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International Association for Hydro-Environment Engineering and Research
Hosted by Spain Water and IWHR, China

Integrated Sediment Transport Management in River Basins

INBO World Basin Summit
16 June 2026
Rio de Janeiro, Brazil

Support: ABAR AGEVAP
Organization: INBO REBOB FÓRUM
Realization: Secretaria de Ambiente e Sustentabilidade GOVERNO DO ESTADO RIO DE JANEIRO Rio2030

Sediment Routing Strategy for Recovering Sediment Connectivity

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Chair, IAHR Japan Chapter

Integrated Sediment Transport Management in River Basins

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Key message

- **Sediment connectivity :**
  Connected transfer of sediment from a 'source' to a 'sink' in a system via sediment detachment and sediment transport.

- **Sediment connectivity is important both for morphological and ecological effects of downstream reaches.**

- **ICOLD Bulletin :**
  'Sediment management in reservoir cascades'

- **How to select suitable methods in cascading systems?**
- **How to implement, monitor and assessed?**
- **How to optimize both for reservoir and river basin sustainability?**

- **Long-term modelling, scenario study, economic and ecological assessment, governance for stakeholder coordination etc. are important.**

Chengdu Declaration on Dams and Reservoirs for Energy transition and Adaptation to Climate Change (May 2025)


Chengdu Declaration on

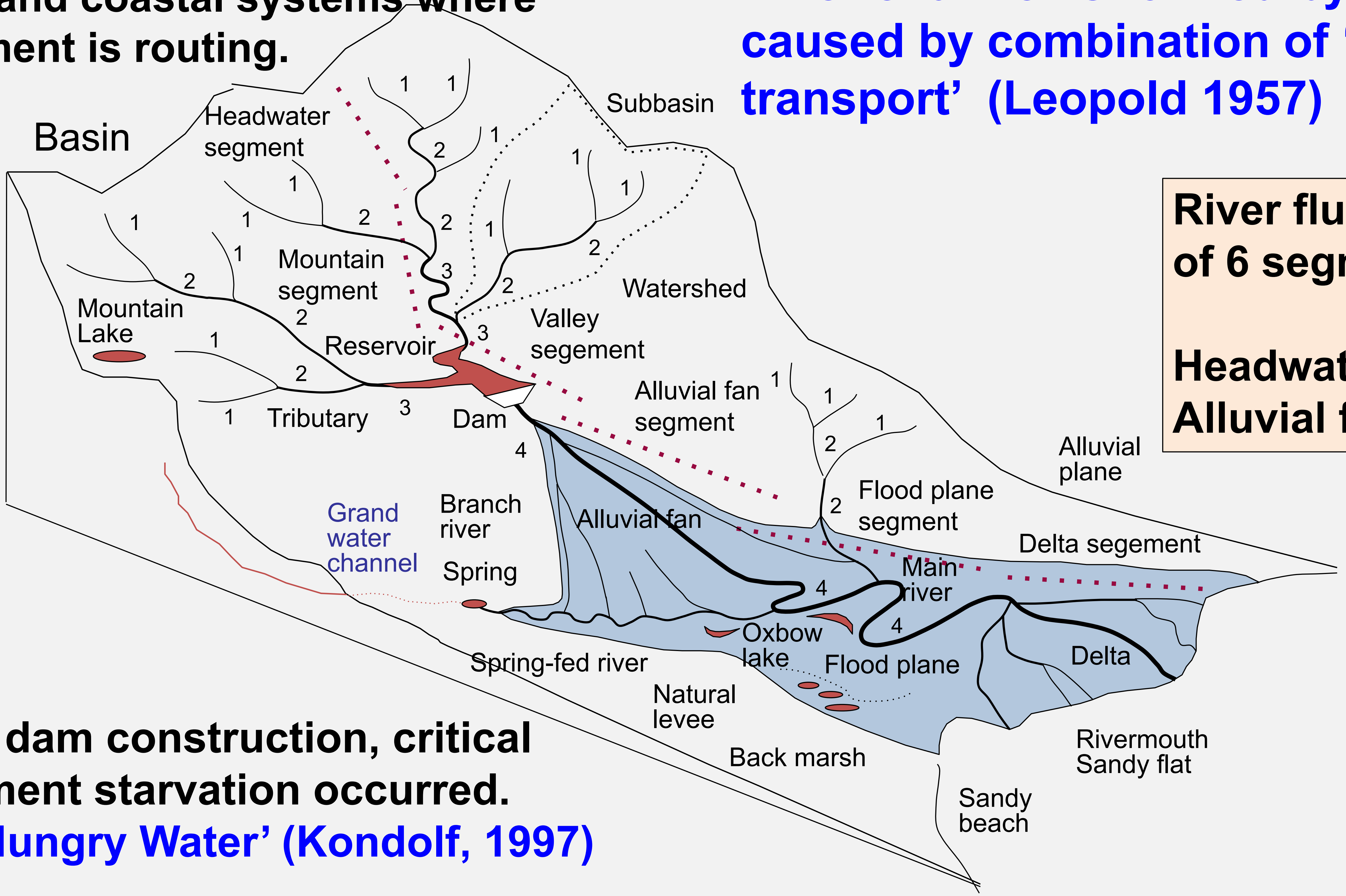
Dams and Reservoirs for Energy transition and Adaptation to Climate Change

- This World Declaration broadly covers global water demand, climate change and its impact, clean energy transition, hydropower as solution, **role of dams in climate change and energy transition**, pumped storage plants, dams and extreme events, dams for water supply, irrigation and environment.
- The declaration has recommended development of storage capacity worldwide, **acceleration of hydroelectric development**, development of hydroelectric potential especially in the developing world, introduction of **energy storage** as a new official use of reservoirs, establishment of a clear and stable regulatory framework for energy storage, administrative reforms and highlighting the **positive environmental impacts of dam and reservoir projects**.
- In addition, the World Declaration also recommends strengthening of **dam safety management**, promoting **sustainable water and sediment management** and research & development.

Mountain-Reservoir-River-Coastal System

Sediment routing system = All river and coastal systems where sediment is routing.

River channel is formed by natural fluvial process caused by combination of 'water flow and sediment transport' (Leopold 1957)



River fluvial system is composed of 6 segments.

Headwater, Mountain, Valley, Alluvial fan, Flood plane, Delta

Key message:

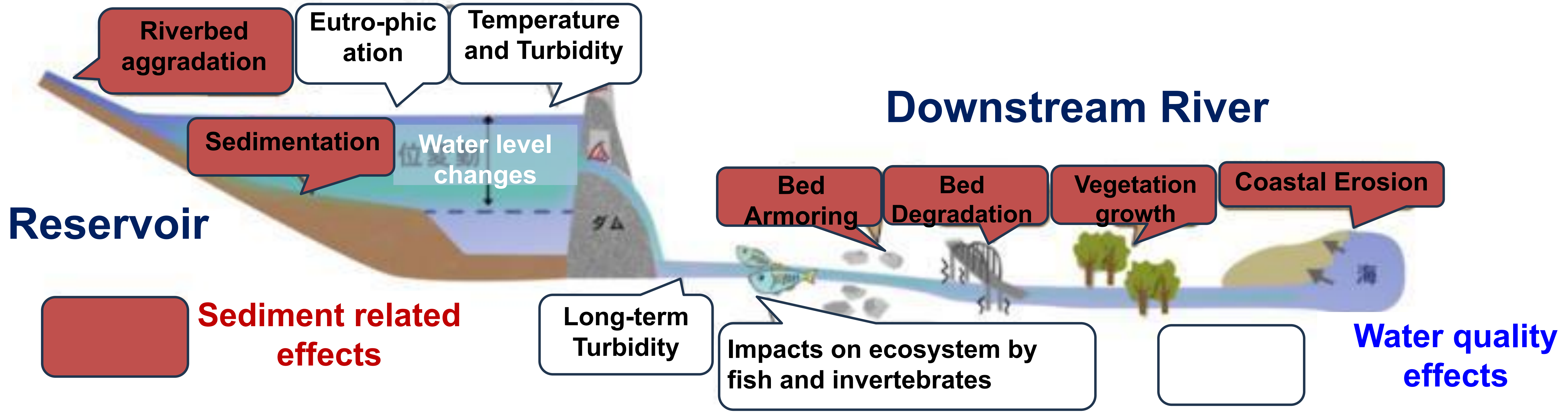
Importance of
- Flow Regime
- Sediment Regime

After dam construction, critical sediment starvation occurred.
'Hungry Water' (Kondolf, 1997)

Climate Change Effects on Reservoirs and Downstream Rivers

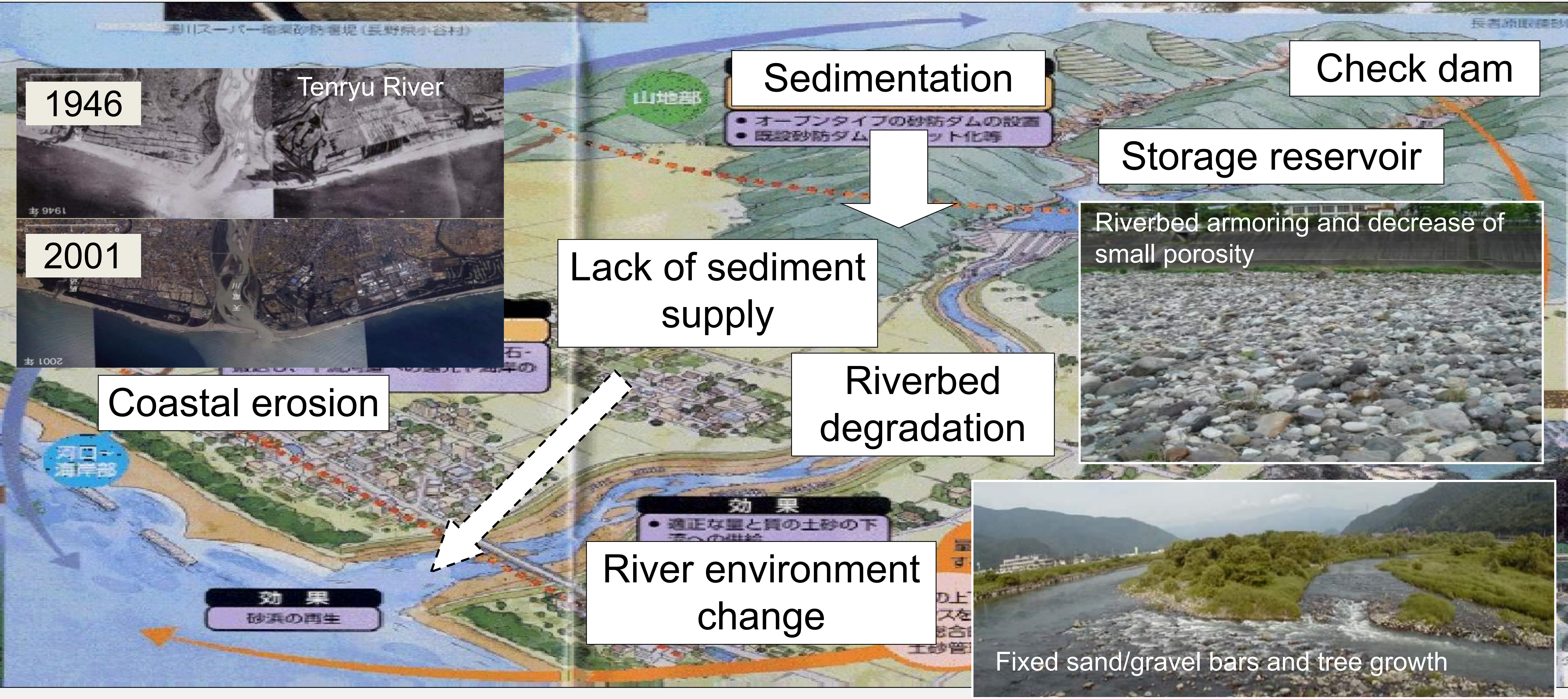
1. Increase of high heat flux and change of thermal stratification in reservoirs
2. Change of water circulation and mixing
3. Increase of eutrophication and algae blooming, DO consumptions in deep bottoms
4. Increase sediment inflow and sedimentation
5. Upstream riverbed aggradation

1. High temperature and no evacuation water area for cold/coolwater fishes in Summer
2. Change on flow/sediment/thermal regimes
3. Critical impacts on Life Cycle of Salmonid Fishes
4. Bed Armoring/Degradation/Coastal Erosion
5. Aquatic habitat degradation by fixed sandy-gravel bars and vegetation growth

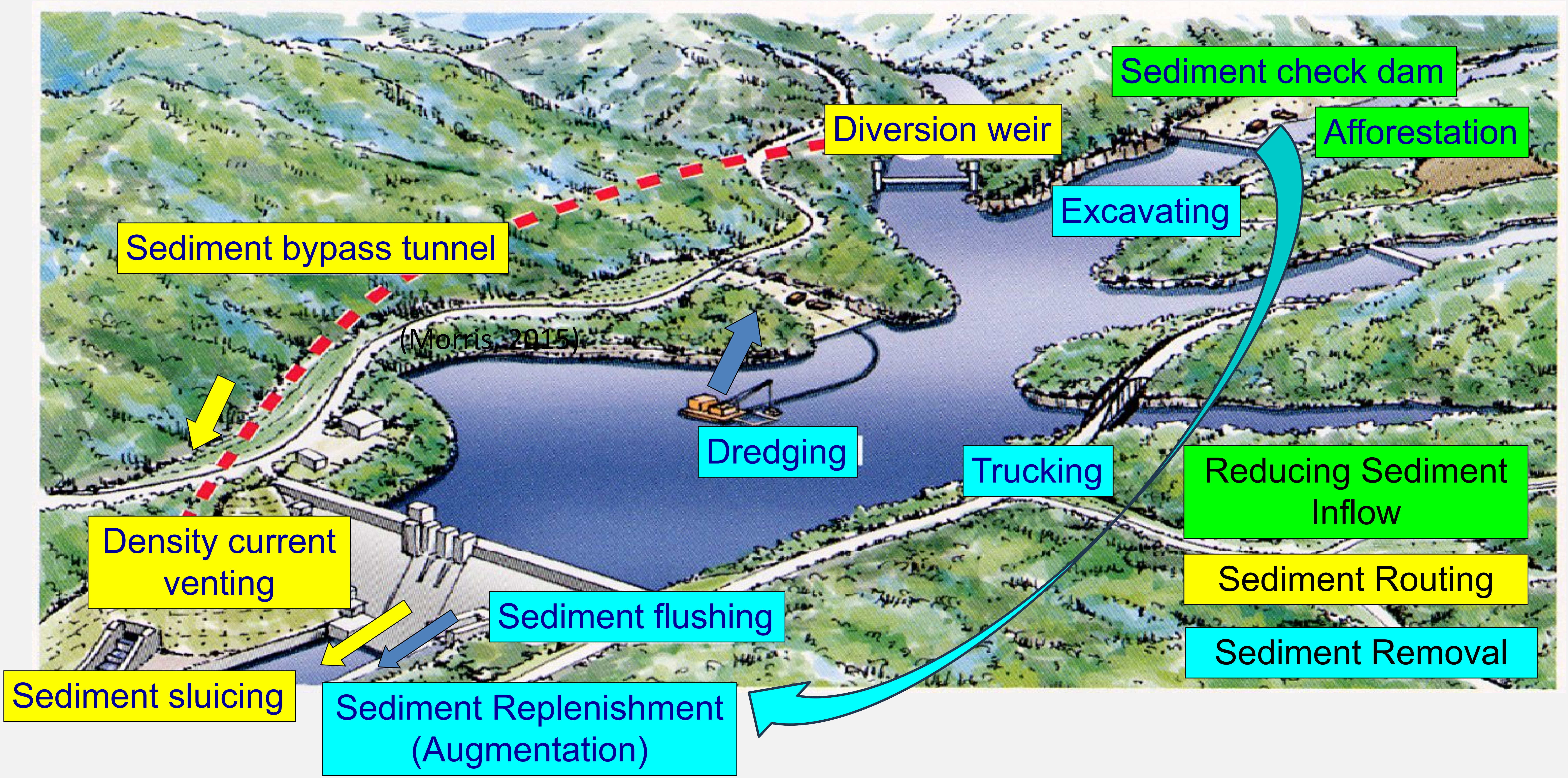


Japanese Strategy on Integrated Management of Sediment Routing System enacted in 1997

Objectives: Balancing of sediment transport from source to sea



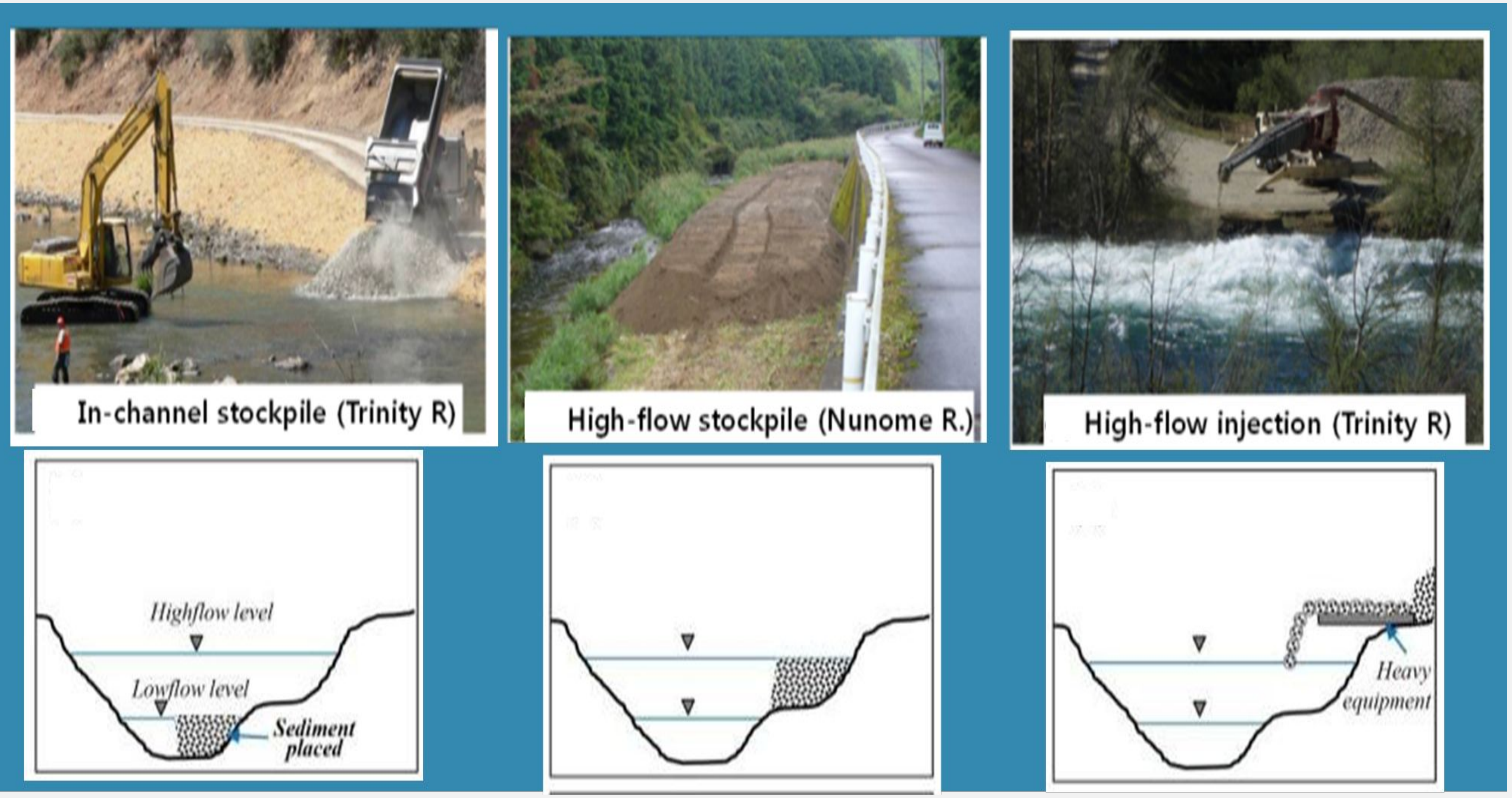
Classification of sediment management strategies for reservoirs

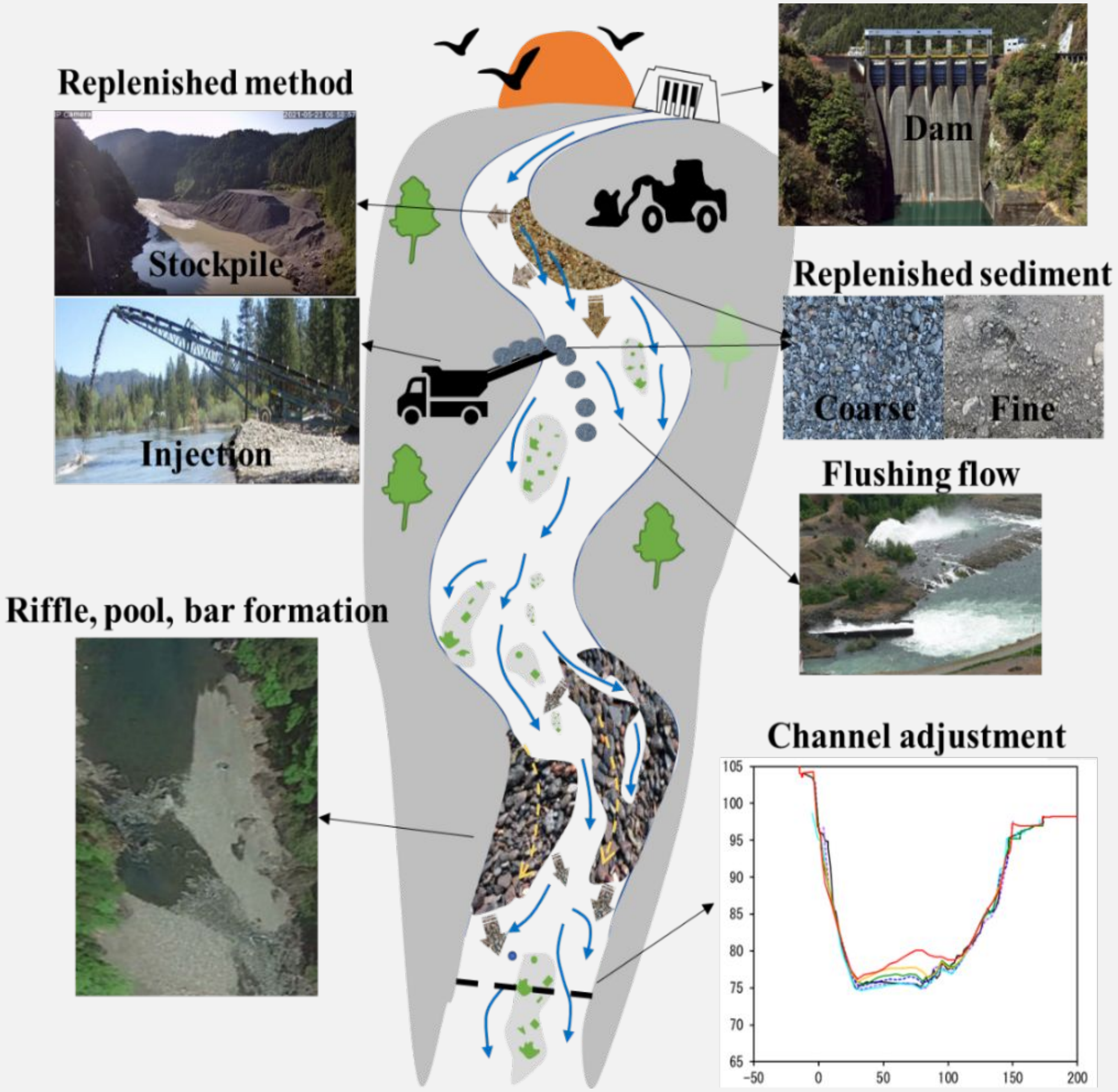


Sediment Replenishment (Augmentation)

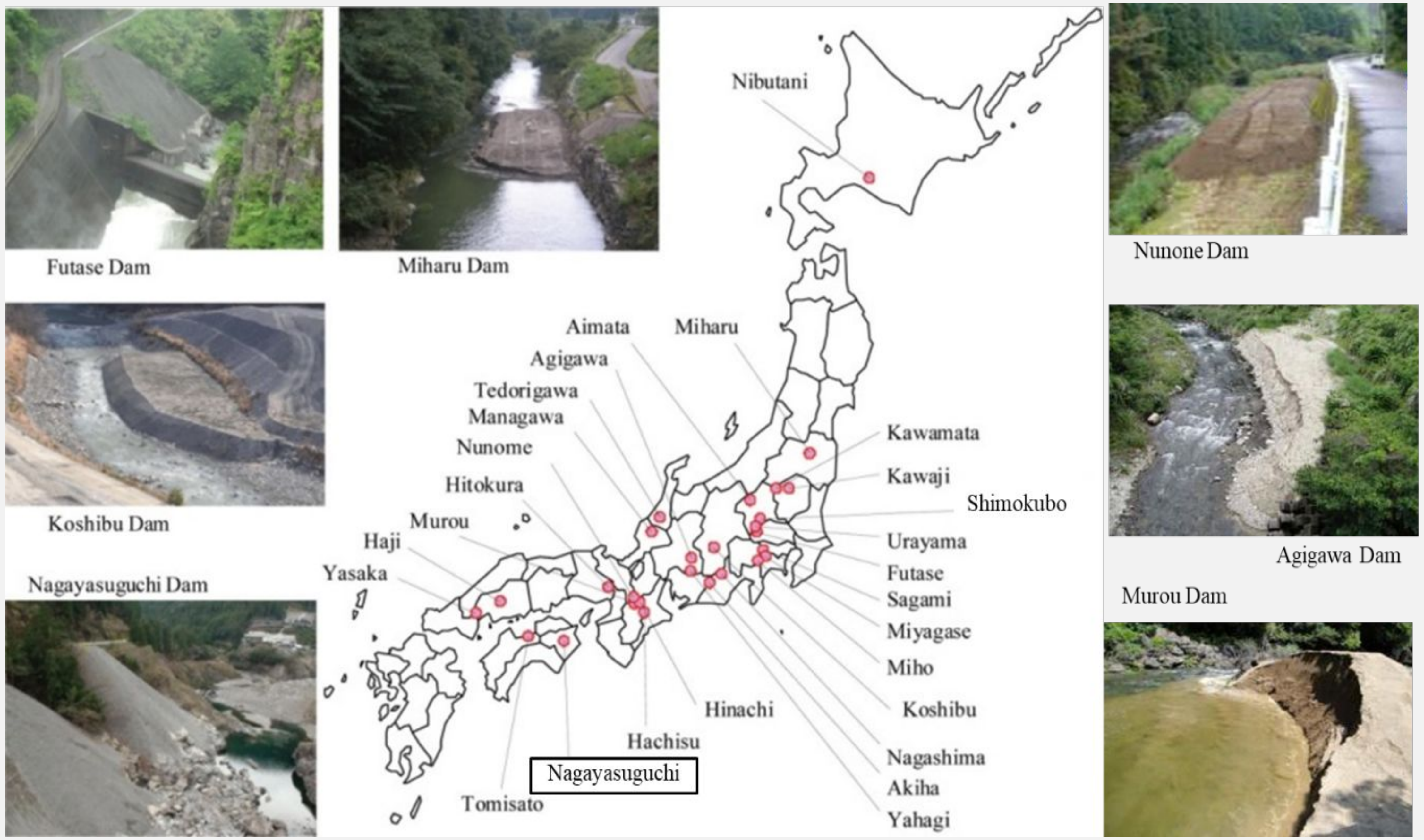
Sediment Replenishment is the first step to supply sediment below dams.

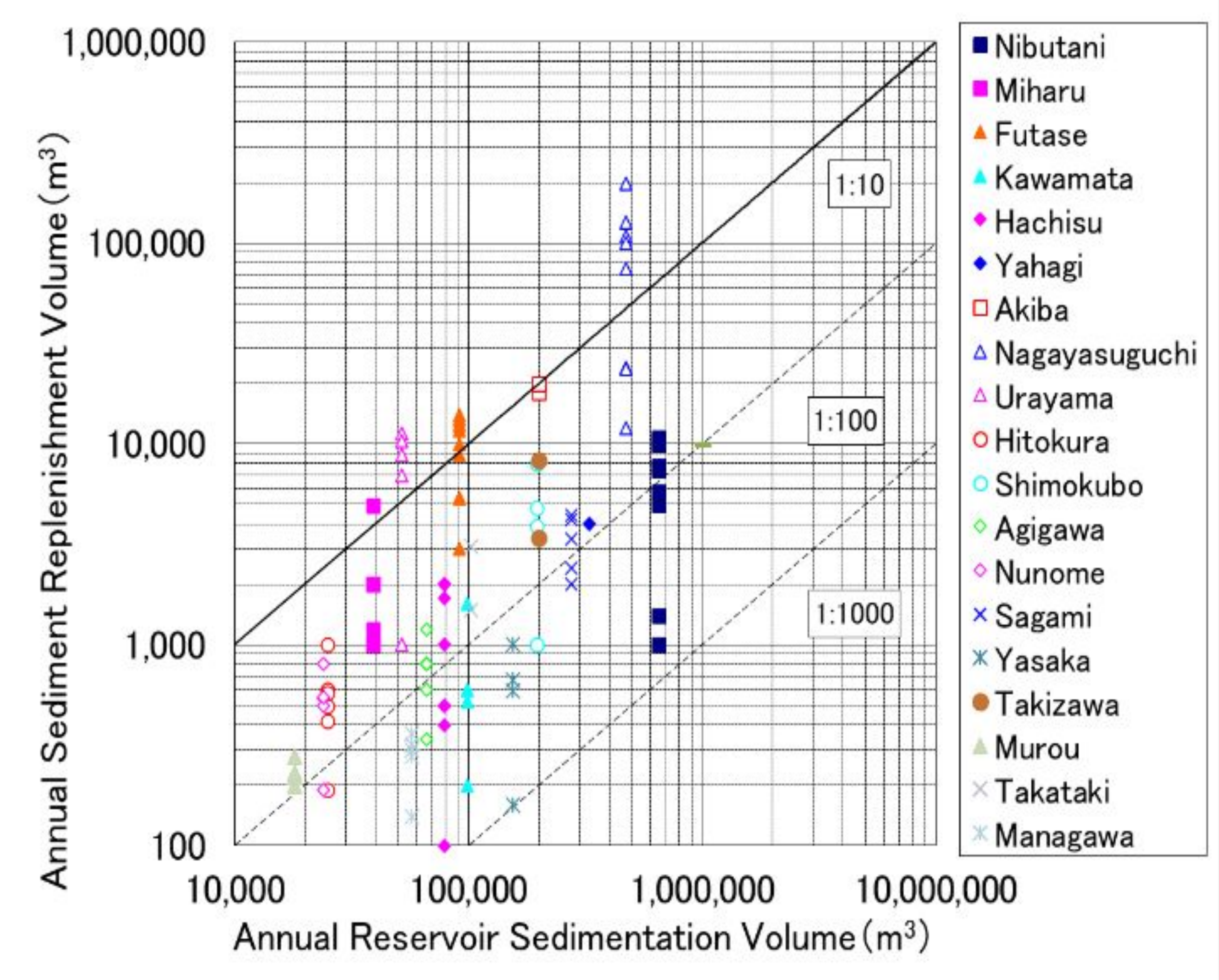
1. Early examples (1970-80s): simply to construct 'spawning riffles' mechanically
2. Modern examples (after 2000s): to support geomorphic processes for channel complexity and substrate quality



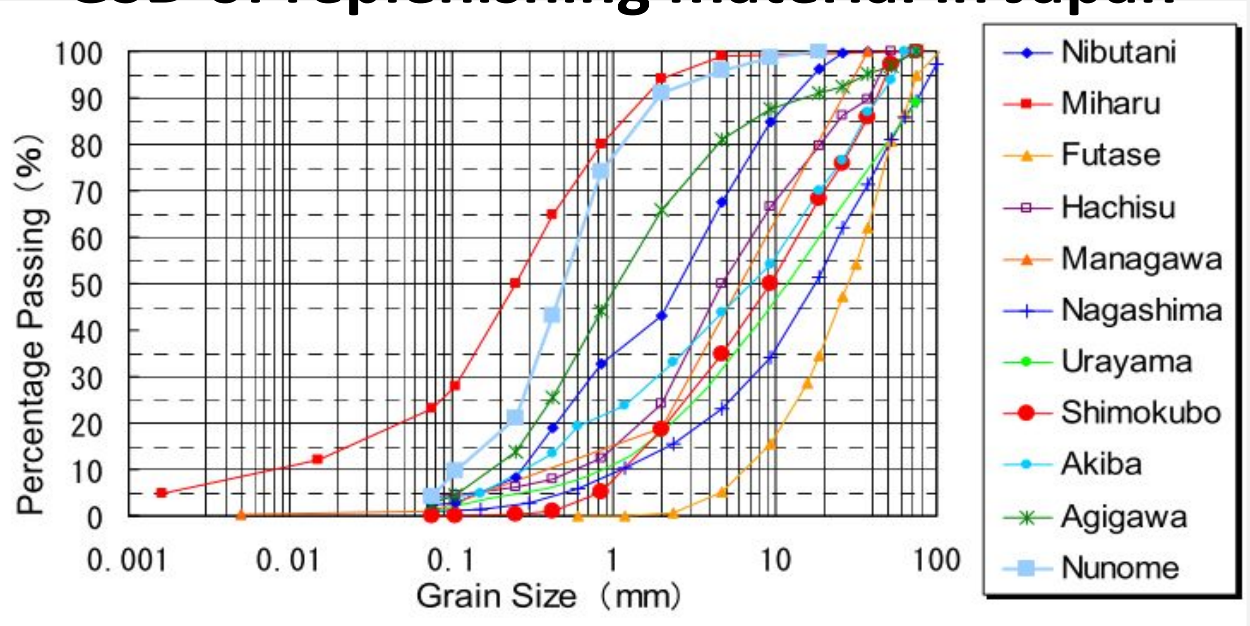


Sediment Replenishment in Japan





GSD of replenishing material in Japan



- More than 30 dams have started to implement sediment replenishment for environment recovery below dams.
- Sediment volume is ranging ca. 1 to 10 % of sedimentation.
- Grain seizes are ca. 1 to 10mm differing on each site.

Sediment Replenishment in Europe

France

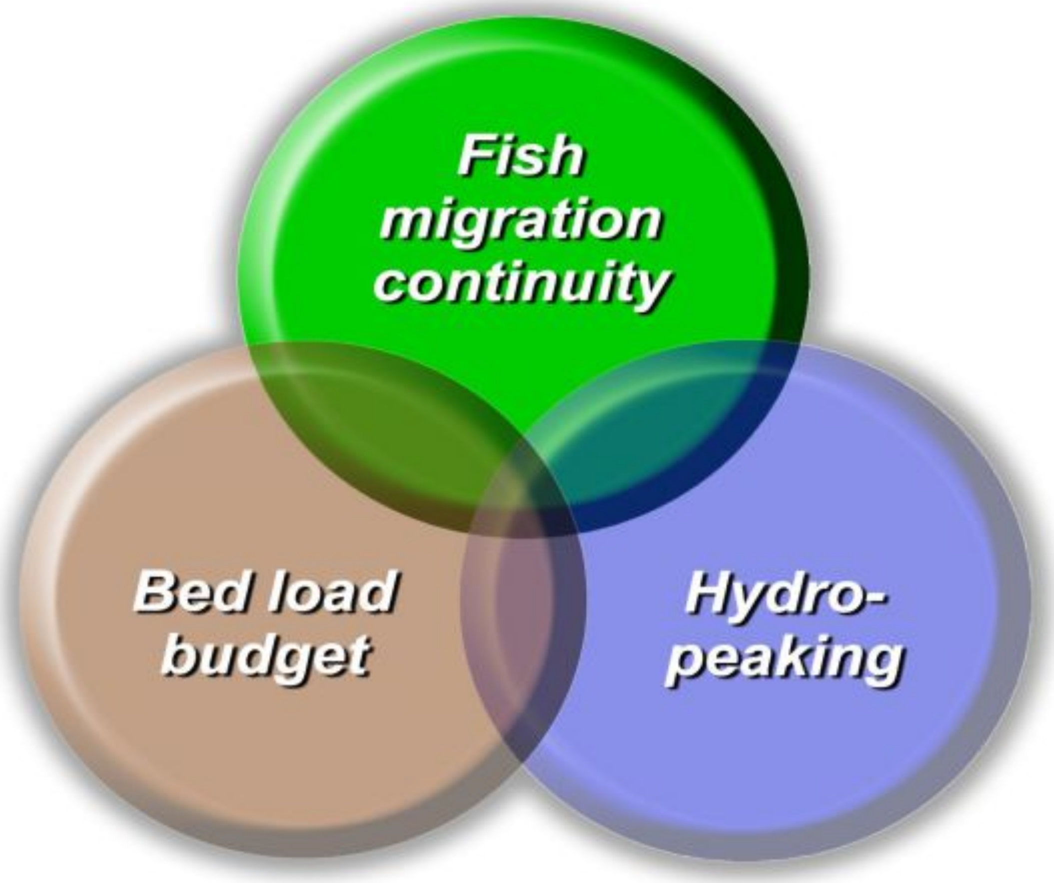
Source: EDF

Key message:
Coarse sediment (Bed Load) is requested to supply below dams.
Bed Load Budget is beneficial to maintain river geomorphology and salmon habitats for spawning.

Switzerland

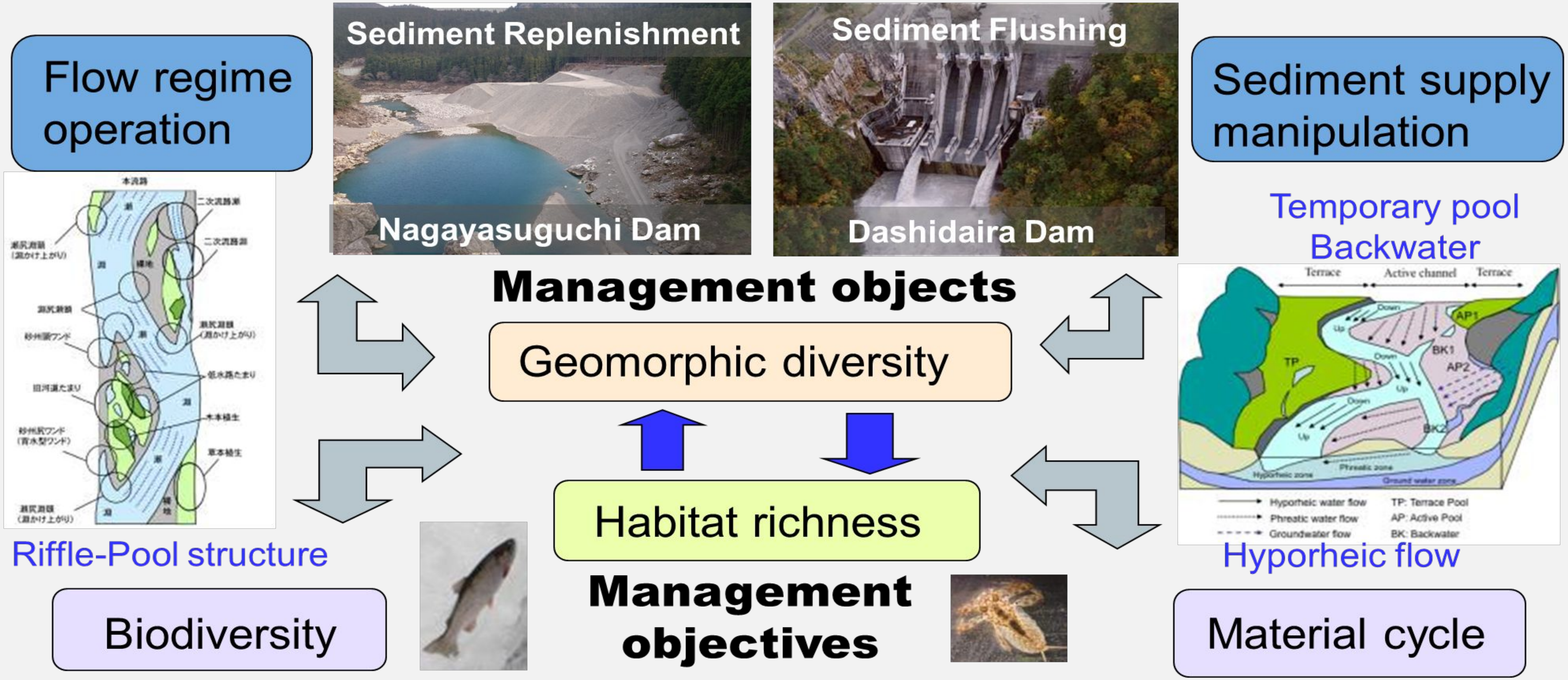
Swiss Federal legislation on the Protection of Waters, WPA, Art. 43a32 Bed load budget (2009, in force 2011)

The French law : L.214-17 (2006) and the circular (2013), sufficient coarse sediment transport



Source: Boes

Sediment management and biodiversity



- **Sediment supply** and **Flow regime** are key drivers to maintain **Geomorphic diversity**.
- **Geomorphic diversity** increases **Habitat richness** for **Biodiversity** and **Material cycles**.
- Relationship between geomorphic diversity and habitat richness can be defined by riffle-pool structure and hyporheic flow conditions.

INBO/ICOLD/IAHR and ICOLD TC-J initiatives on Basin sedimentation management

- **INBO/ICOLD/IAHR**
- **Handbook: River Sediment Transport Management**

- Chapter 1: Introduction (INBO)
- Chapter 2: Why sediment management is a strategic basin issue (ICOLD/INBO)
- Chapter 3: Essential scientific foundations for practitioners (IAHR)
- Chapter 4: Acting: operational strategies and measures (ICOLD/INBO)
- Chapter 5: Governance, cooperation and implementation (INBO)

- Case studies

- **ICOLD TC-J (Sedimentation of Reservoirs)**
- **Bulletin: Sediment management in reservoir cascades**

- Chapter 1: Introduction
- Chapter 2: Planning and design of sediment management measures
- Chapter 3: Operation and monitoring
- Chapter 4: Social and Environmental impacts
- Chapter 5: Economic optimization

- Case studies

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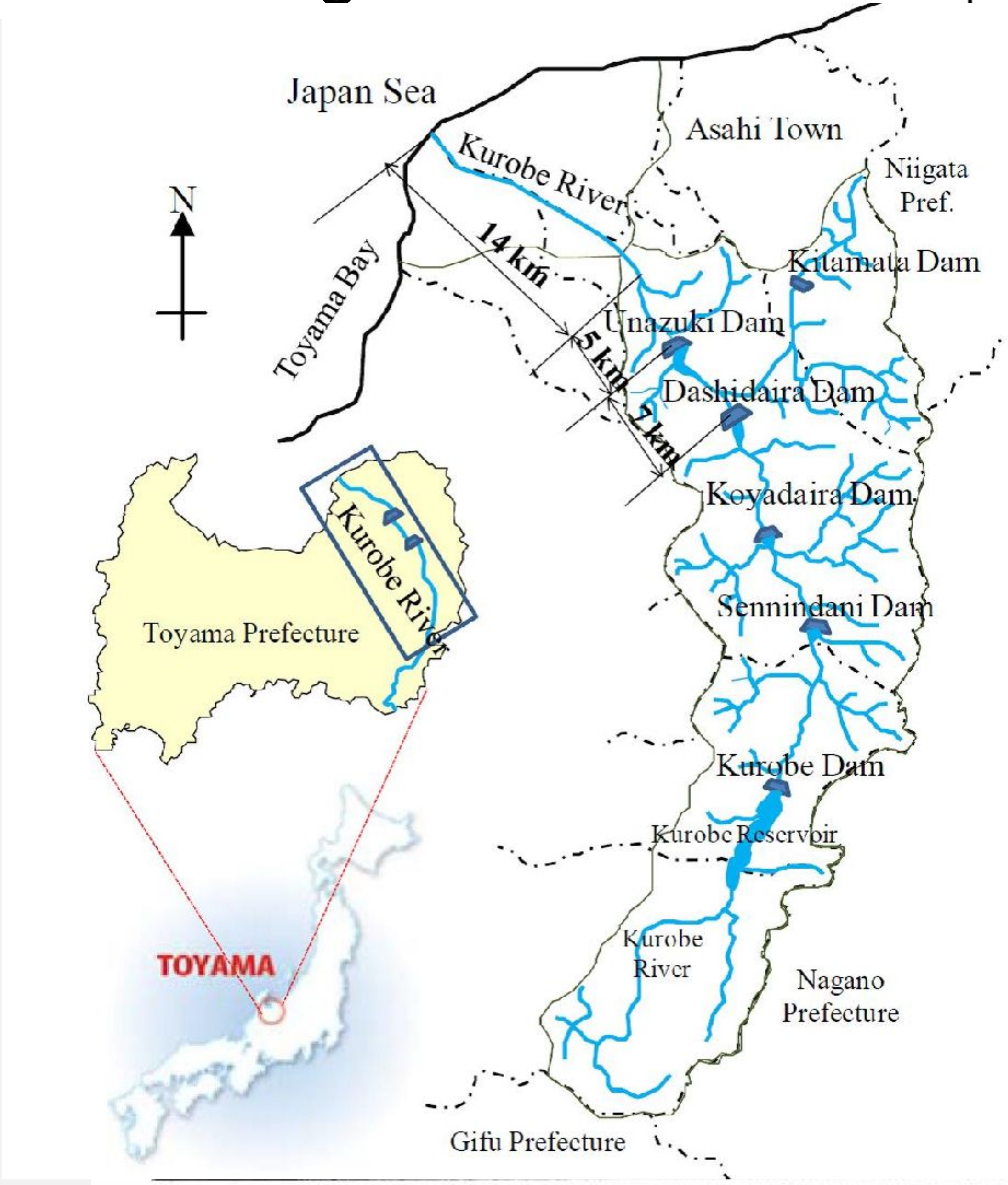
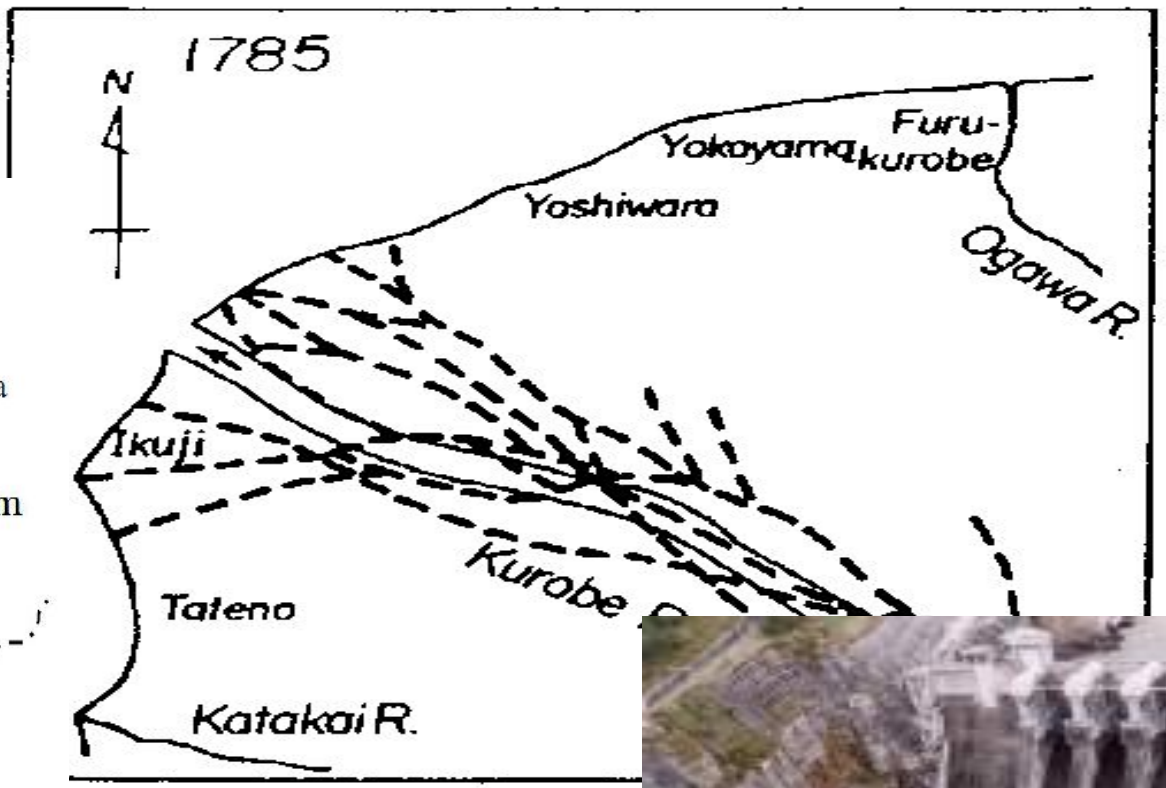
Cascading dams in the Kurobe River, Japan（黒部川）

Catchment area= 682 km^2,
River length= 85 km



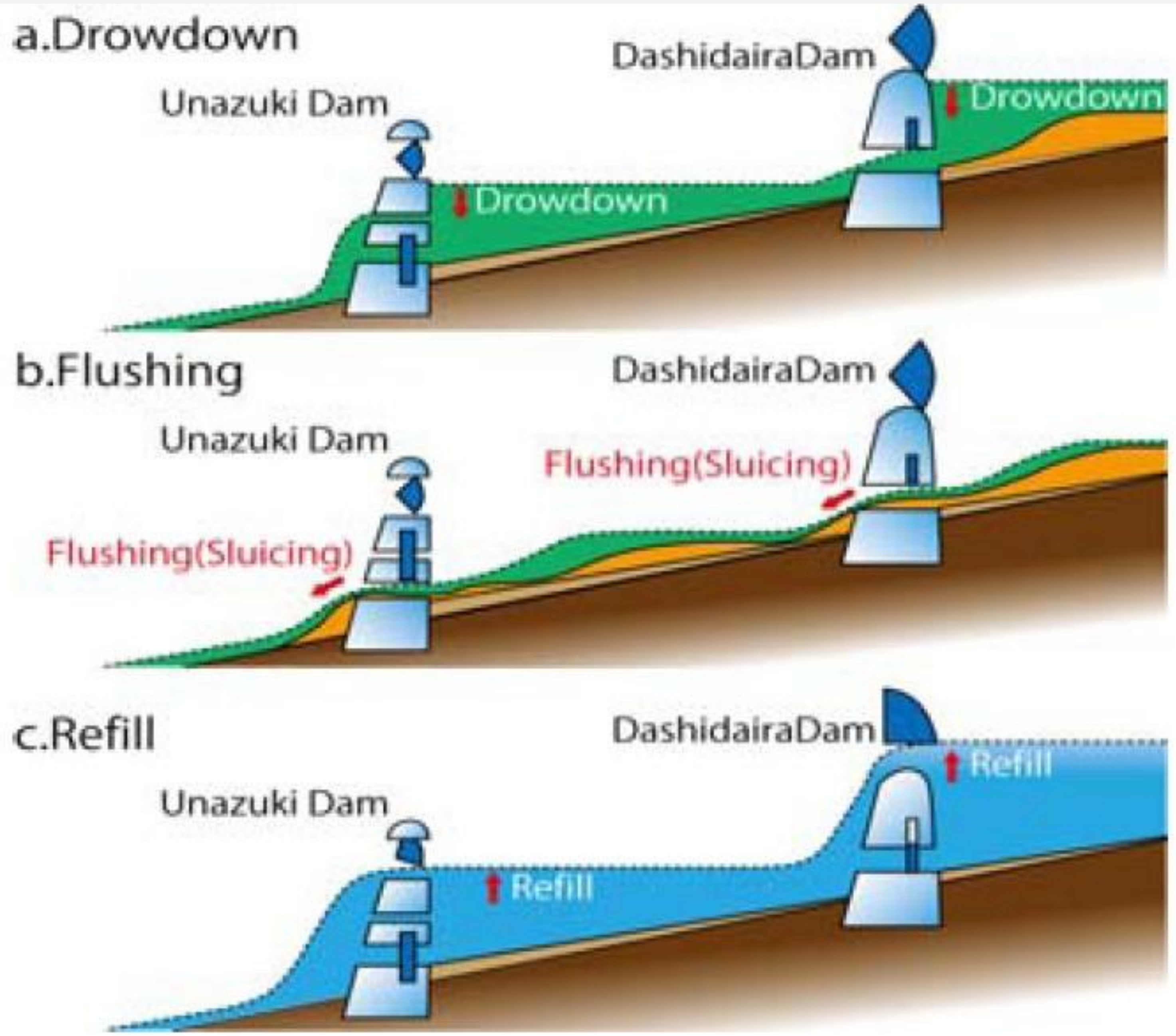


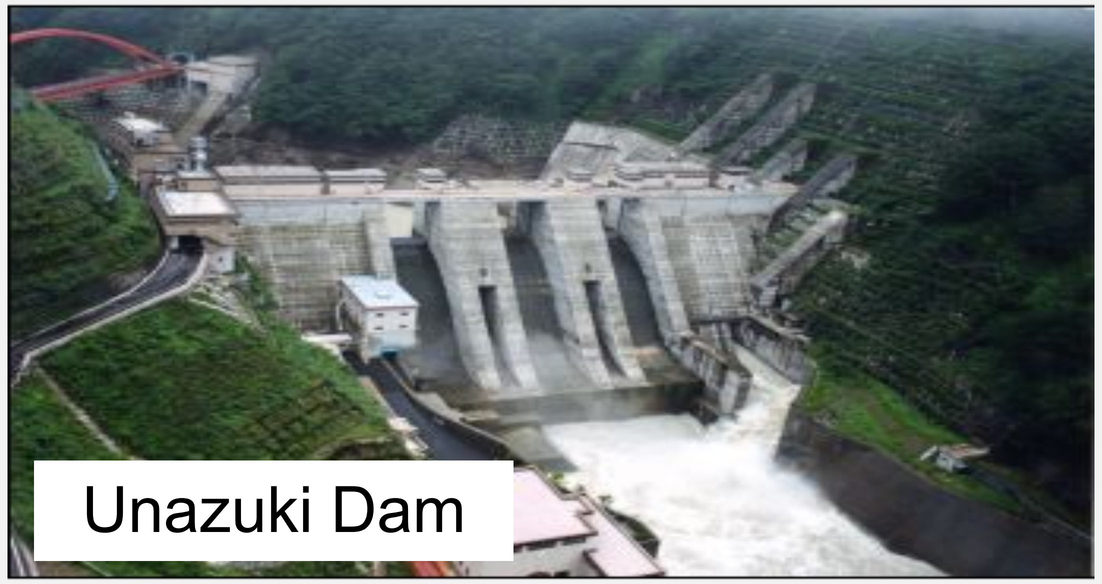
H=185m
199MCM (1961)

H=76.7m, 9
MCM (1985)

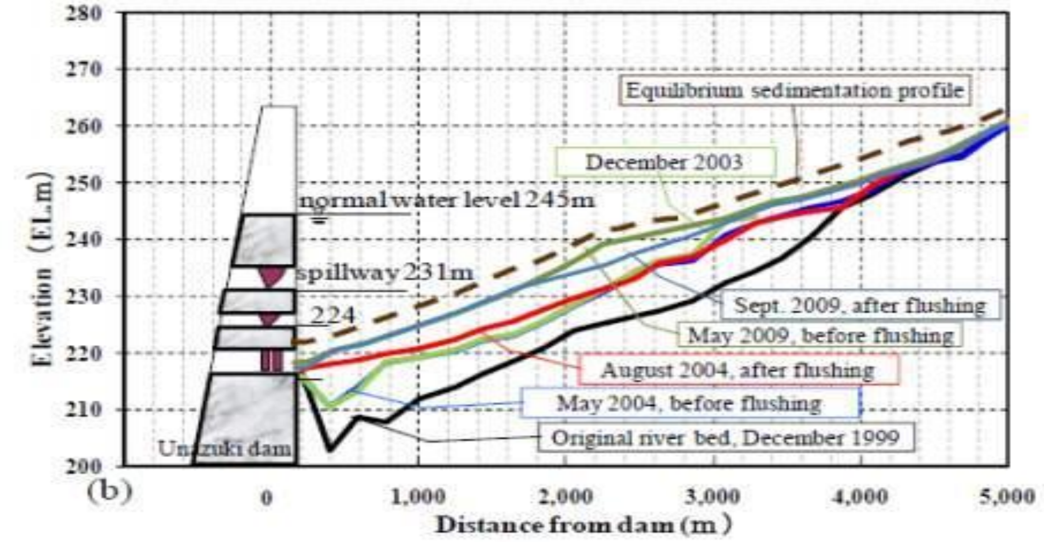
H=97m, 24.7 MCM (2001)

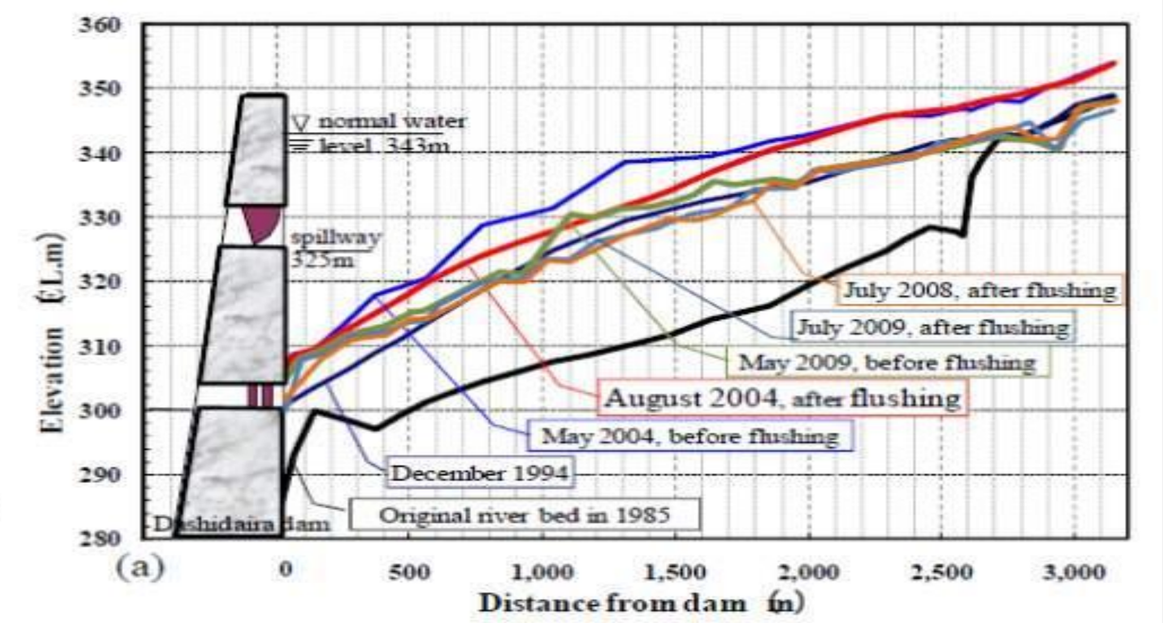
Coordinated sediment flushing in the Kurobe River




Unazuki Dam


Dashidaira Dam

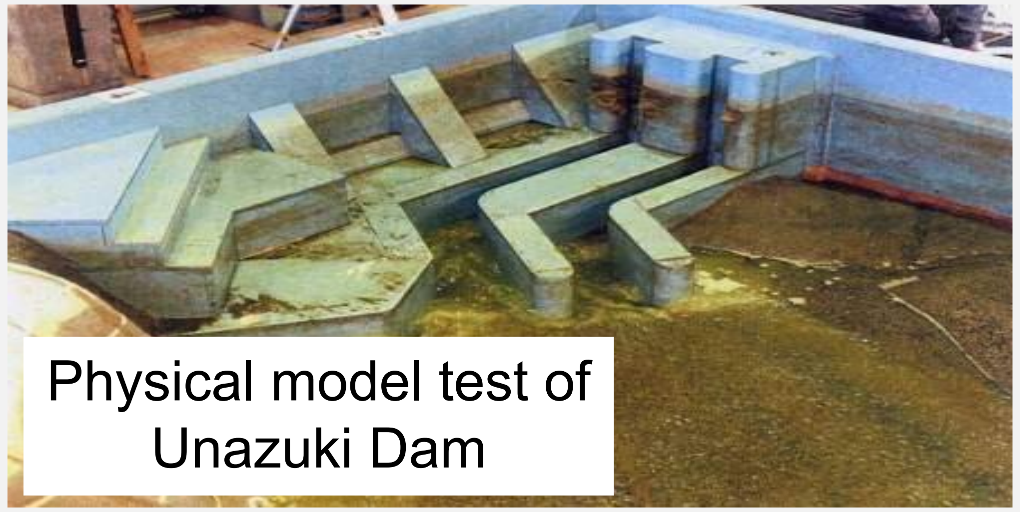




Key message:

Coordinated water and sediment management is important. Rainy season, June-July, and natural flood timing is suitable for flushing.


Drawdown Flushing of Unazuki Dam

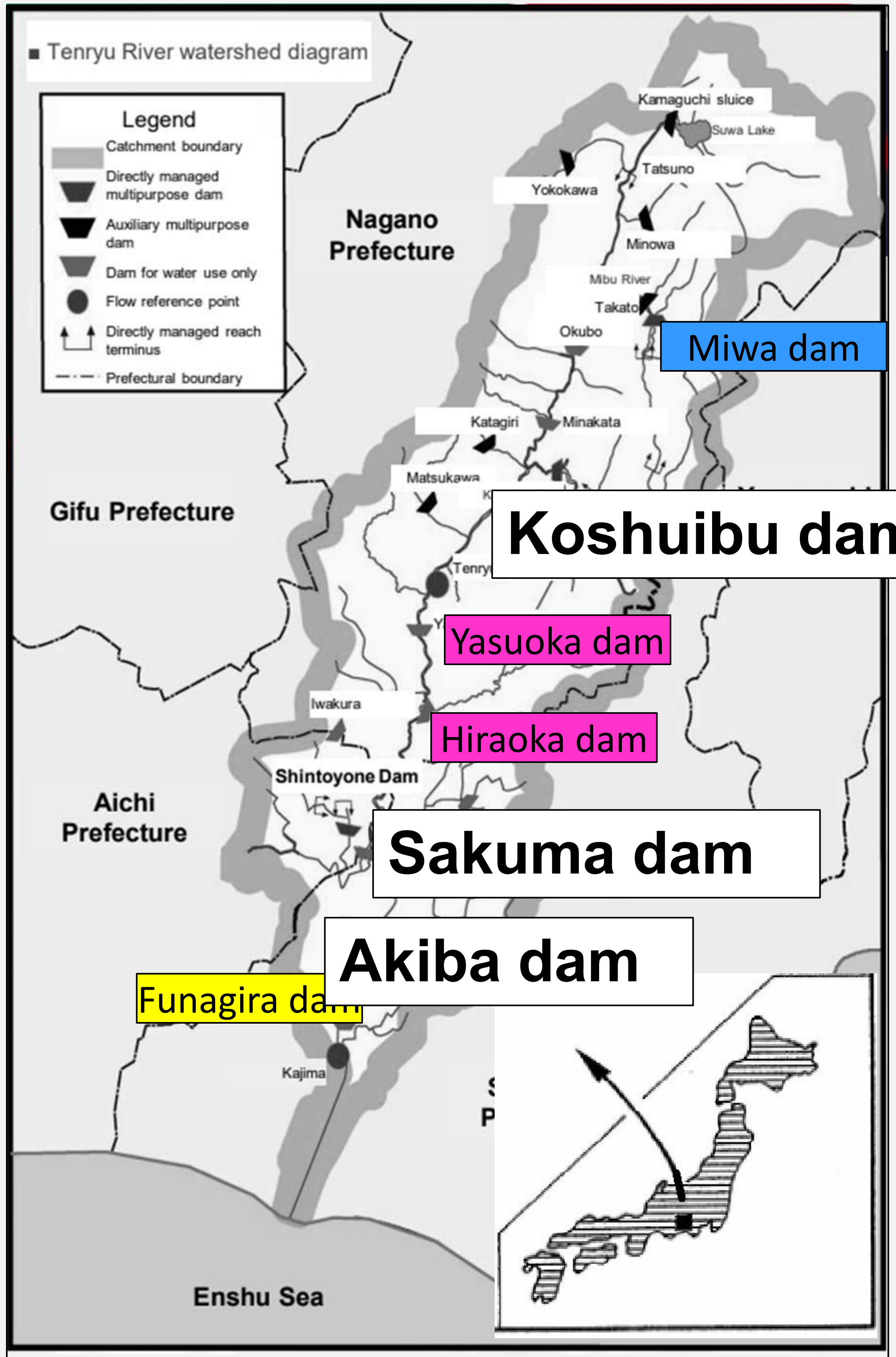

Physical model test of Unazuki Dam

Shoreline Recovery by sediment flushing in the Kurobe River

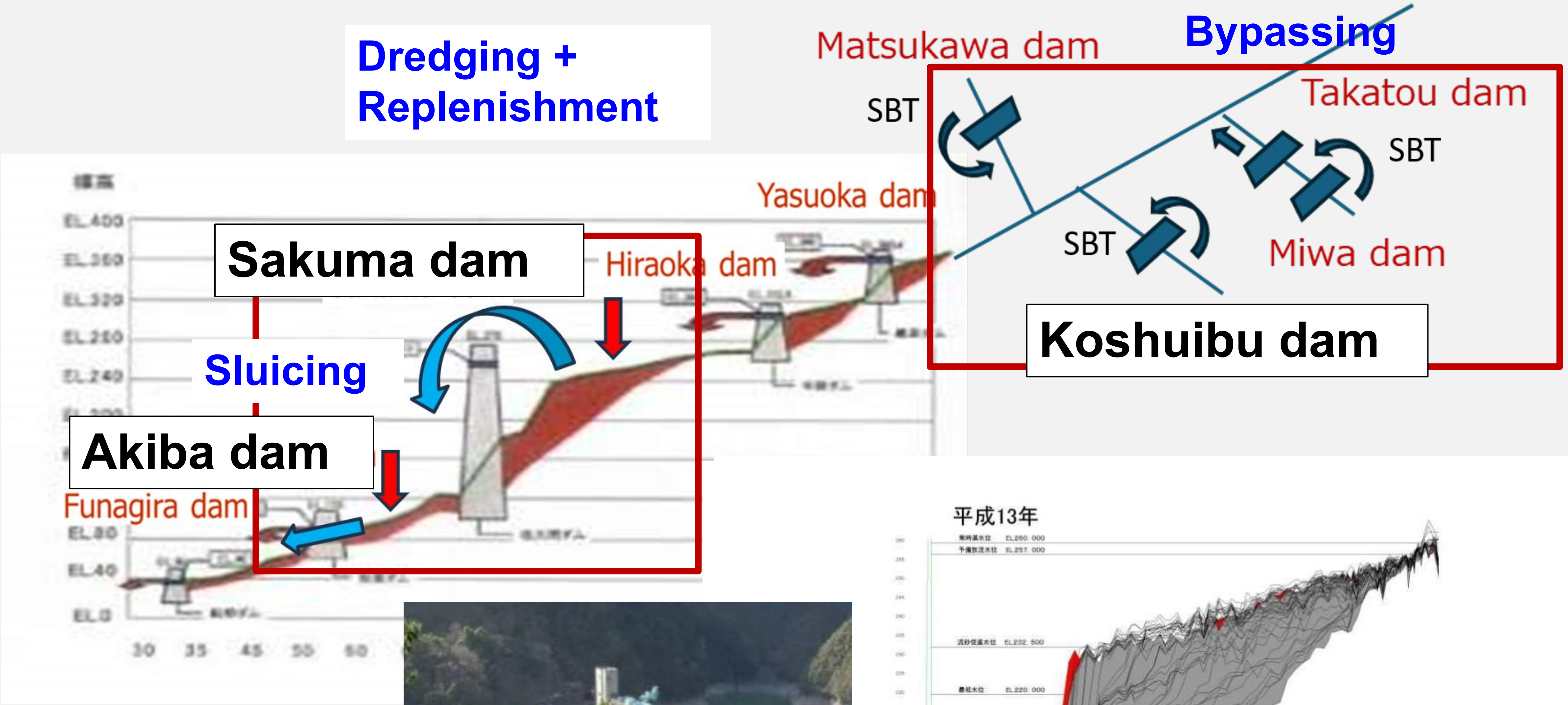
Sediment Flushing Start

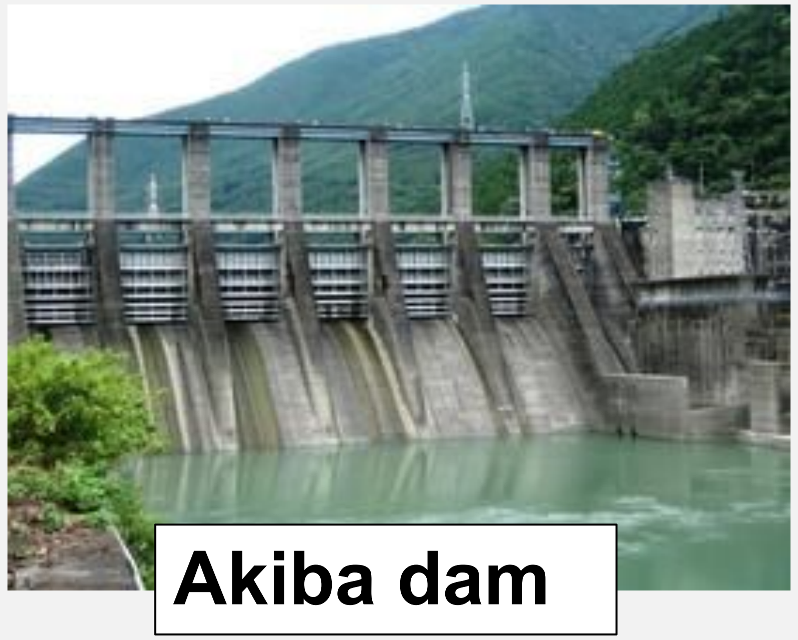
Key message: Coastal erosion occurred from 1950s. After sediment flushing start, shoreline is gradually recovering after 2000 by sediment supply.

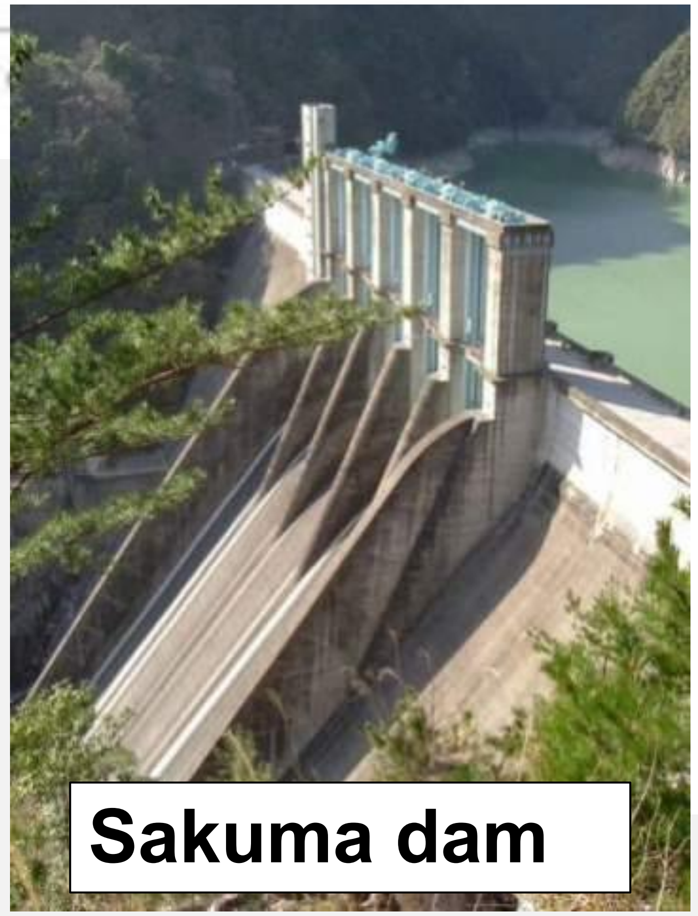
Tenryu River Basin Overview （天竜川）

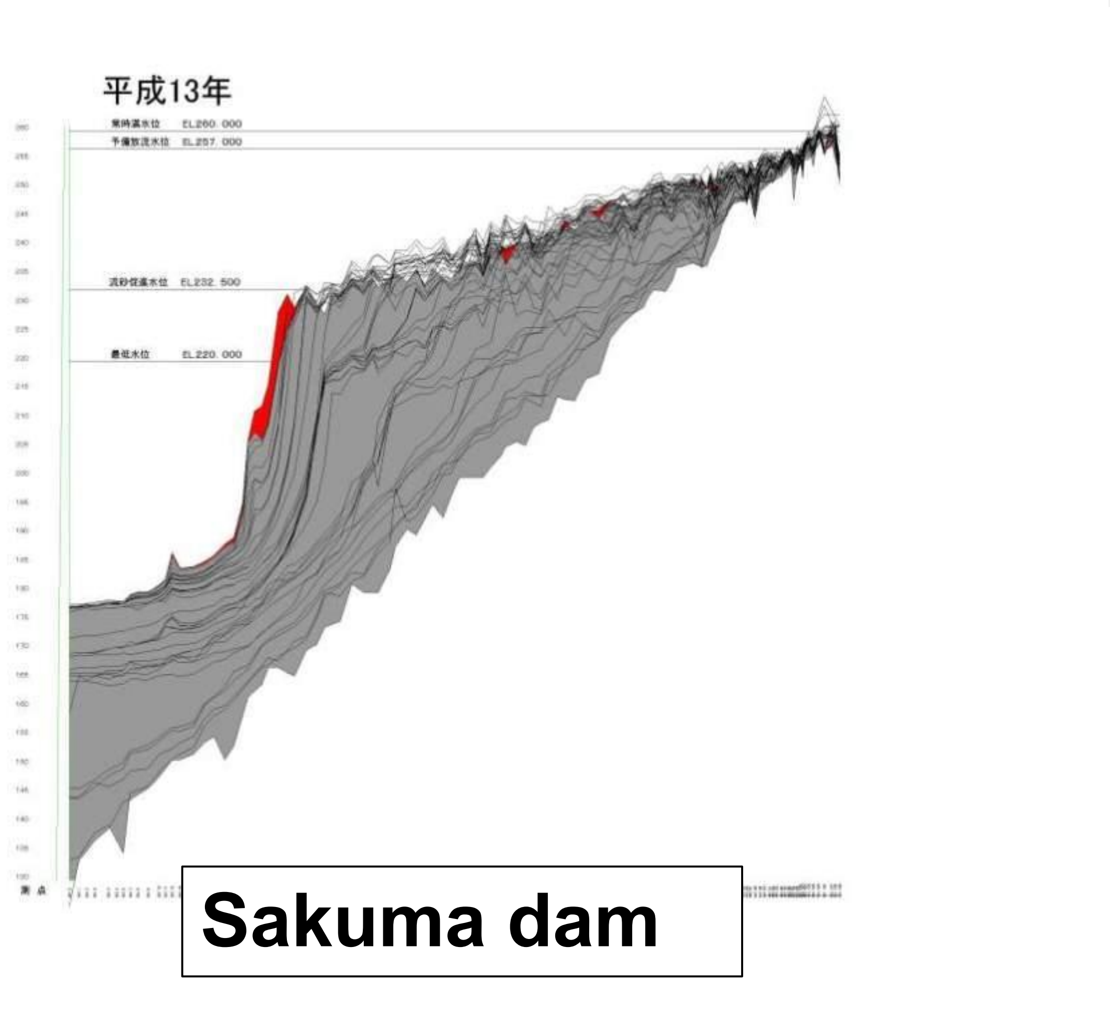


(Source; MLIT website)

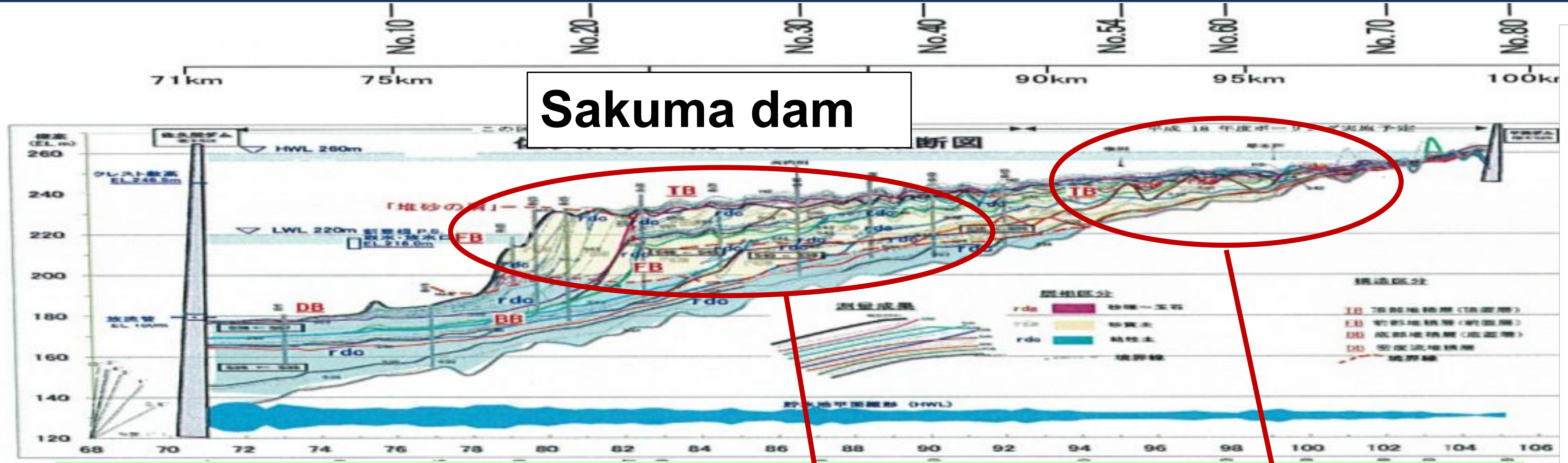


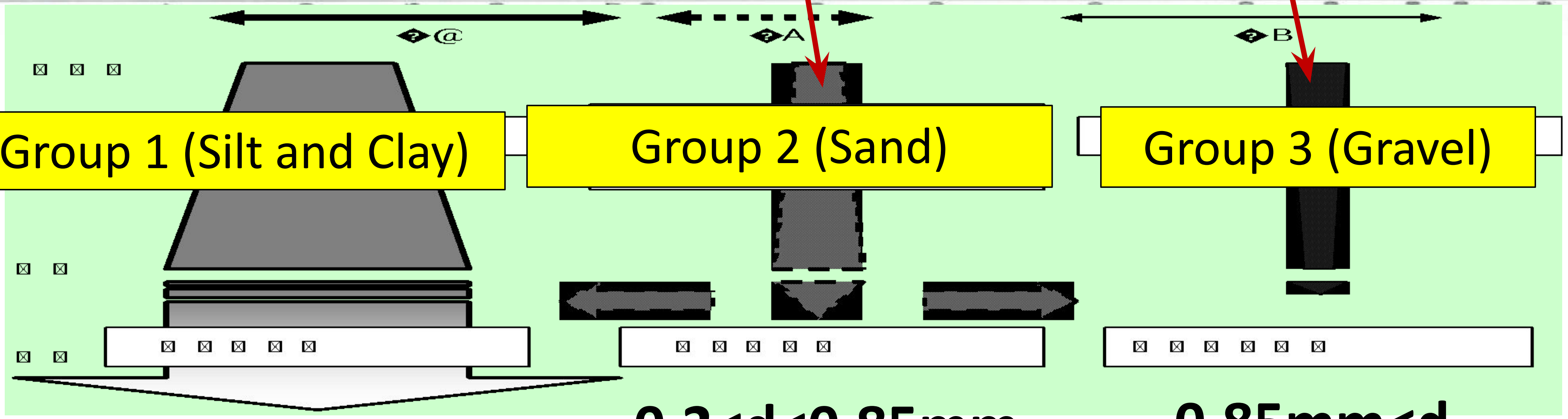






Integrated Sediment Management:
Target grain size and sediment use of reservoir sedimentation



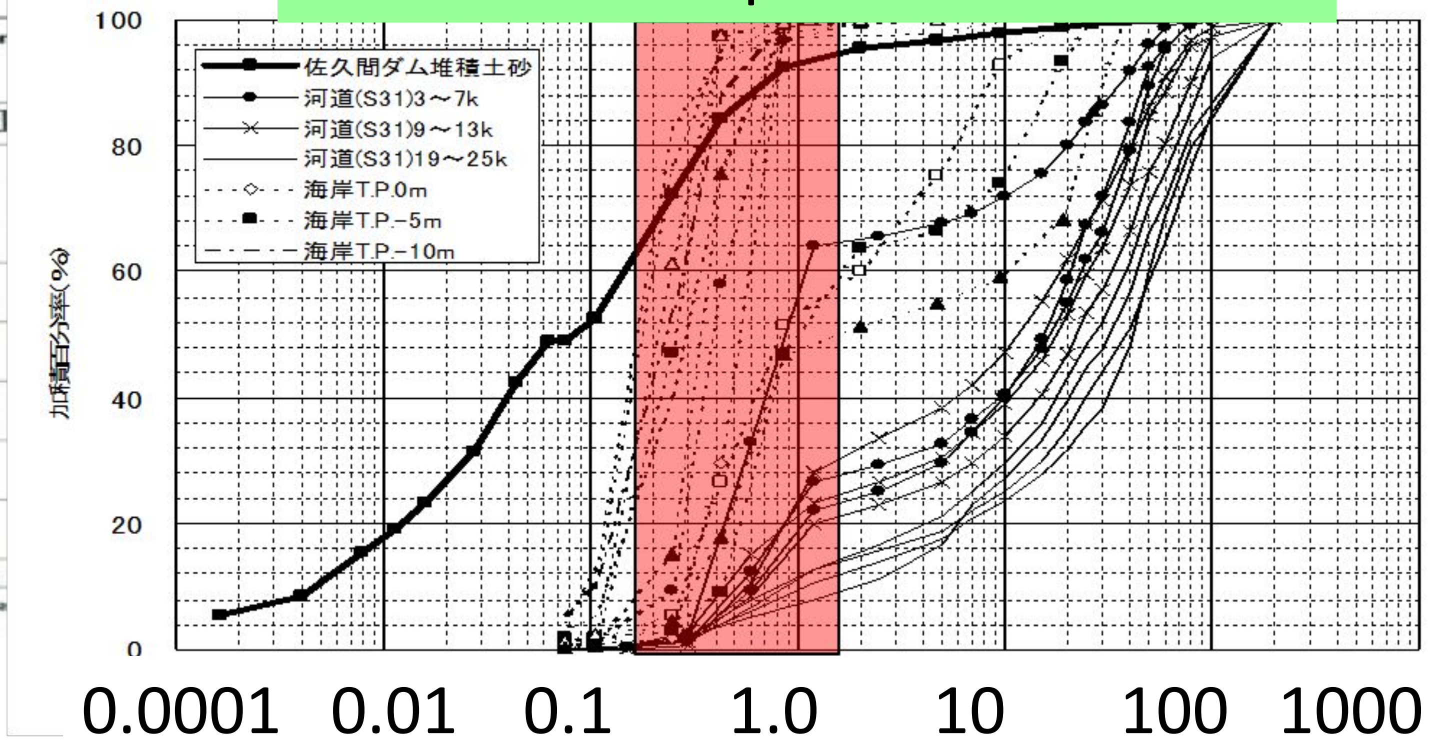


d<0.2mm

0.2<d<0.85mm

0.85mm<d

Grain size of deposited sediment



Group 1 (Silt and Clay)

Group 2 (Sand)

Group 3 (Gravel)

Plecoglossus altivelis altivelis, sweetfish

30-50mm

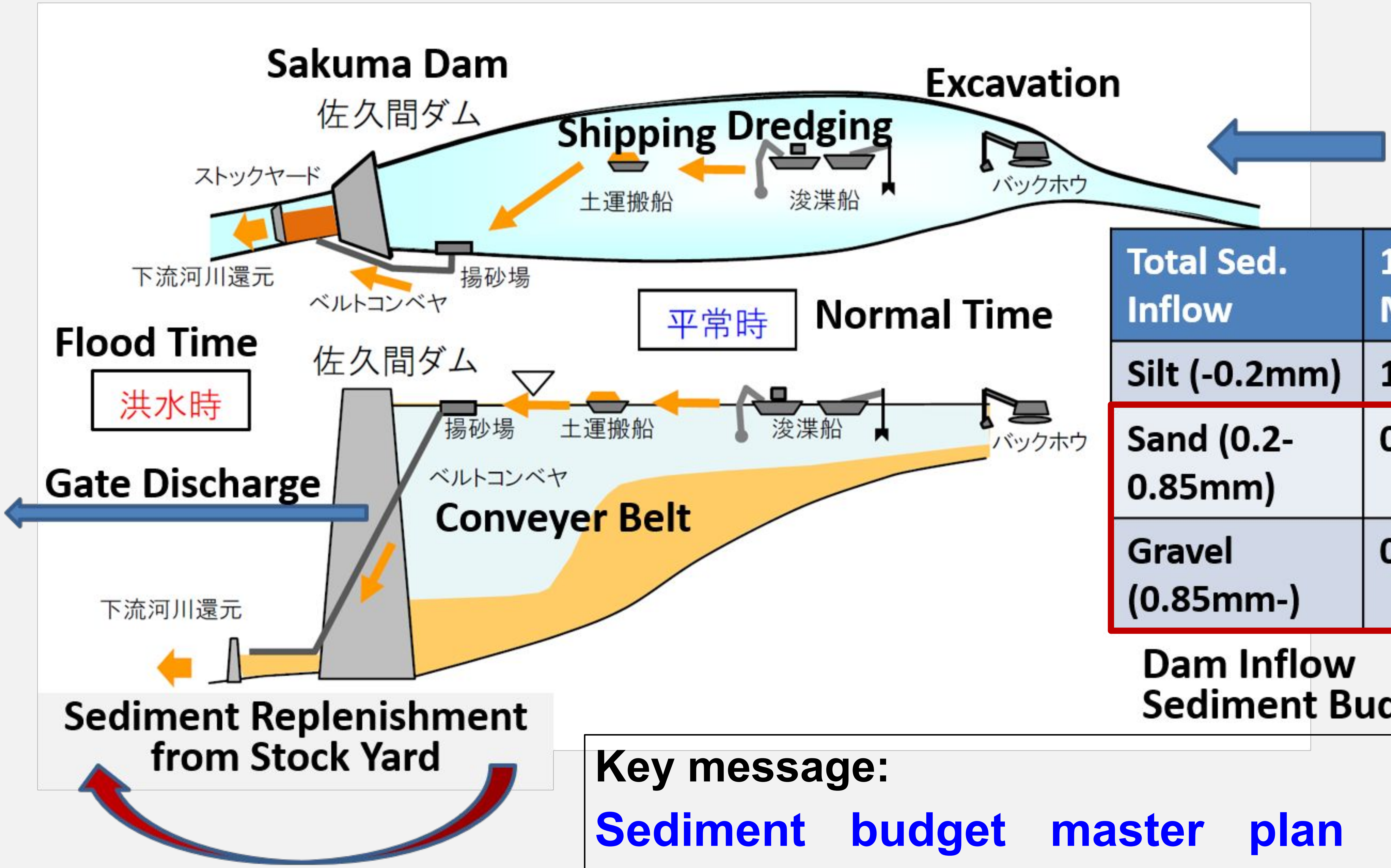
Sediment Budget Master Plan at Sakuma Dam

Before

Gate Discharge	0.36 MCM
Silt	0.36
Sand	0
Gravel	0

After

Total Sed. Outflow	0.62 MCM	
Silt	0.42	
Sand	0.12	30%
Gravel	0.08	73%



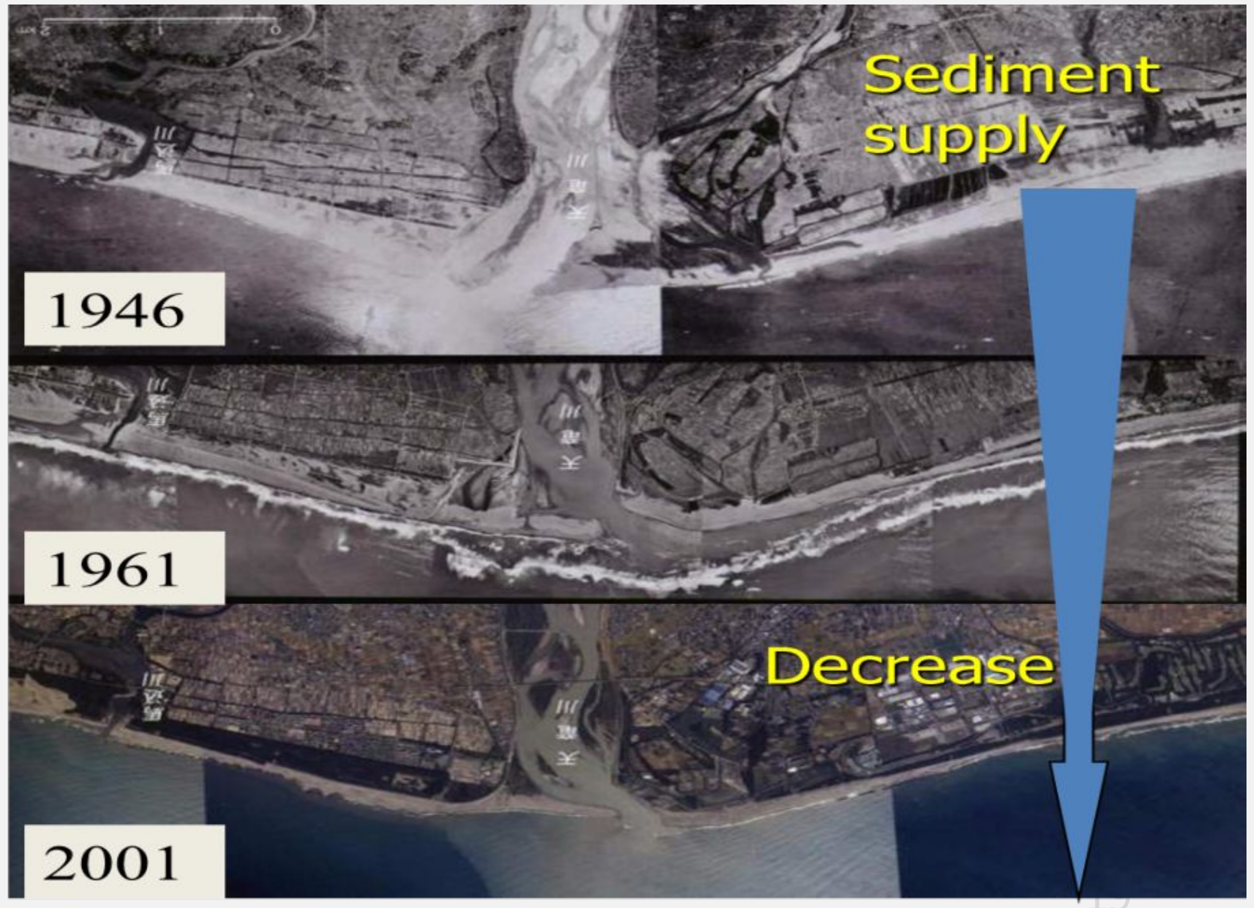
Total Sed. Inflow	1.95 MCM
Silt (-0.2mm)	1.43
Sand (0.2-0.85mm)	0.41
Gravel (0.85mm-)	0.11

Dam Inflow Sediment Budget

Key message:

Sediment budget master plan is needed to define target sediment size and suitable options.

Fifty-three stations on the Tōkaidō (Edo-Kyoto highway in Edo-period (1833) by Hiroshige Ando)



Ecosystem services provided by braided river channels, sandbars and coastal beaches.

Critical Importance for Reservoir Sedimentation Management

- **Prof. Ukichiro Nakaya, Hokkaido Univ., published a paper in 1951.**
- **He is a famous physicist who firstly succeeded to make an artificial snow crystal in the world.**
- **He had also interest on dams and sounded the alarm on the importance of Reservoir Sedimentation Management.**

- ***Japan is a very rich country on water resources. If we can effectively develop, we are totally safe for energy and water. However, we need dams to produce electricity. These dams can also contribute flood protection and irrigation, however, they will receive too much sediment.***
- ***Without any suitable management, these dams will be filled of sediment that means Japan will be buried by sediment.***

Ukichirou NAKAYA
(1900－1962）

The first artificial snow crystal in the world

Takeaway message

- Reservoir sedimentation management is important both for **reservoir sustainability** and **sediment connectivity.**
- Recovering sediment connectivity is effective to maintain **downstream geomorphology** and **habitat diversity**.
- **Sediment Replenishment** is the first step approach in Japan and Europe.
- **Sediment Sluicing, Sediment Bypassing, Drawdown Flushing** are more large-scale approach for higher recovery levels.
- **Basin scale sediment management strategy** is needed to define **key reservoirs**, **target sediment size** and **suitable options**.
- INBO/ICOLD/IAHR and ICOLD TC-J are preparing publications on Basin Sediment Management cross related RBOs.

Tenryu River Mouth（天竜川）

Nakatajima Sand Dune and Sea Turtle

GOBIERNO DE ESPAÑA
MINISTERIO PARA LA TRANSICIÓN ECOLÓGICA Y EL RETO DEMOGRÁFICO

Integrated Sediment Transport Management in Jucar River Basin, Spain

CONFEDERACIÓN HIDROGRÁFICA DEL JÚCAR

Sediment Transport Management in Jucar River Basin, Spain

1. Introduction to sediment transport in rivers
2. Obstacles to sediment transport
3. Case studies to regulate river sediments
4. Conclusions

Sediment Transport Management in Jucar River Basin, Spain

1. **Introduction to sediment transport in rivers**
2. Obstacles to sediment transport
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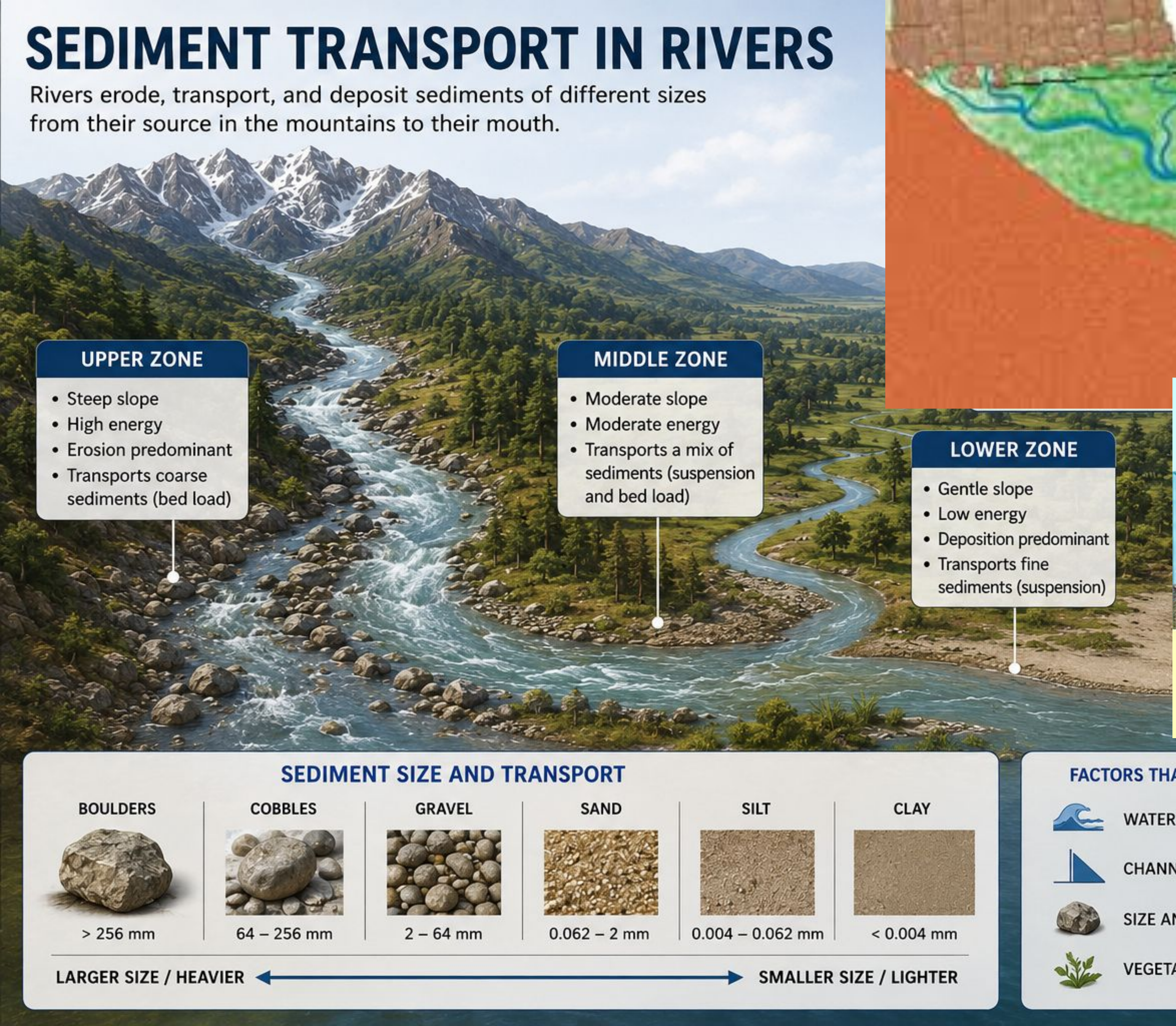
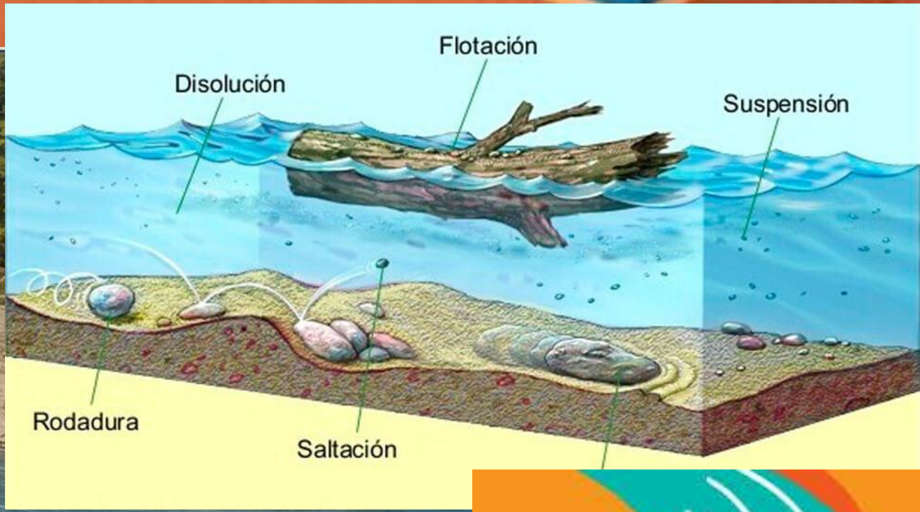
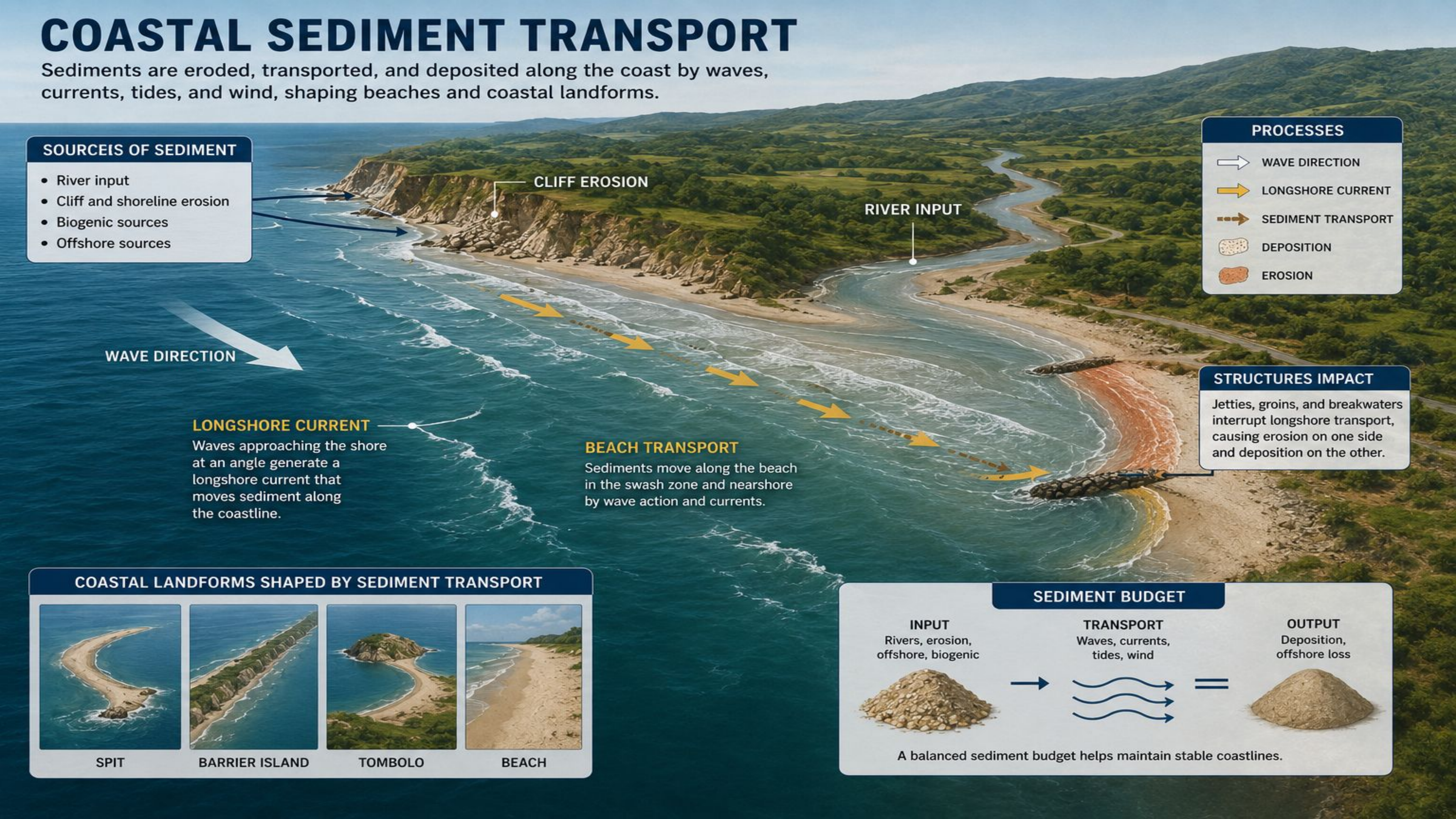

SEDIMENT TRANSPORT IN RIVERS
Rivers erode, transport, and deposit sediments of different sizes from their source in the mountains to their mouth.
UPPER ZONE
• Steep slope
• High energy
• Erosion predominant
• Transports coarse sediments (bed load)
MIDDLE ZONE
• Moderate slope
• Moderate energy
• Transports a mix of sediments (suspension and bed load)
LOWER ZONE
• Gentle slope
• Low energy
• Deposition predominant
• Transports fine sediments (suspension)
SEDIMENT SIZE AND TRANSPORT
BOULDERS
> 256 mm
COBBLES
64 – 256 mm
GRAVEL
2 – 64 mm
SAND
0.062 – 2 mm
SILT
0.004 – 0.062 mm
CLAY
< 0.004 mm
LARGER SIZE / HEAVIER
SMALLER SIZE / LIGHTER
FACTORS THAT INFLUENCE SEDIMENT TRANSPORT
WATER VELOCITY AND DISCHARGE
CHANNEL SLOPE
SIZE AND SHAPE OF SEDIMENTS
VEGETATION COVER AND LAND USE


Erosión
Transporte
Sedimentación

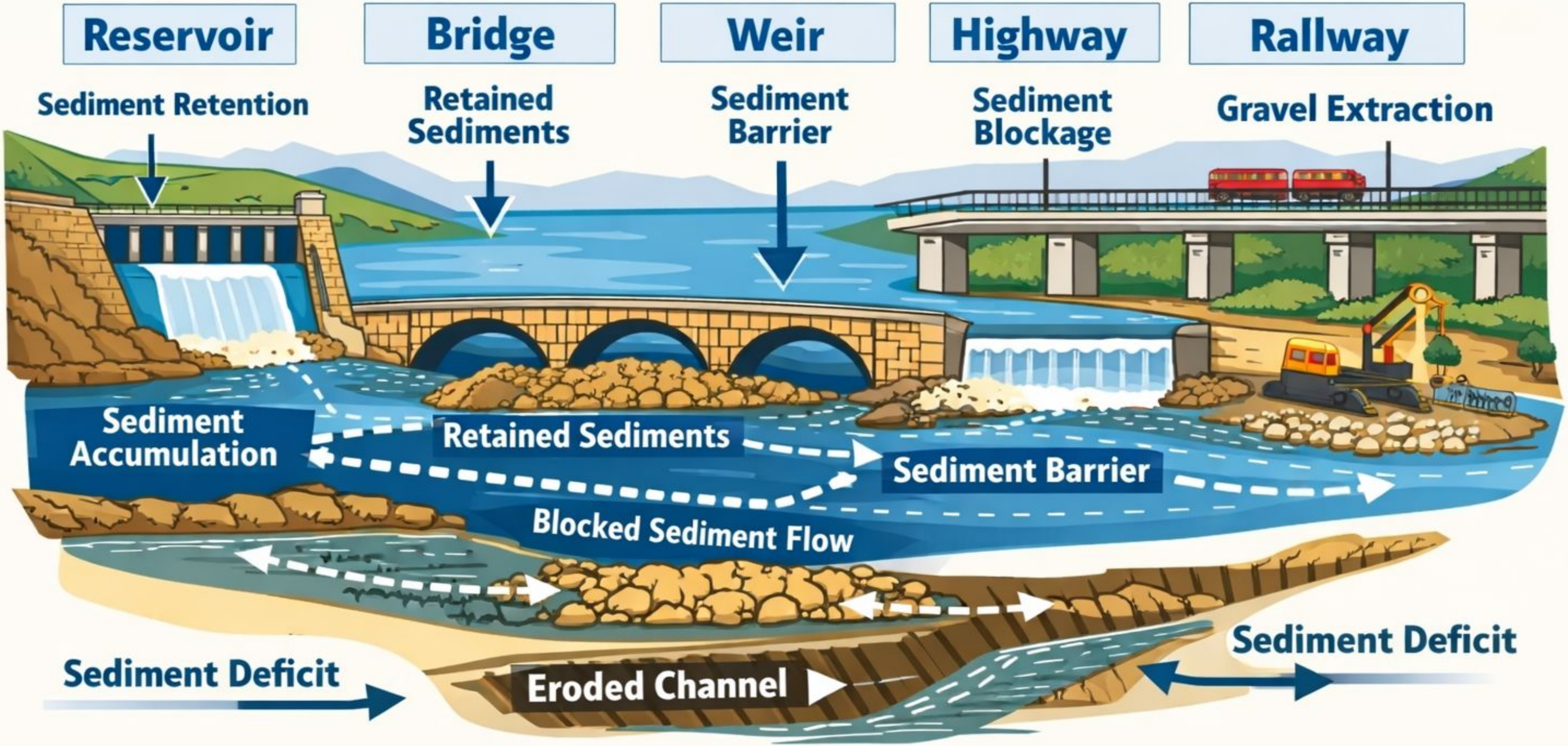

Flotación
Disolución
Suspensión
Rodadura
Saltación


COASTAL SEDIMENT TRANSPORT
Sediments are eroded, transported, and deposited along the coast by waves, currents, tides, and wind, shaping beaches and coastal landforms.
SOURCEIS OF SEDIMENT
River input
Cliff and shoreline erosion
Biogenic sources
Offshore sources
CLIFF EROSION
RIVER INPUT
PROCESSES
WAVE DIRECTION
LONGSHORE CURRENT
SEDIMENT TRANSPORT
DEPOSITION
EROSION
WAVE DIRECTION
LONGSHORE CURRENT
Waves approaching the shore at an angle generate a longshore current that moves sediment along the coastline.
BEACH TRANSPORT
Sediments move along the beach in the swash zone and nearshore by wave action and currents.
STRUCTURES IMPACT
Jetties, groins, and breakwaters interrupt longshore transport, causing erosion on one side and deposition on the other.
COASTAL LANDFORMS SHAPED BY SEDIMENT TRANSPORT
SPIT
BARRIER ISLAND
TOMBOLO
BEACH
SEDIMENT BUDGET
INPUT
Rivers, erosion, offshore, biogenic
TRANSPORT
Waves, currents, tides, wind
OUTPUT
Deposition, offshore loss
A balanced sediment budget helps maintain stable coastlines.

Sediment Transport Management in Jucar River Basin, Spain

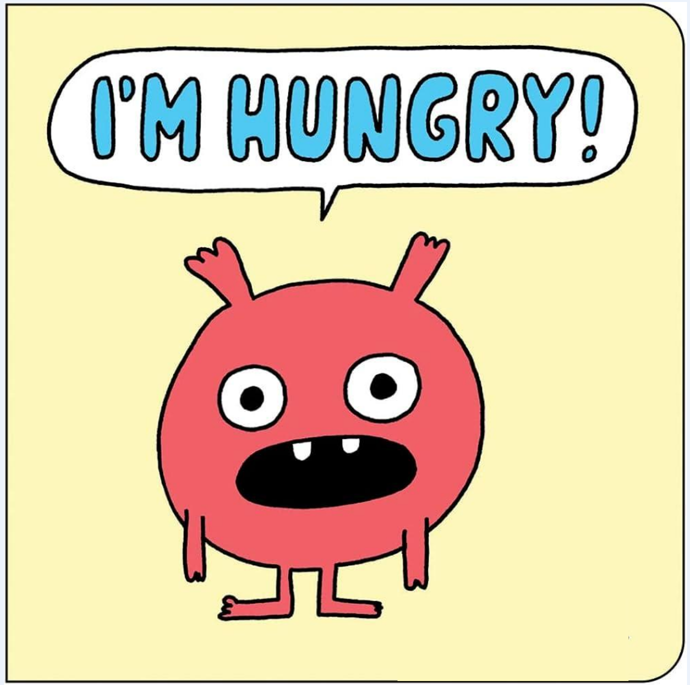
1. Introduction to sediment transport in rivers
2. **Obstacles to sediment transport**
3. Case studies to regulate river sediments
4. Conclusions

Obstacles to Sediment Transport in Rivers



Obstacles to Sediment Transport in Rivers

Rivers and coasts are HUNGRY for sediments



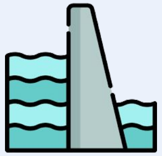
Sediment Transport Management in Jucar River Basin, Spain

1

Water Basin Plan – Law Regulation

Aggregate extraction is **prohibited by default**

Sediments only **purpose** is for the river and marine dynamics



Only allowed where there are **existing barriers** for solid transport (weirs, dams)

Always with **authorization**: control where, when and how

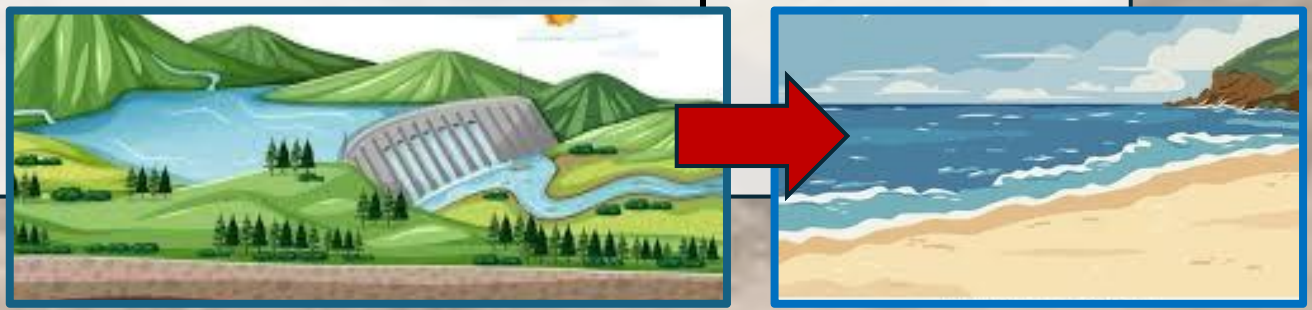
Water Authority **keeps inventory** of all river areas where earth extraction is allowed

2 Protocol between River-Coast Authorities

- Temporary rivers in region.
- Infrastructures limit or prevent free Flow of sediments downstream
- Dams and weirs reduce the volume of sediments that reach the coast
- Sediments in reservoirs reduce storage capacity and efficiency
- Reduction of river sediments input threatens marine ecosystems

2 Water Basin Plan – Law Regulation

- **Basin Authority** identify potential areas for aggregate extraction.
- **Marine authority** proposes area and undertakes extraction
- ONLY for **environmental purposes**
- Transport of **sediments from reservoirs to coastal** renovation projects
- Works during dry season with minimal environmental impact
- No trees cutting



3 Authorization of river extraction in weirs

- 30 years soil accumulation MUST NOT be released in one year
- Only 20% of material is placed downstream, 80% waste manager facility
- **GRADUAL** soil placement before rainy season
- Material **stockpiling** in long thin strips
- **Monitoring** macroinvertebrate

Sediment Transport Management in Jucar River Basin, Spain

Conclusions

- Sediment management at a **basin scale:** river and coast
- **Be realistic.** Return to unaltered river system is not posible. Adaptation is vital.
- Include **sediment by-pass** in dams and weirs as part of its maintenance costs
- Many Stockholders. Need for stronger **Colaboration**
- **New regulations:** simplify burocrazy

Thank you for your attention

Integrated Sediment Transport Management in Jucar River Basin, Spain

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CONFEDERACIÓN HIDROGRÁFICA DEL JÚCAR

Support: ABAR AGEVAP

Organization: INBO REBOB FÓRUM

Realization: Secretaria de Ambiente e Sustentabilidade GOVERNO DO ESTADO RIO DE JANEIRO Rio20 30

"Addressing Sediment-Related Pressures through Integrated Watershed Management in the Alto Araguaia Basin, Brazil"

Project: *Sustainable protection and restoration of rivers, wetlands, and lakes through integrated, sustainable watershed management planning in Brazil and India*

Astrid Carol Sotomayor Chavez

16 June 2026

Funded by the European Union

UN environment programme

The Nature Conservancy Brasil

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Project Objective

The objective of the project is to develop a **replicable and scalable approach to integrated watershed management** that revalues, restores, and reconnects freshwater ecosystems.

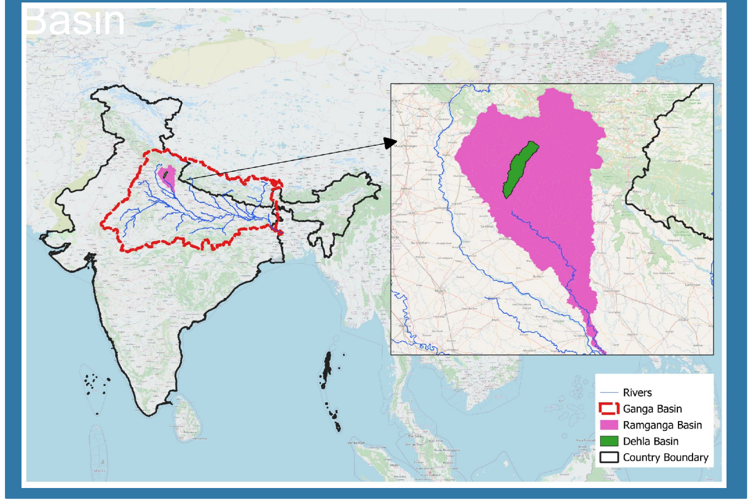
The project aims to achieve:

- Restored and resilient watershed ecosystems
- Improved and sustainable livelihoods for local communities
- Strengthened collaboration between science, policy, and communities
- A scalable global model for integrated watershed management

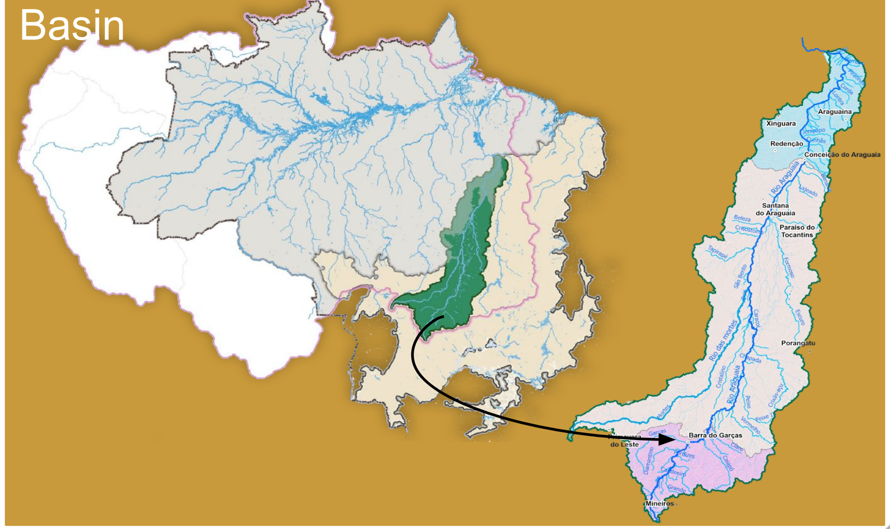
Entry point to the sediment agenda: upstream erosion control through integrated watershed management

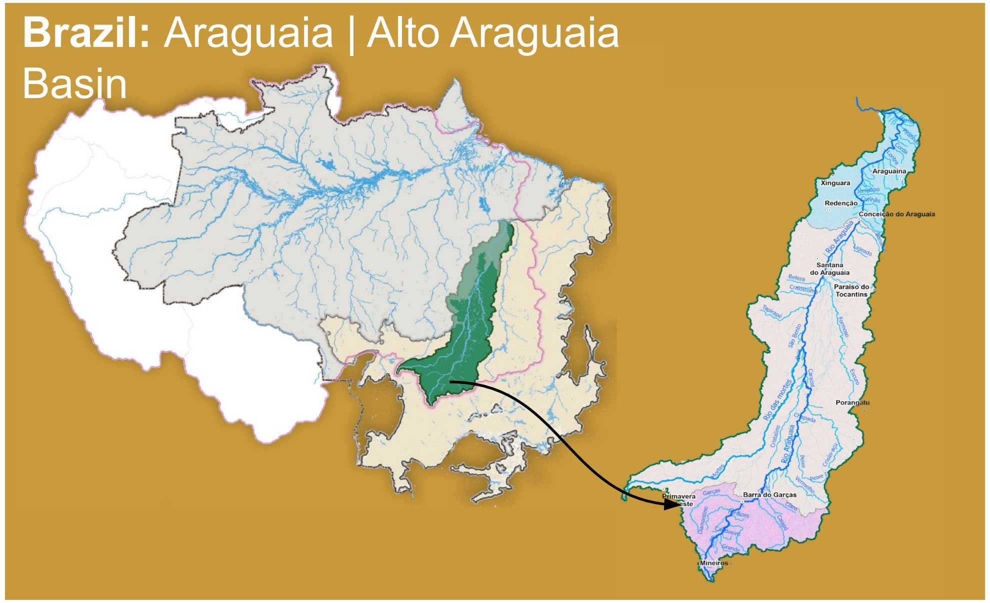
The project adopts a learning-by-doing approach, combining on-ground implementation with knowledge generation

India: Ganga | Ramganga | Delha Basin



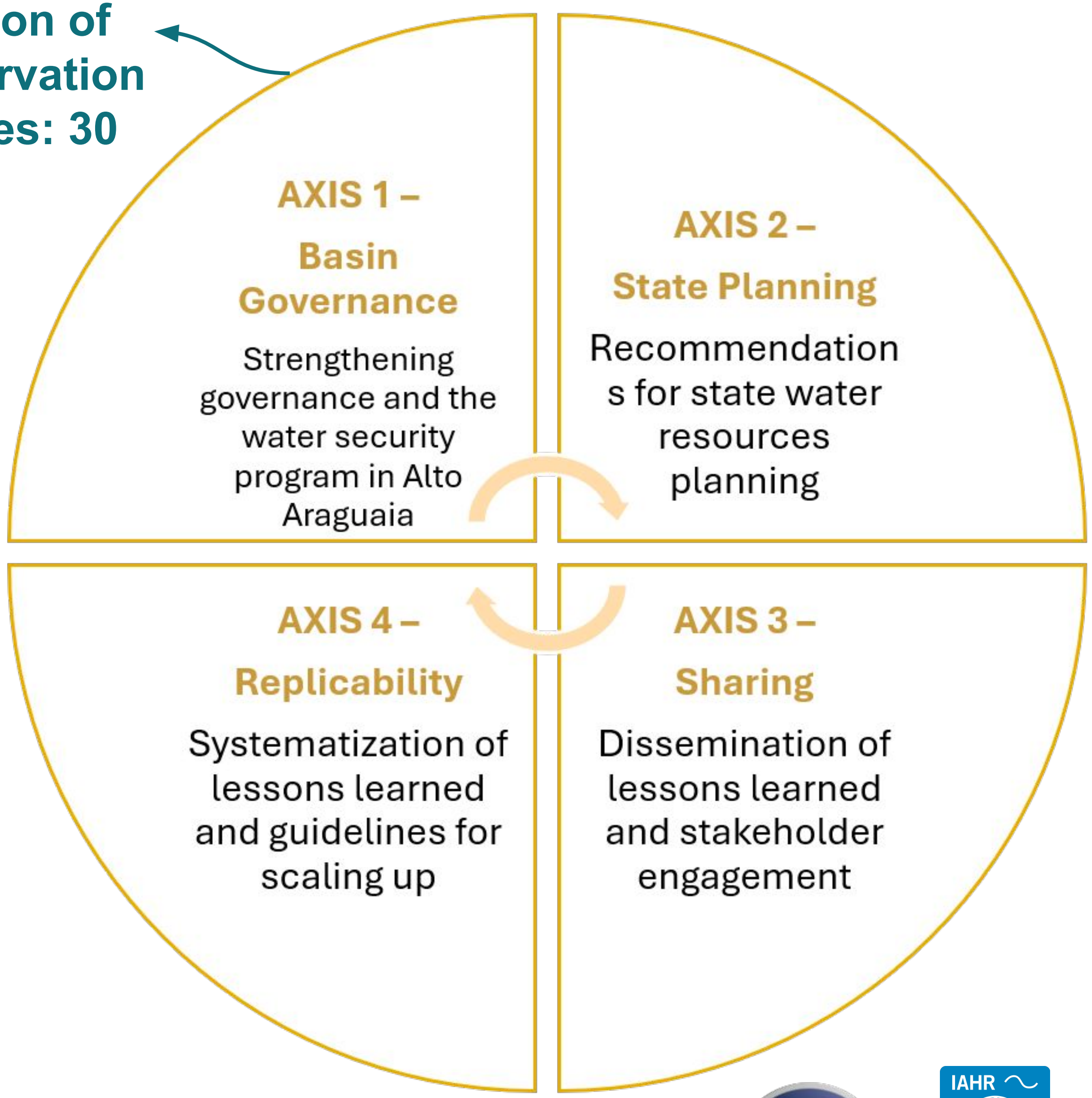
Brazil: Araguaia | Alto Araguaia Basin





- Total Area 36.400 km²
- Region of the main headwaters of the Araguaia River
- The main anthropogenic pressures are related to the expansion of **livestock, agriculture, and mining** (increase erosion, runoff and sediment-related impacts in headwater areas)
- 12 municipalities in the state of Mato Grosso
- **Alto Araguaia Basin Committee**: composed of representatives from the public sector, water users (agriculture, industry, mining), civil society, and Indigenous peoples

Application of soil conservation techniques: 30 ha

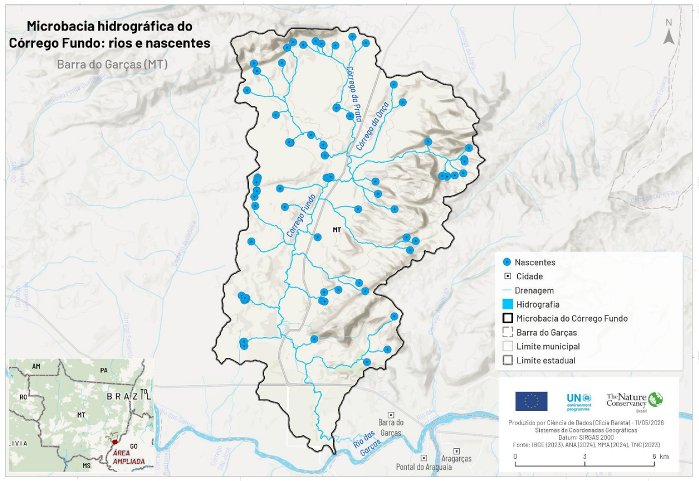


Integrated Sediment Transport Management in River Basins

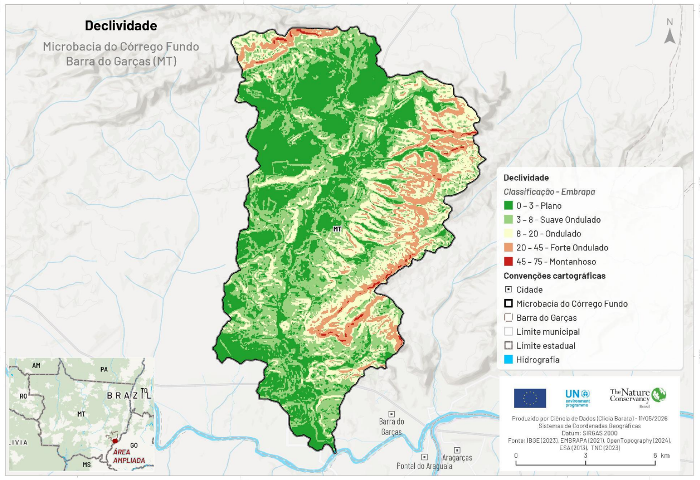
INBO International Network of Basin Organizations
CIGB ICOLD
IAHR AIRH Hosted by Spain Water and IWHR, China

Córrego Fundo micro-watershed: diagnosing erosion and sediment-related pressures

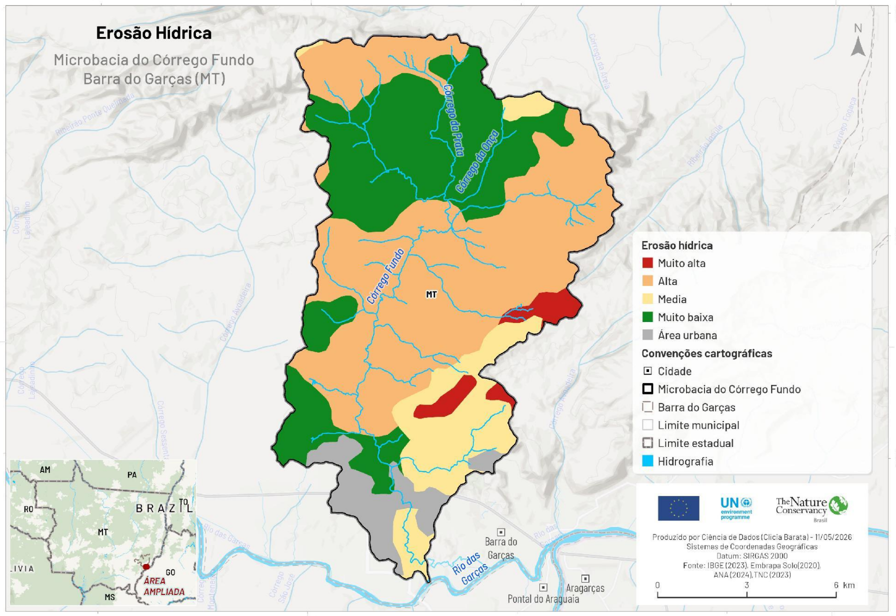
Springs



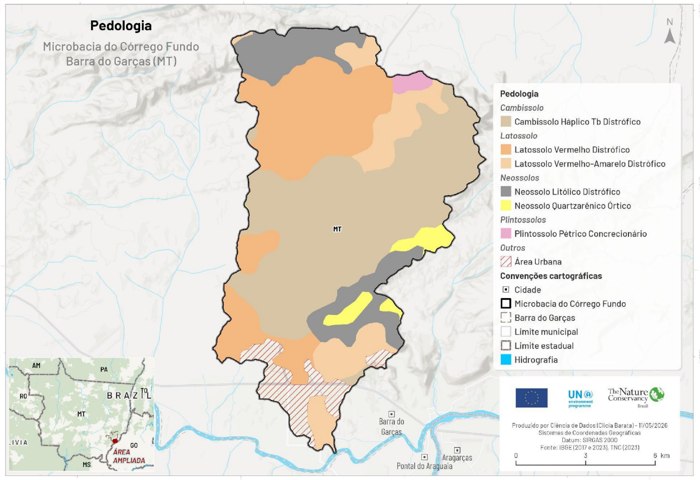
Slope



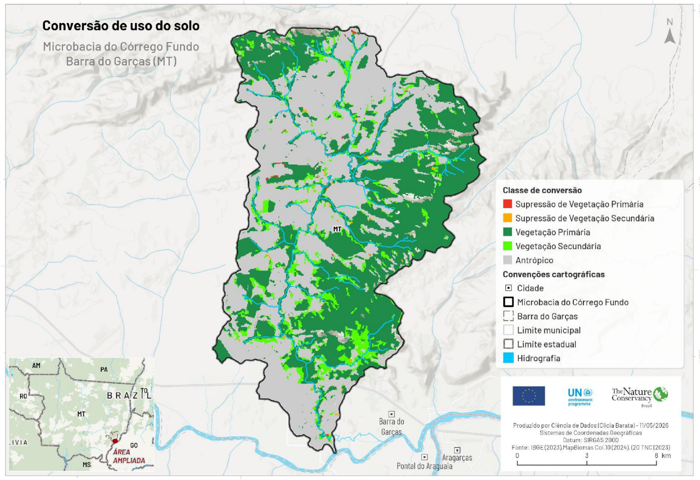
Water Erosion Susceptibility



Soil Types



Land Use Change



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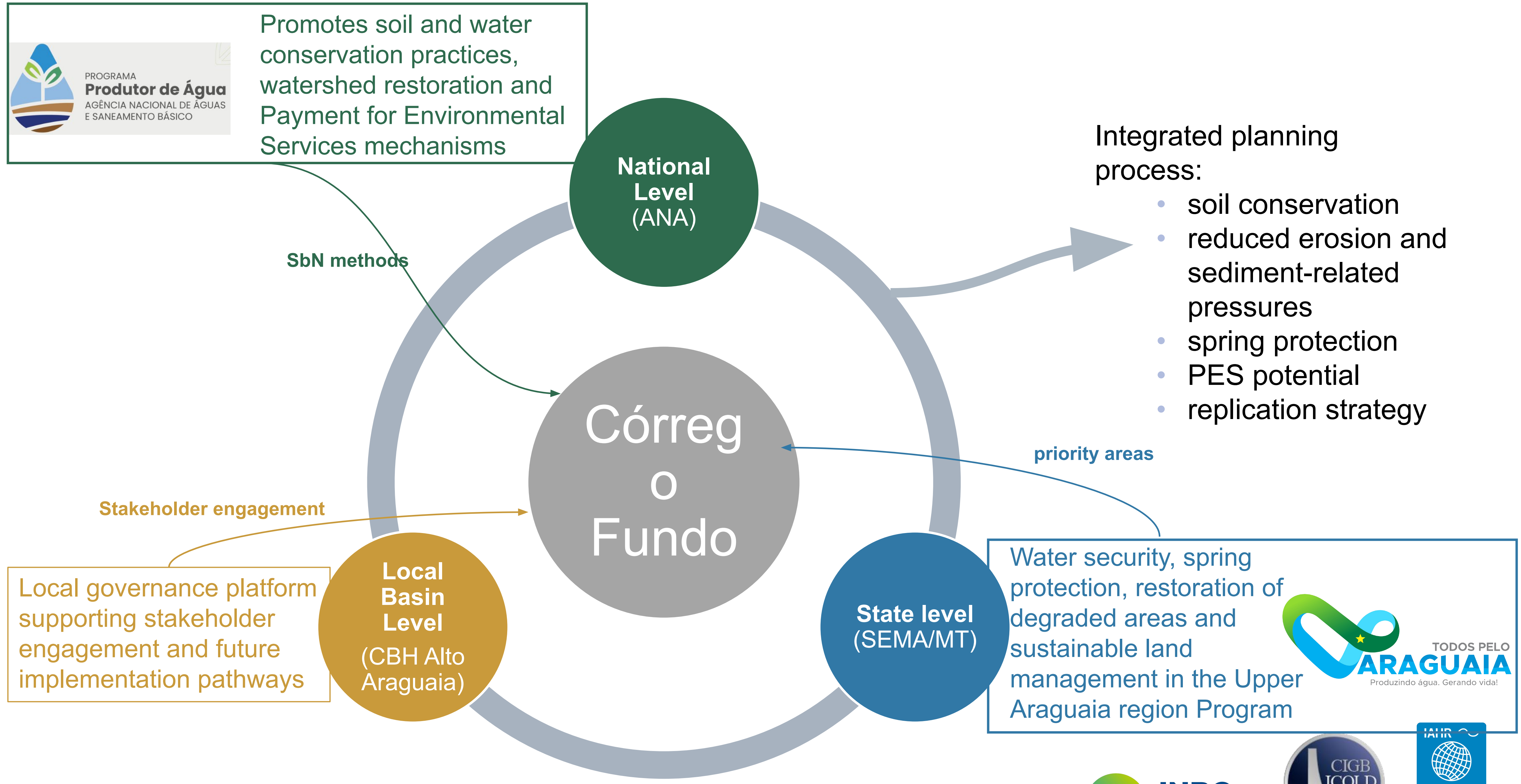

Integrated Sediment Transport Management in River Basins

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From Local Action to Global Learning: South-South Cooperation and Knowledge Generation

UNEP value-added: transforming basin-level implementation into scalable guidance for other watersheds

BRAZIL PILOT
Alto Araguaia Basin
Córrego Fundo
micro-watershed

cross-country exchange of practical approaches

INDIA PILOT
Ganga | Ramganga |
Dehla Basin

Governance
- basin institutions
- stakeholder engagement

Restoration
- upstream action
- erosion prevention

Finance
- PES
- sustainable mechanisms

Communities
- local ownership
- learning-by-doing

KNOWLEDGE GENERATION

Systematizing lessons into global guidance products for practitioners, basin organizations and decision-makers

Sediment relevance: upstream erosion control generates practical learning for sediment-related basin management.

GLOBAL REPLICATION: scalable integrated watershed management approaches beyond the project countries

From erosion control to integrated watershed planning

Upstream action	Governance	Programme alignment	Replication
Erosion control and infiltration	Basin committee and stakeholders	Todos pelo Araguaia + ANA Water Producer Programme	Strategic Plan and PES potential

Practical NbS implementation on the ground

- Pilot in the Córrego Fundo micro-watershed (Barra do Garças) with **soil conservation measures, spring protection and restoration opportunities**.
- Demonstrates how basin planning translates into **visible action, local ownership and learning.**

Programme alignment and capacity-building

- Connecting **the national Water Producer Programme** with the **state-level Todos pelo Araguaia initiative.**
- Technical exchange, prioritization and **institutional strengthening** to move from planning to delivery.

Thank you!

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UN environment programme

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