INDIA WATER WEEK 2026

ANATOMY OF A DISASTER

When Glacial Fury Met Hydropower Fragility, Oct 2023



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INDEX

1. Study Area : Teesta Basin

2. South Lhonak GLOF Event

3. Pre & Post GLOF Documentation

4. Gaps - Operational & Assessment

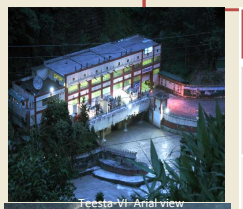
5. Guidelines for GLOF Risk Mitigation

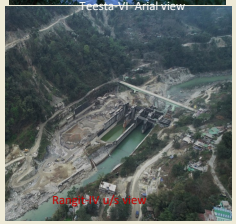
6. Way Forward

HYDROPOWER DEVELOPMENT IN TEESTA BASIN

- Teesta river descends from an elevation of about 5400 m to about 300 m over a distance of about 175 km (slope of 1 in 20 in initial reaches)
- NHPC's projects : Teesta-V,Teesta-VI,TLD-III & TLD-IV, Rangit III & Rangit-IV on Rangit River

Details	Teesta V	Teesta VI	TLD III	TLD-IV	Rangit	Rangit IV
Comm. Year	2008	Under construction	2013	2016	2000	Under construction
Catchment area (km²)	4307	4500	7755	8021	979	1232
Type of dam	Conc. Gravity	Barrage	Barrage	Conc. Gravity	Conc Gravity	Conc. Gravity
Max. Height (m)	88.6	26.5	32	45	43	44
Design Flood	14596	11600	10430	15400	2750	5617
Reservoir Capacity	**13.5 MCM**	**3.18 MCM**	**18.3 MCM**	**36.6 MCM**	**1.79 MCM**	**1.81 MCM**
Installed Capacity	510 MW	500 MW	132 MW	160 MW	60 MW	120 MW

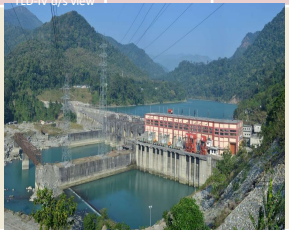

Rangit Power House

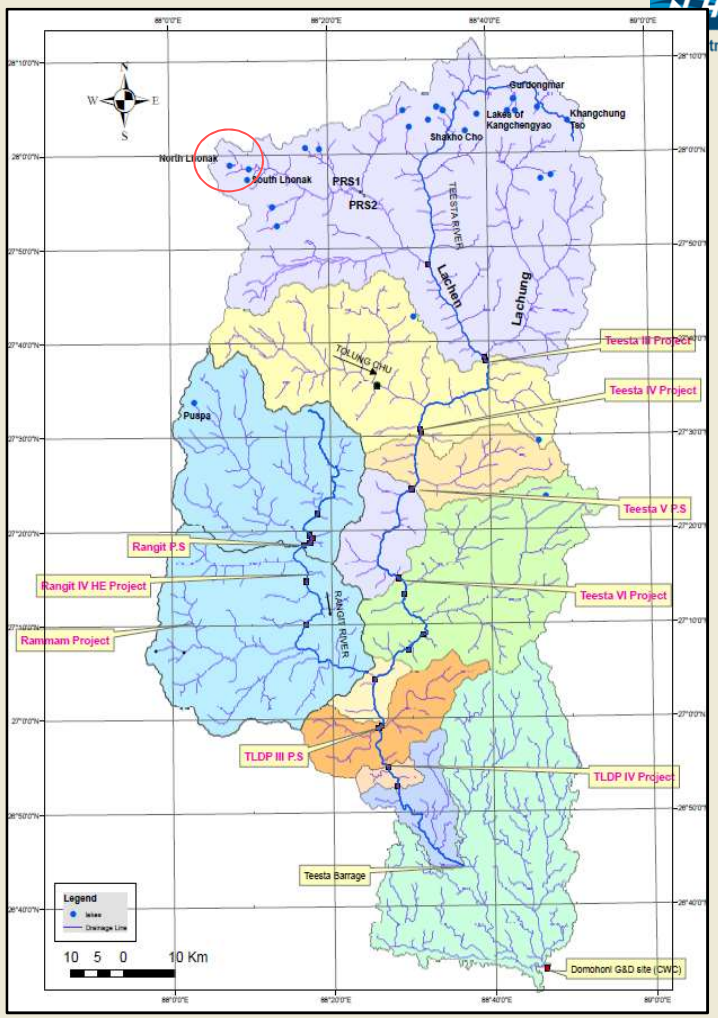

Teesta-VI Arial view



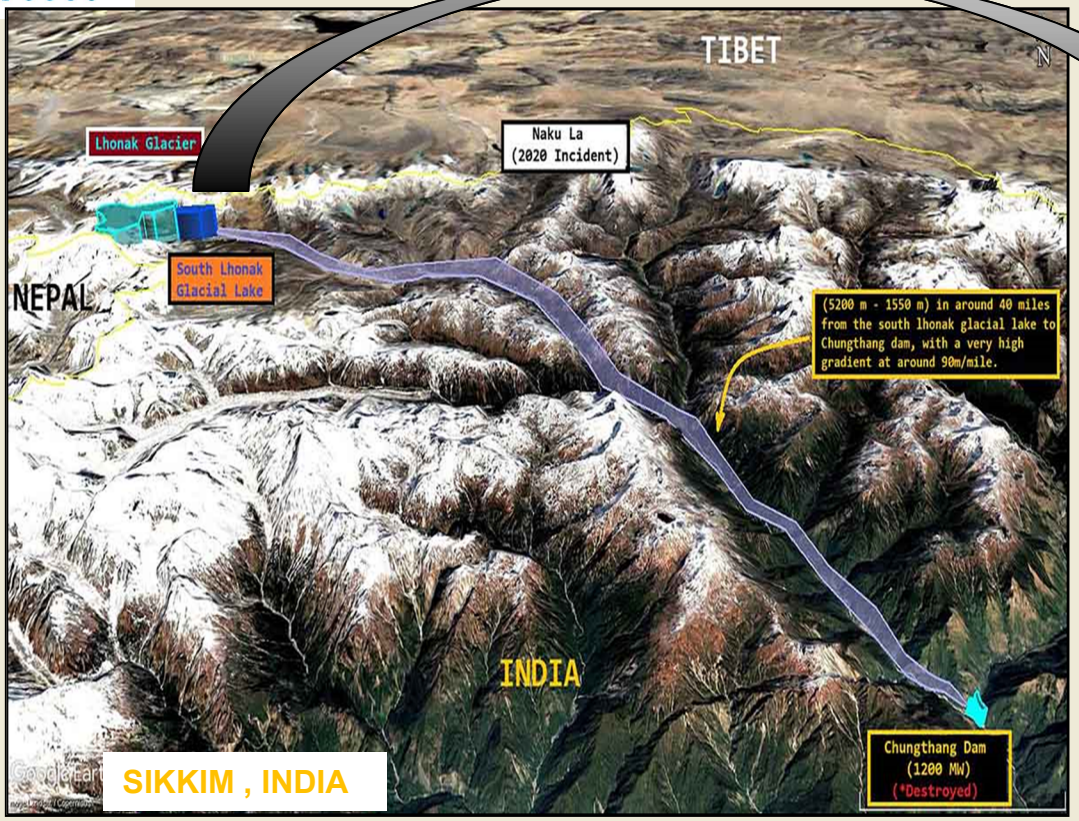

Teesta-V Dam

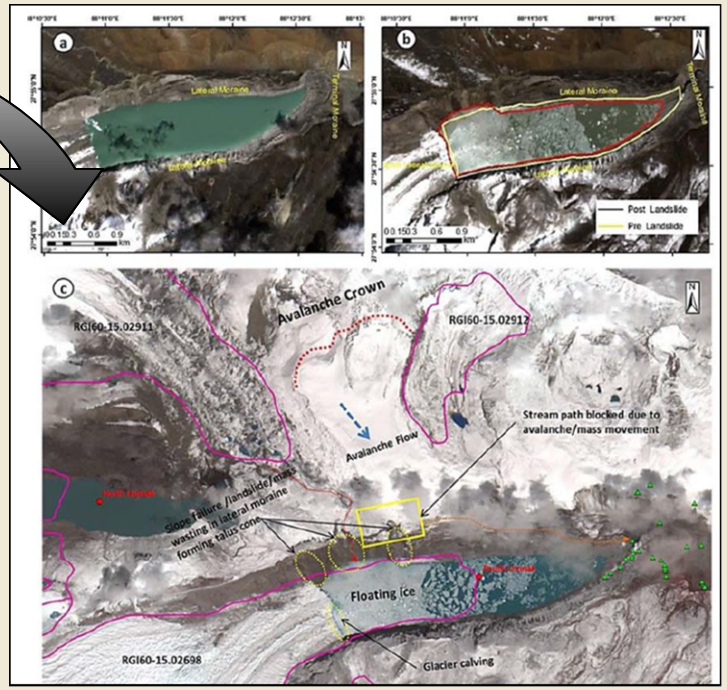



TLD-IV d/s view



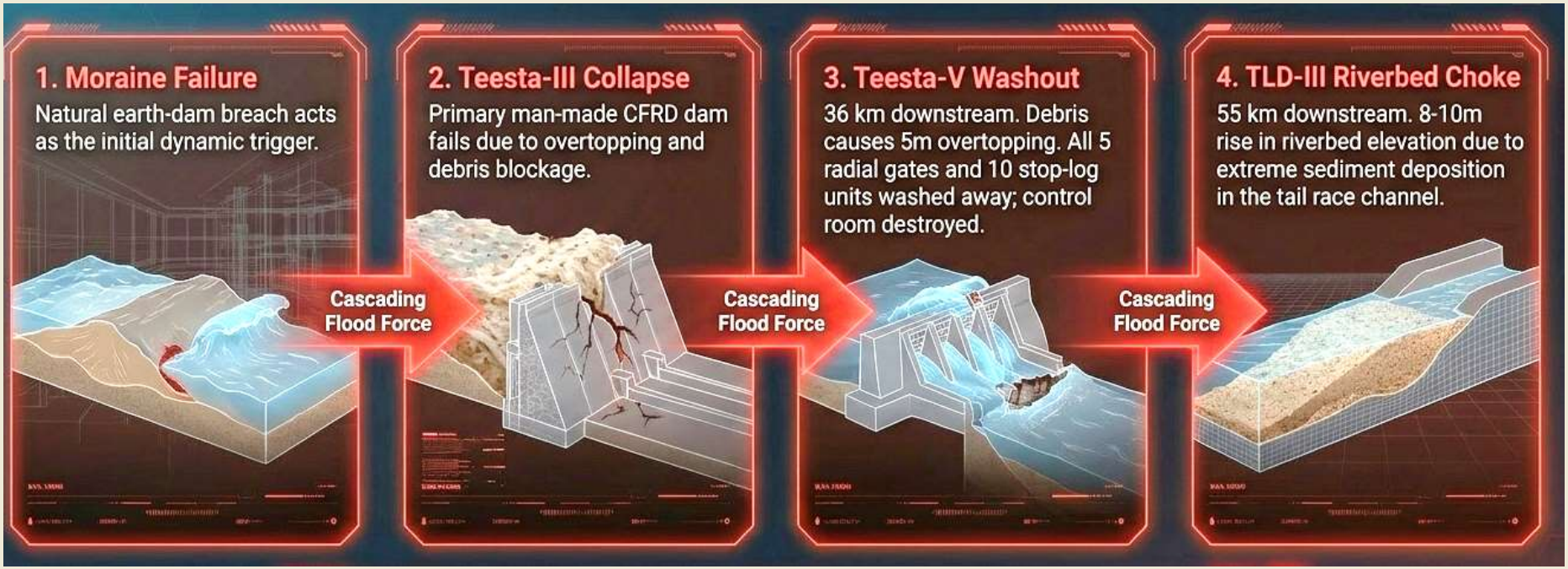
SOUTH LHONAK LOCATION MAP – Lake Breach Mechanism



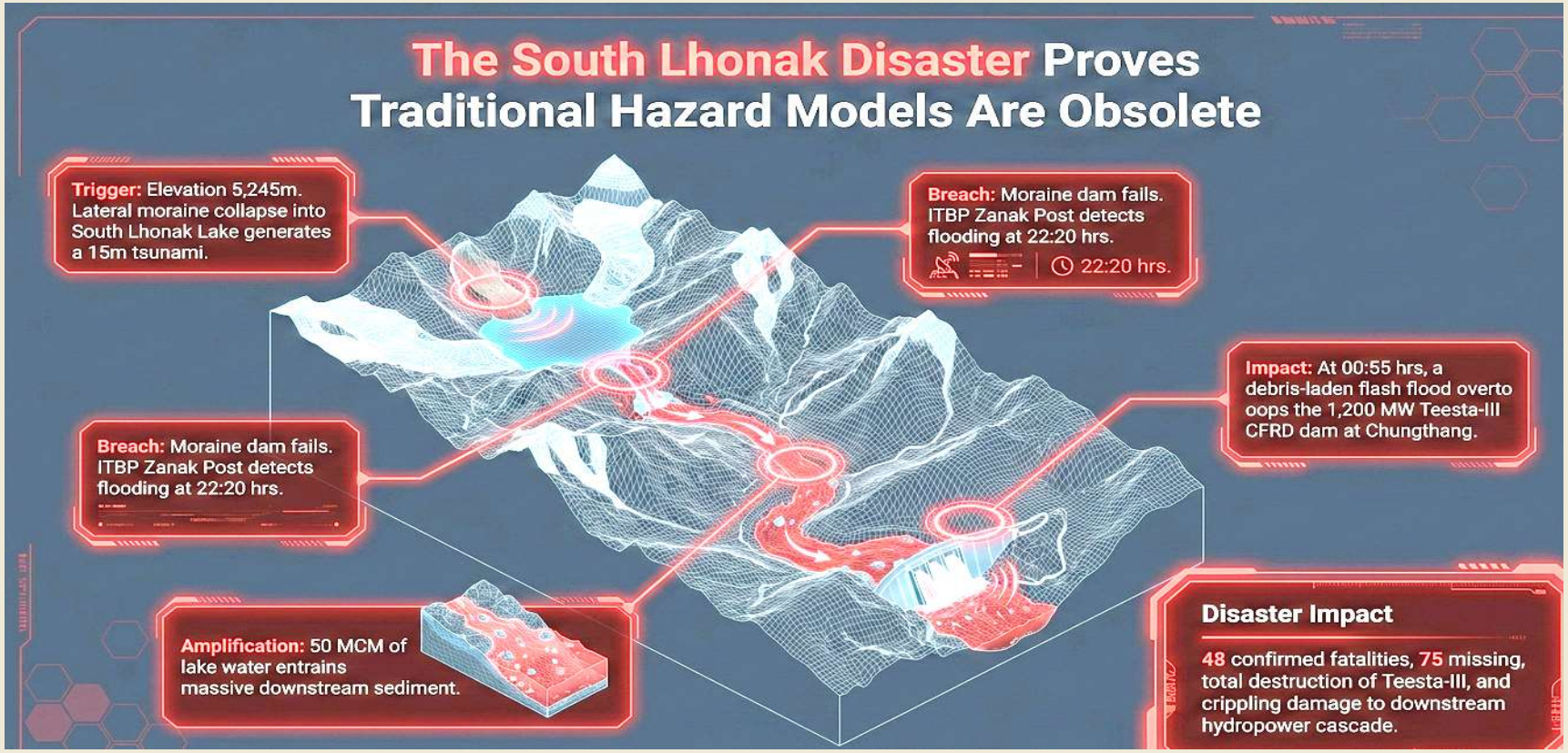


South Lhonak Lake : A glacial–moraine-dammed lake at an elevation of 5,200 m in far northwestern Sikkim, formed by the melting of the Lhonak glacier.

CASCADED HAZARD



CASCADED HAZARD



PRE-GLOF DOCUMENTATION

Timeline (2013-2021)






Identify vulnerable lake

2013-2014 — NRSC, SASE and **DST** identify South Lhonak Lake as highly vulnerable to GLOF. First Field Expedition to Lake

Simulate breach scenarios

2015 — CWC simulates breach scenarios; flags high probability of outburst (discharge **~6,210** cumec) at Teesta-III

Initiate siphoning efforts

2016 — Multi-departmental expedition; siphoning initiated with 3 HDPE pipelines

Predict peak discharges

2019-2021 — Academic models (Sattar et al) Predicted peak discharges up to **6,064** m^3/s at Lake & **2,321–4,311** cumec at Chungthang based on Avalanche triggers

Post-GLOF RESEARCH & RECONSTRUCTIONS

Remote Sensing & Rapid Assessment

ISRO / NRSC, MDPI: Provided immediate spatial monitoring, lake area changes, and basin-wide inventories, though limited by bathymetric and subsurface ground data.

Field & Policy Reports

NDMA, State Govt (PDNA): Focused on ground validation, socio-economic impact assessment, and urgent emergency response recommendations

Numerical & Hydrodynamic Modeling

NHPC, CWC, JWCC, Sattar et al., Singh et al., Peer-reviewed (2024–25): Offered quantified breach physics, flood routing, dynamic erosion, and overtopping simulations, but depend heavily on scenario assumptions and lack physical calibration.

OPERATIONAL GAPS

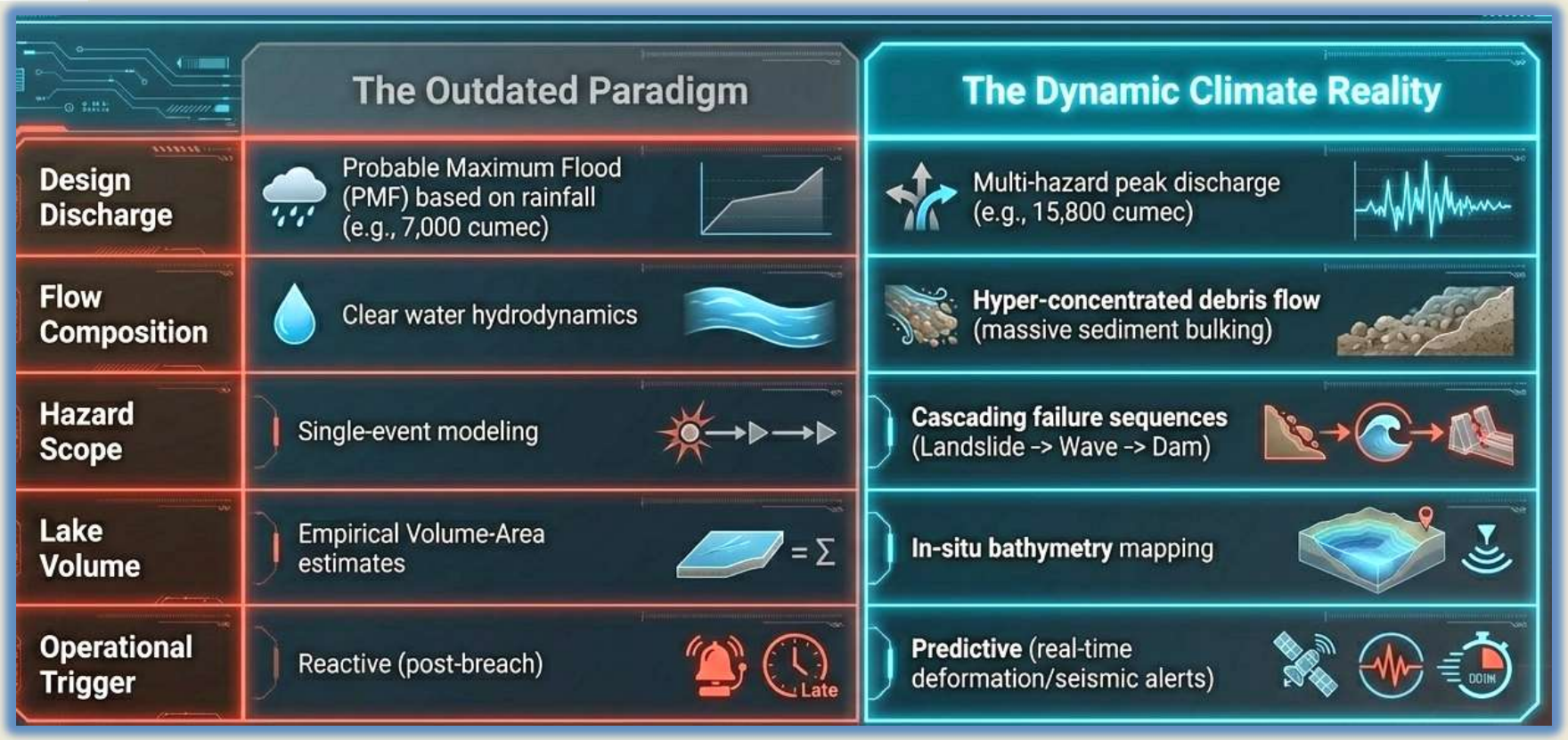
High Altitude sensors	**No working ground-based sensors in proximity to the lake to capture potential movements in immediate surroundings**
Response Time	Limited time window, lack of quality alarms
Underestimated Impact Zones	Pre-event **inundation maps** underestimated downstream reach.Severe riverbed morphing **expanded destruction far past predicted** hazard boundaries.
Thresholds	Absence of monitoring thresholds

CURRENT MODELS IGNORE SEDIMENT BULKING



The 270 MCM of entrained rock and sediment fundamentally altered the flow density destructive power instantly rendering the downstream projects under designed

STATIC HISTORICAL STANDARDS VS DYNAMIC CLIMATIC REALITIES



MAJOR REGULATORY GUIDELINES /DIRECTIONS

Period	2024	July, 2025	July, 2025	2025 onward	2025–26
Guideline / Initiative	CEA - SOP for Early Warning System (EWS) in Hydro Electric Projects	CWC- Assessment/ Identification of GLOF Risk to Dams and River Valley Projects	Guidelines for Structural Measures to Mitigate Adverse Effects of GLOF on Dams	Integration of GLOF considerations into Dam Safety, Hydraulic Safety and Risk Assessment under the Dam Safety Act, 2021 / NDSA framework	Development / Scale-up of GLOF EWS by NDMA / C-DAC/NGRMP/CO DRR
Compliance/ Action by NHPC	**EWS, MCR (gaps?)**	**GLOF studies (gaps?)**	**New : Yes** **Existing : Significant challenges in retrofitting**	**Integrating** GLOF into **dam safety reviews, hydraulic assessments, dam break studies, EAPs** and mitigation planning.	Real-time **lake Monitoring** /lake **mitigations**/Satelite based monitoring (?)

ISSUES IN IMPLEMENTING CWC GUIDELINES FOR EXISTING HYDRO PROJECTS

A Navratna Company

❖ Challenges in Implementing Rapid-Response Spillway Gates :

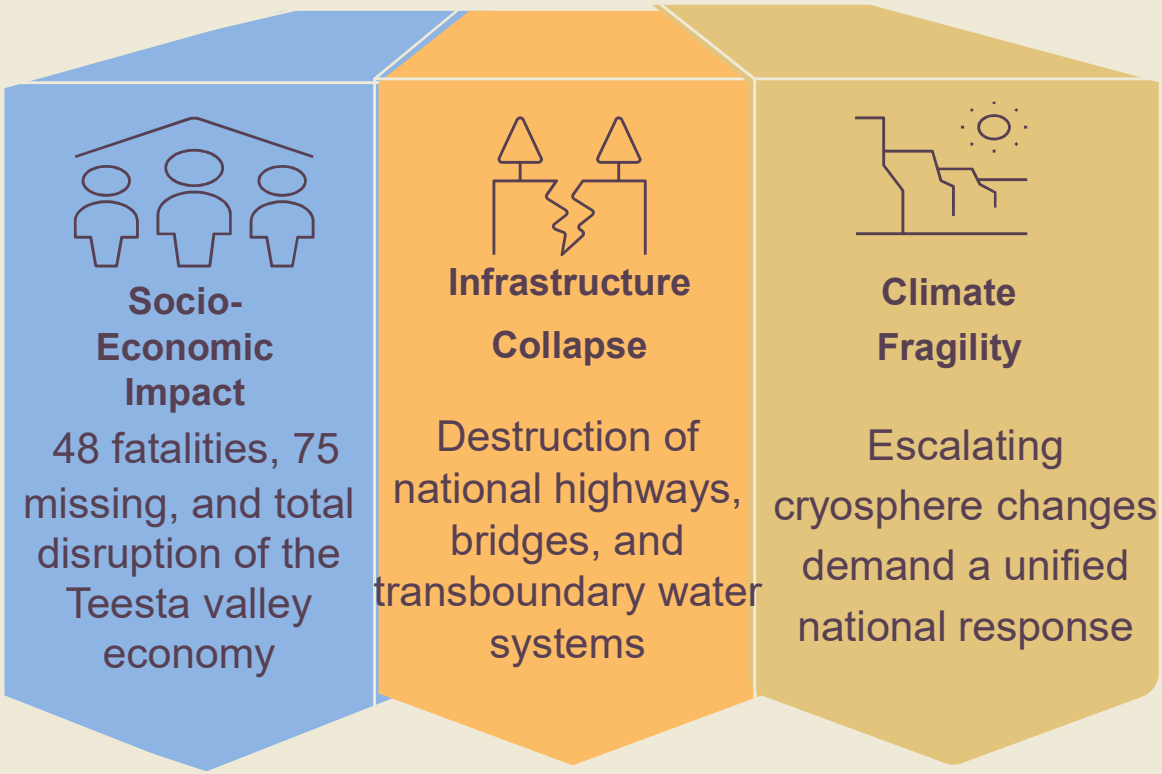
- **High Guideline Speed (1.5–2.0 m/min):** Triggers steep power demands and significantly larger motor pump units.
- **Space Constraints:** Oversized power pack components are physically impractical to fit on-site.
- **Infrastructure Impact:** Requires a 3–4× increase in DG set capacity and overall power supply.

❖ Challenges for existing dams have inherent physical constraints:

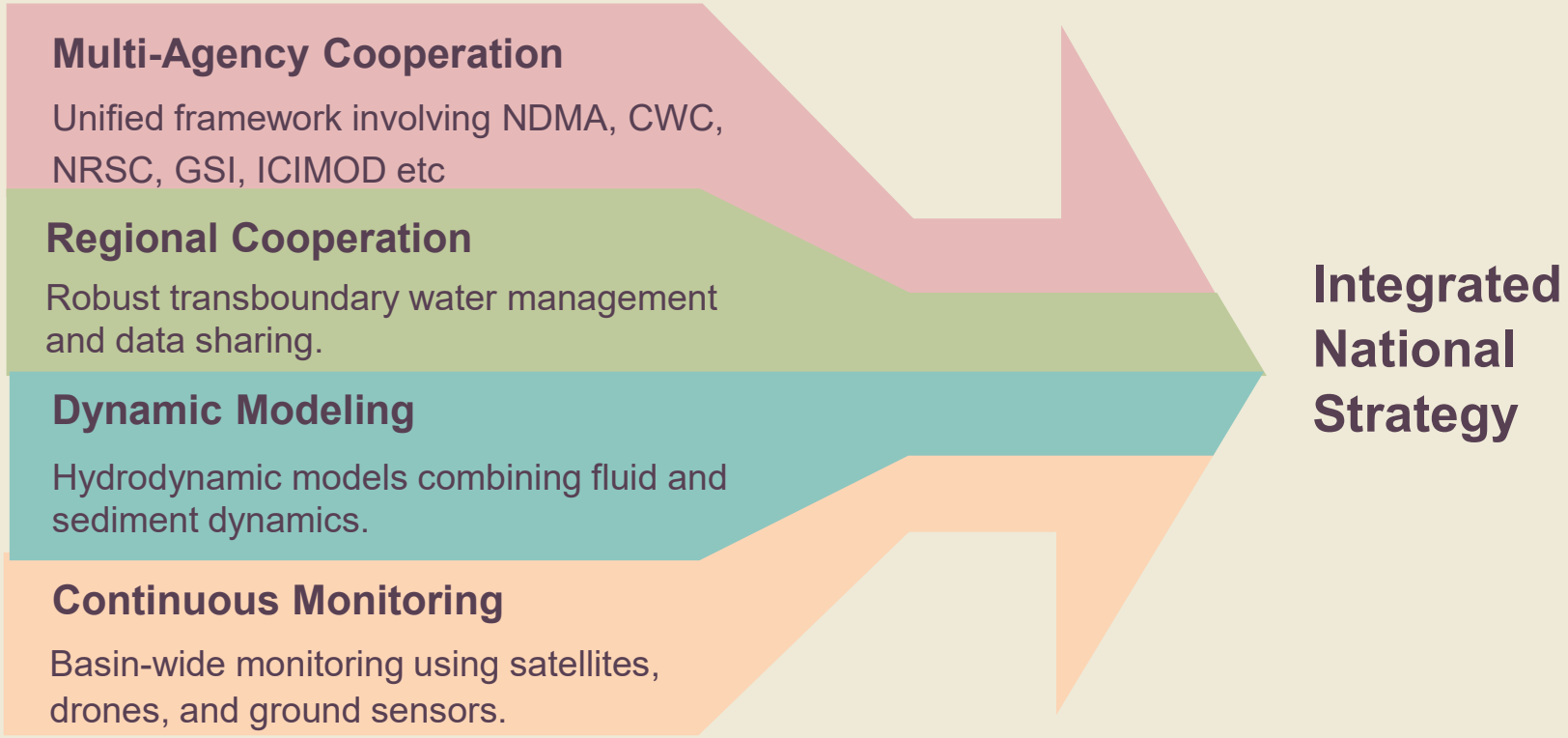
- **Spillway dimensions** cannot generally be enlarged without extensive reconstruction
- Modifications may require **prolonged shutdowns** and significant economic losses
- **Geological and topographical** constraints often limit feasible spillway expansion
- Many Himalayan projects are **run-of-river schemes with comparatively small reservoir storage** and limited flood attenuation.

NATIONAL ISSUE: BEYOND HYDROPOWER

???? Aren't present directives falling short in addressing ***Glacial Risks????***



WAY FORWARD: INTEGRATED NATIONAL STRATEGY



Thank You!

Your time and engagement is highly appreciated .....