CLASS NOTES
FLOOD – INTERLINKINING OF RIVERS

- Indian Agriculture has been heavily dependent on the monsoon rainfall. Droughts and Floods are the two accompanying features of Indian Climate.
- Different regions of the country have different weather and rainfall patterns and, therefore, while some parts face devastating floods, other parts may, at the same time, experience drought conditions

Table 1.1: *Seasonal Distribution of Rainfall in India*

Season	Period	Percentage of Distribution
Pre-monsoon	March-May	10.4
South-west monsoon	June-September	73.4
Post-monsoon (Northeast Monsoon)	October-December	13.3
Winter rains	January-February	2.9

FLOOD

- The temporary overflow of a large amount of water in an area, massivelyaffecting human life, is called a flood.
- Higher water level along rivers/coasts leading to land inundation.
- The National Disaster Management Authority (NDMA) of India defines floods as an overflow of water that submerges land that is usually dry.
- 12 to 15 % India is flood Prone
- About 40 million hectares of land in the country are liable to floods according to the National Flood Commission
- The Nodal Agency for flood Forecasting is: Central Water Commission

CWC:

- Technical organisation that functions as part of the Ministry of Jal Shakti
- Help state governments in devising and analysing flood control measures
- They undertake flash flood forecast as well
- Focus Flood Control, Irrigation, Navigation, Drinking Water Supply and Water Power Development
- HQ Delhi , founded 1945
- 'Water Quality Monitoring Network' consisting of monitoring stations at 552 key locations covering all the major river basins of India

National Water Academy located at Pune is responsible for training of Central and State in-service engineers

Floods in India – Different Agencies for Flood Control in India

1. India Meteorological Department (IMD) – provides rainfall or cyclonic event forecast which is used by all the agencies for preparedness to deal with the floods.
2. National Disaster Management Authority (NDMA) – The job of relief and rescue is carried out by the National Disaster Response Force (NDRF) with state counterparts. NDMA works under Prime Minister Office (PMO) – and National Institute of Disaster Management (NIDM) – works under the Union Ministry of Home Affairs (MHA).
3. Central Water Commission (CWC) – The main job of CWC is to procure the data of hydrology at the national level – like river discharge measurement and water level in dams etc – to alert the states about any imminent or potential flood.

Four Flood Categories According to Central Water Commission flood forecasting network:

- **Normal Flood** - when the water level of the river is below the warning level.
- **Above Normal FLOOD-** If the water level of the river at flood forecasting site touches or crosses its Warning level (Yellow Colour)
- **SEVERE FLOOD: water level** the river at site touches or crosses Danger Level (Orange colour)
- **EXTREME FLOOD:** the water level of the river touches or crosses the "HIGHEST FLOOD LEVEL" recorded at any forecasting site so far. (Red colour)

  Note : Red and Orange Bulletin are disseminated upto the Prime Minister's Office and Cabinet Secretariat and Yellow Bulletins are sent upto Secretaries of various Ministries concerned with flood loss mitigation

Reason :

- Low lying regions more prone to floods
- High intensity rainfall or excessive rainfall, Cloud Burst (excessive rain within short period)

- inadequate carrying capacity of rivers, due to siltation. and blockage in the drains
- change in river course
- blocking of river by landslides
- narrowess of river
- Due to storm surge in coastal areas
- breaking of a dam or
- increased flow of water in an area
- strong tides, storms at sea , cyclones and tsunami
- Melting of ice and snow
- **Global Warming**: Due to the increased rise in global temperature, glaciers of the Himalayan range start to melt. As a result, the seawater level also rises, causing floods in surrounding years

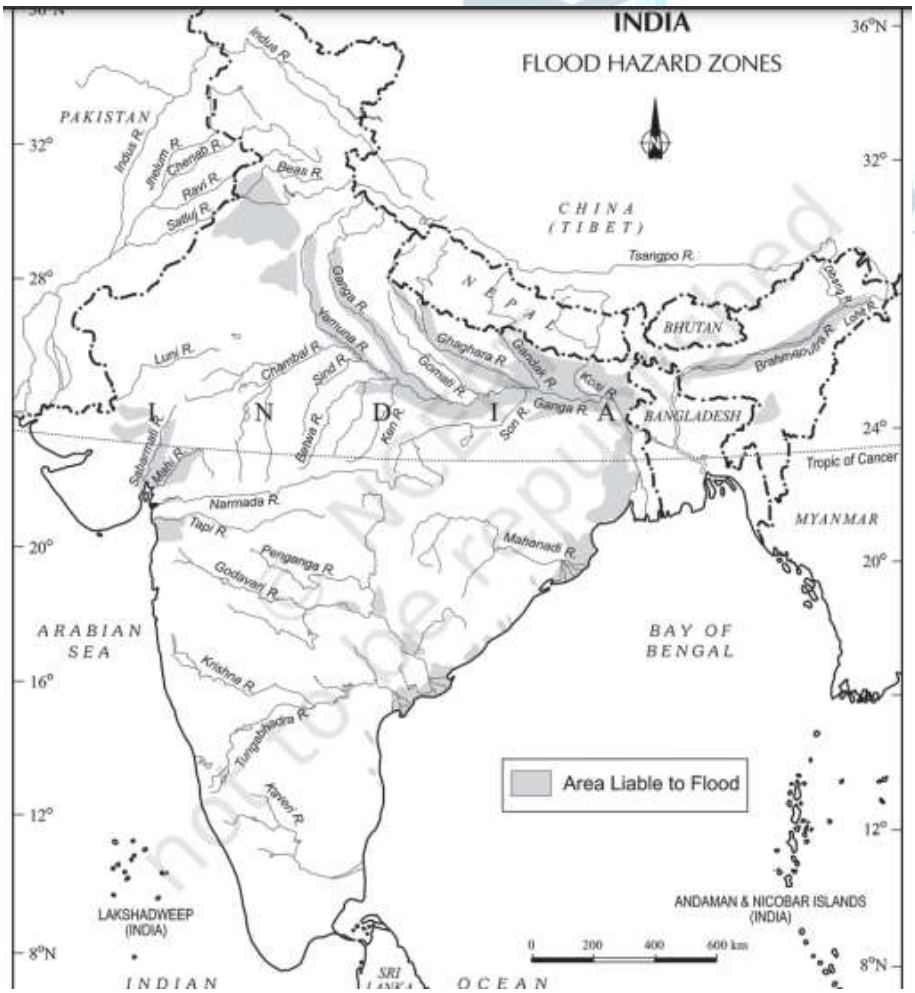
Human Factors: Intensified, Magnitude and gravity of floods

- Human beings play an important role in the genesis as well as spread of floods
- Indiscriminate deforestation
- unscientific agricultural practices
- disturbance along natural drainage channels
- Colonisation of flood plains and river- bedsIncreasing Urbanisation, dumping of Garbage, and Construction of Embankments, roads etc reduce infiltration capacity and increases the surface runoff.

Dam and embankment failure: Dam collapse and river embankment failures due to poor infrastructure can also cause floods

Encroachment on floodplains: Construction and settlement in floodplain areas disrupt the natural flow of water during floods.

Encroachment of water bodies: Encroachment of lakes, ponds and other water bodies aggravates the risk of floods because they cannot contain the extra water when the situation of flooding arrives.



- High Flood Prone Affected Areas shown in Map: Assam, West Bengal and Bihar

- The flood prone regions of India are the
- Himalayan Rivers Basin (Kosi and Damodar Rivers in particular),
- North Western River Basin (Jhelum, Ravi, Sutlej and Beas Rivers) and the central
- Peninsular River Basin (Narmada, Chambal, Godavari, Krishna and Cauvery River).

States	Reason of floods
Punjab, Uttar Pradesh	Vulnerable to Occasional floods
Rajasthan, Gujarat, Haryana ,Punjab	inundated due to flash floods
Tamil Nadu	retreating monsoon during Nov to January
Flood in Orissa and Andhra Pradesh is due to monsoon depression and cyclonic storms	

Examples :

1. Uttarakhand Flood, 2013: Devastating floods with high casualties.

2. Kerala Flood, 2018: Record rainfall led to severe flooding.

3. Brahmaputra Flood, 2019: Significant impact on Assam and surrounding areas.

4. Maharashtra Flood, 2020: Affected Solapur and Pune.

5. Hyderabad Floods: Heavy rains caused flash floods.

6. Kerla flood floods July 2024 – causes 90+ death

7. Delhi flood July 2024

Types of Flood :

- River Floods: These occur when rivers overflow their banks due to excessive rainfall or snowmelt.
- Coastal Floods: These are caused by storm surges during cyclones or high tides, affecting coastal regions.
- Urban Floods: Urban Flood: When the drainage system of urban areas fails to absorb rainwater, it creates urban floods. problem of urban flooding has become serious as evidenced by the floods in Mumbai, Bangalore, Chennai, Vadodara, Ahmedabad, Surat, Kolkata, Hyderabad,

Flash Floods:

- Sudden and intense flooding-- are caused when rainfall creates flooding in less than 6 hours . FF are usually associated with cloud burst, storms and cyclones. Flash floods occur due to high rate of water flow as also due to poor permeability of the soil.
- They can occur in urban areas located near small rivers, since hard surfaces such as roads and concrete do not allow the water to absorb into the ground.

Glacial Lake Outbursts Flood (GLOF):

- is a type of flood where sudden release of water from a glacial lake that can lead to catastrophic flooding downstream
- Shrinking glaciers have led to the formation of a large number of glacial lakes all across the Himalayas.
- Many of these high-altitude lakes are potentially dangerous, because of their potential to cause flash floods
- Many of the big glaciers which have melted rapidly and gave birth to the origin of a large number of glacier lakes.
- These include regions like Himachal Pradesh, Sikkim, Ladakh, Arunachal Pradesh, Jammu & Kashmir, and Uttarakhand.

Consequences :

- Floods have serious consequences on the national economy and society
- Destruction of settlements
- Damage to infrastructure
- Displacement: Floods result in a humanitarian crisis and displacement of the people
- Loss of lives and property

- Spread of disease - cholera, Hepatitis
- Contamination of water supplies
- Crop Loss and Livestock Loss
- Environmental impacts: Floods cause soil erosion, sedimentation, and degradation of ecosystems
- The impact on those affected may cause psychological damage to those affected, in particular where deaths, serious injuries and loss of property occur

Positive Side :

- Fertile Silt deposition
- Recharging water sources: Inundation of the flood plains helps recharge the groundwater, which is an important source of drinking water and is essential for agriculture.
- Rejuvenation of the river ecosystem: The river ecosystem is crucial for the biodiversity of fish, wildlife, and waterfowl, and its seasonal variability and varied sediment and flow regimes help maintain this balance.
- Agriculture: Floodwaters carry nutrients and sediments, which are deposited on flood plains, enriching the soil. Rice paddies are flooded deliberately to take advantage of this natural fertilisation process

Institutional Mechanism for Flood :

- Central Water Commission (CWC): It was set up in 1945 and focuses on flood control, water resource conservation, irrigation, hydropower generation, flood management, and river conservation in the country..
- National Disaster Management Authority (NDMA): NDMA has prepared these Guidelines for Flood Management, to assist the ministries and departments of the GOI, the state governments, and other agencies in preparing Flood Management plans (FMPs).
- The National Water Policy (2012): It emphasises flood control through structural measures, integrated reservoir operation, natural drainage system rehabilitation, farming systems, and non-agricultural development, aiming for long-term solutions to devastating floods.
- Flood Forecasting Network: The CWC has implemented a flood forecasting system with 175 stations across major interstate rivers, enabling real-time data collection, automatic transmission, flood forecast formulation, and efficient information dissemination.
- Flood Management and Border Areas Programme (FMBAP): It is being implemented throughout the country for effective flood management, erosion control, and anti-sea erosion and to help maintain peace along the border.
- Structural Measures: Since 1954, the government has constructed 33,928 km of new embankments and 38,809 km of drainage channels, completed 2,450 town protection works, and raised 4,721 villages above flood levels.
- Post-disaster response and recovery: India has set mechanisms for the post-disaster response, such as search and rescue operations, relief and rehabilitation camps, NDRF forces, and the use of earth observation satellites.
- Cooperation with the neighbouring countries: India has cooperation with neighbours like Nepal, China, and Bhutan for the exchange of hydro-meteorological data for early preparedness of flood management.

M4 Strategy: Mitigation Strategy

- Mapping: E.g., Hazard maps, Identify flood-prone areas
- Manpower: E.g., Trained personnel.
- Money: E.g., Funding and resources.
- Media: E.g., Awareness campaigns and disseminate information.

Flood Management :

1. Redistribution of Excess Water Reduces flood severity in high-risk zones and Reduced Flood Risks by Integrating river link projects

2 Interlinked river systems can enhance drainage capacities in flood-prone areas.

3 Floodplain Utilization-Utilizes floodplains for water storage and management

4 Efficient Water Management: The Indira Gandhi Canal Project can manage floodwater for irrigation and storage. o Benefit: Balances water distribution and reduces flood risks

Flood :

1. Flood Mapping: E.g., Hazard maps.
2. Land Use Control: E.g., Zoning regulations.
3. Optimized Engineering Structures: E.g., Raised platforms.
4. Ongoing Flood Forecasting: E.g., IMD updates.
5. Development of Early Warning Systems: E.g., Real-time alerts

NDMA Guidelines :

Structural Measures:

- Storage Reservoirs/Dams: E.g., Kosi Barrage.

- Embankments/Levees: E.g., Brahmaputra Embankments.
- Drainage Improvement: E.g., Urban drainage projects.
- Channel Improvement: E.g., River dredging.
- Catchment Area Treatment: E.g., Afforestation.
- Construction of Floodwater Storage Structures
- Diversion of Flood Water: E.g., Flood diversion projects.
- Linkages of Rivers: E.g., River linking projects. Implementing River Linking Projects:
- Building Check Dams-Example: Rajasthan's Johads are traditional check dams that capture and store floodwaters for irrigation and groundwater recharge.
- Creating Floodwater Harvesting Pits-Example: Maharashtra's Zai Pits capture and store rainwater from floods to recharge groundwater and support agriculture
- Creating Flood-Proof Infrastructure-Example: Kerala's Kuttanad Region utilizes flood-resistant infrastructure to manage floodwaters and support agriculture.
- Revitalizing Traditional Water Management Systems-Example: The Andhra Pradesh's Tank System uses traditional tanks to store and manage floodwaters for irrigation

Non-Structural Measures:

- Implementation of Flood Plain Zoning: E.g., Zoning regulations (Ministry of Jal Shakti.)
- Flood Proofing: E.g., Raised platforms.
- Flood Management Plans: E.g., Integrated water resources.
- Flood Forecasting: E.g., IMD's forecasting system.
- Flood Mapping: E.g., Hazard maps.
- Integrating Flood Forecasting and Early Warning Systems: o Example: The Central Water Commission (CWC) provides flood forecasts to help manage and utilize floodwaters effectively.
- Legislations: E.g., Flood risk management laws.
- Awareness: E.g., Public education campaigns.
- Flood Insurance: E.g., Risk coverage policies.
- International Cooperation: E.g., China-Kosi collaboration., India Nepal Cooperation
- **Use of space technology**
- The capacity development covers the aspects of flood education, target groups for capacity development, capacity development of professionals, training, research and development and documentation with respect to flood management

Chapter 6 Flood and Droughts and Interlinking of Rivers

Interlinking of Rivers Question:

1. Interlinking of rivers may serve as a major source of assured irrigation and all weather inland navigation in India. Comment on its feasibility taking into account physical, economic, and ecological implication. 20 marks UPSC mains optional 2017
2. Interlinking of rivers may address the issue of paucity of water but poses a serious threat to the indigenous ecological diversity of the said rivers. Comment.
3. The concept of scarcity and surpluses of water must look beyond State Boundaries

INTERLINKING OF RIVERS

Aim : transfer water from surplus to water deficit areas in the country through Inter- Basin water transfer links.

BACKGROUND : Evolution of the Idea

- **Father of Inter Linking of River : Sir Arthur Cotton, 1858, British Irrigation Engineer, draws up plan to Interlink major Indian rivers for export and Import; address water shortages and droughts in South Eastern India ; Boost Inland Navigation.**
- **In 1970s- Dr K. L. Rao , Former Irrigation Minister - Proposed ' National Water Grid'.**
- **Suggested Ganga and Brahmaputra river surplus areas and central and south India water deficit linking .**
- **In 1977 - Captain Dastur Proposal : Construction of Canals - Himalaya and Garland Canal**
- **In 1980, National Prespective Plan- NPP (then Ministry of Irrigation- Now Ministry of Jal Shakti)**
- **In 1982, National Water Development Agency Set up for NPP; identified 30 links.**
- **In 2002. Task Force Set Up for Inter Linking Rivers.**
- **Hashim Commission Report - 2004 -2005**

- **In 2012, Supreme Court directed Centre to constitute expert committee**
- **In 2015, B. N. Navalawala Committee : Task Force For Interlinking of Rivers.**
- **In 2016, Pattiseema Lift Irrigation Project and Ken Betwa Link (First Interlinking of India)**
- **Now NPP - Called as " National River Linking Project "**

BENEFITS :

- **Management of Drought Prone and Flood Prone Regions by River Interlinking .**
- **Mitigate water deficiency and decrease the chances of recurring floods.**
- **Enhancing the availability of water in drought prone and rain- fed area.**
- **Ensure Ecological Security - To Address Water Crisis and water redistribution.**
- **Ensuring Food Security; Hunger ; (Benefits 35 Million hectare of irrigation) from 140 to 175 million hectare Irrigation Potential Increase .**
- **Contain Migration(Rural to Urban)**
- **Ensure Health Security - Boost Drinking water availability .**
- **Distribution Pattern of Rainfall in India is Uneven (Large scale Spatial-Temporal Variation)**
- **Decrease Crop Failure and Farmers Suicides**
- **Optimum Use of Water Resources and Promises Water Conservation efforts.**
- **Solve the water crisis by providing alternative, perennial water resources;**
- **Need Not to have wait for good monsoon and build storage reservoirs .**
- **Regional Imbalance of river water can be reduce -Benefits to Farmers**
- **Energy Security - Increase in Hydropower Potential (Increase 34000 MW electricity)**
- **Water Security - Increase Ground water recharge**
- About 85% of groundwater is used for irrigation every year in our country
- **Increase water consumption demand due to rise in population (in India)**
- **Irregular distribution of Water can be overcome.**
- **Improve Irrigation Pattern , Inland Navigation and Agricultural Food Production.**
- **Inland Waterways - boost River tourism**
- **Boost Rural Economy and Annual Income for farmers and Reduce Poverty**
- **Employment Opportunities will also Increases. (agriculture, power, transport & construction sector)**
- **Increase overall economic activities of the country and increase GDP**
- **Helps to Promote Sustainable Development and Ensure greater equity.**
- **Ensure National Integration; Boosting Communal Harmony ; Foster Cooperative Federalism .**

CHALLENGES IN NATIONAL RIVER LINKING PROJECT :

- **Loss in Forest Cover and threat to biodiversity .**
- **Ken - Betwa Interlink Impact Panna Tiger Reserve.**
- **Change in Physiography may Increase Environmental Issues**
- **May allow free transport of invasive alien species may affect biodiversity.**
- **Conflicts of States ex Karnataka and Tamilnadu Cauvery River Issue**
- **Increase of Economic Cost (expenditure and maintenance cost) and Social Cost (displacement of people)**

DISADVANTAGES :

- **Political Challenges; Economic and Environmental Challenges; International Challenges**
- **Socio -Economic- Political and Environmental Implications:**
- **Economic Implications: Need Huge Capital Investment for dams and reservoir**
- **Social Implications : Displacement of People and Tribal communities; Rehabilitation Issue**
- **Social Unrest and Psychological Damage due to forced resettlement of the people;**
- **Environmental Costs: Deforestation; Soil Erosion and Sedimentation; River Pollution ;**
- **River may change their course**
- **Water Logging, More Evaporation loss, Salinity ; Land Submergence ;**
- **Ecological Implications : Disturb ecological imbalance; Impact Habitat, Ecological Niche and Home range of animals ; Threat to Biodiversity and Impact Protected Areas.**
- **Political Effects: strained relationships with neighbours (Pakistan , Bangladesh); Challenges in Coordination with these countries .**

- **Water being State Subject - difficult to resolve issues of water sharing between States.**

Government Measures :

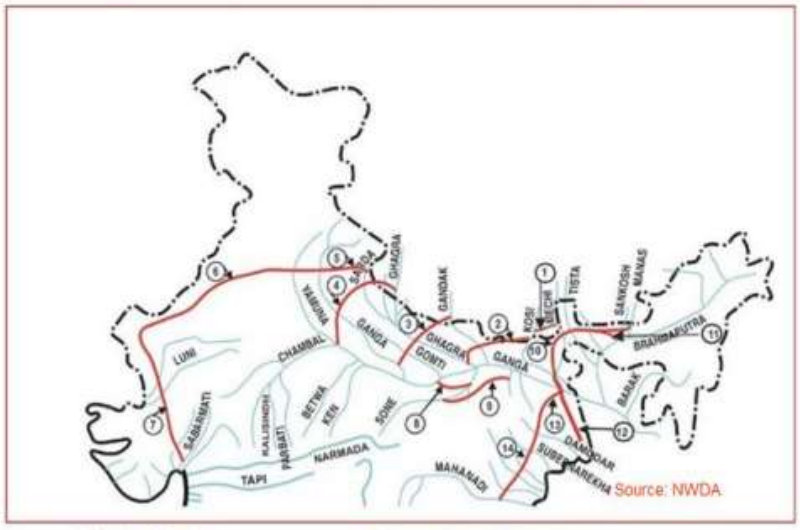
- Detailed planning of this mega-Civil Engineering project - National Perspective Plan - is being undertaken by the National Water Development Agency (NWDA) under Ministry of Jal Shakti .
- Under this project, 30 links and some 3000 storages will connect 37 Intra State -Himalayan and Peninsular rivers.
- Two Components : Himalayan (14 canal links)and Peninsular Component (16 canal links).
- The Ken Betwa Link Project is the first river interlinking project in India.
- The National Water Development Agency (NWDA) is the authority for the interlinking of rivers
- Central government thinks for NIRA- **National Interlinking of Rivers Authority** as independent autonomous body and replace NDWA.

PROJECTS IN HIMALAYAS :

- Under this component, 14 Links have been identified.
- And Construct Storage Reservoir on Ganga and Brahmaputra Basin in India and Nepal.
- Conserve Monsoon Flow for Irrigation and Hydropower generation, along flood control.
- The linkage will transfer surplus flows of the Kosi, Gandak and Ghagra to the west.
- A link between the Ganga and Yamuna is also proposed to transfer the surplus water to drought-prone areas of Haryana, Rajasthan and Gujarat.

PROPOSED INTER BASIN WATER TRANSFER LINKS

HIMALAYAN COMPONENT



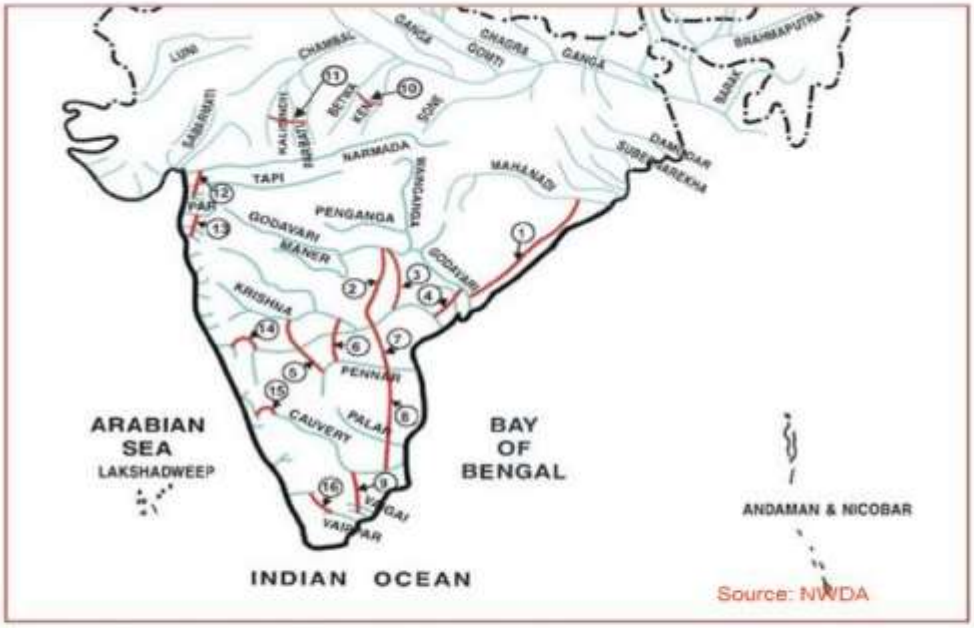
1. Kosi – Mechi
2. Kosi – Ghagra
3. Gandak – Ganga
4. Ghagra – Yamuna *
5. Sarda – Yamuna *
6. Yamuna – Rajasthan
7. Rajasthan – Sabarmati
8. Chunar- Sone Barrage
9. Sone Dam – Southern Tributaries of Ganga
10. Manas –Sankosh - Tista - Ganga
11. Jogighopa – Tista – Farakka (Alternate)
12. Farakka – Sunderbans
13. Ganga (Farakka) – Damodar – Subernarekha
14. Subernarekha – Mahanadi

* FR Completed

PROJECTS IN THE PENINSULAR COMPONENT:

- **Include 16 Links Part of Southern Water Grid.**
- **Connect Rivers of South India**
- It envisages linking the Mahanadi and Godavari to feed the Krishna, Pennar, Cauvery, and Vaigai rivers.
- This linkage will require several large dams and major canals to be constructed.
- Besides this, the Ken River will also be linked to the Betwa, Parbati, Kalisindh, and Chambal rivers.

PROPOSED INTER BASIN WATER TRANSFER LINKS
PENINSULAR COMPONENT



1. Mahanadi (Manibhadra) – Godavari (Dowlaiswaram) *
2. Godavari (Inchampalli) – Krishna (Nagarjunasagar) *
3. Godavari (Inchampalli) – Krishna (Pulichintala) *
4. Godavari (Polavaram) – Krishna (Vijayawada) *
5. Krishna (Almatti) – Pennar *
6. Krishna (Srisailam) – Pennar *
7. Krishna (Nagarjunasagar) – Pennar (Somasila) *
8. Pennar (Somasila)–Palar- Cauvery (Grand Anicut) *
9. Cauvery (Kattalai) – Vaigai – Gundar *
10. Ken – Betwa *
11. Parbati – Kalisindh – Chambal *
12. Par – Tapi – Narmada *
13. Damanganga – Pinjal *
14. Bedti – Varda
15. Netravati – Hemavati
16. Pamba – Achankovil – Vaippar *

* FR Completed

ALTERNATIVE APPROACHES :

- **Increase watershed development and Rain water Harvesting**
- **Change in Appropriate Cropping Pattern**
- **Nature Based Solution- Indigenous Knowledge**
- **Focus more on Water Conservation Practices and Community Participation.**
- **Water use Efficiency and Micro Irrigation Methods- Drip and Sprinkler**
- **Intensive Afforestation Measures**

Way Forward :

- **Interlinking is Contentious Issue requires Balance between Potential Benefits and Risk.**
- **Urgent Need to Examine the feasibility of Inter Linking of Rivers**
- **Detailed Hydrological, Geological, Meteorological, and Environmental Analysis of the Project Should be done .**
- **Detailed Analysis Should be done for Other Possible Alternatives than Concerned Project .**
- **Rehabilitation and Relief Package to resolve development displacement issue .**
- **Including Local Communities, Farmers, Environmentalist in Planning and Implementation Projects .**
- **interlinking of rivers may be pursued in a decentralized manner**
- **In 2011 Ashok Chawla Committee -**underscored the need for a comprehensive national legislation on water either by bringing water in the Concurrent List or through a legal framework for treating water as a unified common resource**.**
  Some Recommdations of Mihir Shah Committee.
- Central Water Commission (CWC) and the Central Ground Water Board (CGWB) should be restructured and unified to form a new National Water Commission (NWC)- will help ensuring sustainable management of water resources
- **to develop a cost-effective and suitable technology to recycle and reuse urban and industrial wastewater.**
- **to formulate and implement programs to control pollution of water bodies and aquifers.**

EXAMPLES

- **Polavaram irrigation Project (National Project Status) - On Godavari River in Andhra Pradesh transfering river water to Krishna River Basin; Boost to Reservoir based tourism in Papikonda National Park.**

- **Pattiseema Lift Irrigation Scheme: Connecting Godavari - Krishna River ; Owner Andhra Pradesh**
- **Ken Betwa Link Project : Ken Surplus water diverted to Deficit Betwa Basin and provide water security in Backward Bundelkhand region of Madhya Pradesh and UP but impact Panna Tiger Reserve (Daudhan Dam- Ken River inside Panna Reserve)**

DAMANGANGA - PINJAL LINK PROJECT :

- Damanganga Emerges From Western Ghats Nashik (MS) And Travels To Arabian Sea.
- Flows Through - Maharashtra, Gujarat, DNH And Daman & Diu.
- The Industrial Towns Of Vapi, Dadra And Silvassa Lie On The North Bank Of The River, And The Town Of Daman Occupies Both Banks Of The River's Mouth
- Damanganga Surplus Water Diverted To Deficit Pinjal River
- Pinjal River -Emerges From Palghar, MS. (Benefits To Mumbai Region)

Par - Tapi - Narmada Link Project :

- Transfer water from Western Ghats Region to Saurashtra and Kutuch (water deficit areas)
- Linking Seven Reservoirs in North Maharastra and South Gujarat
- The seven dams proposed in the scheme are Jheri, Mohankavchali, Paikhed,Chasmandva, Chikkar, Dabdar and Kelwan

Parambikulam Aliyar river project

- Between Kerala -Tamilnadu
- Linking Bharatapuzha and Kaveri Basins
- Benefits Drought Prone Region Coimbatore, TN and Chittur Area of Kerala

Telugu Ganga river Project:

- Krishna River to Penner River
- Andhra Pradesh to Tamilnadu
- Help to Chennai metropolitan area for drinking and irrigation purpose
- Help to Drought Prone Region - RayelSeema , Andhra Pradesh
- Srisailam Reservoir of Krishna - canal linking to - Somasila Reservoir in Pennar Valley .

Manas-Sankosh-Teesta-Ganga (M-S-T-G) link project

- Key Part of Himalaya Component under NRLP.
- Diversion of Surplus water from Manas and Sankosh to Ganga Region,

Kosi-Mechi Interlinking project of Bihar

- Second interlinking project after Ken -Betwa in MP
- Helps to mitigate flood in Kosi River
- Mechi, a tributary of river Mahananda.
- Eastern Kosi Main Canal (EKMC) system provide irrigation benefits to the water scarceMahananda basin command
- Mahananda rises from Darjelling Hills, Basin Includes West Bengal and Bihar
- It is spread over districts of Purnea, Kishanganj, Araria and Katihar in Bihar and Malda, West Dinajpur and Darjeeling in West Bengal.

DAMS

- **India ranks third after China and USA**
- **Total Dams : 5334 (Including 400 Key dams)**
- **These Artificial barrier resulting reservoir used for :**

Benefits :

- Key role in Sustainable Development and Resource Management
- Irrigation

- Hydropower generation
- Flood control
- Groundwater Recharge
- Facilitating Navigation, Aquaculture,
- Supplying water for human consumption
- Supporting diverse sectors and contributing socio-economic development of the Region.
- Tourism Potential

Concerns

- **Displacement and Rehabilitation Issues of community**
- **Threat to Ecological Habitat and Niche- Negative Impact on Ecosystems and Biodiversity**
- **Sedimentation and Siltation- accumulation of silt in reservoirs reduce storage capacity; Impact dam efficiency**
- **Maintenance and cost**
- **Safety concerns of the dams resulted in loss of life and damage to property**

Key Facts :

- **Highest Dam : 260 M Height - Tehri Dam, Bhagirathi river, Uttarakhand**
- **Largest Dam: Bhakra Nangal Dam ,Sutlej River in Himachal Pradesh - Punjab Border**
- **Longest Dam : Hirakud Dam. Mahanadi river**

- **Largest Masonry Dam : Nagarjuna Sagar , Krishna river, Telegana (World Largest Artifical lake)**
- **Oldest Dam : Kallanai Dam , Kaveri River, Tamilnadu**

TOP 10 LARGEST DAMS IN INDIA ARE AS FOLLOWS:

Tehri Dam Bhagirathi	Uttarakhand	260.5 m **Highest Dam in India**
Bhakra Nangal Dam Sutlej	Himachal Pradesh	226 meters
Lakhwar Dam Yamuna	Uttarkhand	204 meters
Idukki Dam Periyar	Kerala	168.91 meters
Nagarjuna Sagar Dam Krishna	Telangana/Andhra Pradesh	124 meters
Sardar Sarovar Dam Narmada	Gujarat	163 meters
Hirakud Dam Mahanadi	Odhisha	60.96 m **Longest Dam in India**
Indira Sagar Dam Narmada	Madhya Pradesh	92 meters
Mettur Dam Kaveri	Tamil Nadu	37 meters
Almatti Dam Krishna	Karnataka	160 meters

DAM FAILURE ?

- a "collapse or movement of part of a dam or its foundation, so that the dam cannot retain water.
- In general, a failure results in a release of large quantities of water imposing risks on the people or property downstream

Reasons for Dam Failure ?

- Geological Instability - Tectonic induced calamities like landslides , earthquakes
- seismic damage by earthquakes
- Design Limitations - Imporper materials ; underestimated water flow calculations, can result in structural weaknesses ; foundational defects
- extreme weather events
- Glacial lake outburst flood ex Sikkim Floods
- Unprecedented Rains ex Kerala Floods 2018
- Structural flaws due to engineering and structural deficiencies
- Human factors -Lack of Maintainence ; Poor operational decisions
- Age of Dam -**like the Mullaperiyar dam**, are over a century old and have witnessed disputes owing to concerns regarding their structural integrity with age, stressing the requirement for continuous assessment and reinforcement of aging dams.

Catastrophic Consequences of Dam Failures on the Downstream Side

- **Loss of Lives: The Machchhu dam failure in 1979** is a heart-wrenching testament to the human toll of dam failures, with thousands of lives lost in a tragic event that shook the nation.
- **Massive Property Damage**
- **Ecological Destruction:** The **Ratnagiri dam failure in 2019 in Maharashtra** brought to the fore the severe environmental repercussions of dam failures, causing an ecological imbalance with the loss of flora and fauna, thereby underscoring the need for eco-friendly preventative measures.
- **Displacement:** The concerns surrounding the **Idukki Dam in Kerala**, emphasize the enormous social issue of displacement, where communities risk losing their homes and livelihoods, creating a cycle of poverty and homelessness that is difficult to break.
- **Long-term Psychological Impact:** The survivors of the **Francis Dam failure in 1928 in the USA** endured long-term psychological trauma, a testimony to the mental health toll dam failures can inflict on individuals, ranging from PTSD to anxiety disorders

Two examples of large dam failures:

1. **Kakhovka Dam failure:** In June 2023, the dam in Ukraine was breached, leading to extensive flooding along the lower Dnieper River. Many experts believe that Russian forces likely deliberately damaged a segment of the dam to hinder the Ukrainian counter-offensive.
2. **Polavaram Dam Failure** – In August 2022, the Polavaram dam in Andhra Pradesh failed to contain the floodwaters of the Godavari river, leading to massive floods in the surrounding areas.

Efforts by Government:

- Proactive measures, such as robust maintenance, monitoring, and community preparedness, are imperative to prevent catastrophic dam failures and safeguard lives and property
- **Dam safety act 2021**: The Act provides for the surveillance, inspection, operation, and maintenance of all specified dams across the country.

- **DRIP project:** World Bank assisted Dam Rehabilitation and Improvement Project (DRIP), to improve the safety and operational performance of selected dams, coupled with institutional strengthening through a system wide management approach

Conclusion

While dams remain indispensable to India's developmental goals, safety cannot be compromised. By **crafting policies inspired by global success stories and grounded in community participation and technological advancements,** India can ensure the safe and sustainable operation of its dams, safeguarding countless lives and precious resources

CHAPTER 7 - DROUGHT :

- Drought is a complex phenomenon characterized by slow onset
- Drought is generally defined as "a deficiency of Rainfall/precipitation over a long period of time (usually a season or more), resulting in a water shortage."The India Meteorological Department (IMD) defines drought in any area

The India Meteorological Department (IMD) defines

- drought in any area when the rainfall deficiency in that area is more than 25% of its long term normal /Long Period average.
- "moderate drought" if the rainfall deficit isbetween 26-50% and
- "severe drought" when the deficit exceeds 50% of the normal.

DECLARATION OF DROUGHT IN INDIA

- In India, the State governments are the final authority to declare a region as a region affected by drought.
- It has been shown that about 68% of cropped area in India is vulnerable to drought
- The drought-prone areas of the country are confined primarily to the arid, semi-arid, and sub-humid regions of peninsular and western India.
- Nodel Agency : Ministry of Agriculture and Farmers Welfare

CAUSES

1. Weak Monsoon/Rainfall: Reduced rainfall (e.g., Central Maharashtra).
2. Environmental Degradation: Loss of green cover (e.g., Jharkhand).
3. Water Stress: Demand exceeds supply (e.g., Rajasthan).
4. Climate Change: Increases drought frequency and intensity (e.g., Andhra Pradesh)

Classification of drought by National Commission on Agriculture :

Types :

- Meteorological drought: occurs in case of rainfall deficiency and resulting water shortage
- **Hydrological drought:** the Water level in surface and subsurface water sources falls below specific levels
- **Agricultural drought:** Inadequate soil moisture resulting in acute crop stress and fall in agricultural productivity
- Ecological drought: When Productivity of natural ecosystem fails due to shortage of water

KEY DROUGHT REGION OF INDIA :

- **Marathwada region and** and west Vidarbha regions **in Maharashtra**
- **Bundelkhand region** spreading across Uttar Pradesh and Madhya Pradesh
- Central part of Malwa plateau and Jhabua belt in Madhya Pradesh experience frequent droughts due to low rainfall
- northern and central parts like **Bijapur, Bidar and parts of Gulbarga district** of Karnataka
- **Jodhpur and Jaisalmer** divisions of Western Rajasthan
- Odisha's districts like Bolangir, Nuapada, and Kalahandi often face drought conditions
- Parts of Saurashtra and Kutch regions of Gujarat face regular droughts.
- Rayalaseema region Region Andhra Pradesh
- Telegana- Dharmapuri and Krishnagiri situated in the rainshadow area of Western Ghats regularly face droughts.
- Tamil Nadu's districts like Ramanathapuram, Thoothukudi, and parts of the interior are prone to droughts, leading to water scarcity and agricultural stress.

CONSEQUENCES

- Crop failure leading to scarcity of foods grains (akal) fodder (trinkal), inadequate rainfall, resulting in shortage of water (jalkal) and often shortage in all of the three (trikal) is most devastating.
- Large scale death of cattle and livestock and other animals,
- Migration of humans and livestock
- Scarcity of water compels people to consume contaminated water resulting water borne disease like hepatitis, cholera and gastro- enteritis
- Reduced crop yields.
- Shortages of water for domestic and industrial users.
- Malnutrition, dehydration and related diseases.
- Famine due to lack of water for irrigation.
- Affects dairy activities, timber and fisheries.
- Increases unemployment.
- Increase water disputes and decrease water table

MNEMONIC: DROUGHT

D - Diversify Livelihoods - Example: Promote alternative livelihoods such as non-timber forest products and goat farming to reduce dependence on water-intensive agriculture.

R - Rainwater Harvesting- Example: Implement rainwater harvesting structures like farm ponds and contour bunds to capture and utilize rainfall efficiently.

O - Optimized Irrigation- Example: Expand irrigation facilities with techniques such as drip irrigation and microirrigation to conserve water and enhance agricultural productivity.

U - Utilize Water Efficiently- Example: Promote water-efficient practices such as in-situ water conservation (e.g., contour cultivation) to maximize water retention.

G - Green Cover Expansion- Example: Implement afforestation and reforestation programs to increase forest cover, which helps in maintaining the water cycle.

H - Hazard Monitoring- Example: Develop drought monitoring systems to track rainfall patterns and water availability, ensuring timely interventions.

T - Training and Awareness- Example: Conduct community training programs on drought management practices and public awareness campaigns to educate and prepare communities.

Risk Management :

To Address Socio Economic and Environmental Challenges , Focus on

- Focus more on Crisis Management to Risk Management
- Water Conservation : Nature based Solutions and Modern Technologies
- Promoting Rainwater Harvesting

- Increase Check Dams, Rock Dam,
- Increase Reforestation and Afforestation and water management
- Irrigation and Agriculture Efficiency
- Crop Diversification and focus more on less water intensive plants
- Construction of Wetlands
- Traditional water harvesting methods
- Early Warning systems
- Drought Insurance and Financial Support
- Public Awareness and Capacity building and increase coping capacity
- Research and Development
- Drought and Flood Resistant varities

Drought resistant crops :

- millets are high resistant to drought such cowpea, foxtail, maize, sorghum, bajra , ragi, can be grown along with some type of oil seeds
- Chickpea, Pigeonpea, Pearl Millet, Finger Millet, Sorghum, and Groundnut.
- Purslane or kulfa possesses evolutionary adaptations that allow it to be both highly productive and drought tolerant.

Serious thought should be given to

- identification of ground water potential in the form of aquifers,
- Transfer of river water from the surplus to the deficit areas
- particular planning for inter linking rivers with ecological considerations
- construction of dams and reservoirs
- use of Remote sensing satellite for mapping

To address the challenge of drought in India, a comprehensive approach that combines preventive measures, sustainable practices, and community participation is necessary. By implementing these measures, the adverse impacts of drought can be minimized, and the resilience of affected areas can be enhanced.

Schemes:

- Pradhan Mantri Krishi Sinchayee Yojana- Enhance irrigation potential and water use efficiency in agriculture
- Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA) - Mitigate drought through employment in water conservation and irrigation activities, like check dam construction, farm ponds, and watershed management.
- National Food Security Mission (NFSM)- Promote sustainable agriculture and increase food grain production in drought-prone areas.
- Pradhan Mantri Fasal Bima Yojana (PMFBY)- Offer crop insurance for financial support to farmers in case of crop loss due to natural calamities, including drought
- National Rural Drinking Water Programme (NRDWP)- Ensure safe drinking water supply in rural areas, including drought-affected regions.
- Pradhan Mantri Adarsh Gram Yojana (PMAGY- Focus on integrated development in villages with marginalized communities. - Develop water resources, promote sustainable agriculture, and enhance livelihood opportunities in drought-prone areas.

LANDSLIDES

- Landslide is a physical phenomenon and type of mass wasting, which denotes any downward movement of soil and rock under the direct influence of gravity.
- They are sudden , unpredictable and are largely controlled by macro or regional factors or highly localised factors .

Controlling Factors : Geology , Geomorphic agent, slope, land use, vegetation cover and Human activities .

Vulnerability Profile :

1. 15% of India's land area is affected by landslides.
2. 30% of the world's landslides occur in the Himalayan ranges

3 GSI, being the nodal agency is engaged in conducting awareness programmes, workshops in different landslide - prone Regions

Geological Survey of India (**GSI**) is a scientific agency of India

- Founded in 1851
- Hq kolkatta
- Under the ministry of mines

- Conducting geological surveys and studies of India, and also as the prime provider of basic earth science information to government, industry and general public, as well as the official participant in steel, coal, metals, cement, power industries and international geoscientific forums.

Key words :

- Zone of accumulation – The area of landslide within which the displaced material lies above the original ground surface.
- Zone of depletion – The area of the landslide within which the displaced material lies below the original ground surface.
- Type of landslide encompasses five modes of slope movement: falls, topples, slides, spreads, and flows. and Subsidence

Major Causes of landslide:

- Geological Weak Material : weakness in the composition and structure of the rocks or soil may also cause landslides,
- Unconsolidated Rocks: Loose material prone to sliding
- Tectonic uplift Fluvial erosion and wave erosion
- Erosion: of slope, due to cutting down of vegetation, construction of roads might increase the vulnerability of the terrain to slide down.
- Steep Slopes: Increases landslide risk.
- Persistent Rainfall/Snowfall: Saturates soil and triggers landslides.
- Earthquakes: Can destabilize slopes.
- Human activities again intensified.: irrigation, Mining and Quarrying, Poor maintenance of remedial measures

ANTHROPOGENIC CAUSES:

- Unplanned Urban Growth: Building in hilly areas.
- Deforestation: Removes vegetation that stabilizes soil.
- Mining and Quarrying: Disrupts slope stability.
- Road Construction: Cuts into slopes, weakening them.
- Unsustainable Tourism: Increased foot traffic destabilizes slopes.
- Grazing: Removes vegetation cover.
- Shifting Agriculture: Cultivation on steep slopes.

Landslide Prone Areas	States & Cities
Western Himalaya	Himachal Pradesh, Jammu & Kashmir, Uttar Pradesh, Uttaranchal
Eastern & North-Eastern Himalaya	West Bengal, Arunachal Pradesh, Sikkim
Naga-Arakan Mountain belts	Tripura, Nagaland, Mizoram, Manipur
Western Ghat region & Nilgiri	Kerala, Karnataka, Tamil Nadu, Maharashtra, Goa
Meghalaya Plateau comprising Peninsular India	The north-eastern part of India

Very High Vulnerability Zone : Highly unstable, relatively young mountainous areas in the Himalayas and Andaman and Nicobar, high rainfall regions with steep slopes in the Western Ghats and Nilgiris, the north-eastern regions, along with areas that experience frequent ground-shaking due to earthquakes, etc. and areas of intense human activities, particularly those related to construction of roads, dams, etc. are included in this zone.

Debris Avalanches and Lanslides occur very frequently in the Himalayas

- Himalayas are tectonically active
- They are mostly made up of sedimentary rocks and unconsolidated and semi consolidated deposits
- The Himalayas, which are formed due to collision of Indian and Eurasian plate, the northward movement of the Indian plate towards China causes continuous stress on the rocks rendering them friable, weak and prone to landslides and earthquakes.
- The Slopes are very steep basically due to some asstmmetriacal pattern or hog back shape of some himalaya regions

Causes	Himalayas	Western Ghats
1. Geological Structure	Young, unstable mountains prone to seismic activity (e.g., **Himalayan Region**)	Older, more stable mountains (e.g., **Western Ghats**)
2. Slope Gradient	Steeper slopes and higher elevation gradients (e.g., **Uttarakhand**)	Gentler slopes compared to the Himalayas (e.g., **Kerala**)
3. Seismic Activity	High seismicity (e.g., **2015 Nepal**	Lower seismicity compared to the

Causes	Himalayas	Western Ghats
	earthquake)	Himalayas
4. Rainfall Intensity	Heavy monsoons and snowfall melting (e.g., **Uttarakhand Monsoon**)	Heavy monsoons (e.g., **Kerala Monsoon 2018**), but less intense
5. Deforestation	Extensive deforestation for agriculture and construction (e.g., **Himachal Pradesh**)	Deforestation present but not as extensive (e.g., **Kodagu, Karnataka**)
6. Soil Erosion	Severe soil erosion due to deforestation and agriculture (e.g., **Arunachal Pradesh**)	Soil erosion present but less severe (e.g., **Sahyadri, Maharashtra**)
7. Human Activities	Rapid urbanization and infrastructure development (e.g., **NH 44 construction**)	Urbanization present but more regulated
8. Road Construction	Extensive road construction on steep slopes (e.g., **NH 44 in the Himalayas**)	Road construction present but on gentler slopes (e.g., **Kerala**)
9. Hydropower Projects	Numerous projects causing destabilization (e.g., **Tehri Dam**)	Limited hydropower projects
10. Glacial Activity	Glacial movements and melting (e.g., **Kedarnath floods**)	No glacial influence
11. Landslide Triggering Events	Earthquakes, heavy rains, and human activities (e.g., **Kedarnath floods**)	Mainly heavy rains (e.g., **Kerala Monsoon 2018**)
12. Vegetation Cover	Sparse vegetation in higher altitudes (e.g., **High Himalayas**)	Dense vegetation cover acting as a natural barrier (e.g., **Western Ghats**)
13. Drainage Pattern	Unstable and changing drainage patterns (e.g., **Himalayan Rivers**)	More stable drainage patterns (e.g., **Western Ghats Rivers**)

IMPACT OF LANDSLIDES

Short Term Impacts	Long Term Impacts
Loss of Lives and Properties	Changes in the landscape that can be permanent
Roadblocks, destruction of railway lines	Loss of cultivable land
Channel blocking due to rock – falls	Environmental impact in terms of erosion and soil loss
Diversion of river courses due to landslides causing floods	Population shift and relocation of populations and establishments
Loss of natural Beauty	Drying up of sources of water

Element at Risk :

1. Damage to Infrastructure: Roads, bridges, and buildings.
2. Loss of Life and Property: Significant human and economic costs.
3. Disruption in Transport: Blocked roads and railways.
4. Destruction of Railway Lines: Key transport routes affected.
5. Diversion of River Courses: Can lead to flooding.
6. Animal and Human Impact: Injuries and fatalities.
7. Destruction of Communication Lines: Disrupts connectivity

GOVERNMENT INITIATIVES - NDMA GUIDELINES

1. Slope Stability Evaluation: Assessing landslide risks.
2. Hazard Mapping: Identifying landslide-prone areas.

3. Afforestation: Planting trees and constructing bunds to reduce water flow.
4. Restraining Structures: Building barriers to prevent landslides.
5. Area-Specific Measures: Tailored strategies for different regions.
6. Restrictions on Development: Limiting construction in vulnerable areas