

ASSESSING THE ECONOMIC IMPACTS OF CLIMATE CHANGE ON COMPETITION FOR WATER RESOURCES IN THE CONTEXT OF THE WATER-ENERGY NEXUS

A HYBRID GENERAL EQUILIBRIUM APPROACH FOR PORTUGAL

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CONTEXT Climate change

- **Projected impacts of climate change in Portugal:**

- Higher temperatures
- Lower precipitation
- Higher potential evapotranspiration
- Higher flood and drought risk
- Reduced runoff
- Increased seasonal and spatial asymmetries of climate variables



Reduced availability of water resources

CONTEXT The 'water-energy nexus'

- Reduced availability of water resources will intensify the existing competition for water resources:
 - as an intermediate input for activities (e.g. agriculture, energy, manufacturing, services)
 - as a final good for households and recreational uses
 - countries sharing common river basins
- Competition and trade-offs among water uses is particularly relevant for the energy sector.
- These interlinkages and resulting externalities are the cornerstone of the so-called '**water-energy nexus**'

CONTEXT

Focus on hydropower

- The interdependency between water resources and the energy sector is particularly acute for hydropower generation:
 - Conflicts about distinct and concurrent uses for scarce water resources are evident
 - In the low carbon economy, energy mixes are rapidly shifting from fossil to renewable (but intermittent) energies which necessarily need to be backed-up (e.g. wind power and solar PV)
 - Due to its characteristics (low operational costs, rapid and efficient start-up, storage capacity), hydropower is considered the most feasible and cost-effective option
 - Although the effective consumption (mainly due to evaporation in the reservoirs and seepage) is low, hydropower is the largest water user

OBJECTIVE

- Assess the economy-wide impacts of the concurrent effects of
 - climate change-driven changes on water availability
 - competition for scarcer water resources in Portugal by 2050

- Emphasis on the 'water–energy nexus', through the simultaneous inclusion of:
 - climate change impacts on the hydrological cycle (via changes in runoff)
 - competition for water between power generation and the remaining users (production sectors and households)

METHODOLOGY Competition for water

No competition

Competition for water resources does not exist, meaning that production sectors and hydropower generation bear similar impacts of climate change on water resources availability.

Total competition

Competition for water resources exists, meaning that production sectors maintain their water consumption and activity levels

while hydropower generation bears the cumulative effects of reduced water availability caused by climate change and of non-adaptation of economic sectors.

METHODOLOGY Competition for water

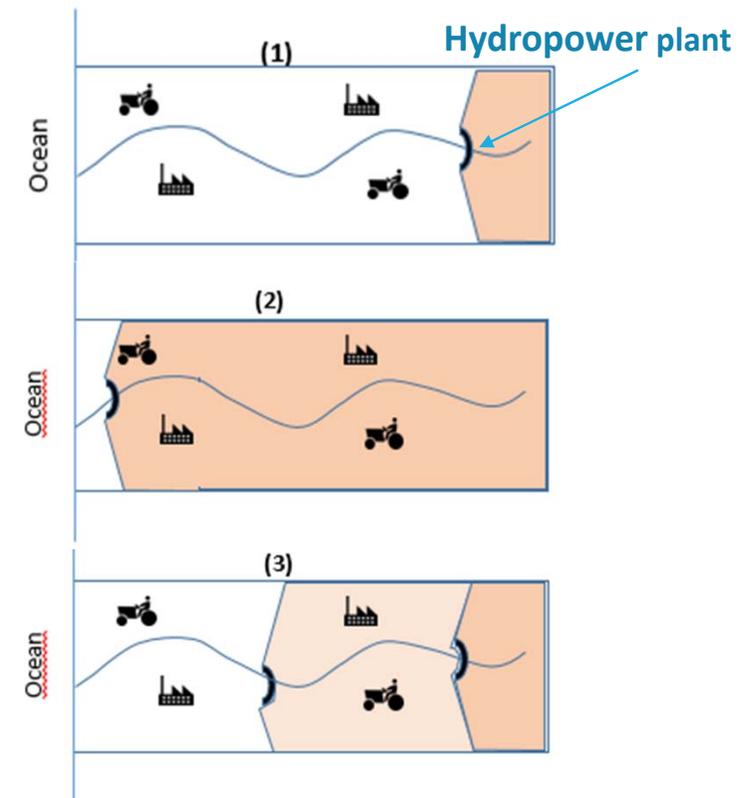
3 possible situations:

(1) No competition - All water used for upstream hydropower generation is available for middle- and downstream sectors

(2) Total competition - Water used by middle- and downstream sectors is not available for downstream hydropower production

(3) Hybrid situation comprising

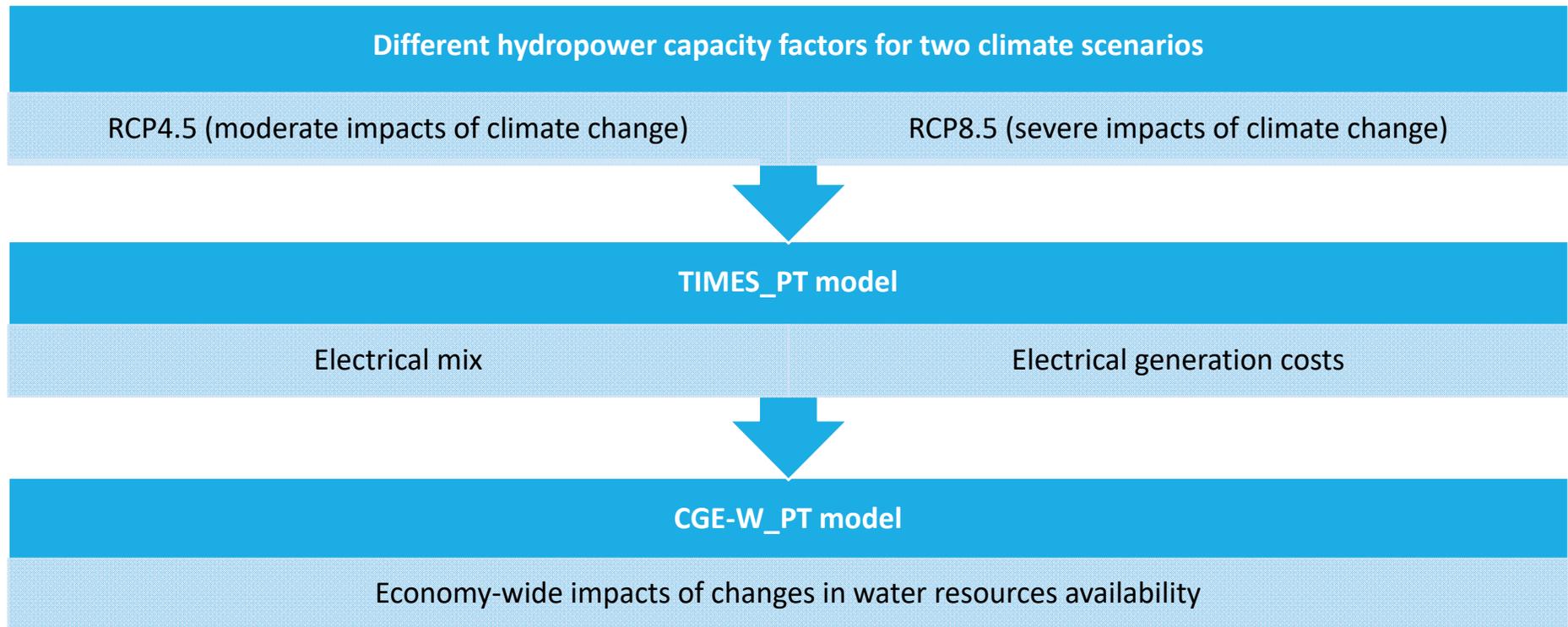
- **no competition** between the middle- and downstream production sectors and upstream hydropower generation, and between the downstream production sectors and middle stream hydropower generation
- **competition** between the middle stream production sectors and hydropower generation



METHODOLOGY Modelling scenarios for water availability

	Scenario	Description	Climate Scenarios				
			RCP 4.5		RCP 8.5		
			Hydropower	Production sectors	Hydropower	Production sectors	
Competition for water	A. No competition	Production sectors and hydropower generation bear identical impacts of climate change on water resources availability		-5.25%	-5.25%	-32.82%	-32.82%
	B. Total competition	Hydropower generation bears all the impacts of climate change on water resources availability while production sectors maintain / increase water consumption	B.1. Production sectors maintain water consumption	-5.73%	0.00%	-35.84%	0.00%
			B.2. Production sectors increase water consumption	-6.04%	0.00%	-37.68%	0.00%

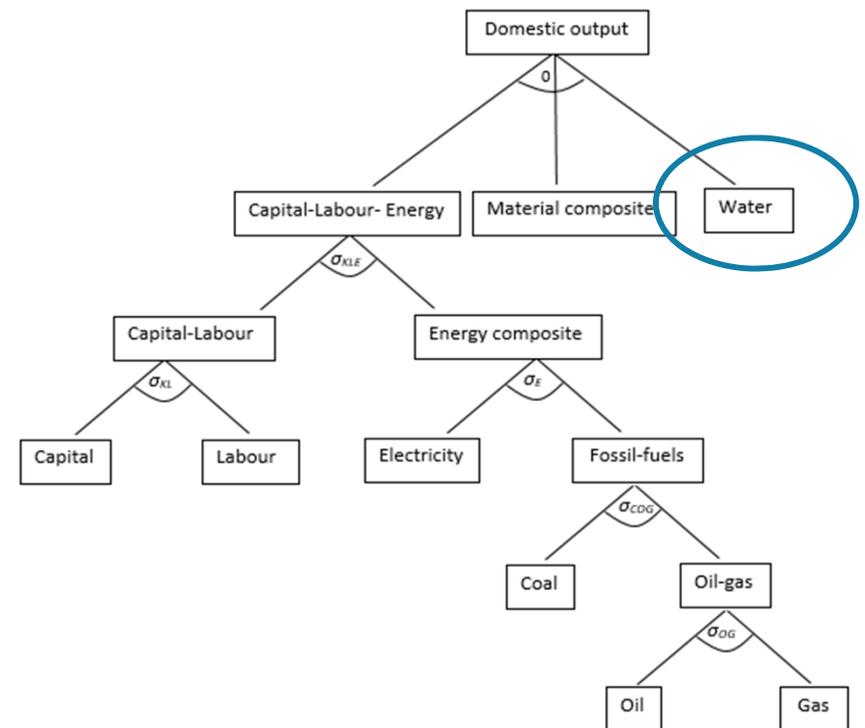
METHODOLOGY Modelling Tools



METHODOLOGY CGE-W_PT model

A static CGE model for a small open economy:

- 31 production sectors
- Involuntary unemployment
- Technological disaggregation of the power sector
- Distinction between **raw** and **distributed water**:
 - Raw water is a production factor
 - Distributed water is provided by the “water distribution” production sector
- Calibrated to base year 2008
- BaU for 2050



RESULTS

Scenario RCP8.5

Economic variable	Unit	No competition	Total competition
Gross domestic product (GDP)	%	-1.3%	-2.0%
Consumer price index	%	+0.5%	+0.6%
Real GDP	%	-1.8%	-2.6%
Real wages	%	-1.8%	-2.4%

- Moderate negative macroeconomic impacts, even in the worst climate scenario (RCP8.5)
- Stronger impacts in the presence of competition between hydropower generation and the remainder of sectors
- As the economy slows down, wages decrease.
- The rise in prices lead to reductions in real GDP and wages, and rising unemployment rates

RESULTS

Scenario RCP8.5

Economic variable	Unit	No competition	Total competition
Electricity generation - production cost	%	+16.7%	+24.6%
Electricity - consumer price	%	+15.0%	+21.7%
Distributed water	%	+71.7%	+89.6%

- Increase in generation costs lead to significant increase in electricity prices
- Higher electricity prices if hydropower and non-energy production sectors compete for water resources
- Reduced water availability increases the opportunity cost of raw water resources
- As a consequence, the price of distributed water increases considerably

RESULTS

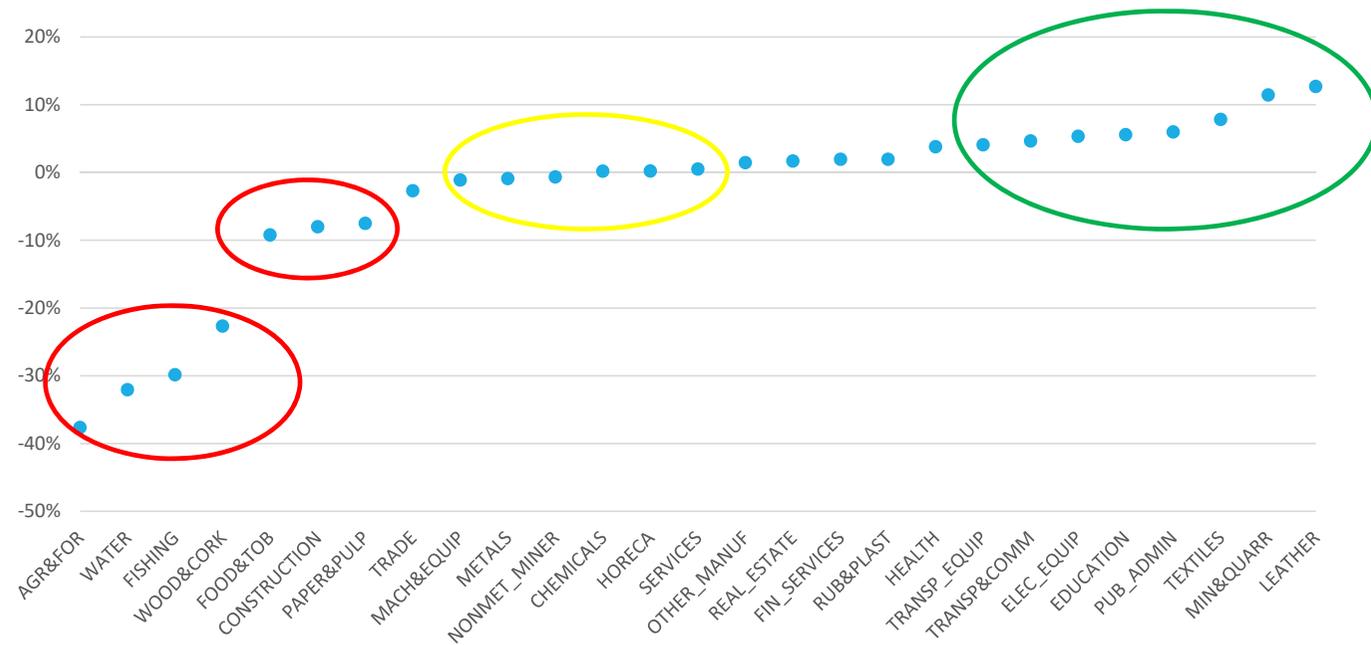
Production sectors

Heterogeneous sectoral impacts

Main factors:

- Water intensity
- Raw water consumption
- Intermediate consumption of distributed water
- Intermediate consumption of Electricity
- Openess to international trade

Impacts on sectoral activity levels – Scenario RCP8.5



CONCLUDING REMARKS

- Alternative simulations that contrast the economic impacts of competition for water with the absence of competition (all sectors adapt) show:
 - Macroeconomic impacts are relatively moderate even in the worst climate scenario
 - Although impacts are stronger in a scenario of competition between sectors, they are not significantly different from those of the scenario without competition
 - This is explained by the relatively low weight of water resources in production functions
 - Even so, sectoral impacts are quite different due to their water intensity and openness to the exterior – that smoothens the negative impacts of electricity prices and water scarcity.



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Quantification of the impacts of competition for water resources

1. Available water resources in the main river basins in Portugal considering their country of origin and geographical location in the country - upstream or downstream of the hydropower plant nearest to the river mouth
2. Regional GVA to obtain the share of national production that will be affected by competition with hydropower generation for water resources (in the interior region of the country).
3. Raw water resources (in physical units) used by production sectors, considering sectoral water intensities
4. Additional reduction in water availability for hydropower generation when production sectors do not adapt to climate change, but, instead, maintain consumption or even increase due to larger evaporation and evapotranspiration