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Economic costs of reducing unsustainable groundwater use: Application of IIASA global hydro-economic modeling framework

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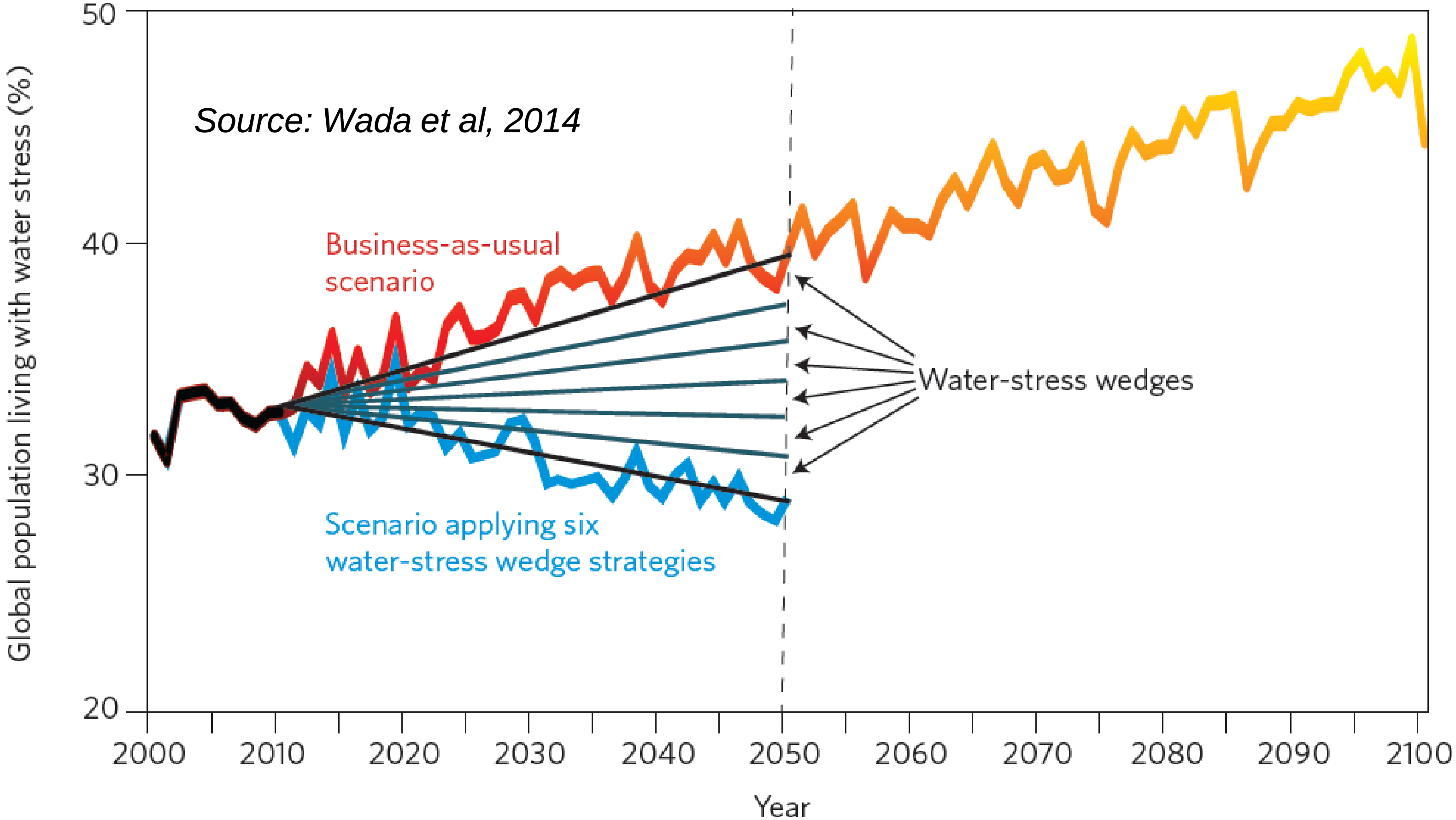
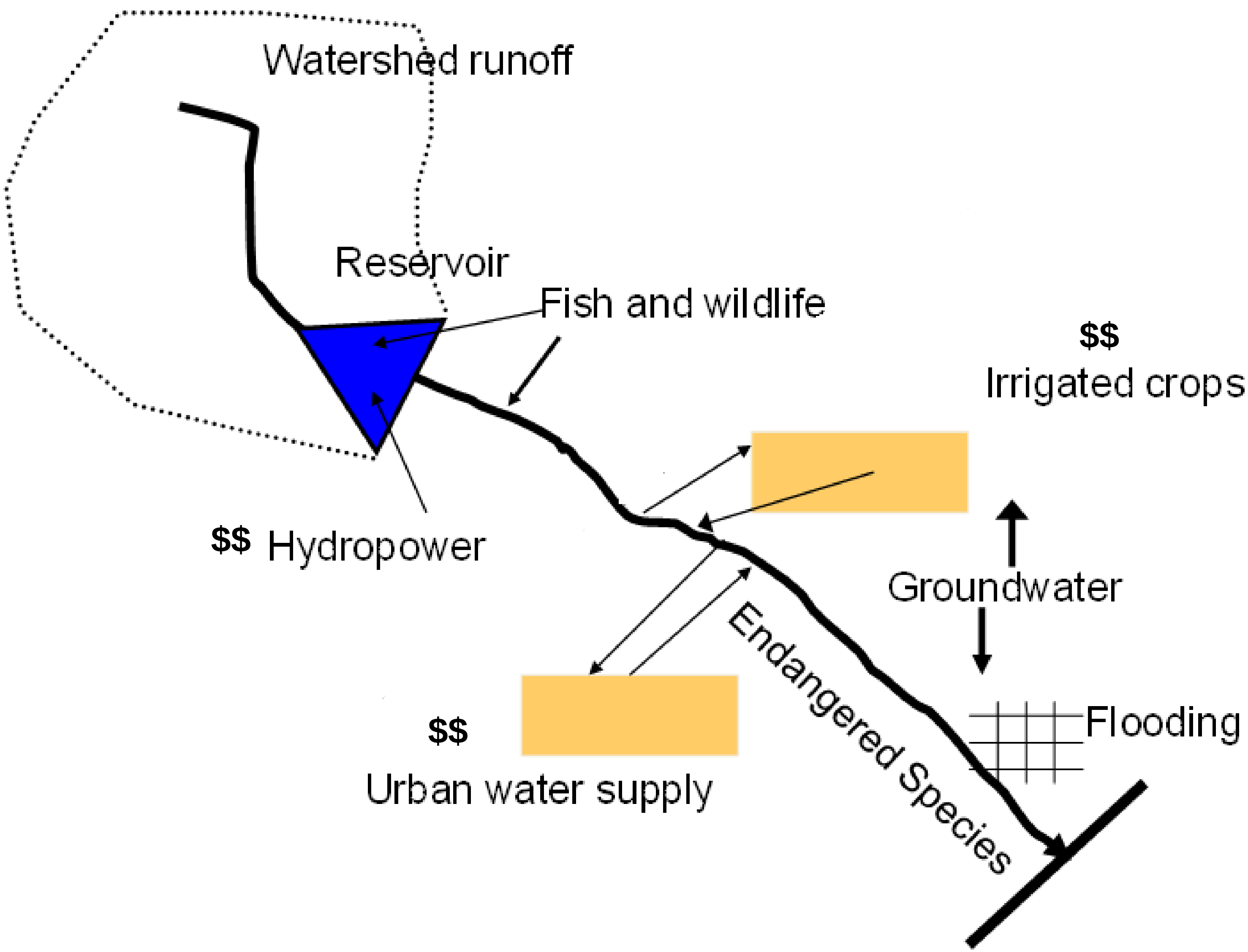
Reducing risks of water stress

Water-stress wedge strategies:
efficiency; recycling; reservoir expansion, desalination, etc.

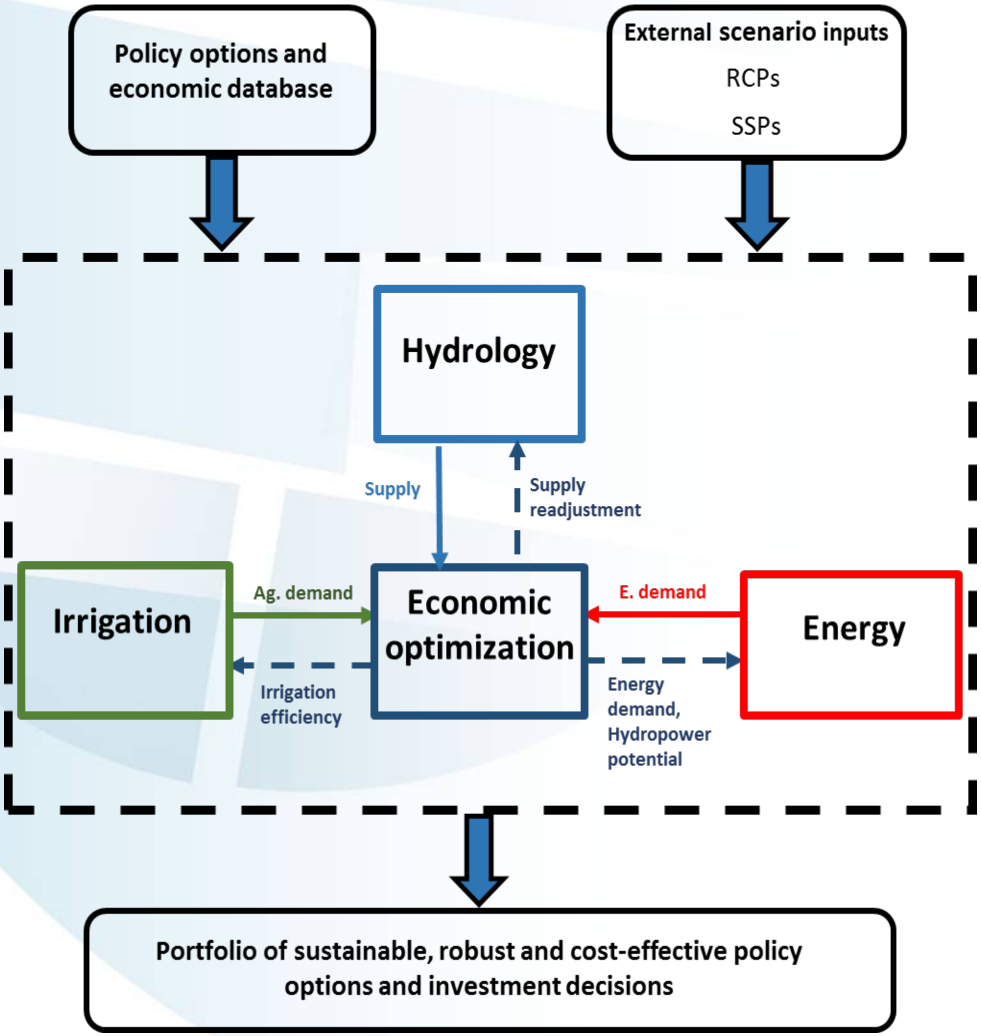


What strategy is best to implement where? How much will it cost? How will this impact land and energy use?

Basin Scale Choices



Hydro-economic modeling framework



Key features represented in the model:

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

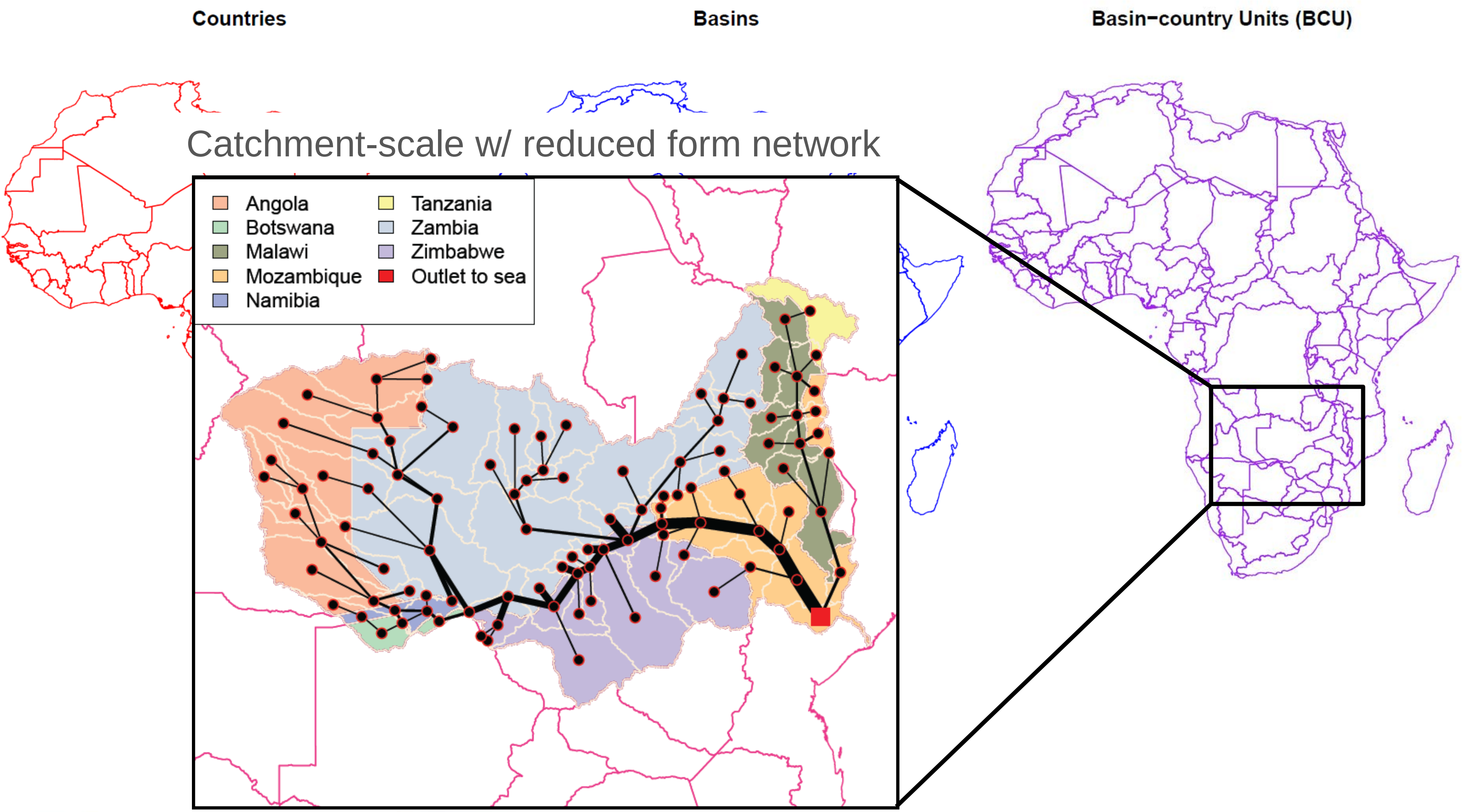
Processes: Reservoir management; Irrigation; Electricity generation; Water pumping; End-use efficiency; Wastewater treatment; etc.

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

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

Innovations

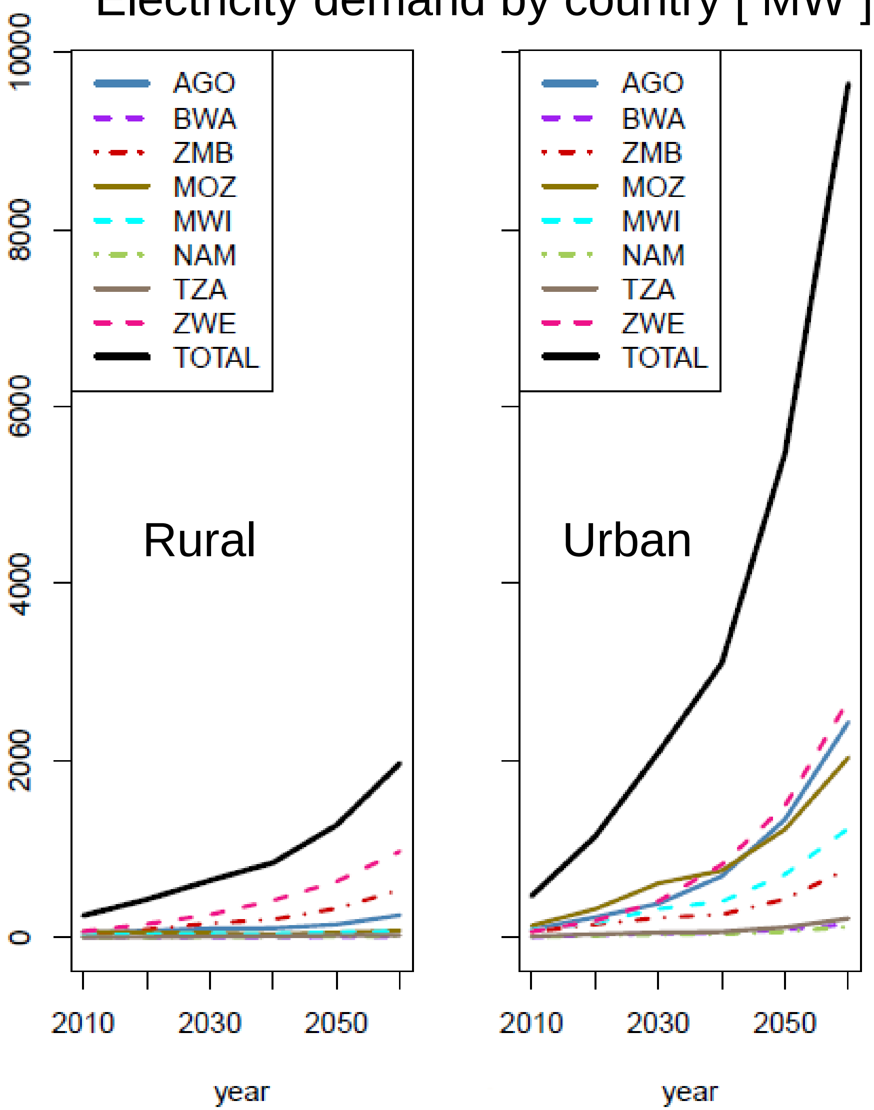
Multi-scale modeling incorporating basin-level decision making



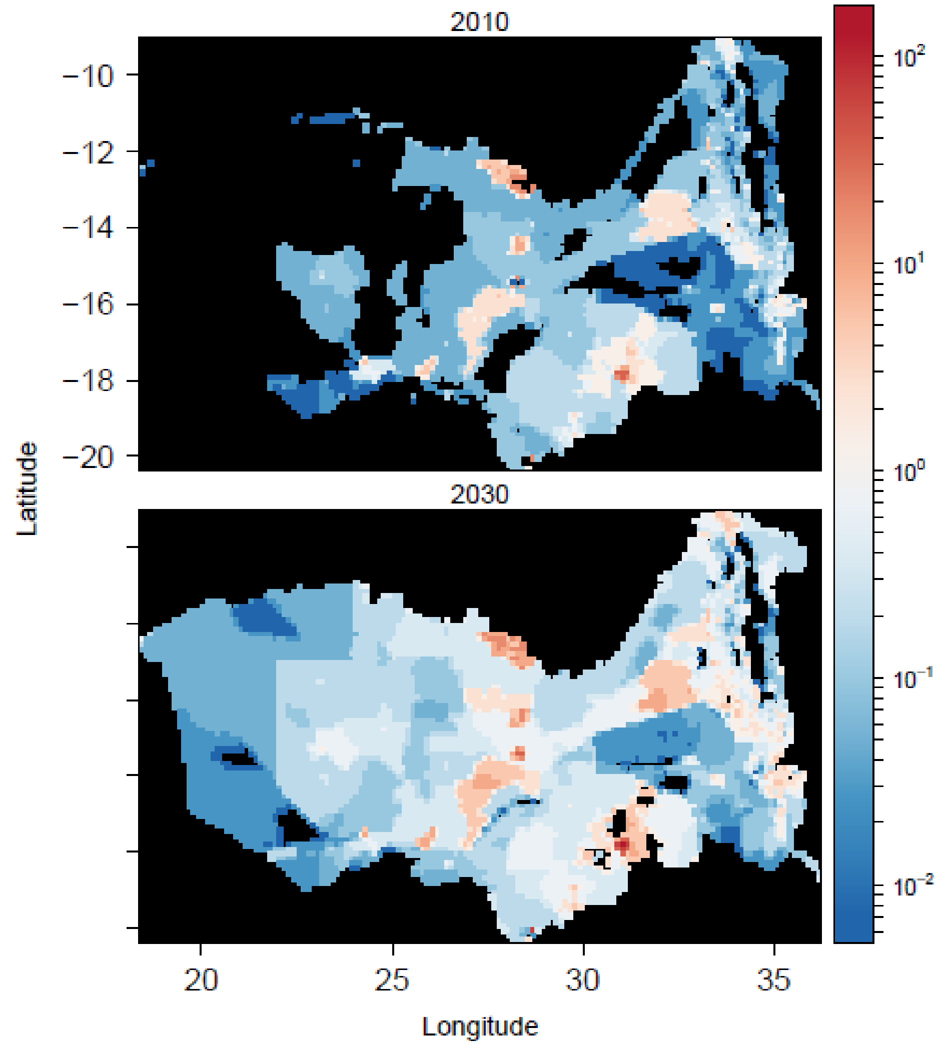
Innovations

Water, energy and food demand modeling at the basin-scale

Electricity demand by country [MW]

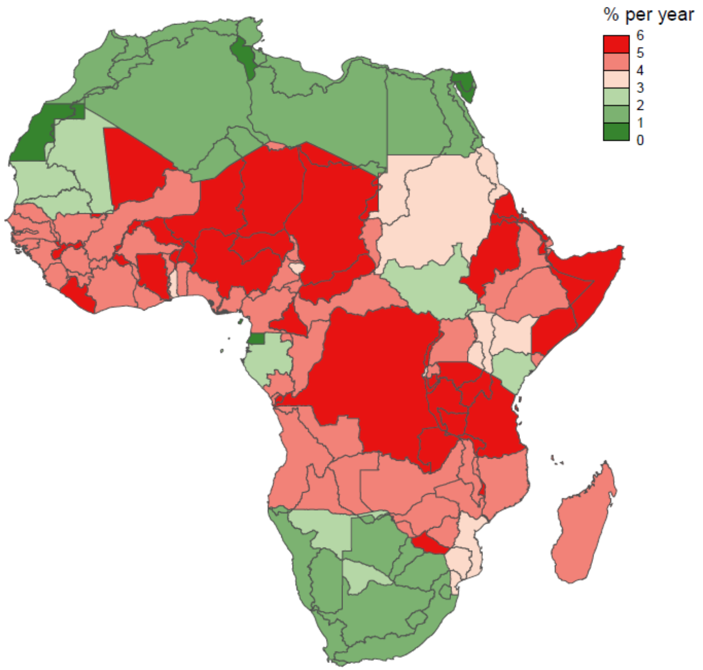


Spatially-explicit electricity demand [MW]

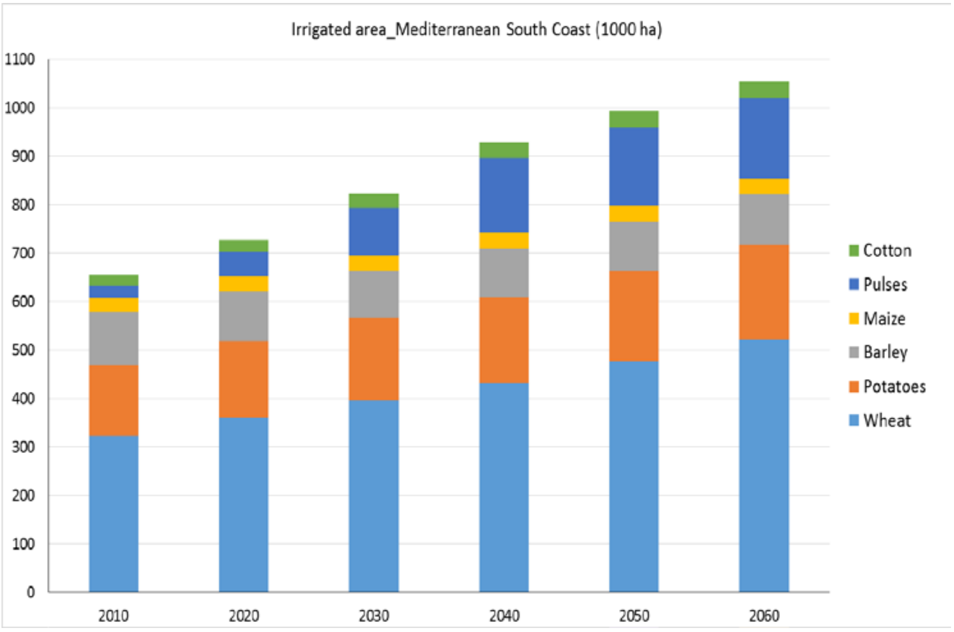


Data requirements

Growth Rate – Urban Water Demand – SSP2: 2010 to 2060

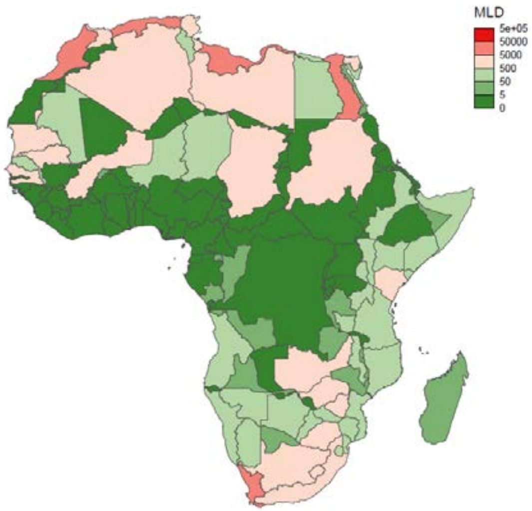


Irrigated area by crop - SSP2: 2010 to 2060 (MIRCA+GAEZ)

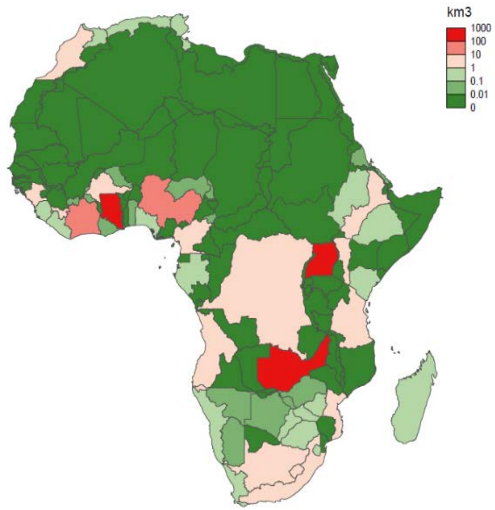


Existing infrastructure

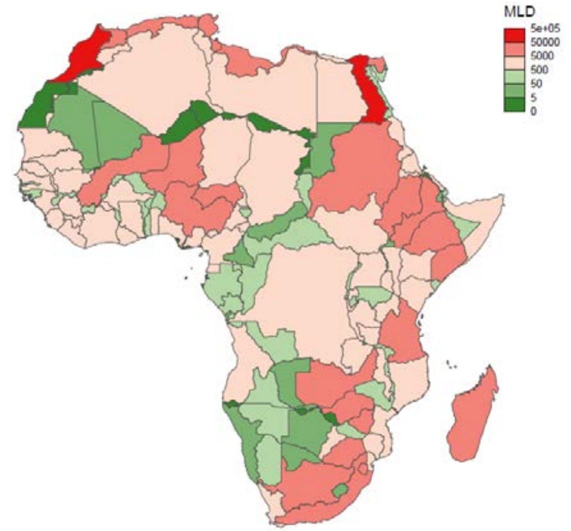
Groundwater Pumping Capacity – 2010



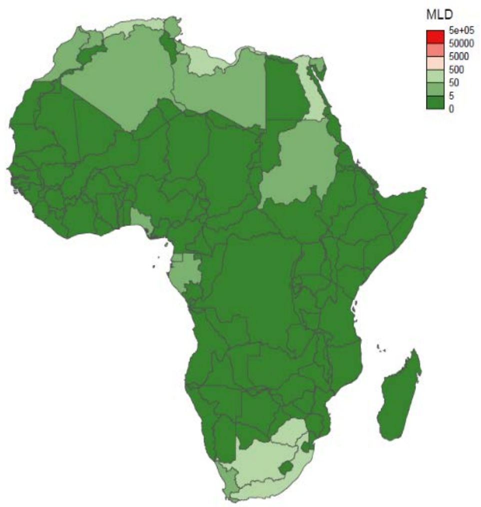
Reservoir Storage Volume – 2010



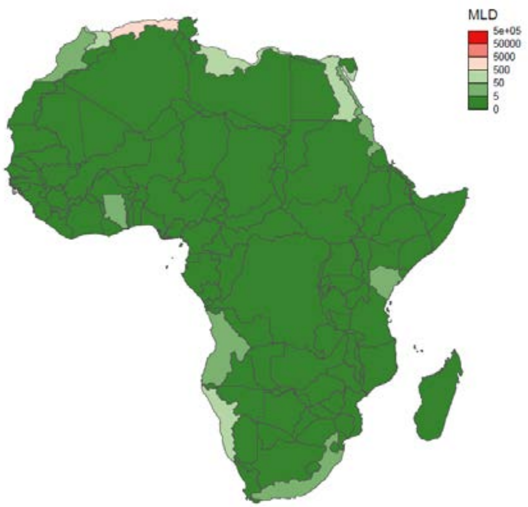
Surface Water Pumping Capacity – 2010



Primary/Secondary Wastewater Treatment Capacity – 2010



Desalination Capacity – 2010



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 allocation rules ▪ Better crop management ▪ Virtual water trade ▪ Improving education ▪ Controlling population growth

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

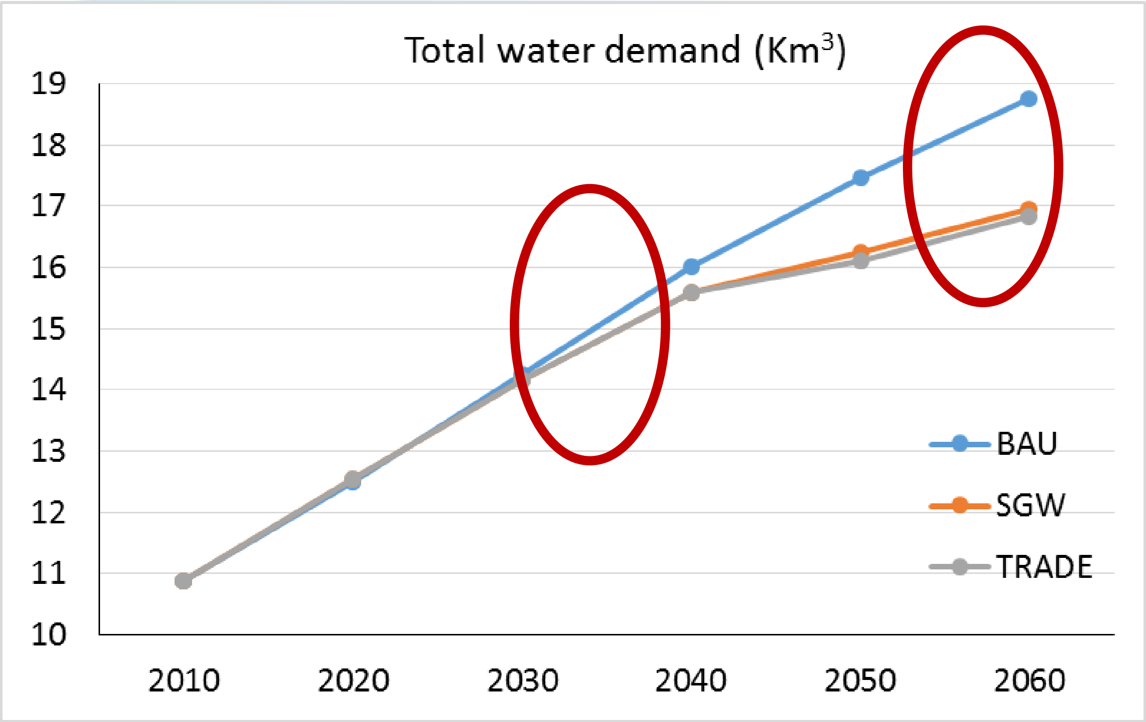
3/ Sustainable groundwater use and virtual water trade policy (TRADE): limiting groundwater use to renewable resources by 2050 and substituting 5% of domestic production of crops by food imports

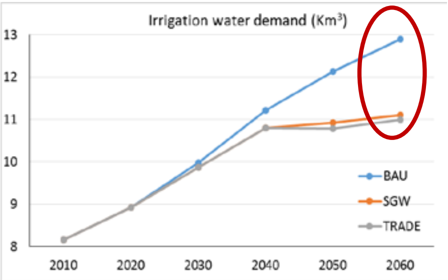
Case study area

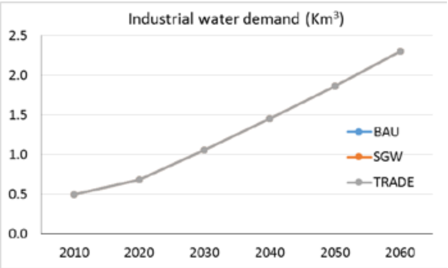
Test case: Mediterranean South Coast basin

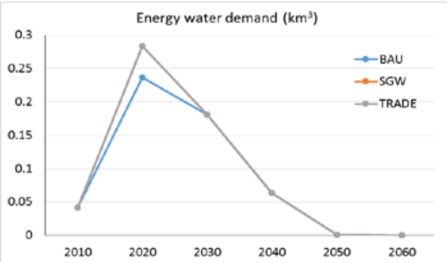
Water scarcity and Groundwater depletion problem: pumping in 2010 ≈ 6 km3, renewable resources ≈ 4.8 km3

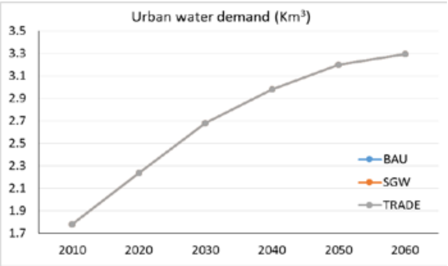
Water demand under each scenario

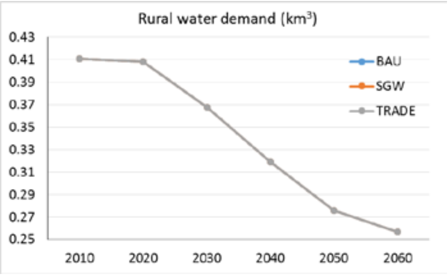






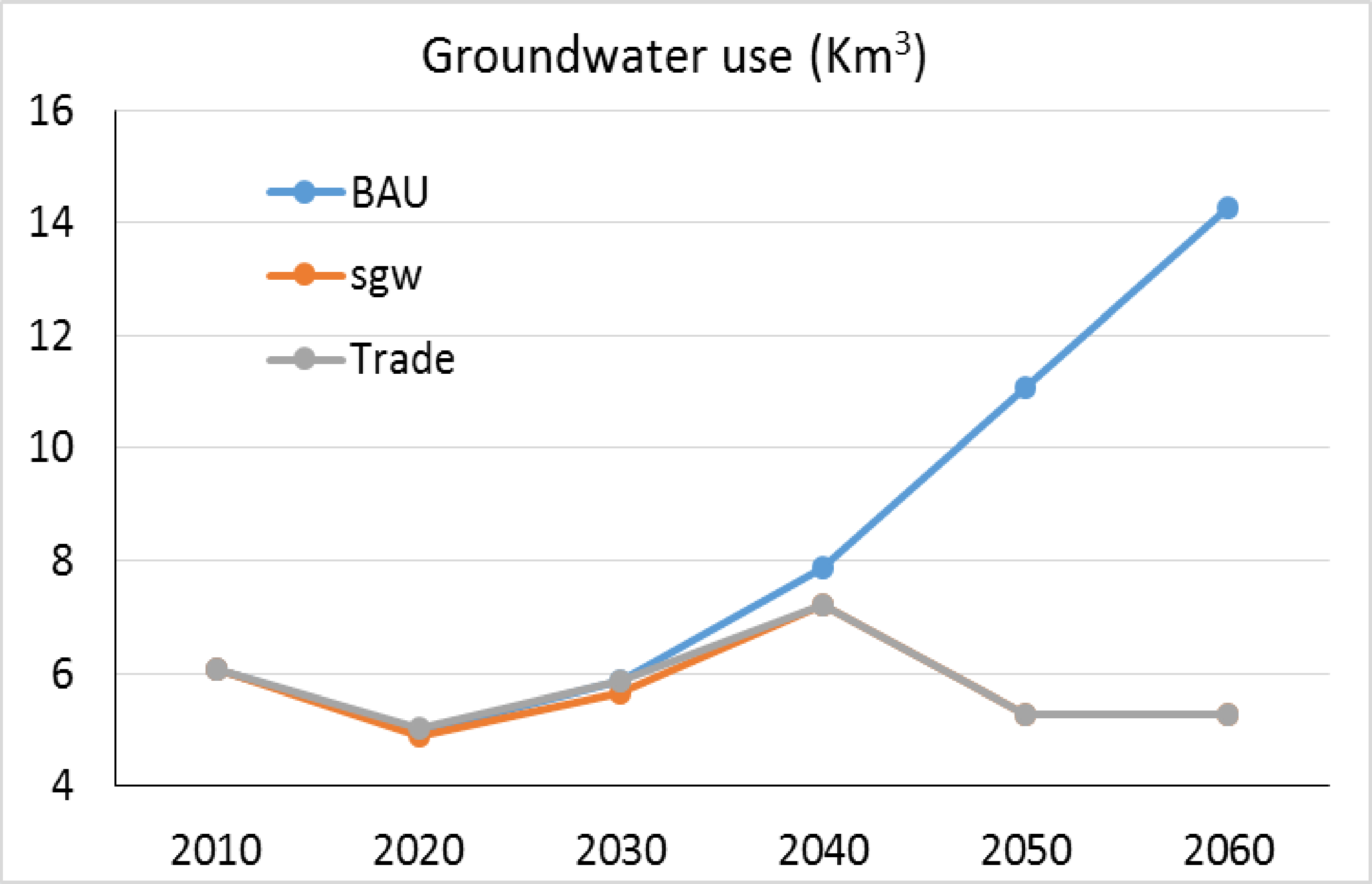






Preliminary results

Optimal allocation of resources under each scenario



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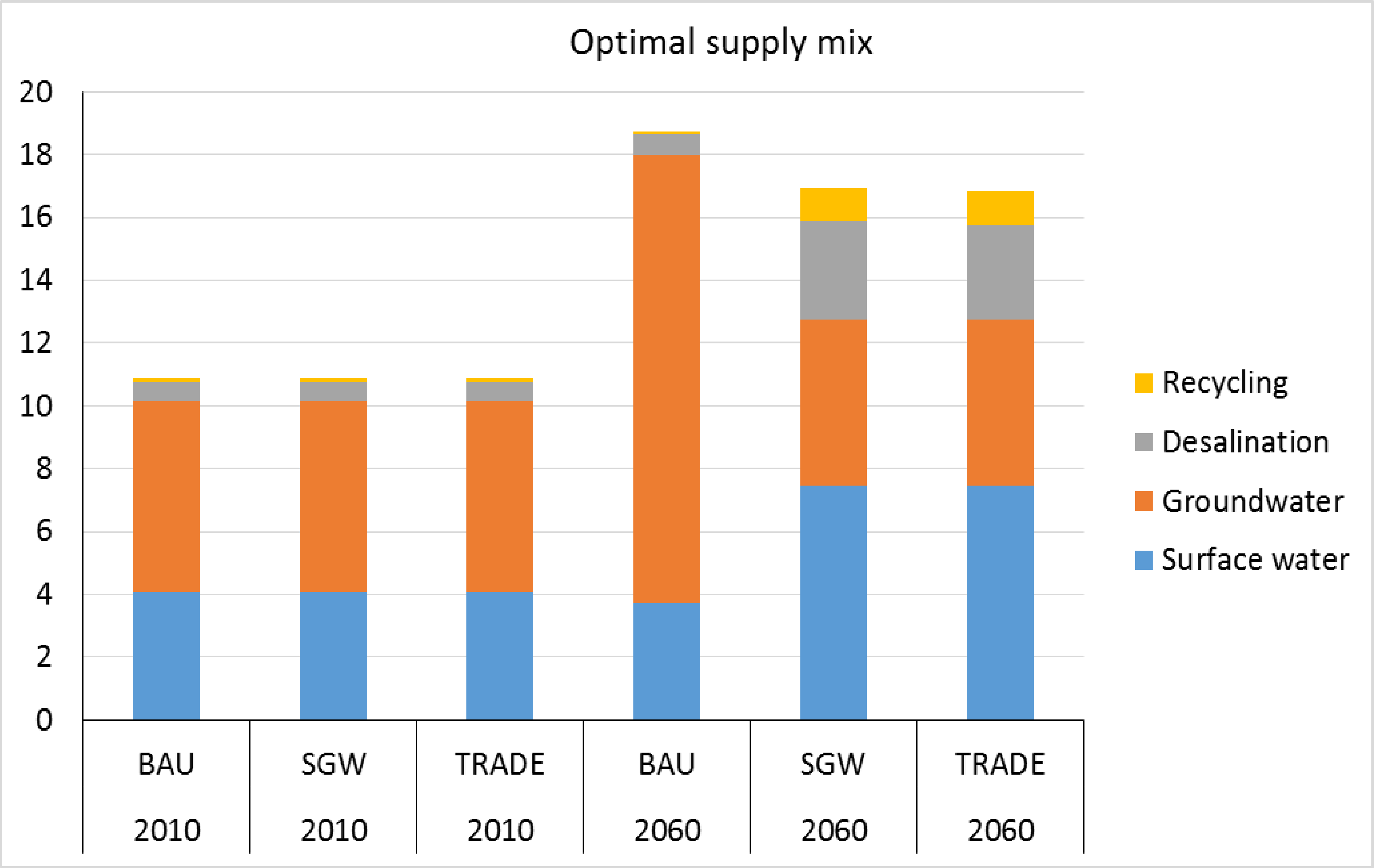
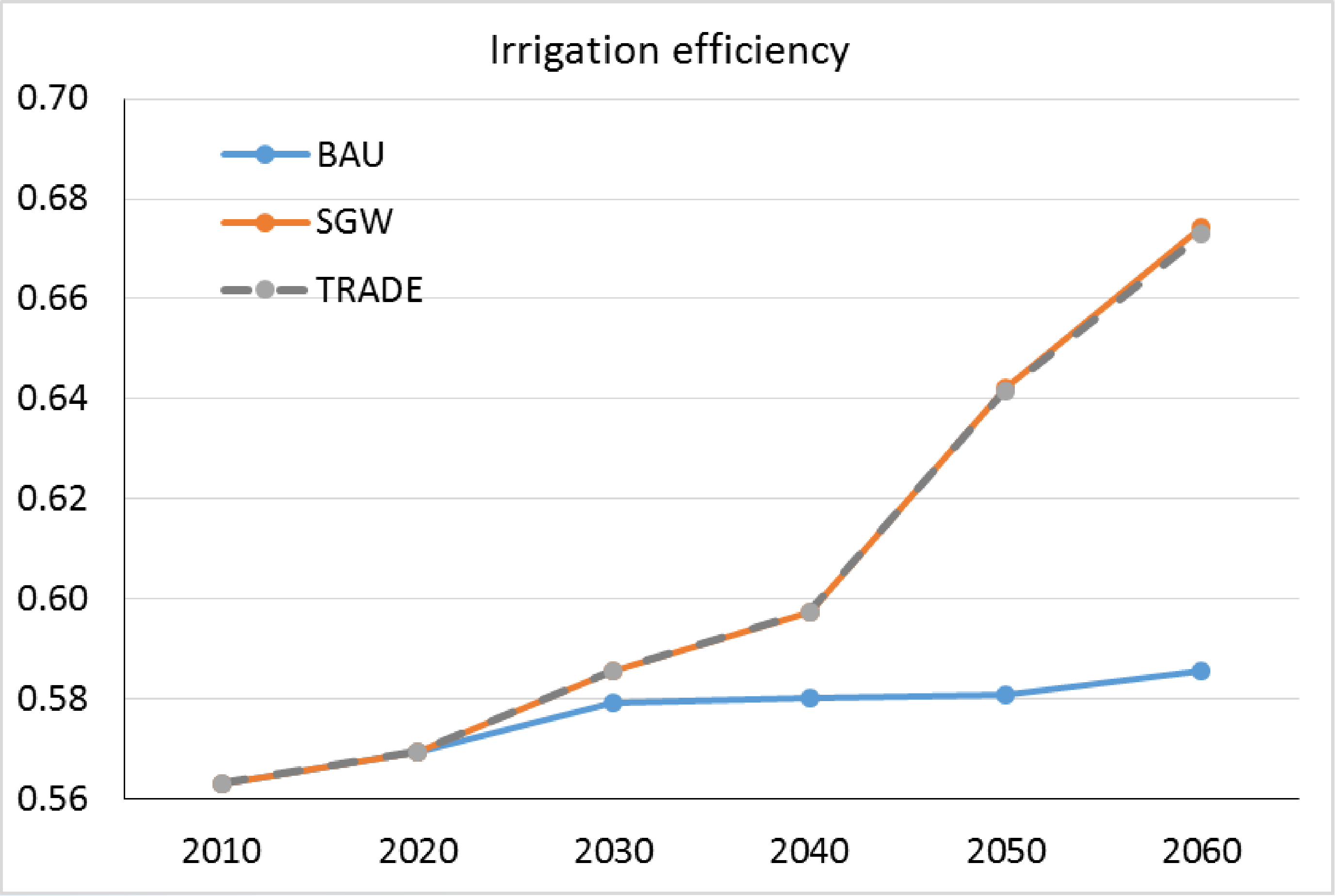


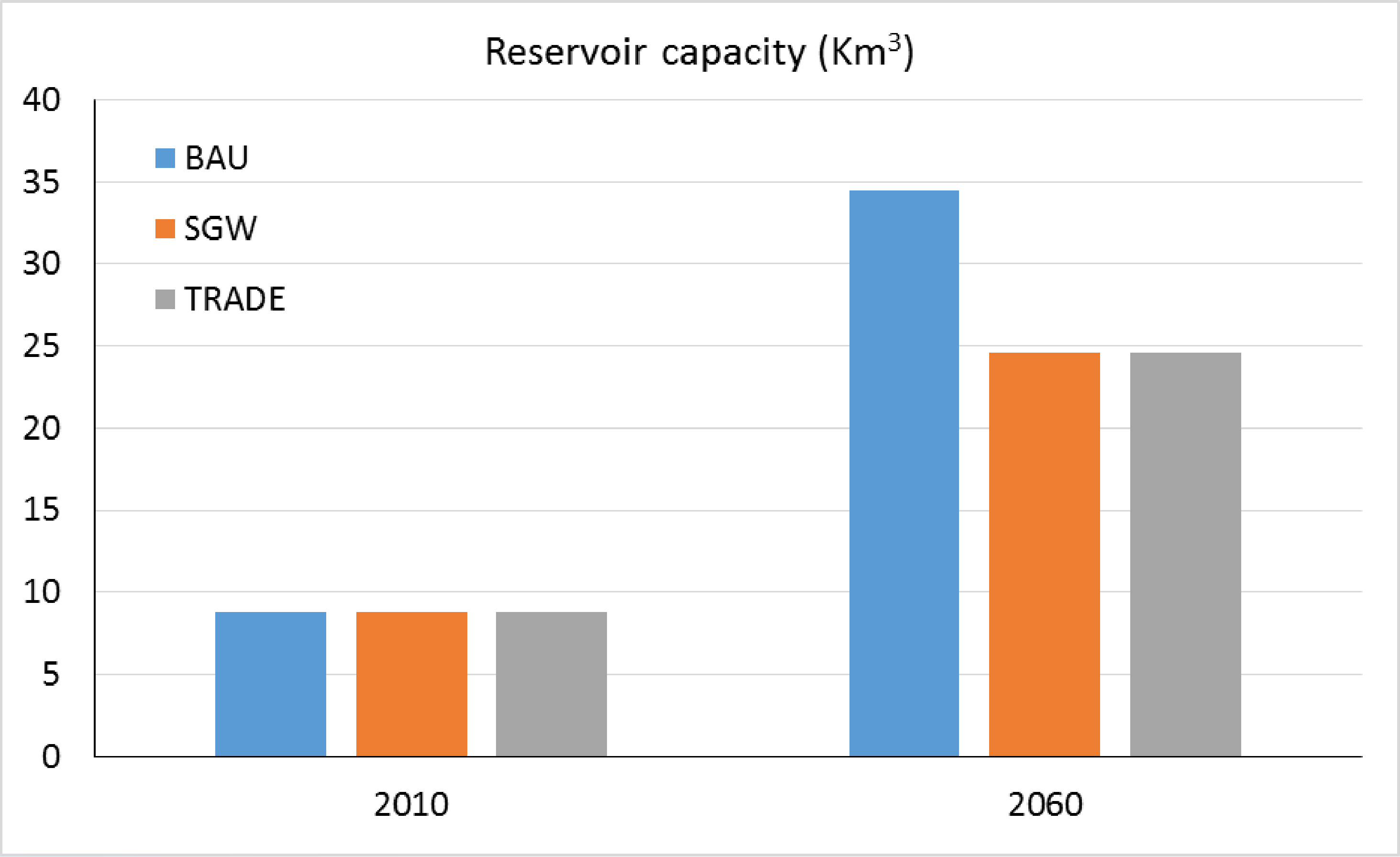
Preliminary results

Adaptation: technology change



Preliminary results

Adaptation: investment in infrastructure



Preliminary results

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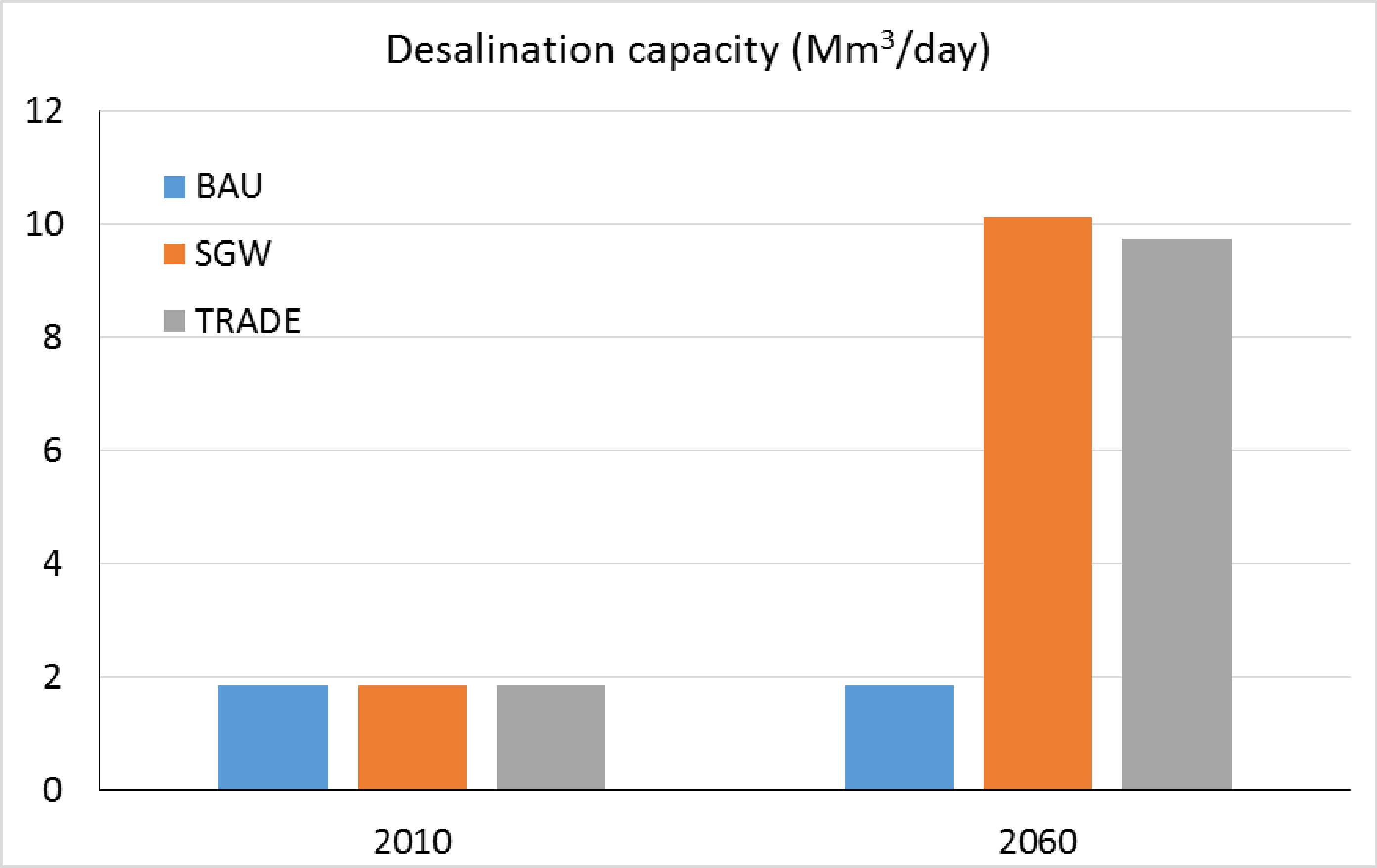

Preliminary results

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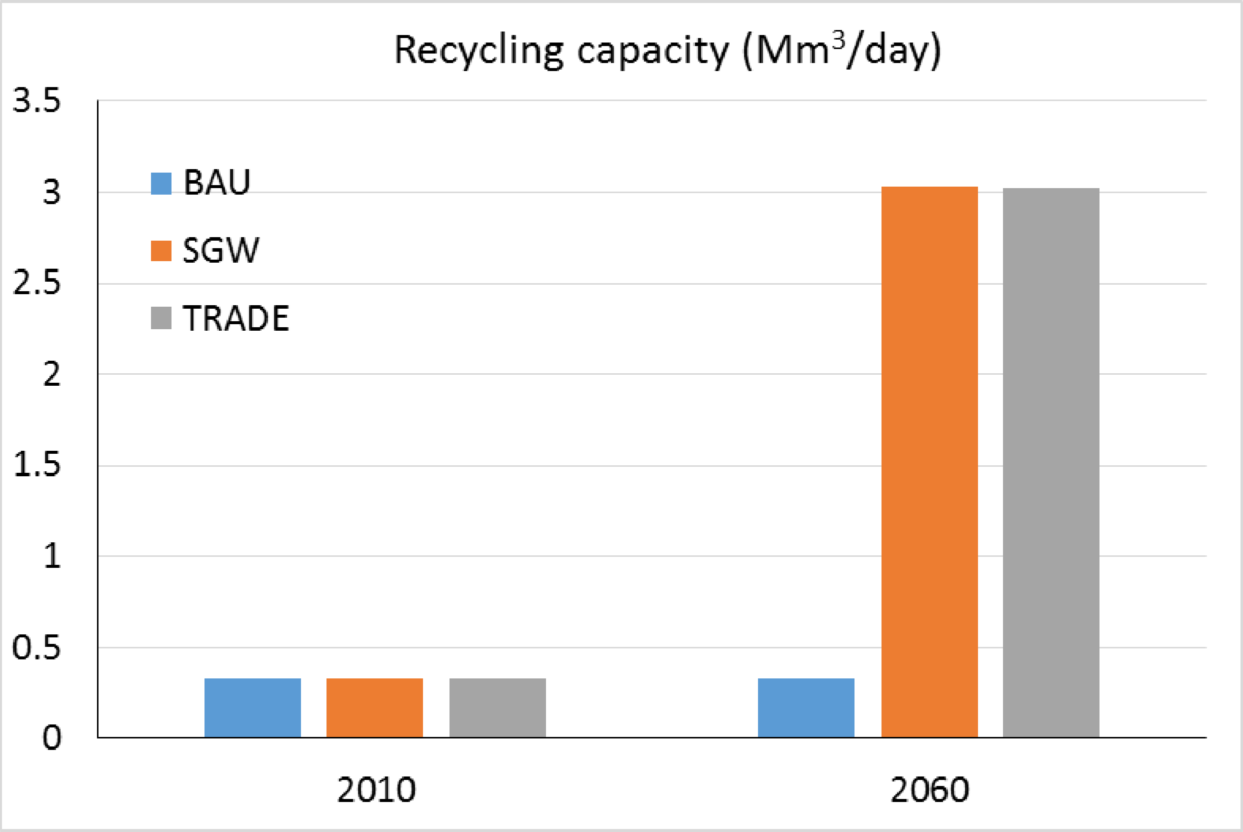

Preliminary results

Related Publications

- Satoh Y., Kahil T., Byers E., et al. Multi-model and multi-scenario assessments of Asian water futures: the Water Futures and Solutions (WFaS) initiative. Earth's Future (Forthcoming)
- Kahil T, Ward F. Albiac J., et al. Hydro-economic modeling with aquifer-river interactions to guide sustainable basin management. Journal of Hydrology 539 (2016): 510-524.
- Kahil T., Connor J. Albiac J. Efficient water management policies for irrigation adaptation to climate change in Southern Europe. Ecological Economics 120 (2015): 226-233.
- Kahil T., Dinar A., Albiac J. Modeling water scarcity and droughts for policy adaptation to climate change in arid and semiarid regions. Journal of Hydrology 522 (2015): 95-109.

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Thank you for your interest in this work!!!