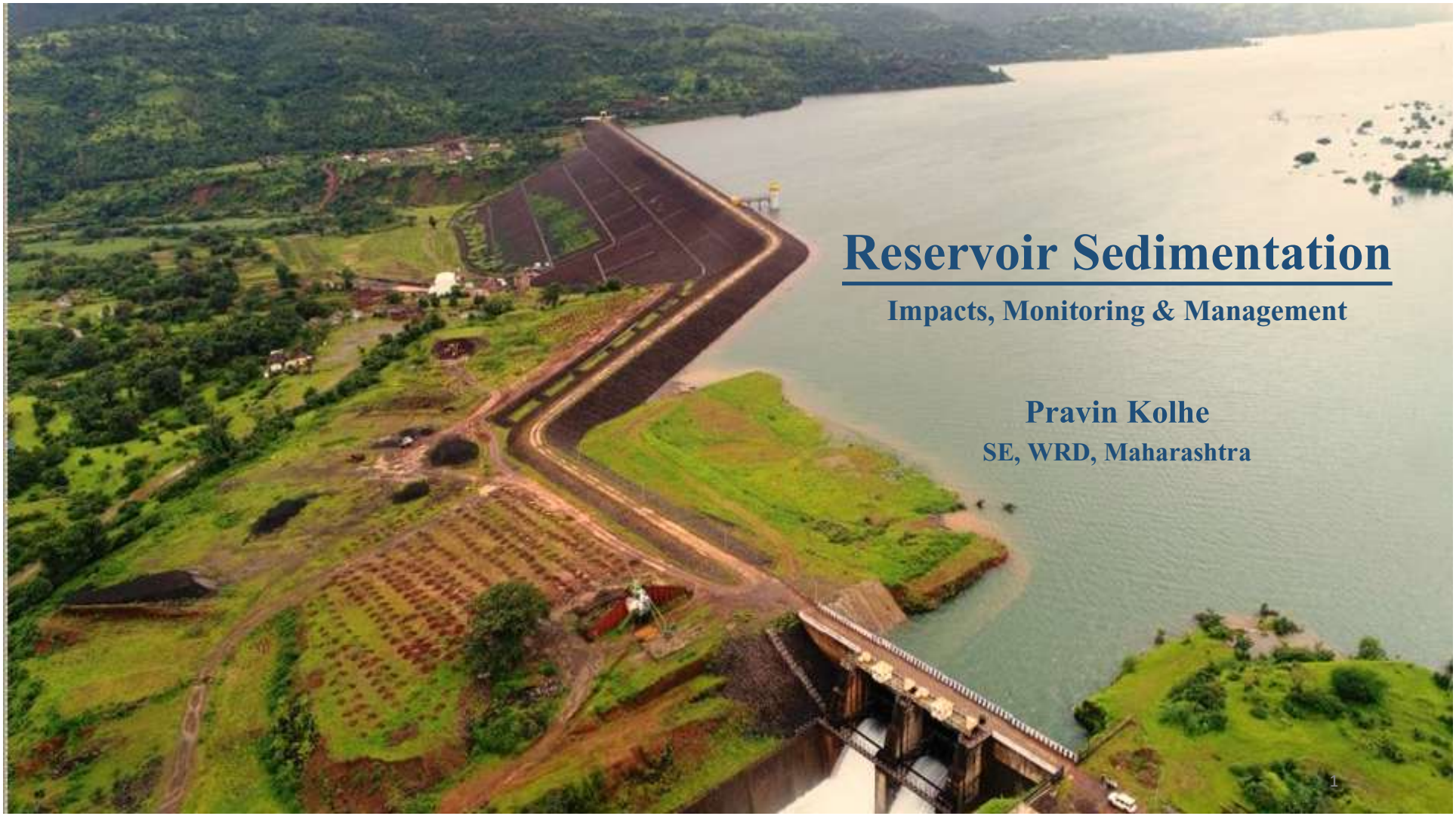


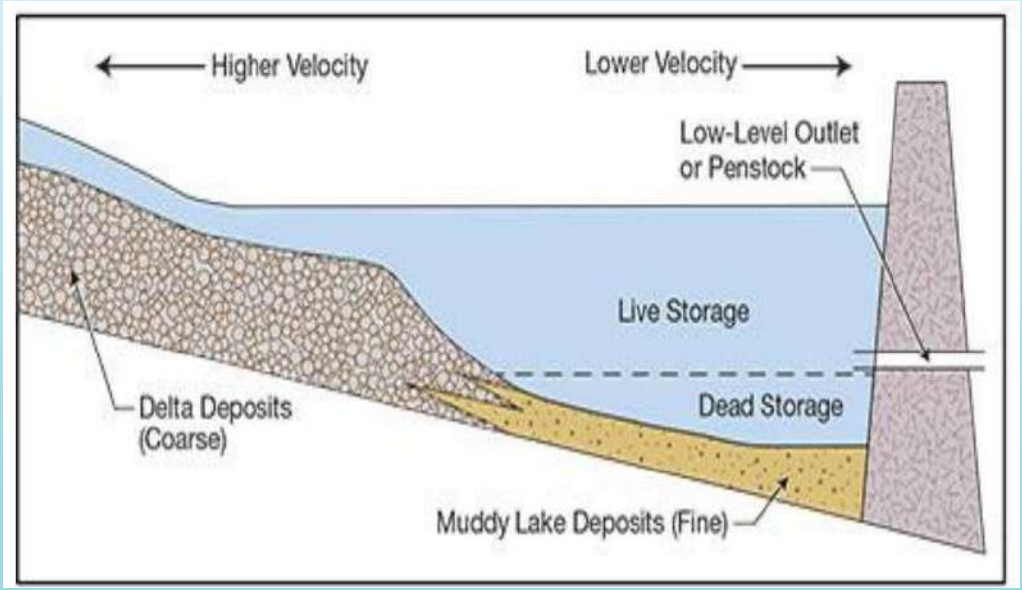
Reservoir Sedimentation

Impacts, Monitoring & Management

Pravin Kolhe
SE, WRD, Maharashtra

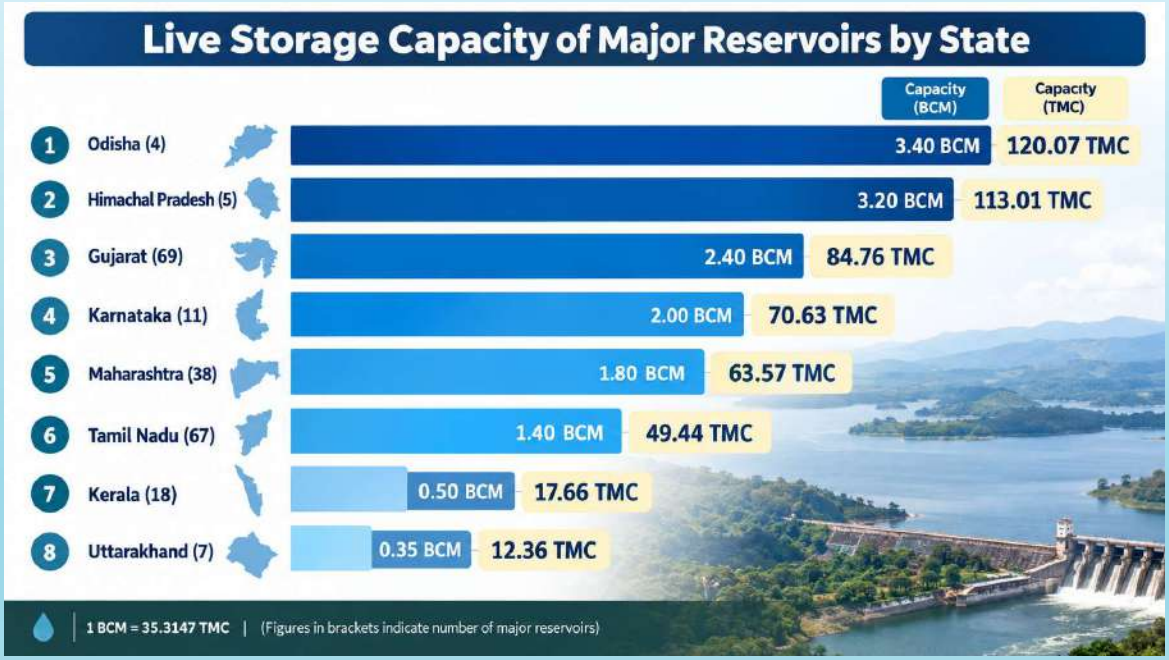
DAMS AND SILTATION

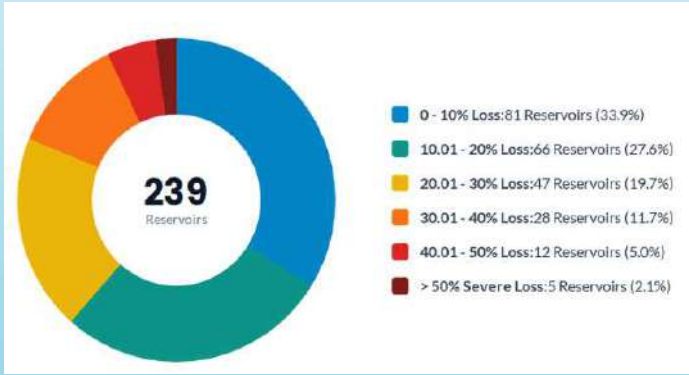
- Total Large Dams in India = 6281 (NRLD-2023)
- Large Dams in MH = 2374 (38%)
- Dams designed for Live Storage
- Dead Storage = Silt Pocket
- Assumed rate of siltation Vs actual rate



Typical Reservoir Sediment Profile (Source: Morris, 1998)

SEDIMENTATION ACROSS INDIAN RIVER BASINS



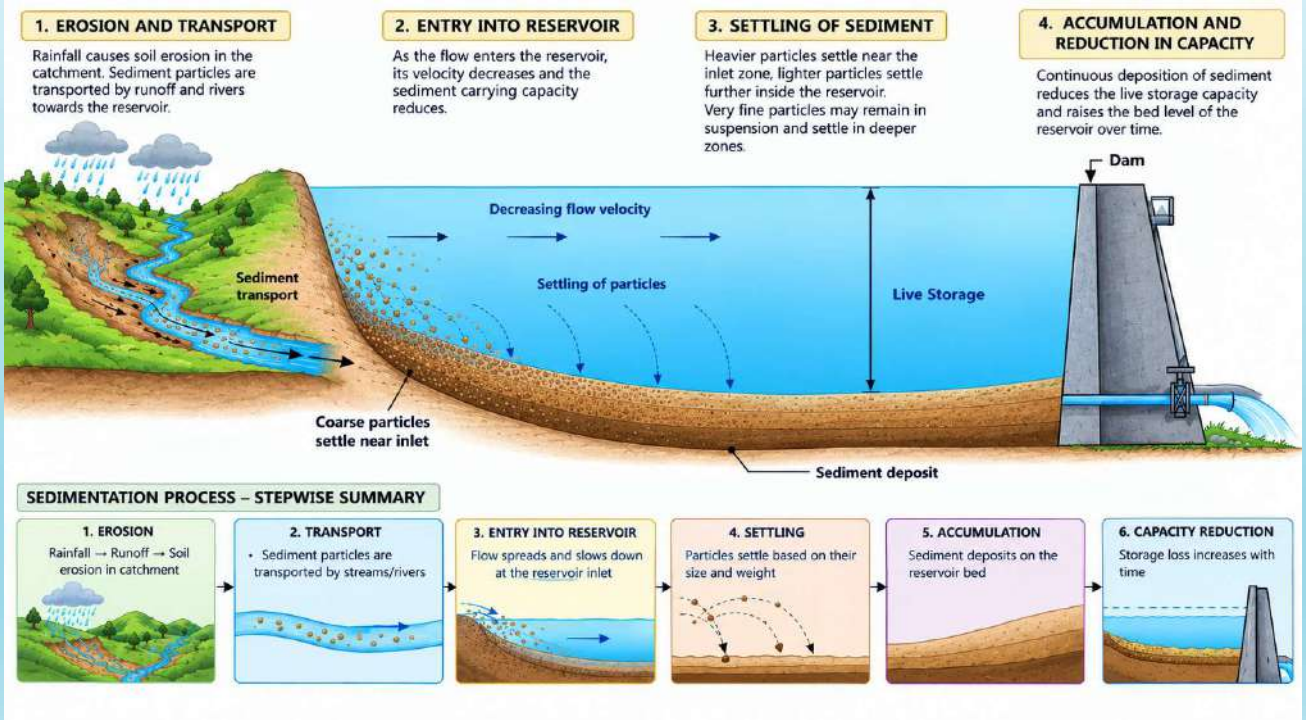


Capacity Loss Severity in 239 Reservoirs

Source: *National register of Large Dams (NRLD) 2018; CWC Handbook for Assessing and Managing Reservoir Sedimentation, Government of India*

THE SEDIMENTATION PROCESS

1 · Catchment erosion > 2 · River transport > 3 · Reservoir deposition



TRAP EFFICIENCY

The share of incoming sediment a reservoir retains – often 80 to 95 %

High trap efficiency is good for water clarity but accelerates storage loss: the more sediment a reservoir holds back, the faster its useful capacity shrinks

Sources of Sedimentation -	Impacts
• Catchment land erosion: natural erosion, landslides etc • Land use changes: deforestation, agriculture and urbanization • Climate-driven runoff: intensifying rainfall and flood events	• Loss of (Live) storage & capacity reduction • Abrasion of Intake & Equipments (Gates / Turbines etc.) • Operation issues – Gate opening

MEASUREMENT OF SEDIMENTATION

Bathymetric Survey

Echo-sounder measures present reservoir bed elevation along survey transects

Pre- & Post-Impoundment Comparison

Compares original and present reservoir bed levels

Sediment Core Sampling

Collects vertical sediment samples from the reservoir bed

Sediment Inflow Monitoring

Measures suspended and bed-load sediment entering the reservoir

Remote Sensing & GIS

Uses satellite imagery and water-spread relationships

Hydrographic Survey

Combines depth measurements with precise positioning

MANAGEMENT STRATEGIES

Prevention

Catchment erosion control, upstream sediment trapping, and bypass sediment before it reaches dam

Removal

Dredging, flushing, sluicing sediments already deposited in the reservoir

Adaptation

Raise intakes, redesign outlets, and plan for a reduced future storage envelope

Source: Strategy classification synthesized from ICOLD, USACE and international reservoir-sedimentation literature.

Removal: Dredging & Flushing

60–80%

of annual inflow can be evacuated during a well-executed flushing operation



Comparison of removal methods

Dredging: Mechanical removal, high cost, continuous operation

Flushing: Drawdown + high velocity flow, most widely adopted

Controlled sediment flushing is the most widely adopted active mitigation measure worldwide

ENVIRONMENTAL, SAFETY AND REGULATORY CONSIDERATIONS

Safety First

No excavation plan should compromise dam stability or downstream safety

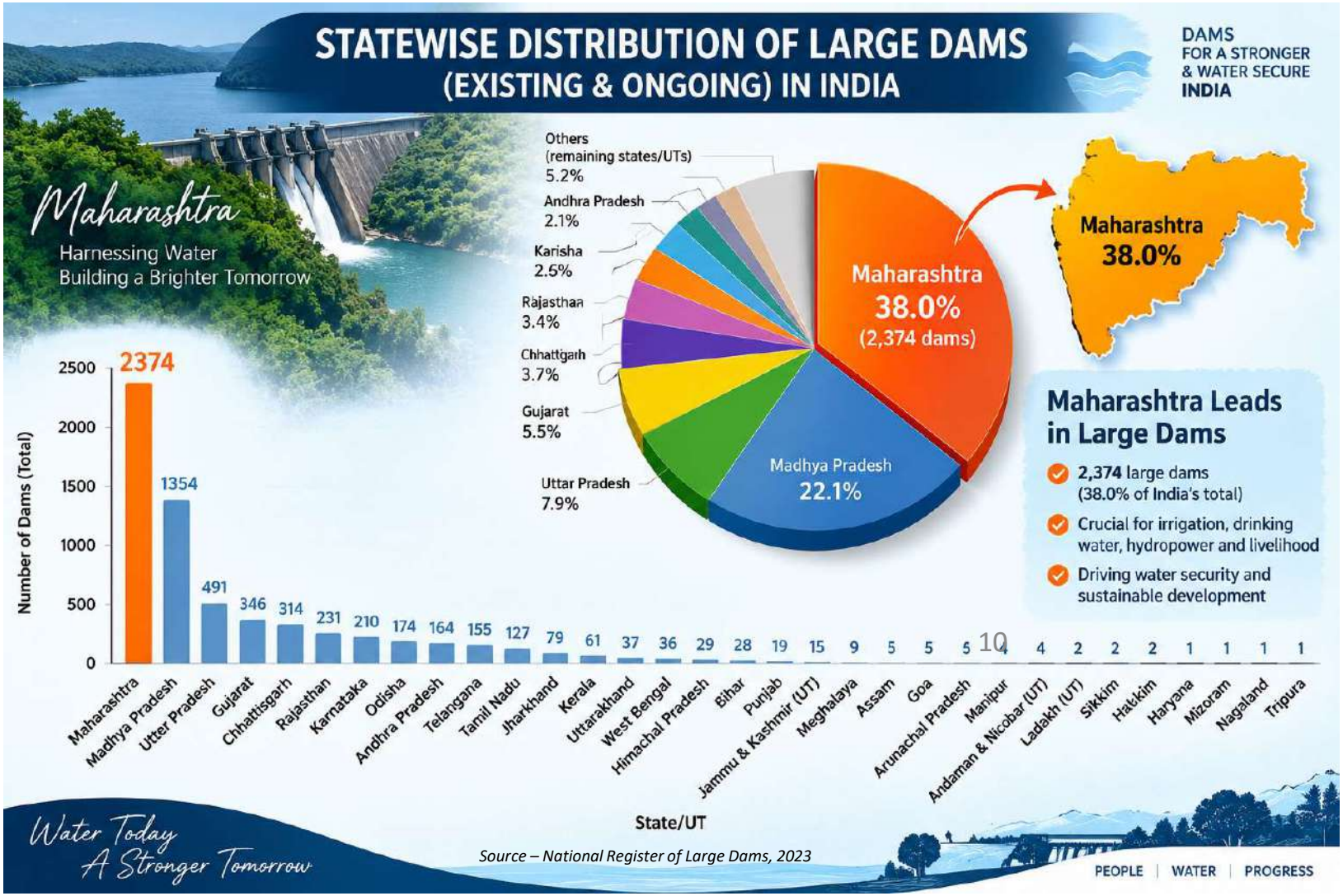
Water Quality

Monitor turbidity and other relevant parameters during work

Compliance

Project-specific statutory approvals, technical conditions must be confirmed before execution

- Maintain drawdown and equipment movement dam and downstream safety during
- Control turbidity and avoid uncontrolled release of sediment-laden water
- Protect fish, aquatic habitat, drinking water intakes and downstream users
- Provide safe access, life saving equipment and emergency response arrangements
- Obtain applicable permissions / environmental clearances and follow dam-safety requirements



Source – National Register of Large Dams, 2023

Ujjani Reservoir De-siltation status



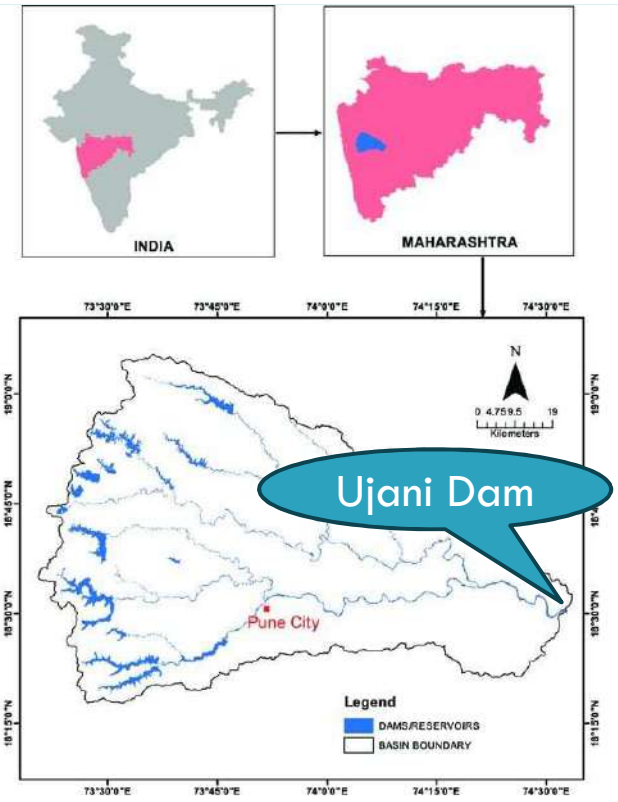
Location: Madha, Solapur (Pune-Solapur Border).

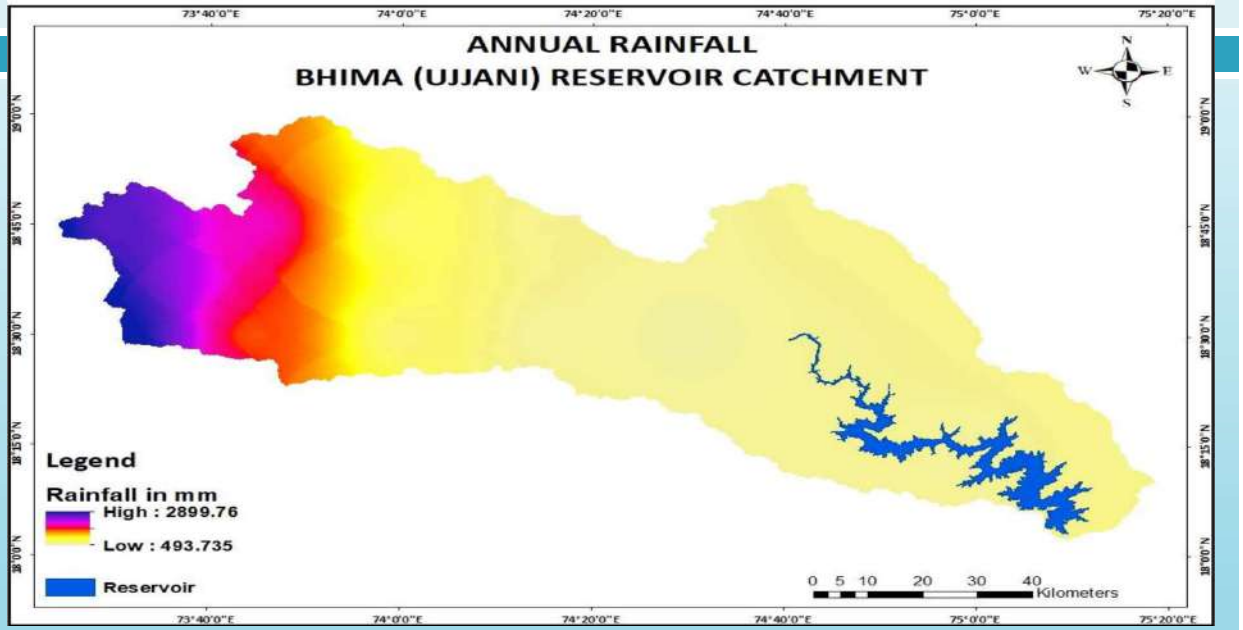
Age: Operational since 1980 (40+ years).

Impact: Primary water source for irrigation, industry, and municipal use in Solapur district.

Case Study

LOCATION OF UJANI DAM





- Ujani Dam is a major terminal reservoir on the Bhima River
- There are 18 major dams on u/s of Ujani
- It is situated at comparatively flatter terrain with low rainfall

Ujani Dam

Yashawant Sagar Reservoir

Key Features at a Glance



Reservoir

Name	:	Yashawant Sagar Reservoir
Gross Storage	:	**3,320 MCM (117 TMC)**
Live Storage	:	**1,517 MCM (54 TMC)**
Dead Storage	:	**1,803 MCM (63 TMC)**

Dam

Location (Lat, Lon)	:	18.0733° N , 75.1208° E
Total Length	:	2,534 m
Masonry Portion	:	914 m
Maximum Height	:	56.40 m



Spillway

Type	:	Radial Gates
Number of Gates	:	41
Gate Size	:	12 m × 7 m (each)
Flood Discharge Capacity	:	18,010 Cumecs (6.36 lakh cusecs)

Instrumentation

Casagrande Piezometers	:	27
Earth Dam V-Notches	:	7
Masonry V-Notches	:	12
U.P. Cells	:	22



Irrigation

Left Bank Canal (LBC)	:	126 km | 29,830 ha
Right Bank Canal (RBC)	:	132 km | 51,800 ha
Total Irrigable Area	:	**1,81,833 ha**



Multipurpose Benefits

Irrigation	:	Yes
Drinking Water Supply	:	Yes
Hydropower	:	12 MW
Annual Generation (Initial Stage)	:	up to 105 MU

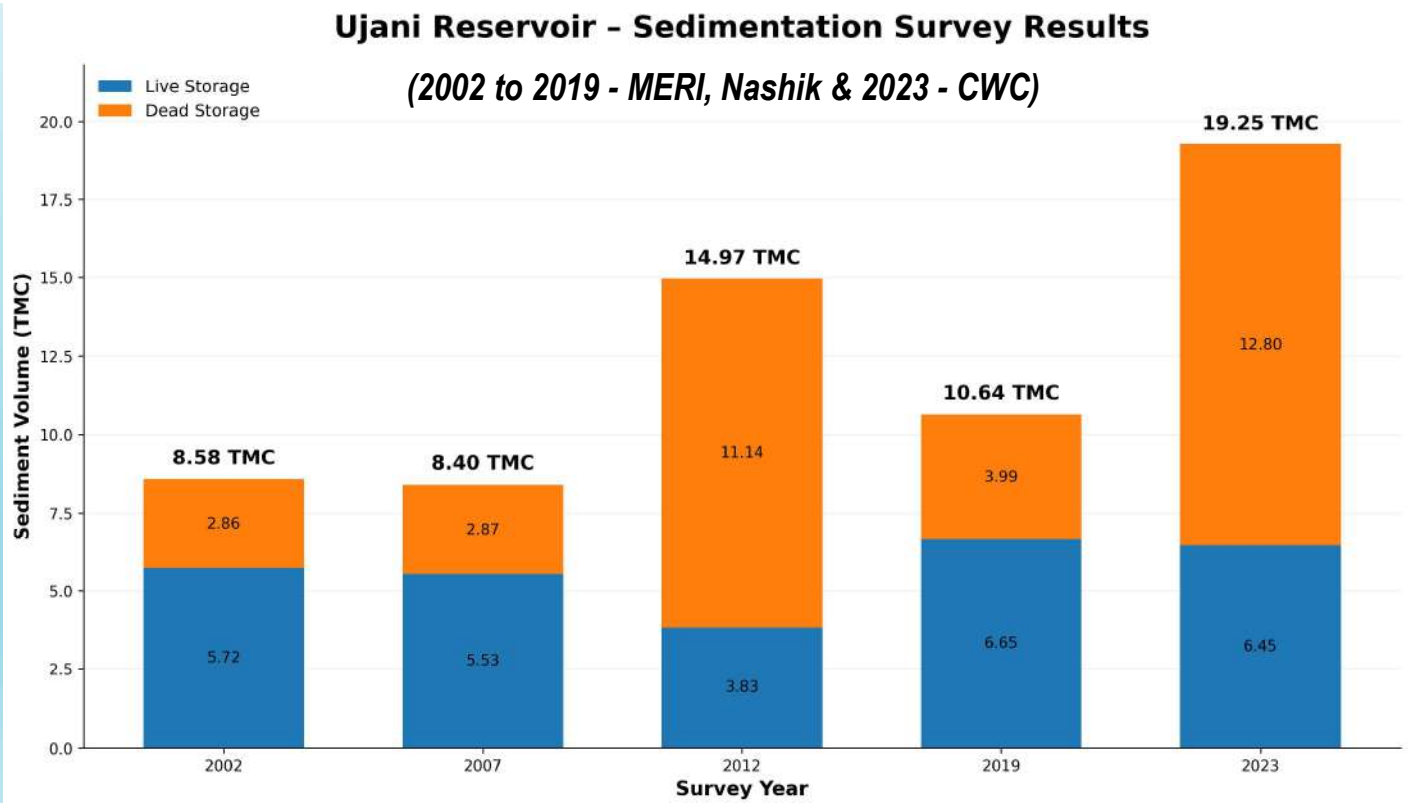


The project was designed with an expected siltation rate of **3.57 Ha.m / 100 sq.km / Year.**
Real-time accumulation has exceeded these design parameters due to upstream land-use changes.

ANALYSIS OF SILTATION STUDY

- Dam construction started = 1966
- Completed = 1977
- Age till 2026 = 50 years
- Catchement area = 9,201 Sq km, Submergence Area = 284 Sq km
- FRL = 496.83m; MDDL = 491.03m

SEDIMENTATION STUDIES



STORAGE LOST (2023 STUDY)

- Designed rate of siltation : 3.57 Ha-m/100 km²/year
- Estimated actual rate : 8.15 Ha-m/100 km²/year
- Annual sediment accumulation: 11.85 MCM/year
- i.e. ACTUAL SILTATION RATE ≈ 2.3 × DESIGN RATE
- Equivalent: 1.29 mm/year

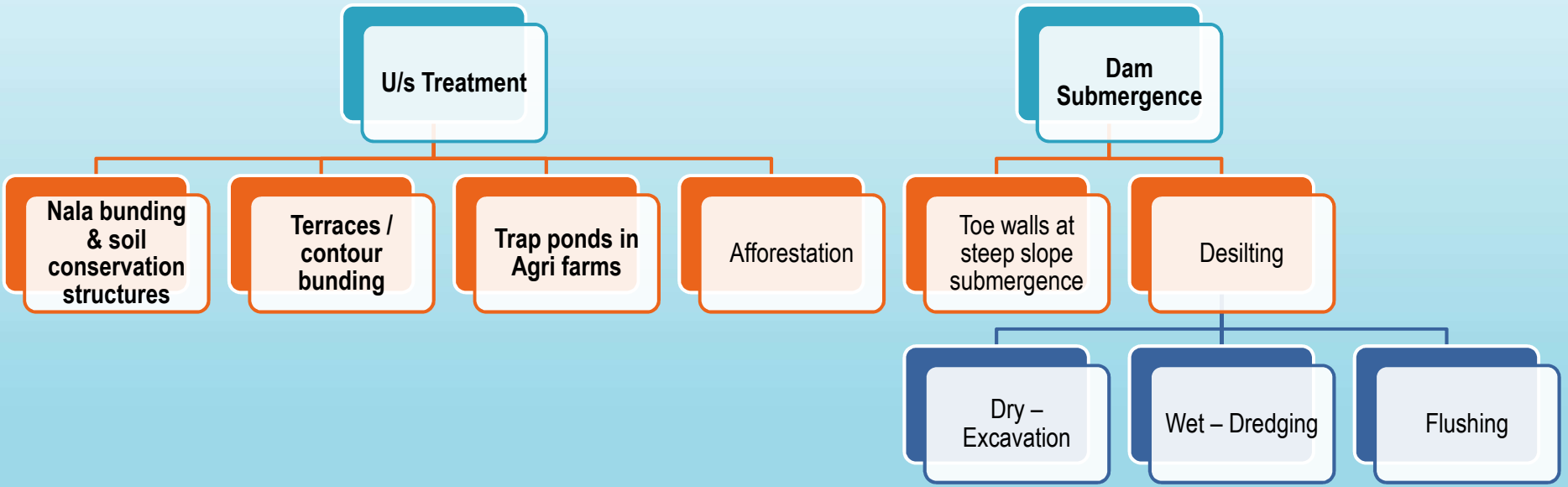
- **Loss in Capacity**
  - Gross: 0.36% per year
  - Live: 0.26% per year
  - Dead: 0.44% per year

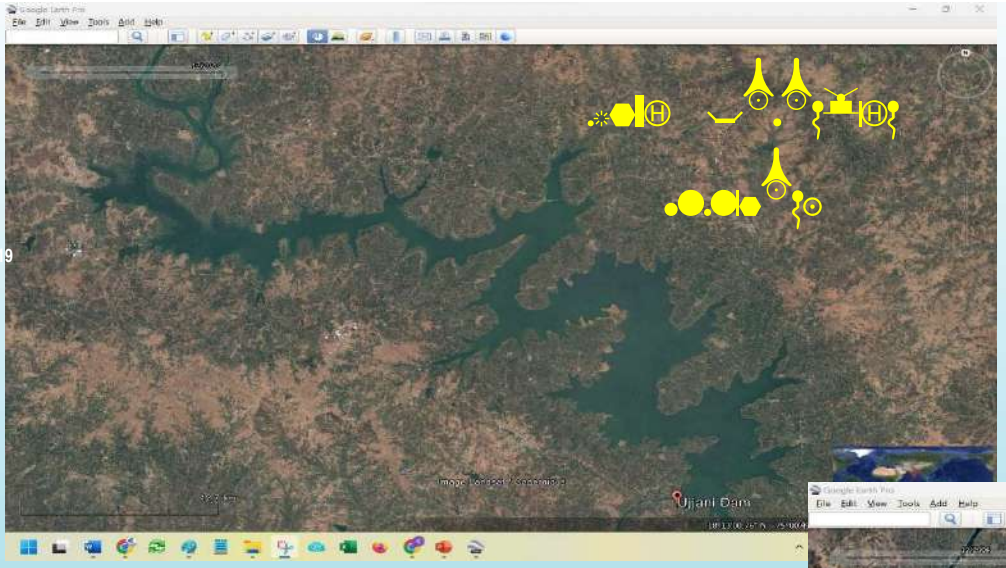
Storage	Original Capacity (TMC)	Sedimentation Loss (TMC)	Loss (%)	Revised 2023 Capacity (TMC)
Live Storage	53.58	6.45	12.04%	47.13
Dead Storage	63.66	12.80	20.11%	50.86
Gross Storage	**117.24**	**19.25**	**16.42%**	**98.00**

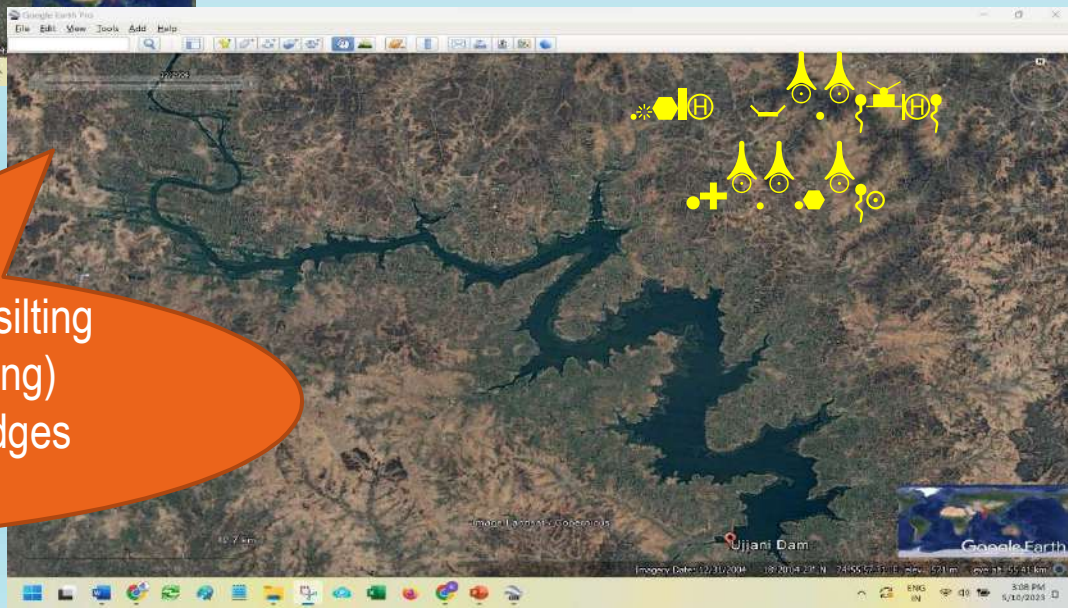
CATCHMENT AREA TREATMENT

- Factors causing siltation
  - Rainfall
  - Soil erodibility
  - Slope length
  - Crop
  - Soil protection
- Catchment Area Treatment based on erosion potential values.
  - Priority 1 = maximum erosion potential
    - 30% area – Soil conservation measures
  - Priority 2 = least erosion potential.
    - 70 % area comes under Priority 5 where no treatment is needed.

REMEDIAL STRATEGIES







June to October (Monsoon) – No Desilting

Oct to May – Wet Desilting (Dredging)

Dec to May – Dry Desilting along edges

Desilting Process & Revenue Model

1 Survey & Quantification

Determine total quantity of silt and sand.



- Hydrographic survey
- Estimate total silt and sand quantity
- Prepare desilting plan and drawings

2 Extraction by Tendering



- Remove **both silt and sand**; extraction of sand alone is not permitted.
- Desilting to leave at least **2 ft above natural ground level.**
- Work to proceed **chainage-by-chainage** from the downstream/end portion towards the head.

3 Separation



- Separate **sand** from silt-mixed material.



Sand (commercial value)

Silt (agricultural use)

4 Utilisation

Sand

Commercial sale by the agency



Silt

Agricultural soil improvement – free of cost to farmers, No royalty



Contractor is responsible for loading silt into the farmer's vehicle.

Transportation at farmer's cost.

₹ Revenue Generation Model

Royalty
to Revenue Department

Upset Price
to Water Resources Department (WRD)

Key *Issues* & Challenges in Desilting

Large-scale handling and utilisation

Enormous quantities of sediment need to be handled, separated and beneficially utilised.



Safety & ecological issues

Potential impacts on aquatic ecosystems and water quality during extraction.



Environmental clearances

Mandatory environmental clearances and compliance with regulatory requirements.



Transportation & logistics

Large volumes of sediment require dedicated transport arrangements and adequate infrastructure.



Monitoring to prevent illegal extraction

Excavation, stockyards and transportation must be closely monitored to prevent unauthorised extraction and movement.



Avoid re-entry of silts during monsoon

Measures are required to prevent re-deposition of sediments into the reservoir during the monsoon.



Continued catchment erosion

Desilting must be combined with upstream soil and water conservation to reduce future sediment inflow.



Way Ahead – Sustainable Sediment Management in Maharashtra

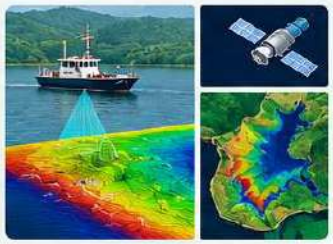
1 State-wide Sediment Management Policy

- Shift from project-specific desilting to a State-wide policy and framework
- Standard guidelines, institutional mechanism and clear roles & responsibilities



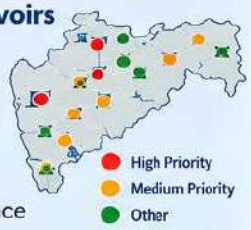
2 Regular Sediment Assessment

- Periodic hydrographic surveys
- Use of GIS, remote sensing and drone surveys
- Create a state-wide sediment database and digital platform



3 Prioritise Reservoirs

- Based on storage loss
- Sedimentation rate
- Irrigation and water supply benefits
- Economic feasibility and regional importance



4 Adopt a Mix of Methods

- Desilting / dredging
- Drawdown flushing (where feasible)
- Sediment trapping upstream
- Site-specific selection based on reservoir conditions







5 Treat Sediment as a Resource

- Separate and utilise sand (commercial value)
- Beneficial use of silt for agriculture, land improvement and construction
- Develop processing, stockyards and quality control mechanisms







6 Viable Financial Models

- PPP and e-tendering
- Resource recovery (sand, silt)
- Revenue to be used for restoration and strengthening of irrigation projects
- Attractive models for private participation with clear risk-sharing



7 Integrate Catchment Treatment

- Soil and water conservation measures
- Check dams, nala bunds, contour trenches
- Afforestation and watershed development
- Reduce future sediment inflow to reservoirs



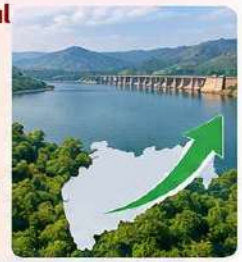
8 Periodic Review & Monitoring

- Assess recovered storage and project benefits
- Monitor sedimentation rates post-intervention
- Use GIS and periodic hydrographic surveys
- Independent evaluation and course correction



9 Scale Up Successful Pilot Projects

- Document outcomes, benefits and lessons learned
- Refine guidelines based on pilot project experience
- Scale up to other major and medium reservoirs across Maharashtra



Vision

From project-level desilting to a sustainable, state-wide sediment management programme for long-term recoupment of reservoir storage in Maharashtra.


THANK YOU