

DISASTER MANAGEMENT

WHAT IS DISASTER?

- Disaster is an undesirable occurrence resulting from forces that are largely outside human control, strikes quickly with little or no warning, which causes or threatens serious disruption of life and property including death and injury to a large number of people, and requires therefore, mobilisation of efforts in excess of that which are normally provided by statutory emergency services”.
- Disasters are also caused by some human activities. There are some activities carried by human beings that are directly responsible for disasters. Bhopal Gas tragedy, Chernobyl nuclear disaster, wars, release of CFCs (Chlorofluorocarbons) and increase of green house gases, environmental pollutions like noise, air, water and soil are some of the disasters which are caused directly by human actions. There are some other activities of human beings that accelerate or intensify disasters indirectly. Landslides and floods due to deforestation, unscientific land use and construction activities in fragile areas are some of the disasters that are the results of indirect human actions
- Natural Hazards are elements of circumstances in the Natural environment that have the potential to cause harm to people or property or both. These may be swift or permanent aspects of the respective environmental settings like currents in the oceans, steep slope and unstable structural features in the Himalayas or extreme climatic conditions in deserts or glaciated areas.
- As compared to natural hazards, natural disasters are relatively sudden and cause large scale, widespread death, loss of property and disturbance to social systems and life over which people have a little or no control. Thus, any event can be classed as disaster when the magnitude of destruction and damage caused by it is very high.
- Almost, 59% of India’s territory is vulnerable to earthquakes.
- Between 1998-2017, earthquakes caused nearly 750 000 deaths globally, more than half of all deaths related to natural disasters.
- More than 125 million people were affected by earthquakes during this time period, meaning they were injured, made homeless, displaced or evacuated during the emergency phase of the disaster.
- Earthquakes may be caused due to tectonic plates movement, volcanic eruption, rock fall, landslides, subsidence, particularly in the mining areas, impounding of dams and reservoirs, etc. have limited area of influence and the scale of damage.
- Earthquakes that are of tectonic origin have proved to be the most devastating and their area of influence is also quite large.
- Some of the most vulnerable states are Jammu and Kashmir, Himachal Pradesh, Uttarakhand, Sikkim, and the Darjiling and subdivision of West Bengal and all the seven states of the northeast.

On Ground	On Manmade Structures	On Water
Fissures Settlements	Cracking Slidings	Waves Hydro-Dynamic Pressure
Landslides Liquefaction Earth Pressure Possible Chain-effects	Overturning Buckling Collapse Possible Chain-effects	Tsunami Possible Chain-effects

Types of Disaster:

Atmospheric	Terrestrial	Aquatic	Biological
Blizzards Thunderstorms Lightning Tornadoes Tropical Cyclone Drought Hailstorm Frost, Heat Wave or Loo.Cold Waves, etc.	Earthquakes Volcanic Eruptions Landslides Avalanches Subsidence Soil Erosion	Floods Tidal Waves Ocean Currents Storm Surge Tsunami	Plants and Animals as colonisers (Locusts, etc.). Insects infestation— fungal, bacterial and viral diseases such as bird flu, dengue, etc.

Earthquakes

- Earthquakes are by far the most unpredictable and highly destructive of all natural disasters.

Consequences of Earthquakes

Infrastructure

Human & Natural

- **Change in Course of River:** A similar tragedy unfolded in 1833 when an earthquake shook the region near Kumaon, India. The Kosi River, also known as the “Sorrow of Bihar,” switched from flowing southeast to a course flowing south. The river flooded surrounding lands, displacing over 100,000 people.

Structural Damage:

Human Factor

Loss of Life & Injuries:

- **Structural Damage:** Earthquakes can cause extensive damage to buildings, bridges, roads, and other infrastructure. Poorly constructed buildings are

especially vulnerable, leading to collapses that can result in injuries and fatalities.

- **Loss of Life:** One of the most tragic consequences of earthquakes is the loss of human life. Buildings can collapse, landslides can occur, and tsunamis may be triggered, all of which can lead to fatalities.
- **Injuries:** Even in areas where buildings are not severely damaged, people can still be injured by falling debris, broken glass, or during attempts to evacuate.
- **Displacement:** Earthquakes can force people to evacuate their homes either temporarily or permanently, leading to displacement and the need for emergency shelters.
- **Economic Impact:** The destruction caused by earthquakes can have a significant economic impact. This includes the cost of rebuilding infrastructure, repairing buildings, and the loss of productivity due to disruptions in business activities.
- **Environmental Damage:** Earthquakes can also cause environmental damage, such as landslides, soil liquefaction, and changes in groundwater levels. These can have long-term effects on ecosystems and water sources.
- **Disruption of Services:** Earthquakes can disrupt essential services such as electricity, water supply, communications, and transportation networks, making it challenging for emergency responders to reach affected areas and provide assistance.
- **Risk of Secondary Hazards:** Earthquakes can trigger secondary hazards such as fires, tsunamis (if the earthquake occurs under the ocean), and gas leaks, further exacerbating the impact on affected areas.

India's Vulnerability

- Nearly 60 percent of India's territory is vulnerable to earthquakes.
- Some of the most vulnerable states are Jammu and Kashmir, Himachal Pradesh, Uttarakhand, Sikkim and Darjeeling and subdivision of West Bengal and all the seven states of the northeast.
- National Geophysical Laboratory, Geological Survey of India, Department of Meteorology along with recently formed National Institute of Disaster Management have made an intensive analysis of more than 1200 earthquakes that have occurred in India in the past and based on these, they divided India into following five earthquake zones:
- However, the Bureau of Indian Standards (BIS) which is the official agency for publishing the seismic hazard maps and codes has grouped the country into four seismic zones by unifying the first two zones.

Other Vulnerabilities:

- **Densely populated cities in India:** Twenty-nine Indian cities and towns, including Delhi and capitals of nine states, fall under "severe" to "very severe" seismic zones, according to the National Centre for Seismology (NCS).
- **Population and Infrastructure:** The proportion of

Child Population in the age group of 0-6 years to total population is 13.1 percent while the corresponding figure in 2001 was 15.9 percent

Earthquake Mitigation

- Establishing earthquake monitoring centres for regular monitoring and dissemination of information among the people in vulnerable areas. Use of GPS can be of great help in monitoring the movement of tectonic plates.
- Preparing a vulnerability map of the country and dissemination of vulnerability risk information among the people and educating them about the ways and means minimising the adverse impacts of disasters.
- Modifying the house types and building designs in the vulnerable areas and discouraging the construction of high-rise buildings, large industrial establishments and big urban centres in such areas.
- Making it mandatory to adopt earthquake resistant designs and use light materials in major construction activities in the vulnerable areas.

New Updates:

- **India Quake App-** The Ministry of Earth Sciences launched the 'India Quake' app to enable users to receive information about natural hazards on land and water.
- It has been developed by the National Centre for Seismology for the automatic dissemination of earthquake parameters such as location, time and magnitude after the occurrence of an Earthquake and avoid delay of information in the event of earthquake.

Some examples of Earthquakes in India:

- **Latur Earthquake (1993):** The Latur earthquake was a 6.2 magnitude earthquake that struck Maharashtra on September 30, 1993. The earthquake caused significant damage to property and infrastructure in the region and claimed more than 9,000 lives.
- **Bhuj Earthquake (2001):** The Bhuj earthquake was a 7.7 magnitude earthquake that struck Gujarat on January 26, 2001. The earthquake claimed more than 20,000 lives and caused widespread damage to property and infrastructure in the region.
- **Sikkim Earthquake (2011):** The Sikkim earthquake was a 6.9 magnitude earthquake that struck Sikkim on September 18, 2011. The earthquake caused widespread damage to property and infrastructure in the region and claimed more than 100 lives.

Tsunami

- India, like many other countries situated along coastlines, faces the potential risk of tsunamis due to its proximity to tectonic plate boundaries and the presence of underwater earthquake-prone zones.
- The most significant tsunami event in recent history for India was the 2004 Indian Ocean tsunami, triggered by a massive earthquake off the coast of Sumatra, Indonesia.

- On December 26, 2004, a 9.1 magnitude earthquake struck off the west coast of northern Sumatra.
- This earthquake generated a massive tsunami that affected several countries bordering the Indian Ocean, including India. Coastal regions of southern India, particularly the states of Tamil Nadu, Andhra Pradesh, Kerala, and the Andaman and Nicobar Islands, were severely impacted.
- The impact of the 2004 tsunami on India was devastating, resulting in thousands of deaths, widespread destruction of infrastructure, homes, and livelihoods, as well as significant environmental damage.
- It prompted India to enhance its tsunami warning and disaster management systems to better prepare for future events.
- Since then, India has taken several measures to improve its preparedness and response capabilities for tsunamis.
- This includes the establishment of the Indian Tsunami Early Warning Centre (ITEWC) in 2007, which is operated by the Indian National Centre for Ocean Information Services (INCOIS).
- The ITEWC is responsible for monitoring seismic activity and issuing timely warnings to coastal regions in the event of a tsunami threat.
- Additionally, India has conducted various drills and awareness campaigns to educate coastal communities about tsunami risks and evacuation procedures.
- These efforts aim to reduce the potential impact of tsunamis on coastal populations and enhance overall disaster resilience.

DAMS IN INDIA

- India has almost 6,000 large dams and about 80% of them are more than 25 years old and carry safety risks. A new Dam Safety Act (DSA) was passed in late 2021
- On October 2023, a glacial lake outburst flood (GLOF) in North Sikkim's South Lhonak Lake washed away one of the biggest hydropower projects in India, the Teesta III dam at Chungthang
- According to a parliamentary panel, there are 234 functional large dams in India that are more than 100 years old, some of them over 300 years old.
- **Arch Dams:** These are curved dams that rely on arch action to resist the water pressure. Example: Idukki Dam in Kerala.
- **Embankment Dams:** These are constructed using compacted earth or rock fill. Example: Sardar Sarovar Dam (Narmada Valley Project).
- **Buttress dams:** They are made of reinforced concrete and supported by a series of buttresses at intervals on the downstream side. They differ from traditional gravity dams because they don't rely on their own weight to resist water thrust. Instead, the upstream face of a buttress dam inclines about 25° to 45. Example- The Mettur Dam on the Kaveri River in Tamil Nadu is an example of a buttress dam in India

Classification of Dams:

Based on Purpose:

- **Irrigation Dams:** These dams are primarily built to store water for irrigation purposes, ensuring a continuous water supply for agriculture. Example: Bhakra Dam in Himachal Pradesh.
- **Hydroelectric Dams:** These dams generate electricity by harnessing the energy of flowing or falling water. Example: Tehri Dam in Uttarakhand.
- **Multipurpose Dams:** These serve multiple functions such as irrigation, hydroelectric power generation, flood control, and water supply for domestic and industrial use. Example: Sardar Sarovar Dam on the Narmada River.

Based on Size:

- **Large Dams:** These are typically taller and have a significant storage capacity. Example: Hirakud Dam in Odisha.
- **Medium Dams:** These have a moderate storage capacity and height. Example: TungaBhadra Dam in Karnataka.
- **Small Dams:** These are relatively smaller in size and are often built for local water supply and minor irrigation.
 - ✓ **Example:** Panchet Dam in Jharkhand.

Based on Structure:

- **Gravity Dams:** These rely on their weight and gravity to hold back water. Example: Mettur Dam in Tamil Nadu.

Based on Ownership:

- **Government-Owned Dams:** These dams are owned and operated by government agencies at various levels (central, state, or local). Example: Nagarjuna Sagar Dam in Telangana/Andhra Pradesh.
- **Private Dams:** Some dams are owned and operated by private companies or entities. Example: Bhira Hydroelectric Project in Maharashtra

Causes of Failure of DAMS

Natural Disasters:

- **Floods:** Heavy rainfall or rapid snowmelt can lead to excessive inflow into reservoirs, causing dams to overflow or breach. Example: The 1979 Machhu Dam failure in Gujarat due to extreme rainfall resulted in massive flooding and loss of life and property.
- **Earthquakes:** Seismic events can cause ground shaking, leading to dam structural damage or failure.
 - ✓ **Example:** The 1967 Koyna Dam earthquake in Maharashtra caused significant damage to the dam and surrounding areas.

Design and Construction Flaws:

- **Poor Foundation:** Improper assessment of geological conditions can lead to settlement issues or foundation failure.
 - ✓ **Example:** The failure of the Malaprabha Dam in Karnataka due to foundation problems in the early 2000s.
- **Inadequate Spillway Capacity:** Insufficient spillway capacity can cause dams to overflow during high inflow, leading to overtopping and potential failure. Example: The 2019 Tiware Dam breach in Maharashtra due to inadequate spillway capacity resulted in loss of life and property downstream.

Maintenance Negligence:

- **Siltation:** Lack of regular dredging and maintenance can lead to silt accumulation in reservoirs, reducing storage capacity and affecting dam safety. Example: The reduction in storage capacity of the Bhakra Dam in Himachal Pradesh due to siltation over the years.
- **Structural Deterioration:** Poor maintenance practices can lead to the deterioration of dam structures over time, increasing the risk of failure. Example: The aging Mullaperiyar Dam in Kerala/Tamil Nadu faces concerns regarding structural integrity and safety.

Human Activities:

- **Deforestation and Land Use Changes:** Alterations in land use patterns, such as deforestation or urbanization near dams, can impact watershed dynamics and increase flood risks.
 - ✓ **Example:** Deforestation in catchment areas contributing to increased sedimentation and flood risks for dams like the Tehri Dam in Uttarakhand.
- **Illegal Mining and Encroachments:** Unauthorized activities like illegal mining or encroachments near dam sites can weaken the stability of slopes and affect dam safety.
 - ✓ **Example:** Encroachments near the Chembarambakkam Lake in Chennai, Tamil Nadu, impacting reservoir management and flood control.

Climate Change Impacts:

- **Increased Intensity of Extreme Events:** Climate change can exacerbate the frequency and intensity of extreme weather events such as floods and storms, putting additional stress on dam infrastructure.
- **Glacial Lake Outburst Floods (GLOFs):** Melting glaciers can lead to the formation of glacial lakes, and sudden outbursts due to damming by ice or moraine can pose risks to downstream areas.

Impact of Dam Failure

- **Loss of life and property:** Dam failures can result in loss of human lives, damage to infrastructure, homes,

agricultural land, and livelihoods in downstream areas.

- **Environmental damage:** Floodwaters from failed dams can cause erosion, sedimentation, and contamination of water bodies, impacting aquatic ecosystems and biodiversity.
- **Disruption of services:** Failure of dams can disrupt water supply for irrigation, drinking water, industrial use, and hydroelectric power generation, affecting communities and industries.
- **Economic losses:** The cost of repairing or rebuilding damaged infrastructure, compensating affected populations, and restoring ecosystems can be substantial, impacting regional economies.

Adaptation and Mitigation:

- **Risk-Informed Decision Making: Example:** The Central Water Commission (CWC) in India conducts risk assessments for dams based on factors such as hydrological conditions, seismic hazards, structural integrity, and downstream population vulnerability. This information helps in prioritizing maintenance, upgrades, and emergency response planning.
- **Advanced Monitoring and Surveillance Systems:**
 - ✓ **Example:** Many large dams in India are equipped with advanced monitoring and surveillance systems that continuously monitor parameters such as water levels, seepage rates, structural vibrations, and weather conditions. For instance, the Bhakra Dam in Himachal Pradesh uses remote sensing and real-time data analysis for early warning and decision-making during flood events.
- **Regular Inspections and Maintenance Programs:**
 - ✓ **Example:** The Dam Safety Organization (DSO) in India conducts regular inspections of dams, including visual inspections, instrumentation checks, structural assessments, and geotechnical investigations. For instance, the Tehri Dam in Uttarakhand undergoes comprehensive inspections and maintenance activities to ensure its safety and functionality.
- **Modernization and Retrofitting:**
 - ✓ **Example:** Older dams in India are being modernized and retrofitted with improved spillways, floodgates, instrumentation systems, and structural reinforcements to enhance their resilience against extreme events. The Sardar Sarovar Dam on the Narmada River has undergone modernization efforts to strengthen its flood management capabilities.
- **Capacity Building and Training:**
 - ✓ **Example:** The National Institute of Hydrology (NIH) and various state-level agencies conduct training programs, workshops, and seminars for dam operators, engineers, and stakeholders on dam safety practices, emergency response protocols, and risk management strategies.

- **Community Engagement and Awareness:**
 - ✓ **Example:** Public awareness campaigns, community meetings, and stakeholder consultations are conducted to educate downstream populations about dam safety measures, evacuation plans, and early warning systems. For example, the Nagarjuna Sagar Dam authorities regularly engage with local communities to promote safety awareness and preparedness.
- **Integrated Emergency Response Plans:**
 - ✓ **Example:** Dams in India have integrated emergency response plans that outline protocols for dam operation during emergencies, evacuation procedures, communication strategies, and coordination with disaster management agencies. The Hirakud Dam in Odisha has a well-developed emergency response plan that includes flood forecasting, dam release strategies, and evacuation drills.

Dam Safety Act 2021

- It provides for dam safety all across the country. DSA has created a regulatory and institutional framework at both the central and at state level.
- It lays down mandatory processes and procedures to be followed by the dam owners, state dam safety organisations (SDSOs) and National Dam Safety Authority (NDSA)
- SDSO is responsible for safe operation of all dams within its jurisdiction except the ones owned by central public sector undertakings or where a dam is an inter-state project. In such cases, the functions of SDSO shall be discharged by the NDSA.
- National Committee on Dam Safety (NCDS): It is the supreme body in the hierarchy of dam safety institutional

framework, has been entrusted with specific functions enumerated in the schedule appended with the Act.

- This includes evolving dam safety policies and recommending necessary regulations as may be required. It is required to meet twice a year (once before the monsoons) and can call in its meeting dam owners and experts as deemed appropriate for effective discharge of its functions.
- NDSA is responsible for implementation of the policies made by NCDS. It formulates regulations on various aspects of dam safety based on the NCDS' recommendations.

The Dam Rehabilitation and Improvement Project (DRIP)

- It is a program that aims to improve the safety and operational performance of existing dams, while also strengthening the dam safety institutional setup of participating states.
- The project was initiated in April 2012 with financial assistance from the World Bank and has three components:
 - ✓ Rehabilitation and Improvement of dams and associated appurtenances: Focuses on structural and non-structural measures at 223 project dams, many of which are more than 25 years old
 - ✓ Dam Safety Institutional Strengthening in participating States and CWC: Focuses on regulatory and technical frameworks for dam safety assurance
 - ✓ Project Management: The Dam Safety Rehabilitation Directorate in the CDSO of CWC is responsible for project oversight and coordination

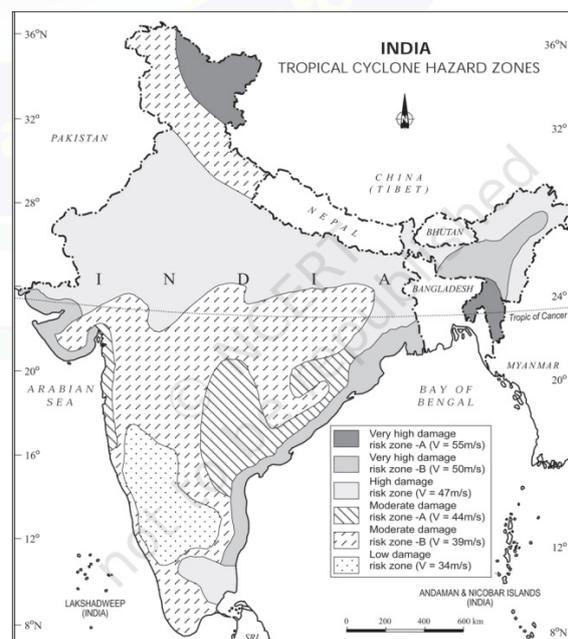
TROPICAL CYCLONES

- Tropical cyclones are intense low-pressure areas confined to the area lying between 30°N and 30°S latitudes, in the atmosphere around which high velocity winds blow. Horizontally, it extends up to 500-1,000 km and vertically from surface to 12-14 km. A tropical cyclone or hurricane is like a heat engine that is energised by the release of latent heat on account of the condensation of moisture that the wind gathers after moving over the oceans and seas.

Conditions for Formation of Cyclone

- Large and continuous supply of warm and moist air that can release enormous latent heat.
- Strong Coriolis force that can prevent filling of low pressure at the centre (absence of Coriolis force near the equator prohibits the formation of tropical cyclone between 0 -5 latitude).
- Unstable condition through the troposphere that creates local disturbances around which a cyclone develops.
- Finally, absence of strong vertical wind wedge, which disturbs the vertical transport of latent heat.

Vulnerability of India to Cyclone



- Most of the cyclones originate between 10°-15° north latitudes during the monsoon season, yet in case of the Bay of Bengal, cyclones mostly develop during the months of October and November.
- Here, they originate between 16°-2° N latitudes and to the west of 92° E. By July the place of origin of these storms shifts to around 18 N latitude and west of 90°E near the Sunderban Delta
- **Property Damage:** Strong winds, heavy rainfall, and storm surges associated with cyclones can cause significant damage to buildings, roads, bridges, and other infrastructure, leading to economic losses.
- **Displacement and Migration:** Cyclones can force people to evacuate their homes, leading to temporary or long-term displacement. This can create challenges related to shelter, healthcare, and livelihoods.

Facts and Figures:

- About 5,700 km of the India's coastline encompassing 84 Coastal districts (roughly 8% of the geographical area) in 13 Coastal States and Union Territories (UTs) are affected by severe tropical cyclones year after year.
- Approximately 40% of India's population is living within 100 km of the coastline.
- Though the frequency of Tropical Cyclones (TCs) in the North Indian Ocean(NIO) covering the Bay of Bengal and the Arabian Sea is the least in the world (7% of the global total), their impact on the east coast of India is relatively more devastating due to storm tidal effect in the area.
- This is evident from the fact that in the past, 21 of the 23 major cyclones (with a loss of about 10,000 lives or more) worldwide occurred over the area surrounding the Indian subcontinent.
- **1977 Cyclone** - 10,000 death Andhra Pradesh
- **1990 Super Cyclone** - 967 people in Andhra Pradesh
- 1996 Very Severe Cyclonic Storm with a fatality of 1,057 people in Andhra Pradesh
- **1999 Super Cyclone** - Odisha with a fatality of about 10,000 people, destroying 275,000 homes and leading to 1.67 million homeless.
- October 12 2013, Cyclone Phailin hit the states of Odisha and Andhra Pradesh with maximum sustained wind gusting up to 220 km per hour, heavy rains measuring up to 25 cm and storm surge over 3 m; the sea pushed in as much as 40 m along parts of the coast.
- Affecting about 13.2 million people in 171 blocks in 18 Districts of the state, and resulting in 44 human casualties.
- It was the strongest cyclone to hit the Indian coast, similar to the Super Cyclone of 1999 which hit Odisha.
- **Impact on Agriculture:** Cyclones can damage crops, livestock, and fisheries, affecting the livelihoods of coastal communities that depend on agriculture and fishing for their sustenance.
- **Environmental Consequences:** Cyclones can lead to soil erosion, flooding, and contamination of water sources, impacting ecosystems and biodiversity.
- To mitigate the impact of cyclones, India has adopted various approaches and measures:
- **Impact based Forecast:** The Impact-based forecast is an innovative approach to not only understand “what the weather will be” but go a step further to inform “what the weather will do”.
- **State of art Early Warning Systems:** India has invested in advanced meteorological technology and established robust early warning systems to forecast cyclones accurately. This allows authorities to issue timely alerts and advisories, enabling communities to prepare and evacuate if necessary.
- **Evacuation and Shelter Management:** Authorities conduct evacuation drills and identify cyclone shelters in vulnerable areas to ensure the safety of residents. These shelters are equipped with essential supplies and facilities to accommodate evacuees.
- **Infrastructure Resilience:** India has focused on building resilient infrastructure that can withstand cyclonic winds and storm surges. This includes constructing buildings, roads, and bridges with cyclone-resistant designs and materials.
- **Community Awareness and Preparedness:** Awareness campaigns and community-based disaster management programs are conducted to educate people about cyclone risks, preparedness measures, and evacuation protocols. This empowers communities to take proactive steps during cyclone events.
- **Mangrove Conservation:** Mangrove forests act as natural barriers against storm surges and coastal erosion. India has undertaken initiatives for mangrove conservation and restoration to enhance coastal resilience to cyclones.
- **International Cooperation:** India collaborates with international organizations and neighboring countries to share expertise, resources, and best practices for cyclone preparedness and response.

Consequences of Cyclones in India

- **Loss of Life and Injury:** Cyclones can lead to casualties and injuries, especially in coastal regions where populations are more vulnerable due to the proximity to the sea.
- As many as 117 cyclones hit India in 50 years from 1970-2019 claiming over 40,000 lives, according to a study on extreme weather events, which also states the mortality rate due to tropical cyclones has come down significantly over the past 10 years.

WHAT ARE CLOUDBURSTS?

- A cloudburst is a localised but intense rainfall activity. Short spells of very heavy rainfall over a small geographical area can cause widespread destruction, especially in hilly regions where this phenomenon is the most common.
- Not all instances of very heavy rainfall, however, are cloudbursts. A cloudburst has a very specific definition: Rainfall of 10 cm or more in an hour over a roughly 10 km x 10-km area is classified as a cloudburst event. By this definition, 5 cm of rainfall in a half- hour period over the same area would also be categorized as a cloudburst.

- Instead of dropping down, raindrops get bigger in size and get pushed up due to the air current.
- Eventually they become too heavy to hold and drop down, leading to more rain than usual.
- There isn't a 'burst' in the literal sense, but an intense version of a torrential downpour that happens.

Instances of Cloudburst:

- Mumbai had experienced on July 26, 2005, which is one of the most extreme instances of rainfall in India in recent years. At that time, Mumbai had received 94 cm of rain over a 24-hour period, resulting in deaths of over 400 people and more than USD 1 billion in economic losses.
- In 2010, dozens of villages and the main town of Leh in Ladakh were hit by the worst floods in its recent history. Homes and farm fields were devastated and over 250 people were killed.

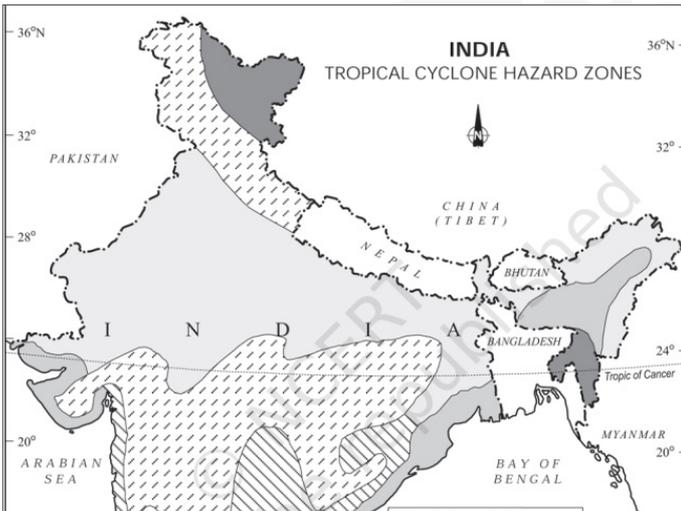
Global warming is leading to more evaporation of water and because of this dense cumulonimbus clouds are forming, resulting in intense rainfall.

Can cloudbursts be forecast?

- The India Meteorological Department forecasts rainfall events well in advance, but it does not predict the quantum of rainfall — in fact, no meteorological agency does.
- The forecasts can be about light, heavy, or very heavy rainfall, but weather scientists do not have the capability to predict exactly how much rain is likely to fall at any given place.
- Additionally, the forecasts are for a relatively large geographical area, usually a region, a state, a meteorological sub-division, or at best a district. As they zoom in over smaller areas, the forecasts get more and more uncertain.
- Theoretically, it is not impossible to forecast rainfall over a very small area as well, but it requires a very dense network of weather instruments, and computing capabilities that seem unfeasible with current technologies.

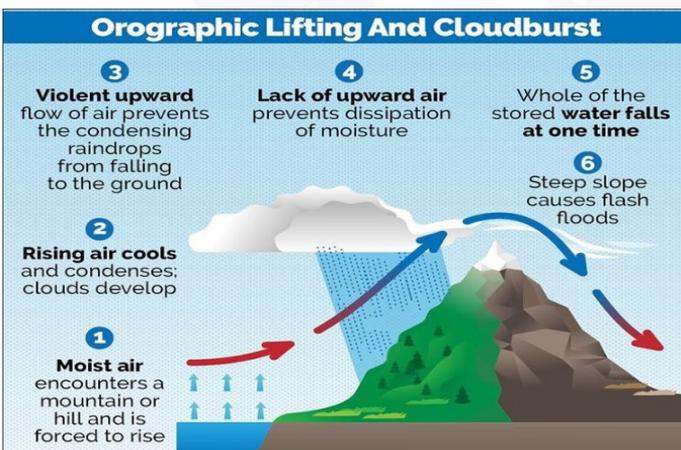
Impacts:

- Experts say excessive deforestation and unplanned developments should be avoided in climate-vulnerable regions such as the Himalayas.



What causes this?

- Cloudbursts happen when saturated clouds are unable to produce rain because of the upward movement of very warm current of air.



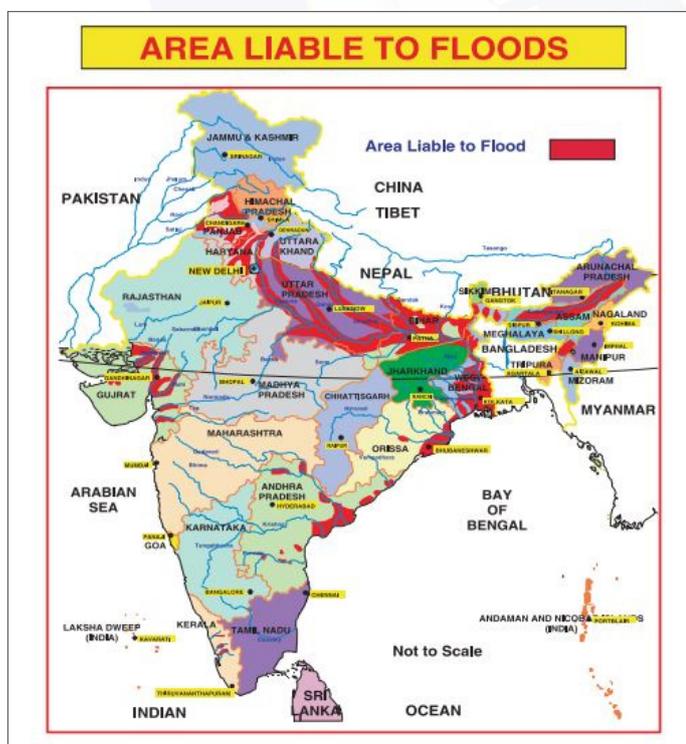
Impact of climate change on cyclones in India

- In 2019, the Arabian Sea witnessed five cyclones as compared to its normal count of three, and the year 2019 corresponds to a positive IOD (Indian Ocean dipole) phase. Hence, under favourable natural climate modes, warming of Arabian Sea can increase the frequency and intensity of tropical cyclones in the North Indian Ocean

Floods in India

- India is highly vulnerable to floods. Out of the total geographical area of 329 million hectares (mha), more than 40 mha is flood prone.
- Floods are a recurrent phenomenon, which cause huge loss of lives and damage to livelihood systems, property, infrastructure and public utilities.
- India is the world's worst flood-affected country after Bangladesh, accounting for one fifth of global death count due to floods.
- Between 1953 and 2011, floods in India caused the deaths of 1,653 people on average each year.
- In 2023, floods have caused extensive damage to several landmarks in Delhi, such as the Red Fort and the Supreme Court.
- In 2010, 965 people died from floods, the highest number of deaths due to floods across the country over the last decade. In 2021, 656 people died from floods

Multiple Factors and types



- ✓ Floods due to Rivers
- ✓ Flood due to Rains
- ✓ Glacial Lake Outburst flood
- ✓ Flash Flood

- ✓ Urban Flood
- ✓ Areas Liable to Flood

- **Frequency:** India experiences floods almost every year, primarily during the monsoon season from June to September.
- **Affected Population:** Millions of people are affected by floods annually. According to government estimates, over 30 million hectares of land are prone to flooding in India.
- **Economic Impact:** Floods cause significant economic losses through damage to crops, infrastructure, housing, and disruption of livelihoods. The economic impact varies from year to year but can run into billions of dollars.
- **Humanitarian Impact:** Floods result in loss of lives and displacement of people. The impact on vulnerable populations, such as children, the elderly, and the economically disadvantaged, is particularly severe.
- **Infrastructure Damage:** Floods damage roads, bridges, railways, power lines, and other critical infrastructure, hampering relief and rescue efforts.
- To mitigate the menace of floods, the Indian government has taken various steps, including:
- **Early Warning Systems:** Implementing advanced flood forecasting and early warning systems to alert vulnerable communities and enable timely evacuation. For example, the Central Water Commission (CWC) and the India Meteorological Department (IMD) provide flood forecasts and warnings.
- **Flood Control Measures:** Constructing and maintaining dams, embankments, and reservoirs to regulate water flow, reduce flood risk, and store excess water during heavy rains. The Dam Rehabilitation and Improvement Project (DRIP) is one such initiative aimed at enhancing the safety and operational efficiency of dams.
- **River Management:** Adopting integrated river basin management approaches to balance water utilization, flood control, and ecological conservation. Projects like the National River Conservation Plan (NRCP) and the National Mission for Clean Ganga (Namami Gange) focus on rejuvenating river systems and reducing pollution.
- **Community Resilience:** Promoting community-based disaster management strategies, including training local authorities, communities, and first responders in flood preparedness, response, and recovery. Initiatives like the National Disaster Management Authority (NDMA) and State Disaster Management Authorities (SDMAs) work on building resilience at the grassroots level.
- **Infrastructure Resilience:** Incorporating climate-resilient infrastructure designs and construction practices to withstand floods and minimize damage. This includes retrofitting critical infrastructure and buildings in flood-prone areas.

- **Awareness and Education:** Conducting public awareness campaigns, educational programs, and drills to increase understanding of flood risks and promote adaptive behaviors among the population.

- Ensure proper maintenance and repair of embankments along river banks to ensure that water does not move into human habitation.

Guidelines of NDMA

- The National Disaster Management Agency has come out with two specific measures structural and non-structural, which can be effective in managing or controlling floods.

Structural Measures

- Regular construction of check dams and reservoirs to keep a check on excess water during heavy rainfall.
- Regular desilting and dredging of water channels to increase their carrying capacity and at the same time avoid spillover to other areas.
- Aggressive afforestation drive in catchment areas of major rivers. More the number of trees in these areas will go a long way in tackling floods by reducing surface runoff and retaining water in the soil.

Non-Structural Measures

- Undertake floodplain zoning measures and regulate land use in these areas.
- Complete prohibition on developing human settlements in low lying and flood risk areas.
- Demarcation of area based on risk level and steps should be taken to evacuate people from high risk areas first.
- Floodproofing- Under this plan, there should be flood shelters in the highlands, availability of food and medical supplies, and proper communication channels between people providing services and those availing of such services.
- NDMA have raised more than 200 Apda Mitras which would provide flood relief services in India's top 30 flood prone districts.

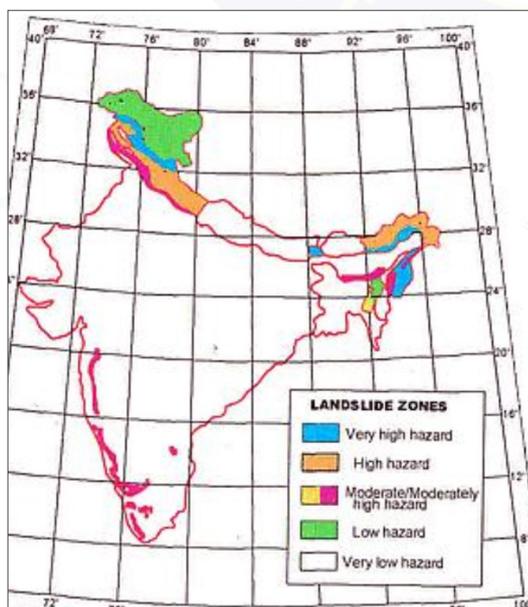
LANDSLIDES

- A frequently used definition of landslide is "a movement of mass of rock, earth or debris down a slope"
- A landslide can be classified and described by two nouns; the first describes the material and the second describes the movement. The material can be rock, debris and earth or a mix. The movement can be fall, topple, slide, spread and flow. Hence, a landslide can be named as rock fall ('rock' is the material type + 'fall' is the movement type), debris flow and so on.

- The mountainous region of the north-western Himalayas (Jammu & Kashmir, Himachal Pradesh, Uttarakhand), the sub-Himalayan terrain of the north-east (Sikkim, West Bengal-Darjeeling, Assam, Arunachal Pradesh, Manipur, Meghalaya, Mizoram, Nagaland, Tripura), the Western Ghat areas (Maharashtra, Goa, Karnataka, Kerala) and the Eastern Ghat areas (Araku area of Andhra Pradesh, Tamil Nadu) are prone to landslides.
- India is considered among the top five landslide-prone countries globally, where at least one death per 100 sq km is reported in a year due to a landslide event.
- Rainfall variability pattern is the single biggest cause for landslides in the country, with the Himalayas and the Western Ghats remaining highly vulnerable.
- Landslides have caused deaths in India, including 380 in 2021, 48 in 2021, and 25 in 2019. In 2014, there were nearly 500 deaths due to landslides

India's Vulnerability to Landslides

- As per the Geological Survey of India (GSI), about 0.42 million km² (covering nearly 12.6% of the land area of our country) is prone to landslides



State	Total no. of landslide events	State	Total no. of landslide events
Mizoram	12,385	Nagaland	2,132
Uttarakhand	11,219	Sikkim	1,569
Tripura	8,070	Himachal Pradesh	1,561
Arunachal Pradesh	7,689	Karnataka	1,904
Jammu and Kashmir	7,280	Tamil Nadu	690
Kerala	6,039	West Bengal	172
Manipur	5,494	Haryana	100
Maharashtra	5,112	Ladakh	23
Meghalaya	2,639	Goa	03
Assam	2,569	Total	80,933

Landslide hotspot areas in India (1998-2022). (Source: Landslide Inventory of India, Landslide Atlas of India, ISRO)

- In 2022, a landslide in Manipur killed 58 people, injured 18, and left three people missing. In 2023, landslides in Himachal Pradesh have killed at least 361 people and injured 342 others
- An international database of fatal landslides prepared by the University of Sheffield, England shows that with close to 11,000 deaths due to landslides in 12 years, India tops a global list of nearly 56,000 casualties from 4,800 landslides around the world between 2004 and 2016.
- As many as 66.5 per cent of the landslides are reported from the North-western Himalayas, about 18.8 per cent from the North-eastern Himalayas, and about 14.7 per cent from the Western Ghats.
- Rudraprayag in Uttarakhand is at the top of 147 vulnerable districts.
- It has the highest landslide density in the country, along with having the highest exposure to total population and number of houses.

Factors Responsible

- Natural causes that trigger it include heavy rainfall, earthquakes, snowmelting and undercutting of slopes due to flooding.
- Landslides can also be caused by anthropogenic activities such as excavation, cutting of hills and trees, excessive infrastructure development, and overgrazing by cattle.
- Generally, hilly regions are associated with slope instability and are prone to landslides. These are influenced by factors such as slope gradient, hill elevation, rock strength, forest cover, built-up area and unconsolidated and semi-consolidated sediments.
- Riverine flow, the cutting down of the toes of slopes and deforestation are some other factors that make a region vulnerable to landslides. Debris flow and underground water make a slope weak and landmass can slip down it.
- The convergence of the Indian plate with the Eurasian plate in the Himalayan region has created subterranean stresses that get released in the form of earthquakes which, in turn, cause fractures and loosen the litho-structures near the mountain surface. This increases the possibilities of rock movement along the slope.

Western Ghats:

- Man-made factors like deforestation, encroachment and haphazard land use and natural factors like heavy rainfall are regarded as some of the key contributing factors behind landslides in
- Factors like deforestation, blasting of hills, haphazard cutting of hill slopes and making changes in the natural drainage system are known to be the aggravating factors that prepares the foundation for a landslide.

Step taken So far:

ISRO Landslide Atlas

- Excluding snow covered areas, approximately 12.6 per cent of the country's geographical land area (0.42 million sq km) is prone to landslides.

National Landslide Risk Management Strategy 2019:

- Landslide Hazard Zonation, Landslide Monitoring and Early Warning System, Awareness Programmes, Capacity Building and Training of Stakeholders, Preparation of Mountain Zone Regulations and Policies
- The strategy describes the formulation of land-use policies and techno legal regime, updation and enforcement of building regulations

Way forward:

- A Council of Himalayan States must be forged to gauge the impact of surface and subsurface stresses. It should try to simulate the hazard scenario caused by natural processes, environmental degradation or climate-induced phenomena, and anthropogenic activities in hill stations or towns.
- The disaster management authorities of the states should come together under the centralised council.
- Town planning must account for the idiosyncrasies of the mountain — heavy constructions should be barred, care should be taken to have a proper drainage system, slope cutting, if necessary, should be done scientifically, and emphasis should be on having retaining walls and adherence to building codes
- Afforestation can be done across the mountain slopes
- Making of walls to stop the materials from falling down towards the valleys
- Terrace farming can be promoted
- Environmental Impact Assessment of the New and existing projects to assess the threat of landslides posed by them

DRAUGHTS IN INDIA

The India Meteorological Department (IMD) defines drought in any area when the rainfall deficiency in that area is $\geq 25\%$ of its long term normal. It is further classified into moderate and severe drought depending upon whether the deficiency is between 26 to 50% and more than 50% respectively

Types of droughts:

- ✓ Meteorological Drought – referring to lack of precipitation.
- ✓ Agricultural drought – referring to lack of moisture in the soil where crops grow.
- ✓ Hydrological drought – referring to low levels of water in reservoirs.
- ✓ Socio-economic drought – referring to water shortages affecting people in society, which impacts availability of foodgrains, fodder, etc.

Meteorological Drought:

The Indian Meteorological Department (IMD) defines a drought as a situation where the average annual rainfall is less than 75% of the normal.

The uneven distribution of rainfall, caused by erratic and concentrated precipitation patterns, often leads to frequent droughts despite India's average annual rainfall of 110 cm.

Causes of Meteorological Droughts:

- ✓ If there is below-average monsoon and lean rainfall.
- ✓ If the onset of monsoon is delayed or there is early withdrawal of monsoons.
- ✓ Prolonged interruptions in monsoon activity.

Hydrological Drought:

This type is characterized by a decrease in water levels, with surface water droughts affecting resources such as rivers, lakes, and reservoirs, while groundwater droughts involve a decline in groundwater levels.

Factors of Hydrological Drought:

- First, Excessive extraction of groundwater.
- Widescale deforestation.
- Environmentally harmful mining practices.

Agricultural Drought:

It occurs when soil moisture falls below the level required to sustain plant growth, resulting in crop failures due to erratic rainfall and insufficient soil moisture.

Factors of Agricultural Droughts:

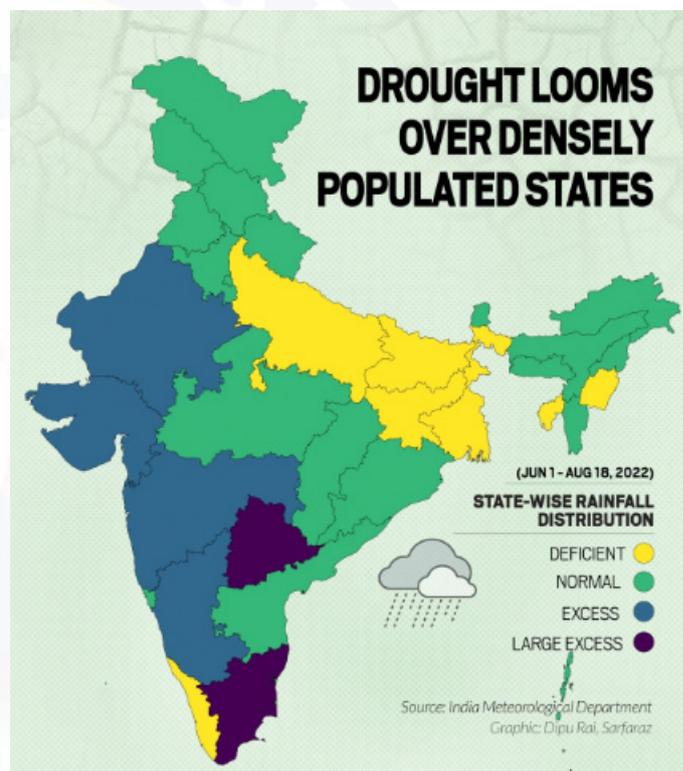
- Over-dependence on High Yielding Seeds (HYV) that demand more water and proper irrigation.
- Changing cropping patterns, such as the increased cultivation of water-intensive crops like rice in regions with limited water availability.
- 18 meteorological and 16 hydrological droughts occurred in India in the time span of 1870 to 2018. The most severe meteorological droughts were in the years

1876, 1899, 1918, 1965, and 2000, while the five worst hydrological droughts occurred in the years 1876, 1899, 1918, 1965, and 2000.

As high as 68 percent of the cropped area in India is vulnerable to droughts of which 33 percent is classified as 'chronically drought-prone' comprising desert and semi-arid regions that receive less than 750 mm mean annual rainfall

Drought Prone Areas

According to the likelihood of a drought occurring, the Indian Meteorological Department (IMD) divides India's drought-prone regions into three categories, as shown below:



1. Areas impacted by a persistent drought:

Chronically drought-prone regions are those where the likelihood of a drought exceeds 20%.

In other words, these areas should prepare for at least one drought every five or four years.

West Rajasthan and the entire State of Gujarat are the two primary regions in India that are frequently affected by drought.

2. Frequently prone to drought regions:

This category has been given to regions with a 10% to 20% chance of experiencing a drought.

East Uttar Pradesh, Uttaranchal, Haryana, Punjab, Himachal Pradesh, Himachal Pradesh, east Rajasthan, west Madhya Pradesh, Marathwada, Vidarbha, Telangana, coastal Andhra Pradesh, and Rayalaseema are among the regions that can anticipate drought

every six to ten years.

- These regions often fall under the dry and moist sub-humid climate zones.



3. Areas least affected by the drought

- The remainder of the country is made up of regions with a drought probability of less than 10%.
- As they generally come under the per-humid and humid regions climate zones, it seems as though they don't provide any issues in terms of rainfall.
- Example-Areas of northeastern India, Assam, Meghalaya, etc.

Challenges of Draughts:

- Droughts are expected to affect over three-quarters of the world's population by 2050, with an estimated 4.8-5.7 billion people living in water-scarce areas for at least one month each year.
- By 2030, drought will displace 700 million people worldwide.
- Drought has killed over 10 million people over the last century, 90% of which have occurred in developing countries.
- Droughts have also impacted fauna, causing the death or displacement of three billion animals and threatening 84% of terrestrial ecosystems.

Impact of Droughts on agriculture in India

1. Crop Failure and Reduced Yields:

- Drought conditions, characterised by prolonged periods of insufficient rainfall, can lead to crop failures and reduced yields. This can result in a decrease in the production of key crops like rice, wheat, pulses, and oilseeds.

2. Livestock and Dairy:

- Drought affects the availability of fodder and water for livestock. Insufficient food and water can lead to a decline in the health and productivity of cattle and other livestock, impacting dairy and meat production.

3. Water Scarcity:

- Drought exacerbates water scarcity issues in agriculture. It reduces the availability of water for irrigation, forcing farmers to rely on groundwater sources, which can lead to over-extraction and depletion of aquifers.

4. Food Insecurity:

- Reduced agricultural production due to drought can result in food shortages, which can contribute to food price inflation and food insecurity, particularly for vulnerable populations.

5. Rural Livelihoods:

- Agriculture is a major source of livelihood for a significant portion of India's population. Drought can lead to income loss and economic distress among farming communities, potentially driving migration to urban areas in search of alternative livelihoods.

6. Increased Debt:

- Farmers often take loans for agricultural inputs and expenses. Crop failures due to drought can lead to an inability to repay loans, increasing indebtedness among farmers.

7. Impact on Cropping Patterns:

- Drought may lead to shifts in cropping patterns, with farmers opting for drought-resistant or short-duration crops. This can have implications for agricultural diversity and food security.

Initiatives taken the Government

- The Drought Prone Areas Programme (DPAP) and Desert Development Programme (DDP) were launched in the 1970s to develop drought-prone areas.
- DDP focuses on restoring desert ecology through sustainable practices. In response to the 1987 drought, the government shifted to long-term solutions, including watershed development, to conserve rainwater, improve soil fertility, and enhance ecosystem health.
- The National Watershed Development Programme for Rain-fed Areas and Watershed Development Programme for Shifting Cultivation also aim to address these challenges.

Drought mitigation measures

- Water and Soil Health Conservation: Drought adaptation and mitigation measures focus on conserving water and soil health in dryland farming.

- **Improved Cropping Practices:** Techniques like ridge farming tillage, no tillage, and stubble mulch farming are more effective than conventional tillage in enhancing crop yields, conserving moisture, and reversing land degradation.
- **Water-Saving Technologies:** Many farmers still lack water-saving technologies and rely on flood irrigation, which reduces water productivity. Modern micro-irrigation methods like sprinkler and drip irrigation face barriers such as high initial investment costs, availability of irrigation water, and power supply constraints.
- **Crop Diversification:** Adaptation options include cultivating less water-intensive and drought-tolerant crops as well as intercropping.
- **Administrative Mitigation Measures:** Government measures like water supply, fodder distribution, employment opportunities, agricultural loans, crop insurance schemes, and waived electricity bills are crucial in addressing drought impacts and reducing farmer suicides.

FOREST FIRE

- A forest fire is an uncontrolled fire occurring in nature.
- Forest fires are a challenge across many countries and also a ubiquitous feature of India's forest landscape.
- Forest fires are considered to be a potential hazard with physical, biological, ecological and environmental consequences.
- In India, forests fires are the most significant and steadily increasing factor in the degradation process, although the extent of total damage is widely disputed.
- However, it is estimated that the proportion of forest areas prone to fire annually ranges from 33% in some states to over 90% in others.
- The Forest Survey of India (FSI) estimated that about 50% of the forest area of the country is fire prone.
- Forest fires are a regular phenomenon in our country often observed during summers.

Types of Forest Fire:



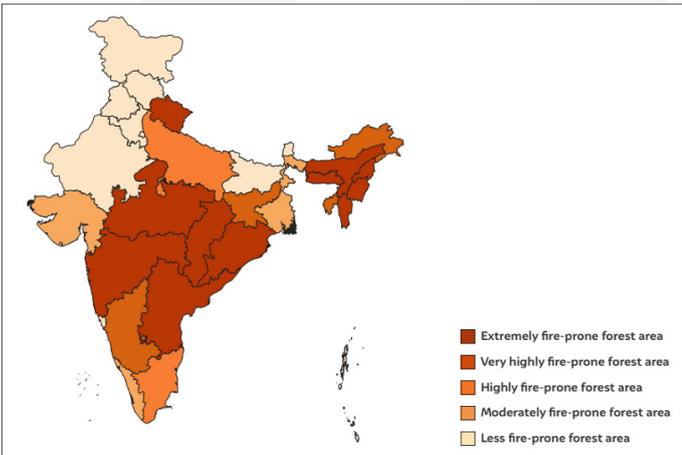
Causes:

Natural:

- Natural causes of fires include:
 - ✓ Fires caused by lightning
 - ✓ Fires caused by rolling stones
 - ✓ Fires may be caused by volcanic eruptions
- Human Factors
 - ✓ The forest floor is often burnt by villagers to get a good growth of grass in the following season or for a good growth of mushrooms
 - ✓ Wild grass or undergrowth is burnt to search for animals
 - ✓ Firing by miscreants
 - ✓ Attempt to destroy stumps of illicit fallings

Unintentional: These fires are caused due to man's carelessness i.e., without intention to set fire. Such fires may be due to the following reasons:

- Un-extinguished campfires of trekkers, laborers, camp of roadside charcoal panniers etc.
- Spark of fire from railway engines
- Careless throwing of fire after honey collection
- Un-extinguished bidis, cigarette butts, matchsticks etc., by grazers, travellers, picnickers or even forest labourers
- Burning of agricultural fields adjacent to forested areas. Such fires is left unattended may spread to forest areas
- During controlled burning by the department, fire may spread to the forest due to negligence of the staff



- More than 36% of the country's forest cover has been estimated to be prone to frequent forest fires.
- Nearly 4 % of the country's forest cover is extremely prone to fire, whereas 6% of forest cover is found to be very highly fire prone.
- Fire is a vital and natural part of the functioning of numerous forest ecosystems.
- Human have used fire for thousands of years as a land management tool.
- However, in the latter part of the twentieth century, changes in the human fire dynamics and an increase in El Nino frequency have led to a situation where fires are now a major threat to many forests and the biodiversity therein.

Impact:

Negative Impact

- **Damage of Biodiversity**- Damage to the trees, new saplings as well as the regeneration ability, loss of various species, some of them can be highly threatened as well
- **Damage to the soil:** The soil ecosystem gets negatively impacted due to heat, loss of moisture, humus etc.
- **Change in micro-climatic conditions** – Impact on the evaporation and rainfall in the concerned area.
- **Damage to the Economy:** Loss of forest as a recreation hub, loss in terms of wood and forest produce, etc.
- Floods, Landslides, Soil Erosion, Air Pollution may also be counted as the impact of Forest Fire.

Positive Impact

- Occasional fires can reduce the fuel loads which otherwise could lead to larger uncontrolled fires
- Getting rid of waste material like dry grass, tree needles, thick bushes, etc.
- Insect pest control.
- Removal of exotic, or non-native, species that compete with native species for nutrients and other needs.
- Addition of nutrients for trees and other vegetation provided by ashes that remain after a fire.
- Removal of undergrowth, thereby allowing sunlight to reach the forest floor to encourage growth of native species.
- Encourage the growth of fire-dependent species.

Government Steps:

- The Ministry of Environment, Forest and Climate Change has prepared National Action Plan on Forest Fire to minimize forest fires during 2018.
- 1. Fire Risk Zonation and mapping**
 - ✓ Risk factors
 - ✓ Use of fire risk zones in forest planning
 - 2. Preventing forest fires**
 - ✓ Effective communication strategy for awareness generation
 - ✓ Empowering Communities to deliver on their responsibilities
 - ✓ Capacity building of communities
 - 3. Increasing the resilience of forests to fires**
 - ✓ Moisture and water conservation
 - ✓ Forest floor biomass management
 - ✓ Weed Management
 - 4. Forest Fire Preparedness**
 - ✓ Forest fire detection and alert
 - ✓ Digitize the location of critical resources and assets
 - ✓ Forest Fire Lines
 - ✓ Control Burning

5. Fire Suppression

- ✓ Training for field staff, fire watchers, and community firefighters
- ✓ Equipping the firefighters
- ✓ Development of adequate infrastructure for fire suppression
- ✓ Arrangements for adequate manpower in fire prone areas

6. Post Fire management

- ✓ Assessment of loss due to forest fires
- ✓ Proper investigation of the causes
- ✓ Restoration of fire affected areas

7. Coordination with Other Agencies

8. Centre of Excellence for Forest Fires

9. Mobilization of Financial resources

Way Forward:

Indirect Methods:

A. Restriction of entry into the forest

- ✓ The entry of the general public can be restricted in the forest during fire season (hot weather season)
- ✓ Collection of honey, seeds etc. should be restricted during the summer to reduce the chances of accidental fire.
- ✓ Denial of benefits of grazing in fire burnt areas by invoking section 26(3) and 33(2) of the Indian Forest Act 1972 for people, who set fire to burn the dry grass to get an early new flush of green grass.

B. Public awareness/public opinion

- ✓ Creating public awareness through press, radio, television, posters and films shows about the causes of fire and their effect will go a long way in preventing the fire.

Direct preventive measures

A. Clearing camping sites and areas along paths and roads

- ✓ A large number of accidental fires start from camping sites where people stay for short periods of time. Inflammable material around such sites should be cleared before the onset of dry season.
- ✓ Fires starting from Bidi or Cigarette slumps thrown carelessly by the roadside can be prevented by controlled burning all grass and leaves.

B. Early burning

- ✓ Early burning is done to burn down all inflammable material such as grass, fallen leaves and broken branches before the commencement of hot weather to prevent the occurrence of fire and even when it does occur it can be easily controlled.