Are we in deep water?
Water scarcity and its limits to economic growth

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Motivation

- The pressure on **water** resources will increase significantly over the coming decades and this will bring problems for food security and environmental sustainability (Alcamo et al., 2007, Ercin and Hoekstra, 2012, Hoekstra, 2014).
- Unclear effect of **climate change** and of **socio–economic** factors.
- Application of **MRIO** analysis to ecological footprints (EFs) is shifting from an ex-post static calculation toward an **ex-ante scenario** (Ferng, 2009, Ercin and Hoekstra, 2012).
- Novelty: combination of two measures of **water scarcity**: **social** (water per capita) and **physical** (water availability).

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Objective and main results

- **Aims** of the paper
  - Assess the heterogenous impact of **climate change** on **Wa** through P/PET changes.
  - Assess the **sustainability**, in terms of the virtual water required for production, based on GDP and population growth scenarios (IPCC, 2014).
  - Build a coherent **framework** to compare social and physical water scarcity.
- Main **results**
  - **Socio-Natural conditions** (climate and population) produce their effect on social water scarcity in the very long-run. The **Falkenmark** indicator is misleading.
  - the issue of **Physical water scarcity** is ubiquitous independently from the level of economic development.
  - **economic** variables (GDP, efficiency and trade) are able to affect over the short period the exploitation of Wa with the most remarkable effect in India and China expected around the year 2025.

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Research Questions

- Are there **water constraints** to economic growth (OECD, 2014)?
- What is the impact of **Climate Change** on Wa and **Scarcity**?
- In case of **un-sustainable** growth, which would be the **technological development** needed to avoid any GDP lost?
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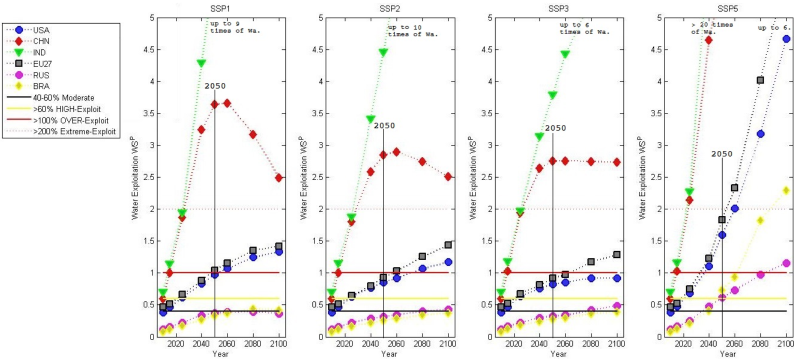
Definitions and Scenarios

Scenario: 'a hypothetical sequence of events constructed for the purpose of focusing attention on causal processes and decision points' (Kahn and Wiener, 1967).

IPCC 2014	GDP	POP	TECH	INEQ	Δ°C	Title
1	M-H	L	H	L	*1.7-3.2*	*Sustainability*
2	M	M	H	M	*1.8-3.4*	*Middle of the Road*
3	L	H	L-M	H	*2.4-4.4*	*Fragmentation*
5	H	M	L-M	M	*3.2-5.4*	*Conventional*

1. Falkenmark Indicator defined as $\frac{Wa}{POP}$, with thresholds: $< 1700m^3$/cap (*stress*), $< 1000m^3$/cap (*scarcity*), $< 500m^3$/cap (*absolute scarcity*);
2. Physical Scarcity: $WS^P = \frac{B+GN+GY}{Wa}$, it is sustainable if $< 60\%$ (Smakhtin et al., 2005);
3. Socio-Economic Indicator: $\frac{WF}{POP}$, where $WF_C = \hat{\gamma}_C L_C f_C$ - $\Theta_C^{BALANCE}$
4. Further Assumptions: Wa updated based on $\Delta(\frac{P}{PET})$, $\Delta\gamma_t$ as provided by Ercin and Hoekstra, 2014, constant technological coefficients (A), γ captures tech progress in *water efficiency*.

Physical Scarcity WS^P



Water constraint to economic growth? **Technological Development**, Not-renewable water resource, Change in consumption bundle.

Trade and 'Sustainable' Technology

WF_{cap} m^3	SSP1		SSP2		SSP3		SSP5	
COUNTRY	**2025**	**2080**	**2025**	**2080**	**2025**	**2080**	**2025**	**2080**
CHN	2.19	2.53	2.10	3.23	2.05	1.70	2.24	2.62
IND	1.32	1.91	1.29	1.36	1.24	0.68	1.26	2.28
ESP	2.74	3.35	2.74	3.37	2.85	4.57	2.67	2.32
UK	2.65	3.06	2.63	3.11	2.67	4.10	2.65	2.11
ITA	2.59	3.37	2.58	3.38	2.60	4.38	2.60	2.66
JPN	2.67	4.90	2.64	4.87	2.67	5.96	2.71	4.23
MEX	2.28	3.21	2.21	2.51	2.12	1.45	2.28	3.84
TUR	3.25	4.37	3.13	3.47	3.10	1.93	3.32	3.84

Sustainable Tech Change (<60% of Wa) would be far greater (from -1.24% up to -2.68% reduction $\frac{m^3}{\$}$ per year) compared to historical trends (from -0.24% up to -1.05% reduction $\frac{m^3}{\$}$ per year).

Conclusion

- **Population** dynamics and **Climate Change** play a **minor** role.
- Water scarcity might limit economic growth in the **short-period**.
- Complex socio-economic-ecological systems require **multidimensional solution** (tech, gdp, consumption, climate).
- **No unique best solution**: water category and sectoral decomposition matter (heterogenous country needs).
- Potential gain for fresh-water reduction due to **GY recycling** (mostly in China).

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THANK YOU
FOR YOUR
ATTENTION