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# A CASE STUDY ON RECENT FLOODS IN VIJAYAWADA

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***Abstract:*** The problem of floods is increasing continuously in India. The cause of the flood problem is humans and nature. This problem is getting worse in the 21st century than in the 20th century. Since this time, it is causing more problems in the riverside villages of India, and it is creating health problems in the lives of millions of people. Along with this, there is huge damage to the cultivated land, animals, forests, groundwater, soil, and environment. This study focuses on the flood control measures specifically tailored for Vijayawada, Flooding has been a recurring challenge for Vijayawada due to its geographical location and dependence on the Krishna River for water resources. While flood management systems have improved over the years with the construction of barrages and dams, the city remains vulnerable to floods, especially during the monsoon season or when upstream reservoirs need to release excess water. The methodology involves a detailed assessment of historical flood data, hydro logical modeling, and simulation of flood scenarios under various conditions. we have discussed in detail the history from 1924 to 2024 and all the flood-affected areas along with their damage and flood management, and mitigation. The study also evaluates the existing drainage systems, embankments, and other structural measures in place. By using Geographic Information Systems (GIS) and remote sensing techniques, we analyze flood- prone areas, water flow patterns, and the impact of land use changes over time. The proposed flood control plan not only aims to protect lives and property but also to enhance the region's resilience to future climatic changes. The study concludes with recommendations for policymakers and stakeholders to adopt a multi-disciplinary approach to flood management in the region.

***Keywords:*** Flood control measures, Hydro-logical modeling, Flood mitigation, Embankments, Climate resilience, Structural flood defense, Multi-disciplinary approach.

## I.INTRODUCTION

Floods are among the most catastrophic natural disasters, causing widespread damage to human societies and ecosystems across the world. Their frequency and intensity have increased over recent decades, driven by factors such as climate change, rapid urbanization, and poor environmental management. The devastating consequences of floods include loss of life, significant economic losses, widespread environmental degradation, and disruptions to daily life. Flood risk management has thus become an urgent global challenge, requiring innovative solutions to mitigate the risks and protect vulnerable populations.

Historically, floods have played a pivotal role in shaping human civilization, influencing settlement patterns, agriculture, and infrastructure development. In many regions, proximity to rivers and coastlines has been a defining characteristic of human settlements due to access to water resources, fertile land, and trade routes. However, this same proximity also exposes communities to the risk of flooding, particularly during extreme weather events. The construction of retaining walls, dams, and barrages has been an essential aspect of flood control measures throughout history. These structures resist lateral pressure from soil or other materials, preventing soil erosion and managing water flow to protect urban areas, agricultural land, and infrastructure.

The challenges associated with flood management have been exacerbated in recent decades due to the growing influence of climate change and urbanization. Climate change has led to altered weather patterns, resulting in more frequent and intense storms, rising sea levels, and unpredictable precipitation regimes. These changes have amplified both riverine and coastal flooding, increasing the risk to communities that were once considered safe. Urbanization, particularly in rapidly developing countries, has further aggravated flood risks. The conversion of natural landscapes into impermeable surfaces such as roads, buildings, and parking lots reduces the land's capacity to absorb rainfall, leading to higher surface runoff and an increased likelihood of flash floods. Compounding the issue, many urban areas lack sufficient drainage systems to handle the increased volume of water, intensifying the risk of flooding.

Vijayawada, a city located near the Krishna River in India, has witnessed several significant flood events throughout its history. These floods have been triggered by a combination of heavy monsoon rains, the release of excess water from upstream reservoirs, and inadequate flood control infrastructure. Some of the most notable floods in Vijayawada's history include those of 1924, 1953, 1969, 1977, 1986, 2009, 2016, 2020, and most recently, the devastating 2024 flood. Each of these events has highlighted the vulnerabilities of the city to riverine flooding and underscored the urgent need for more effective flood management strategies.
The response to these floods has involved a series of control measures aimed at reducing the severity of future events. Key interventions have included the construction and expansion of flood control structures such as the Prakasam Barrage and upstream dams like the Nagarjuna Sagar and Srisailam Dams. Enhanced water management practices, improved forecasting and early warning systems, and the reinforcement of embankments have been integral to these efforts. However, the increasing frequency and severity of floods in Vijayawada and other urban areas continue to challenge the effectiveness of these measures. In addition to infrastructure development, there is a growing recognition that sustainable land-use planning, community-based preparedness programs, and environmental conservation efforts such as afforestation and wetland restoration are critical to reducing flood risk in the long term.
This paper aims to analyze the historical flood events in Vijayawada, assess the effectiveness of flood control methods implemented over time, and propose recommendations for improving flood management in the region. Through this analysis, the paper seeks to contribute valuable insights to the broader field of flood risk management, emphasizing the need for an integrated approach that combines engineering solutions with environmental sustainability and community resilience.

## II. TYPES OF FLOODS

1. ***Flash Floods***

*Flash floods are sudden, intense floods that occur within a short period, often within six hours of heavy rainfall, rapid snowmelt, or dam breaches. These floods are characterized by swift water movement, causing extensive property damage, erosion, and loss of life. Flash floods often happen in areas with steep terrain or poor drainage systems, such as urban environments.*

2. ***Coastal Floods***

*Coastal floods occur when high water levels inundate coastal areas, typically due to storm surges, high tides, or severe weather events like hurricanes and typhoons. They affect regions with low elevations and inadequate defenses, often breaching dunes or dikes. Coastal flooding is managed using structural methods to hold back or redirect water.*

3. ***River Floods***

*River floods are caused by gradual overflow of riverbanks due to prolonged rainfall. These floods can cover vast areas depending on the size of the river and the extent of precipitation. River floods have historically benefited agriculture but are often perceived negatively due to the damage they cause in developed areas.*

4. ***Urban Floods***

*Urban floods occur when heavy rainfall overwhelms a city's drainage system, causing water to accumulate on streets and properties. The lack of natural drainage in urban areas contributes to this flooding, which, despite shallow water levels, can cause significant structural damage and disrupt daily life.*

5. ***Pluvial Floods***

*Pluvial floods occur in flat areas where the land cannot absorb rainwater, causing puddles and ponds to form. These floods are common in rural areas, particularly affecting agricultural activities and properties. Unlike river or coastal floods, pluvial floods result from the intensity and duration of rainfall rather than overflow from water bodies.*

## III.OBJECTIVES OF THE STUDY:

The objectives of designing and analyzing a flood control system are to develop a comprehensive, efficient, and sustainable solution that minimizes the risks and impacts of flooding on communities, infrastructure, and the environment. Below are the key objectives:
***i.Flood Risk Reduction:*** Focus on minimizing the likelihood and severity of flooding to protect lives, property, and infrastructure.
***ii.Resilience to Climate Change:*** Design systems that can adapt to future changes in climate, such as increased rainfall and rising sea levels.
***iii.Integration of Structural and Non-Structural Measures:*** Combine physical infrastructure with planning, policies, and natural solutions for a comprehensive flood management approach.
***iv.Environmental Sustainability:*** Ensure that flood control measures are environmentally friendly, protecting ecosystems and maintaining water quality.
***v.Economic Efficiency:*** Develop flood control solutions that are cost-effective, balancing expenses with the benefits of reduced flood damage.
***vi.Social Equity:*** Ensure that flood control measures are inclusive, protecting all communities, especially vulnerable and marginalized groups.

## IV.SCOPE OF THE STUDY

***i.Geographic Focus:*** Vijayawada and surrounding areas along the Krishna River, particularly low-lying regions and urban areas with poor drainage.
***ii.Natural Causes:*** Excessive monsoon rainfall, Krishna River overflow, and potential climate change impacts.
***iii.Human-Induced Causes:*** Unplanned urbanization, deforestation, inadequate storm-water management, and poor land use planning.
***iv.Infrastructure Damage:*** Assessment of damage to roads, bridges, electricity, water systems, and public buildings.
***v.Economic and Socioeconomic Impact:*** Losses in local businesses, agriculture, displacement of families, and public health risks.
***vi. Flood Dynamics:*** Analysis of downstream effects, dam releases, and the differing flood behavior in flat vs. hilly terrains

## V.STUDY AREA

**VIJAYAWADA:**

Vijayawada, located in the Krishna district of Andhra Pradesh, India, is a prominent city situated along the banks of the Krishna River. The geographical setting of Vijayawada significantly influences its vulnerability to flooding, particularly during the monsoon season. The city lies in a low-lying area, with large parts of it positioned on the floodplain of the Krishna River, making it prone to water accumulation during periods of heavy rainfall. The Krishna River, which flows from the Western Ghats through several states before emptying into the Bay of Bengal, is one of the longest rivers in India. Vijayawada's proximity to the river has historically made it a thriving center for agriculture, trade, and transportation, but this proximity also exposes it to the dangers of riverine floods.

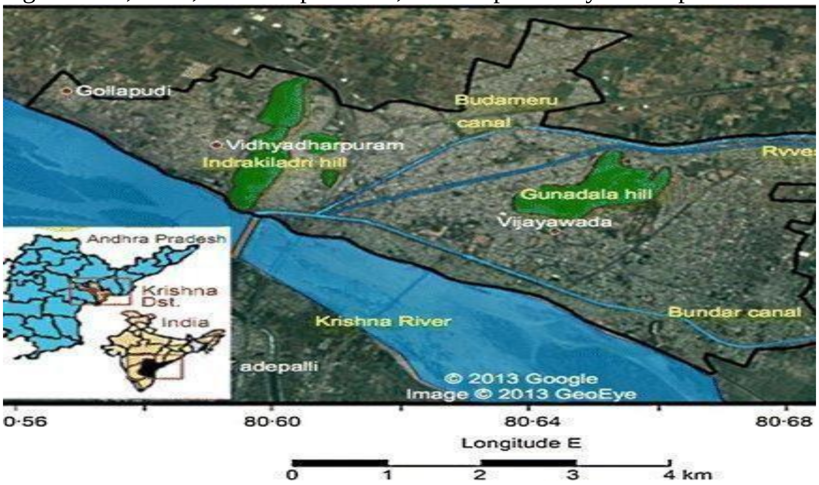



**Fig 1. -Thematic View of Vijayawada River System**

The river's capacity to hold and discharge water becomes critical during the monsoon, when upstream dam releases, such as from the Prakasam Barrage, can lead to significant increases in water levels downstream, causing flooding in adjacent urban and rural areas.Topographically, Vijayawada presents a mix of low-lying regions and elevated terrain, with the city nestled between the Krishna River and a series of hills, including the Indrakeeladri Hills, which provide some natural protection. However, the majority of Vijayawada's population and its built infrastructure are located in the flat, low-lying regions closer to the riverbanks, areas that are particularly vulnerable to flooding.

Regulating river flow but can also be a source of concern when floodwaters exceed manageable levels.Additionally, Vijayawada's drainage system is inadequate to cope with large volumes of rainwater. The city's storm-water drains are frequently clogged or insufficient in size, which leads to water-logging in many parts of the city during downpours.

The city's existing water channels, canals, and natural drains have not been sufficiently maintained or upgraded to handle the increasing water flow due to urban growth.

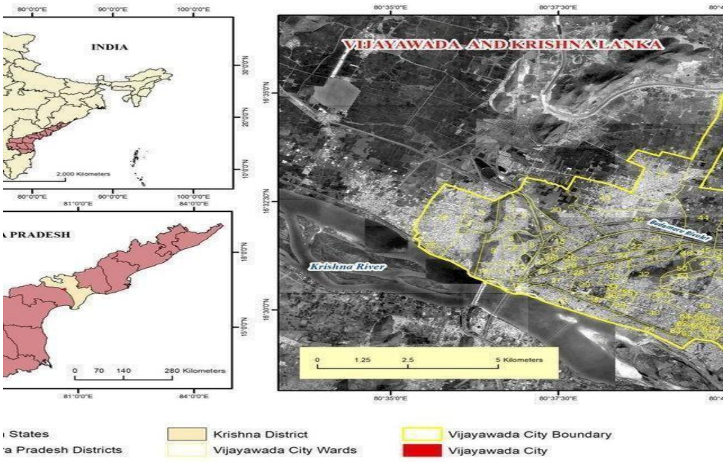



**Fig 2 - Satellite view of Vijayawada**

The presence of a vast network of irrigation canals, stemming from the Krishna River and surrounding reservoirs, also affects the hydro-logical balance in and around Vijayawada. These irrigation systems, while essential for agriculture, can become inundated during periods of excessive rainfall, further contributing to flooding. Over the years, improper management of these canals has led to breaches and overflow during storms, worsening the flood situation in both urban and rural areas. Vijayawada's geographical location along the Krishna River, its low-lying topography, and its complex hydro-logical systems, including the regulation of upstream dams, irrigation canals, and storm-water drains, all contribute to its susceptibility to flooding.

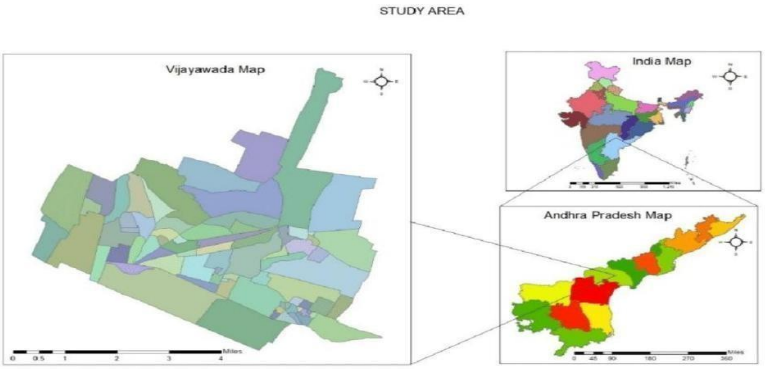
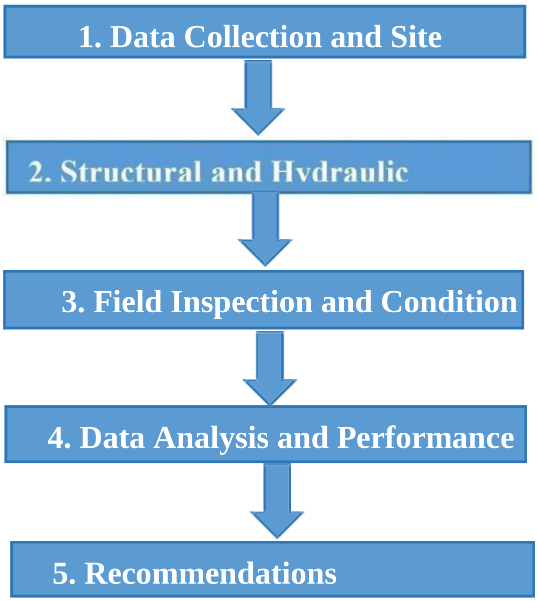



**Fig 3 -Thematic Map of Vijayawad**

## VI. METHODOLOY




**Collection of Historical Flood Data**

The Krishna River, flowing through Maharashtra, Karnataka, and Andhra Pradesh, plays a crucial role in irrigation and flood management in Vijayawada. Its flow rate varies, typically around 3,500 cubic meters per second, but can rise dramatically during the monsoon, sometimes exceeding 50,000 cms during extreme weather. These high flow rates often lead to floods when the river's capacity is exceeded. Increased urbanization, land use changes, and climate change have worsened flood frequency and severity in recent decades. Collecting historical flood data helps authorities understand flood patterns and develop better flood management strategies, including predictive models, infrastructure planning, and early warning systems.

*Table 1: Collection of Historical Flood Data*

| Class | Change in area (%) | | | |
|---|---|---|---|---|
| | 2013-16 | 2016-19 | 2019-23 | 2013-23 |
| **Water** | 0.73 | -1.43 | 1.92 | 1.22 |
| **Urban** | 1.76 | -0.10 | 9.43 | 11.10 |
| **Riverbed** | 1.79 | 0.78 | -1.80 | 0.70 |
| **Forest** | -10.06 | -5.88 | 2.53 | -13.41 |
| **Waste land** | -0.37 | -1.67 | -0.52 | -2.55 |
| **Garden** | 4.33 | 7.61 | -10.94 | 1.00 |
| **Agriculture** | 2.60 | 1.15 | -3.60 | 0.16 |
| **Roads** | -0.73 | -0.45 | 2.98 | 1.79 |

**River flow rates :**

Rainfall in Vijayawada can be categorized into monsoon (seasonal) and non-monsoon (out-of-season) rainfall patterns, both of which have varying impacts on the city's flood risk.The Southwest Monsoon season, from June to September, is the primary source of rainfall.Rainfall is widespread and often heavy, with some years experiencing over 500 mm of rainfall in just a few days. The intensity and duration of rainfall vary, with peak rainfall occurring in July and August. Although the monsoon is the main contributor to annual rainfall, non-monsoon rainfall also occurs, typically during the pre-monsoon (March-May) and post- monsoon (October-December) periods. March-May period sees sporadic rainfall due to convective thunderstorms.

*Table 2- Run-off area for Outfall Nodes*

| Nodes | Sub catchment | Area (ha) |
|---|---|---|
| A | Krishnalaknka, Chalasani Nagar, Ayyapa Nagar, Patamata, Labbipeta. | 254.81 |
| B | Government Polytechnic, NTR Health University, Currencynagar, Veternarynagar, Loyola College, Auto Nagar, RWC Colony, New Postal Colony, Stella College. | 226.23 |
| C | Governerpet, Gundala, Hanumanpet, Gandhi Nagar, Railway quarters, Satyanarayanapuram, Madura Nagar. | 143.66 |
| D | Railway station, Pezzonipet, Kedareswarpet, Ayodhya Nagar, Budameru center. Devi Nagar | 88.97 |
| E | Ajithsingh Nagar, Excel Power Plant, Prakash Nagar, Payakapuram, Rajiv Nagar, U.D.A scheme. | 153.97 |
| F | Tarapet, Mallikarjuna Nagar, Islampet, Tailorpet, Vidyadharapuram, R.R. Nagar, Bhavanipuram, Karakatta South, H.B. Colony, Chitti Nagar. | 131.5 |
| G | Wynchpet, Rajarajeswaripeta, New Rajarajeswaripeta. | 23.1 |
| H | K.L. Rao Nagar, Milk project, Jogi Nagar, Urmila Nagar. | 69.27 |

**Rainfall Patterns & Flood Recurrence in Vijayawada**

***Flood recurrence intervals estimate how often floods of a certain magnitude occur.***

- **1-in-10 Year Flood (10% chance/year):** Moderate floods causing riverbank overflows and minor damage, common due to monsoonal rainfall.
- **1-in-50 Year Flood (2% chance/year):** Major floods causing severe disruption, property damage, and displacement, occurring roughly every 50 years.
- **1-in-100 Year Flood (1% chance/year):** Rare but catastrophic floods, like those in 1949 and 1986, causing widespread devastation.

Upstream reservoirs like Nagarjuna Sagar and Srisailam complicate flood management. Large-scale water releases, especially during the monsoon, have increased high-flow events in Vijayawada

## VII.SUGGESTIONS

*Table 3: Retaining Wall Design Standards*

| S.No | IS Code | Title | Description |
|---|---|---|---|
| 1 | IS 456: 2000 | Plain and Reinforced Concrete | Fundamental for any concrete structure, including retaining walls, ensuring strength and durability. |
| 2 | IS 3370 (Part I to IV): 2009 | Code of Practice for Concrete Structures for Storage of Liquids | Applies to retaining walls holding back water or fluids, with a focus on waterproofing. |
| 3 | IS 3370 (Part 4): 1967 | Code of Practice for Concrete Structures for the Storage of Liquids (Design Tables) | Provides reinforcement and concrete thickness guidancefor walls under hydrostatic pressure. |
| 4 | IS 1904: 1986 | Code of Practice for Structural Safety of Foundations and Retaining Walls | Covers design aspects like bearing capacity, stability, soil pressures, and wall geometry for different soil types and loads. |
| 5 | IS 14458 (Part 1 to 3): 1998 | Guidelines for Retaining Wall Design | Assists in designing retaining walls based on material type, especially for unreinforced retaining structures. |
| 6 | IS 4995 (Part I and II): 1974 | Criteria for Design of Reinforced Earth Retaining Walls and Gravity Retaining Walls | Essential for soil-reinforced retaining wall systems utilizing techniques like geogrids or steel strips |
| 7 | IS 6403: 1981 | Code of Practice for Determination of Bearing Capacity of Shallow Foundations | Ensures that the foundation can support loads without excessive settlement or shear failure. |
| 8 | IS 875 (Part 1 to 5): 1987 | Code of Practice for Design Loads (Other Than Earthquake) for Buildings and Structures | Important for calculating external forces acting on retaining walls, affecting stability. |
| 9 | IS 1893 (Part I): 2016 | Criteria for Earthquake Resistant Design of Structures | Defines earthquake resistance requirements for retaining walls in seismically active areas to prevent structural failure. |
| 10 | IS 13920: 2016 | Ductile Detailing of Reinforced Concrete Structures Subjected to Seismic Forces | Ensures seismic resilience for reinforced concrete retaining walls. |
| 11 | IS 6512: 1984 | Criteria for Design of Solid Gravity Dams | Contains principles applicable to retaining walls designed to control floodwaters or manage water flow near riverbanks. |

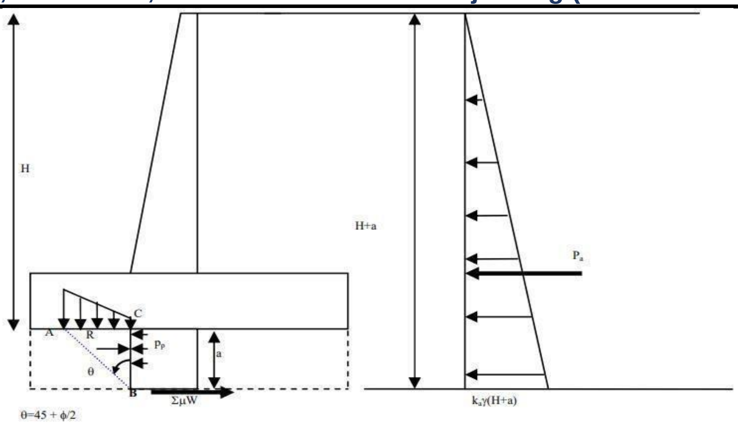



*Fig:4 Retainingwall*

**Hydraulic Pressure and Flood Load on Retaining Walls**

In Vijayawada, retaining walls near water bodies face heavy pressure during floods. Rising floodwaters exert multiple forces, which must be managed to prevent structural failure.

- **Static Water Pressure:** As flood levels rise, water pushes against the wall with increasing force, especially at greater depths. Walls are designed to withstand these forces based on expected monsoon flood levels.
- **Seepage Forces:** Water seeps into the ground, creating pressure that weakens soil stability and adds stress to the wall. Drainage systems help manage this issue and prevent tilting or collapse.
- **Debris Impact:** Floodwaters carry debris like branches and rocks, which can hit the wall with high force, causing damage. Walls in flood-prone areas are reinforced to withstand such impacts.

Proper engineering and maintenance of retaining walls are crucial to reducing flood damage in Vijayawada

## VIII. Conclusion

The September 2024 floods in Vijayawada were caused by intense rainfall, infrastructure challenges, and urban planning issues. Vijayawada, located along the Krishna River, faced severe flooding when the Prakasam Barrage had to release over 1.1 million cu secs of water. While necessary for managing river levels, this led to severe flooding downstream, submerging many low-lying areas. The Budameru River also overflowed, worsening the situation, especially in areas with already overwhelmed drainage systems.

The disaster caused major disruptions—thousands were displaced, roads and railways were damaged, and power outages affected many neighborhoods. Over 6.44 lakh people were impacted, with 44,041 shifted to 190 relief camps. The National Disaster Response Force (NDRF) and local authorities carried out extensive rescue operations, using boats and drones to provide food and medical aid to stranded residents.

Retaining walls played a crucial role in mitigating flood damage, particularly in stabilizing riverbanks and controlling water flow. These structures helped prevent landslides and excessive erosion, reducing destruction in vulnerable areas. However, the disaster emphasized the need for improved flood defenses and better urban planning.

In response, the government set up relief camps, provided essential aid, and initiated financial support for affected families. The floods highlighted the urgent need to enhance drainage systems, upgrade flood defenses, and implement more effective early warning systems. With changing weather patterns, strengthening Vijayawada’s resilience to future floods is now a top priority.

**Future Scope**

***Suggestion :***

***1.Increasing the Height of the Banking of Budameru River:*** *To increase the banking height of the Budameru River, use reinforced earth structures or stone pitching to stabilize the embankments and prevent erosion.*

***2.Construction the Retaining Wall Around the Dams:*** *Ensure the retaining wall is designed to withstand lateral earth and hydro-static pressures using appropriate materials and drainage systems to prevent water buildup. Prioritize durability and stability for long-term performance under varying load conditions.*

***3.Increase the storage capacity of Reservoirs / Enhance drainage system:*** *Raise dam height or implement sediment management techniques to maximize water storage capacity. Optimize outlet structures and integrate advanced drainage channels to ensure efficient water flow and reduce siltation.*

***4.Early Warning Systems / Improve Hazard Indication Systems:*** *Implement Io T-based sensors and AI analytic to enhance real-time hazard detection and provide automated alerts.Integrate community-based monitoring systems with mobile app notifications for faster and localized responses.*

***5.Strengthening Emergency Services:*** *Upgrade emergency communication networks with real-time data sharing and advanced technologies like AI for faster response. Regularly train personnel and provide modern equipment to improve efficiency in crisis management.*

***6.Enhanced Flood Management Infrastructure:*** *Develop robust flood management systems by integrating advanced hydrological modeling with adaptive infrastructure designs to mitigate risks and ensure resilience.*

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