Floods disaster in India, mitigation and their impacts

Article *in* Sustainability Agri Food and Environmental Research · April 2023

CITATIONS
0

READS
1,832

5 authors, including:

Sahdev Sahu
Chhattisgarh Swami Vivekananda Technical University, Bhilai
20 PUBLICATIONS **9** CITATIONS
SEE PROFILE

Bharat Lal Sahu
Guru Ghasidas University
51 PUBLICATIONS **484** CITATIONS
SEE PROFILE

Shobhana Ramteke
Ministry of Environment & Forests (MoEF&CC)
57 PUBLICATIONS **475** CITATIONS
SEE PROFILE

Sustainability, Agri, Food and Environmental Research, (ISSN: 0719-3726), vol 12, special issue. 2024
http://dx.doi.org/

Chapter 1

Floods disaster in India, mitigation and their impacts

Desastre por inundación en India, mitigación y sus efectos

Sahdev, [1,*] Dr. Bharat Lal Sahu, [2] Dr. Shobhana Ramteke [3]

[1, 3] School of Studies in Environmental Science, Pt. Ravishankar Shukla University, Raipur, Chhattisgarh – 492010

[2] Department of Chemistry, Guru Ghasidas Vishwavidyalaya (A Central University), Bilaspur, CG, India

Email - *sahdevsahurkb@gmail.com

ABSTRACT

The problem of floods is increasing continuously in India. The cause of the flood problem is humans and nature. This problem is getting worse in the 21st century than in the 20th century. Since this time it is causing more problems in the riverside villages of India, and it is creating health problems in the lives of millions of people. Along with this, there is huge damage to the cultivated land, animals, forests, groundwater, soil, and environment. The areas most affected by floods are Assam, Bihar, Uttarakhand, Jammu and Kashmir, Kerala, Gujarat, Maharashtra, etc. Extra lives have been lost in these states. Through this review, we have discussed in detail the history from 1943 to 2022 and all the flood-affected areas along with their damage and flood management, and mitigation.

KYEWORDS: Flood in India, causes, flood-prone areas, impact, mitigation.

RESUMEN

El problema de las inundaciones aumenta continuamente en la India. La causa del problema de las inundaciones es el hombre y la naturaleza. Este problema está empeorando en el siglo XXI que en el siglo XX. Desde entonces, está causando más problemas en las aldeas ribereñas de la India y está causando problemas de salud en la vida de millones de personas. Junto con esto, hay un gran daño a la tierra cultivada, los animales, los bosques, las aguas subterráneas, el suelo y el medio ambiente. Las áreas más afectadas por las inundaciones son Assam, Bihar, Uttarakhand, Jammu y Cachemira, Kerala, Gujarat, Maharashtra, etc. Otras personas han perdido la vida en estos estados. A través de esta revisión, hemos discutido en detalle la historia de todas las áreas afectadas por inundaciones desde 1943 hasta 2022 junto con su gestión y mitigación de daños e inundaciones.

PALABRAS CLAVE: Inundaciones en India, causas, áreas propensas a inundaciones, efectos, mitigación.

INTRODUCTION

A high water level that floods the natural banks along part of a stream is called a high tide. Therefore, floods are usually associated with a stream or a river. A river is in flood when its flow is greater than the capacity of its bed. Excess water spills over the banks, flooding adjacent land which is generally dry. When this happens, the channel and floodplain allow the water to flow. On the one hand, floods and droughts are cumulative risks. On the other hand, due to the peculiar nature of the Indian monsoon, floods and droughts can affect different parts of the country at the same time of the year. Floods can therefore be seasonal and ash floods sometimes occur as well [1]. A flood is a flood of water that normally overflows the earth. In the sense of "flowing water", the word can also be applied to the inflow of the tide. There are three common types of floods: Flash floods: caused by rapid and

extensive rainfall. River Flood: Caused when constant rain or snowmelt forces a river to exceed capacity. Floods along the coast: caused by storm surges associated with tropical cyclones and tsunamis. Between 1998 and 2017, 2 billion people worldwide were affected by floods [2]. Over the past 30 years, natural disasters around the world have killed at least three million people and affected millions more [3]. Ninety percent of natural disasters and ninety-five percent of all deaths from natural disasters occur in developing countries [4]. In the top ten countries, in terms of average annual loss of human life from natural disasters. India is one of the most flood-prone countries in the world [4]. Floods are the most common and costly natural disaster in the world, largely destroying both life and the economy. It is defined as: "Alluvial stages in which water overflows from its natural or artificial banks to normally dry land, like a river that overflows its floodplain". This usually local and short-lived event is accompanied by little or no alarm. When the dangers caused by a flood exceed the ability of the affected population to cope, it becomes a disaster [5]. Floods are a recurring phenomenon in India causing massive loss of life, property, livelihoods, infrastructure, and public services. India's high risk and vulnerability are highlighted by the fact that 40 million hectares in a geographical area of 3290 lakh hectares are subject to flooding. On average, 75 lakh hectares of land are affected each year, 1600 lives are lost, and damage to crops, homes, and public facilities is Rs. 1805 core due to flooding. The greatest number of lives (11,316) was lost in 1977. The frequency of major floods is more than once in five years. Recent floods like Kosi mega-flood in 2008 occurred in Bihar state on August 18 and Jammu and Kashmir flood in 2014 which caused major damage [6]. The devastation of life and property is an annual problem in the region [7]. With the Disaster Management Act 2005 (DM Act, 2005), the Government of India (GOI) established the National Disaster Management Authority (NDMA) as the supreme Disaster Management (DM) body in India with the mandate, among others, at the national level, it is to give a paradigm shift from what was once focused on mitigation and post-event syndrome to a proactive GD focused on prevention, mitigation, and preparedness. These efforts will preserve development gains and also minimize the loss of life, livelihoods, and property. These guidelines were developed by the NDMA through a nine-step process [8].

Figure: 1 Photographs showing the severity of the flood that occurred in 2008.

Source: [9]

CAUSES OF FLOOD

A). Natural Causes

Climate Change: According to the International Panel for Climate Change, rainfall intensity, duration, and frequency are going to increase in the future. Also, the incidence of cyclonic circulations and cloud bursts that cause flash floods are increasing due to Climate change [10].

Skewed Rainfall Pattern: 80% of rainfall occurs in the monsoon months from June to September. During this period, the rivers carry heavy loads of sediment from the catchment areas. These, together with insufficient river carrying capacity and drainage congestion, and embankment erosion, are responsible for flooding [10].
Trans-National Rivers: The fact that some of the rivers (like the Brahmaputra, many tributaries of Ganga) cause damage in India to originate in neighboring countries, adds another complex dimension to the problem. Also, sudden change in topography from high mountains to plain areas is also a reason for floods in northern India [10].
Earthquakes: An Earthquake Disaster Risk Index (EDRI), prepared by the National Disaster Management Authority (NDMA), showed that about 56% of India's area is vulnerable to moderate to large earthquakes. As many of the river basins in India lie in earthquake-prone areas, the course of the river is not stable and amounts to flooding [10].
B). Human Causes
Unplanned Development: Unplanned development, encroachment on riparian areas, failure of flood control structures, unplanned reservoir operations, poor drainage infrastructure, deforestation, land use change, and sedimentation in riverbeds exacerbate flooding. When rainfallis heavy, the river breaches the embankments and destroys habitations along the banks and on the sandbars [10].
Urban Flooding: Flooding in the cities and towns is a recent phenomenon caused by the increasing incidence of heavy rainfall in a short period of time. The reason for this is the random invasion of waterways and wetlands, insufficient drainage capacity, and lack of maintenance of drainage infrastructure. Apart from it, poor waste management is exacerbating the problem by blocking drains, canals, and lakes, while ill-planned road projects are cutting off flood flows [10].
Neglect of Pre-Disaster Planning: The history of flood management shows that the focus of disaster management has largely been on post-flood recovery and relief. Many reservoirs and Hydro-electric plants do not have enough gauging stations for measurement of flood level, which is the principal component for flood prediction and forecast [10].

TYPES OF FLOODS
Before looking at the causes and effects of floods, it is important to note that there are different types of floods that can occur around the world. There are two types of floods that are most common: flash floods and river floods [11].
Flash floods, as the name suggests, are the rapid rise in water levels caused by excessive rainfall in low-lying areas. These weather events are incredibly dangerous and can often lead to fatalities due to their destructive power and incredible speed, preventing people enough time to escape to higher grounds or adopting protective measures. Flash floods tend to be more common in areas with a dry climate and rocky terrain due to a lack of soil or vegetation, which acts as a defense or barrier against torrential rains flowing overland [11].
River flooding, on the other hand, occurs when a river overflows its bed and the water in the river can no longer be contained in its bed. These events are more common in areas with a wetter climate and have longer rainstorm seasons, as well as areas close to melting snow and ice. [11].

DFO FLOOD MAGNITUDE SCALE

- The flood magnitude value is a measure of the "severity" of a flood as a purely hydrological event (no damage assessment is involved). "0" is the smallest value reported (flow less than 1.5 years, no flooding). "10" is the most important, it is the record flood (since 1998). A value of 8 indicates that the flood runoff volume is .8 that of the flood of record (the measured current flooding/flood of record) ratio is multiplied by 10) [12].
- To calculate the flood magnitude, total runoff volumes are measured for the flood hydrograph above the bank full discharge, using as this threshold discharge the 1.5 y recurrence interval flow. The reported

current magnitude value is the runoff volume accumulated so far, compared to the flood volume of record, times [10, 12].

- In the algorithm used to automatically calculate the extent of the flood from the River Watch discharge information, a 30-day window is used for that accumulation: to determine the duration of most floods, and avoid incorporating runoff volumes from earlier floods [12].
- To obtain total runoff volume, daily runoff values are summed once discharge exceeds this threshold, and the sum is multiplied by contributing watershed area to measure total flood runoff volume (m^3). The volume increases each day until discharge recedes below the threshold [12].
- A flood of longer duration shows a greater flood magnitude. Additionally, floods that reach higher peak rates will show higher magnitudes. Flood volumes will be greater from larger basins (other factors being equal), but the magnitude value compares the flood volume to the recorded flood: catchment area and river size have no influence on the magnitude number [12].

FLOOD IN INDIA

Here is a list of particularly recorded floods that have occurred in India. Floods are the most common natural disaster in India. The heaviest southwest of the Brahmaputra and other rivers distend their banks, often flooding surrounding areas [13].

Table: 1 This is a list of notable recorded floods that have occurred in India.

Year	Area	Damage	Source
October 1943	Madras (now Chennai)	Damage caused to life and property was immense. However, the estimated figure is unknown. The flood left thousands of people homeless.	[13, 14]
11 August 1979	Machchhu River, Rajkot district of Gujarat	The exact figure for loss of lives is unknown, but it is estimated between 1800 to 2500 people.	[13, to 18]
1987	Koshi river, Bihar	Which claimed the lives of 1,399 humans, 302 animals, and public property worth INR ₹68 billion (US$850 million)	[13]
1993	8 states of India.	Flash floods killed 530 people	[13]
2004	Bihar	In this 885 people lost their lives while 3272 animals died.	[19]
June 2005	Gujarat	A total of 123 people were killed in this.	[19]
26 July 2005	Maharashtra	Killed at least 1,094 people. public property loss was estimated at ₹550 crores (US$69 million).	[19]
November-December 2005	Chennai	50 people were killed in the floods.	[19]
2008	Bihar	About 2.3 million people were affected	[19]
6 August 2010	Ladakh	The flood waters had wreaked havoc in about 71 cities. In this, 255 people lost their lives.	[19]
2012	Brahmaputra river	124 people were killed in this. Not only this, but the flood water had also entered Kaziranga National Park. In which 500 animals were killed.	[19]
3 August 2012	Himalaya	A total of 31 people lost their lives in this.	[19]

June 2013	Char Dham, Uttarakhand	More than 5,700 people were presumed dead	[13, 20]
2014	Jammu and Kashmir	200 people were killed	[21]
June 2015	Gujarat	More than 70 deaths	[13, 22]
July–August 2016	Assam	Affecting 1.8 million people and flooding the Kaziranga National Park killing around 200 wild animals.	[13, 23]
July 2017	Gujarat	Affected by the severe flood resulted in more than 200 deaths.	[13, 24]
8 August 2018	Kerala	Over 445 deaths.	[13]
16 July 2019	Brahmaputra, Assam	Affected a total of 52,59,142 people, and 1,63,962.02 hectares of crop area, In the State, the death toll rose to 59 on 20 July. At least 3,024 villages in the affected districts continued to be underwater and 44,08,142 people	[25, 26]
2020	Brahmaputra, Assam	More than 30,000 were affected, and July landslides affected 1.6 million people in 22 districts of Assam	[25, 27]
May 2022	Assam	According to Assam State Disaster Management Authority (ASDMA), thousands of villages and more than 60,000 hectares (600 km2) of crop area have been affected across the state. Authorities are running several relief camps and distribution centers across the state sheltering thousands of people	[25, 28]

FLOOD-PRONE AREAS IN INDIA

Flood-prone areas in India: The Indian subcontinent has a specific geographical structure that makes different parts of the country prone to flooding. The snow-capped northern Himalayas encompass one of the largest glaciers in the world, the source of various perennial rivers. These rivers form a great plain inhabited by millions of Indians [29]. These gigantic plains are very prone to flooding from rivers that swell due to heavy monsoon rains. According to the NIDM, the average rainfall in India is 1150mm with significant variations across the country. Annual rainfall along the West Coast and the Western Ghats, the Khasi Hills, and most of the Brahmaputra Valley exceeds 2500mm. Most river flooding occurs during the monsoon period and is usually associated with tropical storms or depressions, active monsoon conditions, and monsoon situations [29]. In addition to the river flooding, other causes of flooding are heavy rains, tornadoes, eruptions of glacial lakes, and tsunamis. If we look at the vulnerability of the flood zone in India issued by the Central Water Commission, we see that the flood prone areas in India are mainly the Indo-Ganga-Brahmaputra plain and the coastal areas in the eastern and western coastal regions [29]. A river flood is the result of a collection of water from various tributaries of the river, which carries huge silt and sand and deposits it on the river bed. The deposited clefts reduce the flow of the river and the river begins to expand horizontally, flooding nearby habitats. In most flood-prone states, lows and lows are the two main synoptic systems responsible for flooding. The NIDM mentions in its document that in Bihar 100% and in U.P. 82% of floods are caused by overland depressions and well-defined depressions. In West Bengal, the main cause of flooding is the circulation of cyclones. While in Punjab, Gujarat, Rajasthan, Jammu and Kashmir, the main reason for frequent flooding is low pressure areas [29]. The floods in Orissa and Andhra Pradesh are due to the monsoon depression. Metropolitan cities today face recurring episodes of flooding. This flooding is caused by a poorly managed sewage and sewage system that clogs up due to careless dumping of waste into the sewer system and poor maintenance by the proper authorities. Floods on the coast are mainly caused by cyclones

and tsunamis [29]. Rashtriya Barh Aayog (1980), stated that 12% of the Indian country falls within the flooded areas, which comprise nearly 40 million hectares of land. This is more than 49,815 MHAs according to the database managed by CWC based on data on flood damage reported by states for the period 1953-2010 (Report of the Working Group on Flood Management and Region-Specific Problems for XII Plan (2011) average area and population affected by floods: 7.2 M ha and 3.19 million respectively [29].

The National Flood Commission (RBA) -1980 estimated the total flood prone area of the country at 40 m.ha, including the unprotected floodplain of 33.516 m.ha and the rest as a protected area. Subsequently, the flood management working groups for floors X and XI assessed the country's flood prone area at 45.64 m ha. [30].

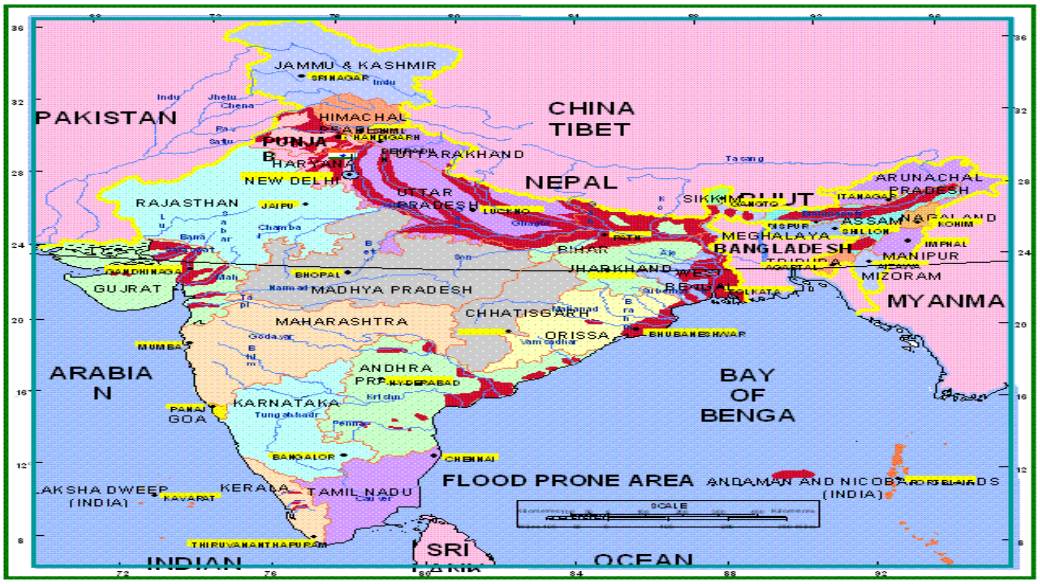

Figure: 2 Flood-prone areas in India

Source: https://indiawris.gov.in/wiki/doku.php?id=flood_management

RIVER SYSTEMS AND ASSOCIATED FLOOD PROBLEMS

The rivers in India can be roughly classified into the following four regions for study the flood problem.

(1) Brahmaputra Region;
(2) Ganga Region;
(3) North West Region; and
(4) Central India and Deccan region [30].

Brahmaputra River Region:

This region is made up of the Brahmaputra and Barak rivers and their tributaries which cover the seven states of Assam, Arunachal Pradesh, Meghalaya, Mizoram, and the northern parts of West Bengal, Manipur, Tripura, and Nagaland. The basins of these rivers receive very abundant rainfall of 110 cm. up to 635 cm. a year that takes place mainly from May / June to September [30]. As a result, the floods in this region are severe and quite frequent. Furthermore, the rocks of the hills from which these rivers arise are fragile and subject to erosion, which gives the rivers an exceptional amount of mud. Furthermore, the region is subject to violent and frequent earthquakes that cause numerous landslides on the hills and

upset the regime of the waterways. The main problems in this region are floods caused by river overflows, stagnant drainage, and the tendency of some rivers to do so. Change their courses. Erosion along the banks of the Brahmaputra has reached serious proportions in recent years [30].

Ganga River Region:

The Ganga River and its many tributaries, of which the Yamuna, Sone, Ghaghra, Gandak, Kosi and Mahananda are important, form this river region. It covers ten states Uttaranchal, Uttar Pradesh in its basin area, Jharkhand, Bihar, South and Central parts of West Bengal, parts of Haryana, Himachal Pradesh, Rajasthan, Madhya Pradesh, and Delhi. The normal annual rainfall in this region varies from 60 cm to 190 cm of which more than 80% occurs during the southwest monsoon. The rainfall increases from West to East and from South to North [30].

The problem of flooding is mostly limited to areas on the north bank of the Ganges. The damage is caused by the northern tributaries of the Ganges overflowing their banks and changing course. Even though the Ganga is a mighty river carrying huge discharges of 57,000 to 85,000 cumec (2 to 3 million cusecs), the inundation and erosion problems are confined to relatively few places. In general, the problem of flooding increases from west to east and from south to north. In the North Western parts of the region and some eastern parts, there is the problem of drainage congestion [30].

The flooding and erosion problem is serious in the States located downstream. In recent years some States which were not traditionally flood-prone have also experienced some incidents of heavy floods [30].

North West River Region:

The main rivers in this region are the Sutlej, the Beas, the Ravi, the Chenab, and the Jhelum, tributaries of the Indus, all originating from the Himalayas. These carry considerable runoff during the monsoon as well as large amounts of sediment. They frequently change course, leaving patches of sand litter. The region includes the states of Jammu and Kashmir, Punjab, and parts of Himachal Pradesh, Haryana, and Rajasthan [30].

Compared to the Ganges and Brahmaputra regions, the problem of flooding in this region is relatively less. The main problem is insufficient surface drainage, which leads to flooding and waterlogging of large areas [30].

Central India and Deccan Region:

The important rivers in this region are the Narmada, the Tape, the Mahanadi, the Godavari, the Krishna, and the Cauvery. These rivers have mostly well-defined stable courses. They have the adequate capacity within the natural banks to carry the flood discharge except in the delta area. The lower reaches of the important rivers on the East Coast have been embanked, thus largely eliminating the flood problem [30].

IMPACT OF FLOODING

It is hardly surprising that rivers have been an important part of human history: They provide food, fresh water, and fertile land for growing crops. Although water is essential for life, it can also be a destructive force. When rivers flood, the effects can be catastrophic [31].

Impact of flooding on humans

- Floods have some human impacts, including:
- People can be injured or killed by flooding
- Floods are often contaminated with sewage, which can cause illness and damage drinking water
- Power supplies can be interrupted
- Businesses may be forced to close
- Facilities such as hospitals and schools may close

- Transportation networks may be affected, such as flood damage to bridges, railways, and roads
- Homes and properties can be flooded
- People may have to leave their property until flood damage is repaired
- Goods can be damaged and taken away [32].

Impact of flooding on the environment

Floods have various environmental impacts, including:

- Wildlife habitats can be destroyed by flooding
- Contaminated flood water can pollute rivers and habitats
- Silt and sediment can destroy crops on farms
- River banks and natural dykes can be removed when rivers reach full capacity
- Rivers can be widened and deposits can increase downstream
- Trees can be uprooted by flooding
- Plants that survive the initial inundation may die due to water inundation [32].

Flood management in India

1. STRUCTURAL MEASURES: Embankments and Flood Walls, Dams and Reservoirs, Channel Improvement, Drainage Improvement, Diversion of Flood Waters
2. NON-STRUCTURAL MEASURES: Flood Plain Management and Zoning, Flood Proofing, Forecasting, Monitoring, and Early Warning Systems, Flood Disaster Relief, Flood Fighting

FLOOD MITIGATION PREPAREDNESS

Excessive rainfall, a broken dam or levee and excessive ice melt are all examples of how a stream can overflow and cause flooding. Some floods can take hours or even days to mature, allowing plenty of time for preparation and evacuation, others can progress quickly with little warning, leaving little or no time for preparation and evacuation [33]. There are mitigation approaches that businesses can take to minimize the impact of flooding. Proper planning for flood events that can jeopardize a business can pay significant dividends when these events occur; this reduces bodily injury, property damage, business interruption, and associated insurable losses [33].

Here are some strategies a business can adopt before a flood occurs to protect its assets and the people for whom it is responsible.

- Identification and knowledge of whether or not facilities under your control are in a floodplain area, history of flooding in such areas, and elevation of facilities related to streams, rivers, and dams;
- Identify and know emergency plans, warning signs, escape routes, and shelter locations in the local community;
- Communicate with local emergency management officials regarding populations with special needs under the supervision of your organization and ensure that effective emergency evacuation plans are practiced and maintained for intervention when needed ;
- Provide routine monitoring of an NOAA weather radio device and establish procedures for facility shutdown and early release of personnel/persons involved;
- Identification and knowledge of where and how to shut down critical plant services such as but not limited to electrical, gas, water, hydraulics, air compressed, sewage systems, etc. ;
- Move as many goods and equipment as possible to higher elevations/terrain for storage. Quality real estate must be a priority;
- Move all vehicles and/or mobile devices to higher elevations/terrain; build storm surge barriers with sandbags or other materials;

- De-energize all components of the electrical system and ensure that all switches, outlets, circuit breakers, cords, and associated devices are at least 12 inches above the intended flood elevation of the facility;
- Turn off all fuel-burning appliances subject to flooding;
- Identification and securing of potential sources of danger before a flood;
- Provide routine inspection/cleaning of drainage systems associated with facilities such as, but not limited to, culverts, gutters, downspouts, and associated piping;
- Access to and/or installation of sump pumps at designated damage control facilities in the event of heavy rain or flooding;
- Access and/or installation of check valves or plugs to identified damage control facilities in the event of heavy rain or flooding [33].

GOVERNMENT'S INITIATIVES AND POLICIES ON FLOODS

After the unprecedented floods of 1954, the Government of India took several initiatives and constituted several Committees to study the problem of floods in the country.

Recommendations of Expert Committees on Flood Management:

- Policy Statement – 1954
- High - Level Committee on Floods - 1957 and Policy Statement 1958
- National Flood Commission (Rashtriya Barh Ayog) 1980.
- Committee of experts to review the implementation of the recommendations of the National Flood Commission of 2003 (Comité R Rangachari)
- National Water Policy (1987/ 2002/2012) [33, to 36].

NATIONAL INSTITUTE FOR DISASTER MANAGEMENT (NIDM)

Under the provisions of Chapter VII of the DM Act, the Government of India has established the National Institute of Disaster Management (NIDM) under an Act of Parliament as the lead institute for disaster management capacity development. Disasters in India and the region. The vision of NIDM is to create a disaster-resilient India by building capacity for disaster prevention and preparedness at all levels [37]. NIDM has been entrusted with key responsibilities in human resource development, capacity building, training, research, documentation, and policy advocacy in the field of disaster management. NIDM has established strategic partnerships with various departments and departments of central, state, and local governments, academic, research, and technical organizations in India and abroad, and other bilateral and multilateral international organizations. It provides technical support to state governments through the Disaster Management Centers (DMCs) of the State and Union Territory (ATI) Administrative Training Institutes. It currently supports up to 30 of these centers. Six of these are being developed as centers of excellence in specialized areas of risk management: floods, earthquakes, cyclones, droughts, landslides, and industrial disasters [37].

CONCLUSION

The problem of floods is increasing continuously in India. If we look at the history from 1943 to 2022, the maximum flood problem has come after 2000. Along with this, there has been the loss of life and property due to floods. To reduce the problem of floods in Uttarakhand, Bihar, and Assam, appropriate steps should be taken by the government for flood control in these areas, which include the construction of dams in the river, and better health services, education, and financial help for the people, etc. to create awareness among the people to deal with the problem of floods.

REFERENCES

1. Floods: Causes, Impact & Measures – UPSC (2021) https://lotusarise.com/floods-upsc/
2. Perennial Disaster – Floods (2022). https://www.drishtiias.com/daily-updates/daily-news-editorials/perennial-disaster-floods
3. Sinha, A., & Sharma, V. K. (1999). Culture of Prevention: Natural Disaster Management. *India, National Centre for Disaster Management, Indian Institute of Public Administration, New Delhi*.
4. Gupta, S., Javed, A., & Datt, D. (2003). Economics of flood protection in India. In *Flood Problem and Management in South Asia* (pp. 199-210). Springer, Dordrecht.
5. Tripathi, P. (2015). Flood disaster in India: an analysis of trend and preparedness. *Interdisciplinary Journal of Contemporary Research*, *2*(4), 91-98.
6. Panda, P. K. (2014). Vulnerability of flood in India: a remote sensing and GIS approach for warning, mitigation and management. *Asian Journal of Science and Technology*, *5*(12), 843-846.
7. Flood Management In India (2020). https://www.drishtiias.com/daily-updates/daily-news-editorials/flood-management-in-india
8. National Disaster Management Guidelines Management of Floods (2008). https://nidm.gov.in/PDF/pubs/NDMA/3.pdf
9. Samanta, R. K., Bhunia, G. S., Shit, P. K., & Pourghasemi, H. R. (2018). Flood susceptibility mapping using geospatial frequency ratio technique: a case study of Subarnarekha River Basin, India. *Modeling Earth Systems and Environment*, *4*(1), 395-408.
10. Flood Management In India (2020). https://www.drishtiias.com/daily-news-editorials/flood-management-in-india
11. What are the Main Causes and Effects of Floods Around the World? (2021) https://earth.org/what-are-the-main-causes-and-effects-of-floods/
12. DFO Flood Magnitude Scale: https://floodobservatory.colorado.edu/SatelliteGaugingSites/DFOFloodIndexExplanation.pdf
13. Floods in India (2020). https://en.wikipedia.org/wiki/Floods_in_India
14. Frederick, Prince (22 November 2011). "Memories of Madras: Story of a submerged city". The Hindu. Retrieved 28 May 2015.
15. Noorani, A. G. (25 August 1979). "The Inundation of Morvi". *Economic and Political Weekly*. 14 (34): 1454. JSTOR 4367866.
16. Noorani, A. G. (21 April 1984). "Dissolving Commissions of Inquiry". *Economic and Political Weekly*. 19 (16): 667–668. JSTOR 4373178.
17. World Bank. Environment Dept (1991). *Environmental assessment sourcebook*. World Bank Publications. p. 86. ISBN 978-0-8213-1845-4. Retrieved 10 January 2012.
18. S.B. Easwaran (27 August 2012). "The Loudest Crash Of '79". *Outlook India*. Archived from the original on 24 December 2014. Retrieved 28 May 2015.
19. https://www.inextlive.com/top-10-major-floods-in-the-history-of-india-201512020030
20. "India raises flood death toll reaches 5,700 as all missing persons now presumed dead". *CBS News*. July 16, 2013. Retrieved 2018-08-26.
21. "Kashmir floods: phones down, roads submerged; toll touches 200, rescue ops on". *Hindustan Times*. 8 September 2014. Archived from the original on 9 September 2014. Retrieved 9 September 2014.
22. "Gujarat floods: 72 people dead, over 81,000 cattle perished due to heavy rains". *Firstpost*. 5 August 2015. Retrieved 23 August 2015.
23. Doshi, Vidhi (27 July 2016). "Flooding in India affects 1.6m people and submerges national park". Guardian. Retrieved 2 August 2016.

24. "PM rushes to Gujarat, announces relief package of Rs 500 crore". *The Times of India*. Retrieved 2017-07-26.
25. Brahmaputra floods, https://en.wikipedia.org/wiki/Brahmaputra_floods
26. "Assam flood waters show receding trend, but death toll rises to 59". The Indian Express. 20 July 2019. Retrieved 21 July 2019.
27. "Assam flood situation worsens, over 30,000 in 5 districts affected". Hindustan Times. 25 May 2020. Retrieved 26 May 2020.
28. "Assam: Assam floods: 26 killed, 5.8 lakh affected across 17 districts". The Times of India. 24 May 2022. Retrieved 25 May 2022.
29. Tripathi, P. (2015). Flood disaster in India: an analysis of trend and preparedness. *Interdisciplinary Journal of Contemporary Research*, *2*(4), 91-98.
30. Flood Management (2021), https://indiawris.gov.in/wiki/doku.php?id=flood_management
31. The Many Effects of Flooding, https://education.nationalgeographic.org/resource/many-effects-flooding
32. Internet geography, https://www.internetgeography.net/topics/how-does-flooding-affect-humans-and-the-environment/
33. FLOOD MITIGATION PREPAREDNESS, https://brim.wv.gov/losscontrol/Documents/Loss%20Outreach%20Articles/FLOOD%20MITIGATION%20PREPAREDNESS.pdf
34. Government Initiatives on Flood Management, https://www.gktoday.in/topic/government-initiatives-on-flood-management/
35. Lohani, A. K., Krishan, G., & Chandniha, S. K. (2017). Hydrological Disasters Management and Risk Assessment. *Current World Environment*, *12*(3), 520.
36. Lohani, A.K., Jain, S.K. & Singh, R.D., Combination of GLOF with applicable design flood, Workshop on Design Flood Issues, 19-20 November, 2013, Central water Commission, New Delhi (2013)
37. National Disaster Management Plan May 2016, https://www.mha.gov.in/sites/default/files/National%20Disaster%20Management%20Plan%20May%202016.pdf

Received: 11th November 2022; Accepted: 20th April 2023; First distribution: 25th April 2023