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La pianificazione strategica delle dighe:
il caso del fiume Mekong

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A global outlook on dams

3,682 dams under construction or planned (~775 GW)

(Animation by Fabio Corso; data: Lehner et al. 2011, Zarfl et al. 2015)

A global outlook on dams

More than 3500 new dams planned globally

Kongo

Amazon

Mekong

Opperman et al., 2017
Winemiller et al. 2017

One benefit multiple impacts

Externalities to dam design

Flooding and re-settlement

Fluvial ecosystem damages

River corridor fragmentation

Sediment connectivity alteration

Many others

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Externalities to dam design

Sediment management in rivers

Upscaling actions and impacts

Sediment management in rivers

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Sediment management in rivers

Upscaling actions and impacts

Modelling sediment connectivity

Enlarging the scale

CONTEXT

Growing interest and effort in **modeling sediment budget** at the whole **network scale**

but so far **mostly qualitative** (e.g. Fryirs et al., 2007; Bracken et al. 2013; Heckmann & Schwanghart 2013)

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CHALLENGE

Quantitative models are needed to support **strategic decision-making**

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OPPORTUNITIES

New data from **Remote Sening** are opening up opportunities for building **quantitative models**

(e.g. Carbonneau & Piegay 2012, Bizzi et. 2016)

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LIMITATIONS

Balance between scales and complexity allows only **for exploratory, parsimonious tools** representing some but not all the processes (e.g. Schmitt et al. 2016)

CASCADE (CAtchment SEdiment Connectivity And DElivery)

OUTPUTS

- Sediment fluxes in each reach
- Sediment provenance in each reach

Schmitt et al., 2017

THE MEKONG RIVER BASIN

sediment trapping vs energy generation: is a balance possible?

The Mekong basin

A life-line of South East asia

790,000 km^2 drainage area

Major hydropower potential
(› 250,000 GWh) in 120 + dam sites

6 riparian countries

60 million people depend on rivers for their livelihood – 20 million people in the delta

Sediment load – 100 – 160 Mt/yr

Building all dams will reduce sediment transport to the delta by › 90 %

Existential threat to delta livelihoods

Network-scale impacts of dam sediment trapping

Project-by-project design

Project-by-project dam development in the Mekong (and elsewhere) does not consider network scale cumulative impacts

Network-scale impacts of dam sediment trapping

Strategic portfolios planning

Project-by-project dam development in the Mekong (and elsewhere) does not consider network scale cumulative impacts

Strategic portfolio planning aims to identify dam portfolios with a **good trade-off between generation and cumulative sediment trapping**

Modelling sediment connectivity

CASCADE

Network-scale river models enable rapid screening of cumulative, network-scale impacts for many different dam portfolios

CASCADE:
Process-based simulation of sediment transport for Mekong tributaries

CASCADE routing models for major rivers in SE – Asia

CASCADE: Schmitt et al., 2016

Strategic planning for less dam sediment trapping

Dams in the lower Mekong tributaries:
15,000 GWh generation, 90 % of basin's sediment trapped

Schmitt et al., 2018

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Same generation could be reached for < 20 % trapping by selecting a different dam portfolio

Schmitt et al., 2018

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Knick-point in optimal portfolios identifies limits for sustainable hydropower expansion

Schmitt et al., 2018

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Dams in the lower Mekong tributaries: **15,000 GWh generation, 90 % of basin's sediment trapped**

Same generation could be reached for < 20 % trapping by selecting a different dam portfolio

Knick-point in optimal portfolios identifies limits for sustainable hydropower expansion **and suggests where to site new dams**

Schmitt et al., 2018

Upscaling strategic planning for dams to the whole basin scale

Analysis Framework

CASCADE model for network-scale sediment routing and dam sediment trapping to identify impacts of different dam portfolios

Evolutionary algorithm to identify **optimal dam sequence** to **minimize sediment trapping** and **maximize hydro generation**

Kondolf, Schmitt, et al., (2018)

Dam site – trap efficiency

Strategic hydropower planning in the Mekong

Sediment trapping of the current dam portfolio

Built

Under construction

Lower Lancang:
China

Current Portfolio

140000 GWh/yr | 55 MT/yr

Lower Mekong tributaries:

Vietnam, Cambodia

(*Schmitt et al. 2018*)

Strategic hydropower planning in the Mekong

Sediment trapping of the current dam portfolio

Built

Under construction

Planned future

Current Portfolio	140000 GWh/yr | 55 MT/yr
Planned Future	› 250000 GWh/yr | ‹ 10 MT/yr

Strategic hydropower planning in the Mekong

Optimizing future delta connectivity

Built

Under construction

Planned future

Optimizing Delta connectivity

Current Portfoliio	140000 GWh/yr | 55 MT/yr
Planned Future	› 250000 GWh/yr | ‹ 10 MT/yr
Optimizing Delta connectivity	› 200000 GWh/yr | 50 MT/yr

Strategic hydropower planning in the Mekong

Optimizing future delta connectivity

Anticipating dam development in the upper Lancang to maintain delta connectivity

Postponing lower Mekong mainstem dams

Challenges for transboundary strategic planning

Equity and energy production

Energy exports

Challenges for transboundary strategic planning

Equity and energy production

Energy exports

Challenges for transboundary strategic planning

Conflicts between environmental objectives

Sacrificing the Lancang to maintain delta connectivity?

Challenges for transboundary strategic planning

Conflicts between environmental objectives

Sacrificing the Lancang to maintain delta connectivity?

Or considering non-hydro alternatives?

Conclusions

Opportunities and future challenges

(1) Strategic planning, siting, and sequencing for minimizing dam impacts on river networks

(2) Transboundary conflicts and conflicts between ecosystem services require quantitative and network scale assessments

(3) Data-scarcity and large scales – quantifying model sensitivity and robustness of optimization results

(4) Integrate strategic planning with dam operation and design

(5) More and better data are needed to support strategic planning

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THANK YOU

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