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science for global insight

Towards Integrated Solutions for Water, Energy, and Land using an Integrated Nexus Modeling Framework

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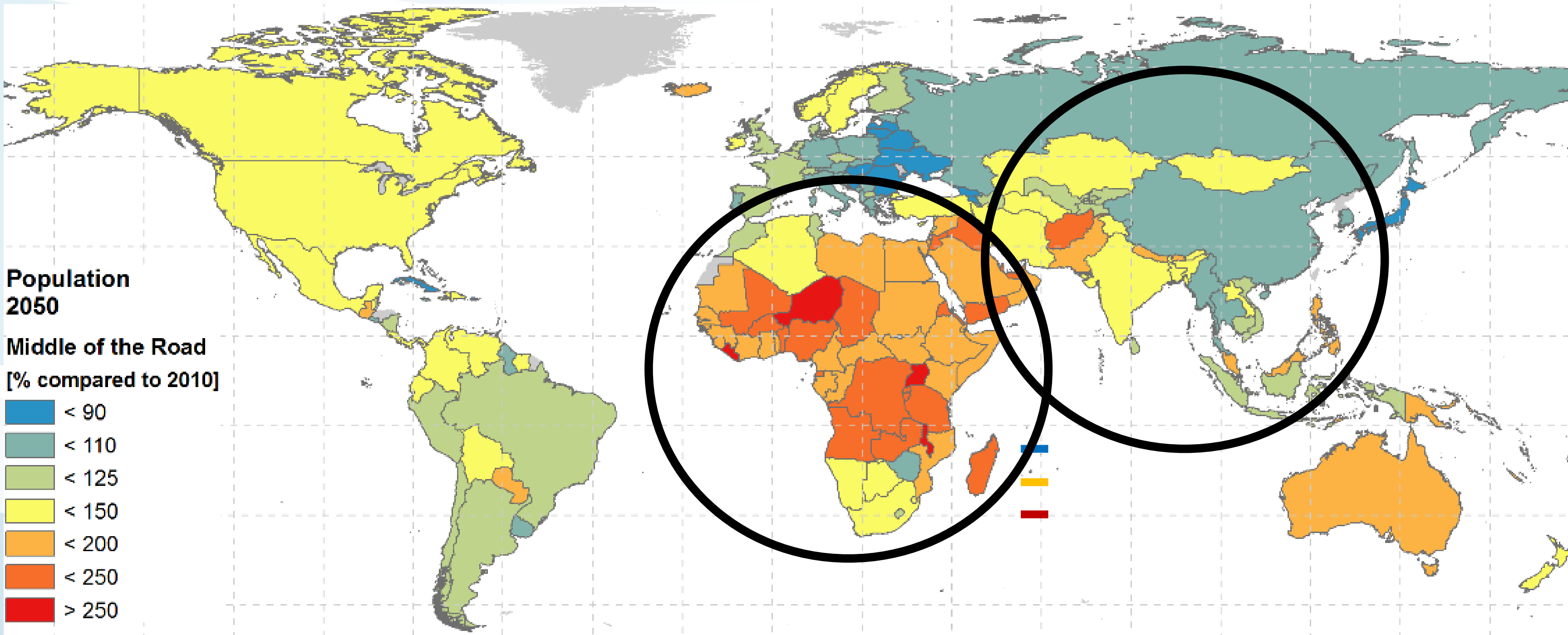
Knowledge Forum on Water Security and Climate Change:
Innovative solutions for sustainable water resources management

UNESCO HQ, Paris, France
18 October 2017

Population and Development Continues



Middle of the Road scenario

- 33% more people by 2050 compared to 2010 globally (6.8 billion to 9.1 billion)

Population in [billion]
GDP [1000 billion US$/yr]
GDP per cap (PPP) in [1000US$/cap/yr

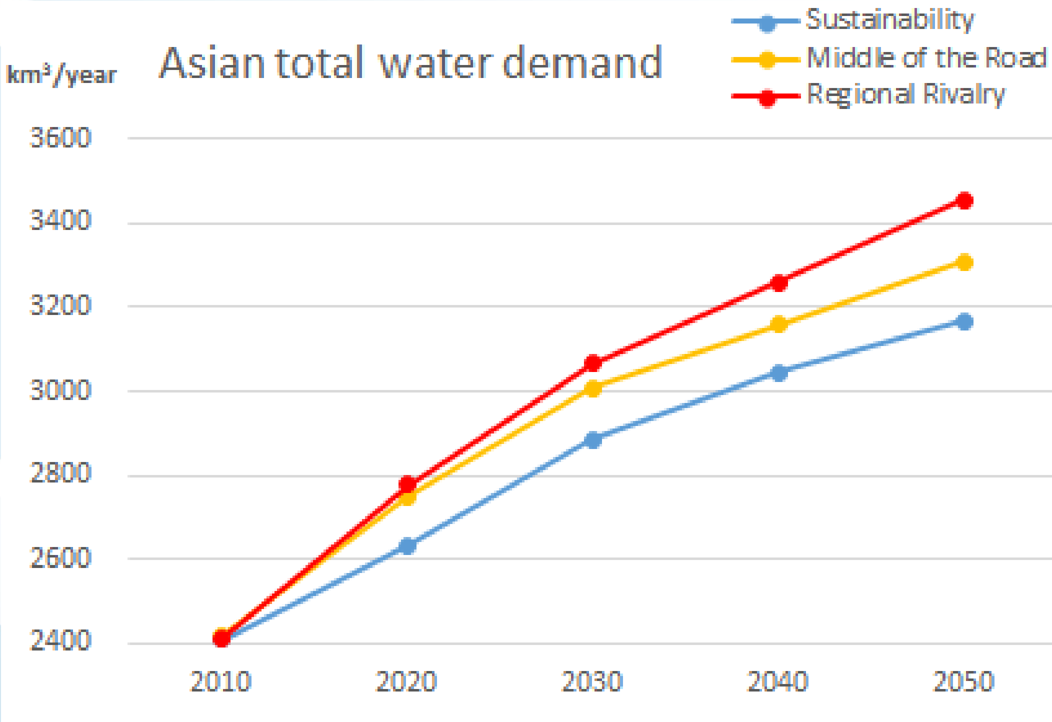
Africa

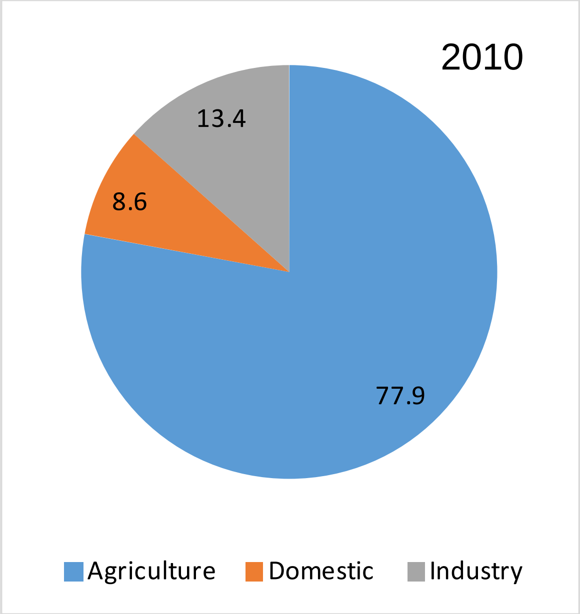
Pop:	1.0 to 2.0	2 times more
GDP:	2.8 to 19.2	7 times more
GDP pc:	2.7 to 9.5	3.5 times more

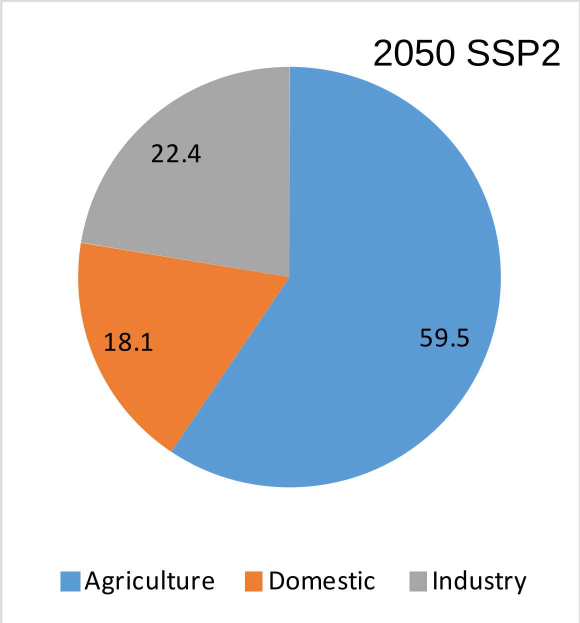
Asia

Pop:	4.1 to 5.1	1.3 times more
GDP:	26 to 123	5 times more
GDP pc:	6.2 to 24.1	4 times more

Water Demand - Asia





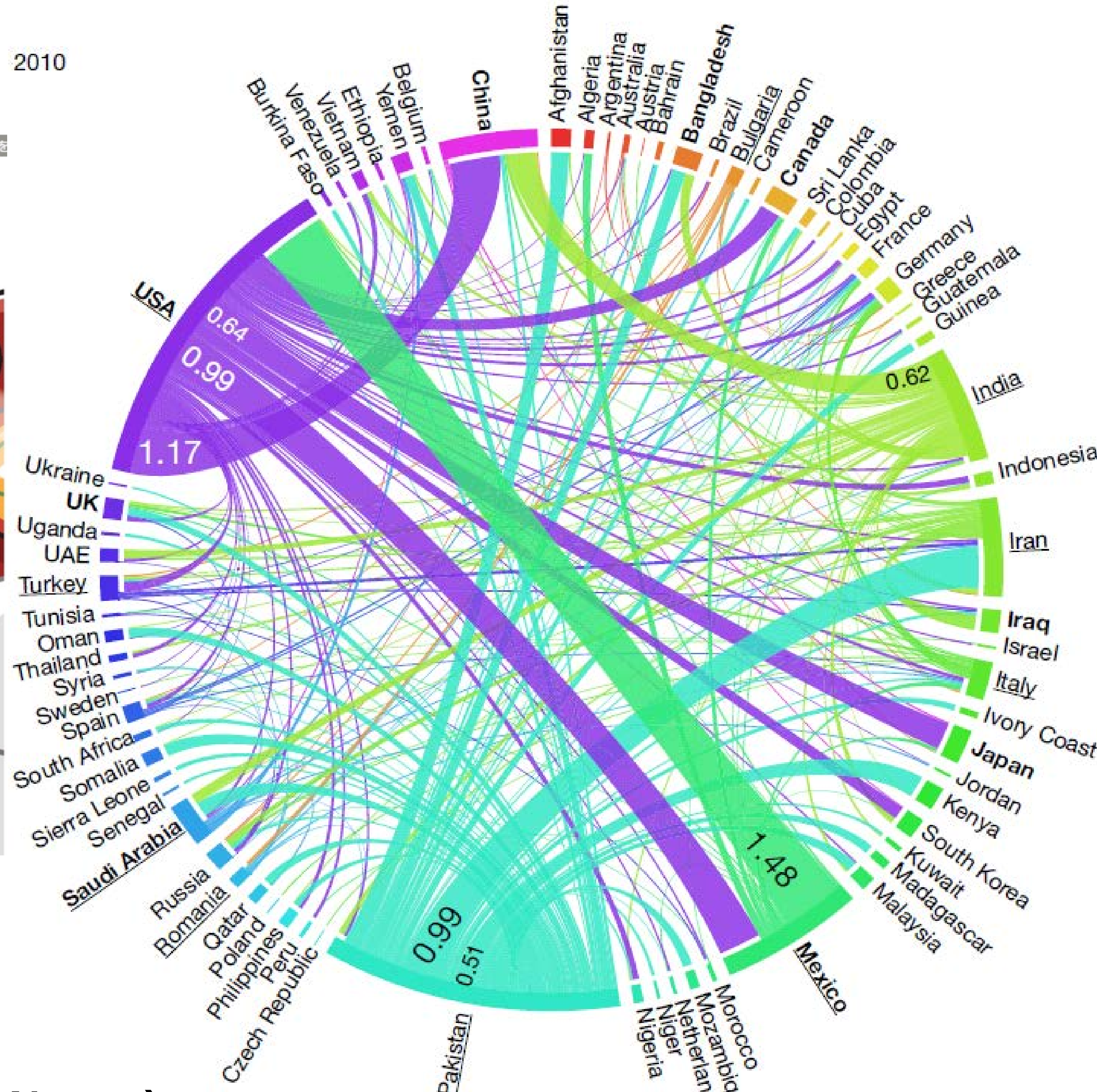


Water demand in Asia region, by sector (km^3/yr).

Asian total water demand in the 2010s is about 2410 km^3/year and will be 3170 - 3460 km^3/year (increase 30 - 40%) under the three scenarios

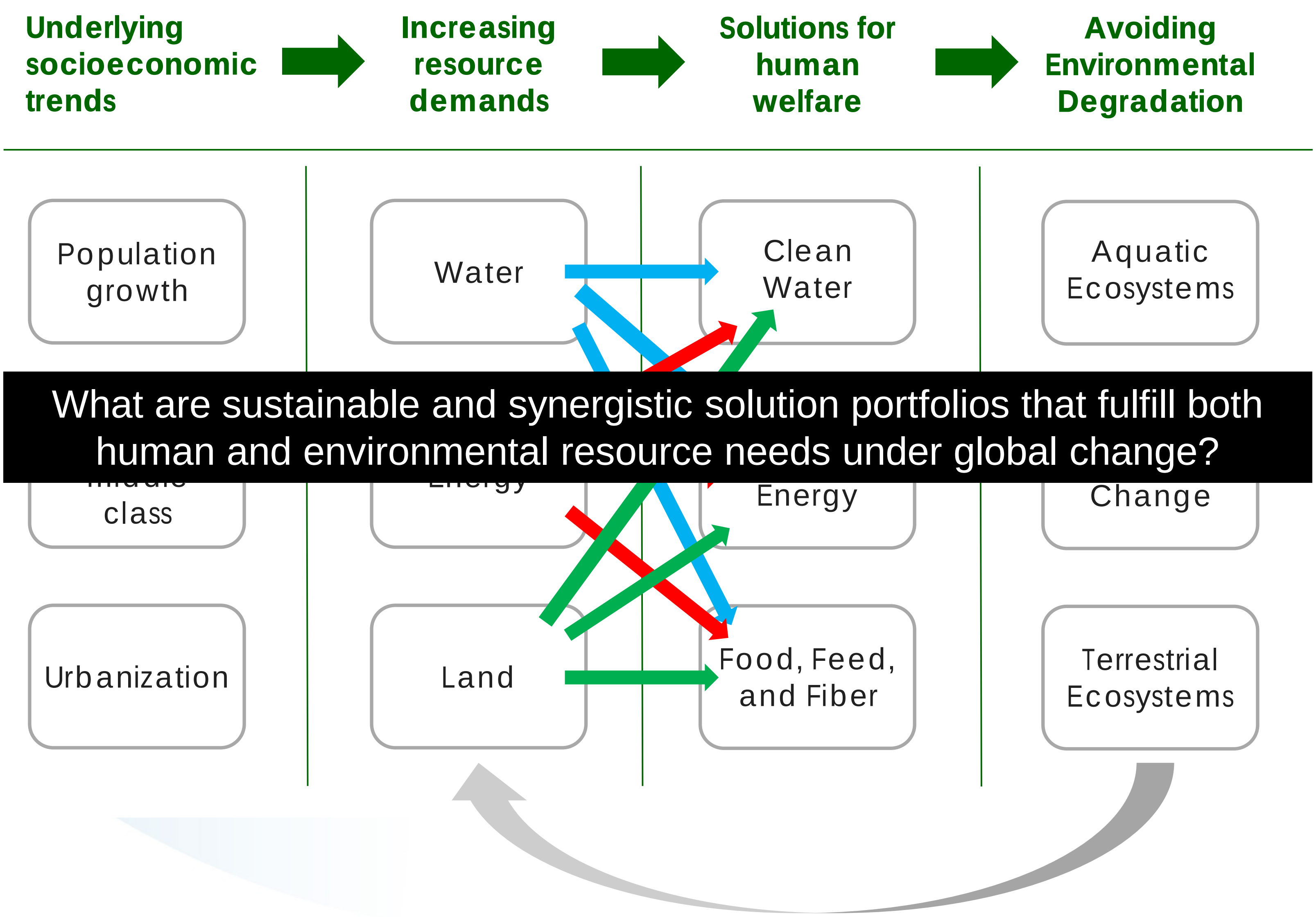
Satoh et al. (2017; Earth's Future)

UN SDGs and Water-Food-Energy Nexus



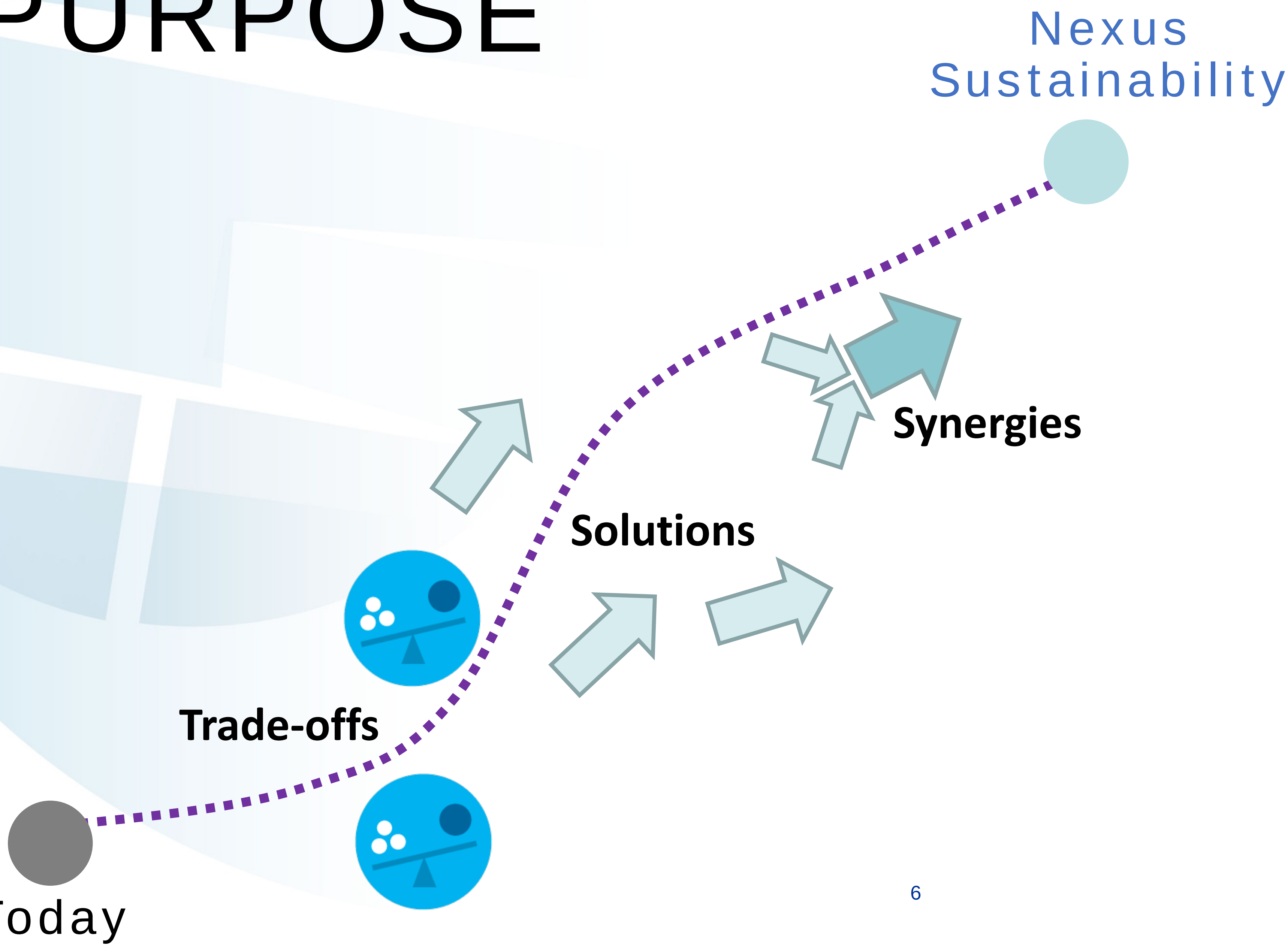
Dalin, Wada et al. (2017; Nature)

The Nexus Challenge



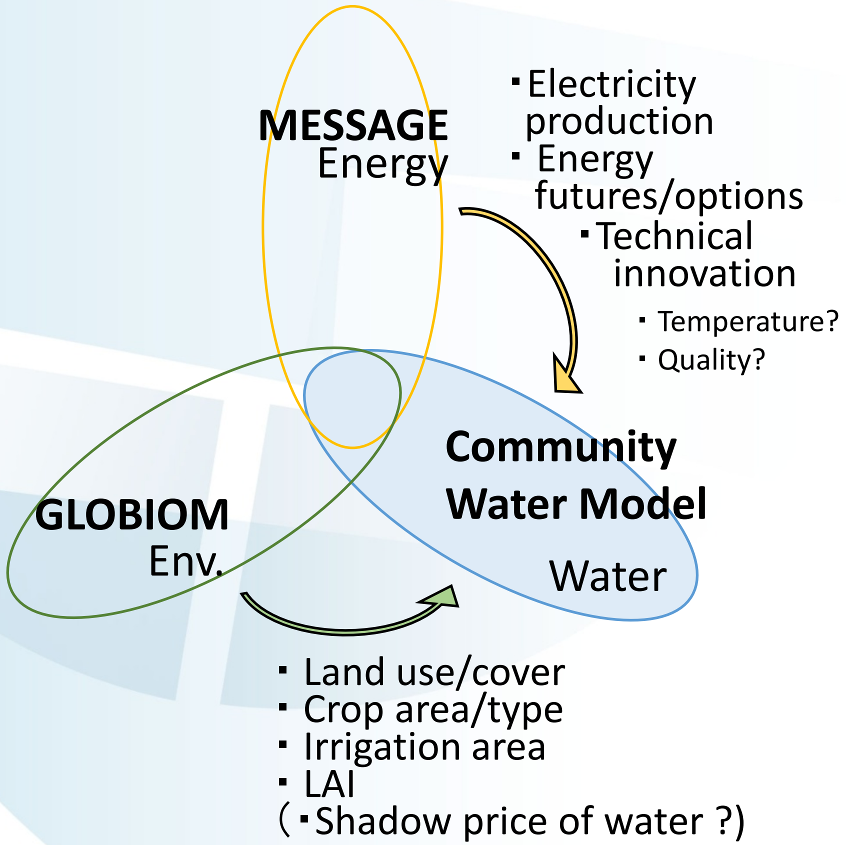
What are sustainable and synergistic solution portfolios that fulfill both human and environmental resource needs under global change?

PURPOSE

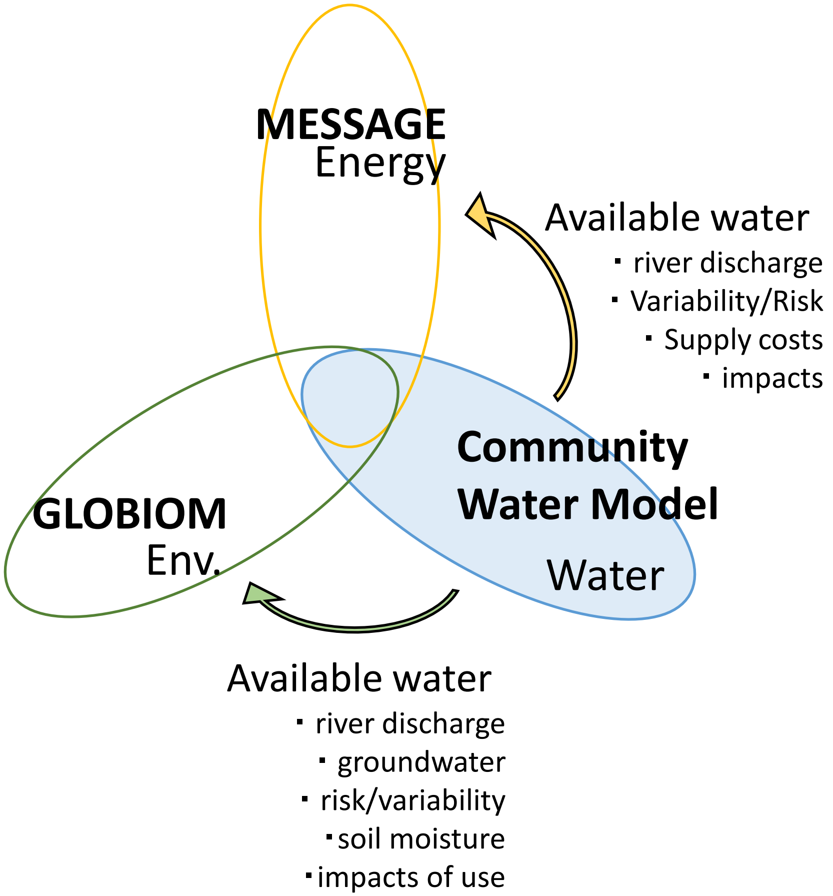

Nexus
Sustainability
Synergies
Solutions
Trade-offs
Today

Nexus Integration towards SDGs

Enhanced water assessments

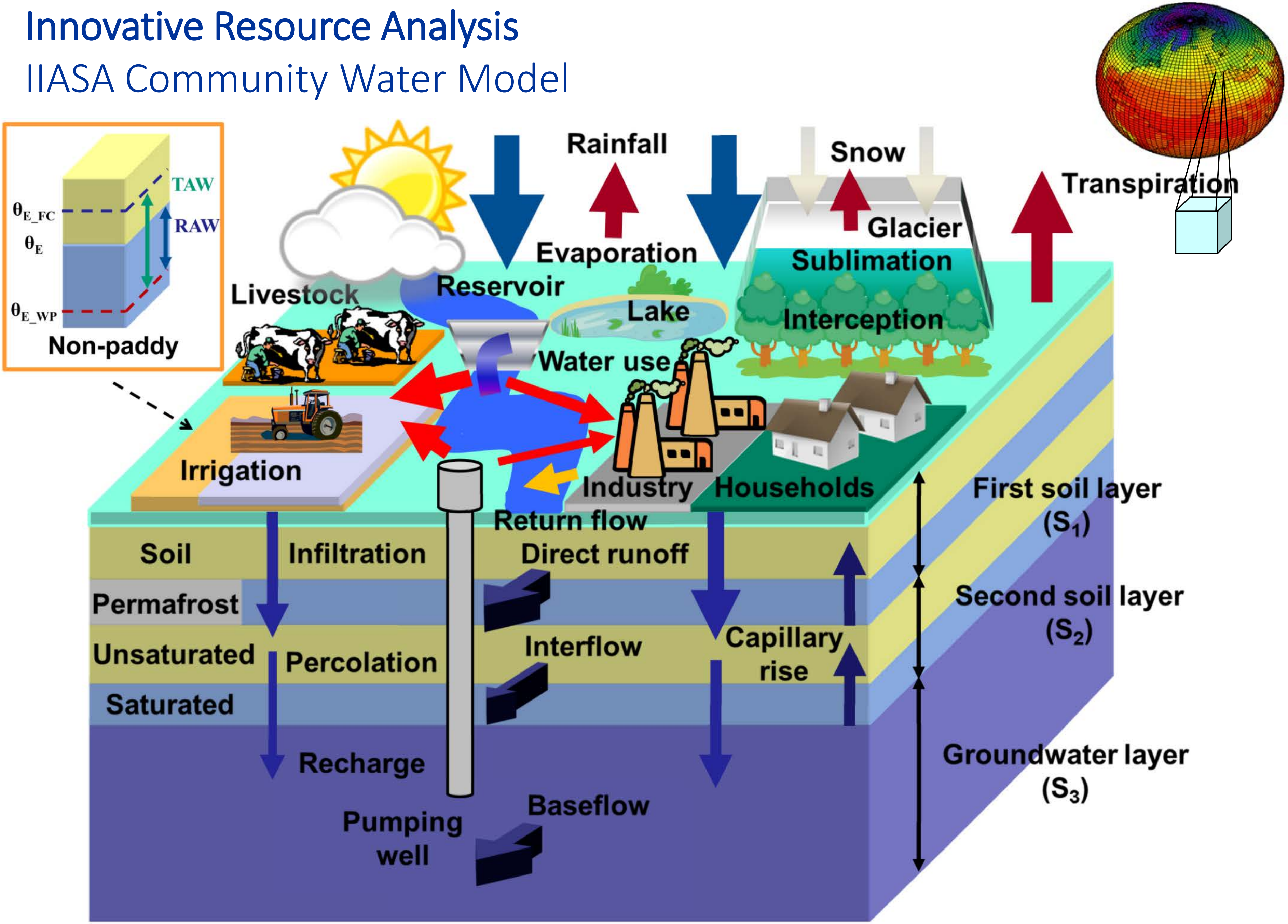


Improved analysis feedbacks



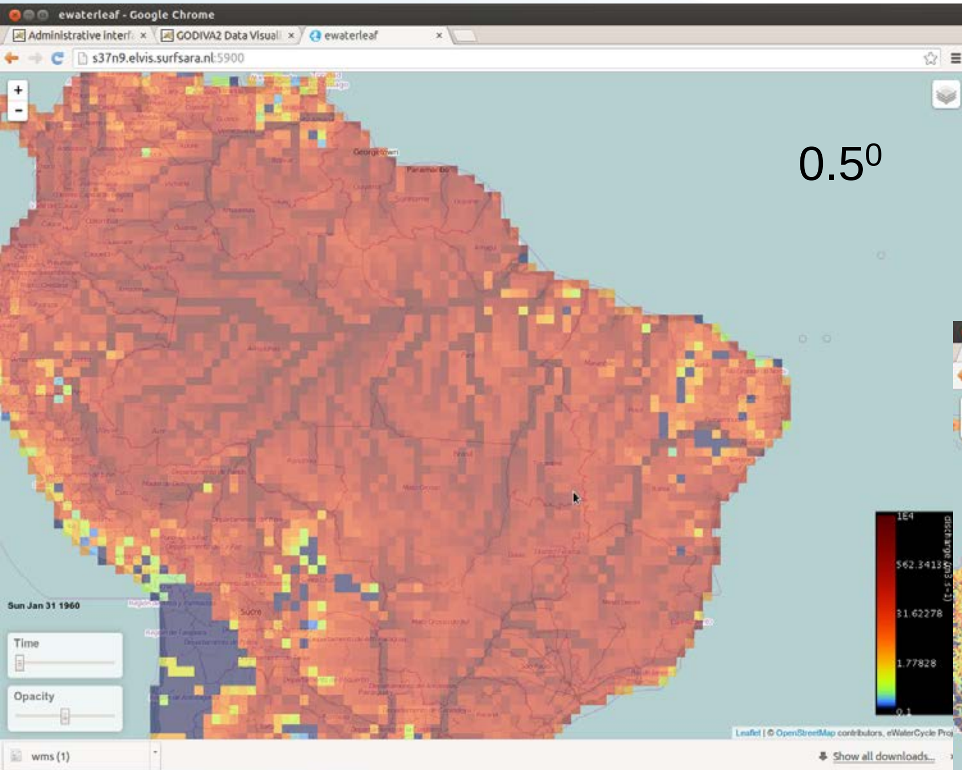
Innovative Resource Analysis

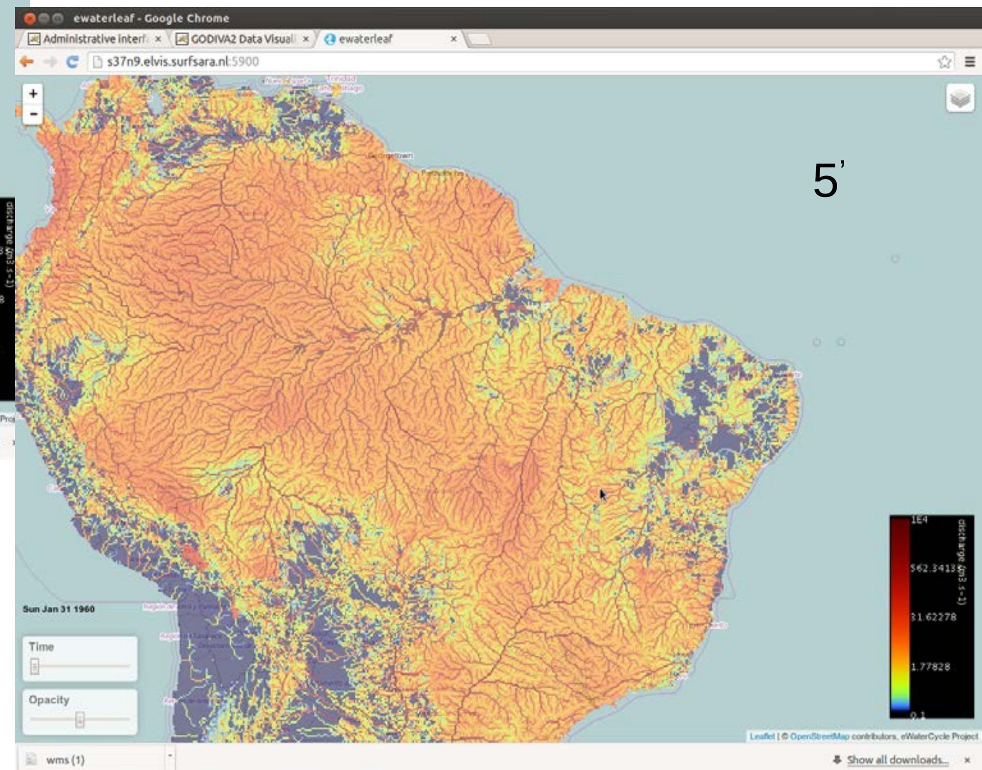
IIASA Community Water Model



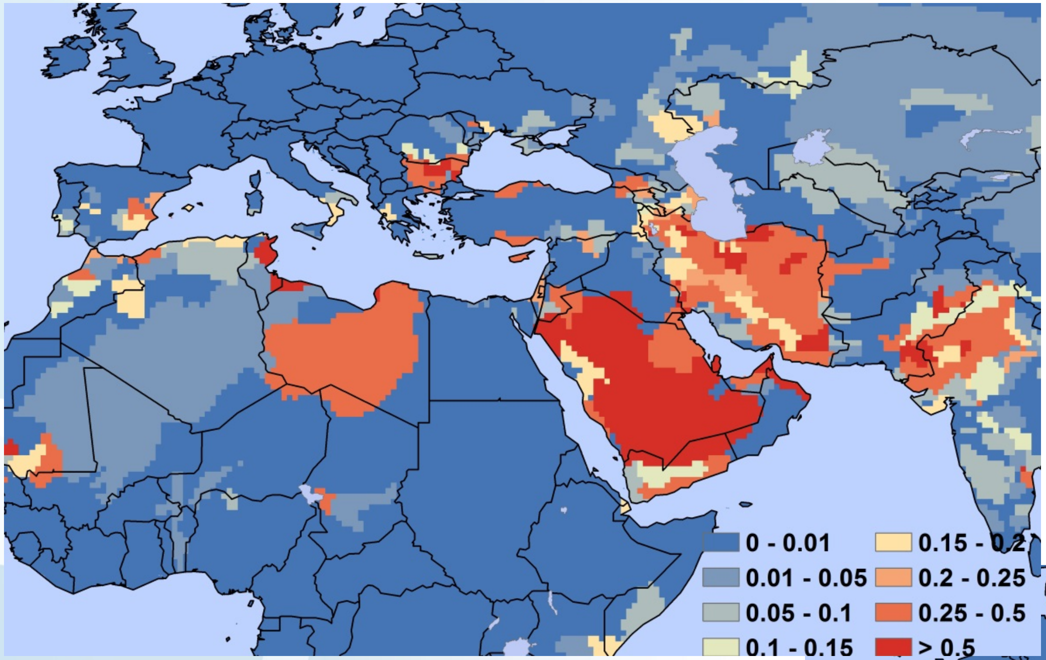
Innovative water supply analysis

High resolution hydrological modeling with local calibration

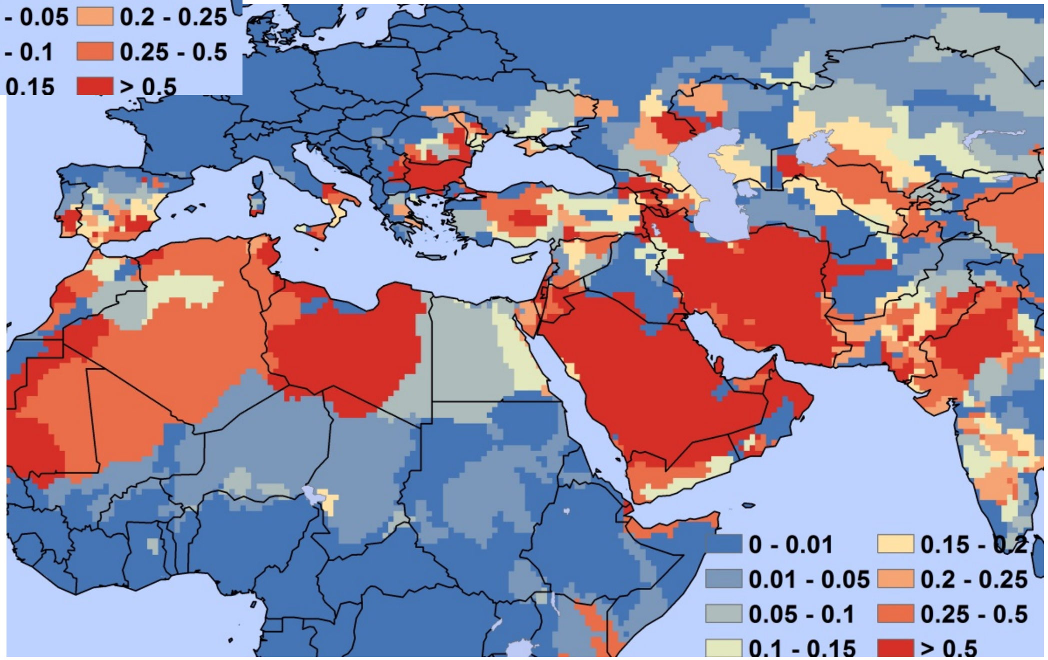




Future Groundwater Sustainability – how much pumping unsustainable [Fraction; 0.5 = 50%]



Current (left)
vs
Future SSP2 with Climate Change (below)



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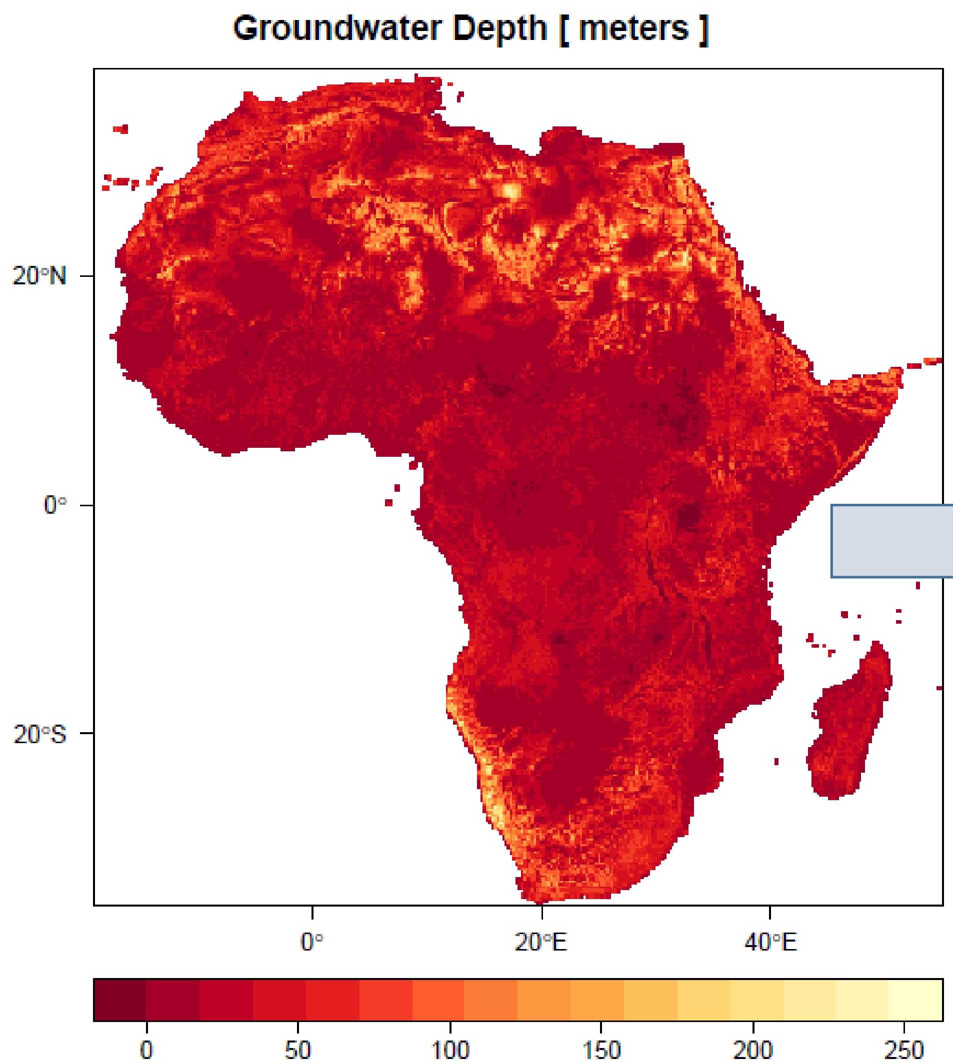
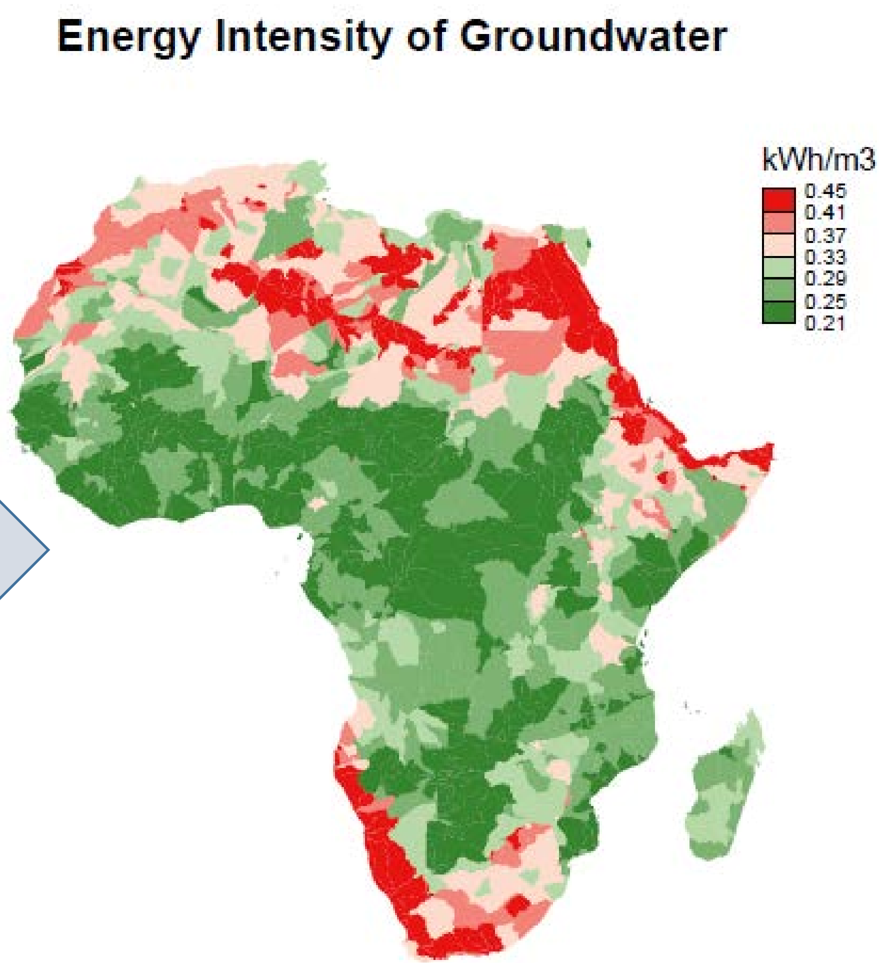
Energy intensity of water supply options





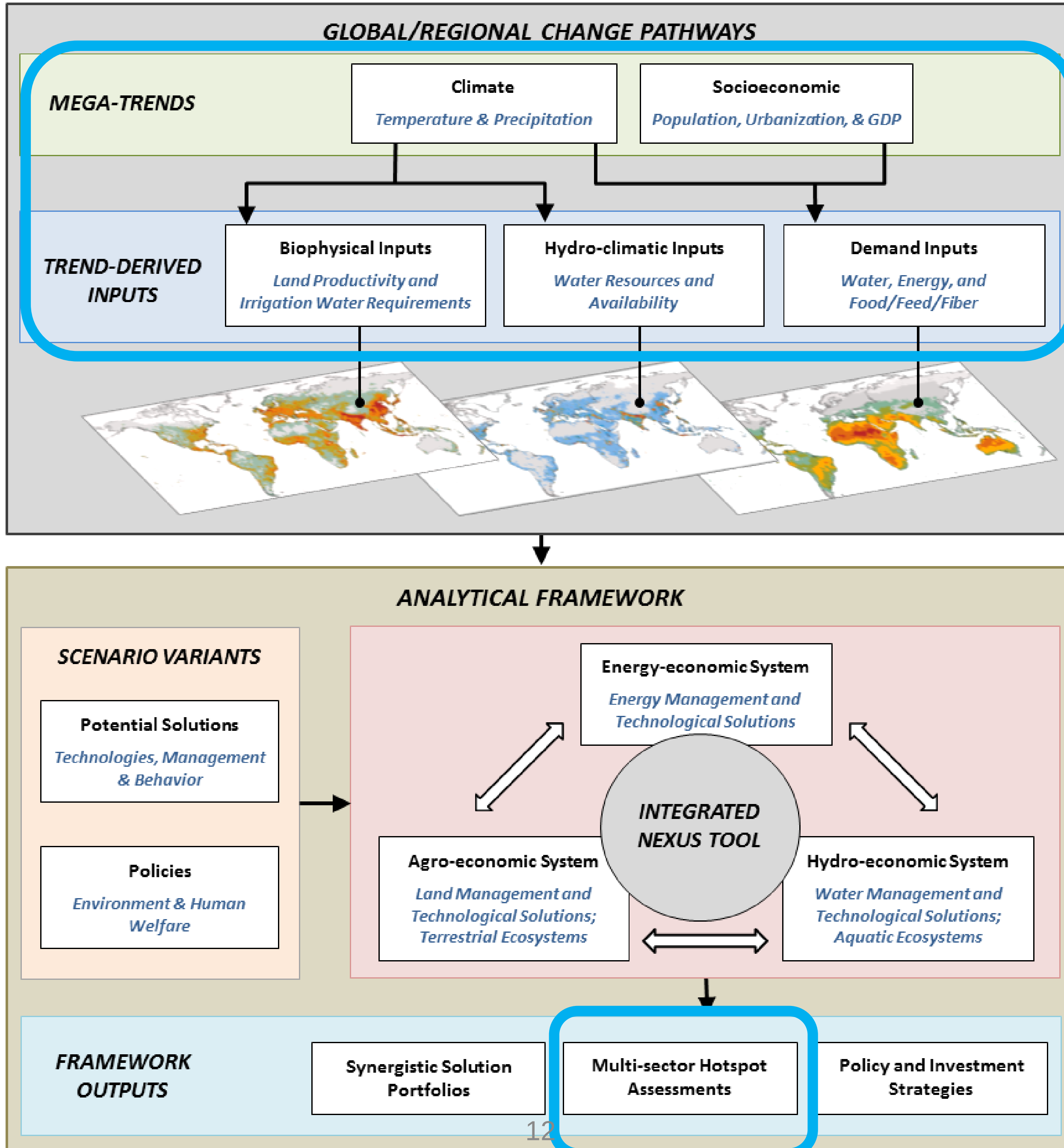
Preliminary results

Data sources: Fan et al. (2013); Wada et al. 2014; hydroBASINS (2015).

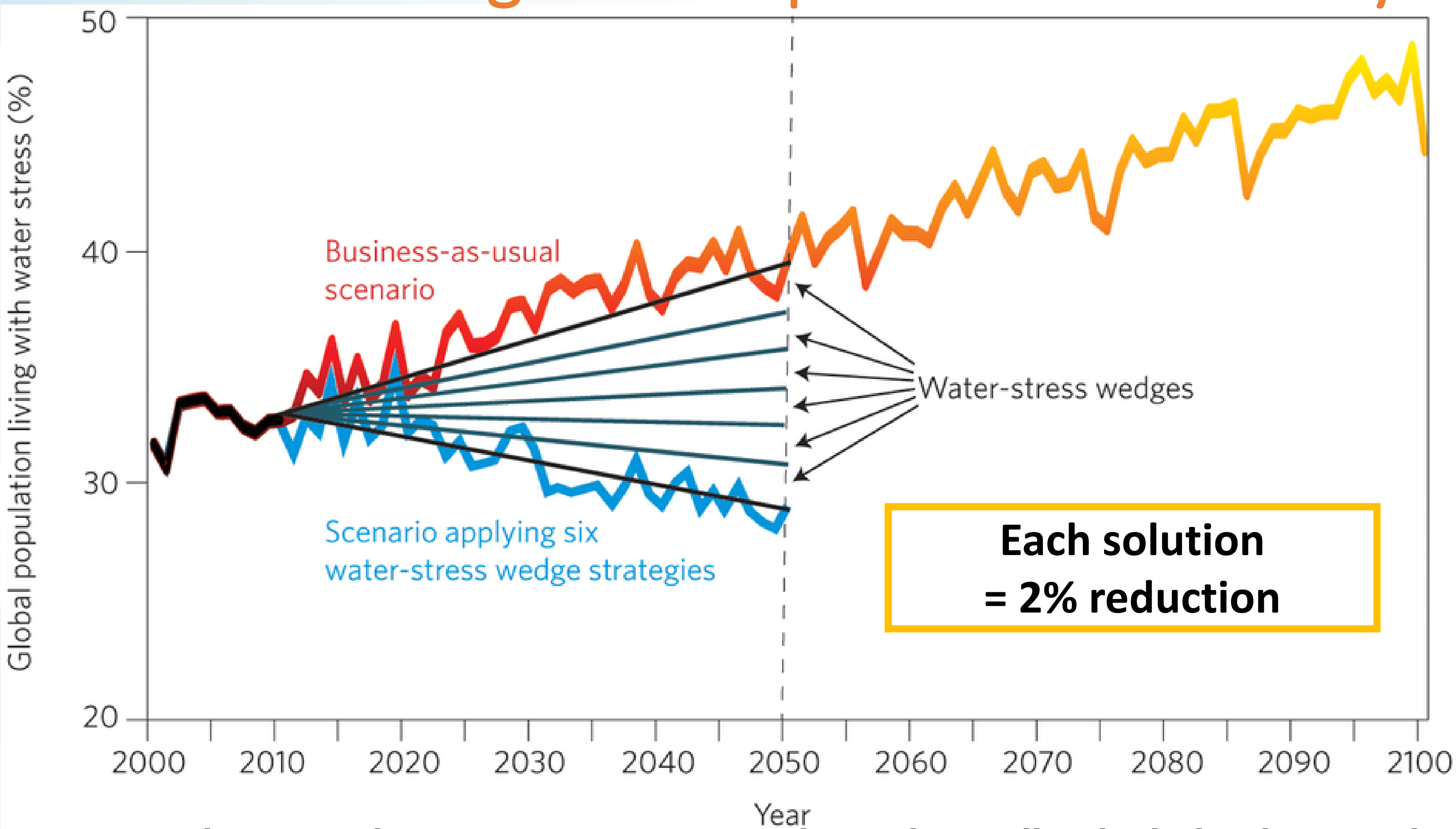
Global hotspots analysis

- Preliminary analysis

- Final analysis



Water Management Options and Economy?



Each solution = 2% reduction

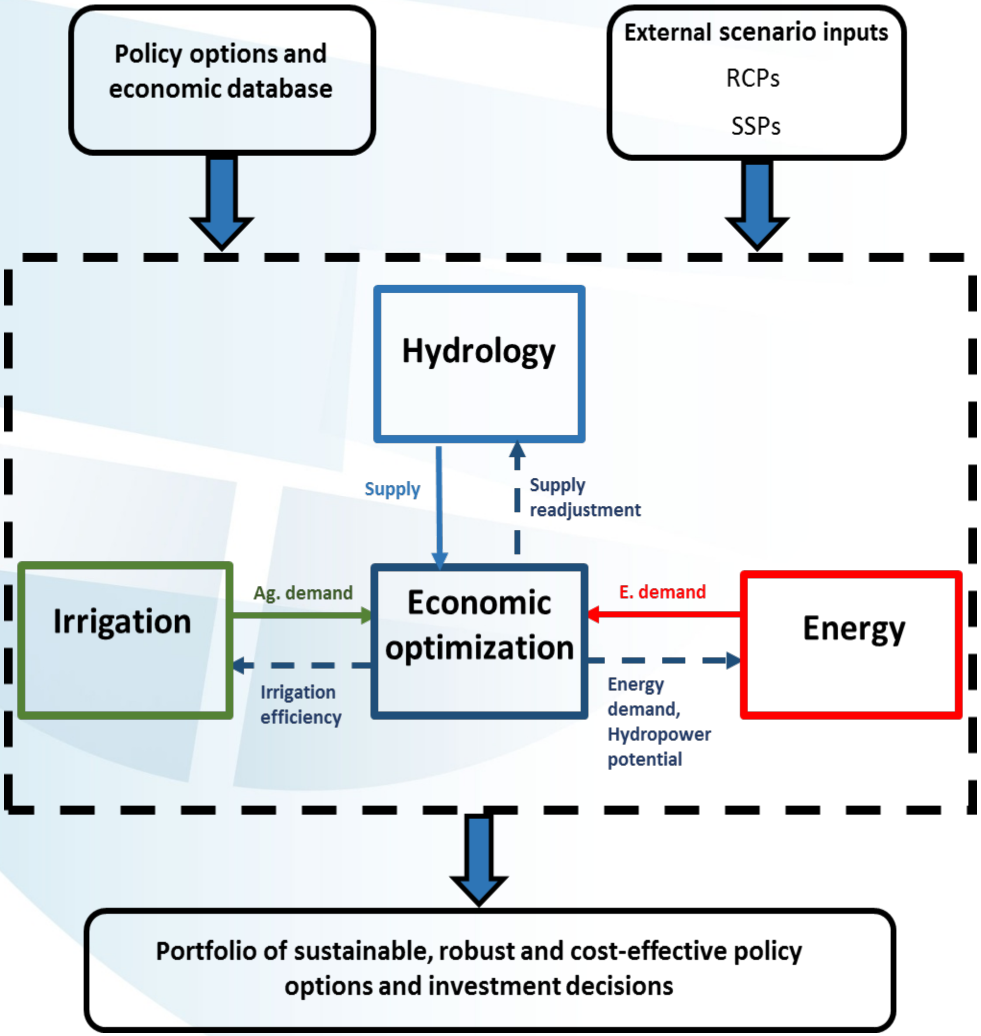
We present six strategies, or water-stress wedges, that collectively lead to a reduction in the population affected by water stress by 2050, despite an increasing population.

- **Water productivity – crop per drop**
- **Irrigation efficiency – decrease losses**
- **Water use intensity – industry and domestic**
- **Population**
- **Reservoir storage**
- **Desalination**

Soft path vs. Hard path

Wada et al. (2014), Nature Geoscience

Hydro-Economic framework for investment options



Key features represented in the model:

Drivers: Demand growth; Resource availability; Climate change; etc.

Processes: Reservoir management; Irrigation use; Electricity generation; Water pumping; End-use efficiency; Wastewater treatment; etc.

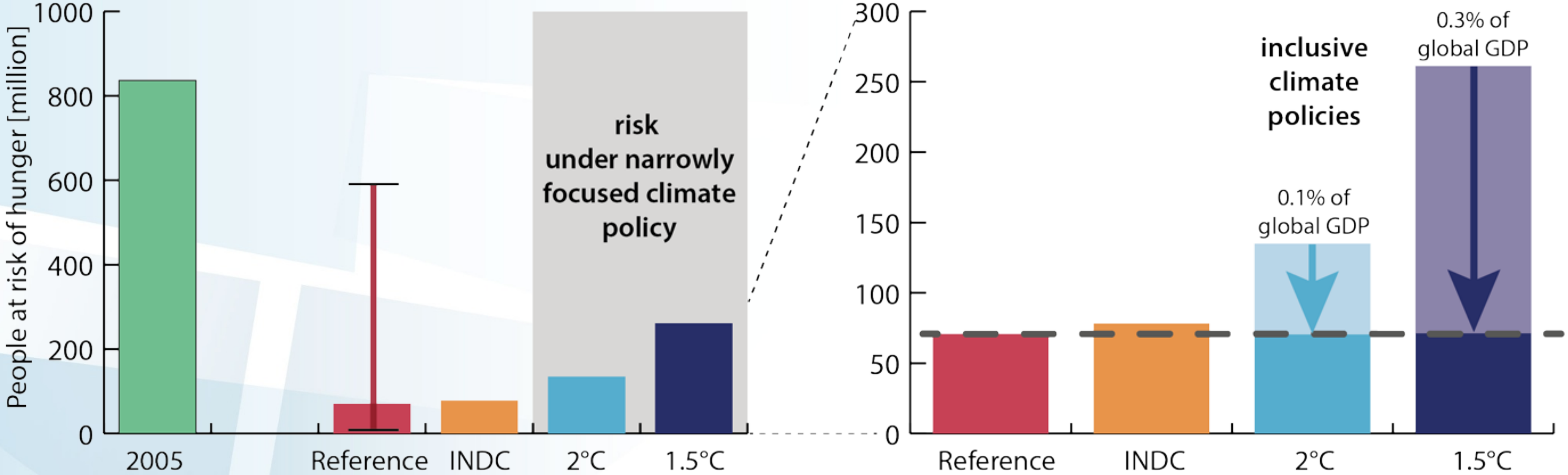
Impacts: Prices; Demands; Emissions; Water quality; Environmental flow; Groundwater depletion; Resource security; etc.

Decisions: Extract resources; Operate infrastructure; Expand infrastructure; Trade resources

Assessment of adaptation measures: technical potential and costs

Supply enhancement	Demand management
▪ Build/enlarge dams ▪ Rainwater harvesting ▪ Drill/improve wells ▪ Reuse of wastewater ▪ Desalination ▪ Reprogram reservoir operation ▪ Inter-basin transfer	▪ Efficient irrigation technologies ▪ Efficient domestic water appliances ▪ Energy cooling technologies ▪ Better crop management ▪ Diet change ▪ Food loss reduction ▪ Improving education ▪ Controlling population growth

Food Security
in 2050



Preliminary Results

Inclusive development & climate policies are key to reduce risk of hunger for simultaneous achievement of SDG 2 (hunger) and 13 (climate).

Policy scenarios

Three policy scenarios:

1/ Business as usual (***BAU***): SSP2-RCP6.0 + no constraint on groundwater use

2/ Sustainable groundwater use policy (***SGW***): limiting groundwater use to renewable resources by 2050

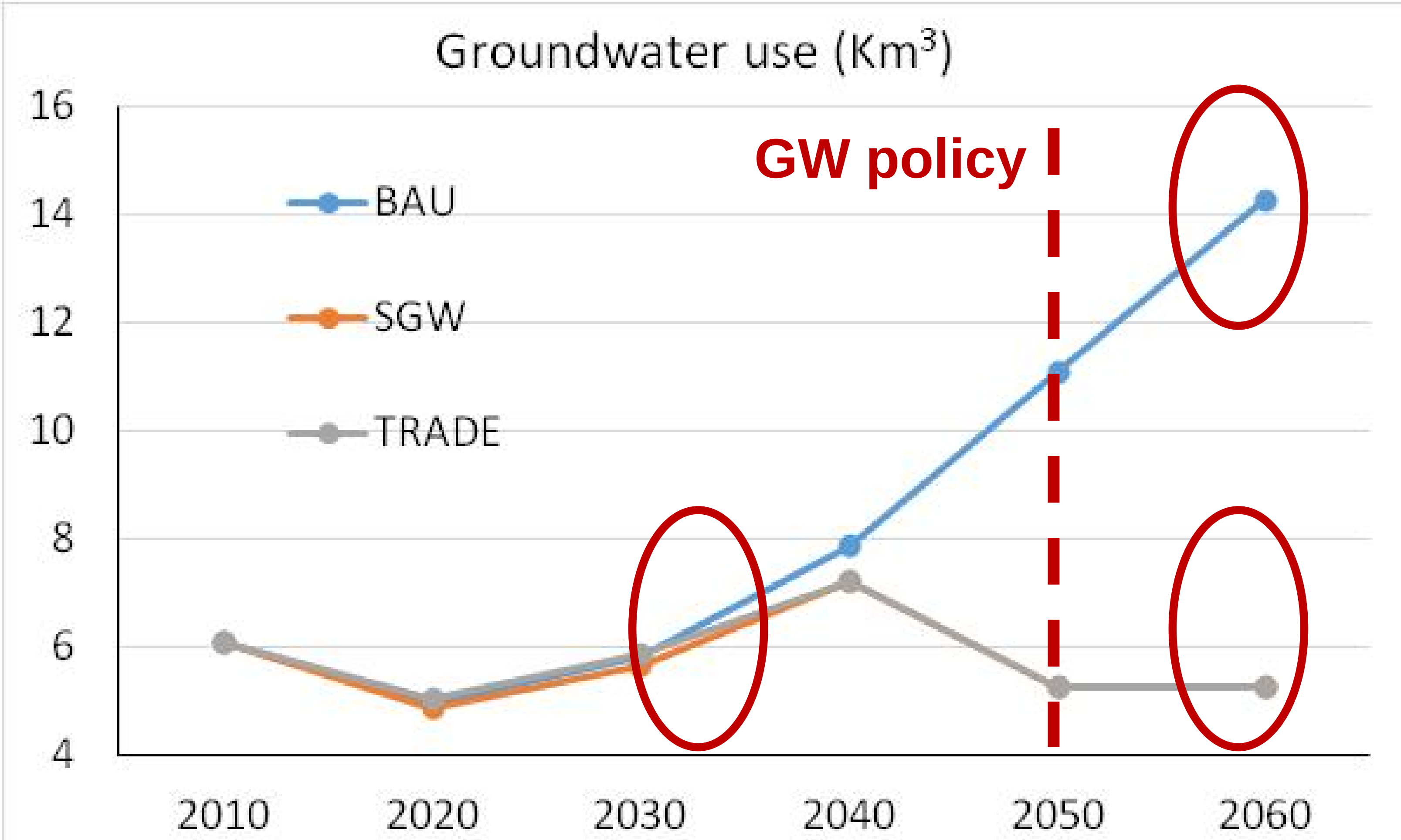
3/ Sustainable groundwater use and virtual water trade policy (***TRADE***): limiting groundwater use to renewable resources by 2050 and substituting 5% of domestic production of crops by food imports

Case study area

Test case: Mediterranean South Coast basin

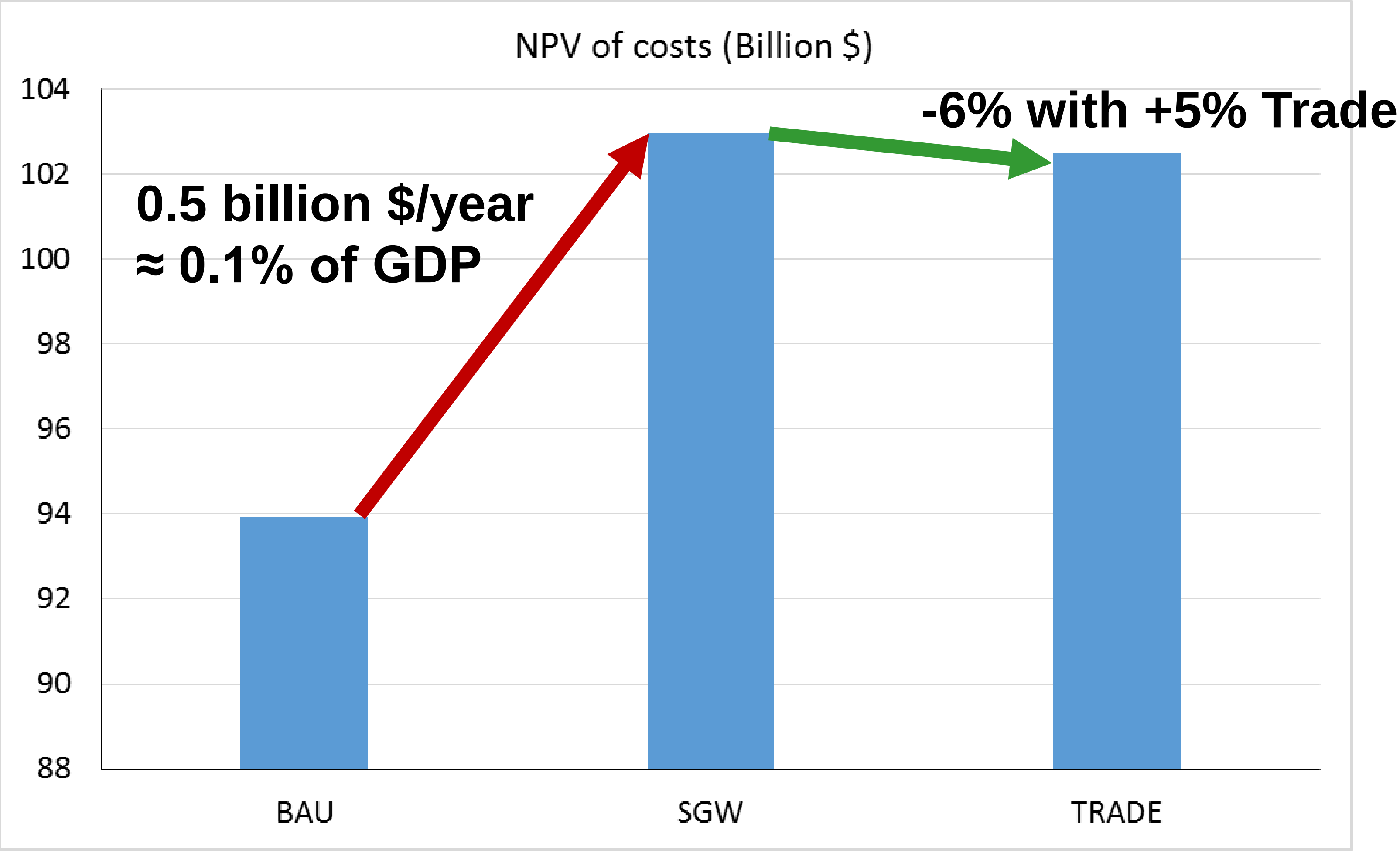
Water scarcity and Groundwater depletion problem: pumping in 2010 ≈ 6 km^3, renewable resources ≈ 4.8 km^3 (depletion ≈ 1.2 km^3/year)

Optimal allocation of resources under each scenario



Preliminary results

Adaptation: Cost implications



Next steps: Scenario analysis of adaptation pathways

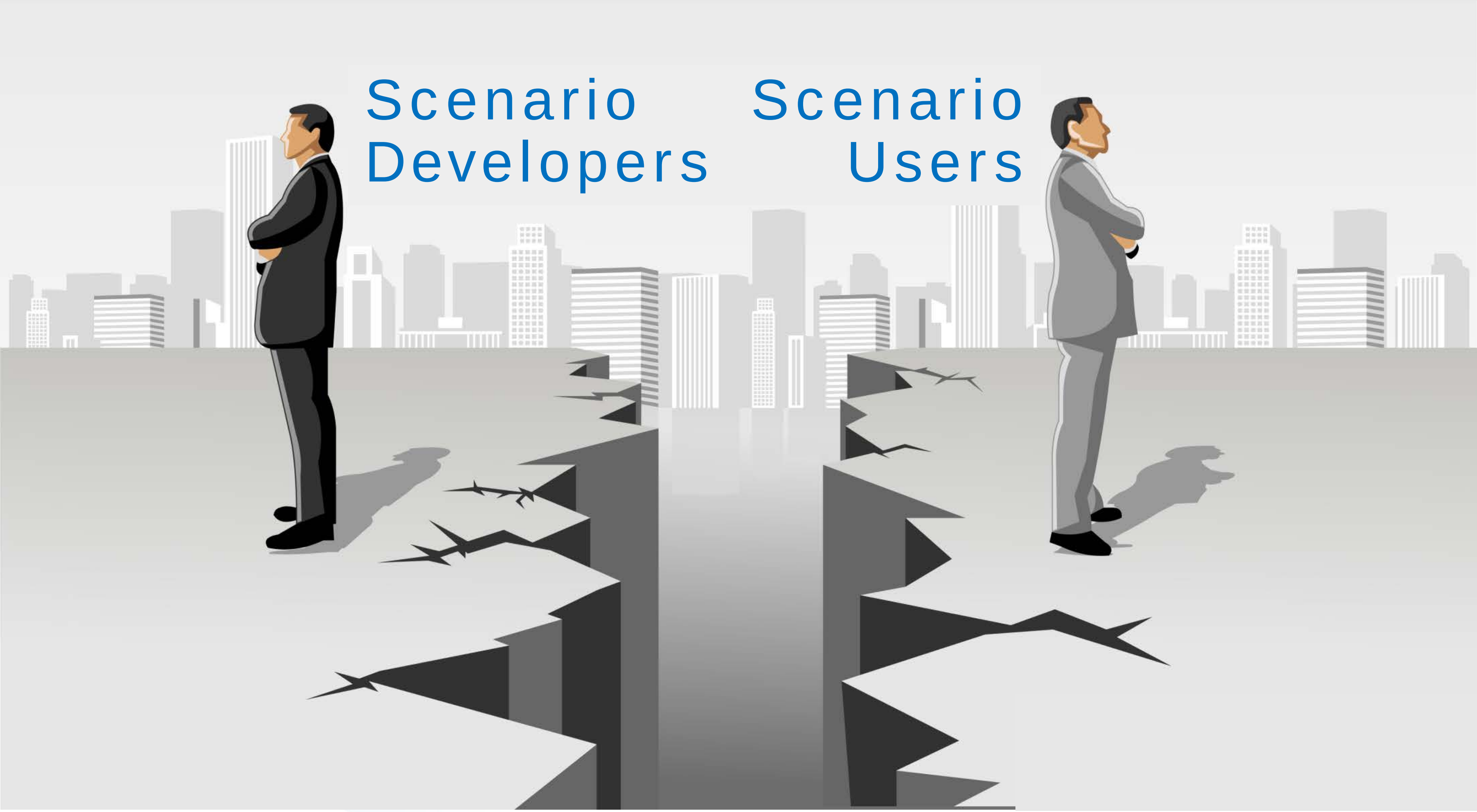
Quantitative SDG targets

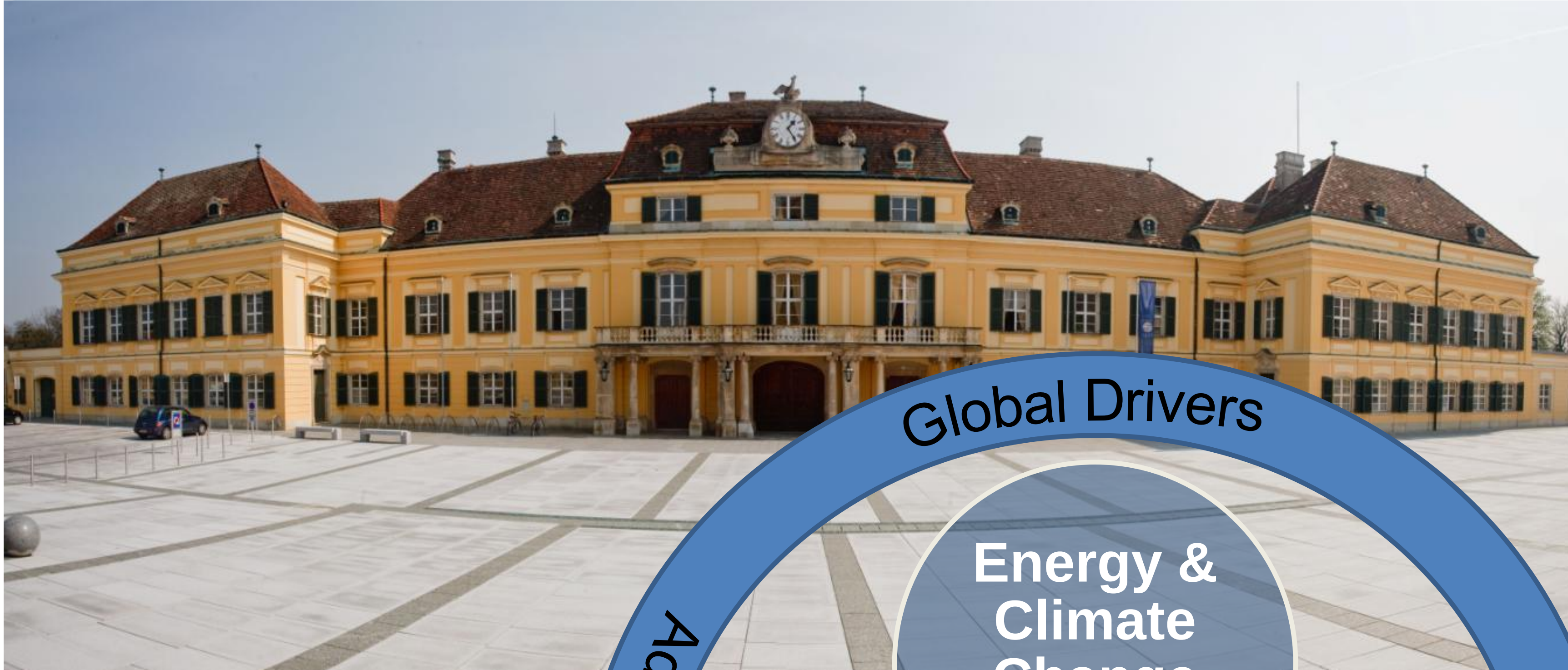
- Population with improved access and treatment
- Increase water efficiency
- Reduce population living in water scarcity

Basin-scale assessment tools

Infrastructure pathways and investments

How to bridge the gap?





IIASA - RESEARCH FOR A CHANGING WORLD