



International Conference on Dam Safety, 2023



Government of India Initiatives on Dam Safety and Management

by

Sanjay Kumar Sibal

Member (D&R), Central Water Commission

&

Chairman, National Dam Safety Authority

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India and Water

- ❖ Water has been integral to **India's growth story** throughout history, influencing its agriculture, culture, economy, and industrialisation.
- ❖ The Indus Valley Civilization, one of the world's oldest **urban civilisations**, thrived along the banks of the Indus River and its tributaries.
- ❖ Water bodies like the Ganges, Yamuna, and other rivers have deep **cultural and religious significance**.
- ❖ **Agriculture** is the backbone of India's economy for centuries. Reliable access to water through river systems, canals, and wells has been crucial for sustaining agricultural productivity.
- ❖ The availability of water resources played a pivotal role in India's **industrial and urban development and energy security**.





Building Storages Historically

India has a long history of water management systems for efficient water storage and distribution, including traditional step wells, tanks, as well as construction of dams and canals.

The Chola dynasty, is renowned for its contributions to dam construction. The Grand Anicut (Kallanai Dam) built on the Kaveri River in Tamil Nadu during is considered one of the oldest functional dams in the world.

Grand Anicut is a massive structure constructed with uneven stones to a length of 329 m and a width of 20 m across the mainstream of the river.



Grand Anicut (Kallanai Dam), 1st Century



Building Dams – Current Status



Post-Independence in 1947, India embarked on a massive dam-building program to support agriculture, hydroelectric power generation, flood control, and water supply for growing urban populations.

Presently, India stands 3rd in terms of Large Dams worldwide

Number of Large Dams World wide about 58,713
(ICOLD 2021)

Sl No	Country	No. of Dams
1	China	23841
2	United States of America	9263
3	India	6138
4	Japan	3130
5	Brazil	1365
6	Korea (Republic)	1338
7	South Africa	1266
8	Canada	1156
9	Mexico	1079
10	Spain	1064



Role of CWC in Dam Engineering

(Established
1945)



- Provides Technical solutions to the specified problem to the State Governments/ Project Authorities in formulation and implementation of schemes for Irrigation, Flood Management, Hydro Power Development, and drinking water, besides guiding the Analysis and design of Dams/Weirs, Barrages, Canals; Gates; Tunnels; Powerhouse; etc.
- Appraisal of DPRs of Water Resources and Hydro Power Projects.
- Hydrological and Basin Studies: Water Availability assessment, Design Flood Estimation.



Notable Contributions by CWC in water security



Hirakud Dam, Odisha

- Composite structure of Earth, concrete and Masonry.
- longest dam of India - 25.8 Km (entire dam).
- Height: 60.98 m
- Gross storage: 8.14 BCM
- Spillway Capacity: 42450 Cumec



Tehri Dam, Uttarakhand.

- CWC associated with planning and design.
- Type: Earth and Rockfill dam
- Height: 260.5m
- Length: 575m
- Spillway Capacity: 13040 Cumec
- Gross storage: 3.54 BCM



Nathpa Jhakri Hydel Project (1500MW), Himachal Pradesh

- Designed Civil and Hydro-mechanical components and firmed up hydrology.
- Concrete Gravity dam
- Height: 62.5m
- Spillway capacity: 5660 Cumec



Sardar Sarovar MPP, Gujarat.

- CWC was involved in the Planning and design consultancy of Power houses and Garudeshwar Weir.
- Type: Concrete Gravity Dam
- Length: 1210 m
- Height: 163.0 m
- Spillway capacity: 86944 Cumec
- Gross Storage: 9.5 BCM



Indian Presence in other Countries



International presence of the Ministry of Jal Shakti, GoI, through its organisations



Salma Dam Project, Afghanistan

- Earth and rock fill dam , 107.5 m high
- 2100 cumecs design discharge
- Planning, design & technical support during construction of dam by CWC



Arun III (900 MW) HE Project, Nepal

- 466m-long and 70m-high concrete gravity dam
- 1300 cumecs design discharge
- Design consultancy and technical support on design and engineering issues by CWC



Punatsangchhu – I (1200 MW) & II (1020 MW) HE Project, Bhutan

- P-I: 136 m height, 239 m length concrete dam
- P-II: 91 m height, 214 m length concrete dam
- Design consultancy by CWC.



Tala 1020 MW HE Project, Bhutan

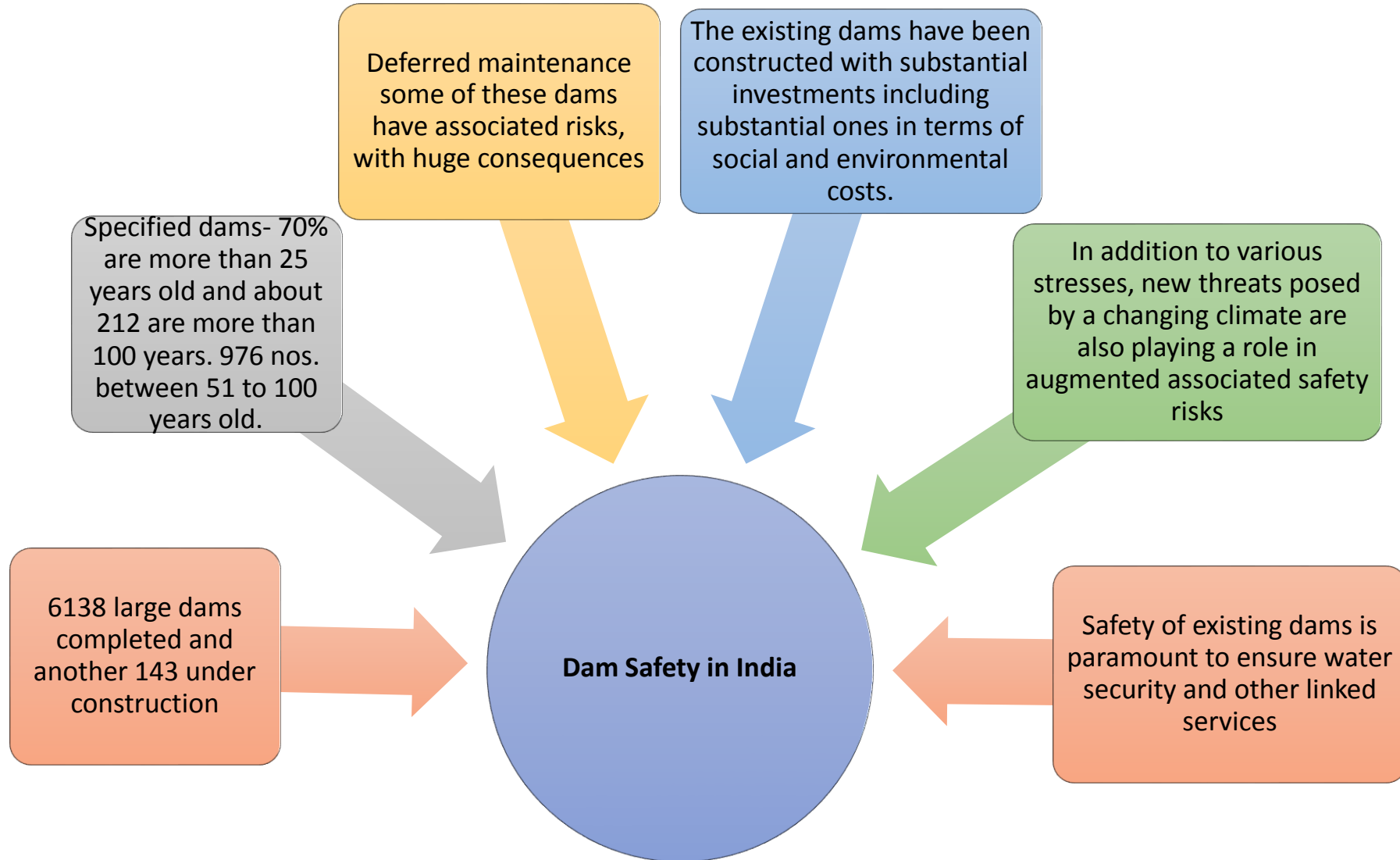
- 92 m height, 128.7 m length concrete dam
- Design consultancy by CWC.

Chhukha H.E. Project, Bhutan

- 92 m height, 128.7 m length concrete dam
- Design consultancy by CWC.



Dam Safety in India



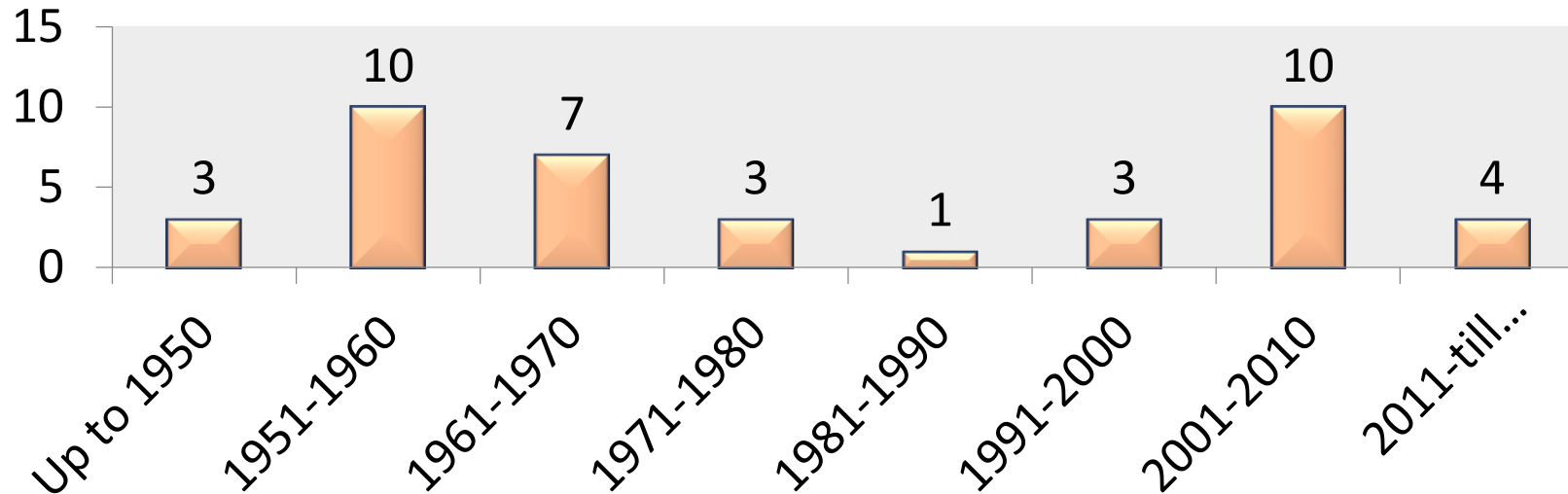


Dam Failures

There are 42 reported dam failures in India. The first dam failure was recorded in Madhya Pradesh in 1917 when the Tigra dam failed due to overtopping.

The worst dam disaster was the Machu dam (Gujarat) failure in 1979, in which about 2,000 people were reported dead.

Most failures involved newly built dams, chiefly in the first ten years.



Tigra Dam failure



Machu II Dam failure



Government of India initiatives in Dam Safety



1. Dam Safety Organizations(DSO), CWC

- established in 1979 in CWC
- working towards developing uniform dam safety protocols by laying down the standard guidelines/ manuals.
- To assist the State Govts. and perform a coordinating and advisory role for States.



2. National Committee on Dam Safety (NCDS)

- Setup in 1987 to evolve uniform, simplified dam safety procedures
- Act as a forum for the exchange of views on issues about dam safety amongst various stakeholders



3. Dam Rehabilitation Programs

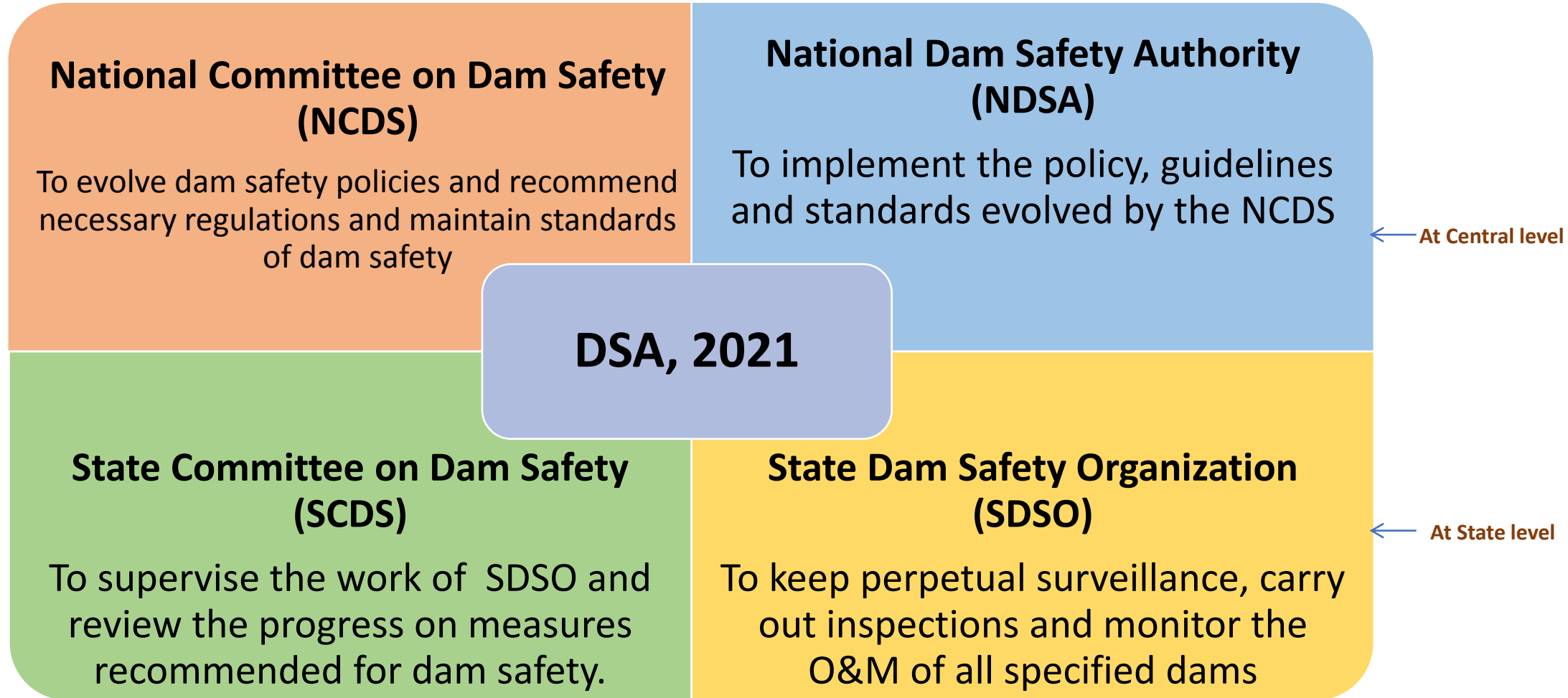
- Dam Safety Assurance and Rehabilitation Project (DSARP) (1991-99)
- Dam Rehabilitation and Improvement Project (DRIP) Ph- I (2012-21)
- DRIP Ph-II & III (2021-31)



4. Dam Safety Act, 2021 (30th Dec 2021)

- Provides:
 - Uniform dam safety procedures
 - Regular surveillance, inspection, operation and maintenance of the specified dams.
 - National and state-level bodies for dam safety.

Institutional Setup at the National & State Level





DSA, 2021 – Major Activities



Year	Pre-Monsoon Inspection	Post-Monsoon Inspection
2022	3,919	5,024
2023	6329	

Pre-Dam Safety Act Period

1200 (Annual)



Pre & Post-monsoon Inspection of Dams & Follow-up



During pre-monsoon inspection 2023, 2 dams were reported as Category-I dams and 183 dams under Category-II dams.



NDSA takes up the matter with the concerned States having Category-I (rehabilitation of both dams proposed under DRIP) and Category-II dams to take immediate remedial measures to ensure their safety and prevent untoward incidents.

Category-I: Deficiencies in dams which may lead to failure (If left unattended)

Category-II: Major deficiencies in dams requiring prompt remedial measures

Category-III: None or minor remedial measures in dams which are rectifiable



Dam Safety Act, 2021- Paradigm shift

- Changing the State Govt. perception of dam safety.
- Regular meetings of NCDS & NDSA for Dam Safety awareness at the Pan India level.
- Formulation of Uniform Regulations by NDSA to be implemented at Pan India level.
- Regular Pre/Post-Monsoon inspections of almost 100% specified dams, i.e. from about 1200 inspections annually before the Act to about 12000 inspections annually after the Act.
- Categorization of dams based on pre and post-monsoon inspections and accordingly planning the prioritised remedial measures for dams at risk.
- Introduction of specially designed M.Tech. Course on Dam Safety at IIT-R & IISc, Bangalore.
- Capacity building of organisations like CWPRS, CSMRS, NWA, etc.
- NDSA has brought a pool of experts to one platform by empanelling Dam Safety Experts.
- Capacity building of dam owners through regular training programs at NWA
- Establishment of International Centre of Excellence at IIT-R & IISc.
- Penal Provisions for Dam Safety lapses



Major Safety and related issues being faced

- Major safety-related issues being faced:
 - **1) Structural:**
 - Seepage
 - Underwater Rehabilitation works.
 - Hydraulic, Hydrological and Operational Safety.
 - Structural Stability
 - Sediment management
 - **2) Institutional:**
 - Lack of well-established organisations and procedures for Dam Safety at the state level.
 - Lack of regular and dedicated funds towards Dam Safety.
 - **3) Non-structural:**
 - Emergency Action Plan (EAP) & Operation & Maintenance (O&M) Manual of all the Specified dams (> 6000 dams).





Dam Safety Rehabilitation Programs



- Externally aided Dam Rehabilitation Programs.
- Helped the dam-owning agencies by providing the latest state-of-the-art dam rehabilitation techniques, institutional strengthening and funds for rehabilitations of selected dams.
- The objective is to improve the safety and performance of dams and associated appurtenances sustainably, along with the Institutional strengthening and capacity building of the SDSO.





DRIP - Key Achievements



Institutional Strengthening

- Institutional setup was strengthened for a sustainable dam safety culture.
- Central Project Management Unit (CPMU): At National level
- State Project Management Unit (SPMU): At State level
- Project Authorities: At the dam level

Uniform dam safety procedures

- 13 Guidelines/Manuals were published to ensure uniform/standardised dam safety practices/ protocols/guidelines/manuals across the country
- Prepared 217 EAPs and 221 O&M Manuals

Capacity Building

- 186 National and international trainings organised benefitting about 5500 officials
- 3 National Dam Safety Conferences and 2 International Dam Safety Conferences organized.
- M. Tech courses in Dam Safety started at IIT Roorkee and IISc Bangalore

DHARMA

- A web-based asset management tool to support effective collection and management of asset and health data of dams
- Multilevel access at Central, State and Project Levels



Structural Issues and State of Art Solutions



Seepage Control



Seepage Control at Malaprabha dam, Karnataka

Initial observed seepage (in gallery) = 850 L/min

- ✓ Dam body & foundation grouting
- ✓ U/s face racking pointing with UV resistant high strength mortar including under water.
- ✓ Seepage after treatment (gallery) = 90 L/min



Seepage Control at Servalar dam, Tamilnadu

Initial observed seepage (gallery) = 742.65 L/min

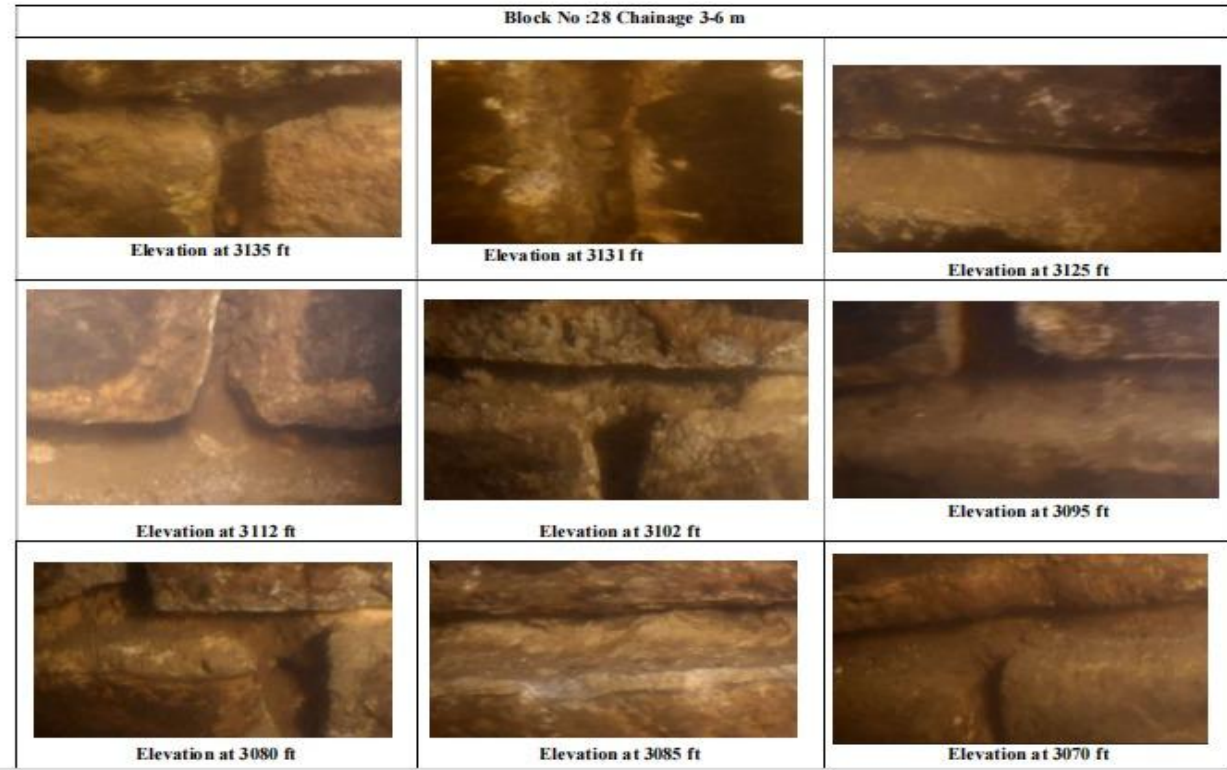
- ✓ Left flank and overflow section u/s face- Geomembrane
- ✓ Right flank – Racking & pointing plus joint treatment
- ✓ Seepage after treatment (gallery) = 66.34 L/min



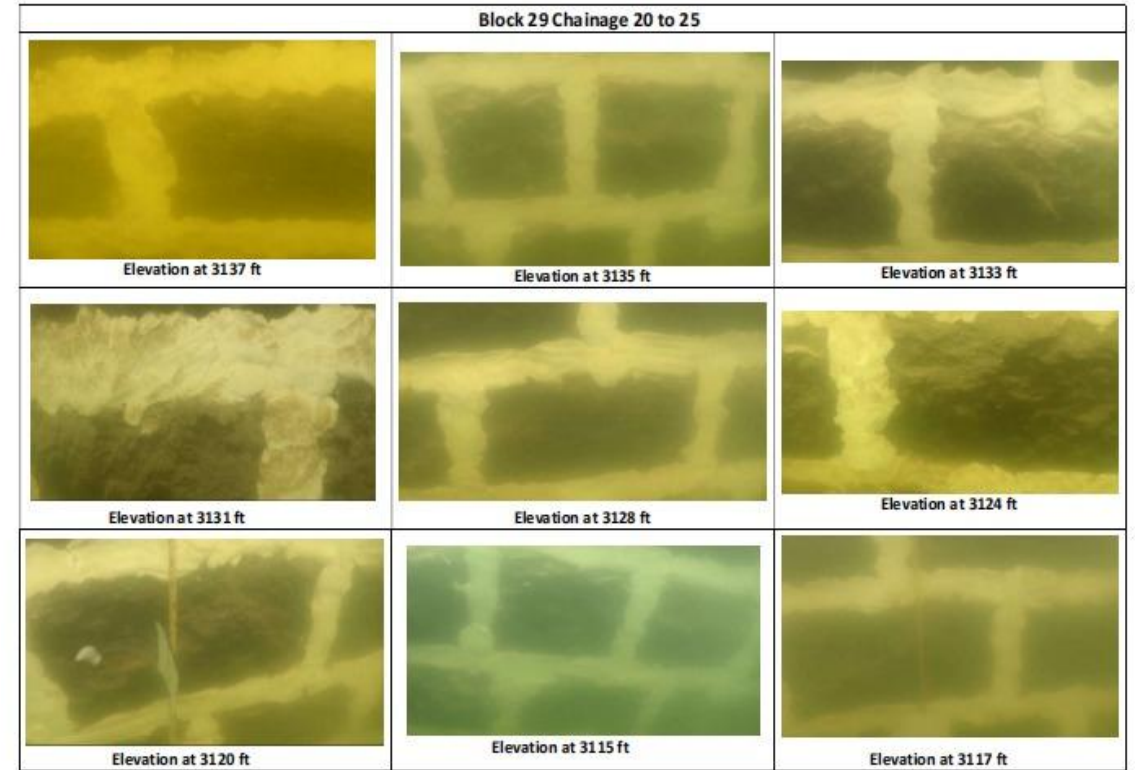
Structural Issues and State of Art Solutions



Underwater Inspection & Dam Rehabilitation :



Before



After

Raking and Pointing at Sholayar Dam



Structural Issues and State of Art Solutions



1-c) Tackling Hydraulic and Operational safety

Hydraulic Safety at Maneri Dam

Repair of spillway glacis and energy dissipater with M90 concrete (Maneri Dam, UJVNL)



Operational Safety at KRS Dam, Karnataka

Ageing of H-M equipments, gate leakage, surface deterioration, poor water quality

✓ *Replacement of 136 sluice gates*



Structural Issues and State of Art Solutions

1-d) Tackling Stability:

Pechiperai Dam, Tamil Nadu

- Seismic Zone - III
- The existing dam was found unsafe under seismic loading

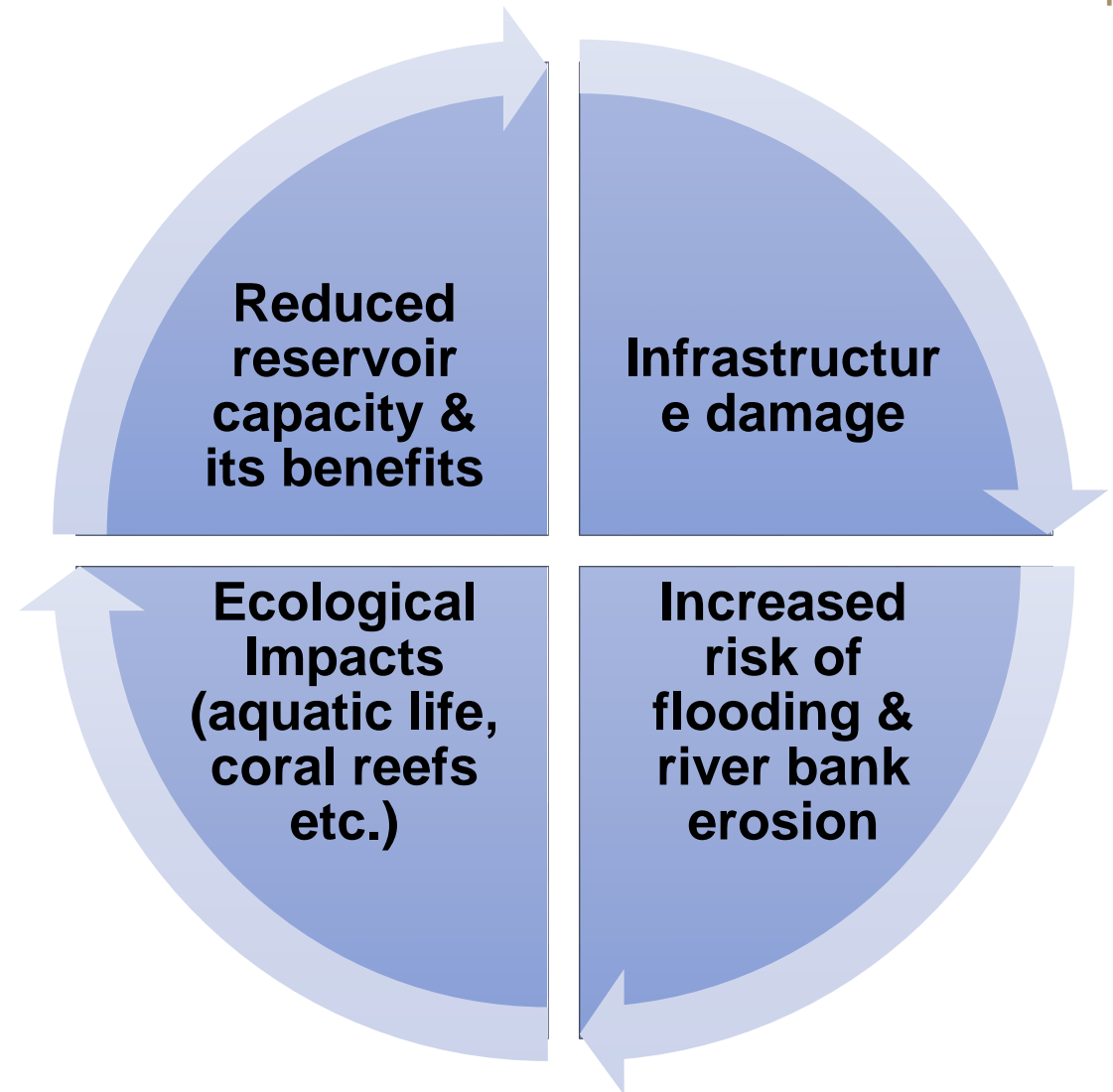
✓ *Backing Concrete*





Sedimentation: Causes & Impacts

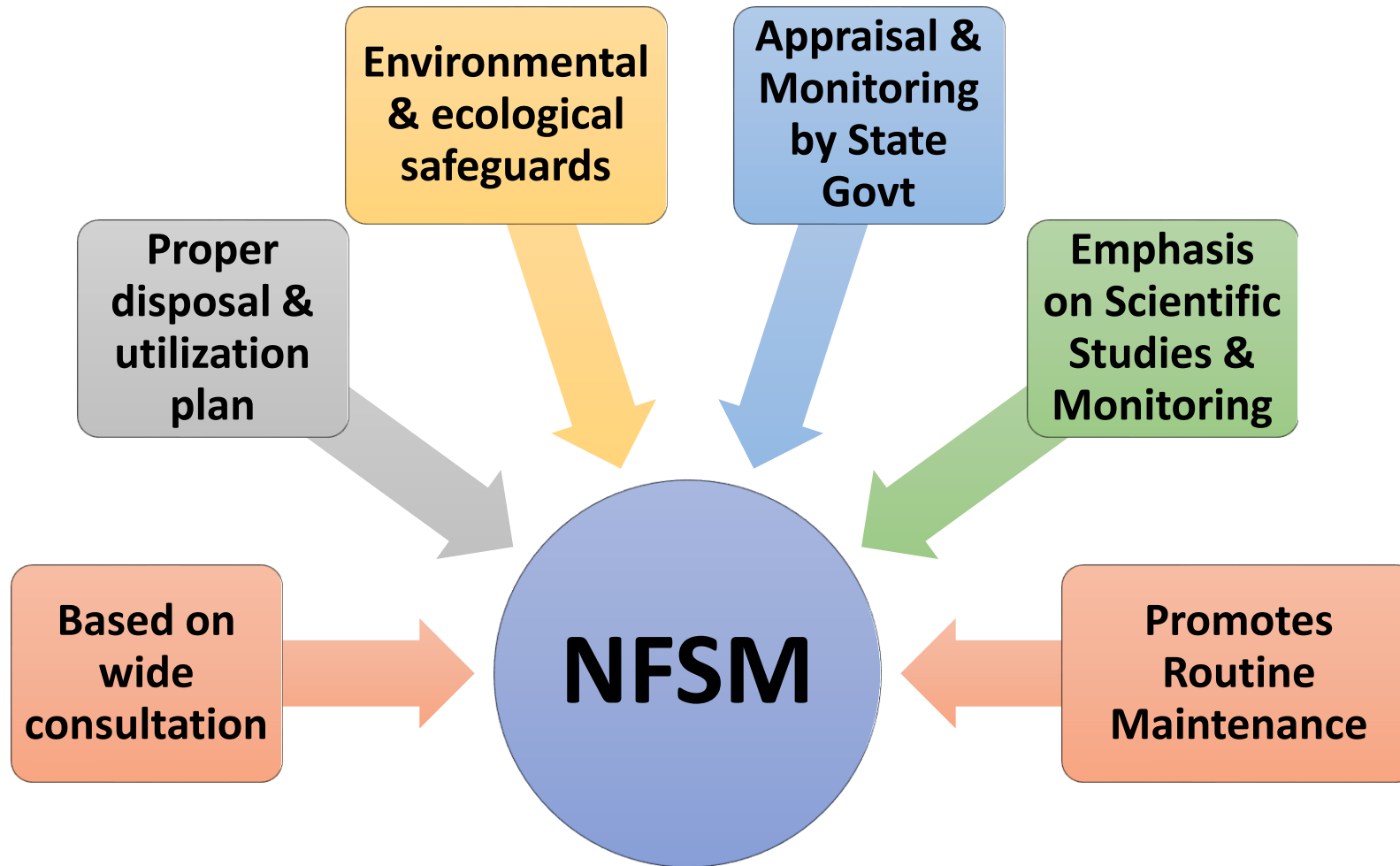
- Deforestation in catchment
- Urbanisation and Industrialization in flood plains
- Encroachment in river bed
- Cloud burst and flash floods
- Changes in land use and land cover
- Mining operations



Estimated Live Storage Loss by 2050: 50 BCM

Sample study of 146 reservoirs has shown 13.30% loss of live storage till 2022

Policy Formulation: National Framework on Sediment Management- Jan,2023



Provisions of Dredging/Desilting

No Clearance Required For

- Navigation Channels- IWAI
- Upkeep Maintenance & Disaster Management

Allowed with Safeguards

- Feasibility Report to include Disposal/Utilization Plan
- EIA studies/Environmental Management Plan

Holistic and comprehensive sediment management for guidance to States

MAITHON DAM WATERSHED MANAGEMENT

Maithon dam (Damodar Valley Corporation - DVC) is a 56.08 m high composite dam constructed across river Barakar, Dhanbad District (Jharkhand). The initial gross storage capacity of Maithon dam is 1196 MCM with live storage of 607 MCM considering the Maximum flood management pool of 150.91 m (495 ft.) and minimum drawdown level of 132.62 m (435 ft.).

- It is a multipurpose dam with main function of flood control, supplying water for irrigation, Municipal & Industrial use, hydro power generation, and tourism. The construction commenced in December' 1951 and completed in September' 1957.
- Damodar Valley Corporation is working since 1949-50 to tackle the soil erosional problems in upper Damodar-Barakar catchment area through soil and water conservation/integrated watershed management programs with multidisciplinary approach by its Soil Conservation Department located at Hazaribagh.



Drainage line treatment



Rainwater harvesting structures



- ✓ Afforestation, Pastoral Development, Contour Trenching
- ✓ Field hedge, pasture and horticultural development, drainage line treatments, silt detention dams, ponds' renovation, reclamation of land, demonstrations on moisture conservation
- ✓ Construction of water harvesting structures

- Measures have played a significant role in arresting sediment deposition by more than 60% which has resulted, among other benefits, in **reducing loss rates in storage capacity from 7.38 MCM/year (years 1955-65) to 1.37 MCM/Year (years 2002-19).**

SHIHMEN DAM (TAIWAN) SEDIMENT MANAGEMENT

The reservoir management in Taiwan faces lots of challenge. The main source of rainfall is the northeast monsoon. Mean annual precipitation is about 2500 mm/year. On an average 3 to 4 typhoon strike the country every year. **Soil erosion is very high, almost having a rate of 3 to 6 mm/year.** Shihmen dam is located very near to Taoyuan city of Taiwan. It was commissioned in year 1964

- The gross storage capacity is 309 MCM. **This dam is a classic example of post construction retrofitting for integrated sediment management.** The journey of sediment management started by construction of 121 check dams which majority of these got filled by year 2007. **It is estimated that annual inflow of sediment in reservoir is 3.42 MCM.**

SUSTAINABLE SEDIMENT MANAGEMENT STRATEGIES AT SHIHMEN DAM

Sediment yield reduction (Check Dams)

Mechanical & Hydraulic Dredging

Sluicing

Routing-venting turbidity currents



Simultaneous operation of spillway and penstock sluice venting turbid density current

- Then structural inventions included modification of permanent river outlet gates (4%) by replacing the original Howell-Bunger valve with a jet flow gate to allow sluicing during high flow events, renovated the power plant penstocks, replacing one penstock with a sluicing pipe and modifying the other penstock for electricity generation (55%), introduction of two nos of sediment-bye pass tunnels i.e. Dawanping (21%, under construction) and amuping (19%, commissioned) silt sluice tunnels. Also, some part is managed by dredging near dam(15%) and dredging upstream of dam(12%). **This arrangement is almost balancing the inflow sediment with outgoing sediment volume**



Tackling Institutional setup



Institutional Strengthening

- Institutional setup has been strengthened for a sustainable dam safety culture under DRIP, which got a further fillip after the passage of the Dam Safety Act.
- All the States now have SCDS and SDSO.
- States/ dam owners are being encouraged to have dedicated funds for the purpose of Dam Safety, which has become obligatory on the part of dam owners after the passage of the Dam Safety Act, 2021.



Non- structural issues

Emergency Action Plan (EAP), Operation & Maintenance (O&M) Manual, Instrumentation and Regular Monitoring of Dams

- For establishing uniform protocols/procedures for dam safety, such as EAP and O&M, etc., CWC has issued 13 guidelines under DRIP.
- NDSA is in the process of issuing regulations/guidelines for uniform protocol/ procedures for ensuring dam safety however, till then, CWC guidelines are to be used.



13 Guidelines published :



Guidelines for Developing Emergency Action Plans for Dams (February 2016)

Manual for Rehabilitation of Large Dams (January 2018)

Guidelines for Instrumentation of Large Dams (January 2018)

Guidelines for Preparing Operations and Maintenance Manuals for Dams (January 2018)

Guidelines for Mapping Flood Risks Associated with Dams (January 2018)

Guidelines for Safety Inspections of Dams (January 2018)

Guidelines for Assessing and Managing Reservoir Sedimentation (February 2019)

Guidelines for Assessing and Managing Risks Associated with Dams (February 2019)

Guidelines for Operation Procedures for Assessing and Managing Environmental Impacts in Existing Dam Projects (November 2020)

Guidelines for Classifying the Hazard Potential of Dams (November 2020)

Manual for Assessing Structural Safety of Existing Dams (November 2020)

Manual for Assessing the Hydraulic Safety of Dams (June 2021)

Guidelines for Selecting and Accommodating Inflow Design Floods for Dams (June 2021)



Conclusion & Way forward



Dam Safety is important to India for protecting the precious assets created and providing safety to the population settled downstream.



The enactment of DSA 2021 has made Dam Safety mandatory on the part of all stakeholders.



Capacity building of all stakeholders is necessary for implementation of provisions of the Act.



Strengthening of Institutional Mechanism is essential for implementation of the Act.



Availability of adequate funds to undertake proper operation and maintenance and also carry out rehabilitation to ensure dam safety.



Collaboration with the States in creating the Eco-system in the country on Dam Safety aspects.



International collaborations with expert agencies specially in advanced areas of dam safety such as Risk Assessment and Comprehensive Dam Safety Review etc.



International Conference on Dam Safety, 2023



Thank You

September 14th – 16th 2023, Jaipur, Rajasthan



Indian Presence in other Countries



International presence of Ministry of Jal Shakti, GoI through its organisations

- ❑ WAPCOS has provided engineering consultancy services to various clients since its creation in over fifty (50) countries, particularly in South Asia and across Africa, in areas of water, power and infrastructure sectors by undertaking engineering consultancy services for various development projects
- ❑ Apart from India, WAPCOS has successfully completed/on-going consultancy assignments in countries covering Asia, Africa, Middle East, South America, Pacific Islands including Angola, Afghanistan, Bangladesh, Benin, Bhutan, Burkina Faso, Burundi, Cambodia, Central African Republic, Chad, DR Congo, Ethiopia, Fiji, Georgia, Ghana, Guinea Conakry, Indonesia, Kenya, Kazakhstan, Lao PDR, Lesotho, Liberia, Malawi, Maldives, Mali, Mongolia, Mozambique, Myanmar, Nauru, Nepal, Niger, Nigeria, Philippines, Rwanda, Senegal, Sierra Leone, South Sudan, Sri Lanka, Swaziland, Tanzania, Tajikistan, Togo, Uganda, Uzbekistan, Vietnam, Yemen and Zimbabwe.
- ❑ Presently, WAPCOS is undertaking ongoing projects in thirty (30) countries i.e., Bangladesh, Bhutan, Burundi, Botswana, Cambodia, Cuba, Central African Republic, DR Congo, Eswatini, Ethiopia, Fiji Islands, Ghana, Gambia, Indonesia, Liberia, Lao PDR, Mozambique, Myanmar, Mongolia, Nicaragua, Niger, Nepal, Rwanda, Suriname, Senegal, Tanzania, Togo, Uganda and Zimbabwe including India