Flash Floods & Urban Flooding

DETAILED ANALYSIS

Context:

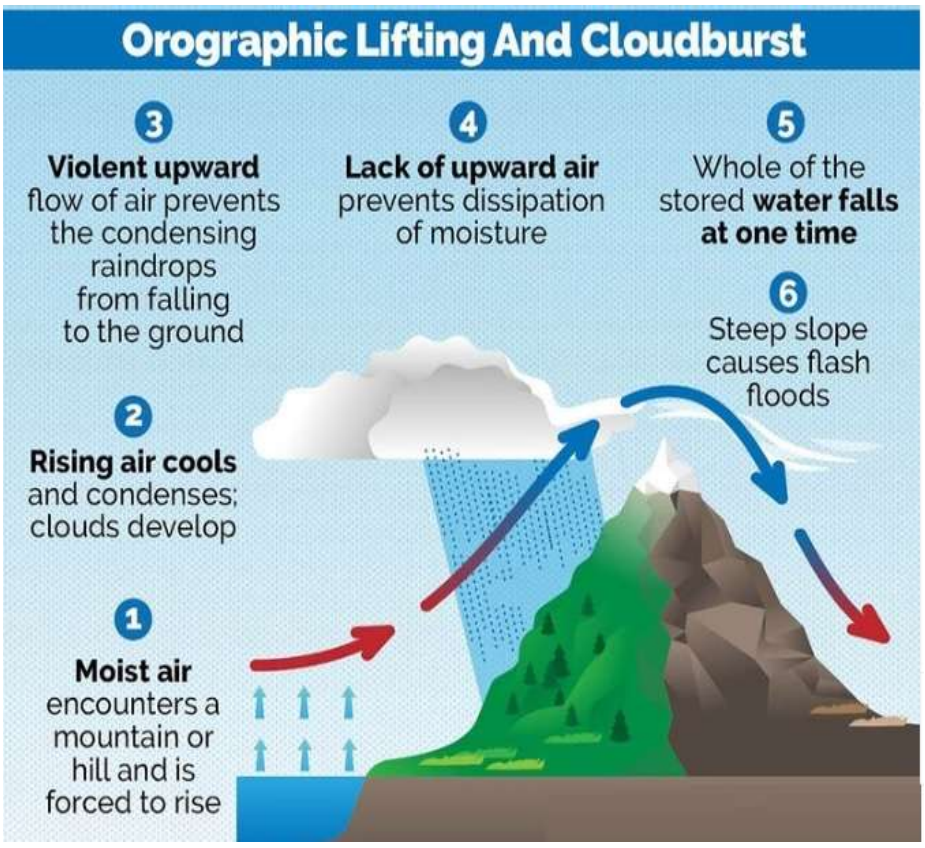
- At least four people died and several remain missing after a **cloudburst triggered flash floods** and a debris slide in **Dharali village near Kheer Gad in Uttarakhand** on **August 5, 2025.**

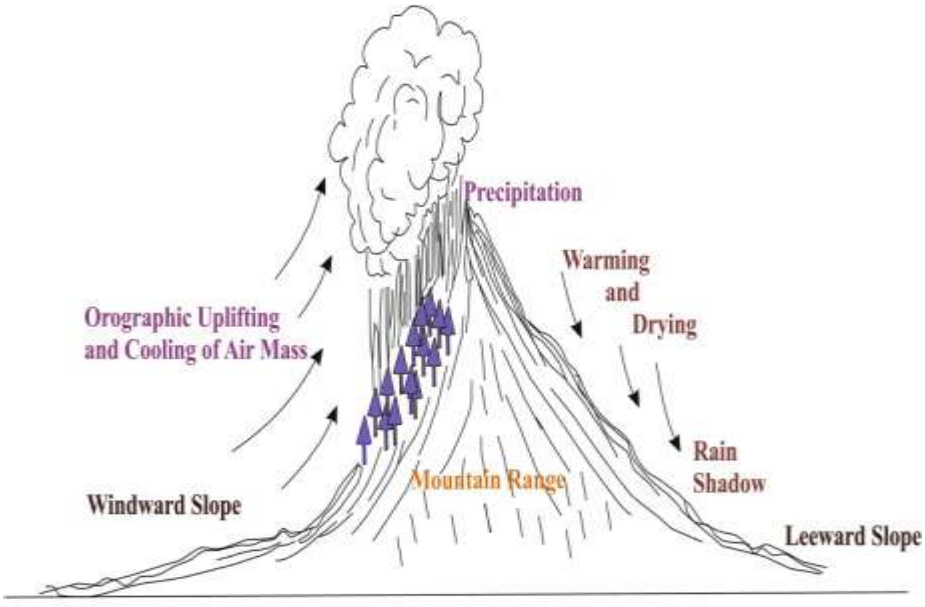
1. What is a Flash Flood?

- A **flash flood** occurs when runoff from **excessive rainfall causes a rapid rise in the water height** (stage) of a **stream or normally-dry channel.**
- According to the **National Weather Service of the United States**, these floodings typically **occur within six hours of heavy rainfall** or other intense water-related events.
- **Flash floods** are more **common** in areas with a **dry climate and rocky terrain** because **lack of soil or vegetation** allows **torrential rains to flow overland** rather than **infiltrate into the ground.**
- They are characterised by **swift and powerful flows of water that can quickly inundate** low-lying areas, such as riverbeds, canyons, and urban areas with poor drainage systems.

2. What are the causes of Flash Floods?

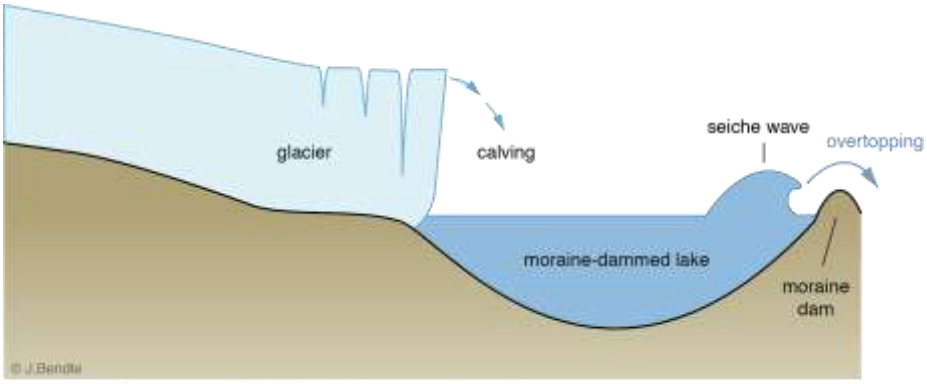
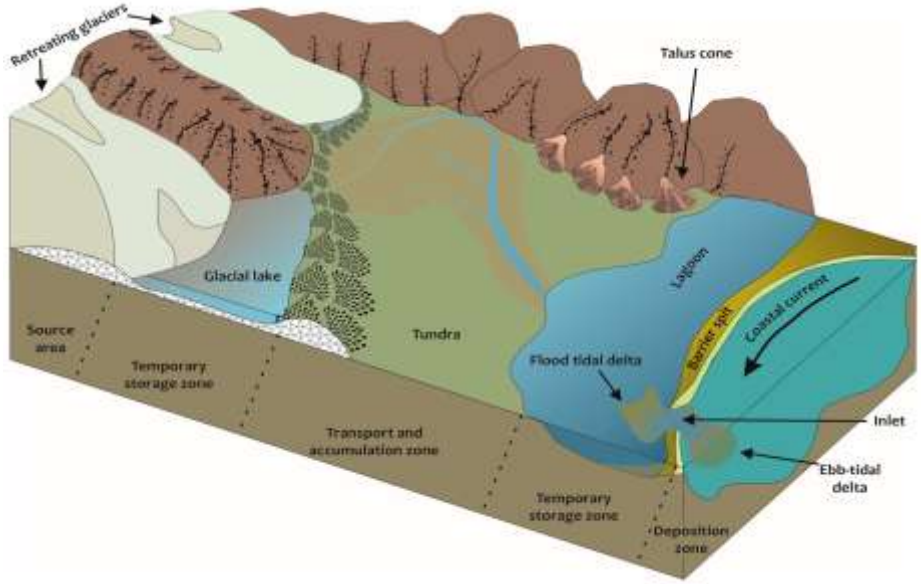
Causes	Description
Cloudburst	• A **cloudburst is a sudden**, very **intense rainfall over a relatively small area**, often accompanied by hail and thunder. • It typically occurs in mountainous regions where **warm, moist air is forced upwards by the terrain**, causing rapid condensation and **heavy precipitation.**



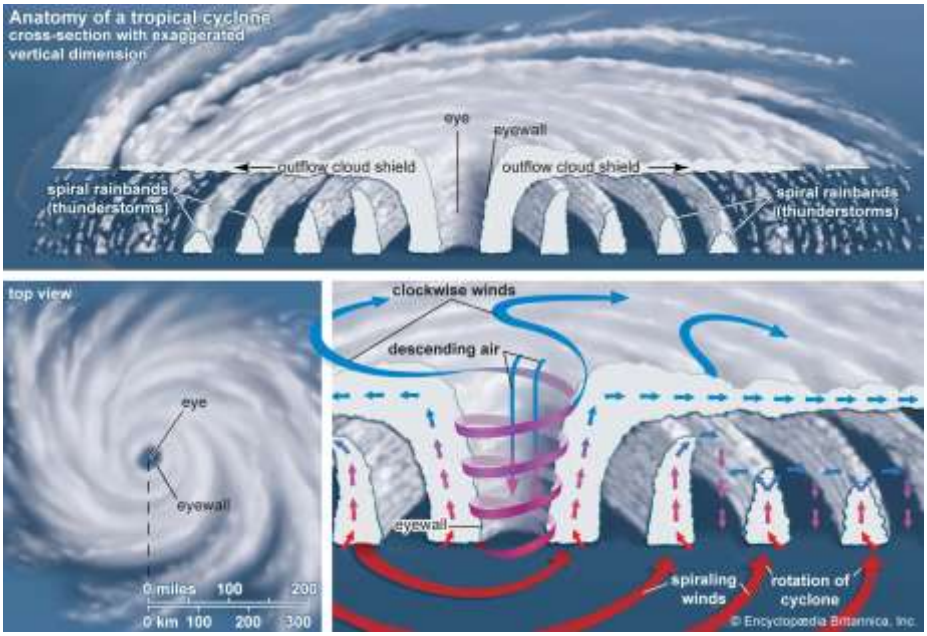


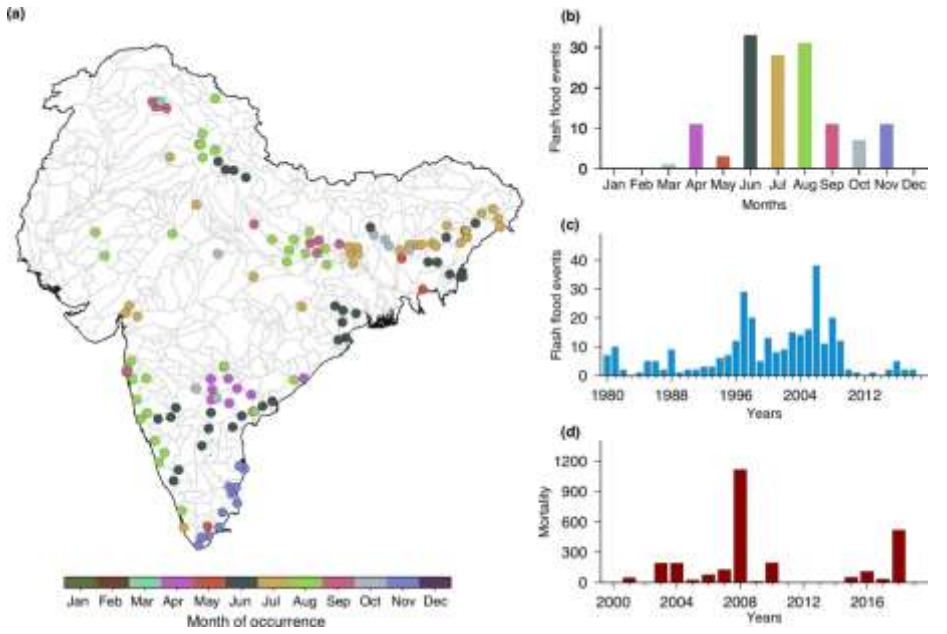
Orographic Distribution of Precipitation

	
Glacier lake outburst	• Technically called a **Glacier Lake Outburst Flood (GLOF)**, these are instances of **large lakes formed from the melting of glaciers**, suddenly breaking free of their moraine — **natural dams that are formed from rock, sediment and other debris.** • The **South Lhonak glacier, located in north Sikkim**, is reportedly one of the fastest retreating glaciers. • The glacier receded nearly **2 km in 46 years from 1962 to 2008.** • It further retreated by **~400 m from 2008 to 2019.** • There are an estimated **7,500 glaciers in the Himalayas and GLOFs** have been associated with major disasters through the years.

	• A report in the **journal Nature** counts the 1926 **Jammu and Kashmir deluge**, the 1981 Kinnaur valley floods in **Himachal Pradesh and the 2013 Kedarnath outburst in Uttarakhand** as examples of GLOF related disasters. • Among the **Himalayan States** in India, **Sikkim has about 80 glaciers** more than any other State. • Over the years climatologists have warned that they could be **responsible for lake outbursts.**  
Heavy rainfall resulting	• **Heavy rainfall** is a common and often dangerous characteristic of tropical weather disturbances such as **hurricanes, cyclones, and typhoons.**

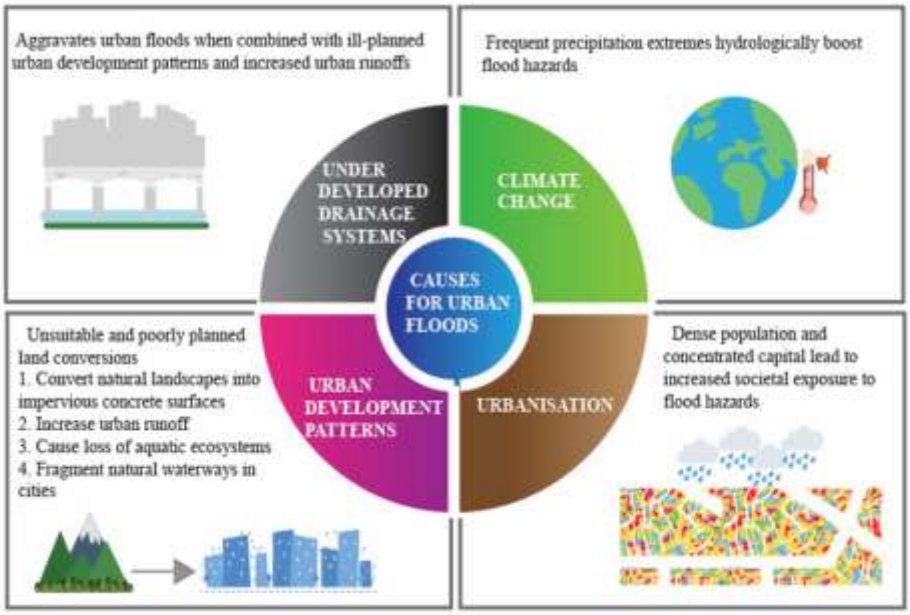
from tropical weather disturbances	• These **storms, fueled by warm ocean waters**, can carry vast amounts of moisture that, when cooled and condensed, **leads to torrential** downpours. • This rainfall can cause s**ignificant flooding, both along coastlines** due to **storm surges and inland as rivers overflow.**

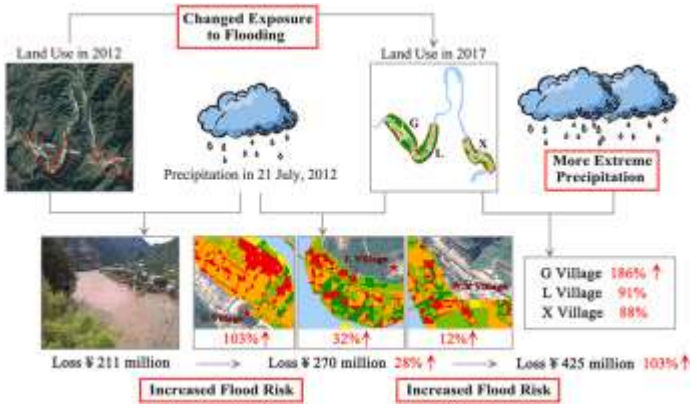


Climate Change	 • With **rising global temperatures**, **extreme weather** events such as **flash floods are increasing** in frequency and intensity across the world. • In India, **between 1981 and 2020**, the yearly frequency of **extreme precipitation events doubled** during the **pre-monsoon season**. • Extreme rainfall during the **monsoon, post-monsoon, and winter** seasons has **increased by 56%, 40%, and 12.5% respectively,** according to the study. • Note that more than **75% of the total flash flood events that occurred between 1980 and 2018** took place during the monsoon season (June-September).
Deforestation	• **Deforestation increases the risk of flooding** by removing trees that absorb and disperse rainwater.

	• Without trees, the **ground becomes less capable of soaking up water**, leading to more runoff into **rivers and streams.** • This increased **runoff raises riverbeds** with **soil and sedimen**t, reducing their capacity to contain water and resulting in more frequent and **severe floods.** • **Reforestation and sustainable land management** can help **mitigate these impacts.** 
Unsustainable Urbanization	**Reduced Infiltration and Increased Runoff:** • Urbanization replaces **natural landscapes** with **concrete and asphalt**, which are impermeable surfaces.

- This **prevents rainwater from soaking into the ground (infiltration),** increasing the amount of **water flowing** over the **surface (runoff).**
- The increased **runoff leads to faster and higher flood peaks**, resulting in flash floods.
- In some cases, **flood peaks can be 1.8 to 8 times higher**, and flood volumes can increase by up to **6 times in urban areas** compared to natural landscapes.



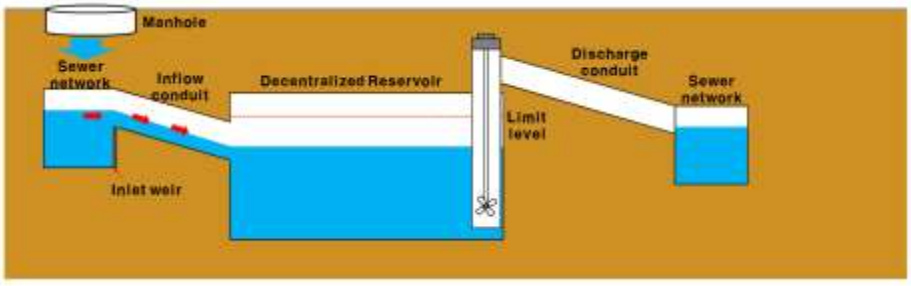
	Loss of Natural Water Storage: • **Urban development often encroaches** on and destroys natural water bodies lik**e lakes, ponds, and wetlands.** • These water bodies act as **natural buffers, absorbing excess water during rainfall and reducing flood risk.** • The loss of these **natural storage areas exacerbates** the impact of heavy rainfall events. **Inadequate Drainage Systems:** • Many cities have **inadequate or poorly maintained stormwater drainage systems.** • This further contributes to the **accumulation of water and increases the risk of flash flooding.** • **Stormwater drains** are often designed to manage runoff from **impermeable surfaces**, but if they are not properly maintained or designed to handle the **increased volume** of water, **they can become overwhelmed.**
Tourism activities	• **Tourism** can **exacerbate flash flood risks** in vulnerable areas, **particularly mountainous regions**, through various activities. 

	• These include **deforestation for infrastructure development,** increased **runoff due to construction and road building, and improper disposal of waste and muck.** • Additionally, u**nregulated construction in high-risk zones like riverbanks** can worsen the impact of floods.  
Inadequate design of drainage channels and	• The E**ffects of Poor Drainage Systems design of drainage channels** and structures can significantly contribute to **flash floods.**

structures	• When **drainage systems** are not designed to handle the **volume and intensity of rainfall, particularly during heavy storms**, water can accumulate rapidly, **leading to overflowing channels, inundation of streets and properties, and ultimately, flash floods.**

(a) Bridge Blocked by LW (b) Culvert Blocked by LW (c) Culvert Blocked by Tree Log

(d) Culvert Blocked by Tree Branches (e) Culvert Blocked by Mixed Debris (f) Culvert Blocked by Tree Branches



Inadequate maintenance of drainage facilities	• **Inadequate maintenance of drainage facilities** is a significant **contributor to flash floods, particularly in urban areas.** • When drainage systems are not properly maintained, they can be easily **overwhelmed by even moderate rainfall**, leading to waterlogging and flash floods. • This can cause **damage to property, infrastructure**, and **pose risks to public health and safety.**  

3. Enlist a few Flash Floods incidents in India?

Various Flash Floods	Description
Dharali village area,Uttarkashi district(August 5, 2025)	• A **cloudburst on August 5, 2025**, triggered flash floods in the **Kheer Ganga river in Uttarkashi district, Uttarakhand**, causing significant damage in the **Dharali village area.**  • The floods, which occurred around **1:30 PM, swept away homes and businesses,** and resulted in at least four confirmed deaths, with others missing.
Yamunotri Highway, Uttarkashi district (June 29, 2025)	• Just over a month ago, a cloudburst struck near the **Yamunotri National Highway, triggering a landslide** that destroyed workers' shelters. 

	 • The **Chardham Yatra** was suspended for a day, and several roads were blocked across the region. • **Authorities had issued a red alert in multiple districts.**
Kedarnath Valley, Rudraprayag district (August 2, 2024)	• A **devastating cloudburst hit the Kedarnath Valley,** resulting in flash floods and landslides last year in August. • The heavy rainfall led to **multiple casualties** and reminded people of the **catastrophic floods in 2013.** 

Ghansali, Tehri Garhwal district (August 1, 2024)	• **The Ghansali area** witnessed a tragic **cloudburst** in which two people died and their son was injured after their eatery near the **Nautar stream was washed away**. • Additionally, a cloudburst near the **Bhim Bali stream caused landslides** that damaged a 25-metre stretch of the **Kedarnath walking path**, temporarily stranding around **200 pilgrims.**
Dharchula, Pithoragarh district (September 2022)	• A **cloudburst at the Khotila village**, situated near the **India-Nepal border**, caused a **flash flood** on the Indian side of the **Kali river.** • The sudden surge in water inundated homes with debris and mud, killing a **local resident, Pashupati Devi.** 

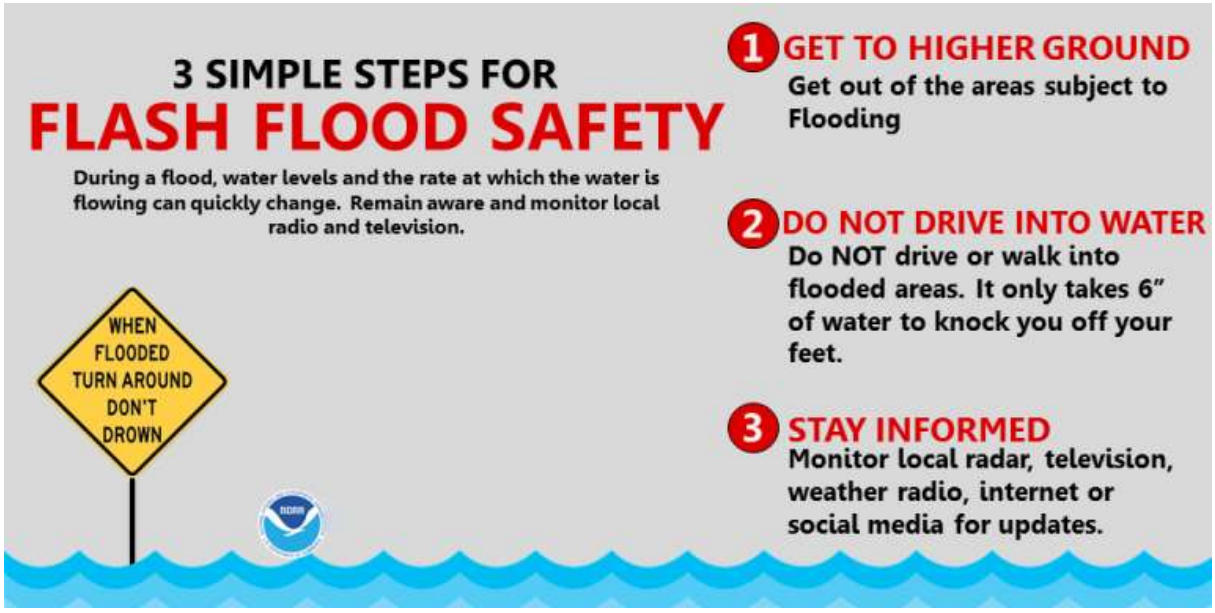
	
Dehradun, Tehri and Pauri Regions (August 20, 2022)	• **Cloudburst-related rainfall** caused rivers to overflow in parts of **Dehradun, Tehri, and Pauri.** • The **Raipur-Kumalda** region saw bridges collapse, while water entered the sacred **Tapkeshwar temple caves** along the Tons river. • The **Song river bridge** was washed away and popular tourist spots like **Kempty Falls** saw dangerously high water levels.

4. What makes flash floods dangerous?

- The defining feature of **flash floods is their speed and unpredictability.** They can **occur without warning, catching people off guard** and leaving **little time for preparation and evacuation.**
- The **rapid rise in water levels can reach several feet in just a few minutes,** destroying property, and the **force of the water** can be **powerful enough to uproot trees, c**arry away vehicles, and damage buildings.
- **Flash floods** also pose a **significant threat to life**, along with **property and infrastructure.**

- These floods are known to **cause drowning, injuries, and fatalities, as well as destroy homes, roads, bridges,** and other structures.

5. Enlist a few mitigation measures for flash floods?



Safety Measures	Description
Early Warning Systems	• The **installation of real-time weather monitoring systems** and flood forecasting systems. • **Mobile Alert, siren announcements, and community radios** are used as radio channels to warn the people.
Disaster Preparedness Plans	• Establish an **efficient drainage system** for the city. • **Restrict constructions in flood-prone areas** and natural waterways.
Afforestation and Catchment	• **Tree planting and restoration** of other vegetation provide the **much-needed water absorption.**

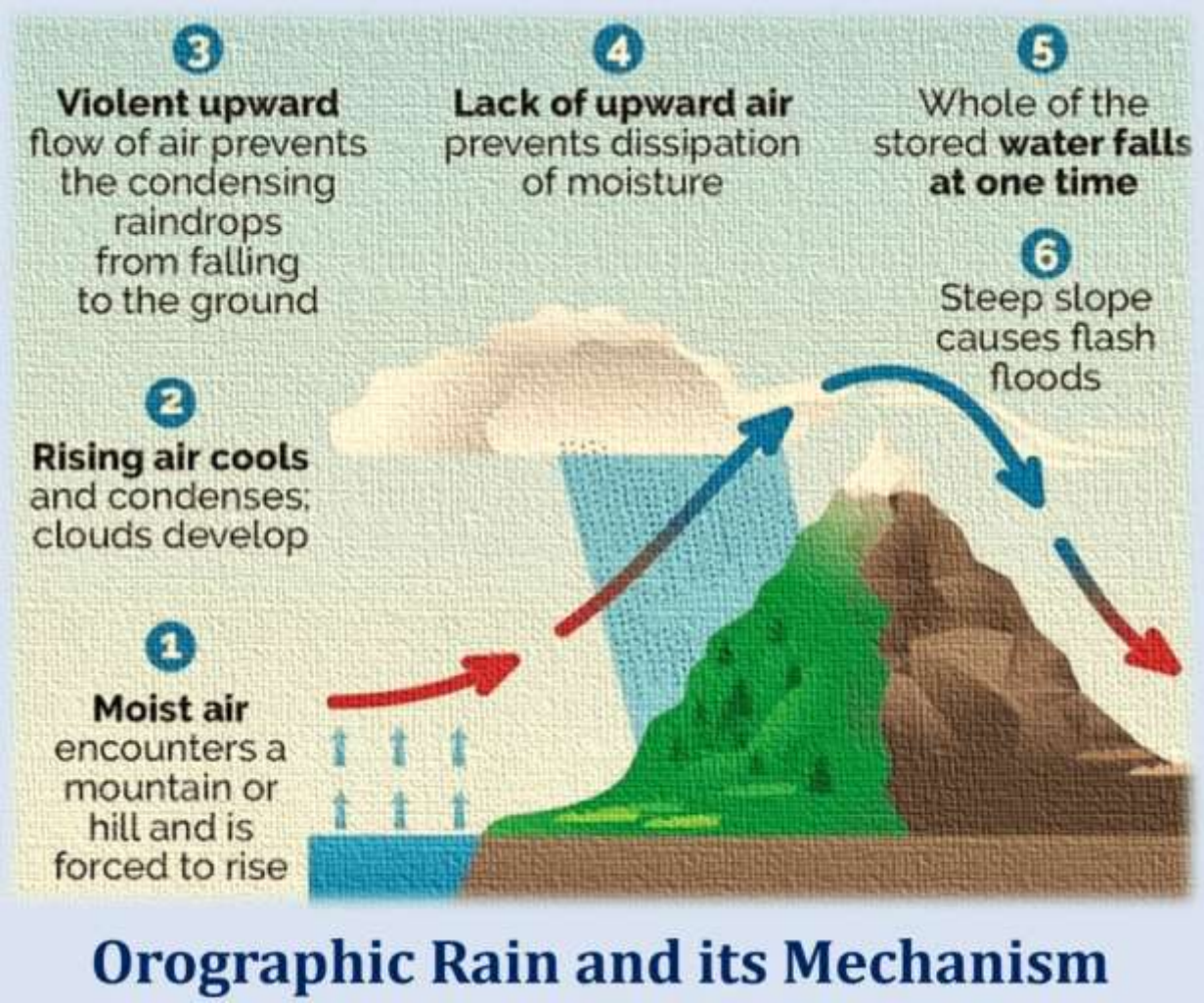
Area Management	• **Soil conservation** in the uplands prevents run-off.
Rainwater Harvesting	• **Promote storage of rainwater** as one of the line defenses to **reduce surface runoff.** • **Restoration of natural vegetative** covers should be exemplified by **rooftop harvesting** in the city for **minimizing runoff.**

6. What is a cloudburst?

- A **cloudburst means very heavy rainfall happening** in a **very short time,** usually over a small area.
- It is common in **hilly areas like the Himalayas.**
- The word doesn't mean that clouds actually burst. Instead, it happens when **thick, rain-filled clouds pour down a huge amount of rain very quickly,**sometimes as much as what a **city gets in a whole month**, all within an hour.

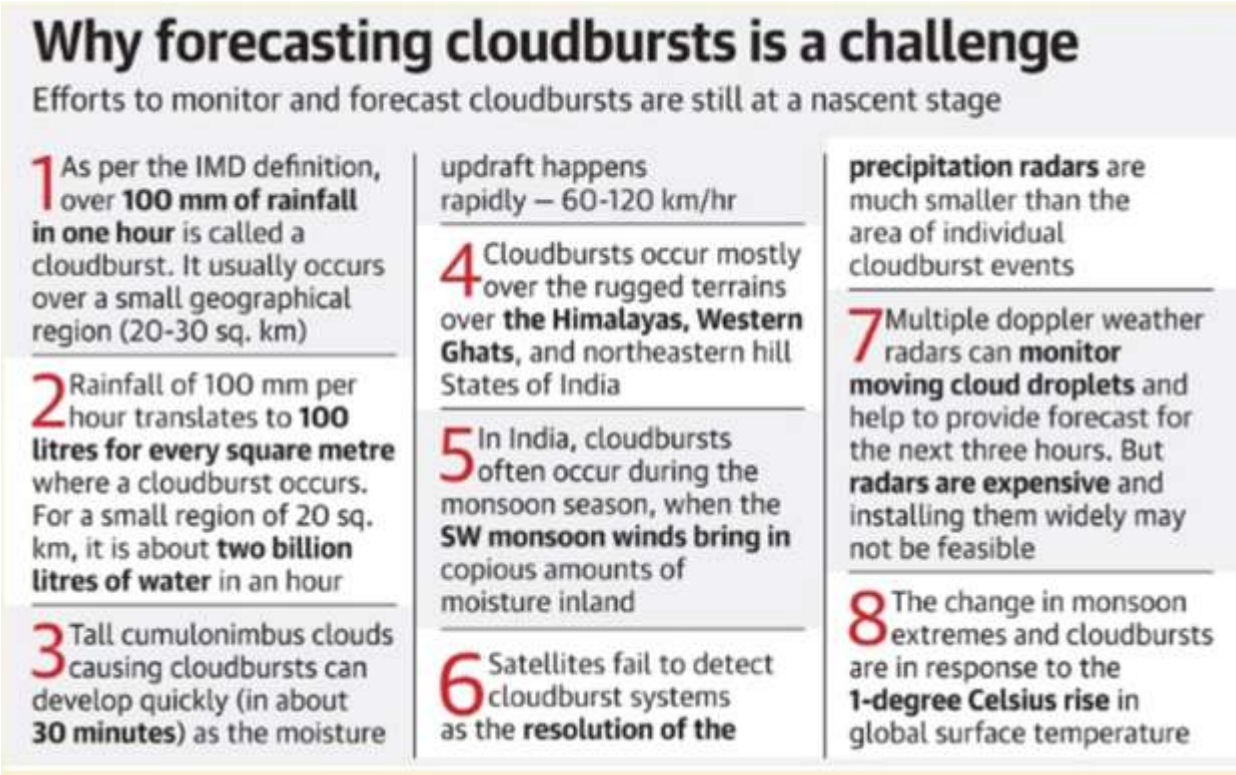
- These cloudbursts **can cause floods, landslides, and a lot of damage.**

7. How does a cloudburst happen?



- **Cloudbursts** happen when warm, **wet air quickly rises up a mountain, cools down suddenly, and turns into rain**.
- This process is called **orographic lif**t.
- It leads to a **heavy downpour in a short time.**
- Sometimes, it also happens when **warm and cold air suddenly mix** or when there's a lot of moisture in the **air at higher place**s.
- All this causes **clouds to release rain very fast,** leading to floods.

8. What are the challenges in forecasting cloudburst?



- 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.

- As a result, **specific cloudburst events cannot be fore**cast.
- **No forecast ever mentions a possibility of a cloudburst.**
- But there are warnings for **heavy to very heavy rainfall events,** and these are routinely forecast four to five days in advance.
- **Possibility of extremely heavy rainfall,** which could result in cloudburst kind of situations, are **forecast six to 12 hours in advance.**

9. Why is Uttarkashi a Disaster Hotspot?

Reasons	Description
Geography Of The Area	• The **Uttarkashi region** lies deep within the **Garhwal Himalayas,** characterised by **mountain slopes, unstable rock formations,** and a dense network of **glacier-fed rivers**. • This topography makes areas like **Dharali, Harsil, and Gangotri** particularly **vulnerable to landslides, flash floods, and debris flows.** 
Source And Flow Of The Bhagirathi	• The **Bhagirathi River originates at Gaumukh,** the snout of the **Gangotri Glacier.**

River	• It is situated at an **altitude of around 4,000 m in Uttarkashi district**. • From there, it flows through **Gangotri, Harsil, Uttarkashi, and Tehri,** collecting tributaries like **Jadh Ganga, Kedar Ganga,** and Bhilangna before merging with the **Alaknanda River at Devprayag where the two together form the Ganga.** • Though **Alaknanda carries a larger volume of water, Bhagirathi** is **culturally considered** the main source of the **sacred river.**

10. How is climate change causing frequent Cloudburst?

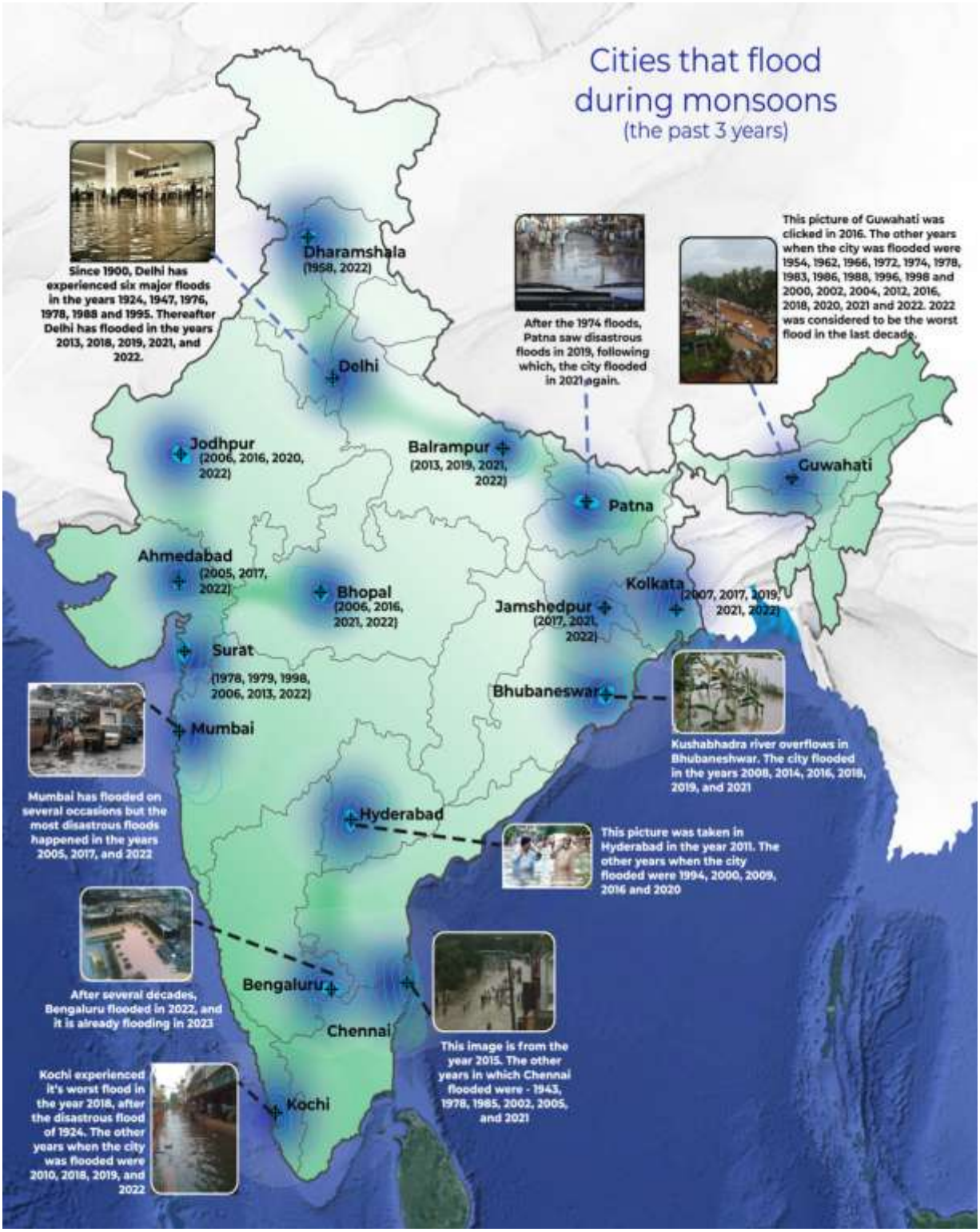
- There is **growing scientific evidence** that **climate change is contributing** to the **increasing frequency and intensity of cloudbursts**.
- A warmer **atmosphere can hold more** moisture, nearly **7 per cent more for every 1°C rise in temperature**.
- This can lead to **more powerful convective storms.**
- The **changing monsoon patterns and warming oceans**, which **result from climate change**, are also altering regional weather systems, especially in South Asia.
- While not every cloudburst can be directly linked to climate change, the **broader pattern of intensifying extreme rainfall events is consistent with climate predictions.**
- A **2023 study published in the Nature journal** showed that **extreme rainfall** events in **India have risen by 20–50 per cent** in some regions **since the 1950s.**

- This **rise is partially attributed to climate change**-induced **shifts in annual monsoon patterns.**
- Data from the **Indian Meteorological Department** also showed a **marked rise in intense rainfall events**, showing the **changing weather dynamics in mountainous regions.**

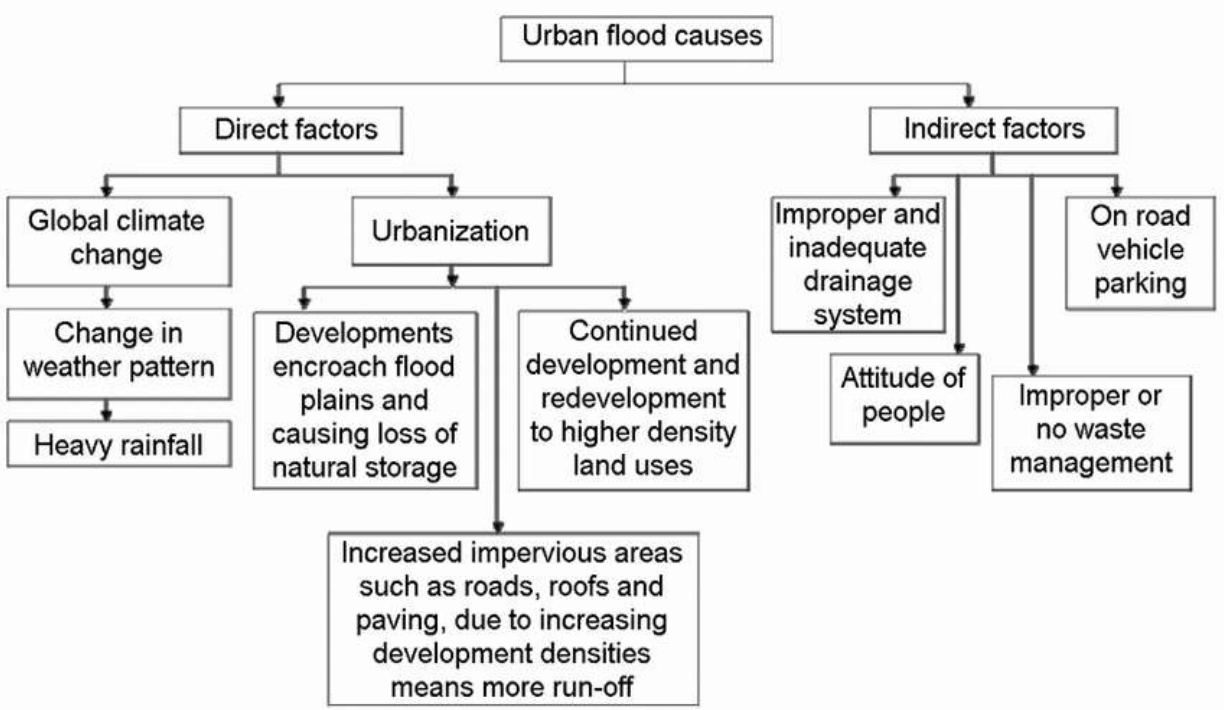
11. What is Urban Flooding?

- **Urban flooding** is significantly different from rural flooding as **urbanization leads to developed catchments,** which increases the **flood peaks from 1.8 to 8 times** and **flood volumes by up to 6 times.**
- Consequently, flooding occurs **very quickly due to faster flow times** (in a matter of minutes).
- Urban areas are **densely populated** and people **living in vulnerable areas suffer due to flooding**, sometimes resulting in loss of life.
- It is not only the event of flooding but the **secondary effect of exposure to infection** also has its toll in terms of **human suffering, loss of livelihood** and, in extreme cases, **loss of life.**

12. Enlist a few examples of Urban floods?

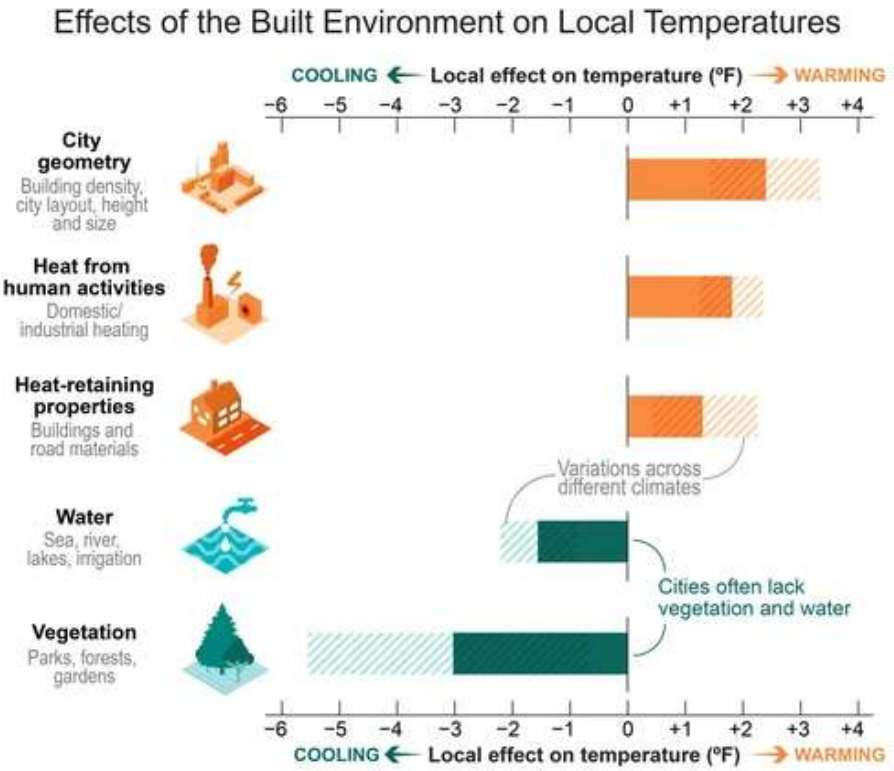


13. What are the causes of Urban Floods?



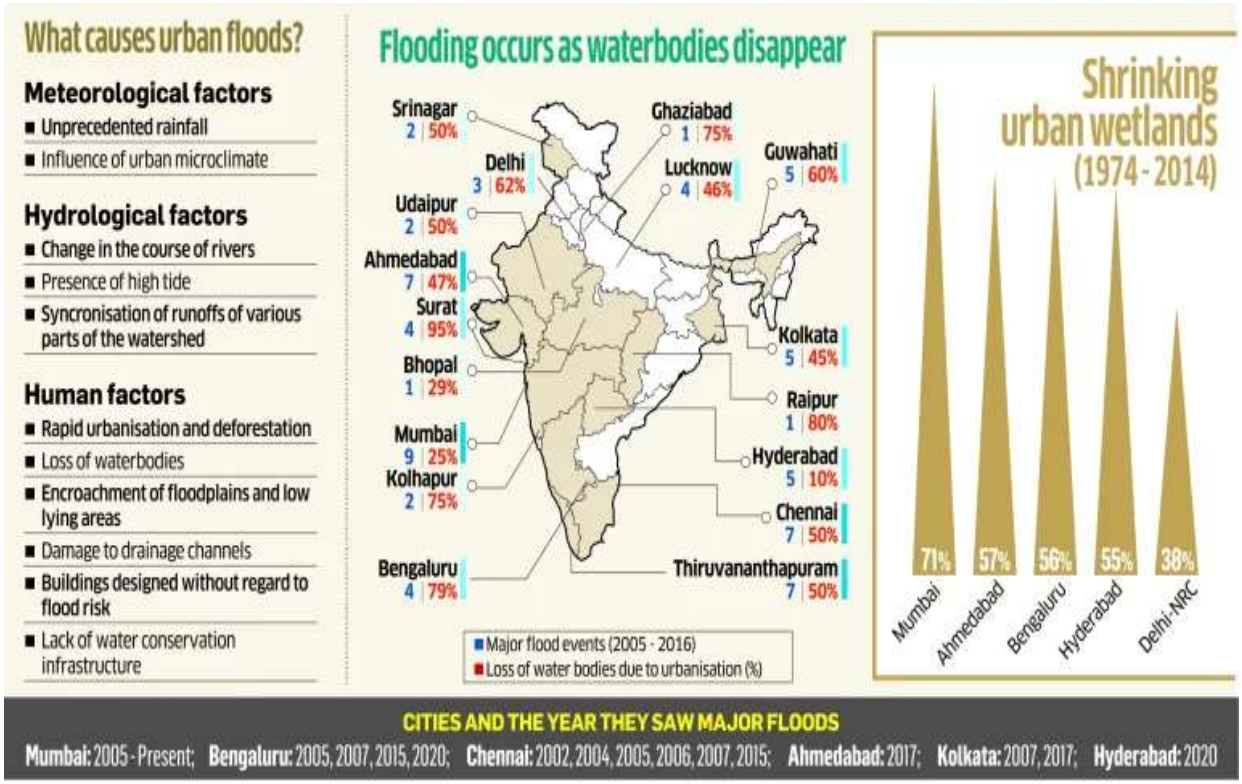
Causes	Analysis
Climate Change	• **Climate change** is altering **precipitation patterns** across the globe. • **Rainstorms and flooding** events are increasing in **both frequency and severity**. • Global warming is adding to the **problem of rising sea levels**, which is **causing flooding in coastal areas.** • In **2024**, **Mumbai experienced 300 mm of rainfall in just six hours**, overwhelming the city's drainage capacity and causing significant disruptions.

	 • Climate change has disrupted the rainfall pattern, and **urban heat islands have increased rainfall** over urban areas resulting in flooding.
Rapid Urbanization	• **Urbanization** is a **significant contributor** to the problem of **urban flooding**. • The development of catchments in **urban areas increases flood peaks** and flood volumes.  • Furthermore, the **capacity of the natural drains has decreased**, resulting in flooding. **Encroachments on drainage areas like lakes, wetlands, and riverbeds** close off ways for excess water to flow, thus causing floods.

	
Inadequate Drainage Systems	• **Inadequate drainage systems** are a significant cause of **urban flooding**. • Many cities have **outdated or undersized infrastructure** that **cannot handle the increased volume** of **runoff from impervious surfaces.** • **Inadequate maintenance of drainage systems** can further exacerbate the problem.
Encroachment of Urban water bodies	• **Lakes and wetlands** are an important part of the **urban ecosystem**. • They perform **significant environmental, social and economic functions** from being a source of drinking water and recharging groundwater to **supporting biodiversity and providing livelihoods.**

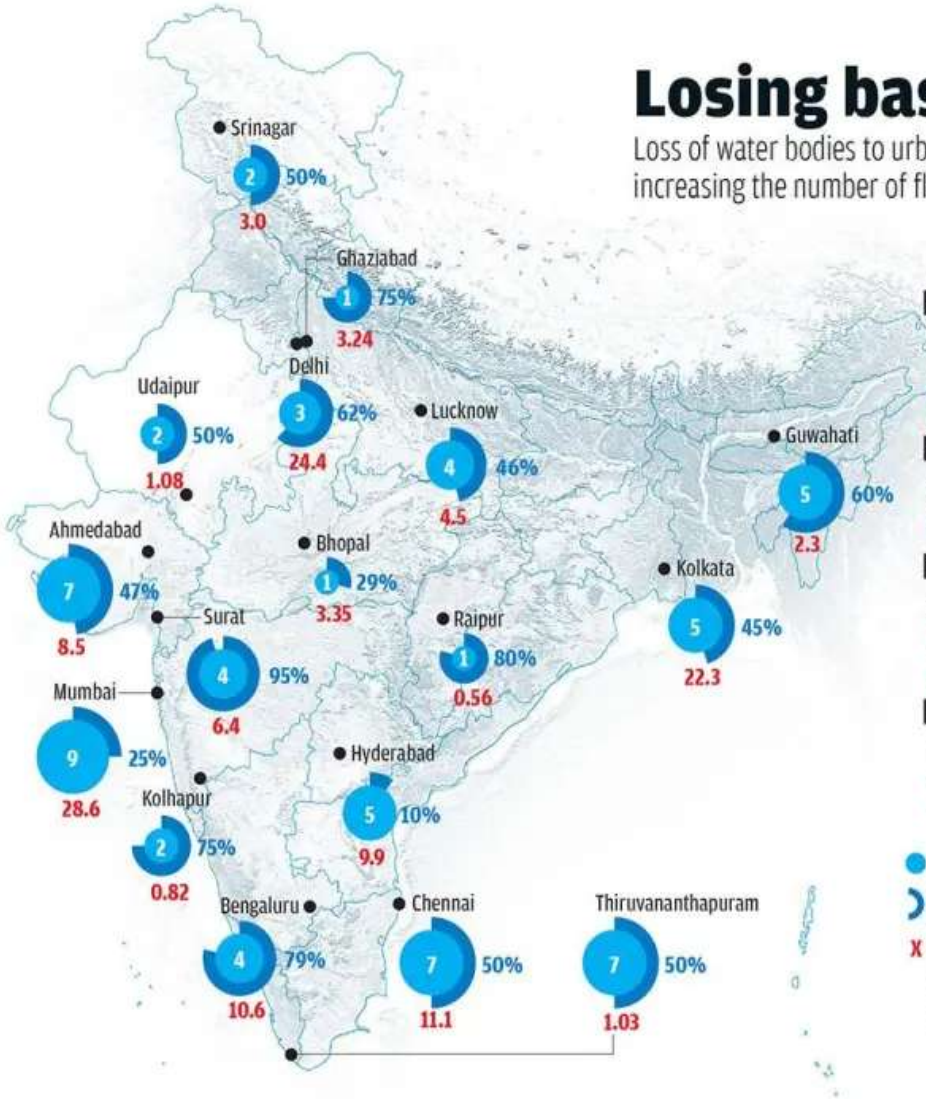
	• For example, **Bangalore had 262 lakes in the 1960s** but now **only 10 of them hold water.** • At **least 137 lakes** were listed in **Ahmedabad in 2001** but now **construction work has started on 65 of them.** • Another example exhibiting this increasing loss of **urban water bodies is Hyderabad.** ▪ In the **last 12 years, Hyderabad has lost 3,245 hectares of its wetlands.**
Unplanned tourism activities	• Using **water bodies to attract tourists** has become a threat to several urban lakes in India. • **Tso Morari and Pongsho lakes in Ladakh have become polluted** because of **unplanned and unregulated tourism.**  • Another example is that of **Ashtamudi Lake in Kerala's Kollam city,** which has become **polluted due to spillage of oil from motor boats.**
Absence of administrative framework	• The biggest challenge is the **government apathy towards water bodies.**

	• A **2010-11 Comptroller and Auditor General of India report** on the plight of **22 lakes in 14 states said:** ▪ The **Union Ministry of Environment & Climate Change (MoEF&CC)** had **not identified wetlands associated** with each river / lake and **no identifications of risks to these wetlands due to pollution of river water** / lake water had been carried **out by the Central Pollution Control Board (CPCB).**



Losing base

Loss of water bodies to urbanisation is increasing the number of flood events



Population in urban India

2011	2031
377 million	600 million

Metropolitan cities

2011	2031
52	87

Population in metropolitan area

2011	2031
160 million	255 million

Level of urbanisation

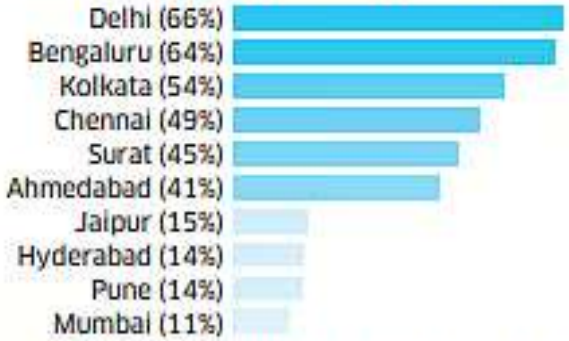
2011	2031
31%	50%

- Number of major flood events after 2000
- Loss in water bodies/water spread due to urbanisation
- X Population projected in 2021 (in million)

Sources: Research articles and documents; personal communication with government officials and researchers; newspaper articles

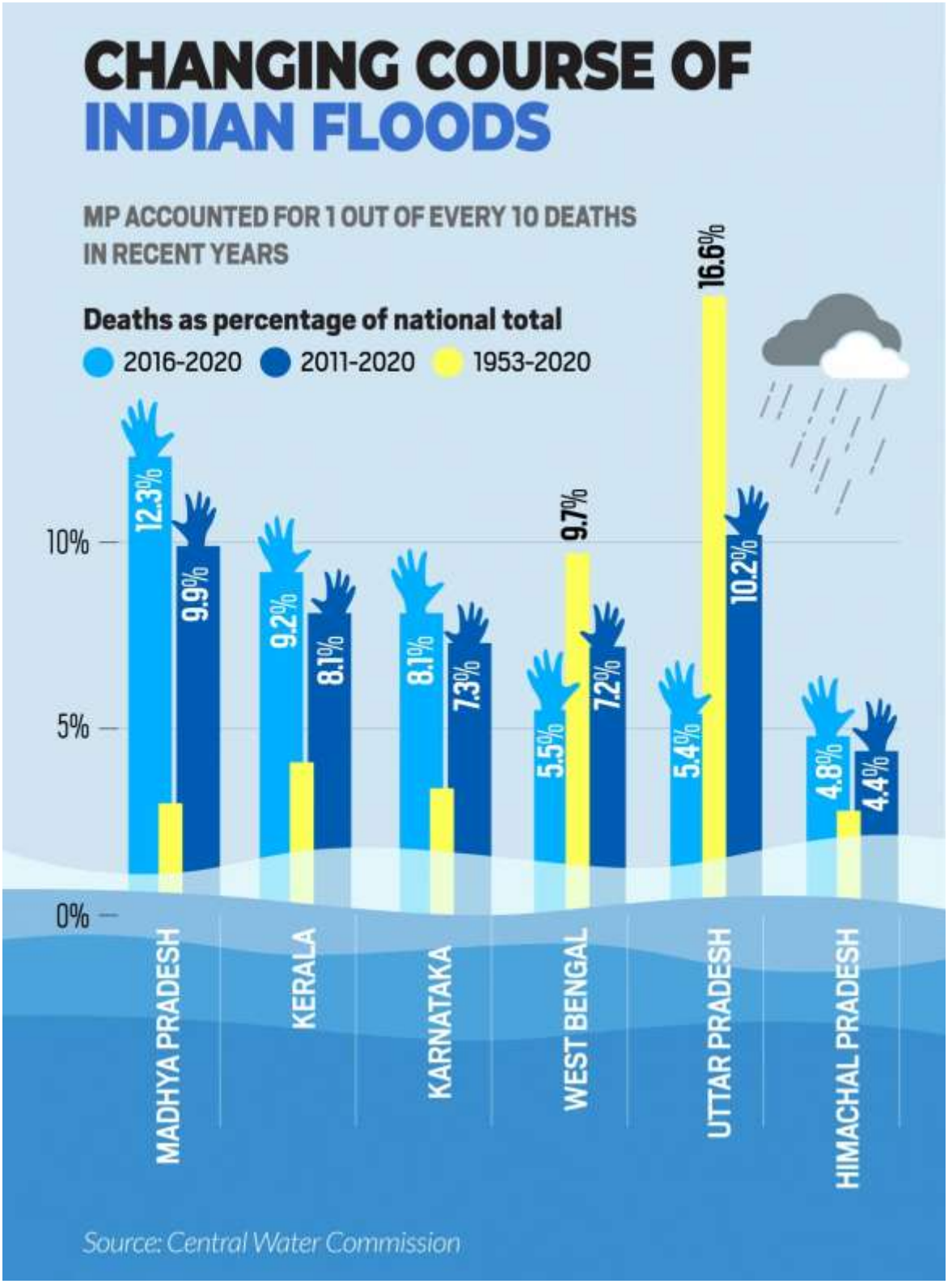
Hindering recharge

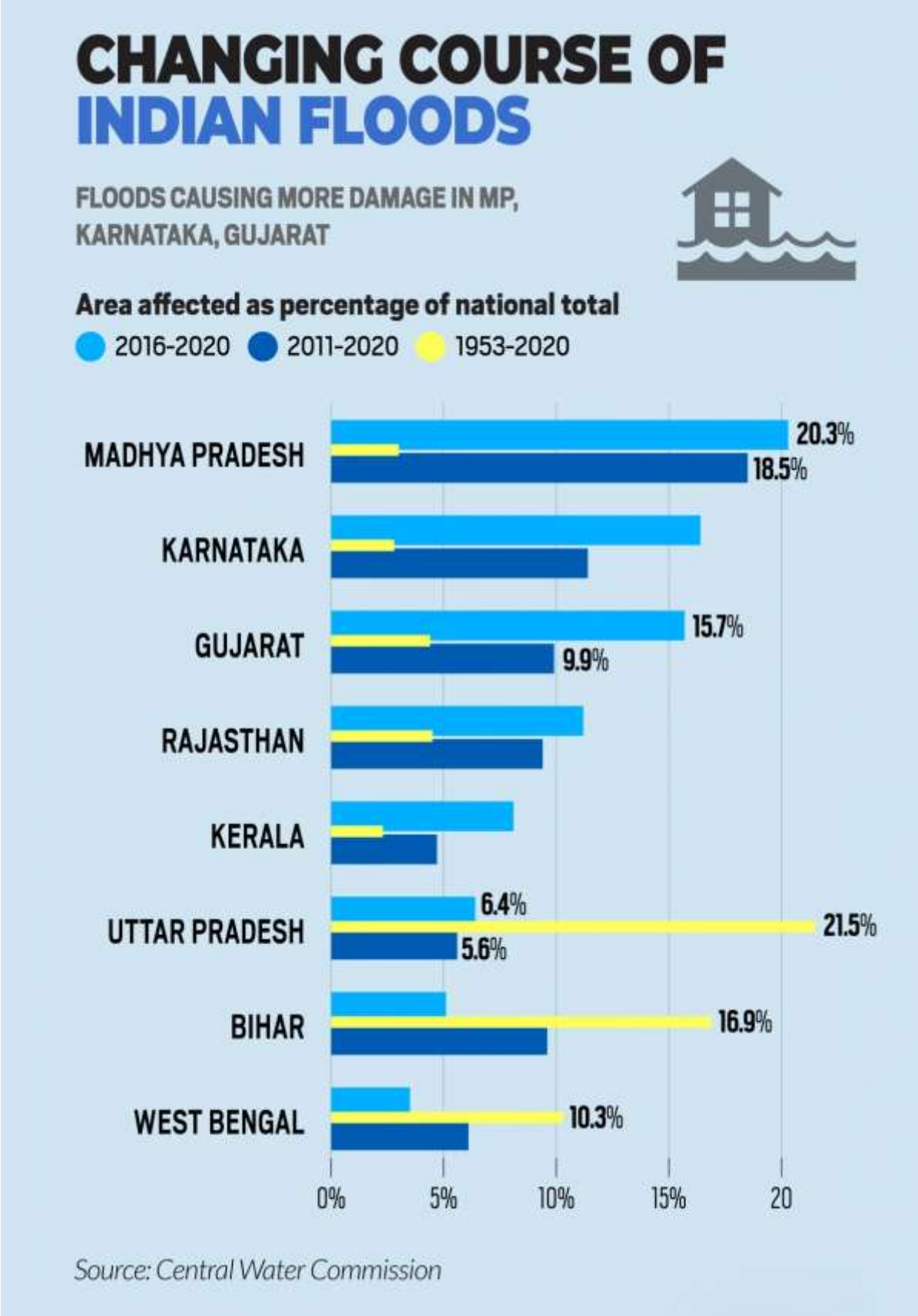
More than half of all new developments have been built on high and very high potential recharge zones in Delhi, Bengaluru and Kolkata



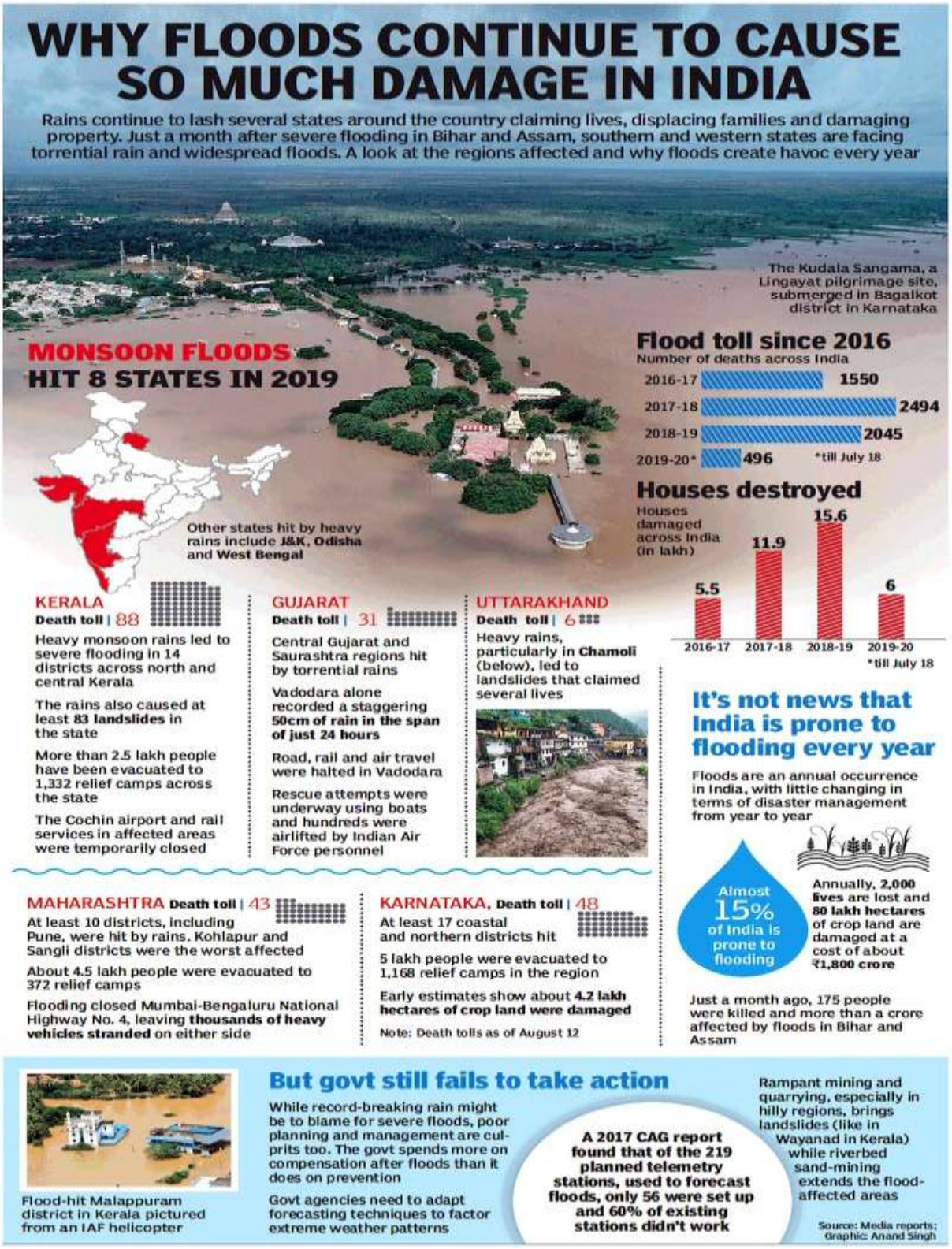
Source: World Resources Institute India's working paper on the impacts of urbanisation on natural infrastructure in India

14. Mention about the changing nature of Floods in India?




CHANGING COURSE OF
INDIAN FLOODS
FLOODS CAUSING MORE DAMAGE IN MP, KARNATAKA, GUJARAT
Area affected as percentage of national total
2016-2020
2011-2020
1953-2020
MADHYA PRADESH
20.3%
18.5%
KARNATAKA
GUJARAT
15.7%
9.9%
RAJASTHAN
KERALA
UTTAR PRADESH
6.4%
21.5%
5.6%
BIHAR
16.9%
WEST BENGAL
10.3%
0%
5%
10%
15%
20
Source: Central Water Commission

15. What are the consequences of Flash Floods and Urban Floods?



Impact	Description
Property Damage	• **Urban flooding** can cause **extensive damage to buildings, infrastructure**, and personal belongings, resulting in significant **financial losses for individuals and communities.** 
Economic Losses	• The costs associated with **urban flooding** extend beyond **immediate property damage.** • Businesses may be **forced to close temporarily or permanently**, leading to job losses and disruption of local economies. • The **World Bank warns that by 2050,** urban flood damage could cost up to **USD 1 trillion annually worldwide** if preventive measures are not implemented. • During the **2022 Bengaluru floods, IT companies** reported **daily losses of Rs 225 crore** due to **employee absenteeism.**

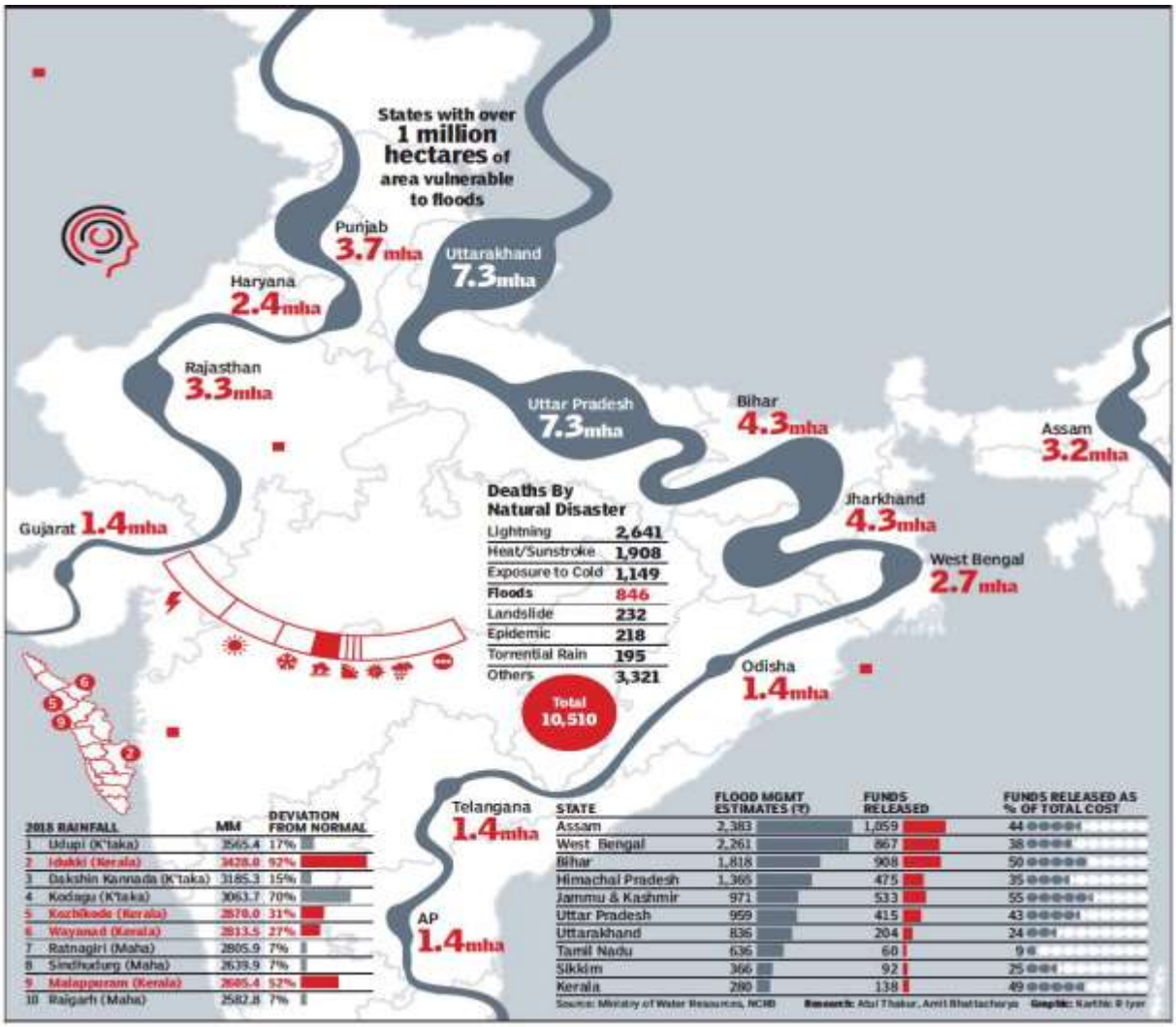
Health Risks	• **Urban flooding can pose health risks,** including exposure to **contaminated floodwaters,** increased **risk of waterborne diseases**, and mental health impacts resulting from the **loss and displacement caused by flooding.** • The **2019 Patna floods** saw significant **cases of malaria and diarrhea**, while the **2005 Mumbai floods triggered a leptospirosis outbreak.** • According to a study, **67% rise in mental health issues among residents in flood-affected areas,** with prevalence of **post-traumatic stress disorder (PTSD) rates reaching 30-40% for years after an event.**
Disruption of Essential Services	• **Floods can disrupt essential services such as electricity, water supply, and communication networks.** • This can lead to **further hardships for affected communities** and hinder rescue and relief operations.
Displacement and Homelessness	• **Urban flooding can force people to evacuate their homes** and seek temporary shelter. • Displaced individuals often face difficulties in finding **adequate accommodation and suffer from the loss of personal belongings**. • **2018 Kerala floods displaced over a million people,** with many struggling to find adequate shelter for months.
Environmental Degradation	• **Urban flooding** leads to **soil erosion**, **water pollution, and damage to ecosystems.** • **Floodwaters carry pollutants and debris**, impacting water quality and harming aquatic life.

It's not humans alone who are hit by the havoc caused by the recent floods, wild animals too are facing the monsoon's frenzied music. The answer to a recent question in the Lok Sabha revealed that these floods have killed about 2,000 wild animals so far. The bulk of these wild animals are blue bull (Nilgai) and spotted deer (chital), which are classified as species of least concern by the International Union for Conservation of Nature. But 10 lions too have died. The Asiatic lion currently exists as a single subpopulation in Gujarat and is vulnerable to extinction from unpredictable events like epidemics or natural disasters

DETAILS OF LION DEATHS DUE TO FLOOD IN GUJARAT

Villages, District, Sex and Age

BAVADI, AMRELI	GARADI VOKLA, AMRELI	GARAJIYA, BHAVNAGAR	GARAJIYA, BHAVNAGAR	GHOBA, BHAVNAGAR	PINGALI, BHAVNAGAR	INGORALA, AMRELI	MAIDHAR, BHAVNAGAR	GHOBA, BHAVNAGAR	KRAKACH, AMRELI
FEMALE, 7-8 YRS	MALE 4-5 YRS	MALE 7-8 YRS	FEMALE 5-6 YRS	FEMALE 5-6 YRS	FEMALE 3-4 YRS	FEMALE 3-4 YRS	MALE 7-8 YRS	MALE 7-8 YEARS	MALE 5-6 YRS



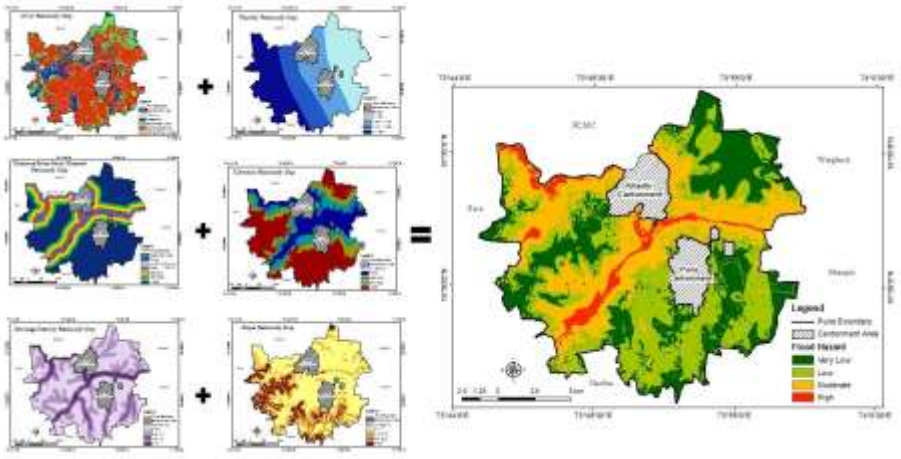
2018 RAINFALL	MM	DEVIATION FROM NORMAL
1 Udupi (K'taka)	3565.4	17%
2 Idukki (Kerala)	3428.0	92%
3 Dakshin Kannada (K'taka)	3185.3	15%
4 Kodagu (K'taka)	3063.7	70%
5 Kozhikode (Kerala)	2870.0	31%
6 Wayanad (Kerala)	2833.5	27%
7 Ratnagiri (Maha)	2805.9	7%
8 Sindhudurg (Maha)	2639.9	7%
9 Malappuram (Kerala)	2605.4	52%
10 Raigarh (Maha)	2582.8	7%

STATE	FLOOD MGMT ESTIMATES (₹)	FUNDS RELEASED	FUNDS RELEASED AS % OF TOTAL COST
Assam	2,383	1,059	44
West Bengal	2,261	867	38
Bihar	1,818	908	50
Himachal Pradesh	1,365	475	35
Jammu & Kashmir	971	533	55
Uttar Pradesh	959	415	43
Uttarakhand	836	204	24
Tamil Nadu	636	60	9
Sikkim	366	92	25
Kerala	280	138	49

Source: Ministry of Water Resources, NCRB

16. What mitigation strategies can be adopted?

Strategies	Description
Bigger drains to match intense rainfall	• A **National Institute of Urban Affairs (NIUA)** factsheet also points out that **urban floods** are a result of inadequate or **poor maintenance of storm-water** drains, improper planning, encroachment of drains and water bodies, **occupation of low-lying areas,** modification of catchment areas, and **climate change.** • **Vishwanath S**, a Bengaluru-based **urban planner and civil engineer,** stressed on the **need to audit all stormwater drains** to have a **relook at their capacity** in the wake of the increased spells of intense rainfall because of climate change.
Build sponge cities	• The **experts pointed** to the **concept of sponge cities** or green solutions that **help the absorption** or **percolation of rainwater** into the ground as a means to **combat waterlogging.**  • **China has a national mandate for all cities to incorporate 'sponge elements'** in design and planning.

Mapping floods, better rain forecasting	• **Mapping rainfall and flood data** will help the authorities **gauge** under what **conditions a city is likely to face problems** and design solutions accordingly. • If a **city publishes its flood maps,** with estimated water levels and **projections based on rainfall trends,** people can make calculated decisions. • A **catchment can be planned** based on its **terrain** and flows to suggest **redevelopment guidelines** in **high-end neighbourhoods** to ensure flood resilience once buildings are rebuilt. 
Flood Governance	• The importance of **Flood governance** is also not taken seriously by the administrators. • There should be **flood governance to reduce the risk of flooding, improve infrastructure**, and protect people and property.

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<td>Green Infrastructure</td>
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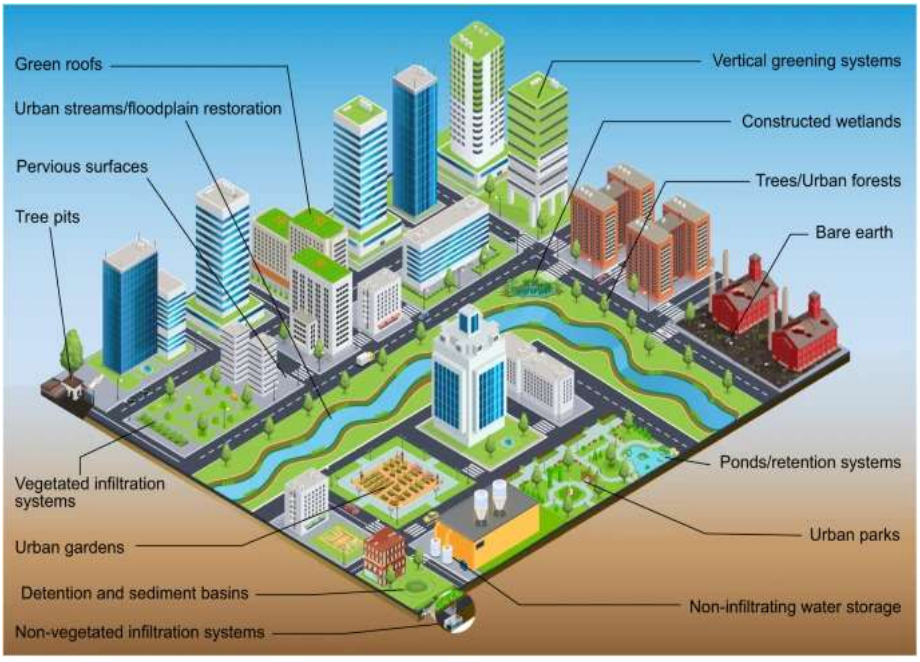
Green infrastructure can be utilized to provide sustainable solutions to urban climate challenges.
The development of blue-green infrastructure will be effective in providing sustainable solutions to urban climate challenges.



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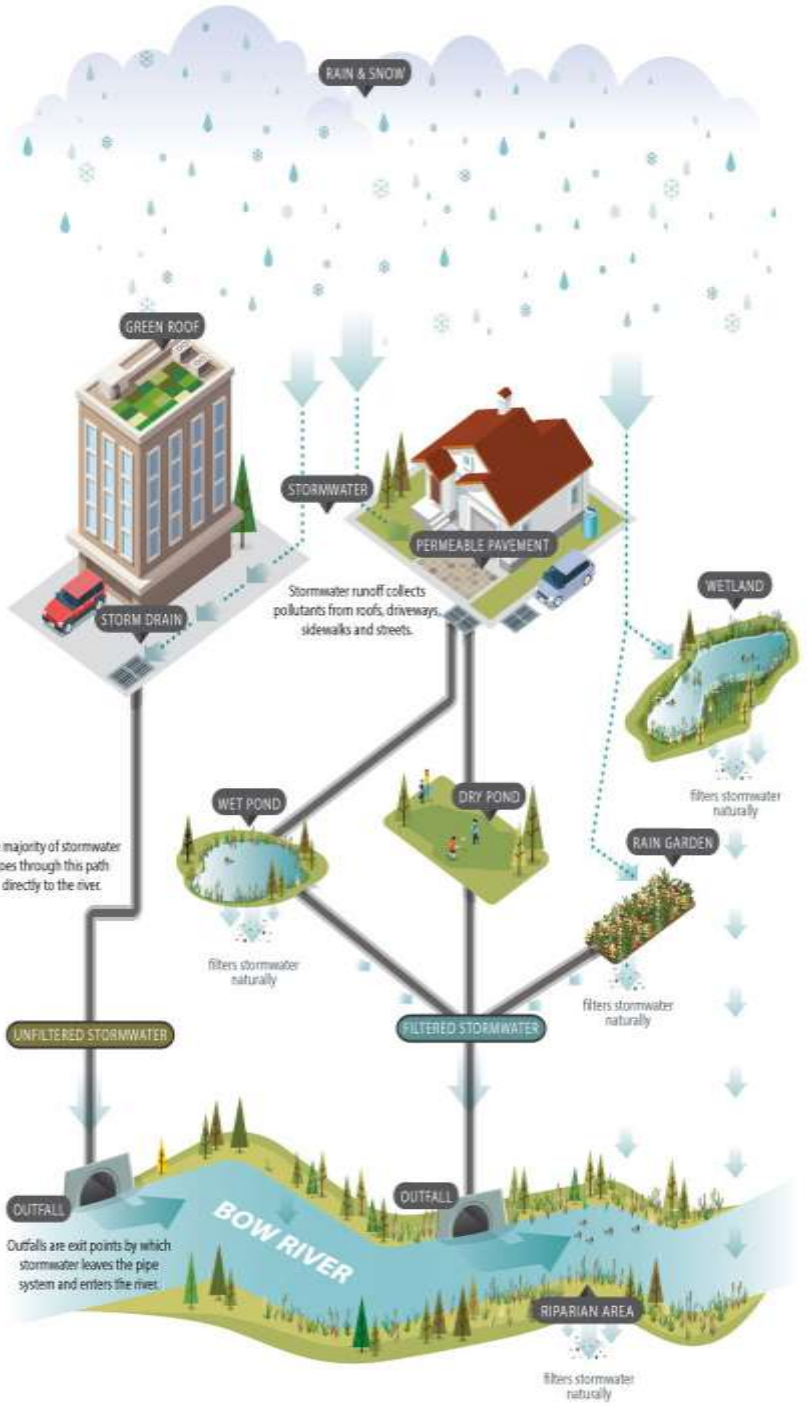
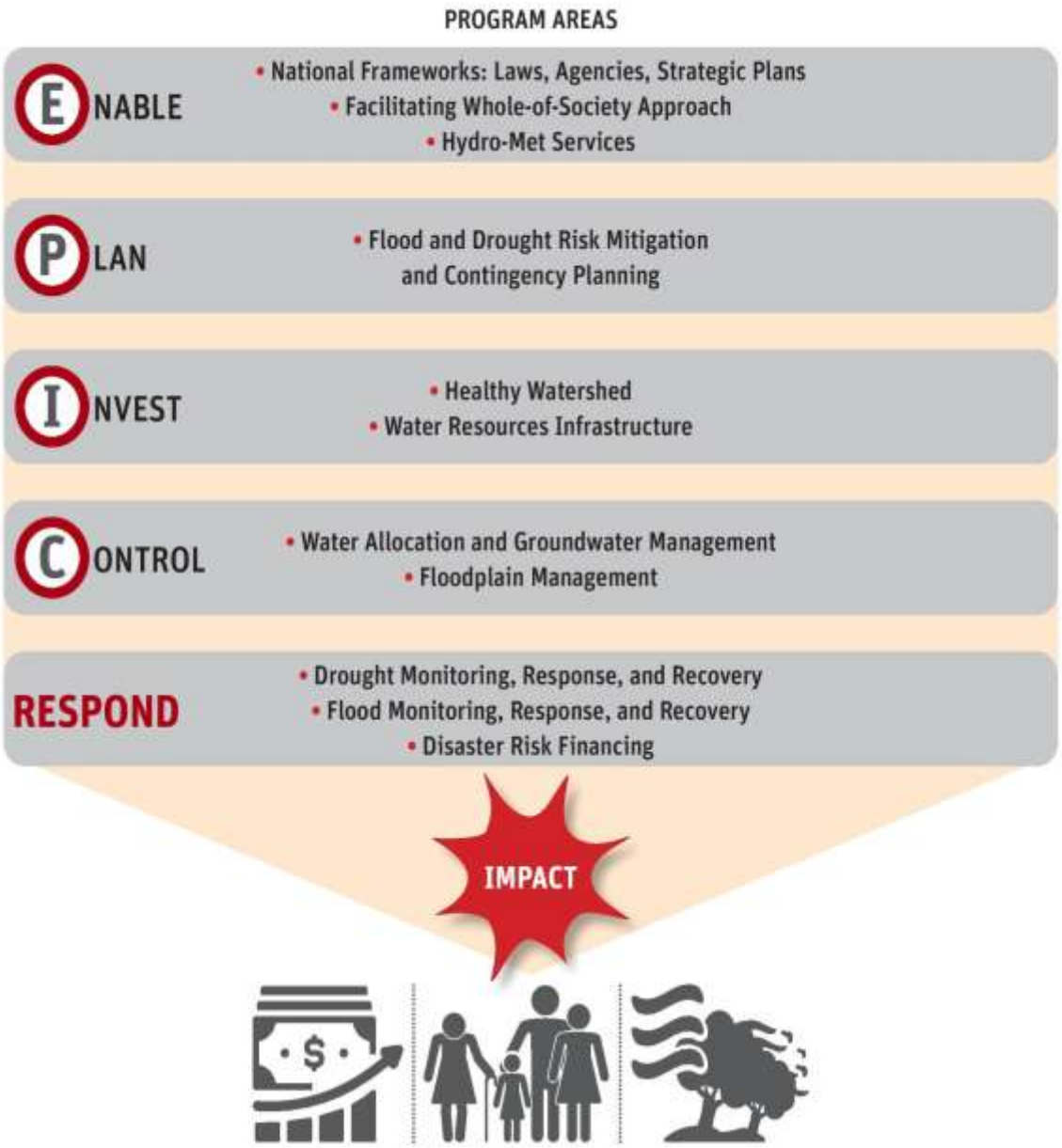
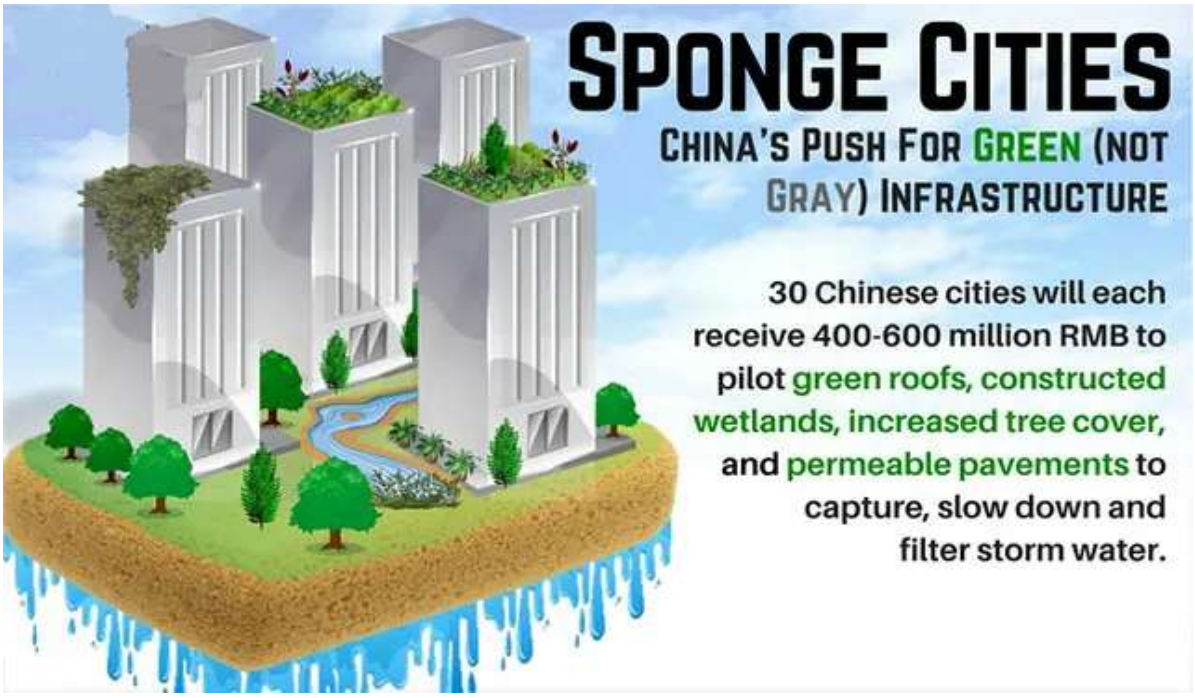
	• Better water management should be ensured, like **including rainwater harvesting in all infrastructure developments.**
Desilting natural water bodies	• The **natural water bodies should be strict**ly desilted and **maintained to ensure the free flow of excess water**. • Water bodies should be made **clear of pollution and encroachment**, and drainage systems should be regularly maintained. 
Stormwater Management	• **Stormwater management** is essential to manage **urban flooding**. • **Municipal water utilities** should invest in **stormwater management** to handle rainfall levels. • The **drainage and sewer infrastructure need to be made resilient**, and sustainable alternatives for receiving and **storing rainwater** should be implemented.


RAIN & SNOW
GREEN ROOF
STORMWATER
PERMEABLE PAVEMENT
STORM DRAIN
Stormwater runoff collects pollutants from roofs, driveways, sidewalks and streets.
WETLAND
filters stormwater naturally
WET POND
DRY POND
RAIN GARDEN
The majority of stormwater goes through this path directly to the river.
filters stormwater naturally
filters stormwater naturally
UNFILTERED STORMWATER
FILTERED STORMWATER
OUTFALL
OUTFALL
BOW RIVER
Outfalls are exit points by which stormwater leaves the pipe system and enters the river.
RIPARIAN AREA
filters stormwater naturally

The EPIC Response Framework



17. What are sponge cities and how do they work?



- The **Sponge City concept** is a **Chinese urban planning model** that relies on **natural stormwater management infrastructure**, with a focus on **flood control and mitigating urban development's** impacts on hydrology and ecosystems.
- Its goal is to **increase infiltration, detention, storage, treatment, and drainage of water** while improving urban livability.
- The **Sponge City model** is similar to many familiar approaches worldwide, such as:
  - **Low Impact Development (LID)**
  - **Sustainable Urban Drainage Systems (SUDS) (U.K.)**
  - **Water Sensitive Urban Design (WSUD) (Australia)**
  - **Active, Beautiful and Clean (ABC) (Singapore)**
  - **Landscape Stormwater Management (Denmark)**
- **Cities** as diverse as **Shanghai, New York and Cardiff** are embracing their **"sponginess"** through **inner-city gardens,** improved river drainage and plant-edged sidewalks.

18. Enlist a few technological solutions for urban floods?

Solutions	Descriptions
Remote sensing and GIS	• To address these challenges, **remote sensing and Geographic Information System (GIS)** technologies have emerged as powerful tools in **flood mitigation.** • These technologies enable **real-time monitoring, flood risk assessment, and early warning systems** that help mitigate urban flooding effectively.

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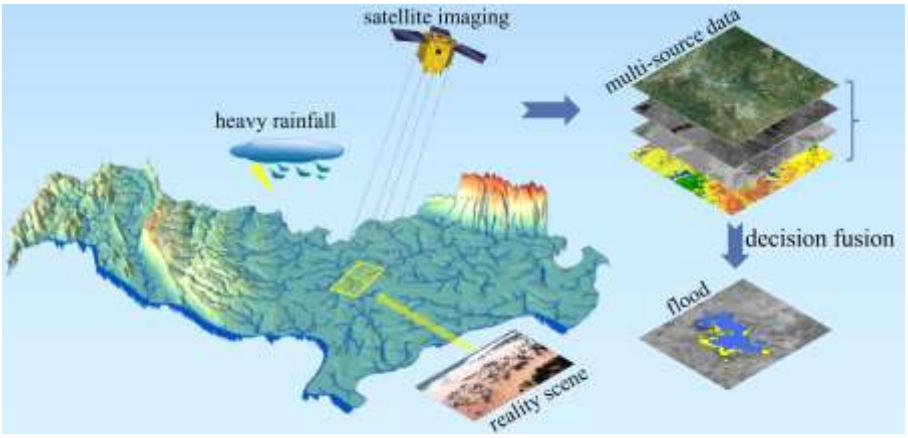
<tr><td></td><td> 
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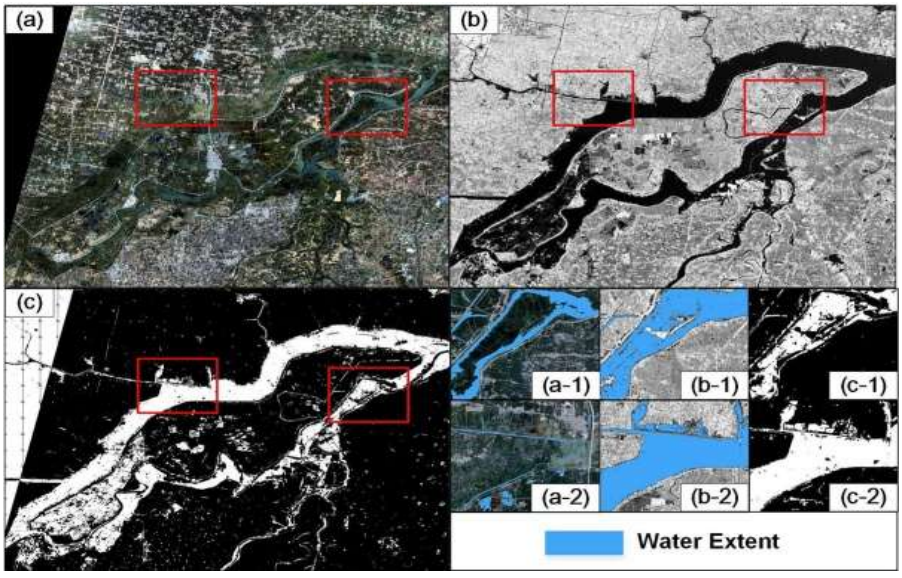
<tr><td>Satellite-based monitoring</td><td>

Organisations like the Indian Space Research Organisation (ISRO) and the National Remote Sensing Centre (NRSC) have been developing satellite-based flood forecasting models using high-resolution imagery.
These satellites capture real-time data on rainfall, land use, and water levels, aiding in early warning systems and disaster preparedness.
For example, satellite imagery has been utilized to assess flood-affected regions, infrastructure damage, and waterlogged areas, enabling quicker response and recovery efforts.



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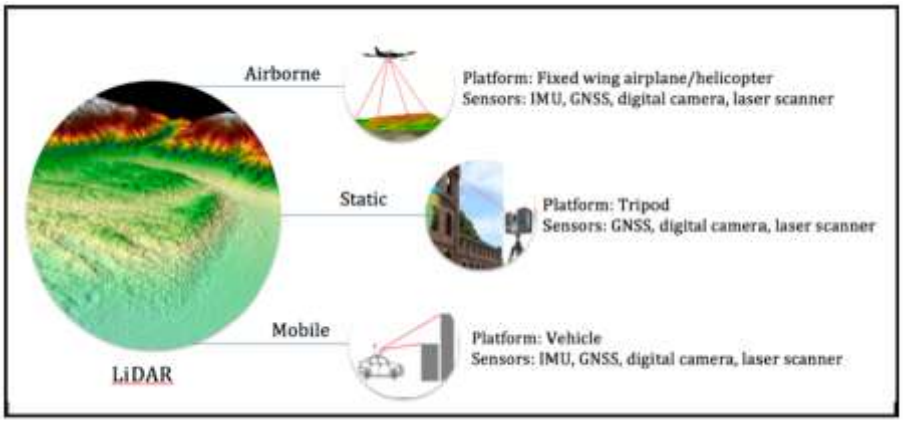
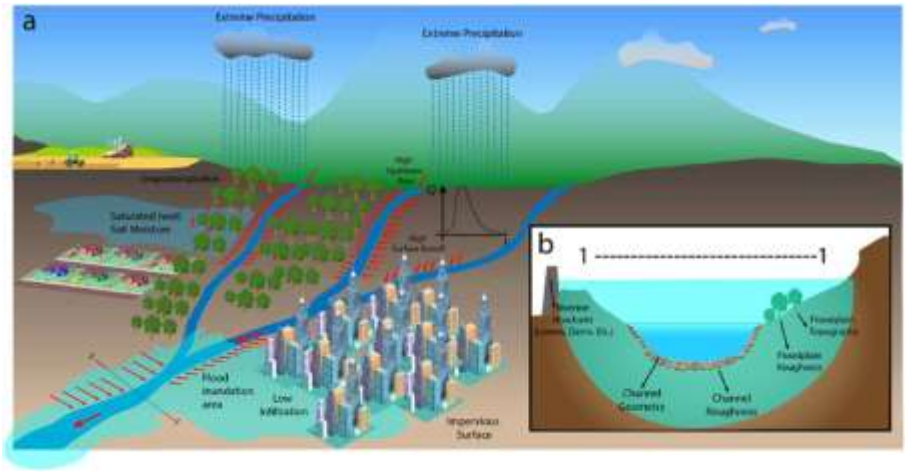
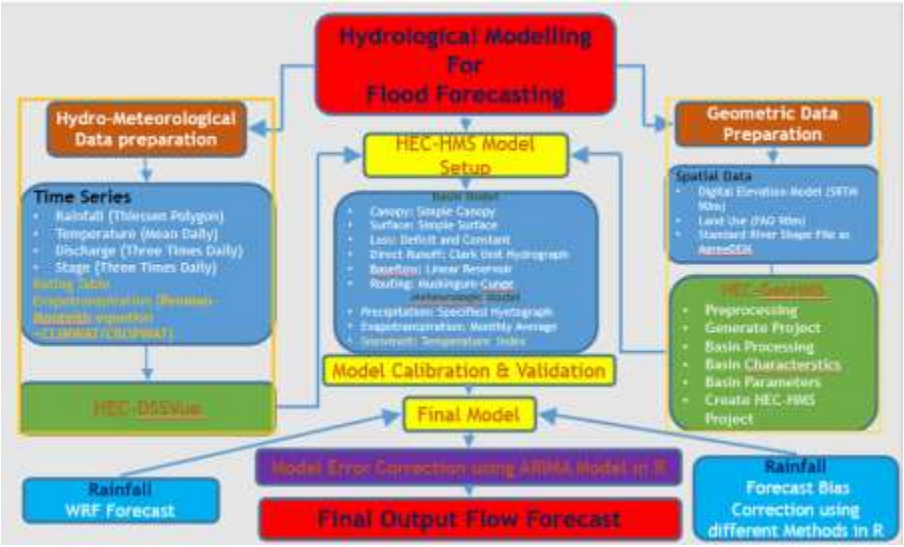
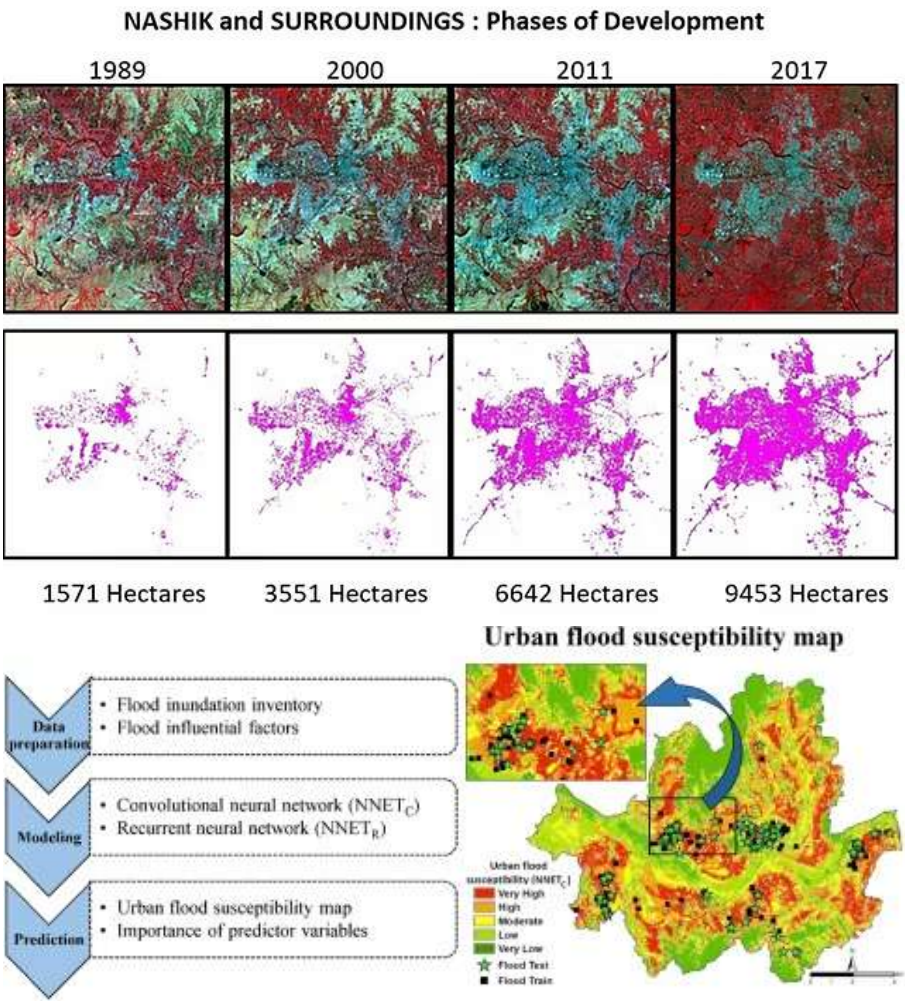
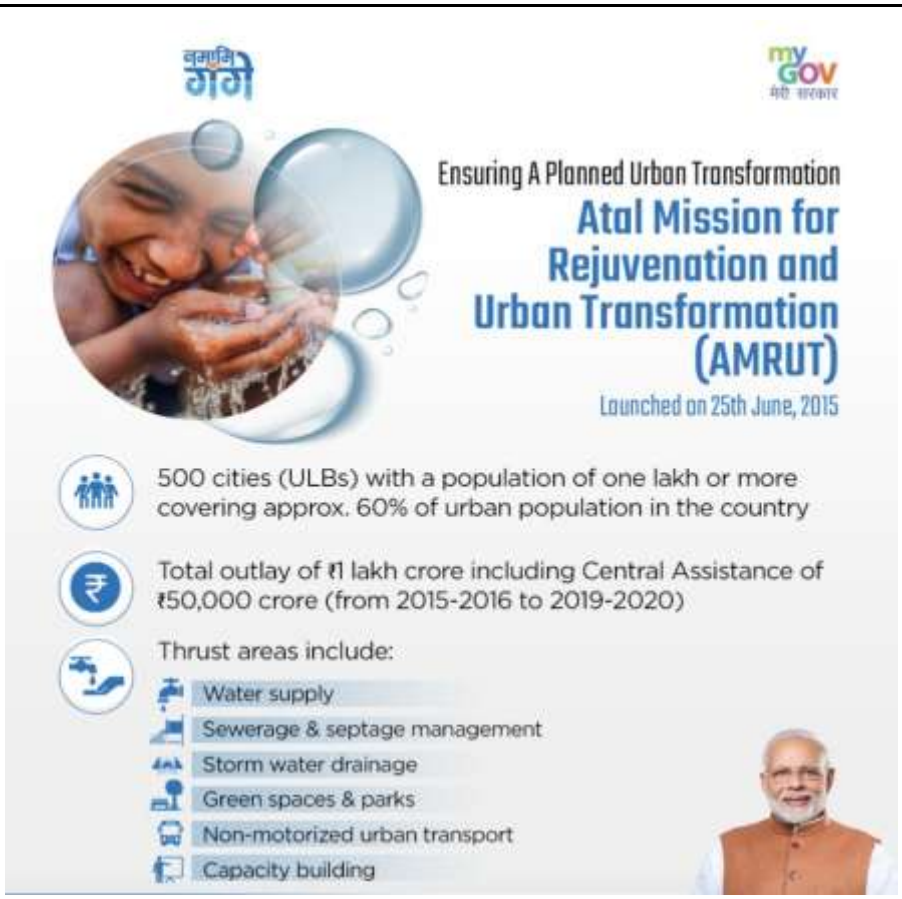
LiDAR data for flood mapping	• **Light Detection and Ranging (LiDAR)** technology plays a crucial role in flood mapping. • By creating **Digital Elevation Models (DEMs)**, LiDAR helps identify flood-prone zones and predict floodwater flow based on terrain elevation, **allowing authorities to take preventive measures.** • High-resolution satellite imagery and **LiDAR data have become essential in monitoring and mapping urban flooding,** enhancing our ability to respond to such events. 
Hydrological modeling	• **GIS-based hydrological models** analyse rainfall patterns, **drainage capacity, and surface runoff to predict flood risks**. • These models **integrate data from multiple sources to simulate potential flood** scenarios and prepare mitigation plans accordingly. • A **comprehensive review of flood modeling** approaches highlights the importance of integrating GIS and remote sensing data to enhance urban flood resilience. • There is software for **hydrological modeling like HEC-HMS and HEC-RAS**.

	 
Urban drainage mapping and encroachment detection	• **GIS tools** help in **mapping stormwater networks, detecting bottlenecks,** and designing effective flood control measures. • Additionally, **remote sensing data** aids in **identifying unauthorised constructions** on **water bodies,** enabling authorities to take timely preventive actions. • **In Ahmedabad,** a **case study demonstrated the use of GIS and remote sensing as decision support tools** for analysing urban flooding and recommending mitigation strategies.

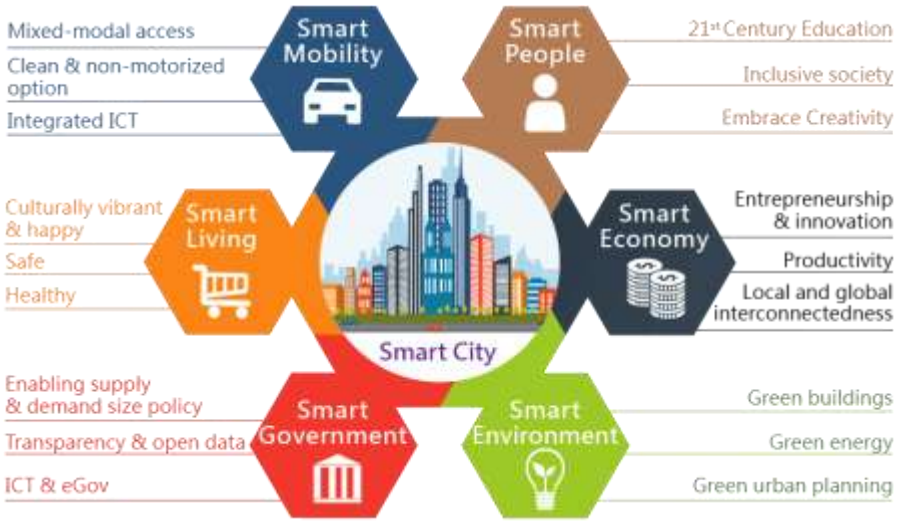
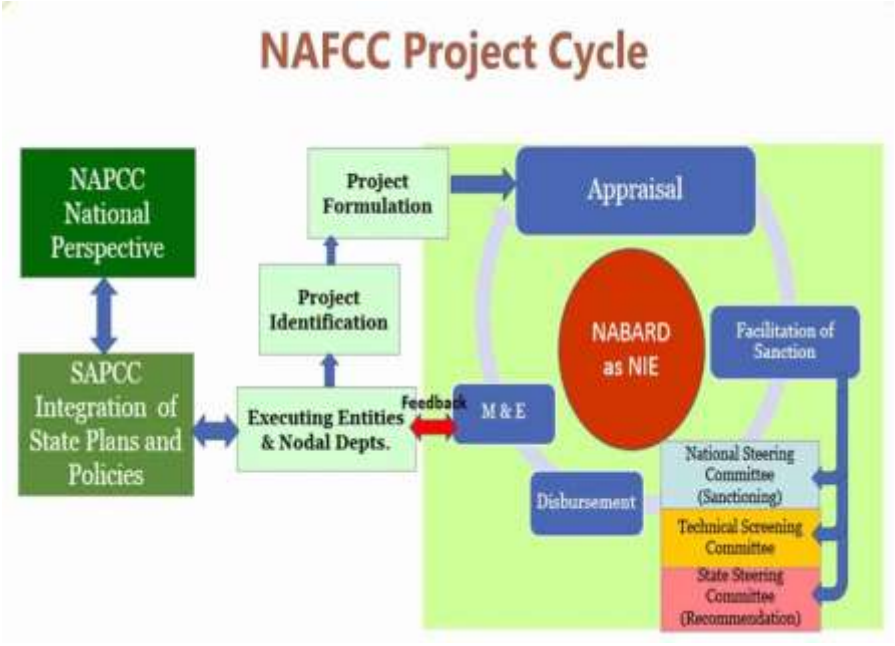


19. Mention a few government initiatives for mitigating urban floods?

Initiatives	Description
AMRUT	• **Atal Mission for Rejuvenation and Urban Transformation** focuses on **urban infrastructure improvements,** including drainage networks, sustainable water management, and **flood control measures.**

	
The National Disaster Management Authority	• The **National Disaster Management Authority (NDMA)** implements guidelines for **flood preparedness, risk reduction strategies**, and early warning systems. • **NDMA works with ISRO** and other agencies to develop **remote sensing-based flood forecasting** and real-time tracking tools.

Smart Cities Mission	• The **Smart Cities Mission** encourages the **use of GIS for sustainable urban planning** and **flood mitigation.**

	 • Many smart cities in India have begun integrating **AI-driven flood prediction models** for enhanced preparedness.
National Adaptation Fund for Climate Change	• The **National Adaptation Fund for Climate Change (NAFCC)** provides **financial support to climate adaptation projects,** including urban flood management solutions and **GIS-based climate resilience planning.** 

20. What is the relevance of the topic for UPSC CSE?

- **For Prelims:** Urban flooding, Extreme weather events, Eco-sensitive zones, Climate change, Malaria, Leptospirosis, Post-Traumatic Stress Disorder, Jal Shakti Abhiyan (JSA), Amrit Sarovar Mission, Atal Bhujal Yojana, Atal Mission for Rejuvenation and Urban Transformation (AMRUT) 2.0
- **For Mains:** Factors Behind Increased Urban Flooding in India, Major Impacts of Urban Flooding.

Some previous years prelims questions.

Q1. Consider the following statements:(2021)

1. 36% of India's districts are classified as "overexploited" or "critical" by the Central Ground Water Authority (CGWA).
2. CGWA was formed under the Environment (Protection) Act.
3. India has the largest area under groundwater irrigation in the world.

Which of the statements given above is/are correct?

(a) 1 only
(b) 2 and 3 only
(c) 2 only
(d) 1 and 3 Only

Ans: (b)

Q2. Which of the following is/are the possible consequence/s of heavy sand mining in riverbeds?(2018)

1. Decreased salinity in the river
2. Pollution of groundwater
3. Lowering of the water-table

Select the correct answer using the code given below.

(a) 1 only
(b) 2 and 3 only
(c) 1 and 3 only
(d) 1, 2 and 3

Ans: (b)

Some previous years mains questions.

Q1. The interlinking of rivers can provide viable solutions to the multi-dimensional inter-related problems of droughts, floods, and interrupted navigation. Critically examine. **(2020-15 Marks)**

Q2. Account for the huge flooding of million cities in India including the smart ones like Hyderabad and Pune. Suggest lasting remedial measures. **(2020-10 Marks)**

Some questions from this year and previous years interview transcripts.

Board Sanjay Verma sir:

- Why was Manali in the news last year?
- What was the cause of floods?
- How will you respond, as a DFO, to encroachments along the floodplains of the river by hotel owners?

Board Sanjay Verma sir:

- What are the reasons for Urban Floods?

Board BB Swain sir:

- Tell me a few reasons for flooding in Kerala?
- What can be done to resolve human reasons for flooding?

Board Sanjay Verma sir:

- Why does flooding still occur and whose failure is it?

Board BB Swain sir:

- Is there any solution for Bengaluru Floods?

Some questions for QUIZ.

Q1. Consider the following Pollutants:

1. Uranium
2. Arsenic
3. Cadmium
4. Fluoride
5. Mercury

How many of the above pollutants can be found in the drinking water in some parts of India?

Select the correct answer using the codes given below.

(a) Only two
(b) Only three
(c) Only four
(d) All five

Ans: (d)

Some questions for POLL.

Q1. Do you think developmental activities have led to frequent flash floods in India?

(a) YES
(b) NO
(c) Can't say.

Q2. Do you think urban floods are man made disasters?

(a) YES

(b) NO

(c) Can’t say.

■■■■