Irrigation water requirements under future economic development pathways – a global CGE analysis

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Freshwater withdrawals and crop production

Current state

- Withdrawals ~10% of total renewable resources globally
- Agriculture by far the largest user – 70% of all withdrawals and 90% of consumption

The pressure

- Irrigated land provides 40% of world crop production
- Agricultural output expected to grow by 60% in the 2007-2050 timeframe (Alexandratos & Bruinsma 2012) – income and population growth
- **What implications for irrigation requirements and the sustainability of freshwater resources uses?**

Research

Aim

- Understanding socio-economic development impacts over irrigation requirements and withdrawals pressure

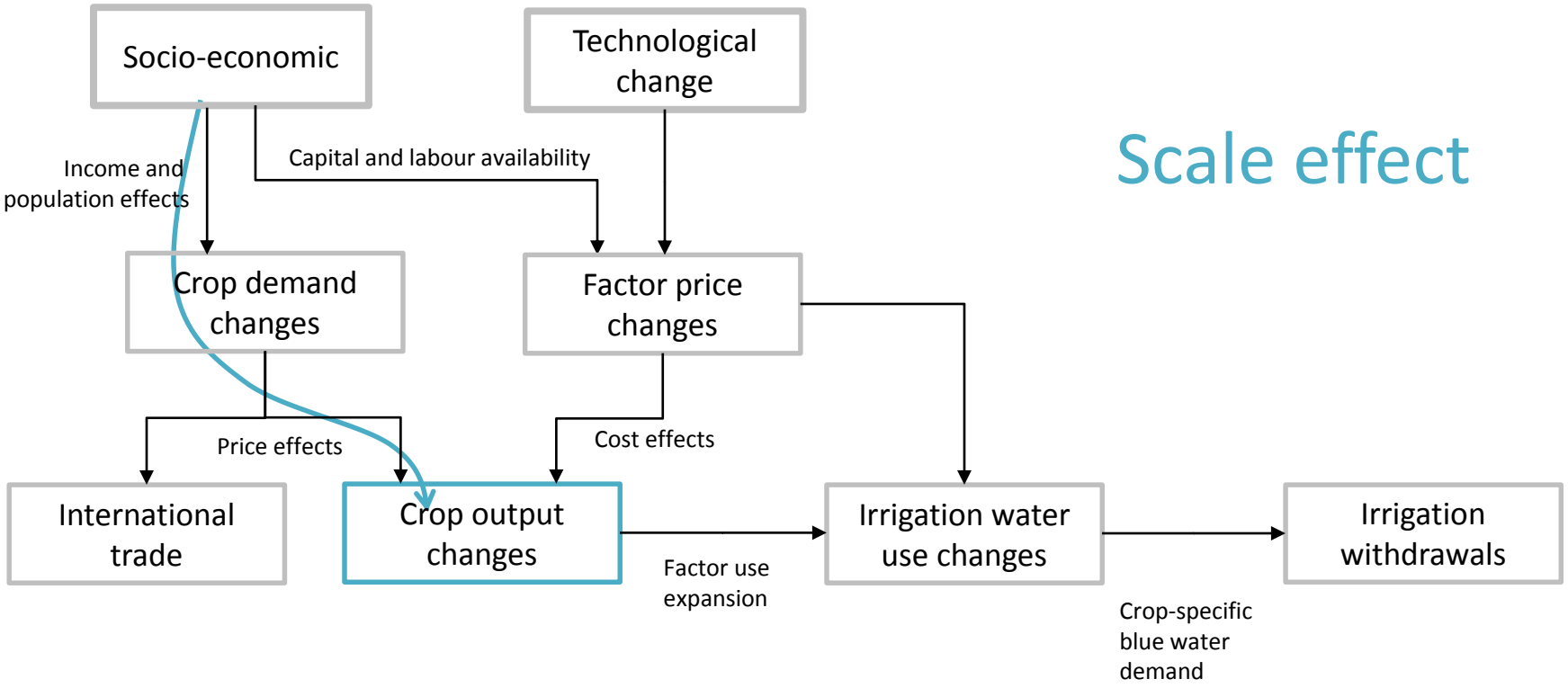
Methodology

- Global CGE framework – RESCU (**Res**ources **C**GE **U**CL) model
- 20 regions, 8 crop classes divided by the rainfed and irrigated varieties
- Irrigation water as a distinct factor of production – new accounting methodology based on GCWM raster data (Siebert & Doell 2010)
- Technological changes through inherent yield changes – IMPACT model data (Nelson et al. 2010)
- Pressure indicator – **Irrigation Withdrawals to Availability IWA** (withdrawals relative to total renewable resources within a region) with an 20% stress threshold

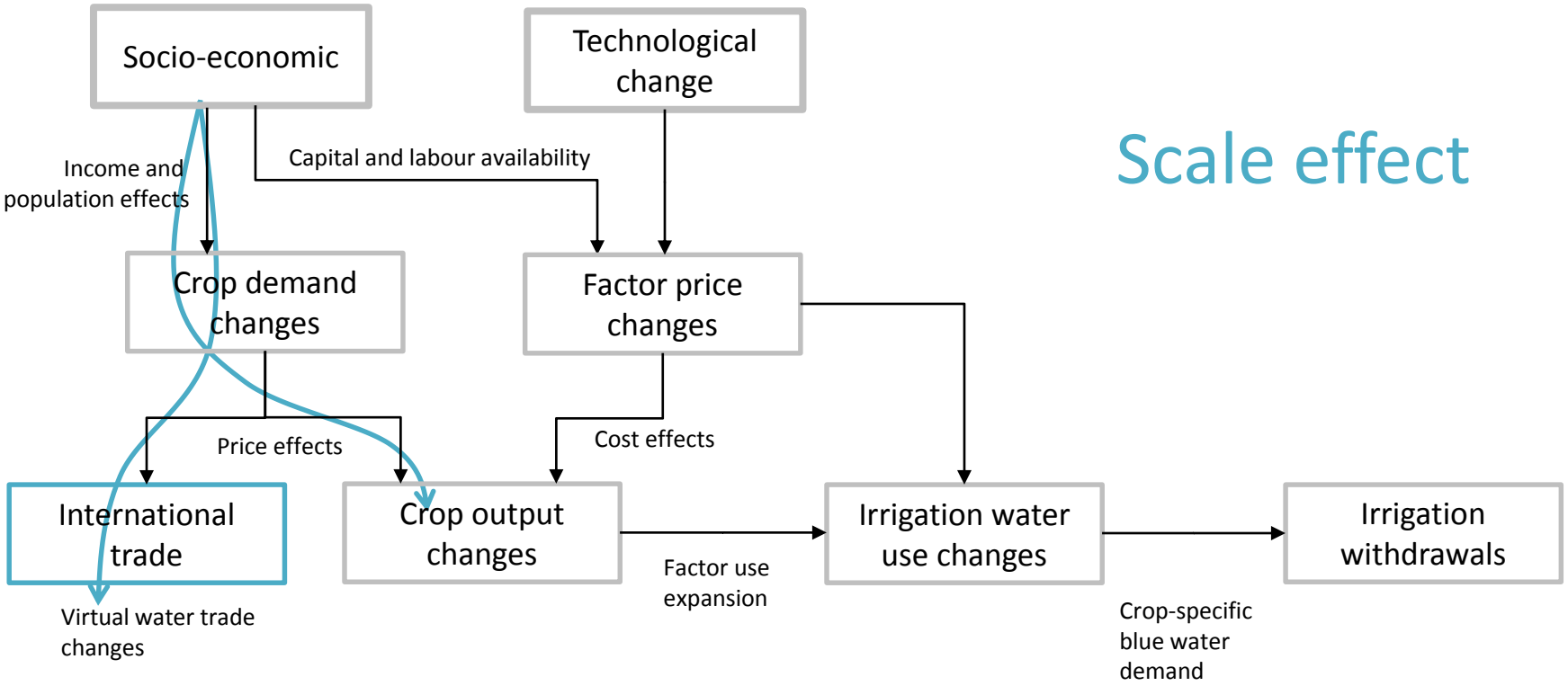
Socio-economic development scenarios

- 3 Shared Socioeconomic Pathways (van Vuuren et al. 2014) – **SSP1** (Sustainability), **SSP2** (Middle of the Road) and **SSP5** (Conventional Development)

Changes in irrigation withdrawals



Changes in irrigation withdrawals



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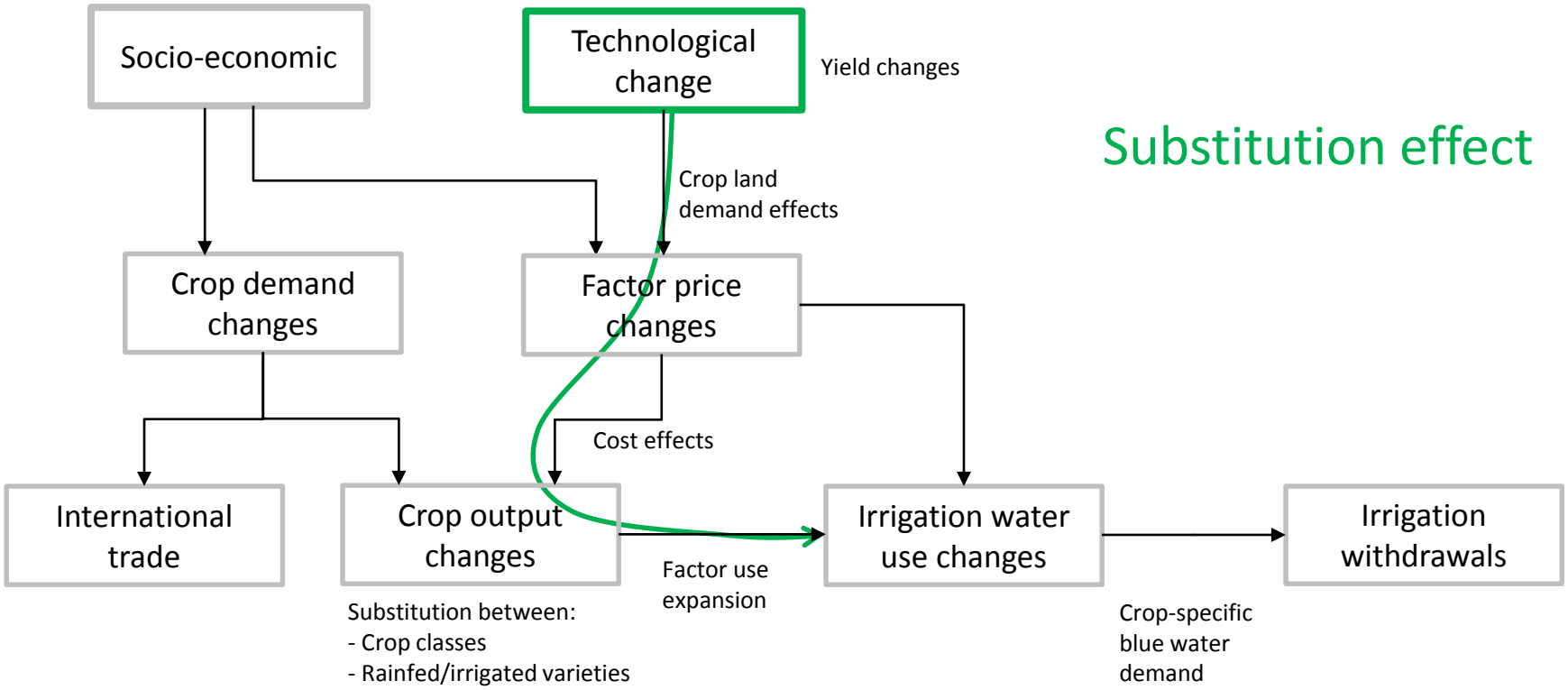
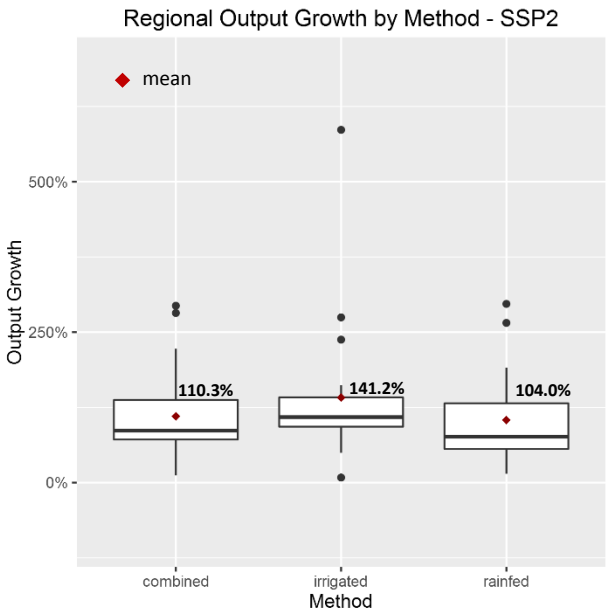


Results – crop output growth 2004-2050

Global Output Growth by SSP

	Overall	Rainfed	Irrigated
SSP2	+83%	+73%	+101%
SSP1	+88%	+77%	+106%
SSP5	+101%	+88%	+124%



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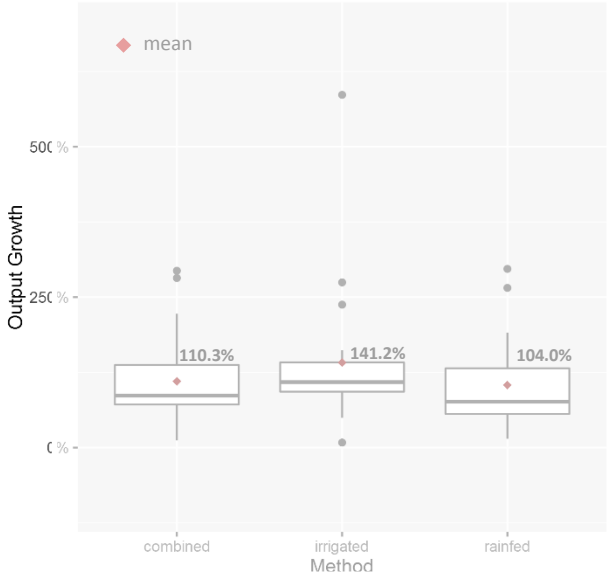
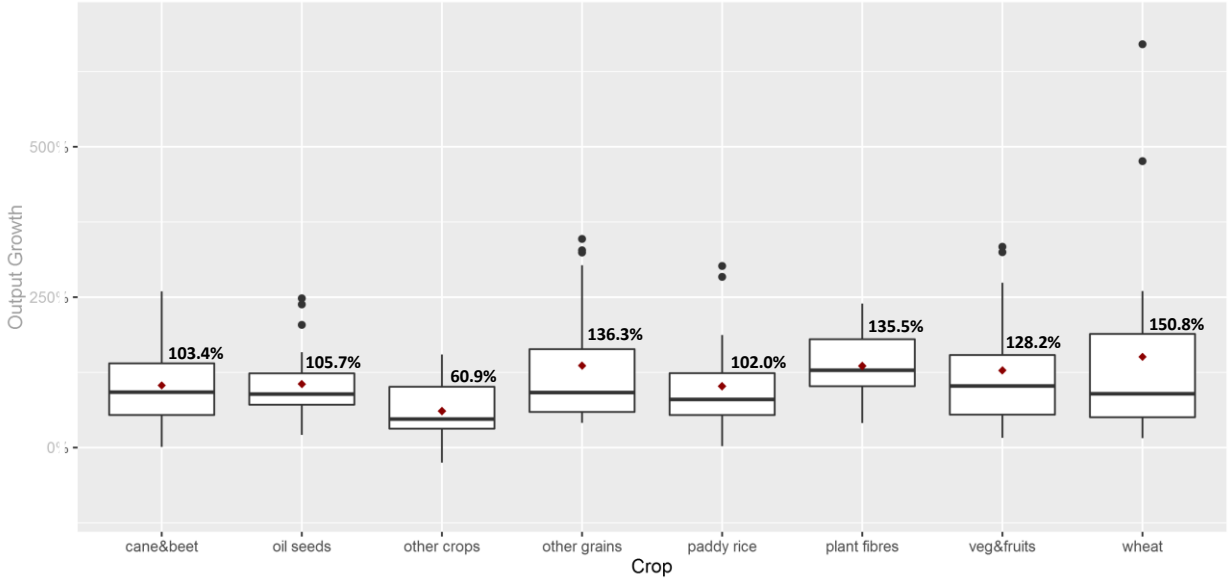
Global Output Growth by SSP and by Crop

Crop	Cane beet	Oil seeds	Other crops	Other grains	Paddy rice	Plant fibers	Veg fruits	Wheat
SSP2	79%	110%	53%	96%	**38%**	149%	91%	**98%**
SSP1	83%	116%	56%	108%	**40%**	155%	96%	**102%**
SSP5	93%	130%	67%	114%	**44%**	168%	113%	**116%**

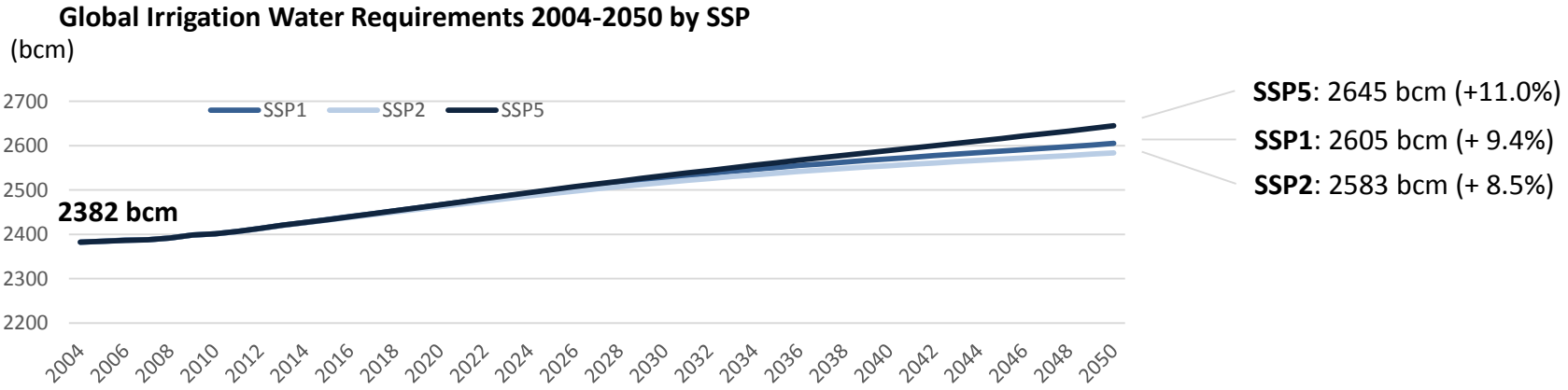
Regional Output Growth by Method - SSP2

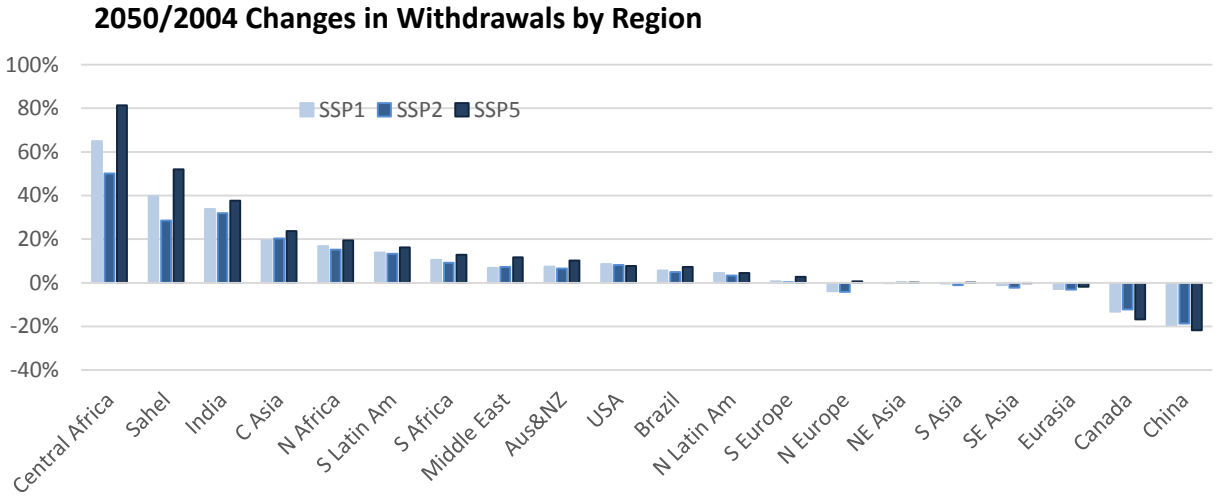


Regional Crop Output Growth - SSP2



Results – irrigation water requirements



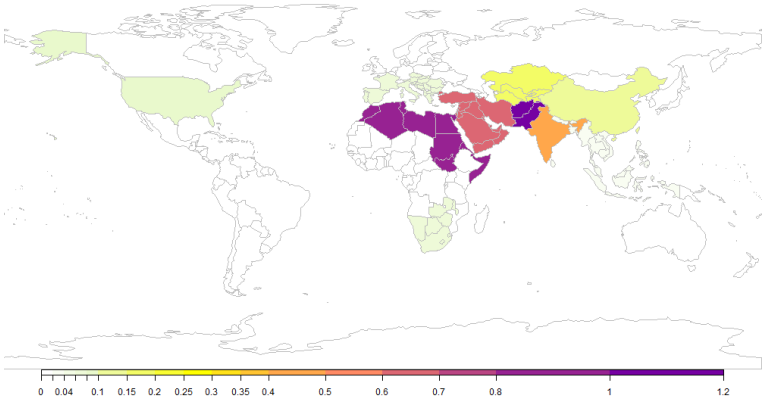


Results – IWA withdrawals pressure

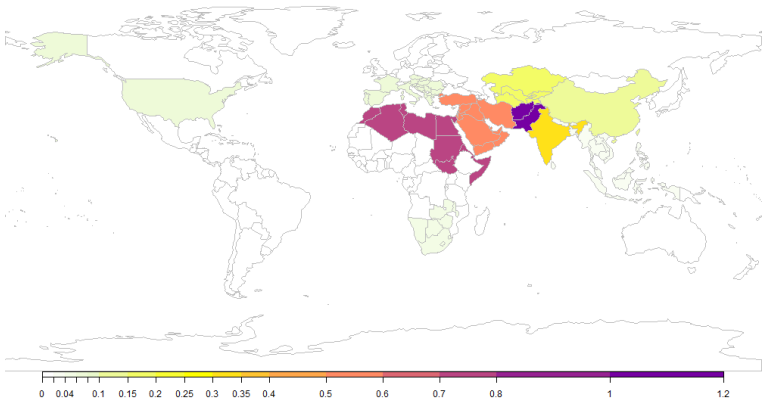
IWA = Withdrawals / TRWR

Region	2004	2050		
		SSP1	SSP2	SSP5
S Asia →	103.89%	103.56%	102.78%	103.96%
N Africa ↗	76.80%	89.70%	88.43%	91.75%
Middle East ↗	58.17%	62.17%	62.38%	64.93%
India ↗	31.61%	42.32%	41.68%	43.49%
C Asia ↗	16.41%	19.59%	19.75%	20.31%
China ↘	12.86%	10.38%	10.45%	10.07%
USA ↗	7.58%	8.24%	8.20%	8.16%
S Europe ↗	7.13%	7.18%	7.15%	7.32%
S Africa ↗	5.55%	6.12%	6.06%	6.26%
SE Asia ↘	2.91%	2.87%	2.84%	2.90%
Aus&NZ ↗	1.78%	1.91%	1.89%	1.96%
NE Asia →	1.84%	1.84%	1.84%	1.84%
N Latin Am ↗	1.37%	1.43%	1.42%	1.43%
S Latin Am ↗	1.08%	1.23%	1.23%	1.26%
Sahel ↗	0.78%	1.09%	1.00%	1.18%
Central Africa ↗	0.61%	1.01%	0.92%	1.11%
Eurasia ↘	0.43%	0.42%	0.42%	0.42%
Brazil ↗	0.13%	0.14%	0.14%	0.14%
N Europe ↘	0.07%	0.07%	0.07%	0.07%
Canada →	0.07%	0.06%	0.07%	0.06%

SSP2 2050



SSP2 2004



Conclusions

- Higher growth scenarios lead to further increases in irrigation water requirements – the scale effect prevails in most regions
- Water-challenged regions continue to expand the pressure over their freshwater resources – importance of efforts to increase water use efficiency (SDG target 6.4)
- Yield improvements have a reducing effect over dependency on irrigation water
- Next steps for modelling
  - Consideration of climate change impacts over yields
  - Inclusion of other freshwater users (livestock, households, industry) for absolute limits on withdrawals

Thank you!

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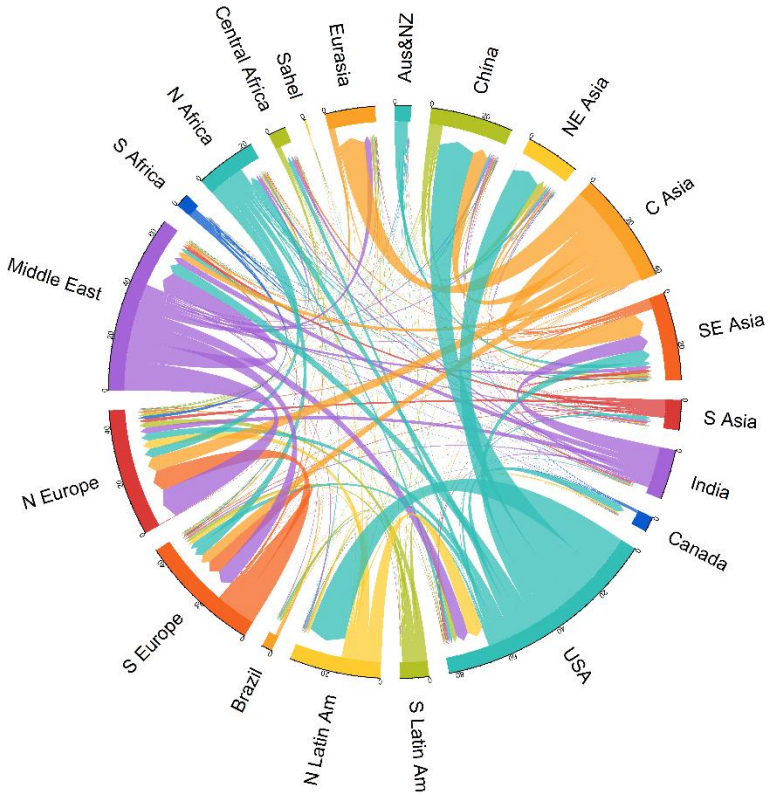
Virtual water flows

2004: 255 bcm



2050: 282 bcm (SSP2)