



# Water for energy: Sustainable hydropower development in the Indus basin

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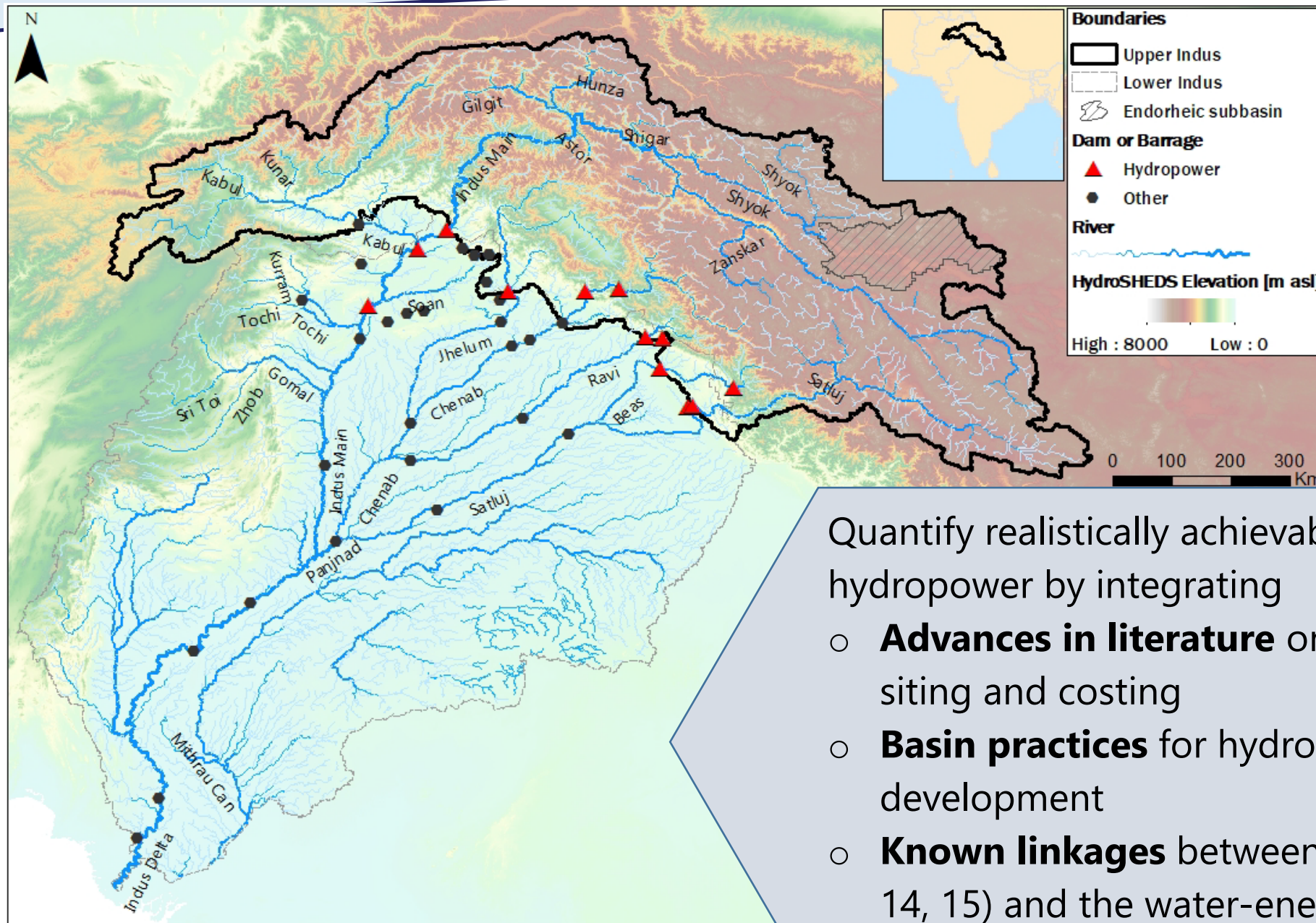
# Objectives

- Envision hydropower development pathways considering future climate and socio-economic changes and the Sustainable Development Goals (SDGs) interlinked by the water-energy-food nexus in the Indus basin

**Phase 1:** What is the realistically **achievable hydropower generation potential** - now and in the future of the Indus basin?

**UIBN Q8:** What are the most suitable and sustainable development options for the upstream part of the basin?





# Phase I

Quantify realistically achievable potential for hydropower by integrating

- **Advances in literature** on hydropower sizing, siting and costing
- **Basin practices** for hydropower design and development
- **Known linkages** between SDGs (2, 6, 7, 9, 13, 14, 15) and the water-energy-food nexus that affect the sustainability of hydropower



# Different classes of "potential"



## THEORETICAL

- ✓ Natural discharge
- ✓ Natural elevation



## TECHNICAL

- ✓ Local design preference
- ✓ Hydropower policy
- ✓ Infrastructure needs
- ✓ Compensation
- ✓ Land use



## FINANCIAL

- ✓ Cost-competitive  
(Below 0.10 USD/kWh)

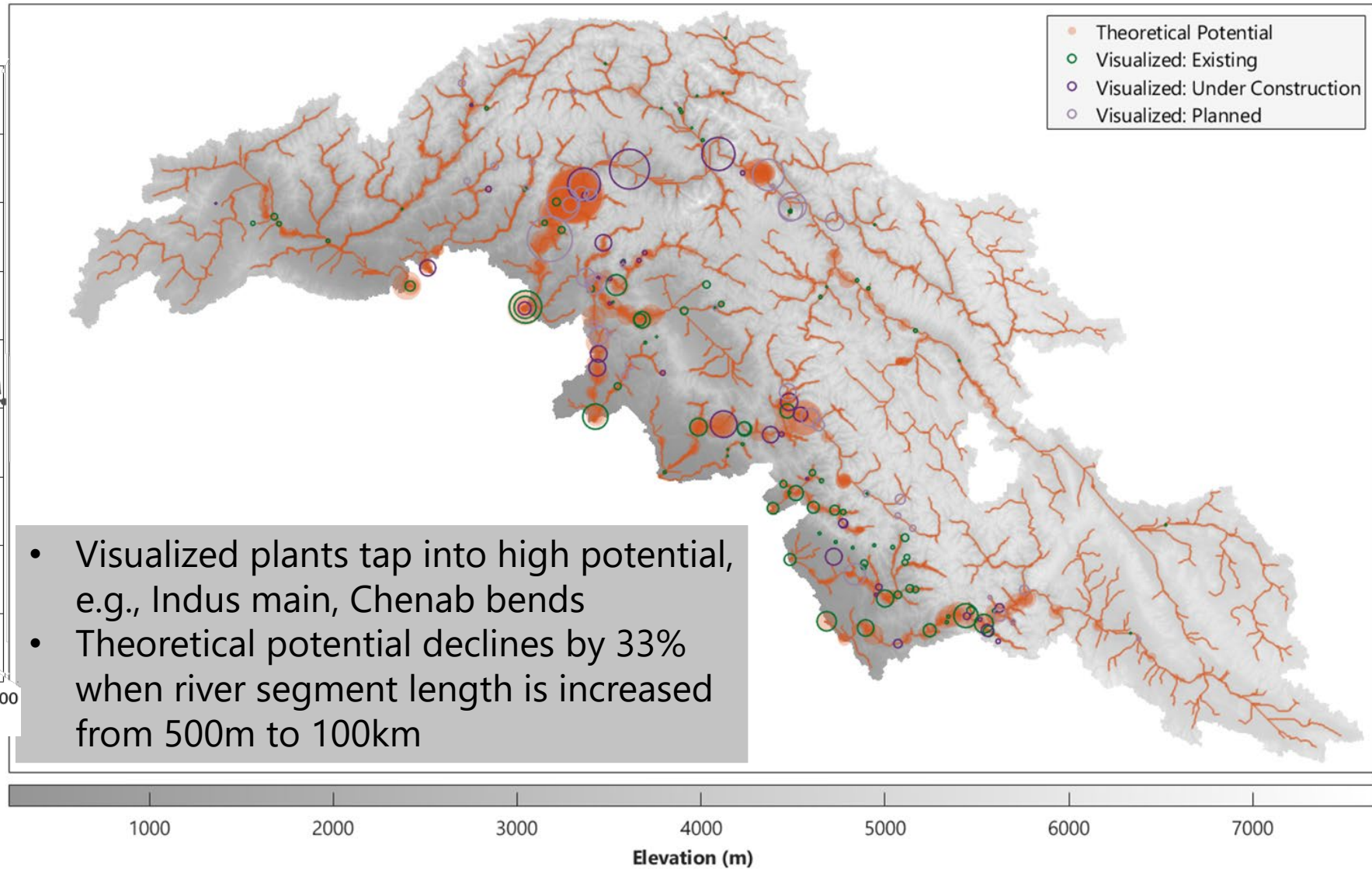
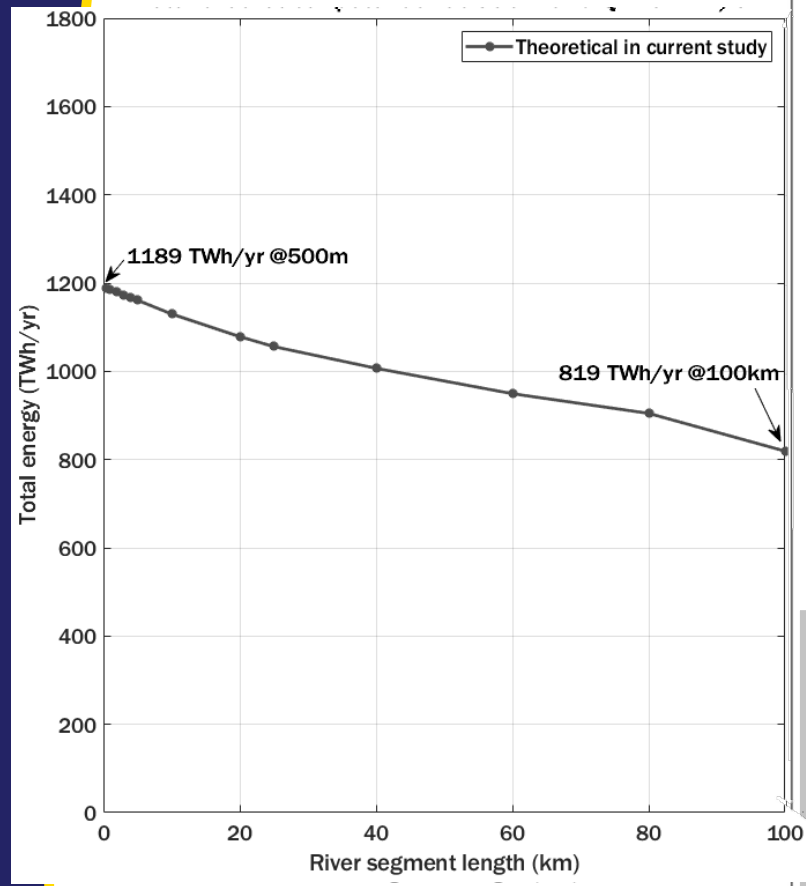


## SUSTAINABLE

- ✓ Other water uses
  - Anthropogenic
  - Natural
- ✓ Other land uses
  - Cultural
  - Natural
- ✓ Geohazard risks
  - Earthquake
  - Landslide
  - GLOF



# Theoretical potential

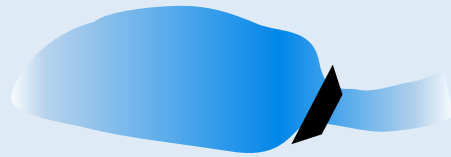


- Visualized plants tap into high potential, e.g., Indus main, Chenab bends
- Theoretical potential declines by 33% when river segment length is increased from 500m to 100km

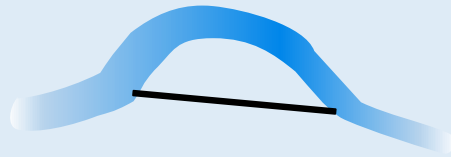




## Two Hydropower (HP) configurations



**River power plant (RP)** = a small dam with ponding storage allows for peaking hydropower operation



**Diversion plant (DP)** = upstream intake diverts water into powerhouse, which eventually releases water downstream

## Three energy development scenarios



### A. Large focus

- 25km river segments
- Large RP and DP

### B. Medium focus

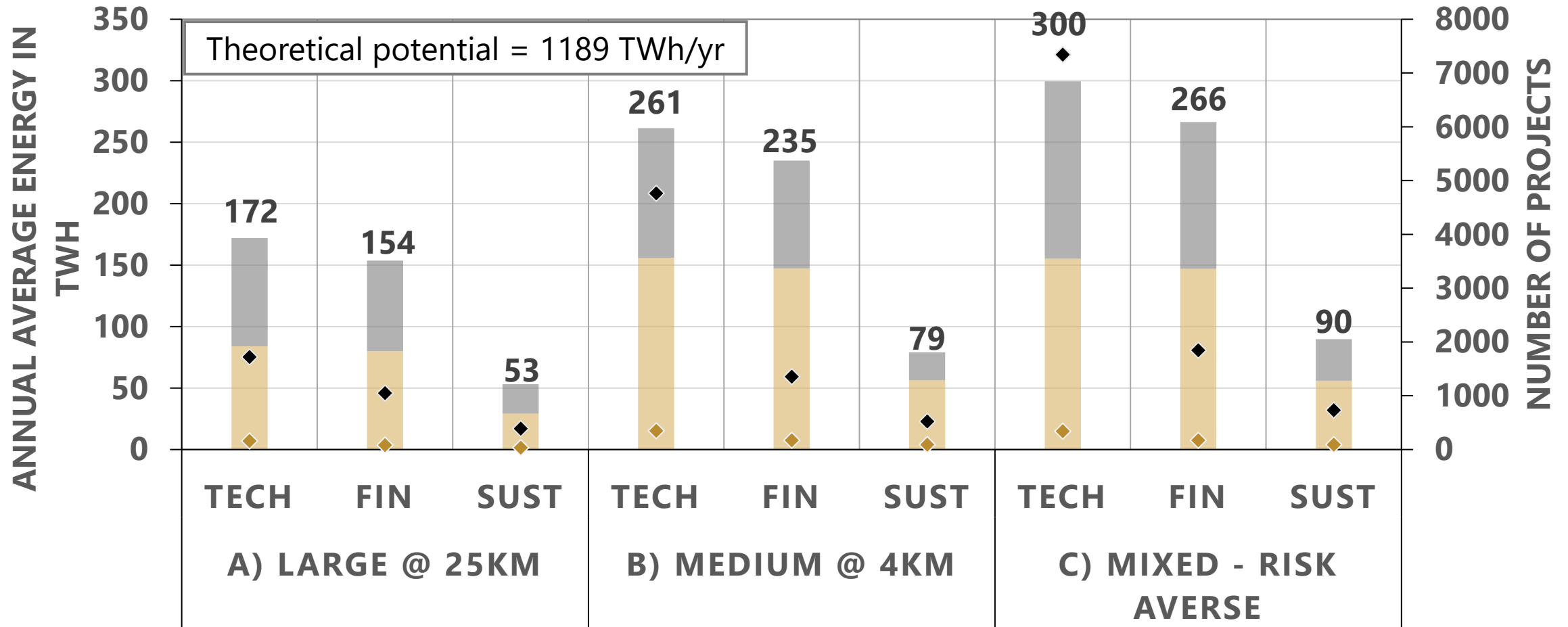
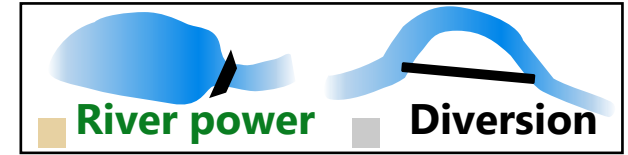
- 4km river segments
- Medium RP and DP

### C. Mixed focus

- Three tier searches in three stream levels
  - Primary = Large RP and DP
  - Secondary = Large DP
  - Tertiary = Small DP
- Separate cost functions for small vs large plants



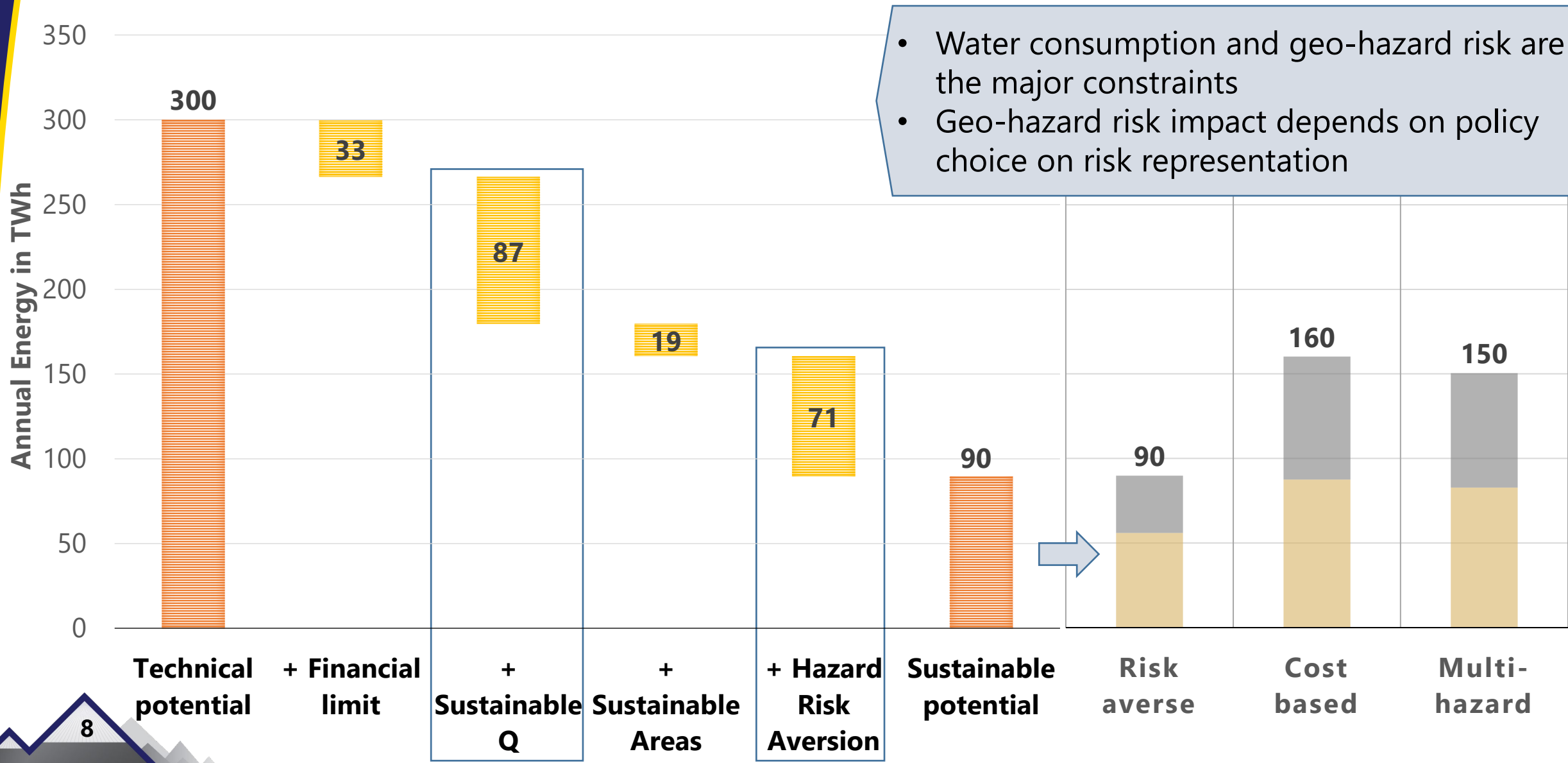
# Three policy scenarios – Full potential



- Mixed search identifies higher potential and a larger number of projects, many small
- Achievable potential is only a small portion of the theoretical potential (4-25%)



# Transition from Technical to Sustainable



- Water consumption and geo-hazard risk are the major constraints
- Geo-hazard risk impact depends on policy choice on risk representation





# Conclusions

- Realizable potential is much smaller than theoretical potential.
- Hydropower potential exploration should reflect local interests.
- Water consumption and geo-hazard risks are dominant sustainability constraints.
- Framework provides a superior list of projects that are more in-line w sustainability.
- Consensus is needed on the definition of “sustainable” potential.





**THANK YOU**