

# Beyond the Tap: The Value of Alternative Water Sources for Climate Adaptation

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**Multidimensional Impacts of a Circular Bioeconomy from Local to Global Scales  
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# Natural Water Scarcity in Mediterranean Countries

Norwegian sovereign wealth fund highlights water-related volatility as a major source of financial risk across its global investment portfolio.

## The Problem: Escalating Scarcity

Driven by:



Population Growth



Economic Growth



Climate Change  
Reduced Precipitation,  
Increased Temperature

## Proposed Solutions: Alternative Sources



Treated Wastewater



Desalination

## The Challenge: Trade-offs & Impacts



Higher Cost

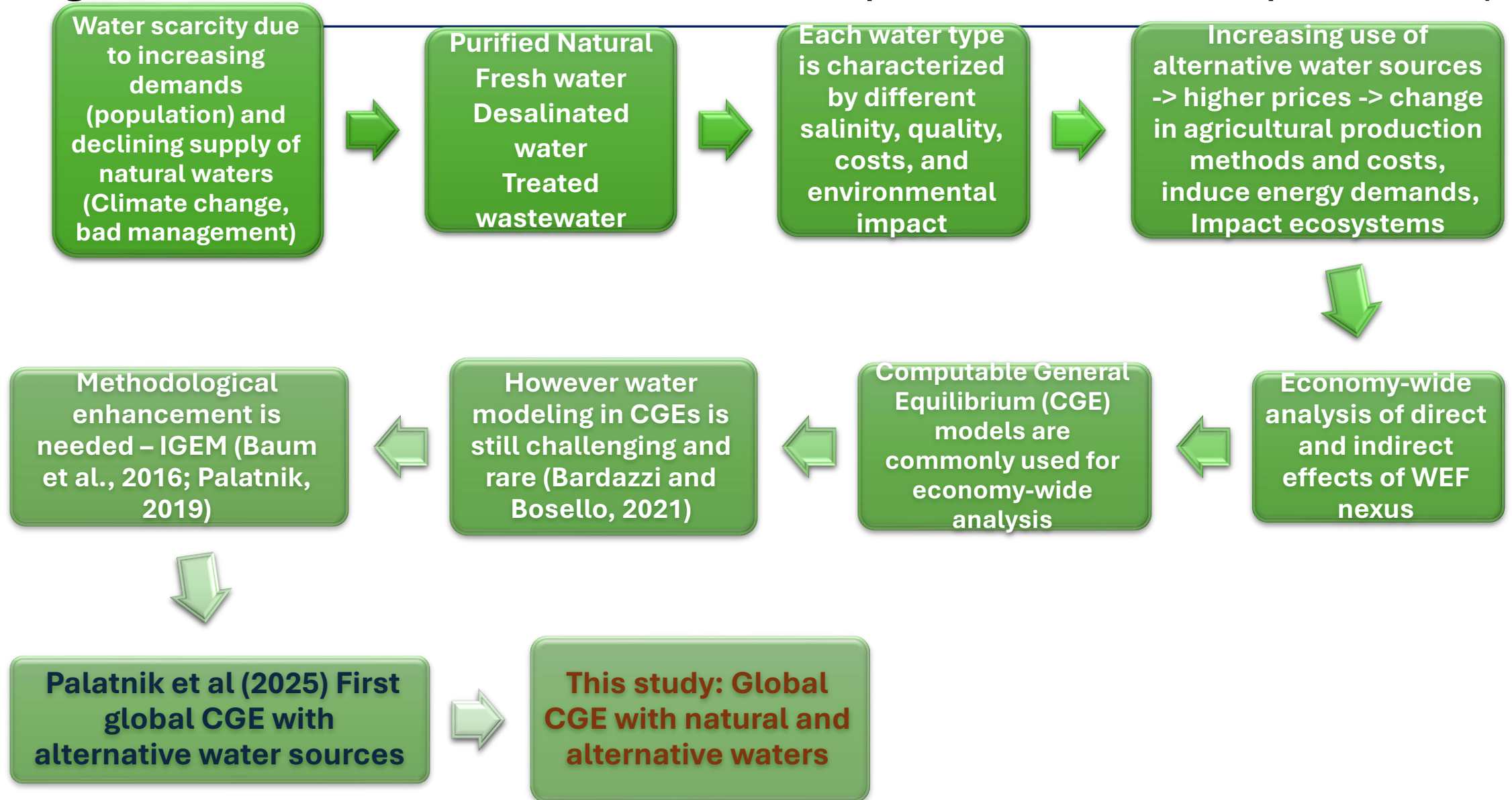


Variable Quality & Costs



Potential Ecosystem Harm

# Background: water, alternative water, Computable General Equilibrium (CGE)



# This Study: The Value of Alternative Water Sources for Climate Adaptation

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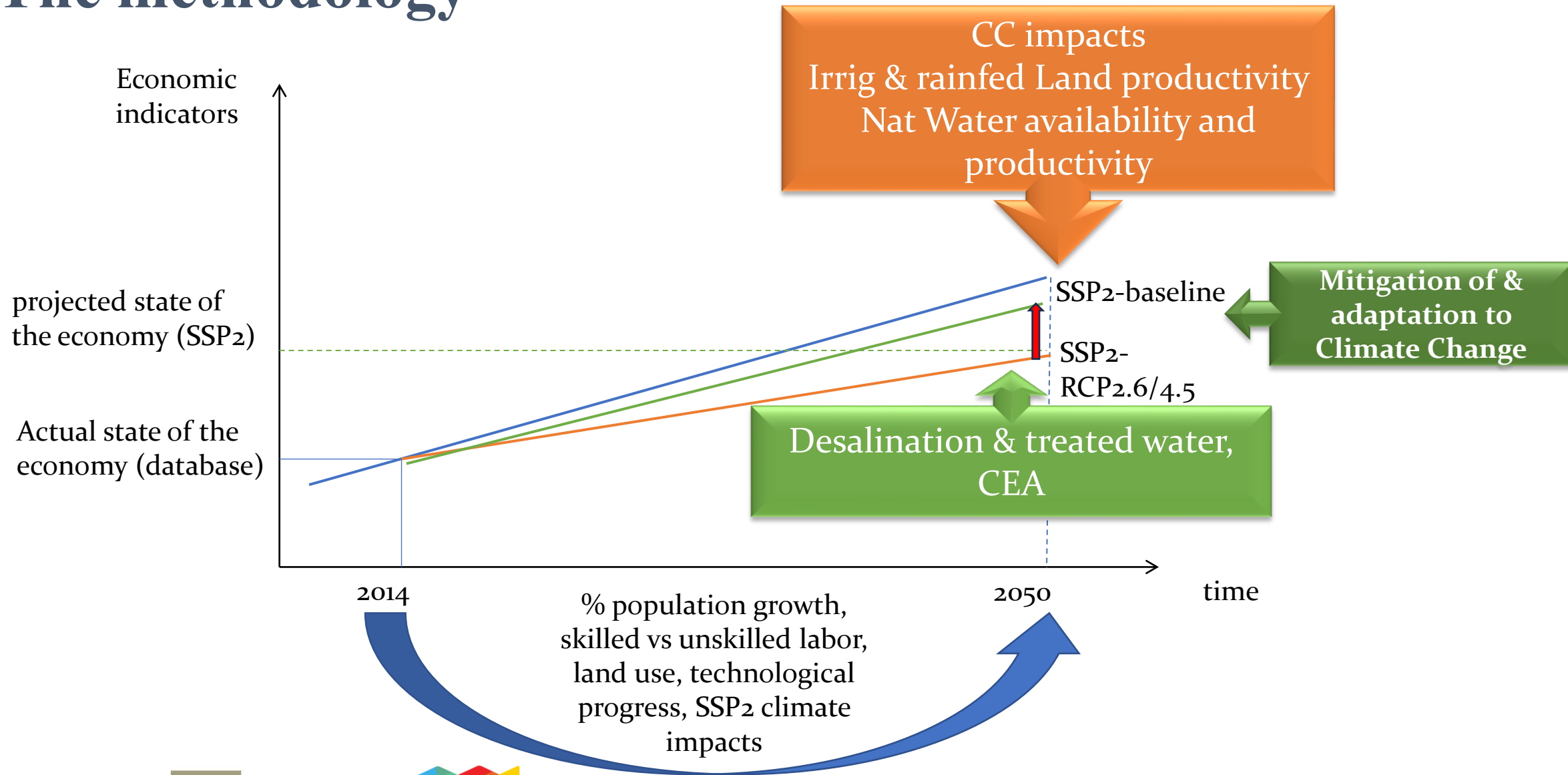
- **First global Computable General Equilibrium (CGE) model with explicit natural water + alternative water sources**
- Models desalination & treated wastewater as economic sectors
- Captures agriculture, energy & international trade spillovers
- Focus on 11 Mediterranean Sea Basin countries within a global model (21 regions)
- Scenario: SSP2–RCP4.5 (most likely near-term trajectory)

## Research Methodology

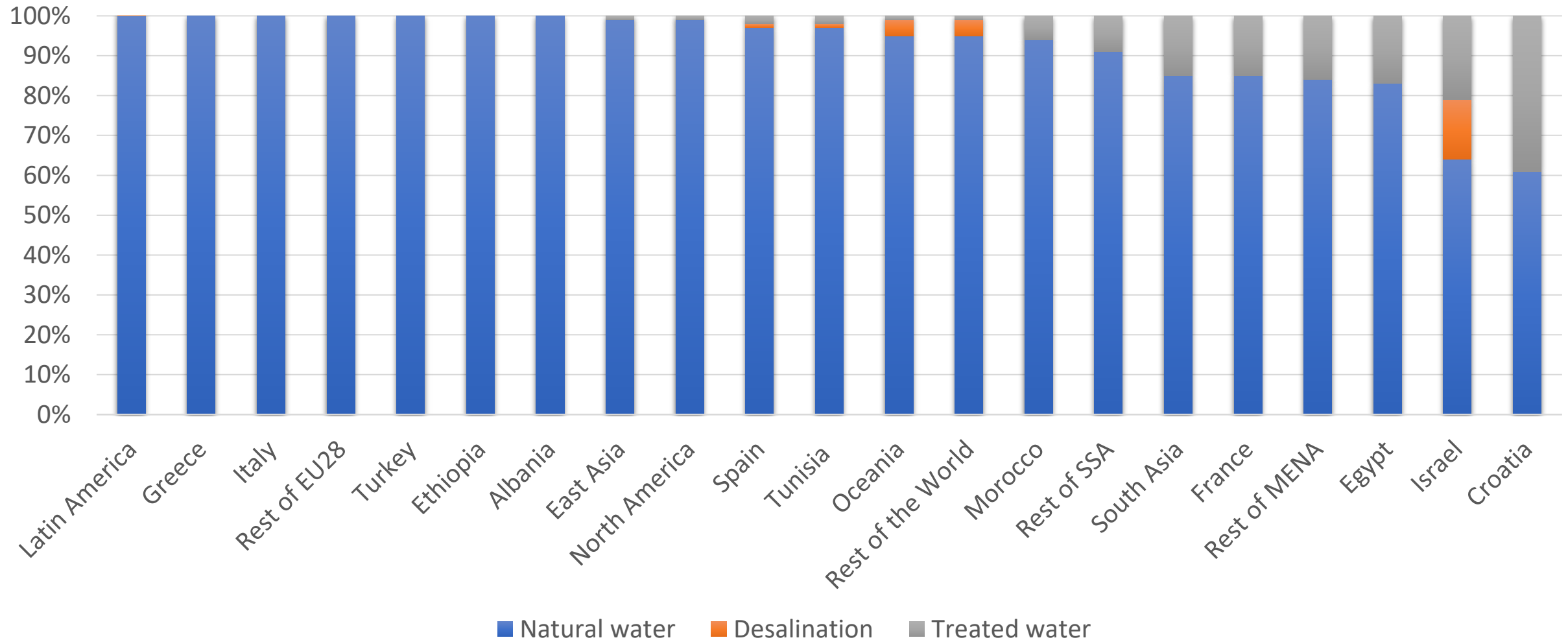
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1. Introduce desalination and treated water into the global CGE model and database
2. From a single water sector to:
  - I. desalinated water (mostly seawater desalination)
  - II. treated water (reused wastewater)
  - III. Water production and distribution (natural water: ground and surface)
3. From single Crops sector into irrigated and rainfed crops.
4. Value of Controlled Environment Agriculture (CEA) technology with characteristics of hydroponics comprises 30% of irrigated agriculture in 2050.
5. Synergy of IAM and CGE estimations for agricultural impacts under climate change extreme events uncertainty
6. Natural water as a primary factor of production to value the contribution of alternative water sources to climate adaptation

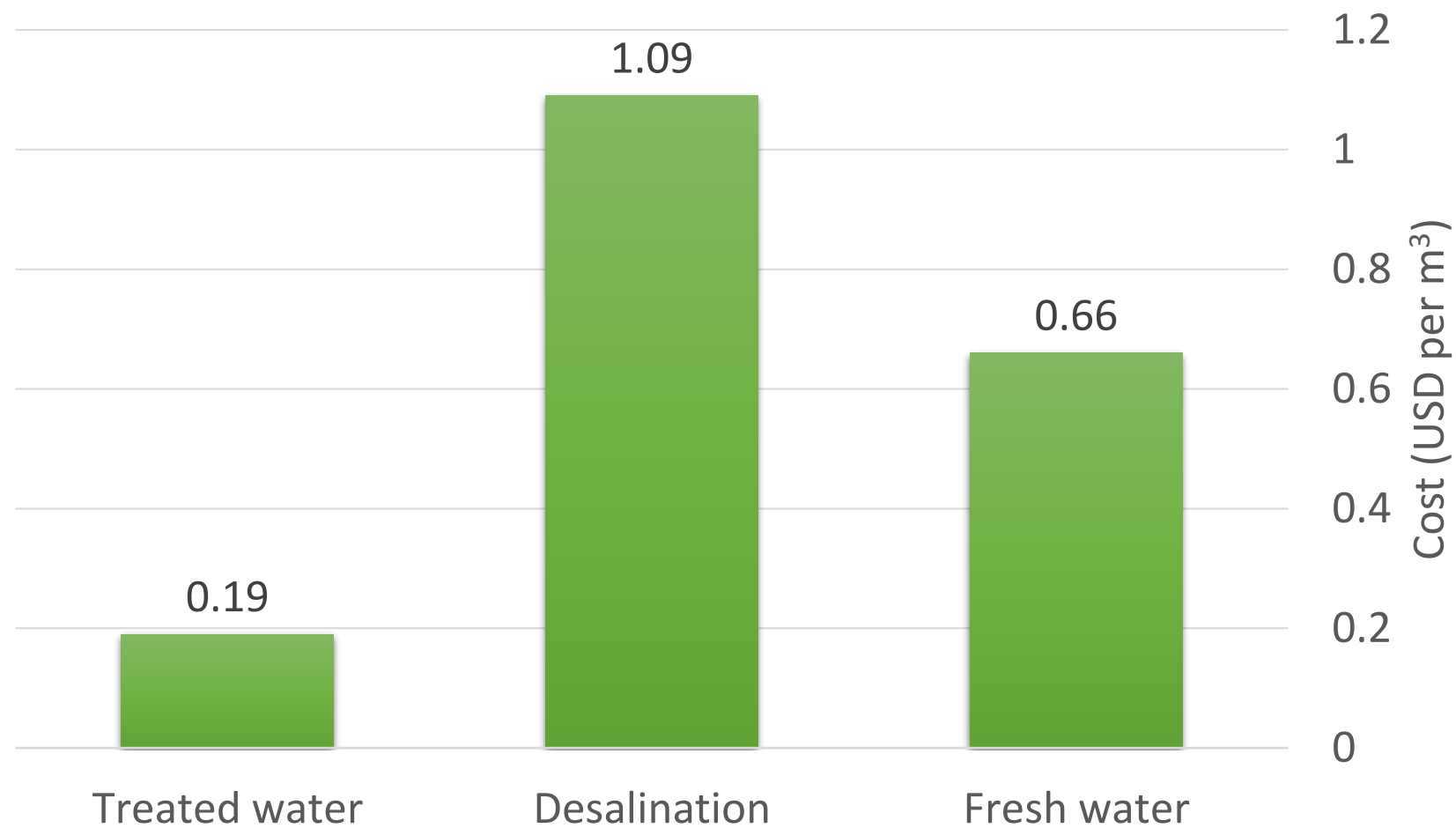
# The methodology



# Regional disaggregation and share of water sources in the base year (2014)



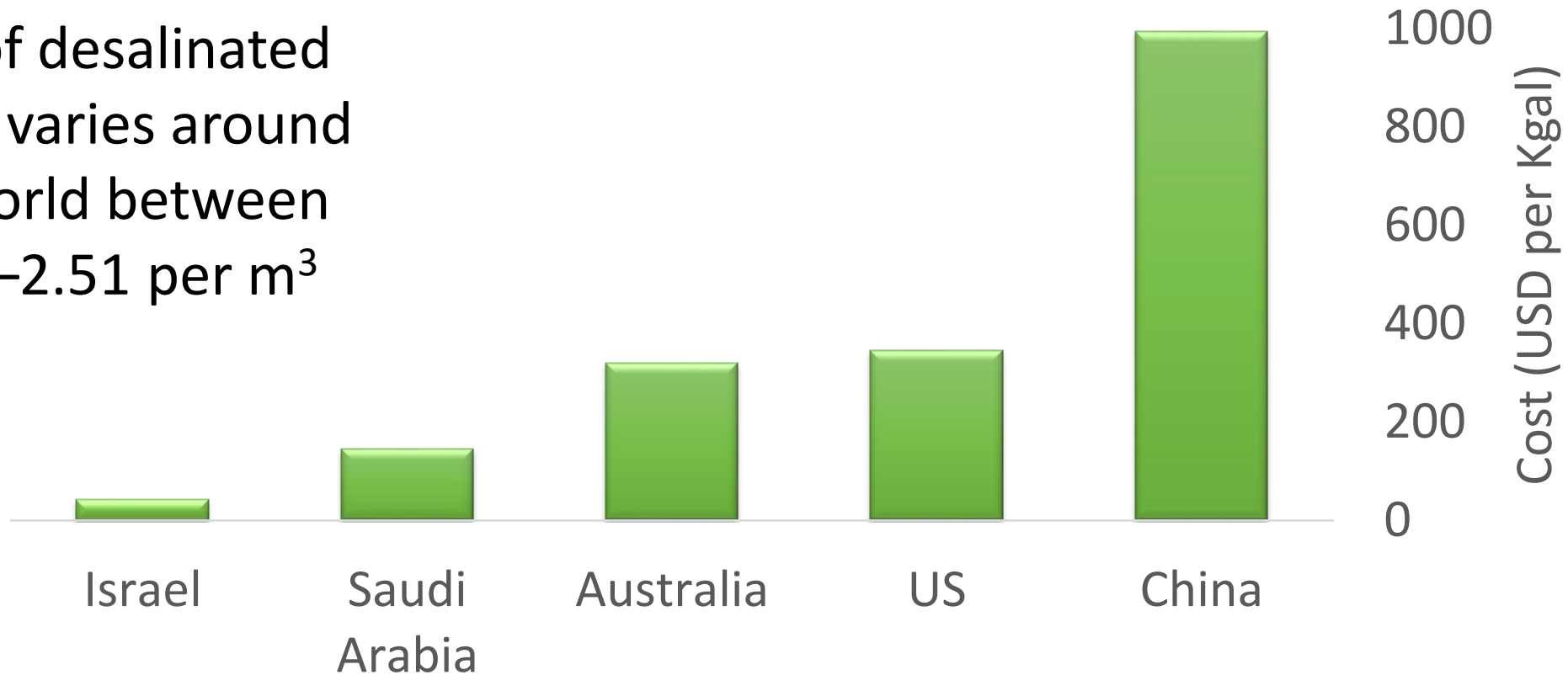
# Costs of water sources in Israel (USD per m<sup>3</sup>)



Sources: (Aquastat, 2014; Plat et al., 2019)

# Normalized average capital costs of RO desalination technology per unit of produced water in selected countries in 2013

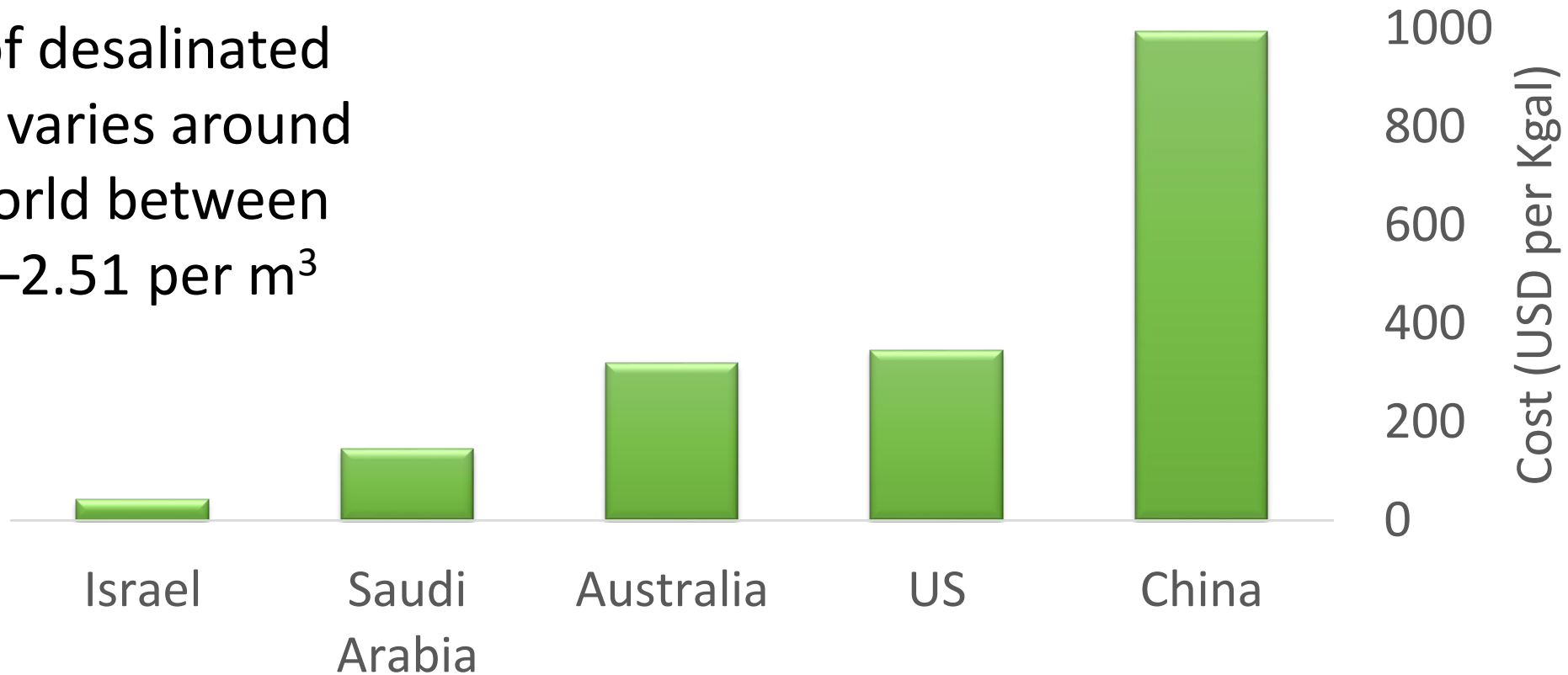
Cost of desalinated water varies around the world between \$0.45–2.51 per m<sup>3</sup>



Sources: (Ziolkowska, 2014)

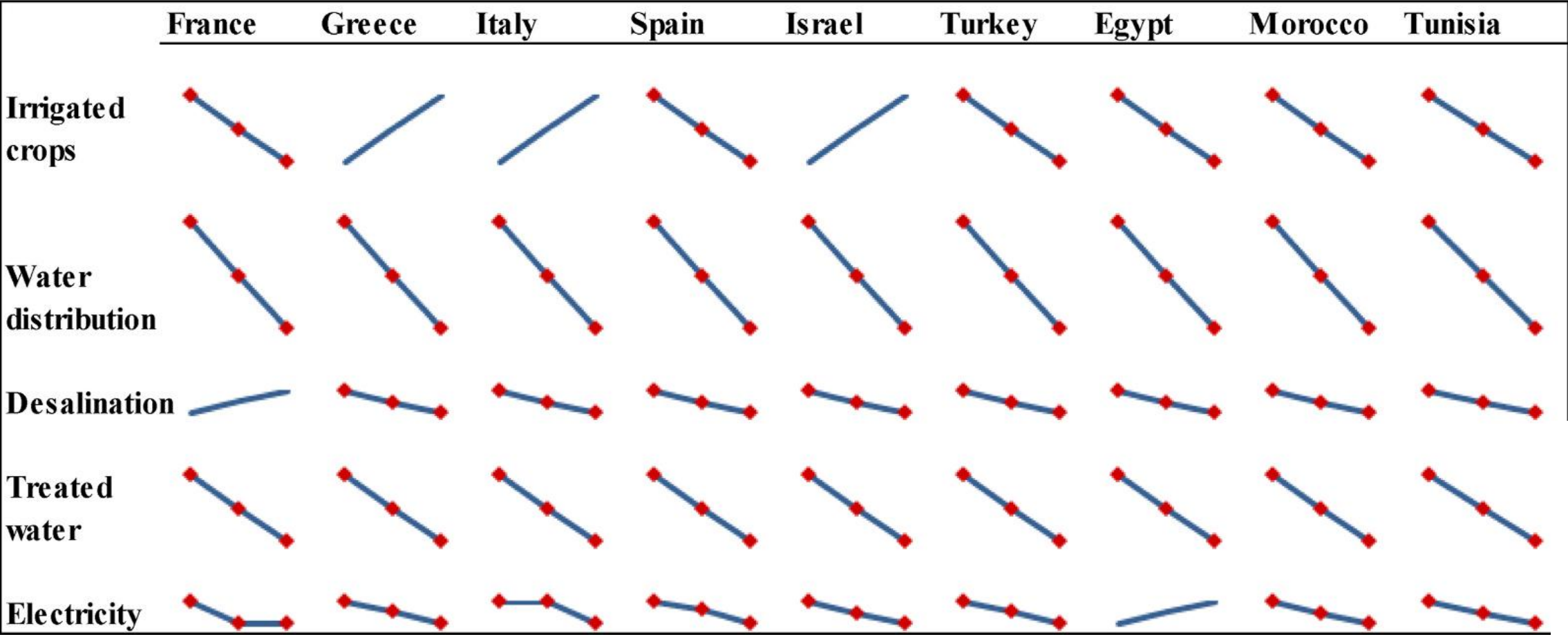
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Cost of desalinated water varies around the world between \$0.45–2.51 per m<sup>3</sup>



Sources: (Ziolkowska, 2014)

# Impact of Controlled Environment Agriculture (CEA) on various indicators under climate scenario



Sensitivity analysis for different adoption shares of CEA in GTAP-AW\_CEA in 2050 SSP2-RCP4.5 vs. GTAP-AW (without CEA). The dotted lines represent a reduction in the change in the value of the indicator between 2014 and 2050 when CEA is applied. The non-dotted lines represent an increase.



Contents lists available at ScienceDirect

Water Resources and Economics

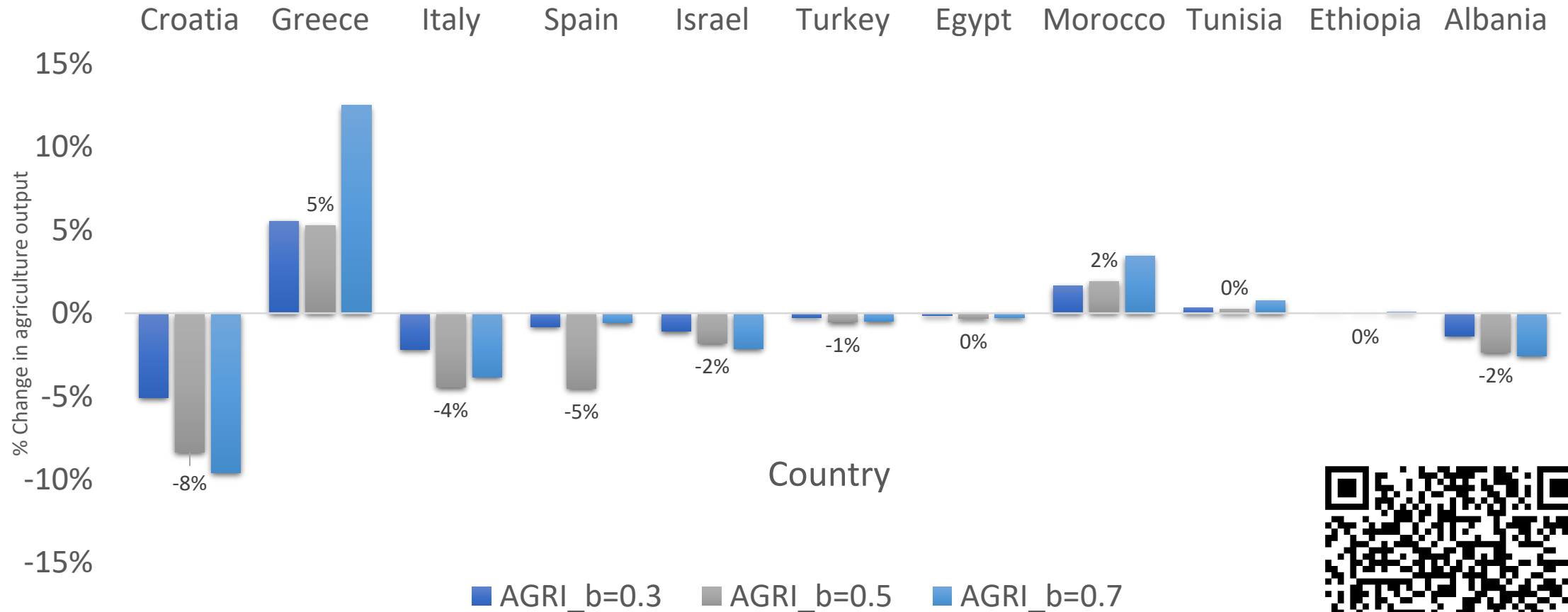
journal homepage: [www.elsevier.com/locate/wre](http://www.elsevier.com/locate/wre)



Water scarcity and food security in the mediterranean region: The role of alternative water sources and controlled-environment agriculture

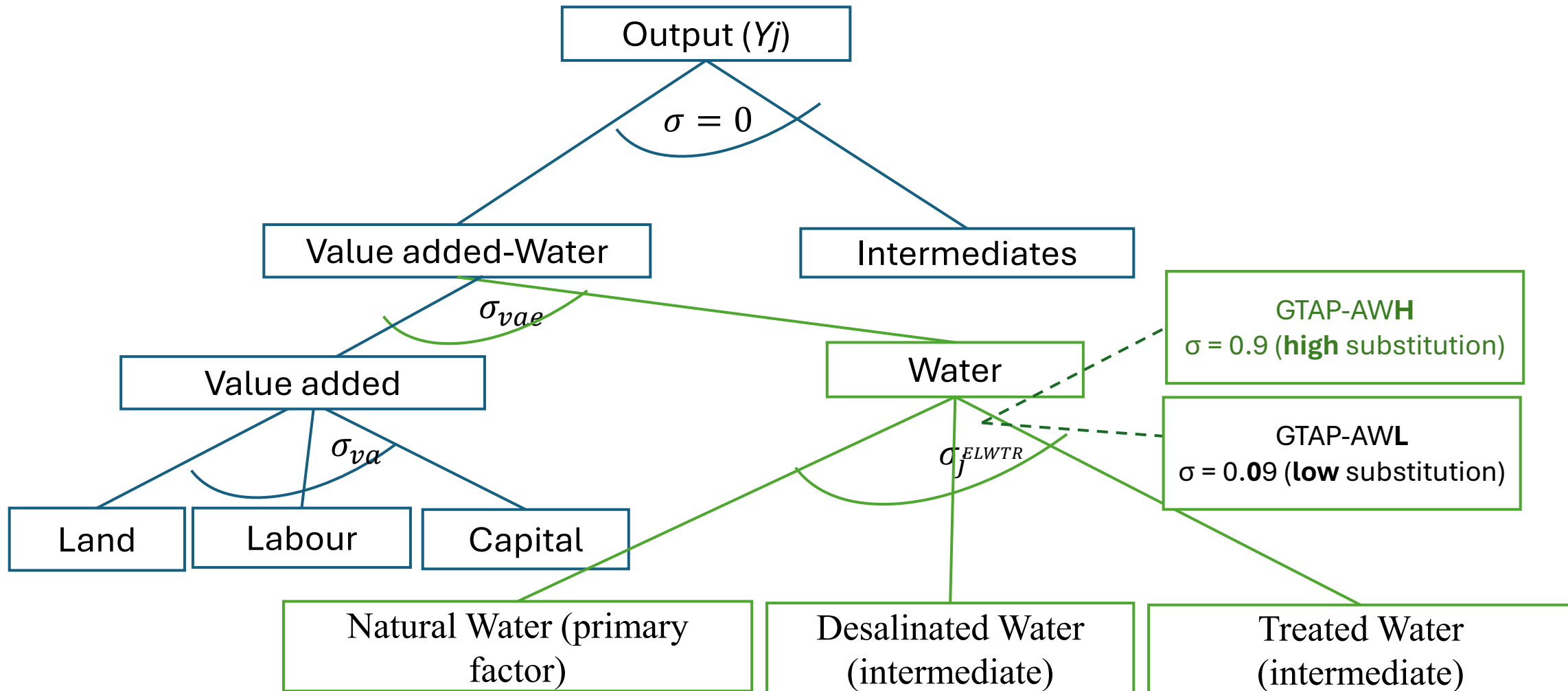
Ruslana Rachel Palatnik<sup>a,b,\*</sup>, Orna Raviv<sup>b</sup>, Julia Sirota<sup>a</sup>, Mordechai Shechter<sup>b</sup>

# Synergy of RICE-Med-U and GTAP-AW: agriculture output change [%] by CC damage, vs. 2050 RCP4.5 baseline



Raviv, O., Palatnik, R. R., Castellini, M., Gusperti, C., Vergalli, S., Sirota, J., & Shechter, M. (2024).

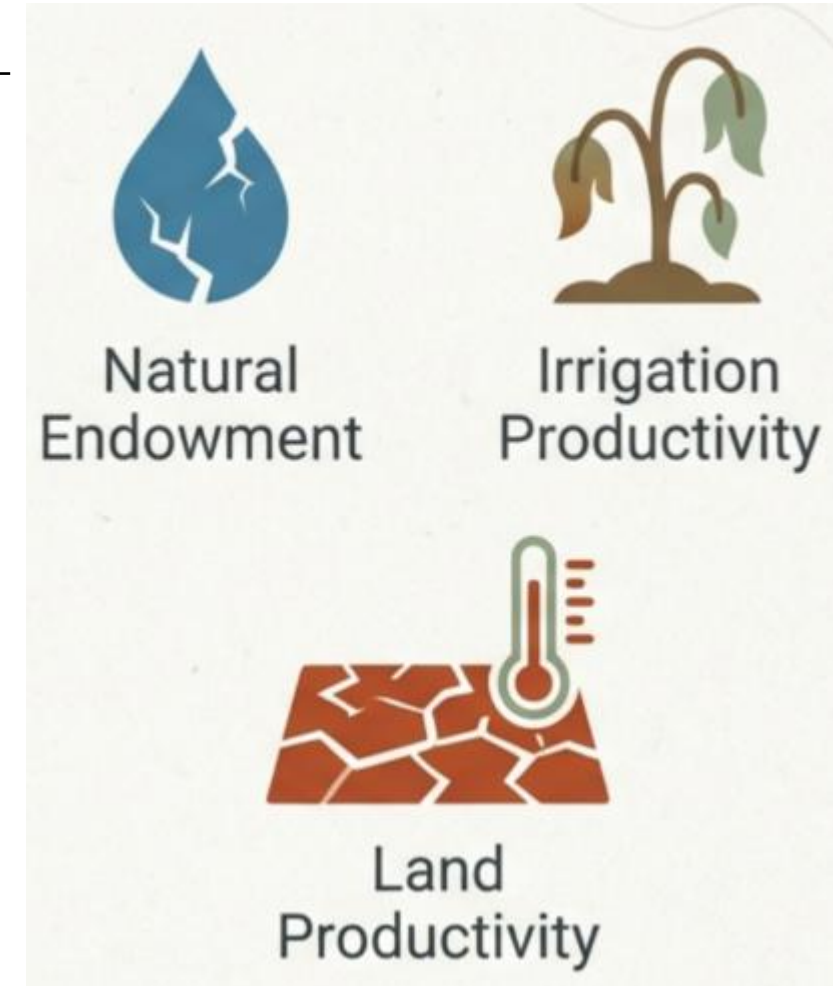
# Production Structure of the GTAP-AW model



# MODELING THE CLIMATE SHOCK (SSP2-RCP4.5)

(% change vs 2014 baseline):

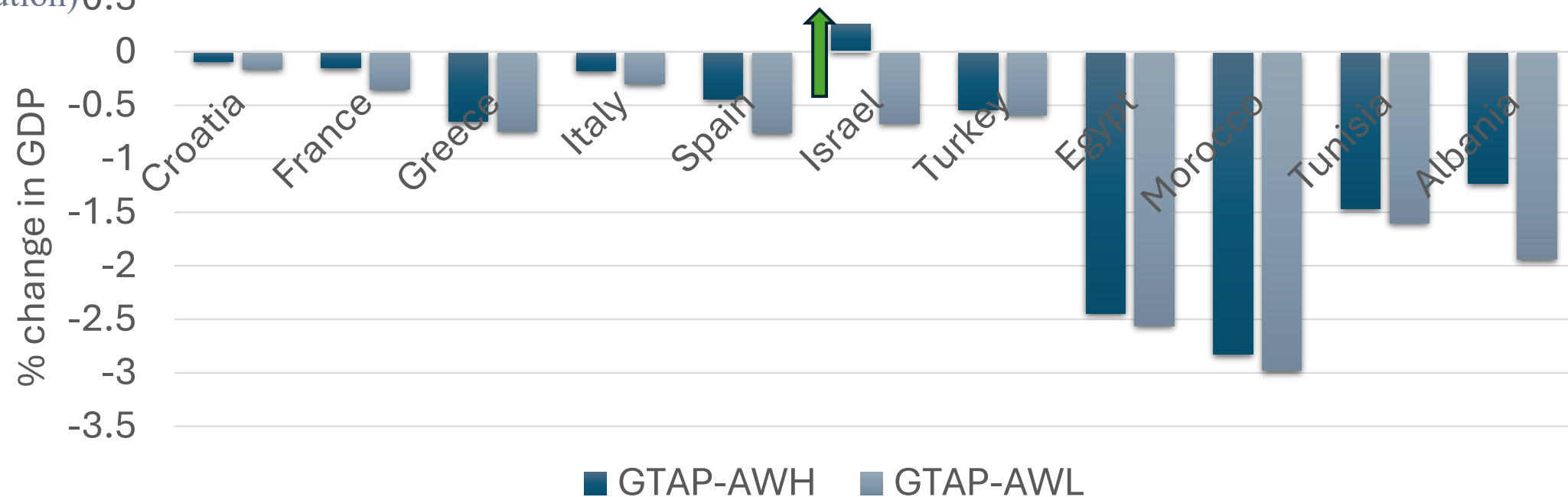
| Country         | Water availability | Water productivity in irrigation | Productivity of irrigated land | Productivity of rainfed land |
|-----------------|--------------------|----------------------------------|--------------------------------|------------------------------|
| <b>Croatia</b>  | -9.91%             | -19.57%                          | 8.97%                          | 8.74%                        |
| <b>France</b>   | -11.96%            | -19%                             | 3.24%                          | 0.28%                        |
| <b>Greece</b>   | -20.18%            | -11.58%                          | 1.17%                          | 3.71%                        |
| <b>Italy</b>    | -12.32%            | -16.27%                          | 0.23%                          | -1.56%                       |
| <b>Spain</b>    | -20.96%            | -11.55%                          | -1.72%                         | -5.53%                       |
| <b>Israel</b>   | -20.28%            | -9.74%                           | 0.44%                          | -0.7%                        |
| <b>Turkey</b>   | -15.03%            | -8.39%                           | 2.37%                          | 8.62%                        |
| <b>Egypt</b>    | -1.89%             | -4.04%                           | -1.4%                          | -12.51%                      |
| <b>Morocco</b>  | -31.34%            | -5.96%                           | 2.17%                          | -7.99%                       |
| <b>Tunisia</b>  | -26.20%            | -7.9%                            | 2.82%                          | -2.85%                       |
| <b>Ethiopia</b> | 1.90%              | -3.16%                           | 2.35%                          | 9.13%                        |
| <b>Albania</b>  | -14.77%            | -16.75%                          | 6.46%                          | 5.84%                        |



Source: Burek et al. (2016); Fischer et al. (2021) — 5 GCMs × 3 GHMs ensemble average

# GDP in 2050: losses shrink when alternative water can substitute

% change in GDP in 2050, SSP2–RCP4.5 vs. SSP2 baseline, by GTAP-AW model version (AWH: high substitution · AWL: low substitution)



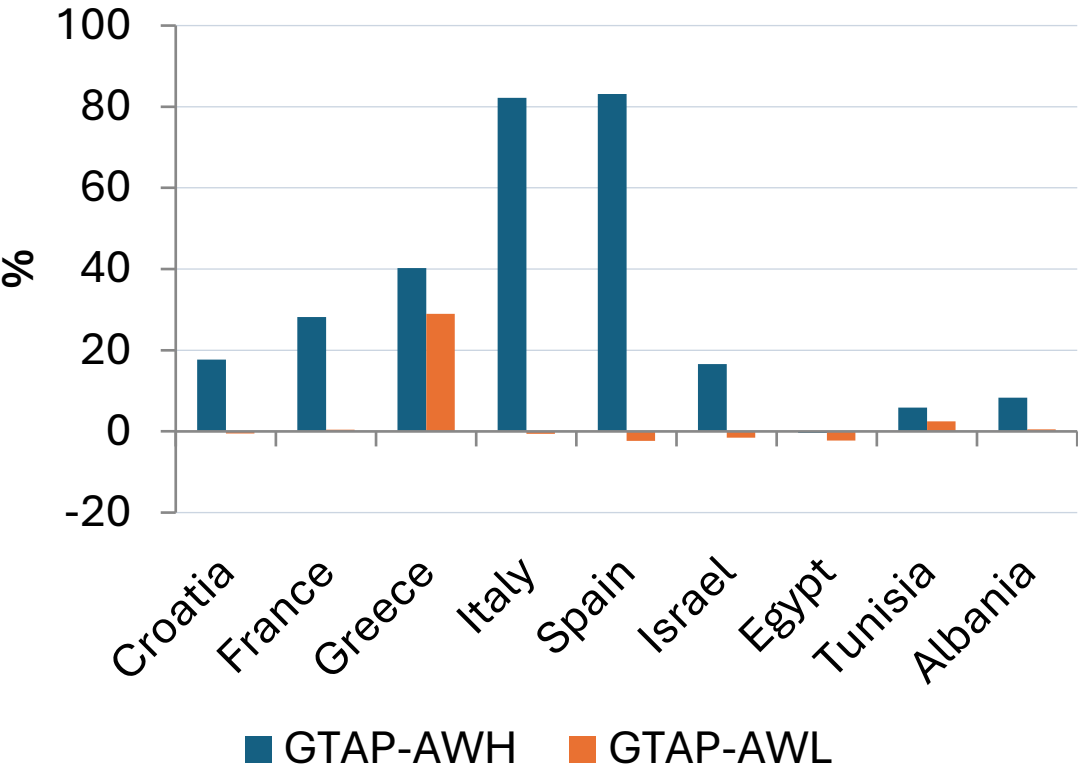
**Main result: Alternative water availability systematically reduces GDP losses across Mediterranean countries — by up to ~1 percentage point of GDP in the most water-scarce economies.**

Gains arise not because desalination and treated wastewater are cheap, but because they relax a binding natural water constraint.

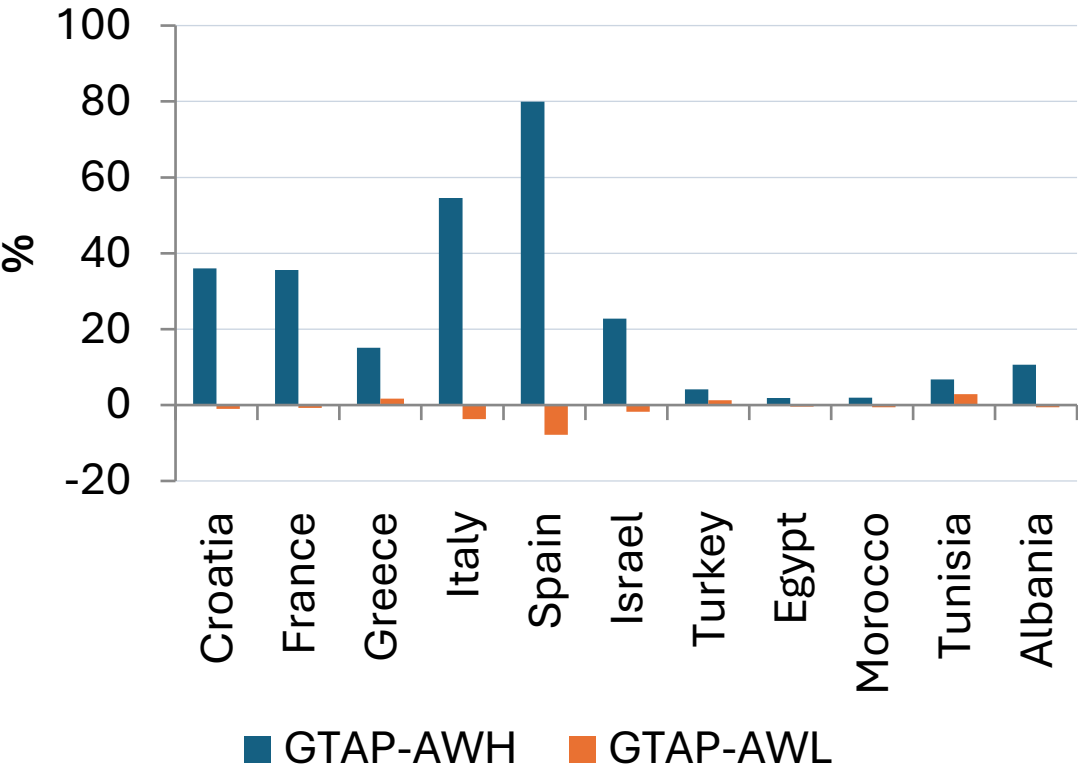
# Mediterranean Countries Ramp Up Alternative Water

% change in sector output under SSP2–RCP4.5 vs baseline — GTAP-AWH vs AWL

## Desalination Output



## Treated Wastewater Output

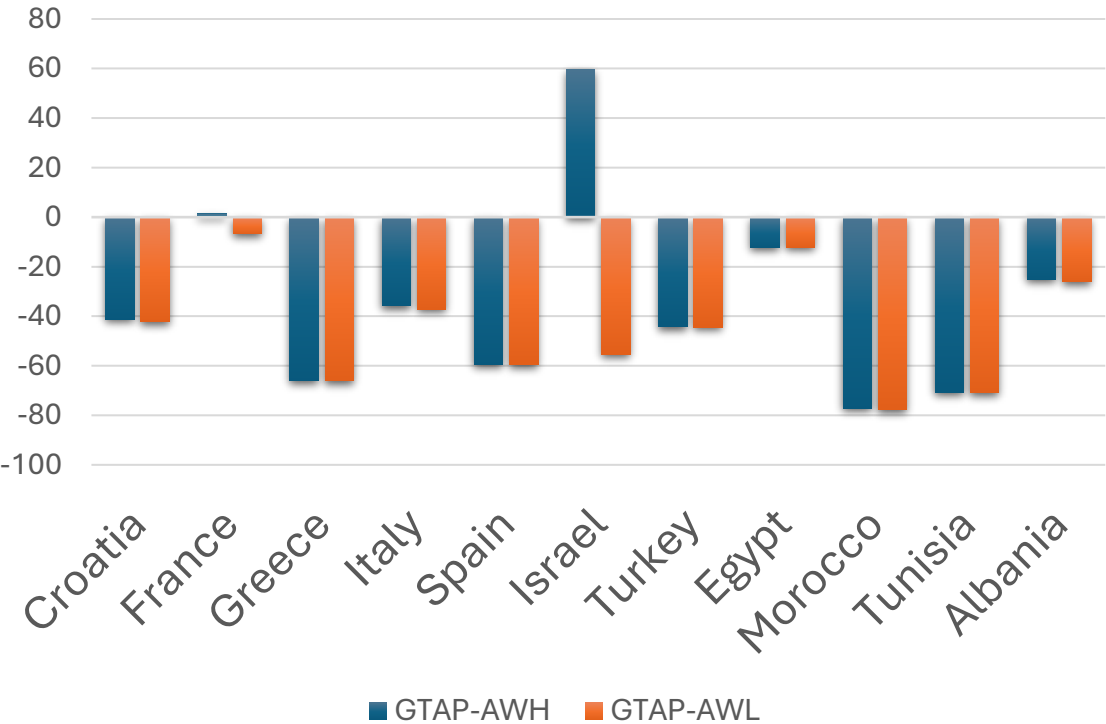


Italy & Spain: ~80% jump in desalination • Israel: largest change in absolute terms (already high baseline)

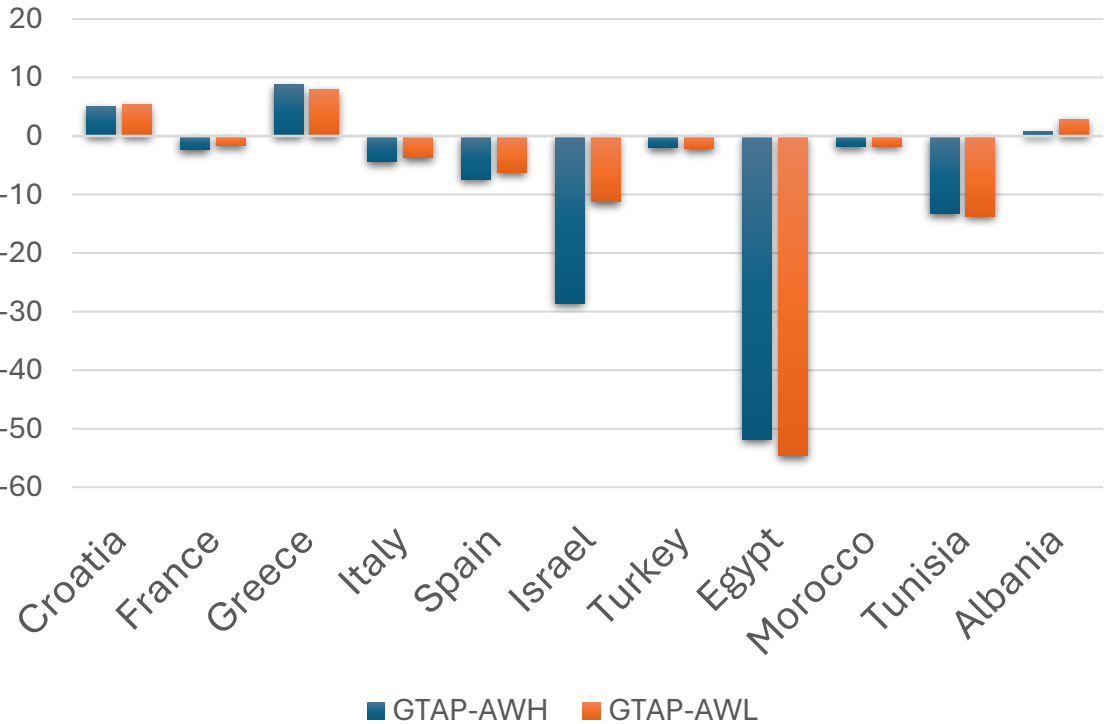
# Agriculture: Mixed Gains

% change in sector output vs baseline (SSP2–RCP4.5)

## Irrigated Agriculture



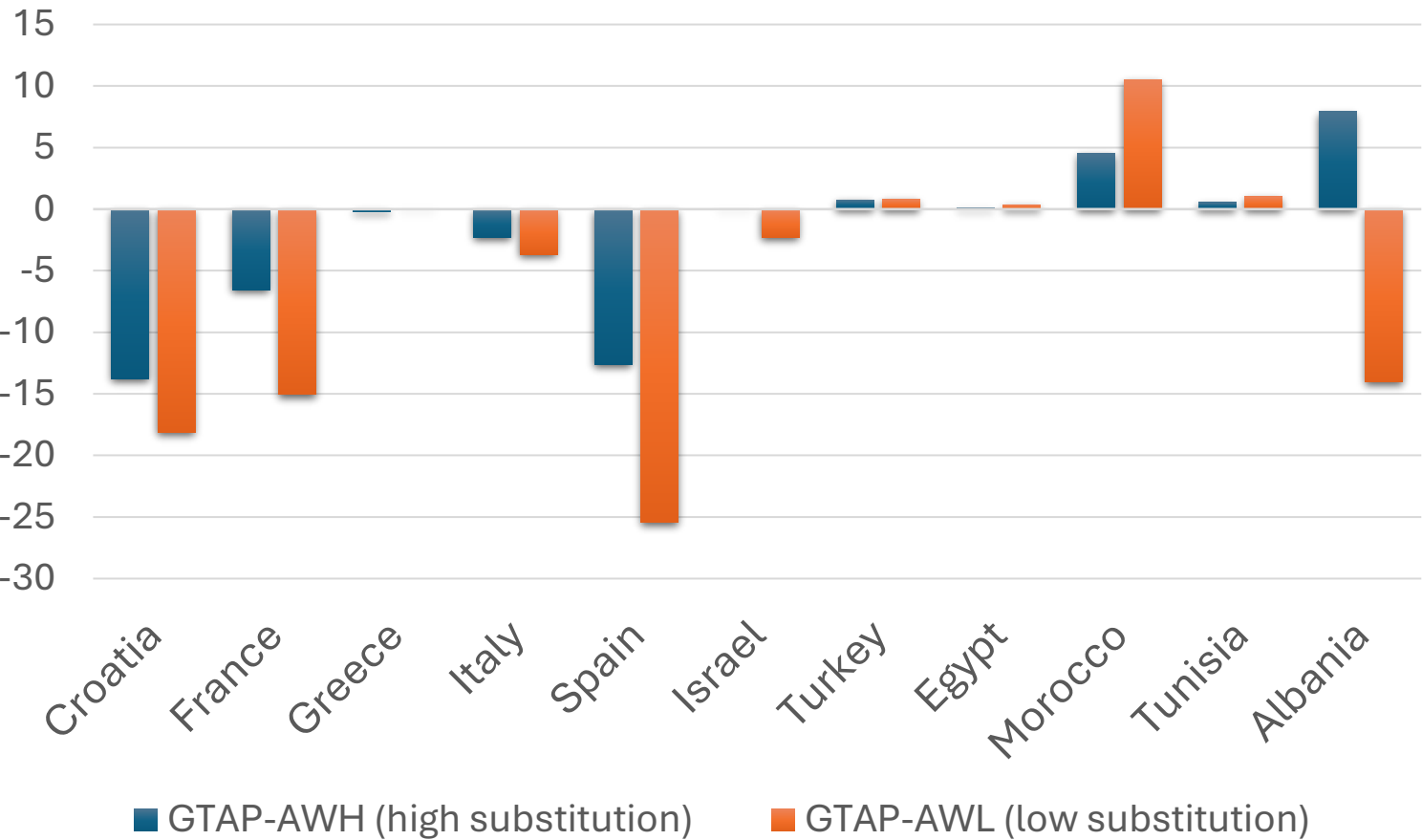
## Rainfed Agriculture



**Key insight:** Israel & France reverse irrigated agric losses into gains. Rainfed farming benefits less — alternative water frees irrigated supply, reducing substitution pressure on rainfed.

# Energy: carries much of the economy-wide gain

% change in electricity output vs baseline (SSP2–RCP4.5)



### Why Energy?

- Water scarcity constrains hydropower & thermal cooling
- Alt. water releases natural water for energy related uses
- Albania (99% hydro): large recovery with AWH
- Not direct use of desalinated water — reallocation effect
- Energy sector = highest marginal value water use

# Key Findings

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1

## GDP Protection

Alternative water sources consistently reduce climate-induced GDP losses across all Mediterranean countries. Israel: climate loss turns to gain (+0.26% vs -0.67%). Spain & France losses nearly halved.

2

## Energy Sector is the Biggest Beneficiary

Water reallocation frees natural water for higher-value energy uses (than agriculture).

3

## Substitution Elasticity Matters — Adoption Should Start Now

The gap between AWH and AWL models reveals the economic stakes of alternative water technologies: higher substitutability = significantly better economic outcomes.

4

## Global Spillovers Are Real

Water scarcity alters comparative advantage in agriculture & energy trade. Effects cascade beyond national borders.

# Conclusions

## **Water policy IS climate policy.**

*Ignoring water in NDCs and climate strategies means leaving resilience on the table.*

## **Alternative water is an economy-wide multiplier.**

*Its benefits flow from agriculture to energy to GDP — the full picture requires a CGE lens.*

## **The water–energy nexus is the critical link.**

*Energy sector gains from water reallocation often exceed agricultural gains in water-stressed economies.*

## **Substitution technology unlocks resilience.**

*Higher elasticity of substitution between water types = dramatically better economic outcomes under climate change. This substitution requires infrastructure that takes years to plan and build — **it should start now.***

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