has been upscaled to cover 100,000 families for reconstruction of hazard safe houses.

e) Lessons learnt:

- The necessity for the Union government, with state and civil society organization support, to invest much more in risk reduction and preparedness between two floods is suggested like other states. The National Alliance for Disaster Risk Reduction at its 3-4 November convention demanded immediate action in favour of states and added that local communities are the first to assist in saving lives. With this in mind, the humanitarian community ought to provide ongoing countervailing balance to national and local preparedness measures in India. The Hyogo Framework for Action of the UN's international strategy for disaster reduction provides a blueprint for such effectiveness.

- Perhaps the time has come to consider establishing a voluntary or more formal certification and accreditation system for humanitarian aid actors.

3.4.7 Bihar, 2007

a) Year/Time of event and its duration: 3rd August, 2007 onwards till 1st week of September 2007

b) Areas affected: The flood affected 19 districts of the state. Some of the worst affected districts were Muzaffarpur, Sitamarhi, Saharsa, East C Supaul, Darbhanga, Patna, Bhagalpur, West Champaran, Kathihar, Madhubani, Samastipur, Sheohar, Nalanda, Khagaria,Gopalganj, Madhepura, Araria and Begusara.

c) Causes and factors: The states of Bihar and Uttar Pradesh were the most affected due to their high population density. Nearly two million people, spread over eleven districts in Bihar, grimly endured the floods. Many major rivers, including the Ganges, Punpun, Bagmati, Gandak and Kosi, were flowing above danger mark. Flooding had submerged more than 40 percent of Bihar. Rainfall in July was five times higher than the monthly average over a 30-year period. The area around the town of Darbhanga was one of the worst affected areas in the state. When heavy rains occur in the mountains of central and eastern Nepal the water flows into the major drainages of Narayani, Bagmati, and Koshi rivers. As these rivers cross into India, they flow into the plains and lowlands of Bihar and break their banks. To protect the Koshi River dam as well as the Koshi Barrage Pool's embankments, Indian engineers who were in charge of the dam in Nepal, further opened the dam's gates which could cause flooding down river in Bihar.

d) Consequences & Impacts: In the state Flood took place during. As per Govt. Death toll was 41 people, and 48 school girls were marooned as on 3rd August. It was learnt that Bihar experiences worst flood in the last 30 years of history (Hindustan Times. 3rd August 2007). Major findings are:

- Total deaths recorded in 2007 Bihar floods was 1,287 (2004 Bihar flood, 2004)
- Diarrhoea were spreaded out in most of the localities
- Ganges, Punpun, Bagmati, Gandak and Kosi Rivers were flowing above danger mark.
- Appx.2 million people, spread over eleven districts in Bihar, grimly endured the floods
- Flooding had submerged more than 40 percent of Bihar.
- Rainfall in July was five times higher than the monthly average over a 30-year period.
- Darbhanga was one of the worst affected areas in the state.
- Many people had to seek shelter on higher ground and many people were marooned.
- More than 4822 villages and 10,000,000 hectares of farm land were affected.
- About 29,000 houses were destroyed and 44,000 houses were damaged by the floods.
- Govt decides to provide compensation to flood victims, damaged house owners, cattle owners who lost the cattles,

e) Actions taken on pre, during, and post-events: Grain (38,86,896 Qtls) distributed to affected families was around 50 lakhs. For emergency expenses (Rs 20/- per adult and Rs 15/- per child) that a person is entitled for, GoB had, till August 2008, paid Rs. 84.05 Crores against a demand of Rs. 1105 Crores made to the Center. This was just about 8 per cent of the requirement.

As far as CRF is concerned, there were no unlimited funds available with it. In the past five years Bihar had received only Rs.123.66 Crores in 2000-01, Rs. 129.84 in 2001-02, Rs. 136.33 Crores in 2002-03, Rs. 143.15 Crores in 2003-04 and Rs. 150.30 Crores in 2004-05. GoB was supposed to add 25 per cent more to this sum to claim the Central assistance. One can well imagine the gap that existed between the available small funds to

the tune of Rs. 150 Crores against a demand of Rs. 8,000 Crores. Some money may be available through the channels of National Calamity Contingencies Fund (NCCF) but that too was drop in the ocean. The rest will have to be borne by the state Government or by the affected family itself. GoB asserted that it had spent all the money that it had with it (Rs. 850 Crores) to meet the flood disaster this year and it had further spent a sum of Rs. 250 Crores from other sources and had no money left to do any relief any more unless some help pours in from outside.

f) Lessons learnt: It's important to translate lessons learnt after each flood into doable action. Humanitarian agencies have individual and collective responsibility to take forward the lessons. The first national congress for disaster risk reduction, organized by the National Institute of Disaster Management on 29-30 November 2006, underlined this knowledge gap.

India has faced floods for the past 60 years. That must make the 2008 response more effective.

3.4.8 Bihar, 2004

a) Year/Time of event and its duration: 2nd week of July onwards till September 2004

b) Areas affected: In the 1st phase of flood in the state the districts so far affected were Supaul, Darbhanga, Bhagalpur, W. Champaran, Muzaffarpur, Sitamarhi, Khagaria, Sheohar Madhubani, East Champaran, Araria, Sharsha and Samastipur. The worst affected districts were Darbhanga, Sheohar, Madhubani and Sitamarhi.

c) Causes and factors: Torrential rain in the upper catchment areas of Nepal had resulted in the rise of the water levels of all the major rivers of Bihar and so far 13 districts (out of a total of 38 districts) had been affected by the flood waters in 1st phase and subsequent phases of flood in state. Approximately 1.6 million families were affected by the unprecedented floods in Darbhanga, Madhubhani, Sitamarhi, Sheohar and East Champaran Districts. Situation is grim with continuous rains over the northern portion of the state and is likely to get critical with rain/thundershowers forecasted over Bihar by the Indian Meteorological department. As per the Central Water Commission report, river Kamala Balan, Budhi Gandak, Bagmati, Kosi, Mahananda and Adhwara group of rivers were flowing above the danger level (India: Situation report - Bihar floods, 13 Jul 2004.

d) Consequences & Impacts: The districts so far affected in 1st flood were Supaul, Darbhanga, Bhagalpur, W. Champaran, Muzaffarpur, Sitamarhi, Khagaria, Sheohar Madhubani, East Champaran, Araria, Sharsha and Samastipur. The worst affected districts were Darbhanga, Sheohar, Madhubani and Sitamarhi

Damages Details:

No. of District affected	:	13
No. of Block affected	:	95
No. of Panchayat affected	:	289
No. of Villages affected	:	1961
Population affected	:	7.9 million
No of Human lives lost	:	25
No. of Cattle lives lost	:	7
No of house damages	:	819
Crop damaged	:	94,700 Hectare
Flood affected area	:	0.12 million

Major findings are:

- Total deaths recorded was 885 (2004 Bihar flood)
- 3272 animals had lost their lives
- Nearly 21.299 million human were affected.

e) Actions taken on pre, during, and post-events: State Govt. carried out rescue and relief operations in all flood affected districts in the 1st phase of flood.

- Six flood relief columns are present in Bihar as on 12.07.04. Their deployment was as follows.

  1. 2 x columns deployed and carrying out rescue and relief operations in Sitamarhi and Muzaffarpur districts.

  2. 2x columns airlifted from Gwalior and reroute to Dharbhanga by road under difficult conditions became effective on 13th July 2004.

  3. 2x columns airlifted from Agra and being grouped into small teams for speedy induction by helicopters to the affected areas of Dharbhanga and Madhubhani Districts on 13th July 2004.
- Indian Air Force (IAF) and Army had been called in for supporting the administration in carrying out the relief and rescue operations.
- Three IAF chopper had been pressed into action to provide relief materials in the affected areas. About 4,500 readymade food packets have been distributed/airdropped in the districts of Sitamarhi, Darbhange and Sheohar
- 69 nos. of relief centers, 47 health centers and 25 veterinary centers had been opened by the administration
- Relief materials distributed - Readymade food: 1132.75 Qtls, Polythenes : 1700 sheets

Measures taken by the Central Government

- Three MI-8 and one Chetak helicopter were made available to the state.
- Adequate stocks of food grains were available with Food Corporation of India (FCI) in Bihar.
- Three hundred tents have been moved from Odisha and two hundred tents are being made available by the Govt. of Gujarat to the State to meet the requirement of Shelter.
- State Govt. of Maharashtra and Gujarat had been advised to assist Bihar State in procurement of polythene sheets.
- Ministry of Petroleum was requested to provide 400,000 litres of Kirloskar oil to Bihar.
- Ministry of Health was requested to provide 5 million halogen tablets and to send a specialist team to flood affected areas of Assam to advice the State Govt. on actions to be taken to prevent the outbreak of epidemic situation.
- Three satellite phones and onsite emergency co-ordination kits had been provided to the Govt. of Bihar by MHA
- Department of Animal Husbandry and Dairying were advised to assist the Govt. of Bihar in the procurement of fodder. Railways will provide rakes for movement of fodder. The department has also been requested to provide 500,000 units each of HS/BQ/FMD vaccine for cattle.
- The central Govt. has already released Calamity relief fund of Rs.305.25 million.
- 325 boats have been deployed for rescue and evacuation operations

f) Lessons learnt: A mix of traditional wisdom and modern intuition would go a long way in curbing the menace.

Flood Warning System: After the 2004 Tsunami, there was a marked improvement in early warning systems in the southern states to prevent another disaster. In this age of GPS-enabled modern tracking system, the state can keep a track of all the relevant parameters like change in river course, dam water level, rainfall prediction over next few days, speed of flow etc. India has its own navigation network now with NAVIC (Navigation with Indian Constellation) which we can use to our advantage as its more accurate than GPS. After proper tracking, dissemination of information to the common masses is very important. Radio and television broadcast, social media, mass automated calls, public announcements at local levels, web application for public awareness about flood situation or anticipation are few of the ideas that could be effective in reaching out to the affected people in time.

Discharge or storage of excess water: Bihar and other Gangetic states had a tradition of creating wetlands called 'Chaurs' which act as sponges to stem the gushing flow of water and later the excess water could be used in irrigation or pisciculture. Due to rapid pace of human encroachment on forest and wetlands, the number of Chaurs have declined significantly. The state can start a survey of such wetlands and set a target for each block to mark out certain percentage of area for these. Additionally, large concrete storage facilities can be built to divert the floodwaters.

Proper protocol: A set of proper chain of command and remedial measures in order of implementation should be adopted in a policy framework. These protocols should be in line with global standards and involve the Central Govt's backing.

Mock drills: Operational preparedness to natural calamities can only be gauged by continuous mock drills. This should involve all the relevant officials and personnel so that they are not caught unawares in an exigency. These drills can also involve authorities of other countries to learn from their experience. This has happened in case of Ebola outbreak when Japan conducted mock drills with a host of nations.

Adequate evacuation logistics: To evacuate people at such a large scale, adequate stock of logistics are required like boats, trucks, tarpaulin sheets, buffer stock of foodgrains, arrangements with food packet vendors, drinking water, ropes, life jackets, medicines etc. These are usually scrambled at the time of floods but the state should ensure the logistics are handy before the flood breaks out.

Flood kits distribution: The state can plan to distribute a flood kit to every household as a backup in case of impending floods. The kit could contain medicines, inflatable boats, ropes, tarpaulin sheets, a flood manual, telephone numbers of relevant authorities etc. This would serve as the last resort for those who are missed out in rescue and relief operations.

Dredging of shallow riverbeds: A number of rivers entering Bihar plains go shallow due to lack of inclined slope. This makes the river go wide and breach banks often. Regular dredging would go a long way in ensuring that banks are safe.

High altitude for important highways: All the important highways and flyovers should be elevated to an extent that it stays clear of the floodwaters. Rescue via road is much more efficient than on boats. The state could also ask the railways to consider elevated tracks on some important routes to enable railways to run relief trains to affected areas.

Strategic planting of trees: The river banks nowadays are mostly devoid of tree cover as they used to in earlier days. The trees and bushes slow down the pace of advancing water and reduce their rampage. The state should monitor green cover along the banks on high priority.

Insurance cover for affected area: The state can engage with the insurance and banking industry to provide the affected population with insurance cover so that the amount of damage rendered to them could be mitigated to an extent.

3.4.9 Bihar, 2003

a) Year/Time of event and its duration: the first wave of flood took place in 30th June, 2003

b) Areas affected: Bihar had been affected by floods in 24 out of 38 districts viz. Darbhanga, Katihar, Khagaria, Madhubani, Muzaffarpur, Sitamarhi, Saharsa, Sheohar, Samastipur, Araria, East Champaran, Supaul, Madhepura, Purnea, W. Champaran, Vaishali a Gopalganj, Bhagalpur, Patna, Bhojpur, Saran, Buxar, Munger and Begusarai were affected in varying degrees due to floods.

c) Causes and factors: The situation became critical on 1st August, 2003, as 6.34 lakh cusec of water was released from Valmikinagar barrage which inundated large areas of Western Champaran and Gopalganj. This high volume of water was released due to heavy rainfall in the upper catchment areas of Nepal. As per information received from IMD, light to moderate rainfall is expected in the catchment areas of all rivers of Bihar & in Upper catchment areas of Son till 22.08.03

d) Consequences & Impacts: Early monsoon rain in Nepal has put the rivers water levels rise in Bihar which is flowing from Nepal. The deluge has displaced thousands of people. 47 people were died. During last week of June incessant downpour in the catchment areas of Nepal had led to critical development of the existing flood situation in Bihar. On 31st July night, 6.34 lakh cusecs of water was released from the Valmikinagar Barrage and this water is likely to inundate large areas of Western Champaran and Gopalganj and largely threatening adjoining districts. All the major rivers are flowing above danger levels and further increased in the water levels is forecasted tonight. Affected districts were Sitamarhi, Saharsa, Madhubani, Muzaffarpur, Sheohar, Darbhanga, Samastipur, E Champaran, Araria, Supaul, Madhepura, Purnia Katihar, Khagaria & W Champaran and Vaishali.Highlights are:

- 18 out of 38 districts were flood affected (India: Flood situation report 5 Aug 2003, n.d.).
- All the major rivers were rising and incessant rainfall in the Nepalese territory in the catchment of Kamla at Janakpur, Bagmati at Simra and at Kathmandu and Kosi at Okhladunga and Taplejang and Gandak at Pokhra & Bhairwa had led to increase in water levels.
- Mahananda at Dhengraghat was also flowing above the danger level.
- The southern embankment of Bagmati River in Khagaria is extremely vulnerable and 2/3rd of the embankment had been damaged by the river, any further spate in the river might totally damage the embankment and the Khagaria town might get flooded.
- The right embankment on Mahananda in Pranpur block was damaged had been repaired but the river was fast eroding the area but since the river was at some distance from the village water had not entered the habitation areas.
- Rainfall in catchment area of Nepal had not been very heavy, only 4.28 lac cusecs water were discharged from Valmikinagar barrage - flood situation might ease.
- Gandak was flowing at very high level & discharge of Valmikinagar barrage was 4,28,000 cusecs. Discharge of Kosi at Bhimnagar barrage was 2,28,707 cusecs.
- River Kamla Balan was flowing above danger mark at Jhanjharpur by 170 cm. Kosi at Baltara and Bagmati at Chandoli and DubaDhar were flowing above danger level.

- Communication on NH 77 at Katujha, Bhanspatti (Sitamarhi) and Janar (Muzaffarpur) connecting Muzaffarpur to Sitamarhi and on NH 104 remains disrupted.
- Some traditionally low-lying areas of the state are inundated due to water logging and accumulation of rainwater.
- No. of Districts affected : 18
  No. of villages affected : 2560
  Population affected : 0.28 million
  Total crop area affected : 215154 hectares
  Total area affected : 5.7 lac hectare (both Agr and Non Agr)
  House damaged : 3666 (Fully) and 1015 (Partially)
  Loss of Lives : 47

Losses to livestock and hutments was also reported. Saharsa had reported heavy damage to the animal population (35,000) and the families dependent on them (approx 31,000 families).

Crop damage had been reported but the figures reflected the value of damages only from 9 districts. Purnia had reported heavy damages but the report stated that the water stayed only for 24 hrs and the situation was fast returning to normal.

e) Actions taken on pre, during, and post-events: In 2003, as per the reports available from the Bihar Government, a corpus fund of Rs. 108.97 crores was available in Crisis Response Fund (CRF) with the state in August 2003. Out of this money, only Rs. 19 crores were released from the fund for carrying out relief operations in the state till August. Yet, the Rabri Devi government in Bihar was flaying the central government for not helping the state with the requisite money.

f) Lessons learnt: The community-based disaster management system at the local level must be given utmost importance and strengthened through appropriate training and awareness programmes.

The mechanism of Incident Response System be established at relevant levels and be dovetailed into the disaster management plans. State and district agencies should build their command and coordination structures to support the local command and coordination structures during an emergency.

3.4.10 Bihar, 2002

a) Year/Time of event and its duration: 27th August 2002

b) Areas affected: 24 districts (Sitamarhi, Nalanda, Muzaffarpur, Darbhanga, Patna, Katihar, E.Champaran, W. Champaran, Sheohar, Gopalganj, Smastipur, Madhubani, Saharsa Supaul, Shekhpura, Siwan, Araria, Kishanganj, Purnea, Madhepura and Khagaria, Begusarai, Saran, Lakheesarai) out of 38 districts.

c) Causes and factors: During year 2002, North Bihar experienced serious flood and overtopping reported in Kamla Balan left embankment and Khiroi right embankment. Four hundred and eighty nine persons died.

d) Consequences & Impacts: The flood situation was improving and flood protection work had been expedited. Almost all the stations received no rainfall in the past 24 hours. Except for Khagaria at Kosi and Kushera at Budhigandak flowing near the danger level, most of the river systems were on the receding trend within the range of 50 cms and below. Appx. 16 million people had been displaced by flood in Bihar, where

338,000 houses had collapsed (India: Bihar Flood Situation Report 06 Sep 2002, n.d.) resulting in a death toll to 351. So far the worst affected districts had been Sitamarhi, Darbhanga, Khagaria, Madhubani and Gopalganj. The map below shows the partial and fully flood affected districts of Bihar as of date. Details of damages are :

Numbers of Blocks Affected	:	203
No of Panchayats	:	2,252
Numbers of Villages affected	:	8,197
Life loss	:	419
Cattle Loss	:	1337
Population affected	:	15.70 million
Houses damaged	:	394,900 estimated value is Rs.4,390.2 million
Total Area affected	:	1.85 million ha.

Crop damage of rupees 51149.61 lacs and public property damage of Rupees 40892.19 Lacs were reported.

Lifeline and critical facilities: Estimated Value of damage to public properties - Rs. 2,980.5 million

Agriculture:

- Cropped area affected: 0.8 million hectares
- Standing crops in 0.2 million hectares worth 1,730 million, had been affected.

Road and Communication:

3 National Highways (NH 57, 77 & 104) had several & long breachs. The road communication to Sitamarhi, which was completely cut off, had been restored and the repair work was still continuing.

Shelter:

Flood had its severe impact on the habitat and shelter sector. A total of houses 394,900 had been damaged.

e) Actions taken on pre, during, and post-events: The Indian Red Cross Society district branches were on full alert, and the district and sub-district branches had started relief and rescue operations in designated areas. ORS packets were not adequate for the affected areas. Most of the doctors are busy in health camps and may need more doctors with medicines after receding of the water. There was a need of bleaching powders, lime and halogen tablets immediately for the 24 districts.

Health problem may be a major threat to these areas. Immunization was totally stopped after 2nd July 2002 due to communication disruption and people were on the road.

f) Lessons learnt:

- Special drive to clean channels leading to water tanks is undertaken before the monsoon season.
- For chronic flooding spots, alternate locations may be explored for accommodating people staying there, Buildings should be constructed on stilts after taking into account the stability of slopes.
- The nallahs / drains / watercourses/ flood plains should be clearly delineated and boundaries fixed in new developments. There will be strict enforcement of the relevant byelaws/regulations in the new layouts.

3.5 State/UT: Gujarat

Major Floods in 2019, 2017, 2015, 2013, 2006, 2005, 2000

3.5.1 Gujarat, 2019

a) Year/Time of event and its duration: 27th August, 2019

b) Areas affected: Different administrative districts of Gujarat

c) Causes and factors: Due to heavy rain in July-August 2019, the city of Vadodara and its administrative district in the Indian state of Gujarat were affected by severe flooding (The Hindu. 2 August 2019). Nearly 50 cm of rain fell on Vadodara within 12 hours, with 424mm recorded in one 6 hour period. As a result, the nearby Vishwamitri River rose to 1 metre below the danger line and the Ajwa dam overflowed, flooding the city.

d) Consequences & Impacts: State affected by severe floods (The Hindu) as heavy rain in beginning of monsoon 2019, lashed in the city on 31 July 2019, nearly 50 cm of rainfall took place on Vadodara within 12 hours. As a result, the nearby Vishwamitri River rose near the danger line and the Ajwa dam breaches flooded the city. NDRF (National Disaster Response Force) and several teams of SDRF (State Disaster Response Force were deployed to rescue the people. The flood caused 8 deaths and the evacuation of more than few thousands people. This flood was Flash flood.

Train services were cancelled few days and Vadodara Airport was closed on 1 August, owing to water-logging, and the electricity supply was interrupted. GSRTC buses were cancelled. Central and South Gujarat were worst affected due to heavy rains. 26 of 30 sluice gates of Sardar Sarovar dam on the Narmada River were opened to release water.

Figure 14 Heavy rain leads to flash flood in Vadodara (News18.com dt 03.08.19) (https://www.news18.com/photogallery/india/gujarat-monsoon-photos-heavy-rains-lead-to-flash-floods-in-vadodara-2255133.html)

The road and rail transport were also affected. Over 370 roads, including six National Highways, and 153 State Highways and 674 Panchayat roads were flooded (Fig 13) and closed for vehicular traffic. The damage was assessed at Rs. 10 crore (US$1.4 million) for National Highways and Rs. 26 crore (US$3.6 million) for State Highways.11 out of 20 trains operating between Mumbai-Delhi were cancelled due to damage to tracks near Palanpur. 915 GSRTC bus trips were cancelled in northern districts. There was breach in Narmada Canal near Thara, Gujarat in Banaskantha. The runway of Ahmedabad airport was damaged and two Air India flights were diverted. As of 26 July, of the 203 dams and reservoirs in state, 38 were full, 19 were filled to between 80–90% of their capacity, 15 to between 70%–80% and 130 were filled to less than 70% capacity. 25% of Kharif crop sowing in Gujarat, especially and Saurashtra and north Gujarat was lost.

e) Actions taken on pre, during, and post-events:

- The sudden increase of water in the first week of August, 2019, left many people stranded. As per requisition of State Government of Gujarat, NDRF deployed its 23 teams, out of which 05 teams were airlifted (from Ex 05 Bn NDRF Pune, MH) in the State at Gandhinagar, Girsomnath, Rajkot, Bhavnagar, Bhuj, Patan, Aravali, Dahod, Valsad, Surat, Palanpur (Banaskantha) & Navsari. NDRF teams conducted non-stop rescue, evacuation and relief operations. During the operation NDRF teams rescued 551 persons, evacuated 4344 persons & 62 livestock and retrieved 11 dead bodies. NDRF teams also provided medical assistance to 2853 needy persons.
- Naval rescue teams on Tuesday recovered one dead body while the search is underway for the second, at Dondi Dam near Chhapra village in Gujarat's Rajkot.
- Extremely heavy rains lashed Rajkot and Jamnagar in Gujarat over the last 24 hours, following which more than 200 people stranded in the flood waters were rescued and over 7,000 people shifted to safer places in the two districts, officials said.
- Heavy rainfall in parts of Gujarat on Sunday created a flood-like situation in many areas including Bharuch, where over 2,000 people from inundated areas along the Narmada River were evacuated following release of water from the Sardar Sarovar dam.

f) Lessons learnt:

- Nature, the Sandy storm and all natural disasters are teaching us to resist nothing and to just allow things to happen as they are meant to happen. We can't force things, we can't force nature and we can't force anything in life, we only THINK we can.
- Flood actualy is the overflow of water through any water body like ponds, river, lakes, streams etc. it has harmful as well as benefiical effects. Harmful effects such as loss of property, deaths of animals, humans, whereas beneficial effects are groundwater recharge, fertile land etc.
- Floods allow a river's water to reach more areas above and below ground. This water can be stored and used by nature and people. They also filter pollutants out of rivers and nourishing lands to support ecosystems and fertile areas for farming.
- To harness the power of new technologies, such as social media and mobile technologies, to increase the efficiency of public administrations in raising public awareness and education regarding floods risks, effects and impact.

3.5.2 Gujarat, 2017

a) Year/Time of event and its duration: lashed in the city on 24-31 July 2017

b) Areas affected: The districts of Banaskantha, Patan, Gandhinagar, Morbi, Surendranagar, Mehsana

and Sabarkantha received 267%, 208%, 189%, 174%, 172%, 130% and 115% respectively of their average rainfall for the same period.

Figure 15 Wide spread deluge in Gujarat (Source: thegurdian.com dt 31.07.17)
(https://www.theguardian.com/world/2017/jul/31/india-monsoon-floods-gujarat-death-toll-over-200)

c) Causes and factors: The districts in north Gujarat received more than 200 mm of rainfall in 24 hours on 24 July. Dhanera recorded 235 mm rainfall in six hours on 24 July resulting in severe flooding (Fig 15). Deesa recorded 269 mm rain while Idar recorded 151 mm on 25 July. Sabarkantha received highest rains in Gujarat at 219 mm, followed by Banaskantha with 150 mm.It was close to the heaviest rainfall in 112 years in the affected region. Thiese floods are Flash Flood.

d) Consequences & Impacts: Flash floods caused widespread devastation in Banaskantha. In fact, heavy downpour as well as outflow of water from dams severely affected many districts. Sipu and Dantiwada dams, which reported an outflow of 2.5 lakh cusecs and 2.3 lakh cusecs of water respectively, were put on high alert. Severe monsoon flooding has killed 213 people in Gujrat and western India fearing the death toll would rise as receding waters that may add also. Nearly 130,000 people have been relocated to safer ground in Gujarat state after hundreds of cities and villages were devastated by weeks of torrential rain. Helicopters and boats are combing areas including the deluged Banaskantha district where 25 bodies, including 17 members of one family, were discovered in two submerged villages last week (India floods: 213 killed in Gujarat as receding waters reveal, n.d.). There was breach in Narmada Canal near Thara, Gujarat in Banaskantha. The runway of Ahmedabad airport was damaged (Fig 16) and two Air India flights were diverted. As of 26 July, of the 203 dams and reservoirs in state, 38 were full, 19 were filled to between 80-90% of their capacity, 15 to between 70%-80% and 130 were filled to less than 70% capacity. 25% of Kharif crop sowing in Gujarat, especially and Saurashtra and north Gujarat was lost.The damage was assessed at Rs.10 crore for National Highways and Rs. 26 crore for State Highways. 11 out of 20 trains operating between Mumbai-Delhi were cancelled due to damage to tracks near Palanpur. 915 GSRTC bus trips were cancelled in northern districts.

Figure 16 Gujrat flood: Ahmedabad airport runway damaged (dnaindia.com dt 26.07.17)
(https://www.dnaindia.com/india/report-gujarat-floods-ahmedabad-airport-runway-damaged-two-ai-flights-diverted-2514119)

e) Actions taken on pre, during, and post-events: More than 113,000 people were evacuated to safety and more than 17,000 of them were rescued with the help of the Indian Army, Indian Air Force (IAF), the Border Security Force (BSF), the National Disaster Response Force (NDRF) and the State Disaster Response Force (SDRF). Ten IAF helicopters, five Army columns, 18 BSF teams and 32 teams from the NDRF, 11 teams from the SDRF and the local teams were deployed for rescue and relief operations. Over 2,000,000 food packets were distributed in affected districts in north Gujarat (Ref. 19). 12,000 people were moved to safety and at least 100 people were rescued in Rajasthan. 90 relief camps were set up for affected people. The electricity supply was restored in 700 villages. More than 1,500 sanitation workers were deployed in Banaskantha and Patan districts to prevent outbreaks and more than 10,400 carcasses were disposed.

Around 2 lakh cusecs (5,700 m^3/s) of water was released from Dantiwada Dam on the West Banas River due to heavy inflow from Rajasthan. Dharoi Dam also released water 1.3 lakh cusec (3,700 m^3/s) of water in Sabarmati River, thus submerging the lower promenade of Sabarmati Riverfront in Ahmedabad. Vasna Barrage was open to release water from the river.

The Government of India announced an interim relief package of Rs. 500 crore (US$70 million). It is also announced that ex gratia of Rs. 2 lakh (US$2,800) be given to the next of kin of the deceased and Rs. 50,000 (US$700) to people seriously injured in the floods.

f) Lessons learnt:

Suitable institutional arrangements should be made between Gujarat and Rajasthan so as to improve preparedness for any probable flood in Banas and Sipu rivers as the two States share the catchment areas of both the river systems. Formation of high level Expert Committee for the Dantiwada dam on Banas and Sipu rivers is essential. This committee in consultation with the State government should take decision on-site to appropriately regulate and release water from upstream lakes/ tanks keeping in view hydrological and meteorological forecasts issued for the region. During heavy rainfall, this committee with information to the State Governments may take decisions on releasing water from lakes/ tanks/ water bodies after reviewing the inflow forecasts.

3.5.3 Gujarat, 2015

a) Year/Time of event and its duration: July 2015

b) Areas affected: Large parts of the Saurashtra region of Gujarat were ravaged by floods

c) Causes and factors: Four days of incessant rain. Between June 19 and 23, the area received twice the average annual rainfall. Some areas recorded more than 300 mm of rain in 24 hours, causing major flooding across the state. Rajkot recorded 206 mm of rainfall, almost as much as the 240 mm it would see on average during the whole of July

d) Consequences & Impacts: The deluge left 72 dead and nearly 50 missing. More than 60,000 head of cattle were washed away and about 1,20,000 houses destroyed (July 2015 Gujarat flood, n.d.)."I do not feel like living here anymore... The water took away everything," said a villager from Shapur village, expressing the shock and desperation of the hundreds of thousands who last month saw their homes and houses, their livestock and belongings, all swept away before their eyes by a spate of water.

Ironically, it had been a dry season till then, and the villagers were beginning to fret as the time for sowing the winter crop approached, and the fertility of the soil remained unrenewed by the annual rains. Then, on June 19, they danced with joy as the dark clouds gathered and it began to rain.But by the fateful midsummer's night, their dream had become a nightmare. After two days, during which sheets of water - gusted by winds of up to

115 kmph - lashed the area with cyclone. The panic-stricken administration, afraid that the water would breach the dams, had to open the floodgates. And the fury of the streams swept across the countryside in an appalling tide of destruction. In addition, the rivers Ojat, Bhadar and Madhuwati overflowed their banks, inundating an area nearly 400 km wide.

Cut Off: As a result, the entire communication network went to pieces. Roads and rail lines were breached, telephone lines down, and at the peak of the disaster, even wireless communication broke down. According to estimates, about 50 highways were damaged. Of the Vanthali-Veraval road, 8 km were washed away.

A railway line breached near Vanthali: Communication disrupted Villagers in remote areas sat precariously perched on rooftops and trees awaiting relief, which in the first few days was virtually non-existent. After days of hunger and fear, they clawed at one another for a share of the bags of grain and the food packets that were air-dropped.The calamity is so enormous that we will not be able to do enough."Cyclonic fury, 27 minor dams in Junagadh district were overflowing, some by over 7ft.

e) Actions taken on pre, during, and post-events: In Sarkhai village in Junagadh, air force helicopters brought bags of wheat flour six days after the village was cut off. As the helicopters took off, a horde of villagers jushed to grab the flour. In the ensuing melee, the bags were torn and half the food lost as the desperate villagers rushed to their half-destroyed huts with meagre handfuls. Desperation was everywhere. Rama Sutar of Shapur village had starved for three days. Dizzy with hunger, and the pain of losing his entire family, he was in semi-delirium driven to eat a dead cat. Later, disgusted by his act, he said: "I cannot explain how sick I feel after eating it."

f) Lessons learnt:

- Regional rescue centres are to identify may be Municipal Corporations as and mandated therewith one of their regular activities so that they are able to operate functionally during any crisis. Such association actually helped during the floods in Gujarat. Similar practices may be replicated by other States.
- Regular monitoring of flood preparedness in the vulnerable areas, collection and compilation of post disaster data, documentation of best practices and lessons learnt has to be done by the state/ district(s). This can further be used for capacity building activities

3.5.4 Gujarat, 2013

a) Year/Time of event and its duration: Between June 19 and 23, 2013

b) Areas affected: Last month, large parts of the Saurashtra region of Gujarat were ravaged by floods, following four days of incessant rain.

c) Causes and factors: As the rainy season starts its journey, Surat and its interior villages transformed into a nightmare. The water level of the Ukai reservoir rose with the incessant rains and to control this, governing authorities of the place had to release water in large quantities. This invariably led to flood havoc in Surat.

d) Consequences & Impacts: The release of water from Ukai Dam, resulted in flooding of upto 1 foot of water in some areas of Surat. Local authorities had ordered that all Surat's educational institutions should be closed for a day. Around 250 residents of flood-prone areas in the city were asked to relocate temporarily. Areas of Surat city which were affected by flooding at the time include: parts of Ring Road, Bharimata, Kailashnagar, RTO office at Pal, Hodi Bungalow, Kadarshah Ni Nal, Ved Road, and the area around the Swaminarayan Temple at Adajan. Currently there were 14 districts with a total population of about 4 million people affected by floods

due to recent heavy rainfall in Gujarat (Fig 17). Gujarat was first hit by flooding brought by this year's monsoon in late June 2015, when dozens of people lost their lives. At the time, the death of several Asiatic lions particularly caught the attention of the world's media. Floods struck again in the state after heavy monsoon rainfall in late July. Between 23 and 28 July, the city of Rajkot saw a total of 423.2 mm of rain. Around 13 people died in the floods during that time (Flooding in Gujarat, India, n.d.), with the worst affected districts being Banaskantha (four deaths), Patan, Rajkot and Kutch (three deaths each). Seventeen NDRF teams had been deployed for rescue and relief operations in Gujarat, and food packages had been distributed by air to the affected areas.

Figure 17 Shapur village near Junagadh: Devastated (Source: indiatoday.in. RAMESH MENON July 18, 2013)

(https://www.indiatoday.in/magazine/indiascope/story/19830731-large-parts-of-saurashtra-region-of-gujarat-ravaged-by-floods-600-dead-770860-2013-07-18)

e) Actions taken on pre, during, and post-events: The floods once again revealed the inability of the Authority to handle crises in time. Even two days after the calamity, the Government machinery remained paralysed; officials knew nothing of the plight of Shapur - only 8 km from the district headquarters at Junagadh, though the water level was 11ft in the devastated village. Villagers rush to a helicopter bringing food packets: Inadequate supplies.

3.5.5 Gujarat, 2006

a) Year/Time of event and its duration: 7-10 August, 2006

b) Areas affected: In the city of Surat and nearby villages flood occurred on 7–10 August 2006, which caused tragedy to residents and other public. About 80–95% of area of Surat was flooded. More than 11000 villages across 17 districts are staggering under the onslaught of rains. The districts worst-hit by the flood are Narmada and Surat in South Gujarat, Surendranagar districts in Saurashtra, Vadodara, Junagadh, Jamnagar and Rajkot.

c) Causes and factors: The sudden release of a large amount of water into the Tapti River from the Ukai Dam caused the deluge. The Government of Gujarat described the flood as a disaster, while other agency described the flood as being the result of mismanagement. This flood was a Riverine flood.

Before 1972, Surat had suffered frequently flood and the peak water flow remains very high (>15lac cfs). Keeping in view of floods taking place and to minimise the effect in the area, a large dam called Ukai Dam was constructed in 1972. The objective was to control flood. There after no flood took place in upstream of Surat till 1998. During monsoon of 1998 flood takes place in 30% area of Surat due to the release of water from Ukai Dam .

In the year 2006, heavy rainfall takes place in upstream of Ukai dam and hence the inflow at Ukai Dam increased (2006 Surat flood, n.d.). The water level of the dam reservoir was increasing rapidly (Fig 18). On the morning of 3 August, the reservoir had already crossed the prescribed rule level of 333.60 feet (101.68 m).

Table - 2 Water level and flow at Ukai dam reservoir

Date (2006)	Time	Inflow (cfs)	Outflow (cfs)	Water level (m)
Aug 5	8 am	85,958	26,664	102.20
	8 pm	48,554	23,640	102.26
Aug 6	8 am	75,087	124,920	102.14
	8 pm	330,216	254,780	102.57
Aug 7	8 am	853,679	409,004	103.46
	8 pm	1,072,680	816,036	104.22
Aug 8	8 am	1,053,133	844,092	104.97
	8 pm	961,466	907,316	105.33
Aug 9	8 am	856,000	850,000	105.34
	8 pm	711,757	650,000	105.38

The inflow at dam was 85,958 cfs on 5 August 8 am, then rose to 330,216 cfs on 6 August 8 pm. On the morning of 7 August, it became 853,679 cfs.

By that time the reservoir was already 90% full, leaving very little empty space left to accommodate the floodwater coming from upstream. The inflow was still increasing. The peak inflow during the flood was about 1,200,000 cfs, but it lasted only for two hours.

Operating the gates of the dams increased the outflow rapidly. The outflow increased from 124,920 on 6 August, 8 am cfs, to 409,004 cfs on 7 August 8.00 am. Maintaining the same pace of increase the outflow was increased to a peak of 907,316 cfs at 8 pm on 8 August. The heavy outflow of about 900,000 cfs for a prolonged period of time caused the flood in Surat and other downstream villages. The high tide of the sea during the flood further reduced the drainage capacity of the river and worsened the damage due to flooding.

Figure 18 Ukai dam is at highest water level 344 ft near threatening (Divyabhaskar.co.in Dt Aug 15, 2010)

(https://www.divyabhaskar.co.in/news/the-ukai-dam-highest-level-at-more-than-344-feet-near-threatening-surface-after-flood-of-2006-in-surat-125829286.html)

d) Consequences & Impacts: The floods had marooned the entire Surat city and south and central Gujarat and had claimed over 250 lives, in direct and indirect rain-related incidents, besides causing immense loss to (oneindia.com) property.

The marooning of Surat city and district and other areas of Gujarat could have been averted if the release of Narmada water from Ukai dam had been started 36-42 hours earlier with a rationalised flow rather than releasing 9 lakh cusecs of water from August 7 that was increased to 11 lakh cusecs within 24 hours. The Surat administration had instructed the Ukai dam authorities to release the water gradually but they failed to follow it. Power supply in more than 2000 villages had been disrupted.

The flood's direct and indirect monetary losses had been estimated at Rs 16,000 crore, of which Rs 9,500-cr was in form of direct damages and Rs 6,500 crore in form of lost production.

e) Actions taken on pre, during, and post-events: With partner organisations Behavioural Science Centre, Maldhari Rural Action Group (MARAG) and Bhal Mahila CCS, Action Aid had surveyed Ahmedabad, Banaskantha, Sabarkantha and Surendranagar districts. What was found is that Dalits and indigeneous tribes were in dire need of relief.

But the district administration had been open about bridging gaps in the relief process. But despite this, food and medicines were urgently needed.

f) Lessons learnt:

- The efficiency of the real time operation of a reservoir system mainly depends upon the data observation and transmission network in the basin.
- As far as possible efforts be made to install automatic data collection and transmission system;
- The version of Activity Resoource Service Protocol (ARSP) model used, works on monthly timestep which though seems to be adequate for planning purpose studies, but the timestep is too large for actual operation of reservoirs;
- It has no capability to analyse the data when the data is available on real time basis through automatic / semi-automatic data transmission systems;
- It does not have the capability to calculate water demands through change in cropping pattern;
- The version of ARSP model employed, is not very user-friendly and has no graphic user interface / graphical outputs well; and
- The main component of operation of reservoir during floods is not there in ARSP version used, as the minimum timestep on which it can work is monthly whereas flood operation requires much shorter timesteps. In any big reservoir water storage from rainfall or receiving from any river should not keep fill more than 80% of its capacity.
- Whenever prolong and intense rain, then flow of water should be sustained from beginning.

3.5.6 Gujarat, 2005

a) Year/Time of event and its duration: 27th August 2005

b) Areas affected: 20 districts (out of 33), with 10 of them severely affected. 117 of the 225 Tehsils (Talukas or mandals), 11 cities were included, and more than 7,200 villages inundated, with up to 10,000 affected.

c) Causes and factors: Owing to unprecedented heavy rains due to monsoon's upper air cyclonic circulation over Saurashtra & Kutch since last four days had resulted into flood situation and inundation of low-lying areas. The situation in the state was reported to be critical in the districts of Vadodara, Kheda and Anand. The state had received a cumulative average of 505 mm of rainfall and 91 mm of rainfall during the last 24hrs.The rivers reported to be flowing above danger levels were Vishwamitri (Vadodara District,) Shedhi and Vatrak (Kheda district).

d) Consequences & Impacts: The monsoon flood, affected the state of Gujarat, included 20 districts (out of 33), with 10 of them severely affected. 117 of the 225 Tehsils (Talukas or mandals), 11 cities were included, and more than 7,200 villages inundated, with up to 10,000 affected. The cumulative 505 millimetres (19.9 in) of rain left approximately 176,000 people homeless during the flooding that included the drowning of a rare Asiatic lion from the Gir wildlife sanctuary. At least 173 people were killed in the flooding while 11 persons are missing. State Government in association with concerned Central Ministries/Departments were taking necessary relief and rehabilitation measures in the affected areas (2005 Gujarat flood, n.d.).

The power supply had been affected in 4547 villages, 31 Towns, while 1800 electricity feeder and 667 electricity distribution transformers had been disrupted. A total of 108 persons had been reported dead either due to drowning, collapse of building walls. The railway tracks at many low lying stretches had been submerged. Transportation in the affected districts were reported to have slowed down due to closure of 210 state managed road routes, but 40 state road routes were remained opened for movement. 1117 panchayat managed roads had been closed for movements. One bridge in Amerli (1- Raidi) was washed away.

e) Actions taken on pre, during, and post-events: 197276 persons had been evacuated from Surendranagar (916) Bharuch (30000), Kheda (28941), Navsari(25096), Surat (28133), Ahmedabad (1108) and Valsad (3800), Vadodara (50869), Anand (13637) Amreli (11525), Bhavnagar (1216), Gandhinagar (390), Jamnagar (200) Junagadh (940), Mahesana (230), Panchmahal (51) Sabarkantha (200) districts. During the past 24 hrs in the worst affected districts of Kheda 2000 persons and in Vadodara 25742 persons had been evacuated to safer places (Ref. 23). In Dakor town of Kheda districts 40 persons had been rescued and moved to temporary shelters. At the relief camps necessary requirements: food, drinking water, light had been arranged. The drinking water arrangements were being coordinated by GWSSB through portable tankers.150,000 food packets and 120,000 drinking water bottles had been distributed. A team of 500 members of which 34 medical officers and 200 Para medics had been deployed in the relief camps. Adequate supply of needed medicines, chlorine tablets and disinfectants had been made available by the administrations. The irrigation department had issued high alter for 33 dams in the affected districts and 9 dams on were on alert while 12 dams are on warning level. The water level of the Sardar Sarover Dam in 110.6 mts and the current level of water in the dam were 111.55 mts. The state has requisitioned 6 army Colums of 500 personnel had been deployed while 6 Indian Air Force Helicopters had been conducting rescue and relief operations. 600 trained SRP personnel and State Police force had been deployed. The trained fire bridge rescue teams from all city municipal Nagarpalikas (city local bodies) were carrying out emergency operations in the affected cities. 35 boats had been deployed for rescue operations Power supply had been restored in 2815 villages and 22 towns with 997 feeders restored and 303 electricity distribution transformers restored.

f) Lessons learnt:

- In order to reduce flood damage in future the effective way is to prevent development in flood prone lands. So the best approach is zoning of such land, however the land use planning as discussed should be adopted so the land contains an outlined use. Zoning can be used to scale back damages from flooding and must be so flexible to acknowledge that different types of land use are compatible.

- All urban water bodies will be protected. Efforts will also be made to restore water bodies by de-silting and taking other measures. Efforts will also be made to revive water bodies that have been put to other uses. Water bodies will be an integral part of the stormwater system.
- The nallahs/ drains/ watercourses/ flood plains should be clearly delineated and boundaries fixed in new developments. There will be strict enforcement of the relevant byelaws/regulations in the new layouts.

3.5.7 Gujarat, 2000

a) Year/Time of event and its duration: The heavy rains at the beginning of the monsoon had caused flooding in and around the city of Ahmedabad, as well as in two other districts from 28th August, 2000 onwards few days flood took place in and around Bharuch.

b) Areas affected: In the western state of Gujarat, the heavy rains at the beginning of the monsoon had caused flooding in and around the city of Ahmedabad, as well as in two other districts.Flooded low-lying areas were along the banks of the Narmada River in Bharuch. Apart from Bharuch, Ankleshwar and Jhagadia talukas were among the worst affected.

c) Causes and factors: Panchmahal, Rajkot, Banaskantha, Vadodara, Botad, Ahmedabad and some other districts received heavy showers, disrupting normal life and causing overflowing of several rivers and lakes. Sardar Sarovar Dam in Narmada district received over 10 lakh cusec (cubic foot per second) of water due to heavy rainfall in its catchment areas. Out of this, around 8.4 lakh cusec water was being released into the Narmada River, which caused it to swell and flooding in low-lying areas in the downstream districts of Narmada and Bharuch.

d) Consequences & Impacts: This happened after a very severe drought that had affected millions of people in the state. In Ahmedabad, the economic and financial capital of the state with a population of 3.5 million people (including 40% urban poor), almost every public utility collapsed. Many parts of the state were cut off as highways and roads were flooded. Some 110 deaths were reported in Gujarat (India - Floods OCHA Situation Report No. 2, n.d.), with the highest number in Ahmedabad alone. The possibility of water-borne disease and infections is high, the biggest threat being a spread of gastro-enteritis.

e) Actions taken on pre, during and post events: The Government of Gujarat put the state administration on high alert, and relief and rescue operations were initiated immediately. By 20 July, some 22,000 cases of fever, diarrhoea and respiratory infections had been identified. Mobile health teams have been set up.

UNICEF received an urgent request from the Government of Gujarat for emergency supplies of ORS, chlorine tablets and doxycycline tablets to meet additional demands and undertake preventive steps. UNICEF has agreed to provide: 1 million ORS packets, 100,000 doxycycline capsules and 20 million chlorine tablets, as well as 100,000 bottles of co-trimaxazole syrup and 100,000 bottles of paracetamol syrup for treatment of pneumonia in young children.

3.6 State/UT: Himachal Pradesh

Major Floods in 2005

3.6.1 Himachal Pradesh, 2005

a) Year/Time of event and its duration: In June, 2005

b) Areas affected: It led to an extensive damage to about 350 kilometers of road length at various places from Samdo to Gobindsagar (Bhakra Dam).

c) Causes and factors: The flood taken place at upper catchment of China where Satluj was flooded in June 2005 after a flash flood of huge magnitude due to sudden breach of Parichu (river) in the Chinese territory, took place. The existing national highway (NH-22), which provides the only road link to these areas, is highly prone to damage due to floods. It runs dangerously close to the river at places and criss-crosses it six times between Wangtu and Khab. Its vulnerability was exposed during the August 2000 floods when 18 small big bridges on the river and vast stretches of road totalling about 20 km were washed away. Consequently, large parts of the tribal belt remained cut off for almost a year.

The latest flood due to the breaching of the Parechu Lake in Tibet had again washed away as many as eight important bridges and wiped out a vast stretch of road. The disaster has underlined the need for constructing an alternative road, particularly for the 100 km stretch from Wangtu to Khab.There was very little population along the banks of the river. The main concern was the highway. It crossed the Sutlej after every few kilometres with bridges at Wangtu, Karcham, Shong Tong, Riba, Khadra and Khab, all of which were wiped out in the August 2000 floods.

d) Consequences & Impacts: As a results of flooding, the 1500 MW Nathpa Jhakri project was shutdown indefinitely after water entered the underground powerhouse submerging the lower portion on 4th September 2005.

e) Actions taken on pre, during, and post-events: The eight member central team, which visited flood-hit areas to assessed the damage.

The team headed by the then Joint Secretary, Ministry of Home, held a meeting with the senior officers at which it sought certain details from various departments.

Meanwhile, the choppers of the Indian Air Force made numerous sorties to airlift as many as 240 persons. While 86 persons each were airlifted from Peo and Sangla, 68 were evacuated from Pooh. Besides stranded tourists, some patients, students and employees were also airlifted. Mr Arvind Sharda, Superintendent of Police, said almost all stranded tourists had been evacuated.

The relief material sent on 21 mules to Leo village reached the destination.

About 25 persons had a narrow escape at Kaksthal, near Karcham, in the flood ravaged-Kinnaur district when boulders hit four vehicles.

People of Leo village, where most of the houses had been destroyed, no relief had been provided till yesterday. There was already a shortage of foodgrains and relief measures on a war footing were required.

f) Lessons learnt:

- The 194 Hectares Lake (called Karak Lake by the Chinese) has since frozen. After winter, as spring sets in March 2005, the people in vulnerable areas in Himachal Pradesh would again be forced to evacuate their homes and another flood would be awaited as the ice melts. Disaster may or may not happen, but one thing this periodic episode indicates is for the countries to cooperate over issues of water resources for peace and prosperity.

3.7 State/UT: Jammu & Kashmir

Major Floods in 2014

3.7.1 Jammu & Kashmir, 2014

a) Year/Time of event and its duration: 2 September 2014 onwards 5 days

b) Areas affected: Flood waters breached the banks of Jhelum, and submerged Srinagar, including the Badami Bagh Cantonment, disrupted

c) Causes and factors: In the wake of heavy monsoon rain and flash floods in Jammu and Kashmir, which allegedly killed over four hundred and rendered hundreds of thousands homeless. Jammu and Kashmir caused severe flooding, the state's worst in 50 years. Ten districts were heavily affected, almost 150 people reported dead, and a number of districts were not reachable. 7 September 14, the third day of incessant rains, when

flood waters breached the banks of Jhelum (Fig19) and submerged Srinagar, including the Badami Bagh Cantonment, disrupted "electricity, water supply and civil communications" and flooded the headquarters of XV Corps.

Figure 19 Srinagar citizens escaping flooded homes in (J&K) 2014 (Photograph: Haziq Qadri/The Vox Kashmir/BI Source: theguardian.com Dt Thu 11 Sep 2014 18.53 BST)

(https://www.theguardian.com/world/2014/sep/11/kashmir-monsoon-floods-million-displace-pakistan-india-aid)

d) Consequences & Impacts: More than 200 people had been killed in Srinagar and bodies had reportedly been seen floating in the streets (Kashmir monsoon floods leave 460 dead and displaced almost, n.d.). Police said some residents of the city had been trapped in the top floors of their homes since heavy rains caused the Jhelum River to surge last week (Fig 19).

In the region of Jammu, landslides triggered by heavy rainfall had caused serious damages to infrastructure and agricultural land. The army had launched a major rescue operation and had reportedly rescued over 200,000 people. However, over 100,000 people were marooned in their houses, with no access to food or clean water (PTI, 2014). The Jhelum River flows from Indian Kashmir to the Pakistan side, then down into the flat fertile lands of Punjab. The two embankments destroyed by the army to pass surplus water near the cities of Muzaffargarh and Multan. The new breaches flooded farmland and small villages (Press Information Bureau, 2014). Total damages crops, houses & public utilities is Rs. 8611 Cr. (Commission, 2022)

Figure 20 Deluged streets in Srinagar (J&K) 2014

(https://www.theguardian.com/world/2014/sep/11/kashmir-monsoon-floods-million-displace-pakistan-india-aid)

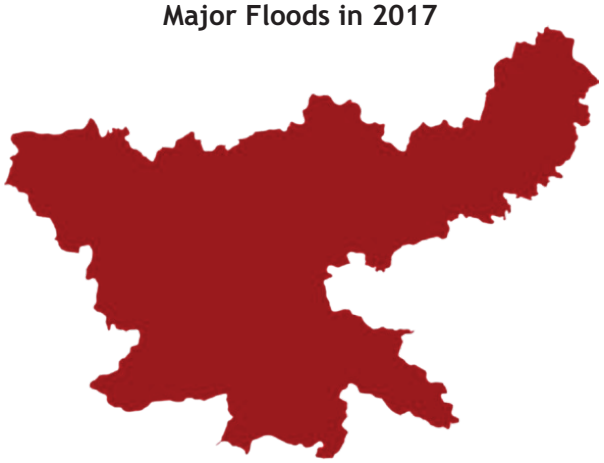
e) Actions taken on pre, during, and post-events: The rescue operations however, did not affect rescue work in "South Kashmir", the worst affected area in the first three days, and the Jammu region. In Srinagar, where the "Army does not operate" except in the "Badami Bagh Cantonment and the area of the airfield", the General said the rescue operations were mainly conducted by "Kashmiris" from Srinagar-based Jammu & Kashmir Light Infantry Centre. During the first few days, the search and rescue operation were hindered by shortage of boats and bad weather. Boats were airlifted from all corners of India, including from far away Tamil Nadu. In the absence of civil boats, the army pressed into service its boats, more appropriate for assault river crossings than rescue assistance during floods. By 11 September, there were 224 army boats and 148 NDRF's inflatable boats in the affected area conducting rescue and search operations. For those who were stranded on roof tops as flood water menacingly swirled around them, Air Force helicopters with IAF Garud Commandos help winch the stranded people to safety. Several hundred were rescued from rood tops. In some cases, the Indian Air Force (IAF) commandos had to break through the roof to rescue the trapped people.

f) Lessons learnt:

- Jammu and Kashmir witnessed intense rains during the week of 1-7 September 2014. The causes of excessive rainfall were the combined effect of the western disturbances (WD) and their interaction with monsoon rains over J&K. With the urbanized and mismanaged floodplains of the Jhelum lending impetus, the situation attained disastrous dimensions. That was also due to the prolonged extreme precipitation events observed over the entire Kashmir valley during the first week of September, exacerbated by the higher snowmelt runoff from the extensive snow-packs observed in the mountainous regions in 2014.
- There are two major reasons behind the flood vulnerability of the Kashmir valley – the inadequate carrying capacity of the river Jhelum from Sangam (Anantnag) to Khandanyar (Baramulla), and the natural flat topography of the Jhelum basin. The capacity of the flood spill channel in Srinagar has reduced from its original 17,000 cusecs to 5,000 cusecs. The Jhelum channel (capacity 35,000 cusecs) and flood spill channel proved insufficient to accommodate the enormous discharge of floodwater in September measuring more than 1,20,000 cusecs. The floodwaters of such enormous volume led to the inundation of Srinagar.
- Four tributaries of the Jhelum simultaneously brought water with enormous force and high speed at Sangam near Ananatnag. This made it difficult to manage the floodwaters. Several experts have suggested that perhaps the timing and arrival of rainwater from each tributary can be staggered to enable management of floodwaters at Sangam. The expert committee set up by the Central Water Commission has also suggested water storage in the mountains on each tributary to which flood waters could be diverted during floods and released slowly after the event. But all these suggestions would need proper studies to see what is possible in this ecologically sensitive mountain area.

3.8 State/UT: Jharkhand

Major Floods in 2017



3.8.1 Jharkhand, 2017

a) Year/Time of event and its duration: in July, 2017

b) Areas affected: Torrential rains over many parts of Jharkhand had resulted in flooding over the plains which includes cities like Giridih and adjoining areas.

c) Causes and factors: Kolhan, Jamshedpur had no respite from rain on July as it continued to pour for the third consecutive day. The release of excess water into Subarnarekha from Chandil dam Kharkai River from Bankil dam in Mayurbhanj (Odisha) on Monday night (i.e.23 July 2017) added to woes of people in low-lying areas.The incessant rain and release of dam water had crippled the lives of people living in the catchment areas. At least 1,400 houses in three urban municipal bodies of Jamshedpur, Adityapur, Jugsalai and Mango were submerged under water. Five people died after being struck by lightning in Jharkhand's Godda district and three others sustained injuries as heavy rain lashed parts of the state, an official here said. This flood was Riverine flood.

d) Consequences & Impacts: Meanwhile, reports from the different parts of the two adjoining towns confirmed that not only slums in the low-lying areas were enormously affected by the rains but several colonies in Sonari, Kadma, Jugsalai, and Adityapur are confronting the woes. The district health department on Tuesday organised health camps. DVVRC: The state government along with West Bengal's government have jointly asked Tenughat dam (Damodar Valley Corporation) officials to keep releasing water constantly to avoid reaching the danger mark and flood like situations due to incessant rainfall.

e) Actions taken on pre, during, and post-events: The district administration had ruled out any immediate need of National Disaster Relief Force (NDRF). Although the water level in two rivers has risen, Bankbil dam did not release water on Tuesday (i.e. 24 July 2017). Besides Chandil dam had also gone moderate in releasing excess water. Close to 1,500 people from the four municipal areas had been evacuated to safer places in the last 36 hours. Meanwhile, the local meteorological office forecasted continuous rainfall for the next 48 hours.

The Ranchi weather office said that in the last 24 hours (i.e. 23 -24 July 2017) the industrial town had received 143.6mm of rainfall. "Rain will continue till the next 48 hours with reduced intensity," the weathermen said.

f) Lessons learnt:

- During the period June to September, there is a significant increase in heavy rainfall days in Koderma, Dhanbad, Ranchi, Gumla, West Singhbhum and East Singhbhum districts. Whereas there was a significant decrease in Heavy rainfall days in Palamu, Latehar, Hazaribagh, Bokaro, Dhanbad, Dumka, Godda, Gumla, Simdega and West Singhbhum districts. While remaining districts did not show any significant change.
- There was a significant increase in heavy rainfall days in Hazaribagh, Koderma, Dhanbad, Bokaro, Ranchi, Lohardaga, Gumla, Simdega, West Singhbhum and East Singhbhum districts during the entire year. Whereas there was a significant decrease in Heavy rainfall days in Garhwa, Palamu, Latehar, Hazaribagh, Bokaro, Dumka, Godda, Gumla, Simdega and West Singhbhum districts.

3.9 State/UT: Karnataka

Major Floods in 2019

3.9.1 Karnataka, 2019

a) Year/Time of event and its duration: 1 August, 2019

b) Areas affected: North, coastal and Malnad districts were worst affected. Other affected districts include Bagalkot, Vijayapura, Raichur, Yadgiri, Uttara Kannada, South Kannada, Shivamogga, Kodagu and Chikkamagalur.

c) Causes and factors: Due to the heavy water discharge from the reservoir, the North Karnataka districts of Belagavi, Bijapur, Raichur, Kalburgi, Yadgir and Uttara Kannada were severely affected by the flood discharge. On 8 August, Karnataka received nearly five times the rainfall it normally used to have, adding to the severity of the ongoing floods in 12 districts that had killed 20 people by 9 August 2019.

Several north, central and coastal districts of Karnataka had continued to suffer in heavy rainfall and flooding in the peak monsoon season.

d) Consequences & Impacts: Damages = 35,160 crore Rupees (USD $4.95 billion and fatalities = 81 dead, 15 went missing. More than 2,00,000 people were evacuated and more than 2200 rescue personnel were deployed (2015 South India floods, n.d.). Some of the affected districts include Kodagu, Belagavi, Dakshina Kannada and Raichur. At least nine people had been killed as a result of the deluge and 50 cattle had perished in the flood waters, local news said. About 1,24,291 people had been evacuated by joint teams comprising of Fire and Emergency, SDRF, NDRF and the army, and 272 relief camps had been set up across affected districts. Nodal

officers were also camping in vulnerable villages. Relief and rescue operations were taken place in all the affected districts, and Chief Minister BS Yediyurappa visited the area on a date to take stock of the situation. Some of the affected districts include Bagalkot, Vijayapura (Bijapur), Yadigir and Udupi. Updates on the flood affected districts were-

Kodagu District: In Kodagu, villages along the Cauvery had witnessed major flooding. Electricity and phone connectivity was down. Two NDRF teams had been deployed, and rescue and evacuation was underway. Assistance from fire and emergency, police, army and home guards was also provided.

Shivamogga District: 1 person had died in Shivamogga. An NDRF team had been deployed to the district, and rescue efforts were underway with the involvement of Civil Défense, fire and emergency and police officials.

Belagavi District: Belagavi was said to be the worst hit district in the state. Six people were killed in rain related incidents, and 40,180 people had been evacuated. Crop loss in Belagavi was reported in 1,36,529 hectares of land. The district was likely to receive continued moderate rainfall over a week and nine NDRF teams had been airlifted to the district. 1,410 km of roads and 211 bridges had been damaged. The Air Force had rescued as many as 25 people from the district, some from treetops.

Dakshina Kannada District: District Collector told that the situation was currently under control but rivers were in spate. There was no major flooding. Floods were also expected in parts of Bantwal and Uppinangadi. So far 80 people had been evacuated. Mitigation measures were taken as required.

Uttara Kannada District: Two rain-related deaths had occurred in the district and one NDRF team was deployed.

Malnad region (Shivamogga, Uttara Kannada, Chikkamagaluru, Hassan, Kodagu districts): Heavy rain had pounded the region since Monday as villages witnessed major flooding and there was overflowing in lakes, tributaries and rivers. The area was expected to receive heavy rain over the next two days.

Raichur District: An Indian Air Force chopper had been deployed to Raichur. Reports say that helicopters were being brought in to rescue families stranded on an island in the Krishna River.

Mysuru District: With heavy rainfall in the Cauvery basin, parts of Mysuru district have been flooded. There were two-three major developments. Lakshman Tirtha River which originates from Virajpet in Kodagu that is seeing a historical flood. After 80 years, this was the greatest water flow. This was affecting one portion of Hunsur taluk. Since Waynad was flooded. There were two small reservoirs which collect water from the forest areas, they are also full which is unprecedented. Mysuru DC reported. 200 plus people had been evacuated from low lying areas, It is a continuous process, There was one casualty where a mud house collapse on the fringes of Nagarhole.

Damages due to Karnataka flood, data released by Karnataka Chief Minister's Office (2019 Karnataka floods explained, n.d.)

- Human lives lost : 61
- People Missing : 15
- Animal death : 859
- People evacuated : 697948
- Animals rescued : 51460
- Relief camps opened : 1160
- People in relief camps : 396617

- Houses damaged : 56381
- Districts and Taluks affected : 103 taluks of 22 districts affected and
- Agriculture and Horticulture crop loss (preliminary assessment) : 6.9 lakh hectare.

e) Actions taken on pre, during, and post-events:

Karnataka State Disaster Management Authority, Karnataka police along with the Indian Air Force, civilians, volunteers, fishermen from coastal Karnataka were actively taking part in the rescue operations in flood-affected regions. A joint rescue team consisting of Fire and Emergency, State Disaster Response Fund, National Disaster Response Force and Indian Army evacuated 6.73 lakh people as of 14 August 2019. Nobel officers were tasked to camp in vulnerable villages. On 4 October 2019, Central Government had released an amount of 1200 Crores as Karnataka flood relief funds on the request of CM Yediyurappa.

f) Lessons learnt:

As the crisis worsened, the flood waters were spreading across 18 districts, not just in the hill regions of the Western Ghats, but widening its coverage into the Deccan plateau, the dry regions of Karnataka and Maharashtra, with the Krishna and its tributaries overflowing, taking toll of both urban areas and the fertile cultivated belt of Belagavi, Kolhapur and Sangli. Compared to the floods of 2018, this year the devastation caused had surpassed all the records in terms of loss of human lives, property, livestock and livelihood.

Karnataka Chief Minister said "that the floods and heavy rains had caused more Rs 6,000 crore worth damage in terms of crop loss and damage to property". About 18 of the state's 30 districts were affected by heavy rains; some three lakh people in 2,000 villages were facing distress due to severe flooding and heavy rains.

3.10 State/UT: Kerala

Major Floods in 2020, 2019, 2018

3.10.1 Kerala, 2020

a) Year/Time of event and its duration: Between 1 June and 18 August 2020,

b) Areas affected: All 14 districts in Kerala

c) Causes and factors: Kerala experienced 5 low pressure systems during the south west monsoon season in August 2020. This combined with strong winds over the Arabian Sea resulted in cloudbursts which

saturated soil structures, further weakening bedrock, overwhelming rivers and drainage systems. Kerala experienced 190% increase in rainfall in the first 10 days of August compared to normal patterns, causing widespread destruction, flooding and landslides (Fig 21). Coastal towns, such as Chellanam, dealt with floods as well as rough seas pushing back on rivers, exacerbating flooding. It was affected with 104 dead and 40 injured. 1,670 villages in Kerala affected (2020 Kerala floods, n.d.). The flood was due to riverine flood.

d) Consequences & Impacts: According National Emergency Response Centre (NERC), 125 people had died in Kerala.

Direct impacts

The landslide in the Pettimudi tea estate saw significantly heavy rainfall, resulting in excessive flooding and landslide over a 1.2km tract. Final reports indicated that it destroyed 4 buildings and killed 66 individuals. Majority of the victims were descendants from the Dalits caste system. Meanwhile, low-intensity mudslides and landslides occurred in other regions.

Indirect impacts

Search and rescue efforts in this area were stalled due to bad weather conditions. The collapse of the Periyavarai bridge, which is the only connectivity for interstate transport between Munnar to Marayur was also an issue.

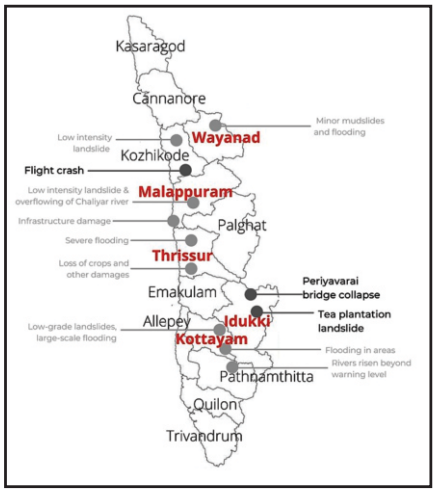


Figure 21 Kerala district map depicting flood (Source: wikipedia)

(https://en.wikipedia.org/wiki/File:Kerala-map-en.svg)

Authorities reported closure of multiple routes including the Pala-Erattupetta road in the Kottayam district where the Meenachil River overflowed into neighbouring towns. Destruction of power lines further affected communication links to the area which caused logistical difficulties in the supply of basic necessities. Evacuation and relocation efforts led to many residing in temporary relief camps. A mild increase in COVID-19 cases was reported in Chellanam's relief camps, complicating the situation. Agricultural produce was also affected with loss of crops, especially in Kuttanad, and disruptions to transportation caused an increase in food prices. According to the Ministry of Home Affairs, a total of 1,670 villages were affected, 104 lives lost and 40 injured. Short-term health consequences post-flood include injuries and communicable diseases (e.g. diarrheoa) while long-term impacts includes poor health outcomes due to aspects like malnutrition and mental health issues.

e) Actions taken on pre, during, and post-events: IMD monitors weather and Kerala State Emergency Operations Centre (KSEOC) issue colour coded extreme weather alerts. KSDMA provides public alerts through their website and social media platforms. KSEOC is working with the Geological Survey of India, Kerala University and Kerala Development and Innovation Strategic Council to develop a landslide early warning system. In 2020, 14 permanent multipurpose shelters were constructed by KSDMA with funding from the World Bank. Civil defence systems have increased training to support search and rescue efforts and the government has given greater autonomy to local agencies and NGOs.

Operations involve the implementation of disaster event preparations from Rapid Action Force (RAF), NDRF and Kerala Fire and Rescue. During the floods, NDRF set up 6,300 relief camps with COVID-19 categorisation. COVID-19 restrictions resulted in fewer vector-borne diseases. Damage and cost estimates are made prior to reconstruction with funding from the State and National Disaster Response Funds.

3.10.2 Kerala, 2019

a) Year/Time of event and its duration: Between August 8 and 29, 2019.

b) Areas affected: Malappuram, Kozhikode, Wayanad, Ernakulam, Idukki and some more districts wereseverely affected.

c) Causes and factors: Due to heavy rainfall in the monsoon season, affected Kerala severe flood. This flood was due to riverine flood.

d) Consequences & impacts: The heavy rains and landslides had resulted in the complete destruction of infrastructure and means of livelihood of people in many places across the (Keala Floods 2019: 121 dead, 1,789 Houses Collapsed, n.d.) (Fig 22) state. The government assessed the magnitude of damage due to heavy rains and landslides in the state that was recovering from last year's flood which claimed the lives of more than 450 people and damaged properties worth Rs. 40,000 crore. As per the data from the Kerala State Disaster Management Authority (KSDMA), as many as 1,789 houses had been damaged fully in between August 8 and 19, whereas the number of partially damaged houses were 14,542.

Figure 22 Kerala flood (Source: News Clickdt20 Aug 2019) (https://www.newsclick.in/Kerala-Floods-2019-Death-Toll-Rise)

The landslides in Kavalappara in Malappuram and Puthurmala in Wayanad washed off the entire area. It was reported that the death toll all across the state rose to 121, while more than 20 people were missing.

e) Actions taken on pre, during, and post-events: Kerala's State Disaster Management Authority, Kerala police,Kerala Fire & Rescue Services along with the Indian Air Force, Indian Navy, civilians, volunteers like Seva Bharati, White Guard Volunteers fishermen from coastal Kerala were actively taking part in the rescue operations in flood-affected regions. However, inclement weather with heavy rains and landslides were hampering the rescue operations in the hilly regions of Wayanad, Malappuram, and Kozhikode districts. 83 National Disaster Response Force(NDRF) teams were deployed in addition to the 173 teams of Army, Navy, Air Force, and Coast Guard to take part in the relief operations.

Animal rescue was carried out by local NGOs and activists on ground mainly in places like Wayanad and Nilambur. Notable work was done by Sally Varma of Humane Society International/India in Nilambur where around 500 kg of dog food and more than 5000 kg of cattle feed and 2500 kg of goat feed was distributed to the starving animals.

Immediate financial aid of up to Rs 10,000 each for all calamity-hit families which had suffered losses in the torrential rains. A sum of Rs 4 lakh would be given to those whose houses had been fully damaged or had

become uninhabitable and Rs 10 lakh to those who had lost their houses as well as land in the rain fury and landslides, Chief Minister's cabinet meeting.Kerala Govt Announces Flood relief Package; Rs 10,000 Immediate Aid to Calamity-hit Families.

f) Lessons learnt:

- The lessons learnt from the disasters and the response reveals that irrespective of the group, all the vulnerable populations substantially lag behind and do not enjoy the human development. In addition to that, these populations were severely impacted by the floods and landslides and their historical marginalisation has been further augmented and complicated. It was found that within each vulnerable group there were sub-populations with differential and layered vulnerabilities.
- The findings reveal that ad hoc measures to address the impact of the disasters on the vulnerable populations serve only as a partial solution, and do not address their historical vulnerabilities. What is really needed is farsighted and focused policy interventions to address the root causes of the vulnerabilities to ensure that the human development that the state claims percolates to the vulnerable populations also. Instead of claiming an edge over the less advantaged geopolitical contexts within the country, it is time Kerala examined how the state has failed the vulnerable populations within it. Taking cognizance of their inherent and newer vulnerabilities, substantial investments are needed to nurture inclusive and resilient communities where no one is left behind

3.10.3 Kerala, 2018

a) Year/Time of event and its duration: July - August 2018

b) Areas affected: Heavy rains in Wayanad and Idukki have caused severe landslides and had left the hilly districts isolated. Flooding took place in 13 out of 14 districts in the State (Fig 23).

c) Causes and factors: Heavy rain Discharges Landslide. Kerala received heavy monsoon rainfall, which was about 116% more than the usual rain fall in Kerala, on the mid-evening of 8 August, resulting in dams filling to their maximum capacities; in the first 48 hours of rainfall the state received 310 mm (12 in) of rain. Almost all dams had been opened since the water level had risen close to overflow level due to heavy rainfall, flooding local low-lying areas. For the first time in the state's history, 35 of its 54 dams had been opened

As per IMD data, Kerala received 2346.6 mm of rainfall from 1 June 2018 to 19 August 2018 in contrast to an expected 1649.5 mm of rainfall. This rainfall was about 42% above the normal. Further, the rainfall over Kerala during June,

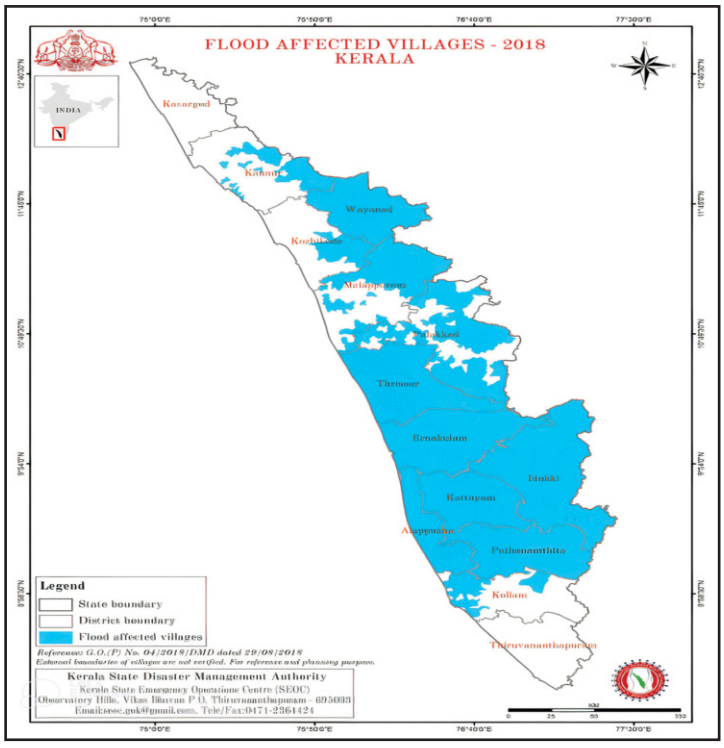


Figure 23 Flood affected areas in Kerala

(Source- https://sdma.kerala.gov.in/wp-content/uploads/2019/08/ Memorandum2-Floods-2018.pdf)

July and 1st to 19th of August was 15%, 18% and 164% respectively, above normal. Month-wise rainfall for the period, as reported by IMD, is given in Table-3.

Table-3 Month wise actual rainfall, normal rainfall and percentage departure from normal

Period	Normal Rainfall (mm)	Actual Rainfall (mm)	Departure from normal (%)
June, 2018	649.8	749.6	15
July, 2018	726.1	857.4	18
1-19, August, 2018	287.6	758.6	164
Total	**1649.5**	**2346.6**	**42**

Malappuram recorded 153.8 mm of rain in 24 hours to 14 June, with Palakkad recording 94.8 mm and Wayanad 104.7 mm during the same period. Kozikod recorded 81.4 mm in 24 hours to 15 June.

d) Consequences & Impacts: Over 483 people died (2018 Kerala floods, n.d.), and 140 were missing, while the local news reported that 33,000 people were rescued. The Kerala State Disaster Management Authority had placed the state in a red alert as a result of the intense flooding. A number of water treatment plants were forced to cease pumping water, resulting in poor access to clean water, especially in northern districts of the state. Over 3,274 relief camps had been opened at various locations to accommodate the flood victims. It is estimated that 1,247,496 people had found shelter in such camps. The flooding had affected hundreds of villages, destroyed an estimated 10,000 km (6,200 mi) of roads and thousands of homes had been damaged or destroyed.The Government cancelled Onam celebrations, and the allocated funds had been reallocated to relief efforts.On 12 August, Cochin International Airport, India's fourth busiest in terms of international traffic, and the busiest in the state suspended all operations until 29 August, following runway flooding. All schools throughout the state except Sainik School Kazhakootam had been closed, and tourists had been dissuaded or banned from some districts due to safety concerns.Kochi Metro was closed briefly on 16 August, and later offered free service to aid those affected by the flooding. Due to heavy rain and rising water levels the southern railway had suspended train services on the Thiruvananthapuram-Kottayam-Ernakulam and Ernakulam-Shoranur-Palakkad sections

e) Actions taken on pre, during, and post- events: Rescue operation at government level the Cabinet Secretary, senior officers of Defence Services, NDRF, NDMA and secretaries of Civilian Ministries conducted meetings with Kerala Chief Secretary. Following the decisions taken during these meetings, the Centre launched massive rescue and relief operations. In one of the largest rescue operations 40 helicopters, 31 aircraft, 182 teams for rescue, 18 medical teams of defence forces, 90 teams of NDRF and 3 companies of Central Armed Police Forces were pressed into service along with over 500 boats and necessary rescue equipments

Rescue Operation by Public

WhatsApp groups sprung up as Control Centers that coordinated help and support across various areas. A good majority of the population were involved in arranging supplies and help material in various ways

Rescue operation by fishermen

According to the government's estimate, a total of 4,537 from the fishermen community participated in the

rescue operation with 669 fishing boats (Ref.36). They managed to rescue more than 65,000 people from various districts. Pinarayi Vijayan, Chief Minister honoured the fishermen and the Fisheries Minister J. Mercykutty Amma said that the government will provide financial aid to repair the fishing boats which were partially damaged in the rescue operations while new ones will be provided for those boats which were completely destroyed. According to estimates, seven boats were completely destroyed, while 452 were partially destroyed

Animal Rescue

Sally Varma of Humane Society International arranged for animals to be rescued and transported to special shelters that housed affected animals. Social media has been used to highlight the rescue of multiple animals - dogs, cats, goats, cows, cattle, ducks and snakes, with animal food and medicine transported to affected areas.

A worker with the Humane Society International spoke out against the tethering and leaving of pets that occurred. "That became a problem. So many tethered animals just drowned. These animals are natural swimmers, and it is better to keep them free so they can swim to higher ground." According to government records more than 8,000 cattle, calves and buffaloes, 3,297 goats, and 47 dogs had died due to the flooding.

The District Collector of Malappuram, and its Chief of Police have instructed the police force to save any animal that they encounter during rescue operations

f) Lessons learnt:

- Kerala had reworked the social media pages of the disaster management cell and improved its outreach with media outlets, sharing constant updates on crucial weather updates. It has brought out an app 'Qkopy' for the same. A hotline phone is also in the works, for direct communication with National Disaster Response Force (NDRF), at a regional center of the cell at Thrissur district.
- Quick decisions and strong leadership can make or break relief and recovery efforts. It is important to demonstrate strong leadership to build confidence and trust of the people and the media.

3.11 State/UT: Ladakh

Major Floods in 2010

3.11.1 Ladakh, 2010

a) Year/Time of event and its duration: 6 August 2010

b) Areas affected: Leh and numerous villages

c) Causes and factors: On 6 August, 2010, in the dark of the midnight, there were flash floods due to cloud burst led to flash flooding, debris flows, and mudflows in Leh in Ladakh region of North India. It rained 14 inches in 2 hours, causing loss of human life and destruction. The rainfall distribution was highly spatially variable. The most intense part of the storm was focused in a 6-kilometre (3.7 mi)-wide band parallel to, and a few kilometers from, the river Indus. This band was centred over most of the major settlements in the area,

d) Consequences & Impacts: Deaths: at least 140 killed. Cloudburst, led to flash flooding, debris flows, and mudflows over the region took place (2010 Ladakh floods, n.d.). The rainfall distribution was highly spatially variable. 71 towns and villages were damaged, including the main town in the area (Fig 24), Leh. At least 140 people are reported to have died, six of whom were foreign tourists, and 200 people were reported missing in the initial aftermath of the storm, and thousands more was rendered homeless after the flooding caused extensive damage to property and infrastructure. Overall, 9000 people were directly affected by the event.

Figure 24 Flash flood hit Ladakh
(https://en.wikipedia.org/wiki/2010_Ladakh_floods)

The rains occurred at night, and surprised everyone. In Leh, many buildings were destroyed including hospitals, the bus terminal, radio station transmitter, telephone exchange and mobile-phone towers. BSNL communication systems were fully destroyed (D.E.J., et al)., Communications were later restored by the Indian Army. The local bus station was severely damaged and some of the buses were carried more than a mile by the mud. The city's airport was damaged but was rapidly repaired to allow relief flights the following day. The village Choglamsar on the outskirts of the city was particularly badly hit.

In neighbouring valleys, large numbers of smaller villages which lay under the main rainfall band were also heavily damaged, with large numbers of casualties. As in Leh, much of the destruction was caused by debris flows coming from the rocky sidewalls of the valleys, not by the flooding itself. Notable impacts occurred in Sobu, Phyang, Nimu, Nyeh, and Basgo villages. In total, almost 1500 homes in 71 settlements across the area were reported to have been damaged. Detailed mapping and estimation of the entrapped sediment mass within the transverse stream valleys of various sectors of Himalaya is required to predict the style of mass transfer during such events.

All of the estimated 3000 tourists in Leh, including 1000 foreigners were safe according to local officials

In Leh, many buildings were destroyed including hospitals, the bus terminal, radio station transmitter, telephone exchange and mobile-phone towers. BSNL communication systems were fully destroyed.

e) Actions taken on pre, during, and post-events: The rescue efforts were hampered by gushing water and mud which was 10 feet high in places. In addition many of the roads and bridges leading to Leh were

damaged, making it difficult to truck in relief supplies. Four hundred critically wounded people were evacuated and some were admitted to the army hospital in Leh. Indian Army soldiers launched a massive rescue operation. The then Home Minister said that over 6,000 security personnel were deployed in Leh for rescue operations. The then Prime Minister expressed grief and announced compensation of Rs. 100,000 to the kin of deceased and Rs. 50,000 for those injured. Chief Minister of the state directed the administration to undertake relief effort on a war footing.

f) Lessons learnt:

- It is impossible to anticipate natural disasters such as flash floods. However, disaster preparedness plans and protocols in the civil administration and public health systems could be very helpful in rescue and relief and in reducing casualties and adverse impact on the human life and socio economic conditions. However, the health systems in India lack such disaster preparedness plans and training. In the present case, presence of the Indian Army that has standard disaster management plans and protocols for planning, training, and regular drills of the army personnel, logistics and supply, transport, and communication made it possible to immediately mount search, rescue, and relief operations and mass casualty management. Not only the disaster management plans were in readiness, but continuous and regular training and drills of the army personnel in rescue and relief operations, and logistics and communication, could effectively facilitate the disaster management operations.
- Effective communication was crucial for effective coordination of rescue and relief operations. The Army's communication system served as an alternative communication channel as the public communication and mobile network was destroyed, and that enabled effective coordination of the disaster operations.

3.12 State/UT: Madhya Pradesh

Major Floods in 2016

3.12.1 Madhya Pradesh, 2016

a) Year/Time of event and its duration: 7th July, 2016

b) Areas affected: Twenty-two of 51 districts in Madhya Pradesh have been affected by heavy rains in the state. Of these, Vidisha and Raisen are worst affected. Earlier, the situation in Bhopal, Satna and Rewa was worrisome

c) Causes and factors: Three days of continuous rain caused floods in Katni, Rewa, Chattarpur, Raisen, Sagar and Satna districts in Madhya Pradesh. At last 17 fatalities had been reported by Jigyasa Watwani, Bhopal received an unprecedented 24 cm rainfall on the night of 9th July 2016 which broke the record of 46 years in the city. The whole city was inundated with the rain water with leaving no area unaffected. The sudden downpour flooded the low lying areas and severely affected the slum dwellers who reside in these areas. The affected people had lost their shelter, property and their normal life being disrupted.

d) Consequences & Impacts: Some victims had died after buildings collapsed in Sagar and Satna districts and more were missing, feared dead. Efforts were made for finding survivors. Military, NDRF and State Disaster Response Force had been engaged for rescue operations over the state. NDRF evacuated 147 marooned people to safer places from Rewa district on 21 August. Rescued and save people trapped by floods Satna, Rewa, Panna and other districts. Relief camps had been set up in safer places for people in flood-hit areas.

Extreme rainfall, Long-term rainfall in the monsoon rainfall over the month of July resulted in floods in several districts of Madhya Pradesh, displacing thousands and leaving dozens dead. Further heavy rain from 19 August led to 17 deaths and rivers in Satna, including Tamas, Simrawal and Chhoti Tamas flowing close to the danger mark. River level of Narmada River at Hoshangabad - July 09 to July 12, 2016 was 292.5 metres. Fatalities 24 people, evacuated 15,000 on 7 July, 2016 Buildings destroyed 2298 buildings. Rescue efforts were being scaled up in Vidisha and Raisen. "In the last 24 hours, 1600 people had been evacuated in Vidisha alone," says DG, Home Guard of State Disaster Emergency Relief Fund, Maithili Sharan Gupta, adding that 372 rescue teams had been deployed across the state (Madhya Pradesh floods: death toll rises to 24; nearly 25,000 evacuated, n.d.). Nearly 25,000 people had been evacuated and 7,500 had been rescued in the state so far.

e) Actions taken on pre, during, and post-events: CASA and its partner organization Anupama Education Society, Satna provided immediate relief to the affected families residing in these villages. They distributed cooked food and non-food items such as clothes to the severely affected families. A total of 1,500 cooked foods were served for three days.

f) Lessons learnt:

- Modernisation of early warning and alert system is required for evacuating people during discharge of water from a reservoir.
- Need for review and revision of rule curves as per actual inflow and discharge data.
- Correlation between rule curve and controlled release of water needs to be established through capacity building of dam authorities and other concerned stakeholders.
- Identification of reservoirs for reviewing and modifying the operation manuals/rule curves by State Governments in consultation with dam authorities, CWC and other stakeholders.
- Establishing a mechanism for better coordination and joint operation for reservoirs on inter-State rivers by concerned State Governments/SDMAs with active inputs of Central Water Commission (CWC).
- Modernisation of flood forecasting, early warning and dissemination of information.

3.13 State/UT: Maharashtra

Major Floods in 2021, 2020, 2005

3.13.1 Maharashtra, 2021

a) Year/Time of event and its duration: 22 July 2021 onwards series of floods took place across the state of Maharashtra in 2021.

b) Causes and factors: A series of floods took place across the Indian state of Maharashtra in 2021. High-intensity floods took place due to incessant rains fortightly clustered extreme weather events in July.

c) Areas affected: The most affected regions were the districts of Raigad, Ratnagiri, Sindhudurg, Satara, Sangli and Kolhapur.

d) Consequences & Impacts: At least 209 people had died due to the floods in Maharashtra and eight still remain missing (Maharashtra rains: Death toll rises to 209; 8 people still missing, n.d.)(Ref. 40). A total of 4,34,185 people from eight districts had been evacuated to safer places, as rescue operations continue. Among the 209 fatalities, the Satara district reported 46 deaths, followed by 35 in Ratnagiri, 15 in Thane, seven in Kolhapur, four in Mumbai, three in Pune, four in Sindhudurg and two each in eastern Maharashtra's Wardha and Akola districts (Al Jazeera. , 2021).

Various infrastructural facilities were impacted and damaged. Around 800 bridges have been submerged (Fig 25), preventing physical communications with various villages. The drinking water supply of around 700 villages was affected and the rainfall also caused

Figure 25 Mumbai flash flood (economictimes.indiatimes.com) (https://economictimes.indiatimes.com/topic/maharashtra-flood)

damage to about 14,700 electric transformers, affecting the power supply to nearly 9.5 lakh (950,000) consumers. As of 28 July 2021, the power supply to about 6.5 lakh (650,000) consumers was restored through repairs of nearly 9500 transformers

A total of 3,221 animals had died. Meanwhile, the floodwater had entered the roads and fields, submerging many areas of the Sangli district in Maharashtra making it hard for people to commute from one place to another.

According to preliminary estimates, losses to public and private properties were over Rs.4,000 crore ($53,88,00,000). Losses due to flooding in Kolhapur and Sangli were Rs.700 crore ($94,290,000).

e) Actions taken on pre, during, and post-events: Around 34 teams from National Disaster Response Force (NDRF) were deployed for rescue missions in various regions. The Central Government on 27 July 2021 declared financial aid of Rs. 700 crore (US$98 million). The Maharashtra state's MLAs of Bharatiya Janata Party also announced that they would donate one month's salary for relief support.

f) Lessons learnt:

- To get relief urban flooding is to review of urban drains in respect of latest observed rainfall and upgradation of the existing system.
- People to be aware of flood disasters, planners are to integrate thinking on drainage and upstream-downstream linkages.
- Long-term plans aimed at desiltation of rivers and improvement of drainage systems are need to be executed in any districts.
- Livelihood restoration support to marginal farmers and the families having lost their family members with agricultural inputs to start micro-scale business.
- Community based disaster preparedness.

3.13.2 Maharashtra, 2020

a) Year/Time of event and its duration: 9th June 2020 and rainfall continued several days

b) Causes and factors: Heavy monsoon rainfall continued to wreak havoc in Mumbai and surrounding areas of the state of Maharashtra in India. The Southwest Monsoon arrived in Mumbai, Maharashtra, India, with dramatic effect on 09 June, 2021. More than 200mm of rainfall took place in less than 12 hours. Roads were inundated along with residential areas due to lack of passage.

c) Areas affected: Twenty-eight persons had died in rain-related incidents in western Maharashtra which comes under Pune division, sixteen in central Maharashtra's Aurangabad division and three in coastal Konkan. Over 2,300 houses were damaged in heavy rains and floods in Western Maharashtra where more than 21,000 people were moved to safer places, as per the Pune Divisional Commissioner's office.14 people died in Solapur, 9 in Sangli, 4 in Pune and 1 in Satara, (Rains claim 47 lives in Maharashtra, crops damaged extensive .., n.d.).

Crops such as sugarcane, soybean, vegetables, rice, pomegranate and cotton, spread over 57,000 hectares in Pune, Solapur, Satara and Sangli districts, had suffered damage.

d) Consequences & Impacts: South Mumbai recorded 225 mm of rainfallin nine hours on August 5, 2020 which usually do not see waterlogging, were flooded and that is record after 1974. Previous records indicate that last time the area had seen heavier rain than was in 1974. Kalbadevi, J J Marg, Gol Deol Areas like Churchgate, Marine Drive, Fort, Girgaum, Khetwadi, Walkeshwar Road etc, areas were inundated badly and

water entered in several houses and floods had claimed at least 47 lives in Maharashtra's Pune, Aurangabad and Konkan divisions.Due to heavy rains, more than 1,020 villages were affected in these districts. Over 375,000 people had been evacuated Crops such as sugarcane, soybean, vegetables, rice, pomegranate and cotton, spread over 2 lakh hectares in Pune, Solapur, Satara, Sangli and other districts, had suffered damage (Roxy, M. K et al).

Figure 26 Heavy rains in Maharastra damaged infrastructure and crop (indiatvnews.com)

(https://www.indiatvnews.com/news/india/maharashtra-floods-damage-homes-crops-western-region-death-toll-657416)

Mumbai experiencing heavy rainfall last 80 years also frequency and intensity is increasing year by year. Earlier abundant open spaces and the then old drainage system, allowed the percolation of water and its faster dispersal but indiscriminate concretization, disappearing water bodies, encroachment on natural drainage systems, unregulated dumping of waste and sewage were some of the reasons being cited for the largescale inundation as and when. However, urban flooding remains an unresolved mystery, requiring comprehension and clarity (Fig 26). This flood was due to Urban flood.

e) Actions taken on pre, during, and post-events: The then Deputy Chief Minister reviewed the flood situation in western Maharashtra and asked the administration to prepare 'panchnama' (inspection report) of damaged crops, houses and other properties immediately.

f) Lessons learnt:

- The change in the course of the river and silt deposition to be cleaned on both side of rivers.
- At the confluence of Rivers deposition of silt to be removed.
- Routing of river is essential phenomenon to get relief from flood.
- River restoration work is one of the important works.
- Drainage system upgradation is very essential.

3.13.3 Maharashtra, 2005

a) Year/Time of event and its duration: 26th July 2005

b) Causes and factors: The floods were caused by the eighth heaviest-ever recorded 24-hour rainfall figure of 944 mm (37.17 inches) which lashed the metropolis on 26 July 2005, and intermittently continued for the next day. 644mm (25.35 inches) was received within the 12-hour period between 8 am and 8 pm. Torrential rainfall continued for the next week. The highest 24-hour period in India was 1,168 mm and this flood is Flash flood.

c) Areas affected: Mumbai Metropolitan Region was struck by a severe storm and subsequent deluge.

d) Consequences & Impacts: Since 24 July 2005, heavy rains over Marathwada, Konkan-Goa, and Madhya Maharashtra flooded upper stream catchments area of river Kal and Savitri, including large areas of the

metropolis Mumbai, a city located on the coast of the Arabian Sea, in which approximately 1,094 people died and 20 million people had been disrupted by the heavy monsoon rains in Mumbai and surrounding areas (Maharashtra floods of 2005, n.d.). Heavy rains had caused disruption in rail and road traffic in Konkan region affecting Ratnagiri, Raigad,Thane and Mumbai districts. During the past 24 hours Raigad and Ratnagiri districts received more than 200 mm of rainfall affecting 3505 families in Mahad, Mangaon and Chiplun taluka, while Mumbai and Thane received more than 500 mm of rainfall ('Mumbai Mega Flood' on National Geographic Channel". afaqs!. 10 July 2007). Mumbai metropolis continued to remain cut off by road and air link. This area was also experiencing gusty winds with a speed of 45 kms to 60 kms per hour. Towns affected severely by floods were Roha, Mahad, Mangaon in Raigad district as well as Khed and Chilun in Ratnagiri district. 150 people had been trapped in a landslide in Juigaon of Mahad taluka, while 23 deaths had been reported from Raigad, 6 in Ratnagiri and 4 in Thane. Villages Charvali and Sonya area (Raigad district) were flooded while 40 houses in Kodoli village in Kalhapur districts were inundated (Fig 27). Major Findings are:

- Heavy water logging took place in low lying areas Mumbai city.
- Roads and streets affecting suburban's railway system and air traffic at Santacruz.
- District and state administrations are constantly monitoring the situation and providing required assistance.
- Many people were stranded on the roads, lost their homes while many walked long distances back home from work that evening.
- The floods were caused by the eighth heaviest-ever recorded 24-hour rainfall figure of 944 mm (37.17 inches) which lashed the metropolis on 26 July 2005, and intermittently continued for the next day.
- 644 mm was received within the 12-hour period between 8 am and 8 pm. Torrential rainfall continued for the next week.
- Unprecedented flood caused a stoppage of entire commercial, trading, and industrial activity for days.
- Preliminary indications indicate that the floods caused a direct loss of about ₹5.50 billion.
- The financial impact of the floods was manifested in a variety of ways:
- The banking transactions across the counters were adversely affected and many branches and commercial establishments were unable to function from late evening of 26 July 2005. The state government declared 27 and 28 July as public holidays. ATM networks of several banks, which included the State Bank of India, the nation's largest national

Figure 27 Mumbai came to stand still on 26th July 2005 (newsabplives.com) (https://news.abplive.com/india-news/flashback-26-july-2005-the-day-mumbai-came-to-a-standstill-387324)

bank; ICICI Bank, HDFC Bank, and several foreign banks like Citibank and HSBC, stopped functioning from the afternoon of 26 July 2005 at all the centres of Mumbai.

- ATM transactions could not be carried out in several parts of India on 26 July or 27 July due to failure of the connectivity with their central systems located in Mumbai.
- The BSE and the NSE, the premier stock exchanges of India could function only partially. Electronic trading platforms of the brokerage houses across the country remained largely inoperative. In partial trading, the Sensex, India's most tracked equity index closed at an all-time high of 7605.03 on 27 July 2005. The Exchanges, however, remained closed for the following day.

Effect on Mumbai's links to the rest of the world

- For the first time ever, Mumbai's airports (Chhatrapati Shivaji Maharaj International Airport and Juhu Aerodrome) were shut for more than 30 hours due to heavy flooding of the runways, submerged Instrument Landing System equipment and extremely poor visibility. Over 700 flights were cancelled or delayed. The airports reopened on the morning of 28 July 2005. Within 24 hours of the airports becoming operational, there were 185 departures and 184 arrivals, including international flights. Again from early morning of 31 July, with increase in water logging of the runways and different parts of Mumbai, most of the flights were indefinitely cancelled.
- Rail links were disrupted, and reports on late evening of 30 July indicated cancellation of several long distance trains till 6 August 2005.
- The Mumbai-Pune Expressway, which witnessed a number of landslides, was closed the first time ever in its history, for 24 hours.
- According to the report an unprecedented 5 million mobile and 2.3 million MTNLlandline users were hit for over four hours.
- According to the .in registrar (personal communication), the .in DNS servers in Mumbai had to be reconfigured because the servers were not operational.

Transport stats

- 52 local trains damaged
- 37,000 autorickshaws spoiled
- 4,000 taxis damaged
- 900 BEST buses damaged
- 10,000 trucks and tempos grounded

Factors aggravating the disaster in Mumbai due to following antiquated drainage system

- The present storm-water drainage system in Mumbai was put in place in the early 20th century and was capable of carrying only 25.1237 mm of water per hour which was extremely inadequate on a day when 993 mm of rain fell in the city. The drainage system was also clogged at several places.
- Only 3 'outfalls' (ways out to the sea) were equipped with floodgates whereas the remaining 102 open directly into the sea for more than 24 hours. As a result, there was no way to stop the seawater from rushing into the drainage system during high tide.
- In 1990, an ambitious plan was drawn to overhaul the city's storm water drainage system which had never been reviewed in over 50 yearsPlan is to doubled the storm water carrying capacity (to 50 mm per hour).

Uncontrolled, unplanned development in Northern Suburbs

Development in certain parts of Mumbai is haphazard and buildings are constructed without proper planning. The drainage plans in northern suburbs is chalked out as and when required in a particular area and not from an overall point of view.

The Environment Ministry of the Government of India was informed in the early 1990s that sanctioning the Bandra-Kurla complex (a commercial complex in northern Mumbai) was leading to disaster.

Destruction of mangrove ecosystems

Mangrove ecosystems which exist along the Mithi River and Mahim Creek are being destroyed and replaced with construction. Hundreds of acres of swamps in Mahim creek have been reclaimed and put to use for construction by builders. These ecosystems serve as a buffer between land and sea (Fig 28). It is estimated that Mumbai has lost about 40% of its mangroves between 1995 and 2005, some to builders and some to encroachment (slums). Sewage and garbage dumps have also destroyed mangroves. The Bandra-Kurla complex in particular was created by replacing such swamps. The most acclaimed Mindspace CBD (Inorbit Mall) in Goregaon & Malad has been built by destroying a large patch of mangroves in Maharashtra.

Figure 28 Mumbai's natural mongrooves buffer against rising tides (dw.com) (https://www.dw.com/en/saving-mumbais-natural-mangrove-buffer-against-rising-tides/a-47992557)

Role of climate change

Climate change has played an important role in causing large-scale floods across central India, especially the Mumbai floods of 2005. During 1901–2015, there has been a three-fold rise in widespread extreme rainfall events, over the entire central belt of India from Mumbai to Bhubaneshwar, leading to a steady rise in the number of flash floods. The rising numbers of extreme rain events are attributed to an increase in the fluctuations of the monsoon westerly winds, due to increased warming in the Arabian Sea. This results in occasional surges of moisture transport from the Arabian Sea to the subcontinent, resulting in widespread heavy rains lasting for 2–3 days. The Mumbai 2005 floods also occurred due to moisture surge from the Arabian Sea, and the heavy rains were not confined to Mumbai but spread over a large region across central India (Roxy, et al., A threefold rise in widespread extreme rain events over central India". Nature Communications, 2017).

e) Actions taken on pre, during, and post-events:

As against all the odds, to cope up with these unprecedented situations, MCGM tried to organize safe evacuation of people through boats and buses. A detailed record of such operations has not been compiled so far. The No. of fleet in operation is not on record. The evacuated people were sheltered in public buildings including schools and transit shelters. Community kitchens were started and free food grains were provided by the Government of Maharashtra [GOM] and MCGM as well as voluntary NGOs and individuals. With the help of

Traffic Police and Fire Brigade, 26,000 stranded vehicles on roads were cleared on the following day i.e. by 14.30 p.m. on 27th July. Gradually power and water supply also got restored. Train services resumed to normal on 28th July. 24,000 animal carcasses were disposed and more than 2 lakhs tonnes of garbage was maneuvered with the help of about 1,000 dumpers & J.C.Bs deployed from all over the State. Support of NGOs and Transport Commissionerate deserves special mention. Around 1.5 lakh people were stranded at the C.S.T. & Churchgate Railway Stations. B.E.S.T. plied 52 extra buses from Churchgate to Mahim and 86 buses from C.S.T. to Sion to facilitate movement of stranded people on 26th July, 2005. The supervisory staff deployed that day was specifically equipped with mobile-vans and wireless communication sets to ensure the safety of the stranded commuters. The Fire Brigade and the "Rescue Teams" of MCGM undertook 282 major and minor rescue operations. Some of the major operations included rescuing school children as well as rescuing people from 140 marooned BEST buses. Thus, the Fire department rescued of around 3,700 stranded people on 26th and 27th July, 2005. Rescue boats of Navy were requisitioned deployed at Kurla, Kalina area. Stranded passengers in 6 buses at Bandra-Kurla Complex could get rescued with the help of Navy and Mumbai Police on 27th July, 2005 itself.

f) Lessons learnt:

- The suburbs, where the bulk of Mumbai's millions live, are served mostly by roadside drains and the nullah system, open drains in which hundreds of tonnes of garbage are chucked each year by citizens, to be removed in an ever-inadequate pre-monsoon 'desilting' exercise. Much of these nullah networks also have long routes, flowing several kilometres through congested localities before discharging into the sea, often through outfalls located below mean sea level. This simply means tidal flow rushes into the city, and if it's raining heavily when the tide is sufficiently high, then drainage is impossible.
- Dark clouds gather over Mumbai threatening to breach the dreaded mark, as it did on that time, it caused a near flood-like situation with water-logging in low-lying areas, collapse of public transport, traffic jams, potholes, and loss of many innocent lives.
- It was no surprise then that when Mumbaikars woke up on Tuesday morning to a near recurrence of the great deluge the horrifying images from 26/7/2005 came back to haunt millions stranded on the roads, trains and in offices.
- The city's premier civic administrative body or the Brihanmumbai Municipal Corporation (BMC) is hamstrung by managerial mediocrity compounded by poor coordination with the Indian Meteorological Department (IMD), the two sharing only a week or two's forecast in advance before monsoon. A committee to probe the 2005 floods had recommended installing of three Doppler Radars for effective weather predictions. But so far only one has been put in place by the IMD.
- The BMC starts its flood preparedness — cleaning of a 3,000-km long storm water drain network — only two months prior to the monsoon clouds arriving on the city's horizon. This is a small window considering the strenuous task relies heavily on several external variables, such as a bunch of unscrupulous contractors who rarely complete the job on time. The outdated way of cleaning drains has bred a system which promotes corruption since there is no scientific way to calculate how much silt the contractors remove from the drains. The BMC, in the last 12 years, has not even bothered to find an alternative either to this contracting system or effectively monitoring the cleaning works.
- Year after year, the corporation maintains it is ready to tackle 350 to 450 mm of rainfall in a day during the monsoon. But the existing drains were not even ready to handle 50 mm of rainfall, while the

pumping stations, most crucial for tidal control and pumping out storm water into sea, often malfunction in the face of "more than heavy rainfall". In 2014, a report of the Comptroller and Auditor General (CAG) validated the claims of mismanagement in construction of pumping stations in Mumbai.

3.14 State/UT: Odisha

Major Floods in 2014, 2013, 2011, 2009, 2003, 2001

3.14.1 Odisha, 2014

a) Year/Time of event and its duration: 5th August, 2014

b) Causes and factors: Torrential heavy rainfall in different parts of the State in Odisha had posed flood situation in the Mahanadi, the Baitarani, the Budhabalanga and other rivers. This was due to Riverine flood.

c) Areas affected: Mayurbhanj, Balasore, Keonjhar, Ganjam, Bhadrak, Jajpur, Kendrapada, Puri, Khurdha, Jagatsingpur, Cuttack, Boudh and Nayagarh, butGajapati, Subarnpur and Boudh were the worst affected and kept on high alert. The low pressure turning into a depression and slated to move towards bordering areas of Odisha, Chhattisgarh and Jharkhand, the Government remained alert on the possibilities of massive flood.

d) Consequences & Impacts: The flood situation had aggravated in 12 districts of north, central and coastal Odisha following rise in water levels of major rivers like Mahanadi, Baitarani, Budhabalang and Subarnarekha and their tributaries. The situation had particularly worsened due to incessant rains, triggered by a low pressure in the Bay of Bengal, during October 2014. The local met office sources said, the rains will continue for another 24 hours before the climatic condition improves. Millions of people in the following districts had been affected with swelling river water overflowing the banks and entering the villages. Besides, there was severe water logging in many coastal towns including twin cities of Cuttack and Bhubaneswar due to continuous rains affecting thousands of residents. The districts hit by the current flood situation were Mayurbhanj, Balasore, Keonjhar, Ganjam, Bhadrak, Jajpur, Kendrapada, Puri, Khurdha, Jagatsingpur, Cuttack, Boudh and Nayagarh (Fig 29). The chief minister had asked the concerned departments to keep watch on the weak river embankments by deploying mobile teams in these areas, keep adequate stocks of fodder and decide for supply of drinking water and health services. Relief Commisioner said the four districts namely Mayurbhanj, Balasore, Keonjhar and Sundergarh were particularly vulnerable since the met department had predicted

heavy rain falls in these areas under the influence of the low pressure, which lay over west Midnapore in neighbouring West Bengal during the time.Low lying areas of Athgarh and Banki sub divisions in Cuttack district and Khandapada in Nayagarh district and most areas in Boudh district were inundated by the floodwater of Mahanadi. During that period, 9.18 lakh cusecs of water was flowing through Mahanadi River at Mundali barrage near Cuttack. Sambalpur and Balasore districts had witnessed highest rainfall recorded at 336.8 millimetre and 226.4 millimetre respectively. The human casualty due to floods had gone up to 46 with the death of a person in wall collapse in Boudh.

Figure 29: Flood water of Mahanadi inundates several villages (Source: zeenews.india.com)

(https://zeenews.india.com/india/flood-water-of-mahanadi-inundates-several-villages-in-odisha-2306344.html)

e) Actions taken on pre, during, and post-events: As many as 9.95 lakh people in 1,553 villages of 89 blocks in 23 districts had been affected due to the floods, the SRC said, adding around 26 small breaches took places causing inundation of vast areas. Around 1.11 lakh people have been evacuated from low-lying areas to safe places and about 240 kitchens were now operating to provide them free cooked food.As many as 2,41,658 people were marooned in 398 villages as surging water of Baitarani and Mahanadi and their tributaries flooded vast areas in Jajpur, Bhadrak, Cuttack, Khurda, Nayagarh, Angul, Kendrapara and Jagatsinghpur districts, he said.Two helicopters of the Indian Air Force were kept on stand-by for use in relief operation, if necessary, the SRC said, adding at present the entire operation was being carried out with the help of boats. The then Union Home Minister on Wednesday called up the then Odisha Chief Minister and assured all necessary assistance in relief operations in flood-hit areas.About a dozen NDRF teams were mobilised in Keonjhar, Jajpur, Bhadrak, Balasore, Mayurbhanj, Cuttack, Kendrapara and Puri districts to assist in rescue and relief operation. Over 184 boats were engaged in the operation.

Around 30 units of Odisha Disaster Rapid Action Force (ODRAF) were also deployed in vulnerable areas, SRC office said, adding fire brigade personnel were put on stand by. In Jagatsinghpur, the focus was on relief work as around 20,000 people were marooned while about 7,000 persons had been evacuated, District Collector S K Mallick said, adding areas like Tirtol and Kunajang were affected.

f) Lessons learnt:

- The states is not only vulnerable to climate extremes like cyclones and floods but also where the majority of households depend on agriculture for their basic livelihoods
- It is also observed that the intensity of above events has increased over the years and is also likely to increase in the years to come. The reported economic losses due to natural hazards (i.e., cyclone, flood and drought) were around INR 1,050 million during the 1970s, which increased to INR 8,510 million, INR 68,810 million and INR 105,040 million during the 1990s, 2000s and 2001-2009, respectively (GoO, 2004, 2011. Further, an average of 0.33 million ha of agricultural land was damaged in the state due to flood between 1953 and 2011 which converts into a financial loss of INR 316.2 million per year; the mean of the total economic losses was INR 2,906.42 million during the same reference period.

3.14.2 Odisha, 2013

a) Year/Time of event and its duration: Dissipated on Oct 14, 2013

b) Causes and factors: Phailin triggered floods in major rivers in five districts of Odisha. With the worst of the storm having passed, huge areas of north eastern India are now facing the heavy rainfall and flooding brought by the aftermath of Cyclone Phailin. Several rivers in Odisha, including Baitarani, Budha Balanga and Subernarekha have dangerously high levels and have burst their banks. The flood was due to Cyclone.

c) Areas affected: 5 districts (Balasore, Mayurbhanj, Bhadrak, Jajpur and Keonjhar) came under the surging flood waters as major rivers like Subarnarekha, Budhabalang, Baitarani and Jalaka were in spate.

d) Consequences & Impacts: Heavy rains caused by cyclone with over 2.5 lakh people marooned in worst-hit Balasore as the twin calamity affected over 1.2 crore people and the death toll had risen to 25 with four people being killed in the floods in Mayurbanj and Bhadrak districts. Phailin, which claimed 21 lives, has dissipated but the heavy rains and floods in its aftermath is a cause of concern for Odisha Revenue department. Apart from Balasore, four other districts - Mayurbhanj, Bhadrak, Jajpur and Keonjhar came under the surging flood waters as major rivers like Subarnarekha, Budhabalang, Baitarani and Jalaka were in spate, The twin calamity of cyclone and the resultant floods affected over 1.2 crore people in the state as more than 10.13 lakh people were evacuated to safe places, Special Relief Commissioner reported.

e) Actions taken on pre, during, and post-events: Government of Odisha and it agency OSDMA evacuated close to a million people to cyclone shelters. Distant storm warning signal was raised to two at the ports of Paradip and Gopalpur of the state. The Chief Minister of Odisha wrote to the Union Defence Minister seeking support from defence personnel, particularly the Air Force and Navy, for rescue and relief operations.The Odisha government had made arrangements for over 1,000,560 food packets for relief.Indian Air Force helicopters were kept on standby in West Bengal to move in for help at short notice. A total of 1,154,725 people were evacuated in the wake of the storm and the following floods in the state.

Heavy rainfall resulted in the death of a woman in Bhubaneswar after a tall tree fell on her Gusty winds resulted in downing of trees and powerlines. It was also reported that due to high winds, seven other people were killed in Odisha. In a period of 24 hours ending on 13 October, Banki and Balimundali in Odisha received heavy rainfall of 381 mm and 305 mm respectively.

f) Lessons learnt:

Dislocated families, and their number runs into millions, would need massive assistance when they come back

to find their homes flattened, their belongings lost. Resettling them would need as much, if not more painstaking effort. It would need as much attention to detail as was given in preventing them from falling prey to the hurricane. Sanitation, shelter, schools, and all else needs to be provided, at some places from scratch, almost. In fact, thinking that disaster relief is over once the cyclone is over and lives have been saved is not even half the job done. In fact, the tougher job lies ahead.

3.14.3 Odisha, 2011

a) Year/Time of event and its duration: Between12 and 22 September, 2011

b) Causes and factors: Due to full moon on 12.09.11 (Monday) and extremely turbulent sea, there was no discharge of flood water into sea resulting in submergence of delta area for three days. Further, heavy rainfall was experienced in these areas due to the effect of active monsoon & depression over Bay of Bengal. During the year Odisha was hit by two spates of flood in September 2011, the first one being caused by heavy rains in the Mahanadi catchment and release of huge discharges from Hirakud dam. The second one was caused by heavy rains and flooding of Brahmani, Baitarani and Budhabalanga rivers.

Figure 30 Flood Image of Odisha (Source: indiawaterporal.org) (https://www.indiawaterportal.org/articles/man-made-floods-orissa-september-2011-key-issues-raised-water-initiatives-orissa)

On 22.09.2011 a depression was formed over Northwest Bay of Bengal off North Odisha West Bengal Coast. Due to the effect of depression, heavy to very 17 heavy rain was experienced over Brahmani, Baitarani, Budhabalanga and Subarnarekha basins resulting in high floods in all these rivers of Northern Odisha (Fig 30). The rivers crossed and remained above danger level for nearly four days.

c) Areas affected: 22 districts of Odisha were flood affected.

d) Consequences & Impacts: The Odisha floods of 2011 pointed to the loopholes in river basin planning and management and called for urgent attention of planners and policy makers. Odisha was hit by two spates of flood in September 2011, the first one being caused by heavy rains in the Mahanadi catchment and release of huge discharges from Hirakud dam. The second one was caused by heavy rains and flooding of Brahmani, Baitarani and Budhabalanga rivers.

Initial calculations by the state government revealed that almost 4.5 million people i.e.nearly 11% of Odisha population had been directly and significantly affected (Fig 31). Crops on 4.78 lakh hectares of land - nearly 7.5% of total cultivable land had been destroyed. At least 68 deaths had been reported. More than 2,900 km of road had been damaged. Thousands of affected people were still desperate for food. An analysis of the water storage and rainfall situation on various dates point to the lapses in dam management.

The floods of 2011 exposed not only how the Hirakud dam, the largest reservoir in Odisha, a multipurpose dam commisazsioned in 1958 in Sambalpur for among other things controlling floods in the state's delta region had failed miserably in managing floods. Both Odisha and Chhattisgarh must understand that Mahanadi needs to flow unabated and a lot has to be done regarding flood plain management including in urban habitations. Large dams had never been effective in flood control. Rather, they had always aggravated the impacts.

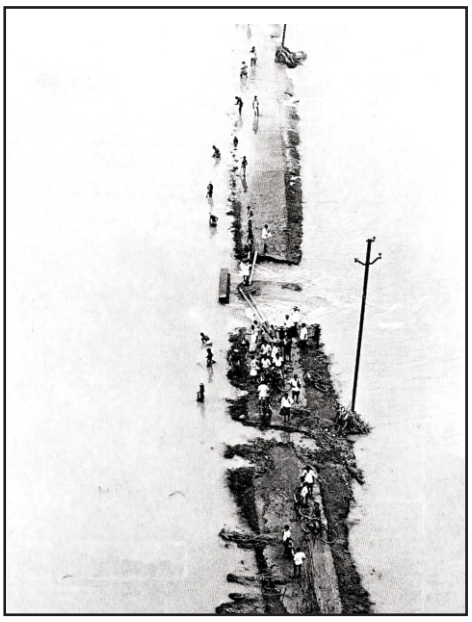


Figure 31 On a narrow strip of land: Waiting for help (Source: indiatoday.in)

(https://www.indiatoday.in/magazine/living/story/19820930-orissa-turns-into-a-land-of-sorrow-as-flood-engulfs-10-million-people-772212-2013-09-26)

e) Actions taken on pre, during, and post-events:

The following structural measures are generally adopted for flood protection:

- Embankments, flood walls, sea walls.
- Dams and reservoirs.
- Natural detention basins.
- Channel improvement.
- Drainage improvement.
- Diversion of flood waters.

The State Government has promptly responded to the situation and took all measures required at the moment to alleviate the distress of the flood affected people. (a) Rescue and Evacuation: All ten units of ODRAF (Odisha Disaster Rapid Action Force) were deployed in Cuttack, Puri, Kendrapara, Jajpur & Jagatsinghpur districts for rescue and relief operation. NDRF battalion at Mundali was also mobilised with boats & emergency equipments for search and rescue operation. 2,80,320 people were evacuated to safer places and kept in temporary shelters during 1st phase flood. Similarly, 1,74,874 people were evacuated to safer places and kept in temporary shelters during 2nd phase flood (b) Deployment of Boats: 2,064 boats were engaged in rescue and relief operations. (c) Free kitchen Evacuated people were provided with adequate quantities of dry food and cooked food through free kitchen centres. 542 free kitchen centres were opened during 1st phase flood and 684 centres during 2nd phase flood. (d) Emergent Relief Emergent relief was

Figure 32 Flood Relief Response in Odisha (Source: slideshare.net)

(https://www.slideshare.net/SaveTheChildrenIn/save-the-childrens-flood-relief-response-in-odisha-2011)

sanctioned for a period of 7 to 15 days for the marooned people of the flood affected districts. Emergent relief in shape of rice, chuda and gud was distributed in the flood affected villages. In addition to dry food, candles, matchboxes, kerosene and other essential materials were distributed. Children and infants in the marooned areas were provided with nutritious baby food for a period of 15 days as per CRF/SDRF Norms. 650MT of INDIAMIX (BABY FOOD) was distributed through Angan Wadi Centers. Q.2,24,931.935 rice, Q.30646.10 chuda, Q.2325.652 gur, 2,60,698 packets of biscuits, 29,341 packets of candles and 68,868 packets of match-boxes were distributed to flood affected people. The helicopters of Indian Air Force, Indian Navy were requisitioned in order to facilitate the air-dropping of food packets in the marooned areas for flood victims. 23,272 food packets were air-dropped through four helicopters in 6 Districts. Similarly during 2nd phase flood in September, 38,789 food packets were air-dropped in the marooned areas in 4 districts (Fig 32).

f) Lessons learnt:

- In fact, the 1980 flood was blamed on the release of water from the Hirakud Dam. However, the problem does not a lie with the dam itself but with its siltation.
- Increased run-off from the upstream catchments following deforestation (which results in increased soil erosion) seems to have rendered inadequate the original live storage of the Hirakud Dam which was designed on the basis of past trends in the run-off from the upstream catchments.
- The Hirakud Dam had drastically reduced large floods in the state. On the other hand, the increased frequency of medium and small floods was seen as the joint result of flood moderation by the Hirakud reservoir and the contribution from the downstream catchments.
- The 1982 flood (in contrast to the first phase of the 2011 floods) was not due to the Hirakud Dam but due to the downstream catchment alone. The increased run-off from downstream seems to have been due to the deforestation taking place in this catchment area. This clearly proves the need for afforestation in both the upper and lower catchment areas of big dams (e g, the Hirakud and the Rengali Dams) of Odisha.

3.14.4 Odisha, 2009

a) Year/Time of event and its duration: August 29 and 30, 2009

b) Causes and factors: Unprecedented rainfall in the downstream catchment of the river Mahanadi below the Hirakud dam caused a peak flood. The simple and common reason for river flooding was the overbank flowing of water due to heavy rainfall at the upper end and catchment areas of the Mahanadi River. It was overflowed due to huge amount of water collected at the river course, the carrying capacity of the river, the river run off to the ocean at the mouth and the flow dynamics-morphological setting system were not tuning with the existing setup. All the major rivers of Odisha after flowing in the varied terrain attain their old stage in the coastal region of flat and low relief nature. They fall in the Bay of Bengal forming network of distributaries and varieties of landforms. Mahanadi River having vast catchment could supply huge amount of sediments to be deposited in the coastal basin to form the arcuate delta. Mahanadi and its distributaries most often cause flood in the low level landforms like delta, peneplains and natural levees along with the adjacent areas of the entire river courses. This flood was riverine flood.

c) Areas affected: The most flood affected districts in Odisha were Nayagarh, Cuttack, Ganjam, Keonjhar, Koraput and Kandhamal.

d) Consequences & Impacts: Floods triggered by heavy monsoon rains killed at least 36 people in the

eastern Indian state of Odisha alone and inundated half a million homes.It was the same tragic tale of destruction, death and misery as the annual floods once again rolled relentlessly across the states of Bihar, Uttar Pradesh and Odisha, turning dry land into huge expanses of water where human beings and cattle struggled for food and survival. The hardest hit of all the states was Odisha where, till last week of Julu, the air-dropping of food for hundreds of marooned villagers was continuing.

In Nayagarh district (87 km from Bhubaneswar) seven people were killed and many others missing when a bus fell into a rivulet after being swept away by flood waters.

The world-famous Sun Temple at Konark was also water-logged, causing hardship for tourists.

The most flood affected districts in Odisha were Nayagarh, Cuttack, Ganjam, Keonjhar, Koraput,Kandhamaland Mahukhanda.Mahukhanda is a large village of 500 households some 30 km from Cuttack. At midnight on August 30, as the villagers were trying to sleep, tormented by thoughts of what the incessant rain was doing to their crops, they were jerked wide awake by terrifying sounds: the roar of water and the cries of human beings and cattle.The worst in 150 years, according to official estimates.

Odisha was drowned in the floods that ravaged its villages and fields on August 31.

Unprecedented rainfall (on August 29 and 30) in the downstream catchment of the river Mahanadi below the Hirakud dam caused a peak flood of 15.8 lakh cusecs to pass through the Mahanadi causing extensive destruction in Sambalpur, Bolangir, Kalahandi, Phulbani, Dhenkanal, Cuttack and Puri districts, engulfing an estimated 10 million people. As per government report - the magnitude of the flood was more serious in nature than any in recorded memory.

So far, the Government has confirmed that 57 persons were killed and that another 42 were missing (Odisha turned into a land of sorrow as flood engulfs 10 mn people; 57 killed, 42 missing, n.d.). Cuttack, Puri, Balasore, Dhenkanal and Keonjhar districts were severely hit by a cyclone a few months ago and the loss was estimated to be about Rs 300 crore.

e) Actions taken on pre, during, and post-events: There was a disastrous cycle of drought, cyclone and flood. Official sources recall that just 10 days before the floods came; the Government sent a report to the Centre regarding the drought and flashed an SOS for foodgrains as it had only 10,000 tonnes.

f) Lessons learnt:

- However, during the unfolding of a natural disaster or the relief, rehabilitation and reconstruction work that follows, the participation of the local community is essential. It should form the core of any disaster preparedness and mitigation effort. The Tenth Five-Year Plan document also emphasised the need for community level initiatives in managing disaster. Similarly, functionaries of panchayati raj institutions must also be involved in relief and rehabilitation work.
- It should also be kept in mind that it is not the government alone that can cope with the high intensity and sudden impact of natural disasters like the cyclone of 1999 and the recent floods in the state. There has to be the widest possible mobilisation of various groups, organisations and institutions at the local, national and international level.

3.14.5 Odisha, 2003

a) Year/Time of event and its duration: 27th August (July-October), 2003

b) Causes and factors: Heavy rainfall in the upper catchment areas. Unremitting rains lashed the four

districts - Kalahandi, Navrangpur, Gajapati and Rayagada in the past two days due to the depression that had developed over the Bay of Bengal. This flood was riverine flood.

c) **Areas affected:** Angul, Balasore, Bhadrak, Boudh, Bolangir, Baragarh, Cuttack, Deogarh, Ganjam, Gajapati, Jagatsinghpur, Jajpur, Jharsuguda, Khurda, Koraput, Kalahandi, Keonjhar, Kendrapara, Malkangiri, Nuapara, Nawarangpur, Nayagarh, Puri, Rayagada, Sambalpur, Sonepur - 26 districts.

Rivers - Baitarani, Mahanadi, Rushkulya, Vamsadhara, Burhabalanga, Indrabati

d) **Consequences & Impacts:** Bhadrak District of Odisha experienced the first wave of floods on the 1st of August 2003 due to heavy rainfall in the upper catchment areas. The amount of rainfall received during monsoon till date had been 773 mm. Dhamnagar and Bhandari Pokhari Blocks have been affected so far by the first wave of floods i.e. Jajpur District had reportedly been flood affected due to heavy rainfall affecting 1 Block and minor breaches at three points. 8 GP's under 16 villages have affected. Major findings are (India: Odisha Flood Sitrep 9 Sep 2003 2200 hrs, n.d.):

Human lives lost	:	54.
Livestock lost	:	1890
No. of houses affected	:	104326
Crop Area affected	:	4.247 m Ha
Population affected	:	13,988

Five breaches had occurred on the left and right embankments of River Genguti. One breach had occurred on River Kochila but it was far away from any human habitation. This breach was about 100 feet wide and occurred at Tiadi Sahi on the right embankment of Genguti. No villages were reported to be marooned. Apart from the breaches, there had been several scouring along the river embankments.114 villages had been affected in 25 GPs of Dhamnagar and Bhandari Pokhari Blocks.

Infrastructure and Logistic: Road Communication had been disrupted at Kothar on Bhadrak Aradi Road and at Dobai on Dhamnagar Sendpur Road. No damage to houses had been reported so far.

Agriculture: Due to the severity of the floods, paddy fields had been reportedly submerged. The total crop area affected was about 14315 hectares. The estimated value of damaged crops will be assessed only after complete recession of the floodwaters. 5.03 lakh Ha. cropped area damaged. More than Rs. 1000.00 crores of PU damaged.

e) **Actions taken on pre, during, and post-events:**

During flood / cyclone and its aftermath, water borne diseases commonly occurred in the community. To address such disasters, health functionnaries located at state, district, block & villages need to make the following arrangements in advance.

1. **Functioning of Control Rooms:-**

- From 15thJune 2003, the control Room will be operational 24X7 at the State, District & Block Head Quarter level.
- During normal time control room should monitor the preparedness activities during pre-disaster, disaster & post diosaster, dissemination of early warning on flood situation received from Revenue Authorities.
- Ensuring initiation of implementation of public health measures, monitoring trend of diseases and cope with any situation arising out of disaster.

- The line list of district RRT & block RRT with mobile No. of key nodal persons in the cut of areas should be available at district level.

2. Identification of Flood / Cyclone Prone areas (Hazard Mapping) & Formation of Zones:-

- The district authorities should identify flood / cyclone prone areas of the district (Block, G.P & Village wise with population) and the list of the affected health institutions based on the last flood / cyclone.
- While hazard mapping, the areas completely submerged / marooned during the last flood / cyclone should be mentioned.
- The districts may be divided into suitable zones keeping in view the operational aspects & each zone is to be assigned to an officer of the rank of ADMO/SDMO for supervision and monitoring and to ensure inter - departmental coordination for smooth implementation of activities.
- Coordination with revenue division needs to be done for identification of marooned/partially marooned areas, shelter homes, high land & low land areas.

3. Casualty Services & Contingency Plan for Medical Relief Centre:-

- During disasters arrangements should be made to provide casualty services 24X7 at all health institutions.
- Contingency plan to open medical relief centers (MRC) at strategic places to be planned in advance. Those centers should be located at strategic places, so that they 96 can render services to disadvantaged population where existing infrastructures are likely to be ineffective.
- State experiences disasters/ flood/cyclone/epidemic each year, the contingency planning should be made in such a way that we need not do the same plan each year & people should be made aware about the plan.
- Mobile Medical team should render the services regularly to displaced persons at their place of shelter and in marooned villages.
- Steps may be taken to make the people aware about the availability of services of 108 ambulances in the districts where ever it is available.

4. Contingency Plan for Mobile Health Team & Deployment of staff:-

- Mobile health teams consisting of one M.O & one Paramedic are to be mobilized from DHH, SDH and non affected blocks within the districts. The teams should be kept in readiness for deployment in the flood / cyclone affected areas.
- At State HQ contingency plan is in force for deployment of medical teams from medical colleges and other non flood / cyclone prone districts within a short notice. Keeping in mind the manpower required during the previous flood, the districts may intimate about the requirement of personnel from outside the district, in case of high flood.

5. Supply of Drugs, logistics & Disinfectants:-

Taking into account the available stock & store position and utilization of drugs during the last flood / cyclone, the anticipated requirements of stock & store can be estimated. Accordingly the District Authorities should take necessary steps to procure medicine & disinfectants etc. from SDMU and ensure that adequate life saving drugs / disinfectants are available with all the health institutions and paramedical workers under their control. Ensure that stock & store are pre positioned sufficiently ahead in the areas likely to be marooned.

- Ensure availability of a minimum of five injection ASV vails (Anti Snake Venom) at PHC (N) and 10 injection ASV vials at Block PHC / CHC. The patient may be administered Inj. ASV as per the need without any ceiling.

- Make available ORS sachets at SC, PHC (N) and Block PHC/CHC of the district. A minimum of 100 sachets with Health Worker at Sub Centre level, 400 sachets at PHC (N) and 1500 sachets at Block PHC/CHC level. ASHAs to be provided with ORS sachets wherever stock is exhausted a minimum of 25 packets may be provided and stocks need to be replenished.
- Halazone tablets may be stored, 1000 tabs at each SC, 3000 tabs at PHC (N) and 5000 tabs at Block PHC/CHC level.
- In each PHC (N) at least 1 bag (25 kg) and at Block PHC/CHC, 3 bags of bleaching powder need to be stored to disinfect the source of drinking water.
- In case of health institutions likely to be affected and the areas likely to be cutoff, bleaching powder as per requirement need to be stocked at identified/alternate sites.
- Stock & store need to be replenished at all levels as & when required.

f) Lessons learnt:

- It should also be kept in mind that it is not the government alone that can cope with the high intensity and sudden impact of natural disasters like the cyclone of 1999 and the recent floods in the state. There has to be the widest possible mobili¬sation of various groups, organisations and institutions at the local, national and international level.

3.14.6 Odisha, 2001

a) Year/Time of event and its duration: July-August, 2001

b) Causes and factors: Torrential rain in July made flooded. The state witnessed severe floods caused by unusual heavy rains of 2001 affecting many districts of Odisha state but during this year from June 6th to July 27th, there was heavy rainfall in various districts, caused by the creation of monsoonal depression/ low pressure over areas near NW Bay of Bengal near Odisha coast. Even Puri recorded 70 cm rainfall in 12-13 June in association with other areas like Paradip. Low pressures are also exhibited a sluggish movement and causes heavy rainstorm in the State between 12th ant 27th July, all are leading to severe flood. This flood was riverine flood.

c) Areas affected: 24 districts (Angul, Balasore, Bhadrak, Boudh, Bolangir, Baragarh, Cuttack, Dhenkanal, Deogarh, Jagatsinghpur, Jajpur, Jharsuguda, Khurda, Koraput, Kalahandi, Kendrapara, Nuapara, Nawarangpur, Nayagarh, Puri, Rayagada, Sundergarh, Sambalpur, and Sonepur)

Rivers were in grim - Mahanadi, Brahmani, Baitarani, Subarnarekha, Burhabalanga, Vamsadhara, Rushikulya, Indravati

d) Consequences & Impacts: Flood takes place in major portions of Odisha and left millions people homeless. Since many of the houses had collapsed; people are still living on the high land/express highways and embankments. With vast

Figure 33 Orissa flood victims trapped (Source: news.bbc.co.uk) (http://news.bbc.co.uk/2/hi/south_asia/1448109.stm)

tract of more than eleven districts were waterlogged (Fig 33) and almost cent percent crop loss, health and drinking water along with livelihood had emerged as the major concern for the government and the civil society organisations.

Water released from the Hirakud dam flooded coastal areas of Odisha affecting more than 9.341 million & about 200,000 people are still marooned

The crop loss of paddy and few non-paddy over an area of 0.891 million hectors was 100 %. These were only the initial assessments.

It was estimated that more than 40000 people continued to be shelter less. About 10000 people had been provided shelter in tents provided by Govt. Major findings (Situation Report Source CRS Posted 1 Nov 2001) losses are (Odisha floods situation report 02 Aug 2001, n.d.):

- Death toll : 98
- Flood affected population : 9.341 million
- Districts affected : 24
- Number of Blocks affected : 216
- Number of Panchayats affected : 2650
- Number of villages affected : 17630
- No. of breaches formed : 944
- No. of Cattle lost : 14142
- Houses Damaged : 242555
- Crop loss : 0.891 million hectares
- Crop loss estimated : 13.54 million USD

7.99 lakh Ha. of cropped area damaged and Rs.883.42 crores of PU damaged.

e) Actions taken on pre, during, and post-events:

- UNDP is planning to take up habitat and livelihood restoration programmes in the affected districts for vulnerable families.
- UNICEF supplied inflatable boats (20) and fibreglass boats (5), which have been delivered to the State relief authorities.
- Tents supplied by UNICEF have also been despatched to the districts.
- Essential drugs have been supplied and support for drinking water has also commenced already.
- UNICEF has provided support for printing of health, water and sanitation IEC messages and they are being distributed through Govt departments and also through NGOs and NUNVs.
- Both UNDP and UNICEF have provided mobility support to officials involved in relief operations.
- WFP has deployed a logistic expert to support OSDMA in management of relief goods and developing a warehousing strategy.
- WFP has provided 1236 MT of CSB/India Mix.
- WFP is in the process of using generated funds toward the purchase of non-food items to assist the rehabilitation of the ICDS project.

- In order to assist children and pregnant/lactating mothers (while adhering fully to relevant Plans of Operations), WFP in collaboration with Department of Women and Child Development has accelerated supplementary feeding in Koraput district and 4 districts and others.

f) Lessons learnt:

- The affected villages were cut up from main cities, the flooding damage to property, destruction of crops, and loss of livestock, deterioration of health conditions owing to waterborne diseases. The following activities are need to be planned and implemented as lots of places in Odisha are still having less infractures -
  a) The disaster mitigation team promoted to join hands with the volunteers
  b) Volunteer deployment in affected areas for rescue, relief distribution and restoration

3.15 State/UT: Puducherry

Major Floods in 2015

3.15.1 Puducherry, 2015

a) Year/Time of event and its duration: 14 to 15 November, 2015

b) Causes and factor: Torential rain in Puducherry caused the deluge in the area. On 24 November, it was reported over 4800 hectares of farmland had been flooded, though it remained too early to determine the extent of crop damage. Heavy rainfall has been lashing the union territory of Puducherry, leaving localities submerged in water and interrupting normal life. This flood was riverine flood.

c) Areas affected: Water entered several houses in low-lying areas, while three houses collapsed in Uppalam. Mudaliarpet, parts of Rainbow Nagar, Muthialpet, Krishna Nagar and Lawspet Main Road were inundated, along with portions of roadways near Karuvadikkuppam and the Shivaji statue on the ECR, causing traffic problems. Several roads were badly damaged, hindering motorists, while some members of the public took the initiative to begin clearing areas of water.

d) Consequences & Impacts: Puducherry sustained relatively minor damage in November as the depression largely remained offshore; some trees were downed and several banana and sugarcane plantations at Kuttchipalayam were severely damaged. Puducherry reported receiving 55.7 mm of rainfall over the 24-

hour period from 14–15 November. Water entered several houses in low-lying areas, while three houses collapsed in Uppalam. Mudaliarpet, parts of Rainbow Nagar, Muthialpet, Krishna Nagar and Lawspet Main Road were inundated (Fig 34), along with portions of roadways near Karuvadikkuppam and the Shivaji statue on the ECR, causing traffic problems. Several roads were badly damaged, hindering motorists, while some members of the public took the initiative to begin clearing areas of water without directions from the government. The then Chief Minister stated that the official machinery had been readied in preparation for any flooding, while local administration officials closed all schools and colleges in Puducherry and Karaikal districts on 16 November, anticipating further rainfall.

Figure 34 Heavy rains in Puducheri lead to major flood (india.com) (https://www.hindutamil.in/news/tamilnadu/735896-heavy-rain-puducherry.html)

More than 500 people were killed and over 1.8 million (18 lakh) people were displaced. With estimates of damages and losses ranging from nearly Rs.200 billion (US$3 billion) to over Rs.1 trillion (US$14 billion), the floods were the costliest to have occurred in 2015, and were among the costliest natural disasters of the year (2015 South India floods, n.d.).

On 24 November, it was reported over 4800 hectares of farmland had been flooded, though it remained too early to determine the extent of crop damage. On 26 November, the union territorial government submitted a preliminary estimate of damages to the central government, requesting it to release an initial ₹1.82 billion (US$26 million) for relief; based on preliminary estimates, Chief Minister Rangasamy reported losses as follows: public works (120.89 crore (US$17 million)), municipal administration (487 million (US$7 million)), agriculture (72 million (US$1 million)), power (31.4 million (US$440,228)), revenue (24.8 million (US$347,696)) and animal husbandry (719,000 (US$10,000)). On 1 December, Rangasamy requested an additional 1 billion (US$14 million) for "immediate interim relief". At the start of December, Puducherry reported receiving 83.4 centimetres of rain during November alone, as opposed to a normal average of 76.7 centimetres during the entire north-east monsoonal period from October to December. Since rain-related damage had continued even after the submission of a report on the earlier flooding in November, and also after the recent visit of a central government survey team, on 4 December the Puducherry government said it would submit a supplementary report assessing additional damages and requesting 1.5 billion (US$21 million) for a total relief-fund requirement of 3.33 billion (US$47 million). From 1 December, torrential rains again inundated portions of the union territory. Puducherry recorded 22 cm of rainfall over a 24-hour period, making it the wettest December day ever. Heavy rain beginning on the evening of 4 December flooded parts of Puducherry, continuing through the following morning. According to the Regional Meteorological Centre, Chennai, Puducherry received nine centimetres of rain during this period. The then Puducherry District Collector said that the rainfall had been "unprecedented in Puducherry, and the volume has been the highest [since] 1975." The administration said that 618 houses had been damaged thus far and over 2,000 people evacuated to safe places. On 5 December, the Karaikal region recorded 110 centimetres of rainfall since the start of the north-east monsoon. In Karaikal, an enclave of Puducherry, nearly 50 houses were damaged due to heavy rain and flooding.

On 5 December, the territorial government announced that nearly 9,000 hectares of paddy fields had been damaged by torrential rainfall, including 4,420 hectares of paddy fields in Puducherry,4,248.34 hectares in Karaikal and 287.15 hectares in Yanam. The government also reported 1,544 hectares of sugarcane fields under cultivation had been damaged, along with 297.73 hectares of plantains, 231.9 hectares of tapioca and related tubers, 168.10 hectares of vegetable fields and eight hectares under betel-leaf cultivation. Proposed compensation rates would be as follows: 50,000 (US$701) per hectare for betel-leaf losses, 35,000 (US$491) per hectare for plantains, 20,000 (US$280) per hectare for paddy fields and 15,000 (US$210) per hectare for losses of vegetables, tapioca, tubers and sugercane. Compensation scales had also been set for losses of cotton, lentils and flowers.

G. Sundaramurthy, a 62-year-old man in Ariyankuppam, was killed on 9 November when a mud wall collapsed, while Anandan, a 53-year-old man in Ouppalam, was subsequently reported to have died because of the rain. On 17 November, S. Chellammal, a 72-year-old woman in Karayamputhur, was killed by the collapse of a rain-weakened mud wall.

Analysis of causes

Unregulated urban planning and illegal construction

The then Union Minister for Environment and Forests termed the Chennai floods a "natural disaster of unappreciated scale", and said it provided lessons to improve urban planning and improve city governance. "Chennai gives a lesson, and we must learn from this lesson and improve our urban planning and improve city governance, which is very essential." He also criticised the Chennai Corporation for not having done enough "to remove all encroachments. Unless you allow the drains to flow freely to the sea, water will be clogged and that is what has unfortunately happened. The Director of the Centre for Science and Environment (CSE), said the unprecedented floods in the Chennai metropolitan region were the direct result of unregulated urbanisation. According to her, “our urban sprawls such as Delhi, Kolkata, Mumbai, Chennai, Srinagar, etc., have not paid adequate attention to the natural water bodies that exist in them. In Chennai, each of its lakes has a natural flood discharge channel which drains the spillover. But we have built over many of these water bodies, blocking the smooth flow of water. We have forgotten the art of drainage. We only see land for buildings, not for water.” According to research conducted by CSE, Chennai had over 600 lakes in the 1980s, but a master plan published in 2008 showed only a fraction of them to be in a healthy condition. State records have shown the total area of 19 major lakes shrank from 1,130 hectares in the 1980s to around 645 hectares in the early 2000s, reducing their storage capacity.

Improper design and maintenance of drainage systems

Media reports stated the Chennai Corporation had ignored September warnings of above-average monsoonal rains issued by the India Meteorological Department, and that extensive and costly projects begun in 2013 to desilt city storm drains had been ineffectively conducted. The drains themselves were reported to have been shoddily built and improperly designed. Drains carrying surplus water from tanks to other wetlands had also been encroached upon, while city storm water drains were clogged and required immediate desilting. Chennai has only 855 km of stormwater drains against 2,847 km of urban roads, resulting in flooding after even a marginally heavy downpour. A 2015 CAG report revealed that a diversion channel from the Buckingham canal near Okkiyum Maduvu to the sea (a drain project under the JNNURM scheme) could have saved South Chennai from flooding; the government, however, dropped the 1 billion scheme, which, had it been completed, would have drained floodwater from southern neighbourhood at a rate of 3,500 cubic feet per second. The 2015 CAG report said the defective planning of flood control projects caused delays and increased costs, defeating the

objective of the scheme. "The fact is that alleviation of inundation of flood water in Chennai city remains largely unachieved", it said.

e) Actions taken on pre, during, and post-events:

During the floods in December, the administration in Puducherry evacuated over 1,000 people to relief centres and distributed over 200,000 food packets to affected citizens. The NDRF deployed two teams in Puducherry; several voluntary organisations launched relief efforts, distributing blankets, food and water.

On 5 December, district collector Manikandan said 173 relief centres had been opened in Puducherry and that those evacuated from low-lying areas had been moved to 22 relief centres. They were given food thrice a day, with children given milk; blankets were also provided. In the past week, 525,475 food packets had been distributed. Special medical camps were conducted and medicines and sanitary napkins were distributed. The administration opened 66 relief centres in Karaikal to accommodate rain affected persons.

On 4 December, the then Chief Minister said the union territorial administration would immediately disburse Rs.1.5 billion (US$21 million) in relief to farmers, hut-dwellers, homeowners and cattle owners in the Puducherry, Karaikal and Yanam regions. He expressed pain at witnessing the "unprecedented havoc the rains had caused in Puducherry and Karaikal regions during the last twenty days, damaging standing crops, horticultural crops and also houses and huts, besides cattle owners". The administration further decided to provide financial relief of 1.24 billion (US$17 million) to 310,000 families covered under the public distribution system (PDS), or 4,000 (US$56) to each family. “All families holding ration cards would be handed relief, and each of 310,000 families would be handed 4,000 (US$56)”. On 11 December, the then Chief Minister gave 400,000 (US$5,600) to each of the families of the victims.

3.16 State/UT: Punjab

Major Floods in 2019

3.16.1 Punjab, 2019

a) Year/Time of event and its duration: Last week of August and first week of September 2019 flood took place

b) Causes and factors: Heavy rains and release of water from the Bhakra Dam. The River Sutlej - one of the five giving Punjab its name - flooded following heavy rain and the deliberate discharge of water into it from

the Bhakra Nangal Dam. Keeping in view of the safety of the dam, it had to resort to controlled release of water. Water was released from 16th August to 19th August in increasing amounts as heavy rain continued to fall. Heavy rain fell in districts near to the dam on 18th August. This would result in a large amount of surface run-off straight into the reservoir and raising water levels rapidly.

c) Areas affected: More than 300 villages, mainly in Punjab's Ropar, Jalandhar and Ferozepur districts, were badly affected in floods by the Satluj Riverand few villages in the Ferozepur district.

d) Consequences & Impacts: Following heavy rains and release of water from the Bhakra Dam, the swollen river Sutlej and its tributaries flooded villages in several areas, causing extensive damage to crops, especially paddy, and houses in low-lying areas. (300 Punjab villages badly affected by floods, n.d.).

The total value of the livestock loss was pegged at Rs 1.2 crores and infrastructure worth hundreds of crores had been destroyed including personal properties, bridges, canals, roads, and public buildings. Over 300 villages had been affected by August 31, 2019, and few villages in the Ferozepur district are still facing a flood threat after a major portion of an embankment in the catchment area of the Sutlej River was washed away due to Pakistan's release of water into the Indian Territory.

e) Actions taken on pre, during, and post-events:

Punjab government on Wednesday said the flood situation in the state was under control and all the precautionary measures has been taken to tackle any untoward situation (The Hindu).

Irrigation Minister said the Punjab government was monitoring the flood situation in the state and, as a precautionary measure, all the deputy commissioners have been instructed to take necessary steps.Employees of the department have been issued directions to maintain round the clock vigil and patrolling along rivers and dams. People living near the rivers had been affected to some extent. Due to the incessant rain in the neighbouring state of Himachal Pradesh, the water level in rivers and dams of Punjab had increased, The Bhakra Beas Management Board, which manages the Bhakra and Pond dams had been releasing water through floodgates that's why reservoirs of both dams received more inflow of water.

f) Lessons learnt:

- The magnitude of disaster is not determined by floodwater alone but also by the pattern of vulnerability in which people live. The lives and livelihoods of many poor people are hardest hit by disasters. These people, often already vulnerable to other disasters and stresses such as HIV/AIDS, drought, food insecurity, cyclones and ongoing conflict, are forced to live in hazardous places, building their homes and growing their food on disaster prone areas.
- Many impacts of disasters are similar between themselves although their magnitude, nature and scale may vary and these impacts may be caused in different ways. The impacts of disasters on lives and livelihoods and the way agencies have addressed them are similar in most parts of the world. The effectiveness of agency interventions has, however, always been conditioned by factors specific to the context and circumstances, size and scale of the disaster and the affected population.

3.17 State/UT: Rajasthan

Major Floods in 2016

3.17.1 Rajasthan, 2016

a) Year/Time of event and its duration: between 06 and 10 August, 2016

b) Causes and factors: Incessant rainfall had caused flooding in many areas in Hadauti region of Rajasthan and cut off road connectivity. The explanation for flooding is heavy rains, overflowing Rivers, Broken Dams, Urban Drainage Basins, Storm Surges, Channels with Steep Sides, Lack of Vegetation etc.

c) Areas affected: Affecting districts are Baran, Jhalawar, Chittorgarh and Pratapgarh

d) Consequences & Impacts: Several parts of Rajasthan were flooded after heavy rain fell from 20 August, affecting the districts of Baran, Jhalawar, Chittorgarh and Pratapgarh. At least 8 people, all members of the same family, died after a part of a house collapsed in Baran district. Severe flooding had affected several villages in Baran and Pratapnagar districts, prompting flood rescues by Air Force helicopters.

e) Actions taken on pre, during, and post-events: Air force helicopter airlifted a total of 33 people from two locations in Pratapgarh district while 24 others were airlifted from Baran on Saturday. NDRF rescued 216 people marooned due to the sudden rise of the Banas River at Shamoli Katla village in Sawai Madhopur District.

f) Lessons learnt:

- During the unfolding of a disaster or the relief, rehabilitation and reconstruction work that follows, the participation of the local community is essential. It should form the core of any disaster preparedness and mitigation effort. The Tenth Five-Year Plan document also emphasised the need for community level initiatives in managing disaster. Similarly, functionaries of panchayati raj institutions must also be involved in relief and rehabilitation work.

3.18 State/UT: Tamil Nadu

Major Floods in 2015

3.18.1 Tamil Nadu, 2015

a) Year/Time of event and its duration: November 2015; The unprecedented rainfall took place in four spells -

i. November 8-10, 2015 causing extensive damages, mainly in Cuddalore district;

ii. November 12-13, 2015 severely affecting Kancheepuram town;

iii. November 15-17, 2015 bringing heavy rain to Chennai and the adjoining districts of Kancheepuram and Thiruvallur; and

iv. November 30 to December 07, 2015 which again hit Chennai and the two adjoining districts with such great intensity that it marooned large parts of the metropolis causing severe damage and destruction, and marooning large parts of the metropolis with people stranded on rooftops for days together, especially in the low-lying areas (Fig 35).

b) Causes and factors: Tamil Nadu recorded an exceptionally heavy rainfall during November - December 2015 due to the North East Monsoons. This unprecedented rainfall took place in four spells. Though the unusually heavy rainfall in southern India during the winter of 2015 has been attributed to the 2014-16 El Niño event, In addition, unplanned and often illegal urban development had led to many wetlands and natural sinks being built over; this, along with ageing civic infrastructure and poorly designed drainage systems, had resulted in an increased frequency of severe flooding. This flood was due to urban flood.

Figure 35 Aerial view of submerged Chennai airport (Source: bbc.com)

(https://www.bbc.com/news/world-asia-india-34992000)

c) Areas affected: The area severely affected were Cuddalore district, Kancheepuram town, Thiruvallur town, Chennai town etc.

d) Consequences & Impacts: On the 4th spell of rainfall Chennai city and adjoining diatricts were flooded and created a devastating scenario of flash flood at the area (Fig 35). This had given a havoc impact on major roads and public amenities, damages to irrigation infrastructure as well as loss of human lives and livestock. Around 500 people lost their lives and over 18 lakh people were evacuated. With approximations of damages and losses ranging from 50000 crore (US$7 billion) to 100000 crore (US$15 billion), the floods were the costliest to have occurred in 2015, and this was declared as Natural Disaster.

Major Findings

1. Incessant rainfall accumulated in the city Chennai and flow into major rivers, Adyar, Cooum and Kosathalai. After saturated the water back to densely populated areas and it was impounded within City and other areas
2. Above incident create Chennai as an island around flood water many feet high and create the life a hell in all aspect. Urban populaces of these areas in great difficulty and caused severe damages to public and private property. Water entered buildings, even in first floors in some areas, stranding residents on building rooftops without essential provisions - food, water and electricity, besides completely damaging all their household durable assets and motor vehicles, and rendering their homes uninhabitable for long period to come.
3. Due to concretization all around in urban areas infiltration component of the hydrological cycle is drastically reduced. Many construction has also been taken place on natural drains/rivers and waterbodies, therefore it is facing difficulty to flow the water in its nomal course and passage.
4. The concept of compound wall effect'create an heavy obstraction of different institution where due to the accumulation of incessant rains could not discharged in the flowing path. Some where the drainages are totally blocked through boundary wall and blocked the passage route.
5. Earlier the city had large wetlands, marsh lands and vast tract of pasture land which used to act as the flood sink of the city, Afterwards due to urbanisation and to make them use in various purposes like waste disposal, housing, commercial and industrial etc., those were dimishes and finally destroyed. Therefore, the flood sink was not in action.

Neyveli received 483 mm (19.0 in) of rainfall between 9 and 10 November 2015; rains continued to lash Cuddalore, Chidambaram, Tiruvallur, Kanchipuram and Chennai. Several low-lying areas in Kanchipuram, including major thoroughfare Gandhi Road, were inundated as the city and its neighbourhood received a heavy precipitation of 340mm during the 24-hours that ended with 8.30 a.m. on 13 November 2015. The Manjalneer Kalvai, primarily a flood drain channel for the city, overflowed after the Netteri lake breached on the Kancheepuram-Vellore Road in the wee hours of Friday, flooding the entire stretch of Gandhi Road and Munusamy Mudaliyar Avenue and forcing the police to close for traffic the prime junction Moongil Mandapam where the Gandhi Road joins with Vallal Pachaiyappan Salai. Kanchipuram Collector told reporters that a total of 7,294 persons were rescued from inundated areas and accommodated in 26 shelters opened by the civic body. Boats were used to rescue the people from inundated areas in Pillayarpalayam. Also Vembakkam close to Kanchipuram recorded 470mm of rain on 13 November 2015. Continuing rains led to low-lying parts of Chennai becoming inundated by 13 November, resulting in the evacuation of over 1000 people from their homes.

The flooding in Chennai city was worsened by years of illegal development and inadequate levels of flood preparedness. Much of the city remained flooded on 17 November, though rainfall had largely ceased. Chennai received 1,049 mm (41.3 in) of rainfall in November, the highest recorded since November 1918 when 1,088 mm (42.8 in) in of rainfall was recorded. Kancheepuram district registered the heaviest rainfall—183% higher at 181.5 cm as against average rainfall of 64 cm in October–December period and Tiruvallur district recorded 146 cm compared to average 59 cm of rain. The flooding in Chennai city was described as the worst in a century. The continued rains led to schools and colleges remaining closed across Puducherry and Chennai, Kancheepuram and Tiruvallur districts in Tamil Nadu, and fishermen were warned against sailing because of high waters and rough seas.

Though rainfall from the earlier low pressure system ended on 24 November 2015, another system developed on 29 November 2015, bringing additional rain and the Indian Meteorological Department predicted heavy rainfall over Tamil Nadu until the end of the week. On 1 December, heavy rains led to inundation in many areas of Chennai. By afternoon, power supplies were suspended to 60% of the city while several city hospitals stopped functioning. For the first time since its founding in 1878, the major newspaper The Hindu did not publish a print edition on 2 December 2015, as workers were unable to reach the press building. The Southern Railways cancelled major train services and Chennai International Airport was closed until 6 December.

Chennai was officially declared a disaster area on the evening of 2 December 2015. At the MIOT Hospital, 14 patients died after power and oxygen supplies failed. With a letup in rainfall, floodwaters gradually began to recede in Chennai on 4 December, though 40 percent of the city's districts remained submerged and safe food and drinking water remained in short supply. Though relief efforts were well underway across most of the area by 3 December, the lack of any coordinated relief response in North Chennai forced thousands of its residents to evacuate on their own. As intermittent rains returned, thousands of displaced residents from Chennai, Kancheepuram and Tiruvallur districts attempted to flee the stricken region by bus or train and travel to their family homes. Chennai International Airport was partly reopened for cargo flights on 5 December, with passenger flights scheduled to resume from the following morning. By 6 December, rescue efforts had largely concluded and relief efforts intensified, with the Chennai Corporation beginning to disburse relief packages. Mobile, banking and power services were gradually restored; fuel and food supplies were reaching their destinations, the airport had fully reopened and rail services slowly resumed. Many city neighbourhoods, however, remained flooded with some lacking basic necessities due to the uncoordinated distribution of relief materials. With the city slowly beginning to recover, state and national health officials remained watchful against disease outbreaks, warning that conditions were right for epidemics of water-borne illnesses to occur. Chennai Corporation officials reported at least 57,000 homes in the city had suffered structural damage, mostly those of working class. State housing boards said they would conduct safety inspections of both public and residential buildings. After being closed for the past month, schools and colleges across the affected districts began to reopen from 14 December. Relief operations were largely wound up by 19 December.

South of Chennai, heavy rains and flooding persisted into the second week of December. In Kancheepuram district, Chengalpattu, Kanchipuram, Nandivaram- Guduvanchery, Perungalathur, Tambaram, Mudichur and Anakaputhur were inundated in floodwaters up to 7 metres deep by 5 December 2015, which washed away roads and severed rail links; 98 people from the district were reported to have died. During 4–5 December 2015, parts of Villupuram and Tiruvarur districts received up to 10 centimetres of rain, while some towns in Cuddalore district saw up to nine centimetres. Flood alerts were broadcast to 12 villages in the neighbourhood of the Tirumurthy dam in Tirupur district on 7 December 2015, as the dam was likely to reach capacity within two days; the residents of those villages were urged to evacuate. Due to rainfall in Tirunelveli district, all of its

dams had reached or were approaching full capacity by 7 December, forcing local authorities to discharge thousands of cusecs of water from reservoirs and causing the Thamirabarani River to reach flood stage. Torrential rains inundated hundreds of acres of paddy fields in Thanjavur, Tiruvarur and Nagapattinam districts, and caused residential areas to flood by 8 December. Large parts of Thanjavur city were marooned by rising waters, while several houses collapsed under the brunt of rainfall in Kumbakonam and Veppathoor.

After Chennai district, Cuddalore district was among those most severely affected by the flooding. Six of the district's 13 blocks suffered extensive damage during the floods in November. The resumption of heavy rainfall from 1 December again inundated the Cuddalore municipality and the district, displacing tens of thousands of people. Rains continued through 9 December 2015. Despite the state government and individuals sending rescue teams and tonnes of relief materials to the district, thousands of those affected continued to lack basic supplies due to inadequate distribution efforts; this resulted in several relief lorries being stopped and looted by survivors. Large swaths of Cuddalore city and the district remained inundated as of 10 December, with thousands of residents marooned by floodwaters and over 60,000 hectares of farmland inundated; over 30,000 people had been evacuated to relief camps.

The state government reported preliminary flood damages of Rs.84.81 billion, and requested Rs.20 billion for immediate relief efforts. On 5 December, a senior state revenue official said the state's official estimates of flood-related losses in November alone exceeded Rs.98 billion (US$1 billion); he added the catastrophic flooding thus far in December could escalate total losses to well over Rs.1,000 billion. On 9 December, The then Chief Minister wrote to the then Prime Minister, requesting him to immediately declare the "unprecedented, catastrophic and cataclysmic" flooding as a "national calamity."

On 13 December 2015, the state government requested the central government to release a total of Rs.102.50 billion towards relief and rehabilitation efforts, including Rs.50 billion for a housing project to accommodate 50,000 displaced people, Rs.7.5 billion to rehouse another 50,000 people who had formerly lived in huts destroyed by the floods and Rs.45 billion to rebuild damaged roads, drains, tap water pipes and sewers in urban localities (2015 South India floods, n.d.).

e) Consequences of flooding:

In Chennai, over 150,000 street vendors sustained losses of over 3 billion. The persistent rainfall and flooding forced several major automakers in the region, including Ford, Renault, Nissan and Daimler AG, to temporarily halt production, resulting in estimated losses of up to 10 billion. Industry analysts estimated total industrial losses as a result of the floods to be in the range of 10,000 to 150 billion. All of the major auto- and truck makers in the Oragadam and Sriperumbudur manufacturing belts resumed operations by 8 December, despite ongoing damage assessments; some employees were forced to continue working from their homes. Many major information technology companies, including Infosys and Tata Consultancy Services, closed their offices and had their employees work from their homes, or transferred operations to other locations in cities including Pune and Bengaluru. Several Indian IT giants like Tata Consultancy Services and Wipro also informed their stake holders about an expected material impact on its third-quarter earnings due to the floods and then to the low volume revenue during Christmas and New Year holidays in the west. Car makers were also hugely affected due to shut down of plants, thus leading to lower production volume.

f) Actions taken on pre, during, and post-events:

In January 2016, the state government issued a detailed final statement which said 421 people in Tamil Nadu had died of flood-related causes between 28 October, when the first monsoonal rains had arrived in earnest,

through 31 December; however, relief workers alone had reported hundreds more who were missing, and various police reports had placed the death toll in the Chennai region alone at over 500 as of mid-December. Chennai-area morgues and crematoria were reported to have been "piled up" with bodies as floodwaters began receding in the second week of December, while all of the still-functioning area cemeteries had recorded over three times the usual number of burials, up from a normal 25–30 burials per week. According to the Tamil Nadu government, 3042,000 (3.042 million) families had suffered total or partial damage to their dwellings. 3,8276.8 million hectares of crops had been lost due to flooding, including over 347,000 hectares of agricultural crops and 35,471 hectares of horticultural crops; roughly 98,000 livestock animals and poultry had died. On 25 April 2018, the skeleton of a man reported missing during the floods was discovered in the Chennai neighbourhood of Peerkankaranai near Tambaram, though a definitive identification could not be made immediately.

Relief efforts

In Tamil Nadu 12 cyclone shelters were built in Nagapattinam district, while 11 teams of the National Disaster Response Force (NDRF) were dispatched to Tamil Nadu. Over 10,000 people had been rescued by 14 to 27 November and dozens of relief camps established (Fig 36). The Indian Air Force deployed four helicopters to airlift flood victims from inundated parts of Chennai city. Over 5,300 people had been rescued by 16 November and dozens of relief camps established. Tamil Nadu Govt msde initial allocation of 5 billion (US$70 million) for relief and rehousing, with 400,000 (US$5,600) for each family who had lost relatives in the floods.

Figure 36 Relief efforts by the NDRF and rescues (Source: dnaindia.com)

Andhra Pradesh state government announced an initial ex gratia payment of 500,000 (US$7,000) to the relatives of flood victims, while 140 relief camps were established in Nellore district, the worst affected. 20 million (US$280,400) of relief supplies were distributed to fishermen, weavers and local communities in the district; other organisations helped to distribute food packets and blankets. On 24 November, the central government stated it had released an initial 10.3 billion (US$144 million) towards relief efforts, with further funds possible following an assessment. In Chittoor district, 8,455 affected households were given a total of 42.9 million (US$600,000) in compensation, while 10,797 people were sheltering in rehabilitation camps.

4,714,000 (US$66,000) was sanctioned to compensate for livestock and poultry losses. On 3 December, the then Chief Minister offered support to Tamil Nadu, which had likewise been severely affected by the floods.

In Puducherry, NDRF were deployed two teams in Puducherry; several voluntary organisations launched relief efforts, distributing blankets, food and water. 173 relief centres had been opened in Puducherry and that those evacuated from low-lying areas had been moved to 22 relief centres. They were given food thrice a day, with children given milk; blankets were also provided. In the past week, 525,475 food packets had been distributed. Special medical camps were conducted and medicines and sanitary napkins were distributed. The administration opened 66 relief centres in Karaikal to accommodate rain affected persons.

3.19 State/UT: Uttarakhand

Major Floods in 2021, 2013, 2010

3.19.1 Uttarakhand, 2021

a) Year/Time of event and its duration: 7th February, 2021

b) Causes and factors: Due to the sheer volume of water that passed through the valley. It was caused a large rock and ice avalanche consisting of material dislodged from Ronti peak. Among the places most severely hit by the floods are Joshimath, Raini, Nanda Devi National Park, Tapovan Vishnugad Hydropower Plant and Sridhar (2021 Uttarakhand flood, n.d.). This was due to Glacial Lake Outburst Flood (GLOF).

c) Areas affected: Caused flooding in the Chamoli district, most notably in the Rishiganga river, the Dhauliganga river, and in turn the Alaknanda-the major headstream of the Ganges. Severly floods affected places are Joshimath, Rini, Nanda Devi National Park, Tapovan Vishnugad Hydropower Plant and Sridhar.

d) Consequences & Impacts: The 2021 Uttarakhand flood, also known as the Chamoli disaster, began on 7th February 2021 in the environs of the Nanda Devi National Park. Large rock and ice avalanche consisting of material dislodged from Ronti peak, releasing the water trapped behind the ice of the Nanda Devi glacier and causing a glacial lake outburst flood, creating an avalanche and deluge that quickly turned into flash floods (Fig 37). It caused flooding most notably in the Rishiganga River, the Dhauliganga River and in turn the Alaknanda in the Chamoli district that is the head stream of the Ganges. The result of an avalanche that dropped about 27 million cubic metres of rock and glacier ice from the nearby Ronti Peak, destroying a dam known as the Rishiganga Hydroelectric Project, the impact catapulted water along the Dhauliganga River, damaging another

power project downstream in the Tapovan area. In satellite images, a 0.5 mi (0.80 km) scar is visible on the slopes of Nanda Ghunti, a 20,700 ft (6,300 m) peak on the southwestern rim of the Nanda Devi sanctuary, a wall of mountains surrounding the Nanda Devi massif.

Figure 37 Uttarakhand flood: Glacier burst in Chamoli dist (businesstoday.in)

(https://www.businesstoday.in/latest/trends/story/glacier-bursts-in-uttarakhand-itbp-personnel-start-rescue-operation-286893-2021-02-07)

In June 2021, the International Charter 'Space and Major Disasters' published a study that confirmed a large rock and ice avalanche as the cause of the disaster. The result was based on data from earth observation satellites (Fig 38), as well as seismic records, numerical model results, and eyewitness videos. It was estimated the avalanche at about 27 million cubic meters, consisting of 80% rock and 20% glacier ice. The glacier ice turned into water over the course of the 3.2km elevation difference from the peak, which further worsened the impact by causing a debris flood wave.

Figure 38 Satellite data reveals tha cause of Chamauli disaster (Source: https://www.esa.int)

Casualties and damage

The disaster killed 204 workers at the Tapovan dam site and Rishiganga Power Project (2021 Uttarakhand flood, n.d.). Boulders along with debris hampered rescue efforts in Tapovan tunnel.

e) Actions taken on pre, during, and post-events: Many villages were evacuated as authorities emptied two dams farther down the river to stop the floodwaters from reaching towns of Haridwar and Rishikesh.

f) Lessons learnt:

- Uncontrolled construction (dams, hotels, and carelessly constructed roads) weakens the hills and the resultant loss of lives and livelihoods by means of disaster.
- The Himalaya apart from its cultural significance and strategic importance, is a biodiversity hub. As tall as they stand, the mountains are environmentally fragile, making them prone to earthquakes, floods, and landslides, which makes safeguarding the range all the more important.
- Development anywhere in the nation must be sustainable. One should stop mimicking the western industrial growth model that relies on capital- and energy-intensive model, which can not work in a country as densely populated as India.

3.19.2 Uttarakhand, 2016

a) Year/Time of event and its duration: 1st July, 2016

b) Causes and factors: Due to monsoon rain triggered landslides in parts of Uttarakhand. Also, cloudburst hit Singhali area (near Pithoragarh)

c) Areas affected: Most affected areas were the districts of Chamoli and Pithoragarh. Rainfall level 40 mm in 24 hours June 25 to June 30, 2016, as per IMD that parts of Uttarakhand have seen heavy rainfall since 25 June 2016, with several locations River level Overflowing Alaknanda River and Mandakini River,, Uttarakhand - July 1 to July 2, 2016.

d) Consequences & Impacts: Heavy rain between 19 and 20 August triggered a landslide in Pauri Garhwal district of Uttarakhand. River levels have increased dramatically and reported that the Alaknanda River and a tributary, the Mandakini, have both overflowed. It was known that at least 30 people dead or missing and several houses destroyed or washed away in the districts of Chamoli and Pithoragarh. The Pauri-Srinagar highway was also blocked due to the cloudburst, according to Uttarakhand disaster officials. Some more casualties are:

- 18 bodies have been recovered in Singhali area near Pithoragarh.
- 8 persons died in Pithoragarh District.
- 4 Lives claimed by heavy rains in Chamoli district.
- Two persons were swept away by the muddy waters and debris rushing down the slopes into Siron village in Chamoli.
- One person was killed in Ghat block and another in Sithel village.

e) Actions taken on pre, during and post events:

- Centre sent the rescue teams of National Disaster Response Force to Uttrakhand, which had been hit by torrential rains and landslides

f) Lessons learnt:

- Uttarakhand is a hill states and fragile, part of new mountain that is prone to high intensity rainfall events, including cloud bursts. A very good amount of rainfall take place each year in Uttarakhand.

- The state is also prone to flash floods and landslides.
- The state is having large number of rapidly flowing silt laden rivers that can turn into ravaging, eroding, force of destruction if not handled carefully.
- Uttarakhand state is seismically active area in zone IV and V, with tectonic activities that can lead to impact on land, rivers, increasing the disaster potential.
- The state has very high proportion of area under forests, which is necessary for the sustained existence of the local environment, people and biodiversity. Livelihood and water security of people in both states majorly depends on these natural resources.

3.19.3 Uttarakhand, 2013

a) Year/Time of event and its duration: 16th-17th June, 2013

b) Causes and factors: The affect of cloudburst in 12 out of the 13 districts in Uttarakhand. The Nanda Devi glacier had broken off in Uttarakhand's Chamoli district, triggering an avalanche and a deluge in the Alaknanda river system that washed away hydroelectric stations. A glacial burst was widely considered the main reason for the incident a massive flood in the Dhauli Ganga River, other reports citing cloudburst as another possible one, but the Sunday's incident was quite "peculiar" as there was no rain or melting of snow. This flood was flash flood.

c) Areas affected: 4 districts that were worst affected were Rudraprayag, Chamoli, Uttarkashi and Pithoragarh.

d) Consequences & Impacts: The banks of the Chorabari lake in Kedarnath collapsed due to a cloudburst that had resulted in a major flash flood causing widespread destruction in Uttarakhand (Fig 39) and led to heavy losses to infrastructure, agriculture lands, human and animal lives.

Westerly cyclonic circulation combined with a intense western disturbances Uttarakhand and adjoining areas received heavy rainfall leading to 375% more than the benchmark rainfall during a normal monsoon. This caused the melting of Chorabari and eruption of the Mandakini River which led to heavy floods near Gobindghat, Kedar Dome, Rudraprayag district, Uttarakhand, Himachal Pradesh and Western Nepal, and acute rainfall in other nearby regions of Delhi, Haryana, Uttar Pradesh and some parts of Tibet. As of 16 July 2013, according to figures provided by the Government of Uttarakhand, more than 5,700 people were "presumed dead. This total included 934 local residents. The main tourist and pilgrimage season, significantly enhancing the number of the casualties and adversely affecting the rescue and relief operations. The impact of disaster was most pronounced in the Mandakini valley of the Rudraprayag district. Torrential rains, coupled with the probable collapse of the Chorabari Lake, led to flooding at the Kedarnath Shrine and the adjacent

Figure 39 Glacial burst in Uttarakhand a grim reminder of Uttarakhand

(https://www.business-standard.com/article/current-affairs/glacial-burst-in-uttarakhand-a-grim-reminder-of-2013-kedarnath-deluge-121020700694_1.html)

areas (Fig 40) of Rambara, Agastyamuni, Tilwara, and Guptkashi. Other pilgrimage centers in the region, including Gangotri, Yamunotri and Badrinath, which are visited by thousands of devotees during the summer season, were also affected. People in important locations, such as the Harsil, Roopkund and Hemkund Sahib, were stranded for days together. Over one lakh people were stuck in various regions of the State due to damaged roads, landslides and flash flood-induced debris.

Figure 40 Uttarakhand flood case study – a closer look (Source: cidm.co.in)

The disaster caused heavy loss of precious lives and extensive damage to private properties and public infrastructure. More than nine million people were affected by the flash floods. As far as casualty to human lives is concerned, as informed by the State Government on 09 May 2014, a total of 169 people died and over 4021 people were reported missing (presumed to be dead). As per estimates, the disaster has cost Uttarakhand Rs 50,000 crore in infrastructural loss. Uttarakhand Jal Vidyut Nigam Limited had suffered loss of Rs 77 crore apart from the Rs 50 crore lost in power generation.

1.	Number of dead and Missing person (presumed dead)	:	169 + 4021
2.	Number of houses and cowsheds damaged	:	20141
3.	Animals lost	:	11091
4.	Total damages crops, houses & public utilities	:	Rs 34977.00 Cr.

Major Findings

1. The terrific incident happened due to heavy down pourin between 2nd & 3rd week of June 2013. It was resulted as flash floods in all the major river valleys in the region. Also triggered lot of landslide at numerous locations caused totally stop of life.
2. Total rainfall recorded during the specific period was 385.1 mm, against the normal rainfall of 71.3mm, which was in excess by 440%.
3. In lieu of above, it is resulted tremendous water discharge in various rivers and streams.
4. As per the eye witnesses and technical inputs received from various agencies, the possible causes of the disaster could be summarized as:-
   - Collision of western disturbances with monsoon easterlies
   - Excessive precipitation in very short span of time
   - Heavy erosion and the accumulation of large volume of water and sediment accumulation in major river beds due to excessive rainfall
   - Run - off of loose debris, moraine and boulders with excessive force washing off all that came in its way

5. Kedarnath shrine area (Gaurikund to Kedarnath) witnessed a catastrophic incident. Also experienced similar kind of tragedy in the Mandakini valley, the Alaknanda valley (at Gobindghat and upstream), the Pindar valley, and along the banks of the river Kali in Dharchula area.

6. Also suffered unprecedented devastation with very heavy loss of life and property.

e) Actions taken on pre, during, and post-events:

Rescue operations

The Indian Army, Air Force, Navy, Indo-Tibetan Border Police (ITBP), SDRF, National Disaster Response Force (NDRF), Public Works Department and local administrations worked together for quick rescue operations. Several thousand soldiers were deployed for the rescue missions. Activists of political and social organisations were also involved in the rescue and management of relief centres. The national highway and other important roads were closed to regular traffic. Helicopters were used to rescue people, but due to the rough terrain, heavy fog and rainfall, manoeuvring them was a challenge.By 21 June 2013, the Army had deployed 10,000 soldiers and 11 helicopters, the Navy had sent 45 naval divers, and the Air force had deployed 43 aircraft including 36 helicopters.From 17 to 30 June 2013, the IAF airlifted a total of 18,424 people - flying a total of 2,137 sorties and dropping/landing a total of 3,36,930 kg of relief material and equipment.

On 25 June, one of 3 IAF Mil Mi-17 rescue helicopters returning from Kedarnath, carrying 5 Air Force Officers, 9 of the NDRF, and 6 of the ITBP crashed on a mountainous slope near Gauri Kund, killing all on board.The deceased soldiers were given a ceremonial Guard of honour by Union Minister of India, at a function organised by the Uttarakhand State Government. Animals suffered greatly during the calamity

Indo Tibetan border Police (ITBP) a Force which guards the Indo China borders on the high Himalaya with its 3 Regional Response Centres (RRCs) based at Matli (Uttarkashi), Gauchar (Chamoli) and Pithoragarh swung into action and started rescue and relief operation. 2000 strong ITBP force with its mountaineering skills and improvisation methods started rescue of stranded pilgrims. It was a simultaneous effort by ITBP at Kedar ghati, Gangotri valley and Govind ghat areas. According to official figures by ITBP, they were able to rescue 33,009 pilgrims in 15 days on their own from extreme remote and inaccessible areas. Before Army or Air Force called in, being deployed in the nearby areas, ITBP took the first call and saved many lives. They also distributed food packets to stranded pilgrims who were in a pathetic condition being not having any food for more than 72 hours at many places.

Aftermath

The then Prime Minister of India undertook an aerial survey of the affected areas and announced 10 billion (US$140 million) aid package for disaster relief efforts in the state. Several state governments announced financial assistance, with Uttar Pradesh pledging 250 million (US$3.5 million), the governments of Haryana, Maharashtra and Delhi 100 million (US$1.4 million) each, the governments of Tamil Nadu, Odisha, Gujarat, Madhya Pradesh and Chhattisgarh 50 million (US$700,000) each. The US Ambassador to India extended a financial help of US$150,000 through the United States Agency for International Development (USAID) to the NGOs working in the area and announced that the US will provide further financial aid of US$75,000. The help was later politely rejected by Government of India. The Government of Kerala offered 20 million Rupees and all ministers offered one month's salary.

The Government of India also cancelled 9 batches, or half the annual batches of the Kailash-Mansarovar Yatra, a Hindu pilgrimage. The Chardham Yatra pilgrimage, covering Gangotri, Yamunotri, Kedarnath and Badrinath

was cancelled for 2 years to repair damaged roads and infrastructure, according to the Uttarakhand Government.

Government agencies and priests of Kedarnath temple were planning mass cremation of the hundreds of victims, after one week of tragedy. Local youths from several affected villages near Gangotri helped stranded tourists and pilgrims, by sending messages to their places and by providing food. Rescuers also retrieved approximately 10 million Rupees US$140,000 and other jewellery from local persons, including some people dressed like sadhu babas, who reportedly collected it from a destroyed building of a Bank and damaged shops.

Nehru Institute of Mountaineering (NIM) was given the responsibility of Rebuilding Kedarnath. They mastered high-altitude training. NIM was successful in rebuilding Kedarnath.

f) Lessons learnt:

- State is prone to climate change impacts in major way, Himalayas have already seen increase in temperature that are 2-3 times higher than the average global temperature rise of 0.9° C. These climate change impacts include greater frequency of high intensity rainfall, including cloud bursts that can also increase the potential of landslides and flashfloods.
- While using the riverbanks in the region for any type of habitation, construction, or developmental activity, it is essential that river history and other information related to past disasters be taken into account, so that these spots do not become death traps for tourists and pilgrims. Besides, ecological, slope and drainage characteristics of upper reaches should also be taken into account. While planning for tourism related developmental activities, besides environmental and socio-cultural issues, the carrying capacity of tourism sites should also be kept in mind. There must be provision for registration of pilgrims and tourists entering the ecologically sensitive areas to effectively regulate the tourist influx.
- Need to develop/revise and update/improve Disaster Management Plans at District/local levels, ensuring (i) adequately detailed Hazard Vulnerability Capacity Risk (HVCR) analysis with clear approach of vulnerability assessment, (ii) risk mitigation plan with clear time-frame, roles and responsibilities, and mechanism of integrating DRR/mitigaiton measures into departments plans/schemes, and (iii) a functional operational structure and establishing a clear and accountable process for all disaster preparedness efforts. Take into consideration the effects of climate change, ecological and natural resources, livelihood and local development issues. Need to develop Standard Operating Procedures (SOPs) for mitigation, preparedness and response in case of all major disasters with assigning duties and responsibilities to key role players and stakeholders. Capacity building of all the stakeholders in disaster management, especially of main role players, is essential for effective response.
- Landslide risk micro-zonation using ground truth of landscape, geology, ecology, vegetation, soil characteristics, human settlements, landslide and flood history of the site.
- Appropriate guidelines, regulations and codes for landslides risk assessment and mitigation through an integrated approach, involving State agencies/departments and local administration.
- Blasting for developmental activities must be avoided because frequent blasting may destabilize the weak rocks of the region, which may result in landslides and rock falls andslide management
- River Bed Mining related issues are to be tackled systematically, based on the scientific investigations, taking care of ecological aspects. The issue needs an area specific approach before

giving lease for River Bed Mining. Unsustainable mining of the riverbeds must not be allowed and illegal mining must be stopped immediately

3.19.4 Uttarakhand, 2010

a) Year/Time of event and its duration: 21st Sept 2010

b) Causes and factors: Monsoonal rain causes floods that had struck various parts of Uttarakhand. There were three reasons that led to the devastating flash floods: one, heavy rain, even though it is not unusual; two, rain on the glacier; and three, snow and glacier run-off along with the newly formed lake. Snow and ice melt faster when they come in contact with water

c) Areas affected: Almora, Chamoli, Uttarkashi and Nainital were worst hit districts.

d) Consequences & Impacts: The flood situation in the state continued to remain grim in 3rd week of September.

Major findings are

- Major rivers continue to swell.
- Over 76 people dead and thousands homeless.
- The Ganga in Haridwar flowing above the danger level and breached its embankment at Bishanpur Kundi village inundating areas like Luxor, Rayasi and Gangadaspur.
- Almora, Chamoli, Uttarkashi and Nainital were worst hit districts
- In Tehri, the reservoir level reached 831.05 meter and heavy discharge was being made from the hydel project. A high alert has been issued in low-lying areas in Tehri.
- The construction work of 400 MW Koteshwar dam had been stopped due to rise in the water level of Bhagirathi River.
- The then Chief Minister, made an aerial survey of flood and disaster-affected areas in the state. The then Prime Minister, sanctioned an ex-gratia amount of Rs. 1,00,000/- lakh to the next of kin of each of the deceased and Rs. 50,000/- to those seriously injured in the floods.

e) Actions taken on pre, during, and post-events:

In the wake of the worsening flood situation, the Railways had cancelled some trains bound for Dehradun and Haridwar while a few others were diverted or short terminated at various stations. The steps were taken after landslides were reported between Haridwar-Motichur sections and breaches between Raisi-Balawali on Moradabad Division, said a Northern Railway spokesperson. NDRF has been deployed for rescue operations.

f) Lessons learnt:

- Ensure credible environmental and social impact assessment of all activities including all dams and hydropower projects above 1 MW capacity, such assessments should include how the projects can increase the disaster potential, how they will affect the adaptation capacity in the context of climate change.
- Ensure credible environmental compliance mechanism for each project in which local people have a key role.
- No projects should be cleared until there is credible cumulative impact assessment including carrying

capacity study for all projects in the river basin/sub basin. An urgent review of under construction and under planning projects should be taken up.

- Certain rivers, forests and high risk zones should be declared as no project areas in each basin.
- All districts must have an active state disaster management authority with key role in development decisions.

3.20 State/UT: Uttar Pradesh

Major Floods in 2021, 2016, 2010

3.20.1 Uttar Pradesh, 2021

a) Year/Time of event and its duration: 15th September 2021; caused severe flooding in several districts of Uttar Pradesh state in northern India.

b) Causes and factors: The rain caused river levels to rise and as of 17 September, the Kwano, Sarda, Ganges and Ghagra rivers were above danger levels in several districts including Gonda, Ayodhya, Kheri, Badaun and Ballia. This flood is riverine flood.

c) Areas affected: Districts of Amethi, Ayodhya, Azamgarh, Bahraich, Barabanki, Basti, Chandauli, Fatehpur, Ghazipur, Gonda, Gorakhpur, Jaunpur, Kaushumbi, Lucknow, Mirzapur, Pilibhit, Pratapgarh, Prayagraj, Rae Bareli, Sitapur and Sultanpur. Severe flooding affected wide areas of the state in August this year 2021 (India - Fatalities After Floods and Severe Weather in Uttar Pradesh, 2021).

d) Consequences & Impacts: Disaster authorities in the country reported as many as 58 people have lost their lives in incidents related to severe weather from 15 to 19 September. Fatalities were reported in the districts of Amethi, Ayodhya, Azamgarh, Bahraich, Barabanki, Basti, Chandauli, Fatehpur, Ghazipur, Gonda, Gorakhpur, Jaunpur, Kaushumbi, Lucknow, Mirzapur, Pilibhit, Pratapgarh, Prayagraj, Rae Bareli, Sitapur and Sultanpur.

e) Actions taken on pre, during, and post-events: With floods affecting 619 villages in the state, the Uttar Pradesh government had set up 1,102 relief shelters to mitigate the impact of the calamity. The UP government had deployed around 4,392 boats and 938 medical teams in the flood-hit areas. The Uttar Pradesh administration instructed the deployed teams of National Disaster Response Force (NDRF), State Disaster Response Force (SDRF) and the State Disaster Management Authority to work round the clock in an active mode to carry out relief operations.

Over 59 teams, including those of the NDRF, SDRF and PAC, had been positioned to tackle the floods in 41 districts of the state.

Orders had been given to not delay relief operations in areas affected by floods and excess rain. To expedite the relief measures, the UP government had deployed around 4,392 boats and 938 medical teams while 1,293 flood posts and 1070 animal relief camps had been set up.

"We are monitoring the entire flood situation. Adequate measures have been taken and we have ensured that there is ample supply of drinking water, dry food packets, medicines, clothes, utensils and bedding among others amid adherence to Covid protocol," a government official said.

237 villages flooded in UP's Mirzapur, villagers allege administration is helping them. More than 73,162 dry ration kits had been distributed by the government so far, with 1,381 people getting the kits in the last 24 hours. The state government had distributed 3,48,405 lunch packets to the affected people till now. In the last 24 hours itself, 3,480 lunch packets had been distributed. Along with this, around 33 animal camps were set up in the last 24 hours for the protection of wildlife. The government had set up around 1,070 animal camps in the state. In these camps, vaccination of more than 6,44,149 animals had been done.

The Government of Uttar Pradesh was fully alert to prevent the damage caused by the floods with over nine teams of NDRF deployed in as many districts of the state -- Mirzapur, Prayagraj, Bahraich, Shravasti, Siddharth Nagar, Gorakhpur, Lucknow, Ballia and Varanasi.

11 teams of SDRF had been deployed in Moradabad, Agra, Bareilly, Balrampur, Prayagraj, Lucknow, Kushinagar, Gorakhpur, Ayodhya, Ballia and Varanasi.

Similarly, 39 PAC teams had been deployed in the districts of Sitapur, Bahraich, Balrampur, Prayagraj, Kaushambi, Pratapgarh, Pilibhit, Kheri, Fatehpur, Rae Bareli, Banda, Etawah, Agra, Auraiya, Azamgarh, Gorakhpur, Ballia, Bijnaur, Deoria, Maharajganj, Kushinagar, Siddhartha Nagar, Ayodhya, Gonda, Shravasti, Hardoi, Barabanki, Chandauli, Kanpur Dehat, Kannauj, Hamirpur, Amroha, Bulandsheher, Meerut, Bhadohi, Prayagraj, Aligarh, Kasganj and Muzzafarnagar.

Teams of NDRF and SDRF had evacuated 35,187 people from the flood-affected areas and shifted them to relief camps. In Varanasi flood due to rising Ganges inundate 141 villages, 11 blocks.

f) Lessons learnt:

- An able coordination mechanism is key to motivate the hundreds who are already in the flood impacted areas and for the many more to come. Strong coordination mechanisms will also help to assign roles and responsibilities and avoid duplication of efforts and wastage of precious resources.
- The community centres are in need of construction in the flood prone districts especially in all the 14 districts of eastern part of U. P. for cyclone/ flood shelter centres, where fooding, lodging and other basic amenities may be kept ready. Such shelters shall be useful to car/bus users and they would not attempt crossing streams at causeways or breached roads and thus endangering their life, while hurriedly trying to reach safer places.
- Flooding due to frequent embankment breach has been found one the reasons during flood season. Hence, need for Embankment monitoring system using drone technology along with pre & post flood inspection and their proper maintenance with adequate budgetary support which may be pulled from some relavent sector like Road or agriculture sector.

3.20.2 Uttar Pradesh, 2016

a) Year/Time of event and its duration: 14th July to 19th August 2016 in between few floods took place.

b) Causes and factors: Extreme rainfall during monsoon rain brought flooding to at least 6 districts of Uttar Pradesh in mid July. This flood was riverine flood.

c) Areas affected: The affected districts include: Amroha, Kushinaga, Pilibhit, Lakhimpur Kheri, Basti, Barabanki and Bahraich. Further rain from 19 August, heavy losses took place.

d) Consequences & Impacts: The recent floods in Uttar Pradesh had affected 870,000 people in 987 villages of 28 districts. Over 60,000 people had been evacuated, mostly from the districts of Varanasi, Allahabad, Ghazipur and Ballia and 30,247 were staying in relief camps. Banda, Jalaun, and Ghaziabad districts had also been badly affected. 43 people killed in rain-related incidents in eastern Uttar Pradesh, Bundelkhand and Terai regions, with over 800,000 affected.

Figure 41 Flooding in Uttar Pradesh, India, August 2016
(https://floodlist.com/wp-content/uploads/2021/08/Floods-in-Uttar-Pradesh-India-August-2021.jpeg)

As per Central Water Commission, the water land in the Ganga Rivers where above warning levels in 14 different locations. The flood situation had worsened due to release of water from Nepal and adjoining states of Madhya Pradesh and Uttrakhand which led to further rise in water levels of major rivers. The Ganges at Ballia was at a record high of 60.39 metres, beating the previous high of 60.25 from September 2003. At Allahabad, the Ganges stood at 85.33 metres, well above the danger level of 84.73 metres, although levels were expected to fall. At Varanasi, the Ganges is 72.56 metres, above danger levels of 71.26 m but below the record of 73.90 m set in September 1978. Levels were expected to fall over the next 24 hours.

Table - 4 Damages and areas affected during 2016, Uttar Pradesh Flood

Category	Details	Date Range	Location
Affected People	11,854	July 14 to July 16, 2016	6 districts of Uttar Pradesh
Fatalities	4 people	July 14 to July 16, 2016	6 districts of Uttar Pradesh
Buildings Destroyed	17 buildings	July 14 to July 16, 2016	6 districts of Uttar Pradesh
Fatalities	43 people	August 19 to August 23, 2016	Eastern Uttar Pradesh, Bundelkhand, and Terai regions
Affected People	870,000	August 19 to August 25, 2016	Eastern Uttar Pradesh, Bundelkhand, and Terai regions

e) Actions taken on pre, during, and post-events: Nineteen teams from the NDRF were working in affected areas, carrying out rescue and relief operations. Helicopters from the Indian Air Force were also being used to air drop supplies to affected areas.

f) Lessons learnt:

- An able coordination mechanism is key to motivate the hundreds who are already in the flood impacted areas and for the many more to come. Strong coordination mechanisms will also help to assign roles and responsibilities and avoid duplication of efforts and wastage of precious resources.
- Information sharing is the first step towards good coordination. Not just with the people but also flowing back from the people to decision makers.
- Lessons from elsewhere show context and needs of flood survivors change quickly, and sometimes it is necessary to smoothly shift the recovery effort's focus from rescue and relief mode. Such a shift encourages those impacted by the flood to actively engage in relief and recovery efforts.
- The engagement and participation in relief efforts is a fuel which drives recovery.

3.20.3 Uttar Pradesh, 2010

a) Year/Time of event and its duration: 19 September to 2 October 2010

b) Causes and factors: Unprecedented flood situation in Uttar Pradesh along the Ganga River. Due to heavy rains in the upper catchment areas, Yamuna River crossed the danger mark causing flooding in low-lying areas, at three gauge stations (i.e. Kannauj, Ankinghat and Kanpur) located along the Ganga River, water level exceeded the previous high-flood water level ever recorded at these sites. The flood situation was described to be unprecedented by CWC (Central Water Commission), which is the nodal organization for carrying out the flood-forecasting activity on the major rivers and has fixed warning level (WL) and danger level (DL) at important sites in India. This flood was riverine flood.

c) Areas affected: 17 districts of western Uttar Pradesh (Basti, Kannauj, Bijnore, Moradabad, Lakhimpur Kheri, Bahraich, Pilibhit, Sitapur, Deoria, Gonda, Rampur, Shahjahanpur, Mathura, Bareilly, Saharanpur and Kanshiram Nagar.

d) Consequences & Impacts: Flood situation in Uttar Pradesh worsened with the swirling waters of its major rivers inundating 177 villages in 30 districts where 9 more persons died taking the toll in rain-related incidents this season to 256 . Flood situation was especially grim in the nine districts of western Uttar Pradesh where road and rail traffic had been adversely hit with flood waters submerging the roads and tracks. One person was killed when a jeep was washed away in Naahal River in Bareilly district where three persons

drowned as a boat capsized in Ramabai Nagar. Two women were killed in Badaun, two deaths were reported from Shahjahanpur and one from Pilibhit. Flood fury claimed 68 more lives in Uttar Pradesh even as the deluge situation was not improving (Hindu 24th September), Flood situation was bad in Bijnore because of discharge of water from Haridwar in Ganga and about 2000 people being marooned, the spokesman said adding that Kosi and Ram Ganga were rising menacingly in Rampur leading to erosion and motor boats have been rushed from Moradabad where 36 villages were marooned (Fig 42) with the discharge of water in Kosi and Ram ganga. Situation is also grave in Muzaffarnagar where Ganga is on the rise and a "kutcha" embankment had been damaged following which water has entered a number of villages.

Figure 42: Flood situation worsen in Western UP
(Source: https://www.oneindia.com/)

e) Actions taken on pre, during, and post-events: PAC and motorboats have been deployed in all the affected villages where food packets are also being dropped for the people cut off due to floods at Bareilly, Moradabad and Rampur, officials said.

f) Lessons learnt:

Historical satellite images analysis can be very useful for building a library consisting of inundation maps that have been created in advance of a flood for predetermined stream stage, by which decision-makers can quickly access the map corresponding to the forecasted or real-time stage data.

From the hydrological observations, it is clear that from 19 September 2010 to 2 October 2010, flood situation was very severe along the Ganga River in Uttar Pradesh, when the river water levels attained by the Ganga River at Kannauj about 12 years back, at Ankinghat gauge station about 32 years back and at Kanpur gauge station about 42 years back were surpassed, attaining a new Highest Flood Level (HFL). The hydrological, meteorological and satellite-based observations made for the unprecedented flood event can be a good input for researchers to investigate the changes in climate regime which caused the river water levels to exceed after a decade. The spatial extent of inundation and villages identified to be affected under new HFLs experienced after a gap of more than a decade will be useful for updating the existing information on flood-prone area inventory and list of flood affected villages.

3.21 State/UT: West Bengal

Major Floods in 2021, 2017

3.21.1 West Bengal, 2021

a) Year/Time of event and its duration: 26th May, 2021

b) Causes and factors: Cyclone Yaas (very damaging Tropical Cyclone) made landfall on May 26, 2021 in Odisha. A low pressure area formed over east-central Bay of Bengal is likely to intensify into a very severe cyclonic storm by May 25. The storm, named Cyclone Yaas, moved towards West Bengal, Odisha and Bangladesh around May 26, 2021 morning.

May 2021 onwards in several phases' heavy rain took places in different district of W B. Several areas of Howrah, Hooghly, Paschim Medinipur, Paschim Bardhaman and Birbhum had been affected Heavy rains lashed parts of West Bengal on September 21 and on 22 Sep, 2021. A flooded area revealed at Udaynarayanpur in Howrah district on October 1, 2021. This flood was Cyclonic flood.

c) Areas affected: Entire east coast of West Bengal (districts like East Midnapore, South 24 Parganas and parts of North 24 Parganas) were most affected and Orissa.

d) Consequences & Impacts: Evacuations were made inlow-lying areasin East Midnapore and West Midnapore and Jhargram, Hooghly, Kolkata and North 24 Parganas and South 24 Parganas from West Bengal. Starting on May 25, heavy rains and strong winds started to brush the coastal and inland areas of West Bengal, storms reaching as far as Kolkata, where 62 kmph winds and gusts of 90 kmph were recorded (Ajeyo Basu). Digha and surrounding areas were mostly affected by flood (Fig 43). 3 Perons were died. More than 4,500 villages were damaged. Various rural homes and agricultural lands were hard-hit, and basic needs such as drinking water, sanitation, and the like were also hard to come by. At least 143 marine vehicles were broken into pieces.

In normal monsoon, the districts of Purba Bardhaman, Paschim Bardhaman, Paschim Medinipur, Hooghly, Howrah and South 24 Parganas were bearing the brunt of flood after heavy rain in different phases.At least 23 people died in the flood.300,000 affected. More than 4 lakh hectares of agricultural land in these seven districts was under water now. Heavy rain and subsequent discharge of water from dams in the last few days had inundated large parts of Purba and Paschim Bardhaman, Paschim Medinipur, Hooghly, Howrah, South 24 Parganas and Flood situation in south Bengal remained grim after fresh water was released from barrages, compounding the woes of over 37 lakh people.

Figure 43 Sea was dangerous ahead of Cyclone Yaas scinerio at Digha, W B (Source: PTI)
(https://www.newindianexpress.com/states/odisha/2021/may/26/cyclone-yaas-weakens-after-pounding-odisha-bengal-coasts-rainfall-to-continue-till-thursday-2307817.html)

e) Actions taken on pre, during, and post-events: The state government had set a control room to monitor the situation at the state secretariat Nabanna', which will work round the clock. The CM remained present at the control room in Nabanna on the days when the cyclone is about to hit the coastal areas of the state. She was accompanied by other senior officers of the government. All precautionary measures had been taken by the administration.

f) Lessons learnt:

- Taking lessons from last cyclone (Amphan), a central unified command war room has been set up at the Kolkata Police headquarters for cyclone Yaas, which will work to ensure cutting down response time.
- Along with state agencies, the Army has deputed four columns for this purpose in the city. The National Disaster Response Force (NDRF) will be using nine teams for their rescue operations with 30 members in each. The state's disaster management group (DMG) has increased its manpower for the job and formed 44 teams to be spread across police divisions and boroughs- especially in areas of Ballygunge, Kalighat, Haridevpur and Behala.
- A 24-hour control room has been set up by New Town Kolkata Development Authority (NKDA) in New Town and the authorities have arranged for cleaning of drains and water channels, trimming of branches and lowering of high-mast lights. The authorities have kept diesel generators and operators ready at water pumping stations and set up cranes at strategic positions. The water level at Bagjola canal will also be monitored. At Salt Lake, BMC authorities are trimming branches and checking up on drainage pumps apart from clearing sewerage lines. There will be a control room and all ward coordinators will monitor the situation from their offices. A quick action team comprising over 100 civic officials is being kept ready. Some school buildings in Rajarhat and Gopalpur are being prepared to shelter people if needed.

- In case the city loses connectivity, a 22-member HAM radio team will help cops take stock of the situation. A HAM station has been created at the wireless wing on Ripon Street. Traffic guards have been asked to remove high-mast lights and billboards

3.21.2 West Bengal, 2017

a) Year/Time of event and its duration: July and August, 2017

b) Causes and factors: Flooding due to heavy rain. The Land Depression 01 in its precursor low & poor maintenance of dams caused dangerous floods in West Bengal. State irrigation minister said that in some districts of south Bengal, there had been around 400 mm rainfall during the last three days. In some districts of south Bengal, there had been around 400 mm rainfall during the last three days. The rivers Silabati in West Midnapore, Dwarkeswar in Bankura, Dwaraka and Kuye in Birbhum were flowing above the danger level. Some villages at Suri block II got flooded due to incessant rain. Some parts of the Hooghly and West Midnapore, including Ghatal, Khirpai, Chandrakona went under water since Saturday night. Bankura recorded the state's highest rainfall at 274 mm during the same period, while Digha recorded 104 mm, Halisahar recorded 189 mm and Burdwan received 72.6 mm of rains. The water discharge from DVC dams was in excess of that in 1978 which saw an unprecedented flood in the state. So far 2.78 lakh (278 thousand) cusecs of water had been discharged by DVC as of 1 August. The situation in Bengal got worse on Thursday after Damodar Valley Corporation (DVC) released more water from its dams and sounded a red alert in the lower catchment areas of the Damodar River. An additional 249,450 cusecs of water was released from Durgapur barrage on Thursday morning. As a result, more areas in east Burdwan, Hooghly and Howrah were hit by flood. This flood is riverine flood.

c) Areas affected: Entire North and South Bengal were under flood during the 2nd week of August.

d) Consequences & Impacts: West Bengal was affected by severe flooding due to heavy rain in July and August 2017, reported to have caused 152 deaths since 1 August. (The Hindu, 2021). Soon after these floods, North Bengal also witnessed floods that wreaked havoc over the seven districts and killed several people. Total damages crops, houses & public utilities was Rs 17727.940 Cr.

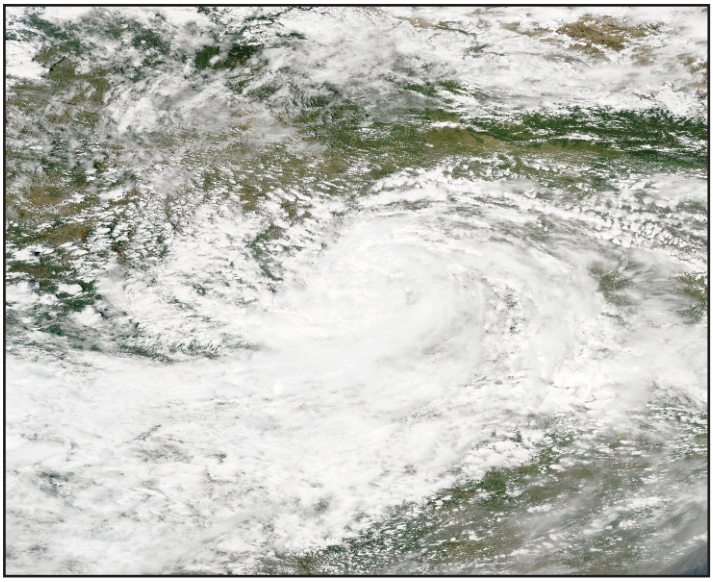


Figure 44 The depression which in its precursor low caused dangerous floods in West Bengal. (Source: Wikipedia)
(https://www.wikiwand.com/en/2017_West_Bengal_floods)

Cause and extent of the disaster

Gangetic West Bengal

The Land Depression in its precursor low & poor maintenance of dams caused dangerous floods in West Bengal (Fig 44). In some districts of south Bengal, there had been around 400 mm rainfall at a stretch of three days. The rivers Silabati in West Midnapore, Dwarkeswar in Bankura, Dwaraka and Kuye in Birbhum were flowing above the danger level as the rivers were filled with silt. Some villages at Suri block II got flooded due to incessant rain. Some parts of the Hooghly and West Midnapore, including Ghatal, Khirpai, and Chandrakona went under water since last 2 days. Bankura recorded the state's

highest rainfall at 274 mm during the same period, while Digha recorded 104 mm, Halisahar recorded 189 mm and Burdwan received 72.6 mm of rains. The water discharge from DVC dams was in excess of that in 1978 which saw an unprecedented flood in the state. So far 2.78 lakh (278 thousand) cusecs of water had been discharged by DVC as of 1 August. The situation in Bengal got worse on Thursday after Damodar Valley Corporation (DVC) released more water from its dams and sounded a red alert in the lower catchment areas of the Damodar river.

An additional 249,450 cusecs of water was released from Durgapur barrage on Thursday morning. As a result, more areas in east Burdwan, Hooghly and Howrah were hit by flood. The flood affected districts had received record rainfall from 20 to 25 July. Compared to the normal rainfall received in July, Bankura received 754 per cent, Burdwan 334 per cent, Birbhum 313 per cent, East Midnapore 500 per cent, West Midnapore 424 per cent, Howrah 427 per cent, Hooghly 359 per cent, Kolkata 367 per cent, Murshidabad 174 per cent, and Purulia 721 per cent more rainfall. The cumulative rainfall received in Birbhum from 20 to 26 July was over 600 mm.

From the weather system, the capital city of Kolkata received 142 mm of rain in 48 hours. July 2017 was the second wettest in Kolkata since 2008 with rain count 72% above the normal mark - the city received 621.5 mm rain. Only once - in 2015 - in the last decade has Kolkata received more rain in July from Cyclone Komen.

These floods in Gangetic West Bengal were soon followed by floods in North Bengal that affected 7 districts. These floods were caused by the shifting of the monsoon trough in the sub-Himalayan region.

Effects of flood

In Gangetic West Bengal, Dhaniakhali of Hooghly district and Ghatal in West Midnapore district were the two worst affected areas. 1,79,321 hectares out of 10,82,285 hectares of paddy seed beds were damaged. At least 50 people died while nearly 20 lakh (2 million) were affected in over 160 villages, which were inundated due to heavy rains. 2,301 people were evacuated from their houses and 2,02,957 hectares of agricultural land was submerged (66). Around 7,868 houses were entirely destroyed while 44,361 were partially damaged in West Bengal. The state lost around Rs.553 crores (US$86.6 million) due to the storm. An additional eleven people were reported to be killed in Jharkhand due to heavy rains. Around 50 people have so far lost their lives, and according to government figures, about 11,974 hectares of land under paddy cultivation, and 23,096 hectare under vegetable cultivation, has been inundated. State government officials said the Subarnarekha river burst its banks after water was released from the Galudi dam in Jharkhand. In Hooghly district, embankments along the Darakeswar river were washed away and flood water gushed towards Arambagh town.

In North Bengal, the floods claimed seven lives so far in the region, while about one lakh (100 thousand) people were affected in the five districts—60,000 of them in Alipurduar and Jalpaiguri alone —and many of them had taken shelter in the relief camps. Communication between Falakata and Madarihat in Jalpaiguri district remained cut off due to large-scale inundation and a majority of the residents of the two areas had taken shelter in the relief camps.

e) Actions taken on pre, during, and post-events:

More than 27,00,000 people in 106 blocks of 14 districts of West Bengal were affected by the flood. Several villagers were stranded in Pratapur and Harishchandrapur in Ghatal. Those rescued were mostly women and children and have been kept at a State-run rehabilitation camp. The government had set up 311 relief camps where over 47,000 people have taken shelter, adding it has also set up 131 medical camps. Over 16,000 animals were sheltered in relief camps for animals and veterinary doctors were looking after them. The government had also sent medicines, water pouches and other items to all the districts. Chief minister visited flood-hit

areas in Amta and Udaynarayanpur in Howrah. She accused the DVC of releasing water indiscriminately. State government sought help from the armed forces for the first time when eight districts in south Bengal were hit by flood. The air force pressed into service a helicopter to rescue 39 people who were trapped inside a two-storey house at Pratappur village in the Ghatal sub-division of West Midnapore district. NDRF on 6 August 2017 team conducted rescue and relief operation at Ghatal, West Medenipur, WB and evacuated 03 persons and distributed relief material water pouches- 2200Nos, Dry Ration- 16 bags, Milk powder 6 kg, and Gur60 kg. So far teams have rescued 253 persons, evacuated 1029 persons and retrieved 05 dead bodies and distributed food 1500 Pkts, Water pouches/ bottles- 25564 Nos, Dry Ration (Rice, Dal, Suger, Chura etc – 236 Bags, Baby food - 244 Ctns, Milk- 1056 Pkts, Gur -2205 kg, Tarpoline- 58 Nos, Vegetable- 540 kg and Medicines.

4. Recommendations

The measures of flood management are the approach combining structural and non-structural measures to prevent and/or minimize losses from floods. The non-structural measures which alter the exposures of life and property to flooding (flood plain landuse planning, elevated structures, property buyouts, permanent relocation, zoning, subdivision, and building codes flood forecasting & warning, flood proofing, assistance, and evacuation routes etc.) and damaged the structural measures alter the physical characteristics of flood (reservoir operation, upstream catchment management, channel modifications, floodwalls/seawalls, floodgates, levees operation of hydraulic works etc.).Flood protection measures are being implemented by various competent institutions, most of them public sector bodies (state administration bodies, local communities etc.). Detail measures of structural and non-structural are discussed below:

4.1 Non-Structural Measures

Non-Structural measure data viz flood plain zoning approach, hydro-meteorological data, flood forecast data and its transmission, are required to be maintained by concerned stockholders and they should be liable to use it at appropriate time and place. The projects for interlinking of rivers for diversion of flood water to water scarce areas may be part of plan.

In view of change in trend of rainfall, demand of water over the years due to rapid increase of population, urbanisation and industrialisation, the dams and reservoirs are required to be updated in their plan and maintenance. Inflow forecasting measures are to be made mandatory for all reservoirs. Emergency Action Plan (EAP) for dam break/extreme flood situations should be ready including flood inundation maps, flood waves and time analysis. Further, SoP for water releases to be made mandatory for all reservoirs. Water release information for downstream areas should be provided with sufficient response time and channel encroachment in downstream stretches of dams to be removed.

Application of space technology and use of state of the art technology in spatial flood early warning and near real-time monitoring and mapping of floods should be given proper attention for implementation.

In order to check the threat of urban flooding, each city should have their flood mitigation plans (floodplain, river basin, surface water etc.) amalgamated within the overall land use policy and master planning of the city.

Capacity building for the strengthening on flood risk management to be thought, therefore, incorporated with the best available technical and non-technical inputs on flood risk management in educational curricula to be introduced. In this regard, multi-faceted aspects of flood risk management covering the pre- and post-flood situations that include the prevention, mitigation and preparedness as well as effective and prompt response, relief, rehabilitation and recovery to be provided to the students/citizens.

The raising and strengthening of existing embankments, new embankments, channelisation, drainage and channel improvement, anti-erosion works, to be taken up as a flood control and erosion management measures as per requirement of the flood prone states & UTs.

Watershed management works in the hilly catchments of the rivers originating in Nepal, Bhutan as well as in hilly areas of India should be selectively chosen and implemented. Effort may be made to treat the hilly catchments to reduce/ minimize the sediment yield from such areas. The steep sloped rivulets/streams in hilly region may be re-graded/ longitudinal slopes reduced to control the velocity with the flow by adopting various river training measures. Such measures will arrest the sediment at source or near the source. This will further stabilize the hill slopes adjacent to the rivers. Adopting such methods will further improve the ground water recharge and release to such water over extended period of time back to the river system. This will in a way attenuate the peak of the hydrograph, reduce the flooding and ill effects of sedimentation in downstream areas.

To avoid flooding in urban areas, the following measures should be adopted: 1) Combating erosion by minimizing sedimentation of natural drainage and built up through rigorous and extensive soil erosion control and irregular disposition of urban garbage and construction rubble , as well as the expansion of the river gutters; 2) Combating waterproofing with the creation of domestic and business reservoirs, as well as the expansion of green areas; 3) Forbidding traffic on high traffic avenues when nearby rivers overflow; 4) Implantation of avenues covered by vegetation that, in cases of overflowing rivers or streams, water would be absorbed by the pavement free soil; 5) Constructing great swimming pools to receive rainwater and mini swimming pools in houses and buildings; 6) Investing in small and large streams of the urban center to support the increase of water and act as containment barriers; 7) Review of occupied areas – continuous planning and land-use planning; and 8) Action and planning – preparation of a plan to deal with the occurrence of floods as well as extreme climatic variations, and construction of reservoirs capable of storing billions of cubic meters of water and their use for non-potable purposes.

Conventional anti-erosion works along with cost effective methods like riparian vegetation which interacts with a range of geomorphological, geotechnical, hydrological and hydraulic factors to affect the type and extent of riverbank erosion to be taken into consideration.

The activities related to control of coastal erosion in an integrated manner to provide environmentally and economically acceptable coastal protection system need to be promoted.

Victims and damage can be avoided if specific action is taken in advance. The concerned stakeholders who lives in flood prone area should take precautions well in time before a flood and keep the resources that may be required immediately after a flood. The parameters, agencies, communes and in some cases the local emergency services can provide information on the endangered areas, in most cases for individual plots of land.

Flood control is a short-term approach to ensure that day-to-day living of people resident along the river are not affected; on the other hand, flood risk management is a comprehensive strategy that involves management of the ecology system. There are many plans and programmes to reduce flood hazards. So, the main concern is to prepare a time-bound action plan to accelerate the completion of all the long-term river management projects. Strong political will at both national and state level, besides active participation of all stakeholders, is necessary to accomplish these objectives.

Learn from your personal experience and take action as necessary for future flood events. Homeowners and renters need to educate themselves before moving into a new home to determine if their home is in a floodplain area. By identifying the potential home is in floodplain area you can decrease your risk of being a flood victim.

4.2 Structural Measures

Structural flood management measures are used to protect people and property and counteract the flood event in order to reduce the hazard or to influence the course or probability of occurrence of the event. This kind of measures range from heavily engineered interventions, such as dams, dykes and reservoirs, to more natural approaches like wetlands and river restoration. They cover water management at the catchment and urban level. The structural measures for flood management/erosion control (may further be classified into long term measures and short term measures) which bring relief to the flood prone areas by managing the flood flows and thereby the flood levels are: a) Creation of reservoir; b) Diversion of a part of the peak flow to another. Structural measures are any physical construction to reduce or avoid possible impacts of hazards, or the application of engineering techniques or technology to achieve hazard resistance and resilience in structures or systems.

i. The construction of Dam/Reservoir on rivers/catchment may help in floods risk reduction through appropriate water resources management. Hence, some more Dam/Reservoirs are very much required to be constructed for flood prevention and mitigation keeping in view of present scenario.

ii. Basins are to be restored to their original state so that flood control could be manage to some extent, therefore, encroachment wherever are, need to be removed or reduced.

iii. Every embankment is to be strengthened, additional embankments, drainage and channel improvement anti-erosion works are to be done further for reducing the inundation and impacts of floods. Also erosion management measures are to be adopted.

iv. Without further delay, interlinking of rivers for diversion of flood water to water scarce areas may be adopted for mutual benefit.

v. Local governments can help to reduce a community's risk to flooding by investing in adaptation strategies. These can be physical barriers such as levees or seawalls, natural barriers such as wetlands or open spaces, or non-structural policy measures such as reducing development in flood prone areas.

vi. On the river bank/ embankments appropriate anti erosion works (viz. agro-forestry/appropriate vegetation)which interacts with a range of geomorphological, geotechnical, hydrological and hydraulic factors to affect the type and extent of riverbank erosion to be taken.

vii. There is a need for afforestation in both the upper and lower catchment areas of big dams (e g, the Hirakud and the Rengali Dams). Another long-term measure could be the provision of safer houses for people who could be potentially affected.

viii. The reclamation of the existing wetlands/ natural depressions should be prohibited by state government and they should formulate an action plan for using them for flood moderation.

ix. Emphasis to be laid on Integrated flood management which calls for a paradigm shift from the traditional, fragmented and localized approach and encourages the use of the resources of a river basin as a whole and setting up of river basin organization for its effective implementation.

x. Carry out structural works on the building in flood prone area: Raise the height of light wells, eliminate weaknesses in leaky doors, windows, passive air inlets and power supply lines; build flood protection walls; install backflow preventers in sewers (separate roof water and waste water drainage) etc.

xi. Adapt the interior layout, e.g. ensure living and work rooms are not in endangered areas, position electrical installations away from areas which may become flooded and secure heating oil tanks to prevent them floating away.

xii. Store water-polluting and flammable substances (chemicals, fertilisers, fuels and lubricants, paints, thinners etc.) outside the critical zone.

xiii. Integrated flood management (IFM) calls for a paradigm shift from the traditional, fragmented and localized approach, and encourages the use of the resources of a river basin as a whole, employing strategies to maintain or augment the productivity of floodplains, while at the same time providing protective measures.

xiv. From the Eco-hydrological perspective, river floodplains are extremely important and capacious ecosystems which, being periodically flooded, absorb flood and pollutant peaks and may minimise the danger of flooding. Increased natural water retention capacity in floodplain areas. Therefore, emphasis to be given on priority to protect the water bodies and flood plain areas, if needed, appropriate actions to be suggested and implemented.

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National Institute of Disaster Management (NIDM) was constituted under an Act of Parliament with a vision to play the role of a premier institute for capacity development in India and the region. The efforts in this direction that began with the formation of the National Centre for Disaster Management (NCDM) in 1995 gained impetus with its redesignation as the National Institute of Disaster Management (NIDM) for training and capacity development. Under the Disaster Management Act 2005, NIDM has been assigned nodal responsibilities for human resource development, capacity building, training, research, documentation and policy advocacy in the field of disaster management.

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