ENVIRONMENTAL INTELLIGENCE | LAB

This presentation participates in OSPP

EGU

Outstanding Student & PhD candidate Presentation contest

BALANCING SEDIMENT CONNECTIVITY and ENERGY PRODUCTION

via OPTIMIZED RESERVOIR SEDIMENT MANAGEMENT STRATEGIES

POLITECNICO MILANO 1863

EGU

WHAT IS SEDIMENT CONNECTIVITY ?

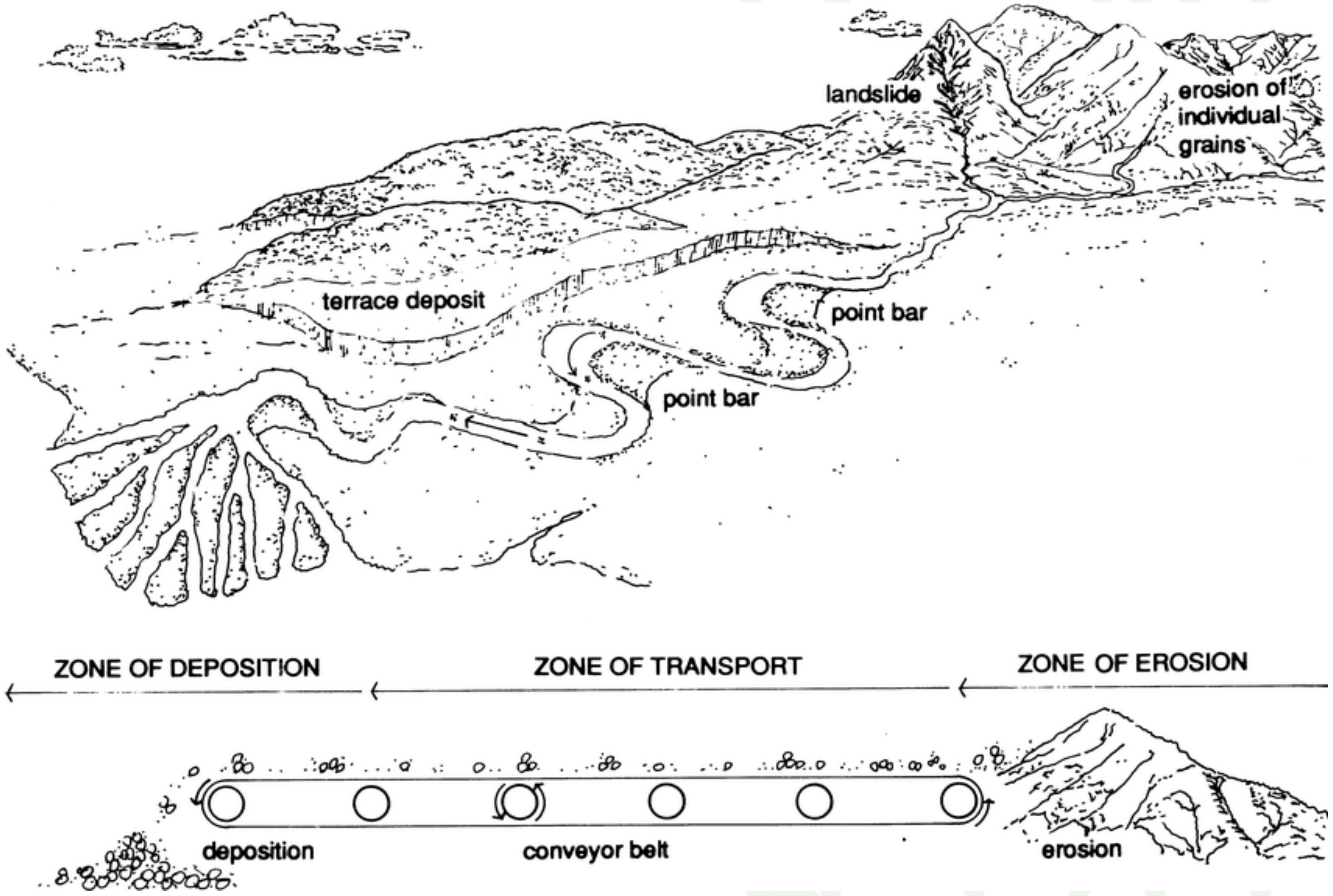
ENVIRONMENTAL INTELLIGENCE LAB

A BROAD DEFINITION

Rivers are **deeply interconnected and complex systems.**

Sediment transport plays a fundamental role in the process of **fluvial geomorphology, ecosystem integrity, transport of nutrient and erosion.**

Figure from Kondolf (1997).



SEDIMENT CONNECTIVITY DISTRUPTION

Reservoir may starve river system of sediment, while filling with material

Multiple reservoirs may lead to cumulative effects difficult to predict with a local analysis

LSS2 reservoir – Laos. NASA imagery

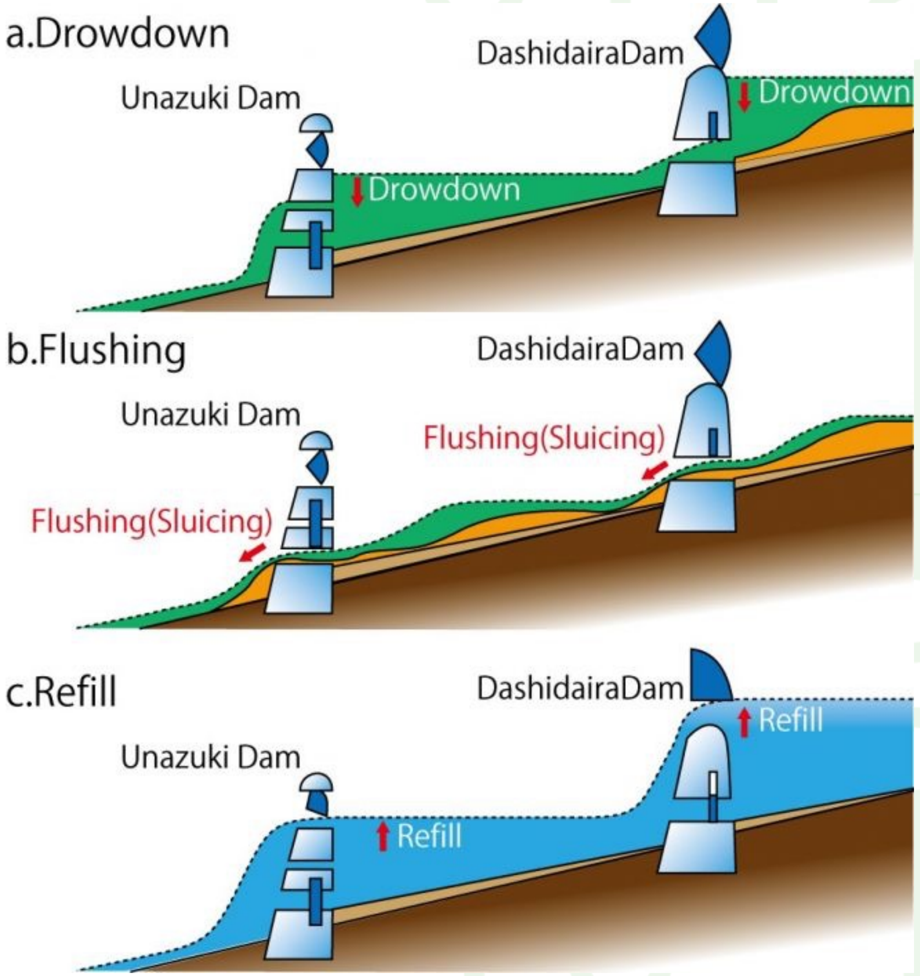
RESERVOIR SEDIMENT MANAGEMENT

ENVIRONMENTAL INTELLIGENCE LAB

Reservoir management strategies such as **DRAWDOWN SEDIMENT FLUSHING** may reduce impacts on the reservoir and the river system.

Sediment flushing stops regular hydropower operations, at the cost of energy production

If multiple reservoir are present, sediment flushing must be synchronized



Flushing operations in the Dashidara and Unzauki dams https://www.hydropower.org/sediment-management-case-studies/japan-dashidaira

CASE STUDY

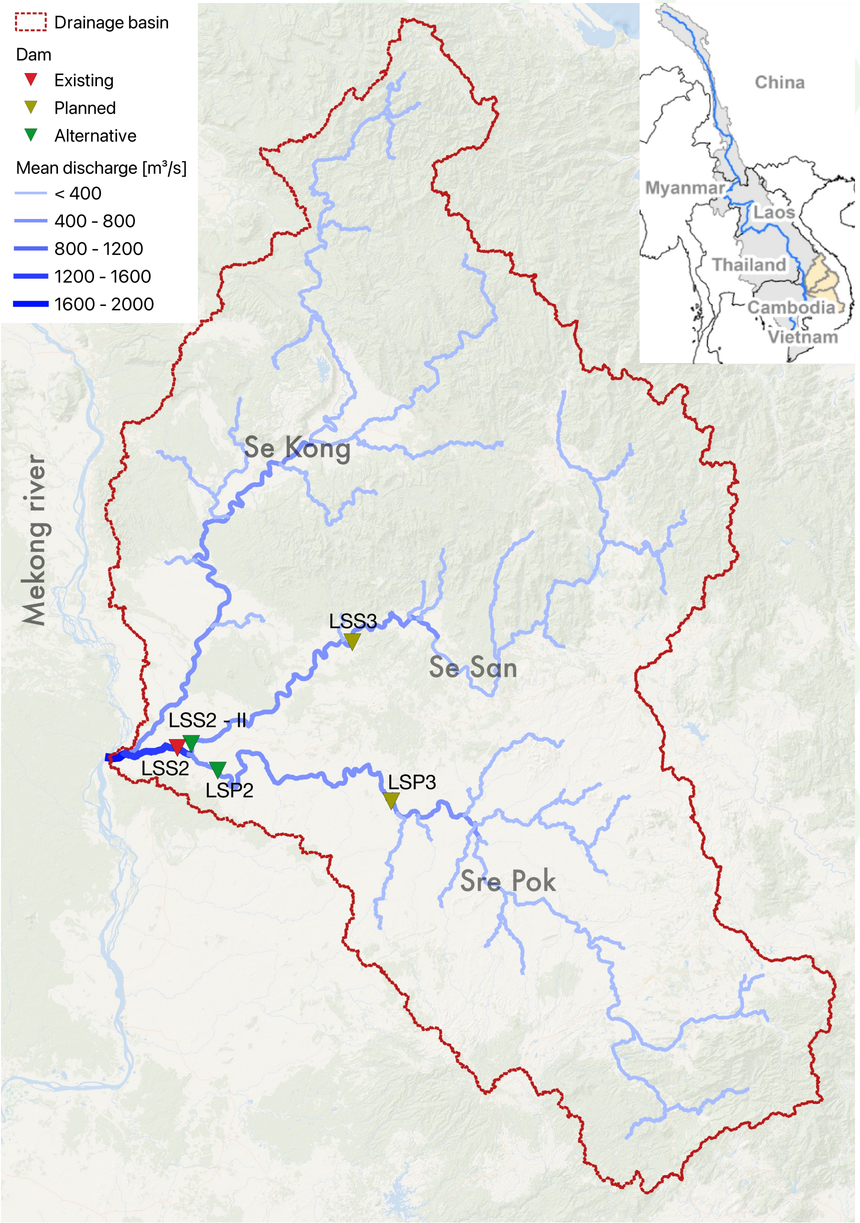
Location - Lower Mekong

Drainage area – 82.600 km^2

Water regime - Monsonic (May to October)
17-20% of the annual discharge of the Mekong

Sediment Delivery – 16/22 Mt/y

Heavy sand contribution to the Mekong Delta

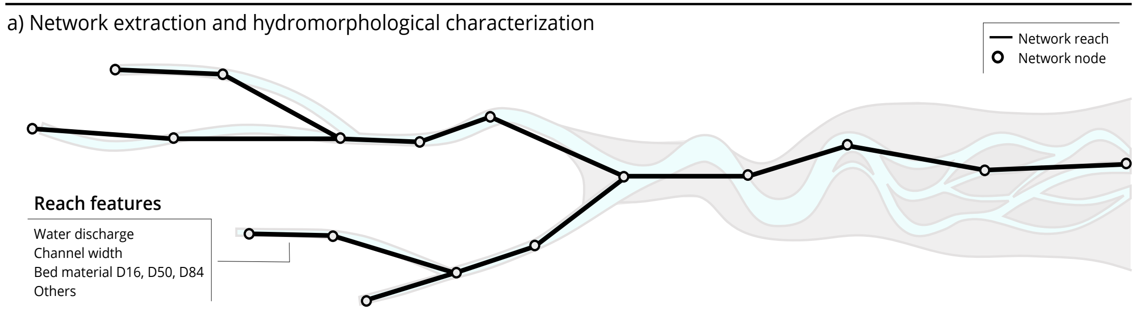


D-CASCADE MODEL

D-CASCADE is a large-scale, dynamic, exploratory sediment (dis)connectivity model

Outputs:

- **Distributed, time-varying sediment transport patters**
- **Information on sediment provenance, type and destination**



Initialization

- Network extraction
- Network fetures and hydrology definition
- Sediment contribution definition
- Simulation boundary conditions definition

Main CASCADE Loop

For each timestep, for each reach

1) Sediment mobilization, erosion and deposition
   - Define incoming and deposited sediment layer
   - Compose active layer
   - Measure daily trasport capacity
   - Define mobilized sediment volume and new deposit layer

2) Reach features changes modelizations

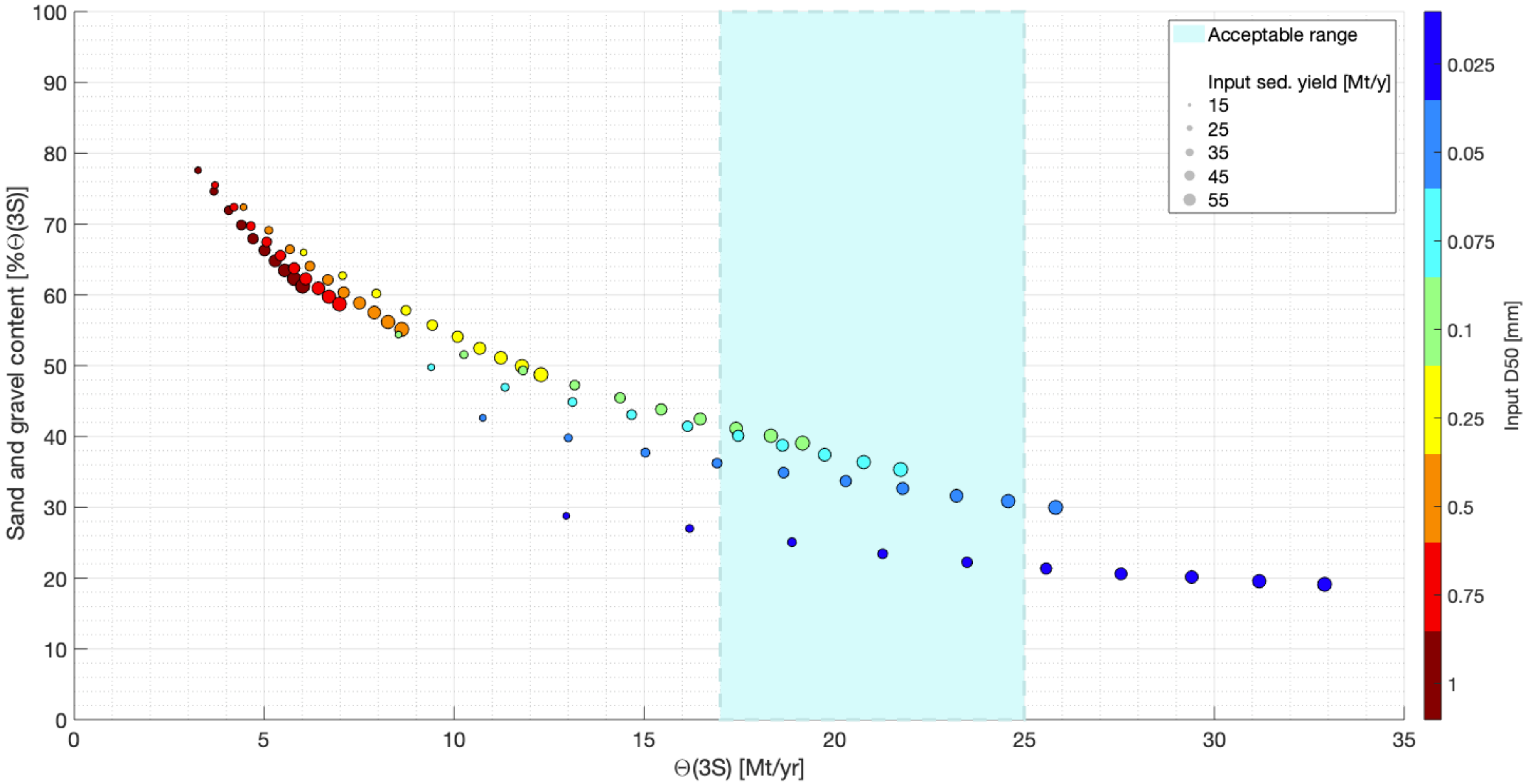
3) Sediment trasport and delivery
   - Define sediment velocity
   - Deliver mobilized sediment volume to destination

Visualization of the D_CASCADE modelling structure

I. PRISTINE SEDIMENT BUDGET DEFINITION

Using distributed catchment sediment yield input

- **11 GSD scenarios: D50 =** 1 - 0.005 mm
- **10 Sed. yield scenarios: Tot yield** = 15 - 60 Mt/y

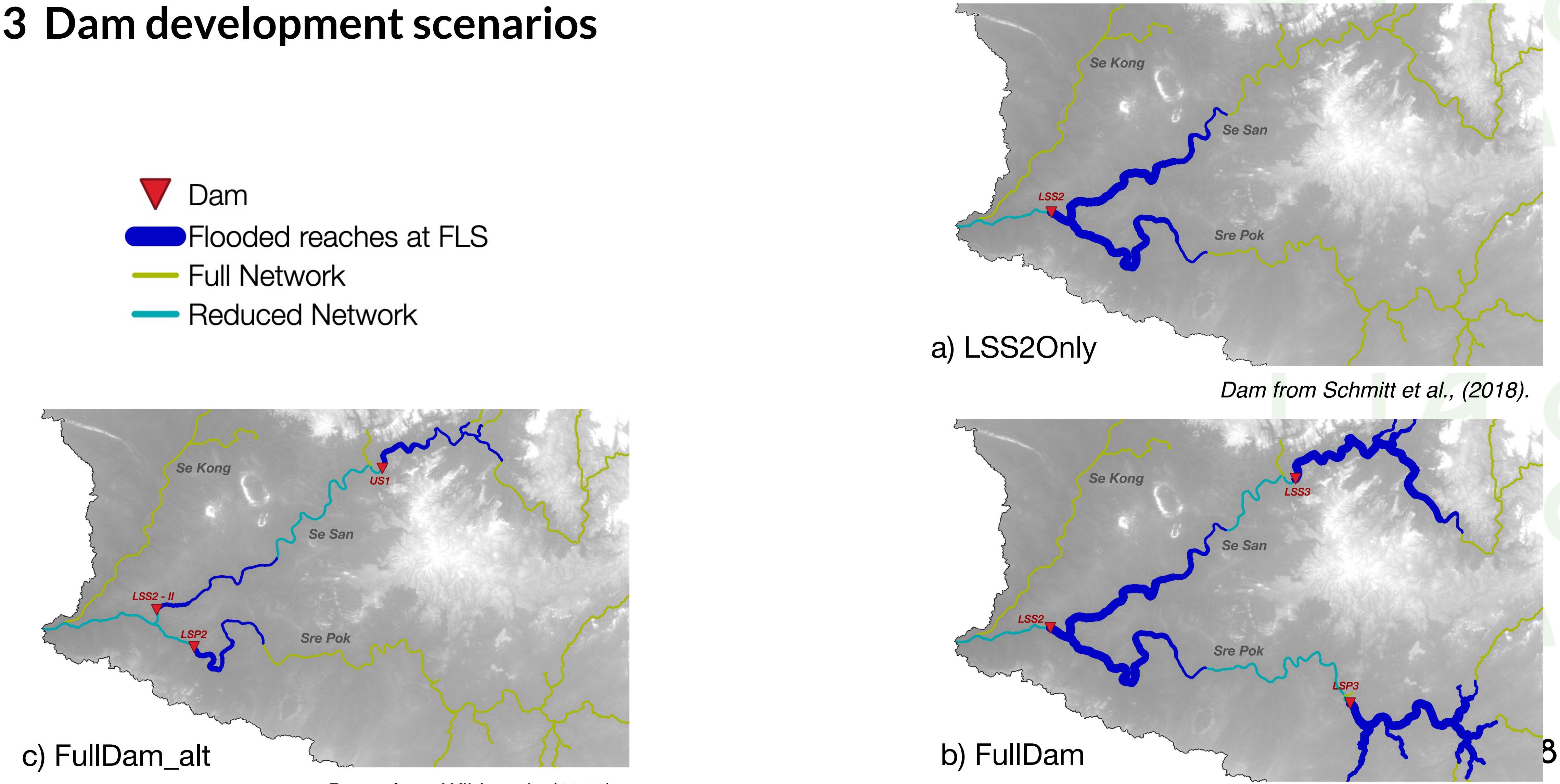


II. DAM IMPACT ASSESSMENT

On outlet sediment delivery

ENVIRONMENTAL INTELLIGENCE LAB

3 Dam development scenarios

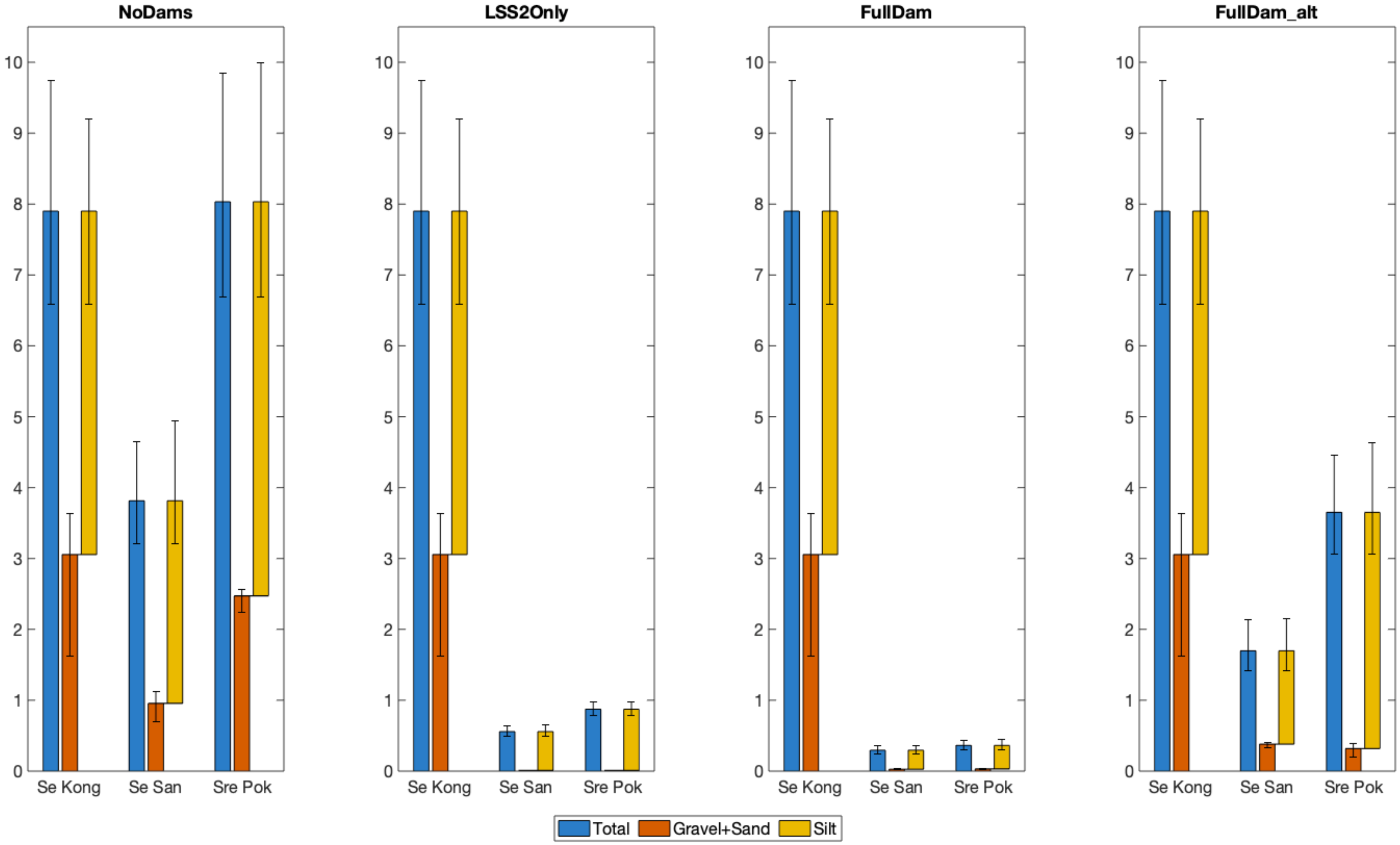


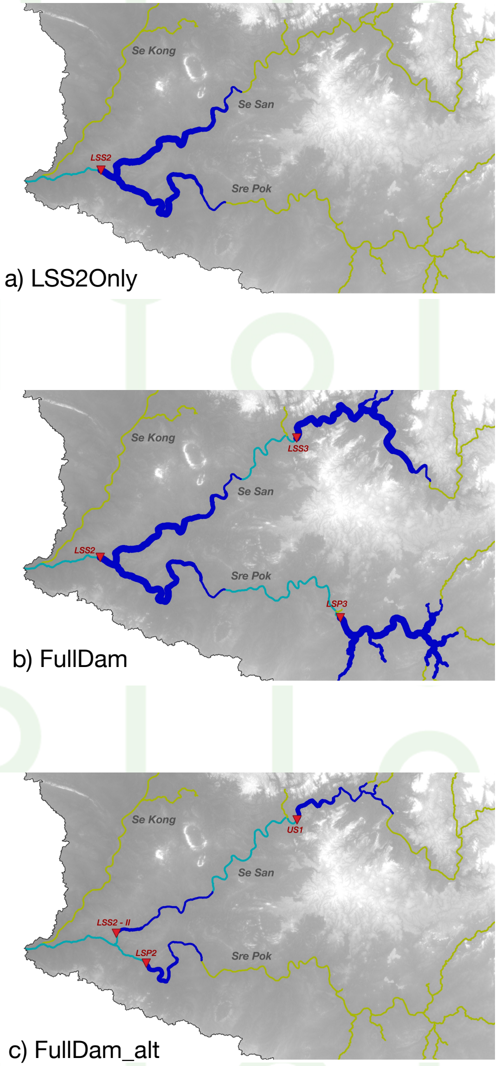
Dam from Schmitt et al., (2018).

Dams from Wild et al., (2016).

II. DAM IMPACT ASSESSMENT

On outlet sediment delivery





a) LSS2Only

b) FullDam

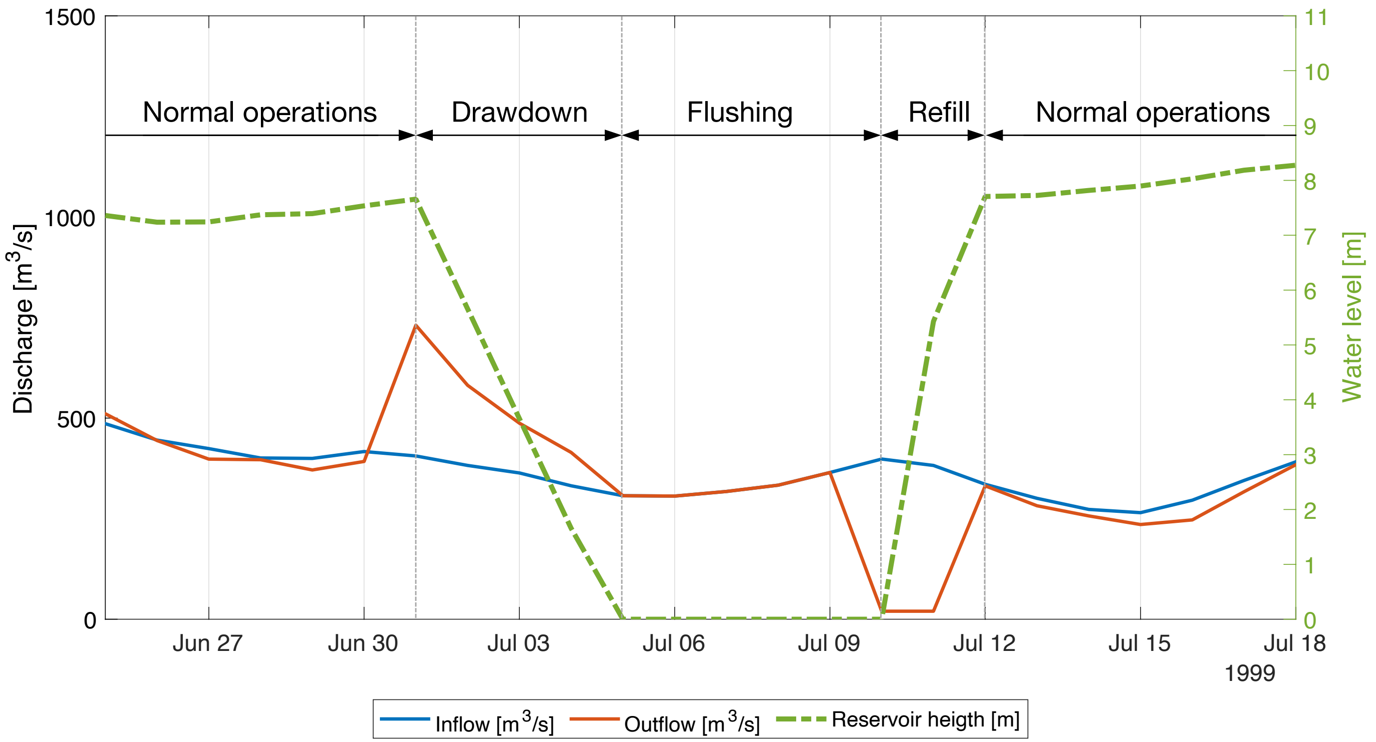
c) FullDam_alt

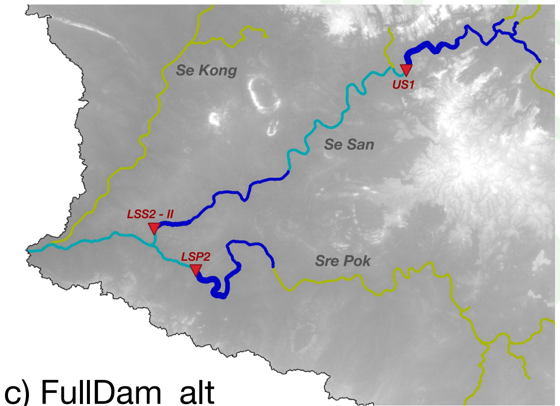
III. OPTIMAL FLUSHING STRATEGY

Via Borg Multiobjective Evolutionary Algorithm (MOEA)

Optimization Parameters:

1. Flushing Frequency
2. Starting Month
3. Minimum Inflow
4. Duration
5. US1 / LSS2-II Synchronization

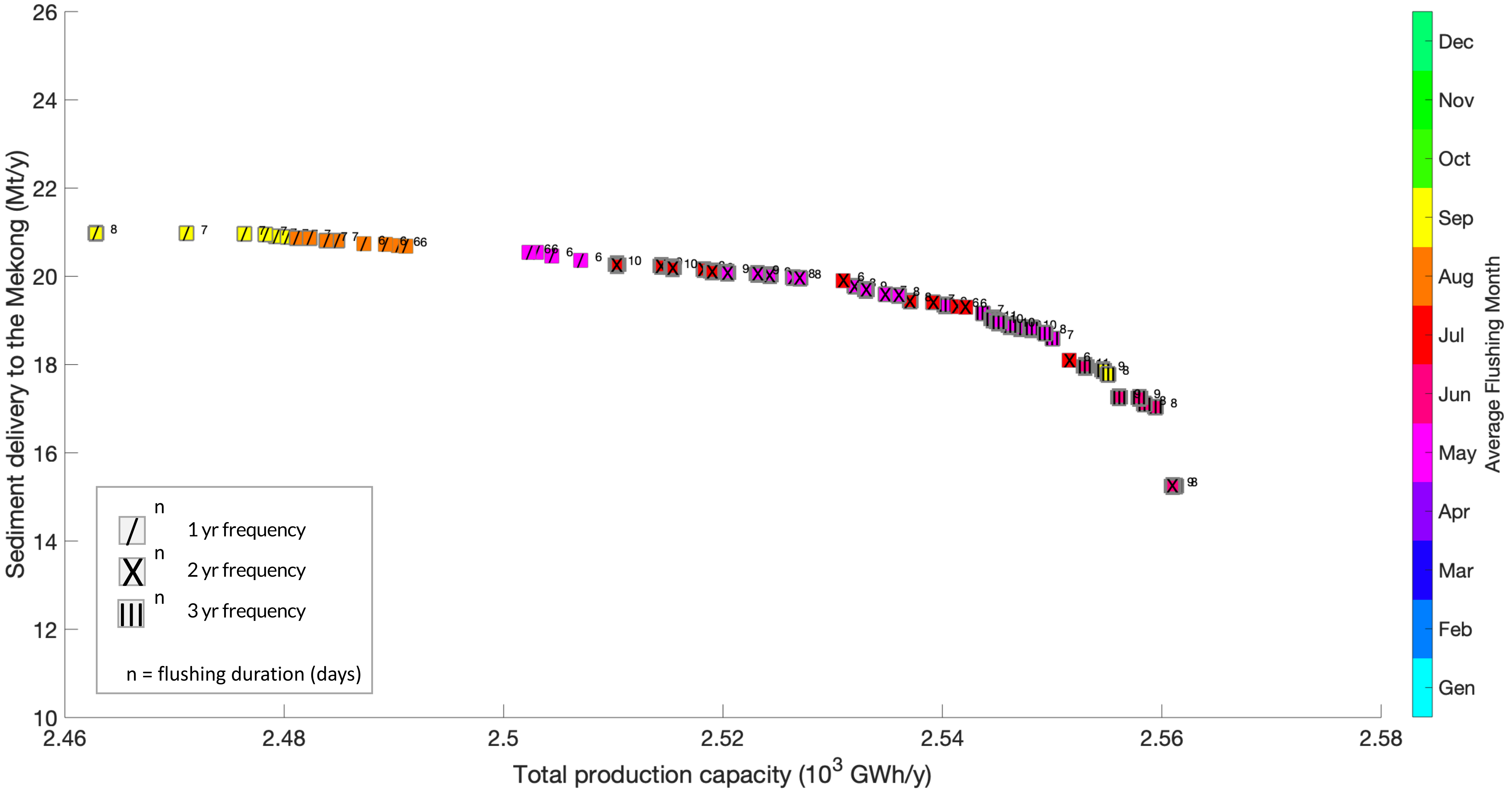




c) FullDam_alt

III. OPTIMAL FLUSHING STRATEGY

Via Borg Multiobjective Evolutionary Algorithm (MOEA)



Conclusions

- D-CASCADE generated credible patterns of sediment delivery in a data scarce environment

- We successfully integrated reservoir water and sediment management in the model

- D-CASCADE can be integrated in multi-objective decision-making frameworks for sediment management optimization

ENVIRONMENTAL INTELLIGENCE LAB

This presentation participates in OSPP

Outstanding Student & PhD candidate Presentation contest

Thank you

POLITECNICO MILANO 1863