Multi-system modeling framework

Economic modules

TALANOA-WATER Workshop on modeling framework

Ramiro Parrado
CMCC and Ca' Foscari University of Venice

Universidad de Salamanca
Virtual meeting
1st April 2022

Centro Euro-Mediterraneo sui Cambiamenti Climatici

Introduction - Why is model linking important?

- Micro-economic models provide insights circumscribed to specific issues (partial equilibrium) that could also represent a specific regional or local reality.

- Macro-economic models (computable general equilibrium, input/output) are useful for economy-wide assessments with insights based on aggregated data at the macro-sector level or for the whole economy.

- Consequences of policies spread throughout the economy through forward and backward linkages among economic sectors (Hertel and Liu, 2016).

- This demands tools for economic analysis capable of assessing both the local and economy-wide impacts of agricultural adaptation policies, and the interconnections between them (Hasegawa et al., 2016; Parrado et al., 2019; Ronneberger et al., 2009).

- These analyses could be enriched with other models (hydrologic, climate, or other process-based) to include additional (useful) information in integrated policy/impact analyses.

Holistic modelling approach

- Integrates microeconomic and macroeconomic features in one single model.
- Advantages:
  - effective representation of interdependencies and causal relationships between micro- and macro-economic systems.
  - allow for a more straightforward representation of the microeconomic system which can be fully integrated into the architecture of the macroeconomic model.
  - Saves computational resources eliminating the need to assess shocks separately in each system.
- Limitations:
  - limited spatial detail
  - Simplification of assumptions

Modular approach

- Keeps the microeconomic and the macroeconomic systems in separate modules
- Allows the output of one model to be used as an input in the other through feedback protocols.
- Advantages:
  - Provides a more detailed representation of each sub-system.
  - Enables the explicit representation of two-way feedbacks between micro- and macro-economic systems.
- Limitations:
  - Each module must be developed, updated, and executed separately.
  - relationships and interdependencies between systems are also more challenging to represent.

Examples of the modular approach in previous studies

<table>
<tr><th>Micro-economic models</th><th>Macro-economic models</th></tr>
<tr><td>Land use models (KLUM) (Ronneberger et al. 2009)</td><td>GTAP (CGE model) National level data</td></tr>
<tr><td>Revealed Preference Model (RPM) (Pérez-Blanco et al. 2016)
Positive Multi-Attribute Preference Model (PMAUP) (Pérez-Blanco & Standardi, 2019, Parrado et al. 2019, 2020)
PMAUP + SWAT (Hydrologic model) (Pérez-Blanco et al. submitted)</td><td>ICES (CGE developed at CMCC and based on the GTAP model & database) Regionalized version (NUTS2 level for selected EU countries)</td></tr>
</table>

ICES – regionalized CGE model

- Multi-region, multi-sector computable general equilibrium model
- Increased spatial scale: NUTS 2 regions for selected EU regions

Main features of CGEs:

- Allow describing economic interactions of agents and markets within countries (production and consumption) and across countries (international trade) in a stylised way.
- All markets are interlinked as changes in relative prices induce input reallocation in the entire economic system.

Main assumptions:

- Representative agents for households and firms
- Markets are cleared by adjustments in prices (demand = supply).
- Perfect competition
- Full employment of production factors
- Savings-driven investments

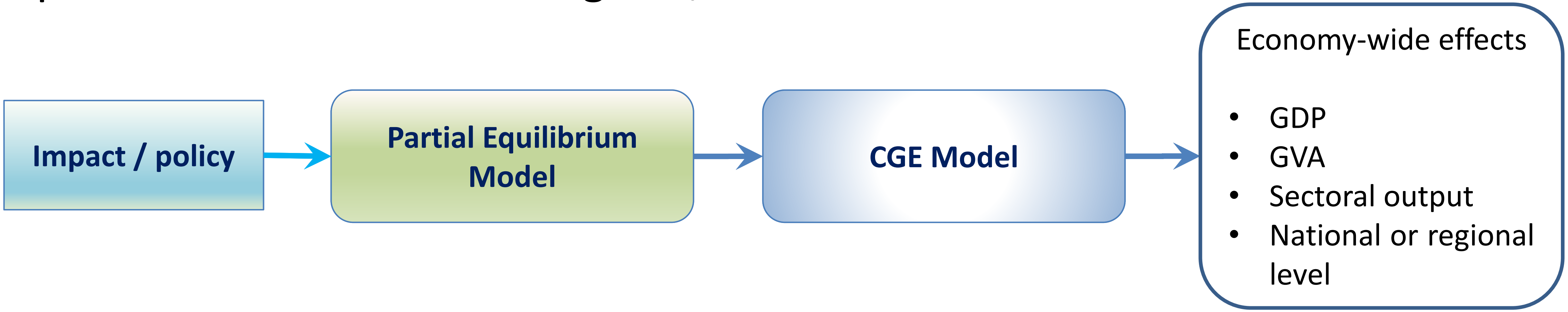
ICES – economic sectors

- Based on the GTAP database with 57 sectors and more than 140 regions which could be aggregated for specific purposes.
- 8 crop sectors

Sectors	
Crops	1) rice
	2) wheat
	3) other cereals
	4) vegetables and fruits
	5) oil seeds
	6) sugar cane and beet
	7) plant-based fibers
	8) crops not elsewhere classified
Industry	9) livestock
	10) extraction, fishing and forestry
	11) food industry
	12) rest of industry

One directional link

- Linking Partial Equilibrium models => CGE
- Assess economy-wide effects of specific policies or impacts (Carrera et al., 2015; Pérez-Blanco et al. 2016, Pérez-Blanco & Standardi, 2019)
- Aggregate indicators (GDP, Output)
- National or regional level
- Spillover effects on other regions/countries



Two-way feedbacks

- Coupling Partial Equilibrium models with CGE model (Ronneberger et al. 2009; Parrado et al. 2019, 2020).
- Modifying both models to exchange information between them.
- **Convergence of results**: Information exchanged between models does not result in meaningful changes between two successive simulation iterations (Ronneberger et al. 2009; Hasegawa et al. 2016).

Contents lists available at ScienceDirect

Journal of Hydrology

journal homepage: www.elsevier.com/locate/jhydrol

ELSEVIER

Research papers

Micro-macro feedback links of agricultural water management: Insights from a coupled iterative positive Multi-Attribute Utility Programming and Computable General Equilibrium model in a Mediterranean basin

Ramiro Parrado[a,*], C. Dionisio Pérez-Blanco[b], C. Gutiérrez-Martín[c], Gabriele Standardi[a]

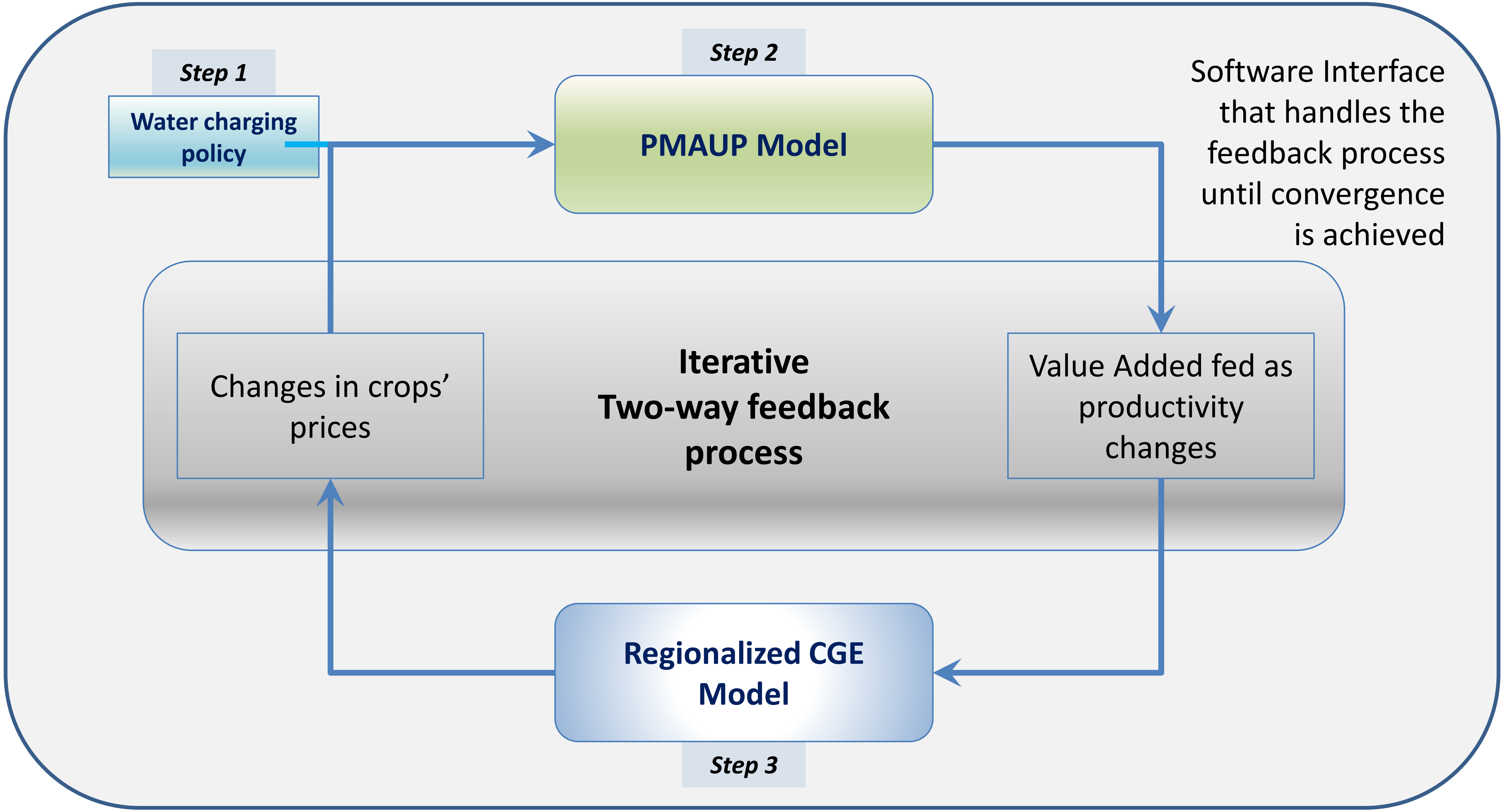
[a] RFF-CMCC European Institute of Environmental Economics, Centro Euro-Mediterraneo sui Cambiamenti Climatici, Italy and Università Ca' Foscari Venezia, Italy
[b] Universidad de Salamanca, Spain
[c] Universidad de Córdoba, Spain

- Coupling between a decentralized representation of irrigators (PMAUP) and a regionally-calibrated CGE model to assess interlinkages between the micro- and macro-economy.

- Analysis of irrigation water charges in the Murcia Region in Spain.

- Results show that the coupled micro–macro model yields lower abatement costs as compared to the stand-alone micro model.

Coupling micro- & macro-economic models



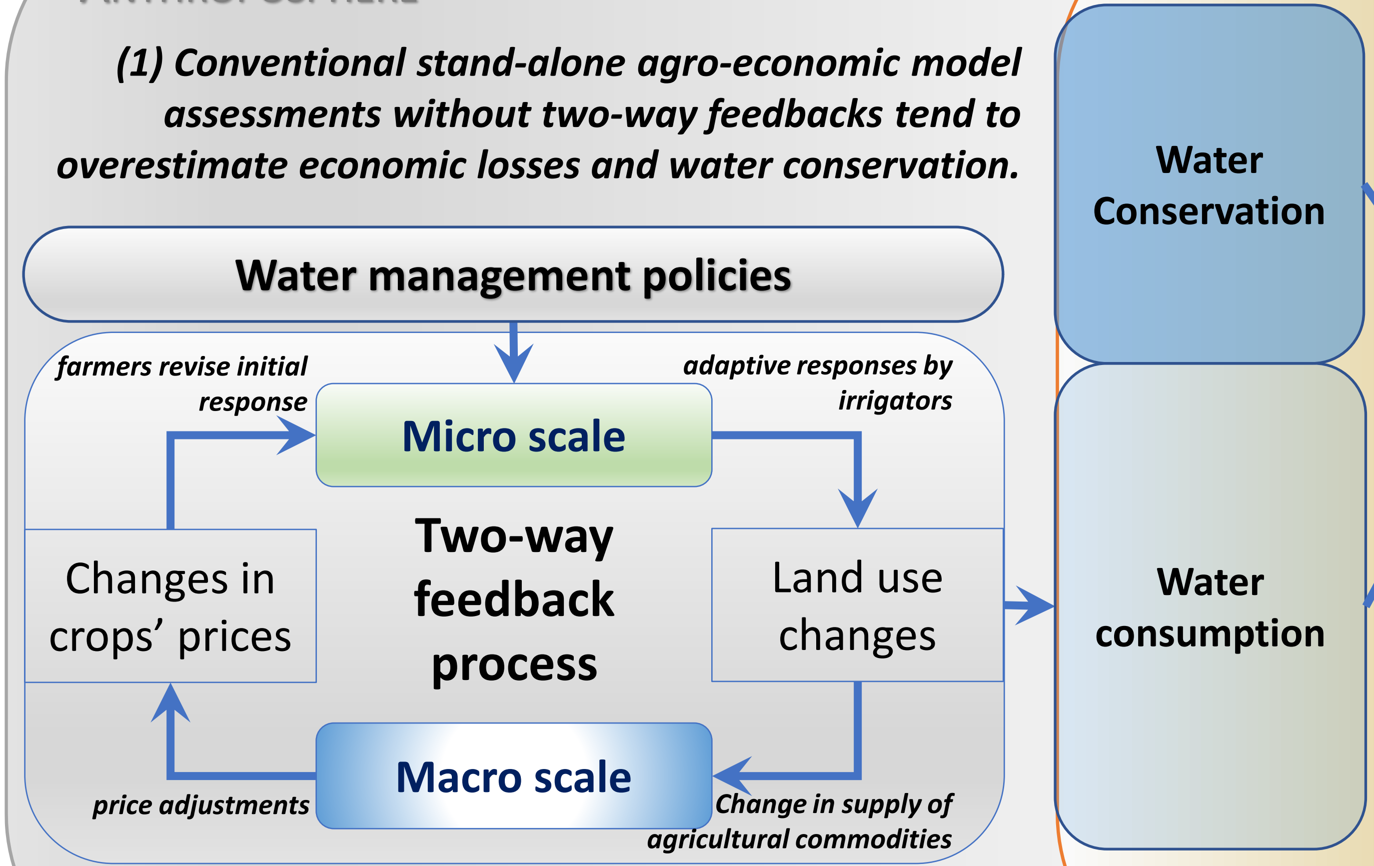
Source: Parrado et al. (2019)

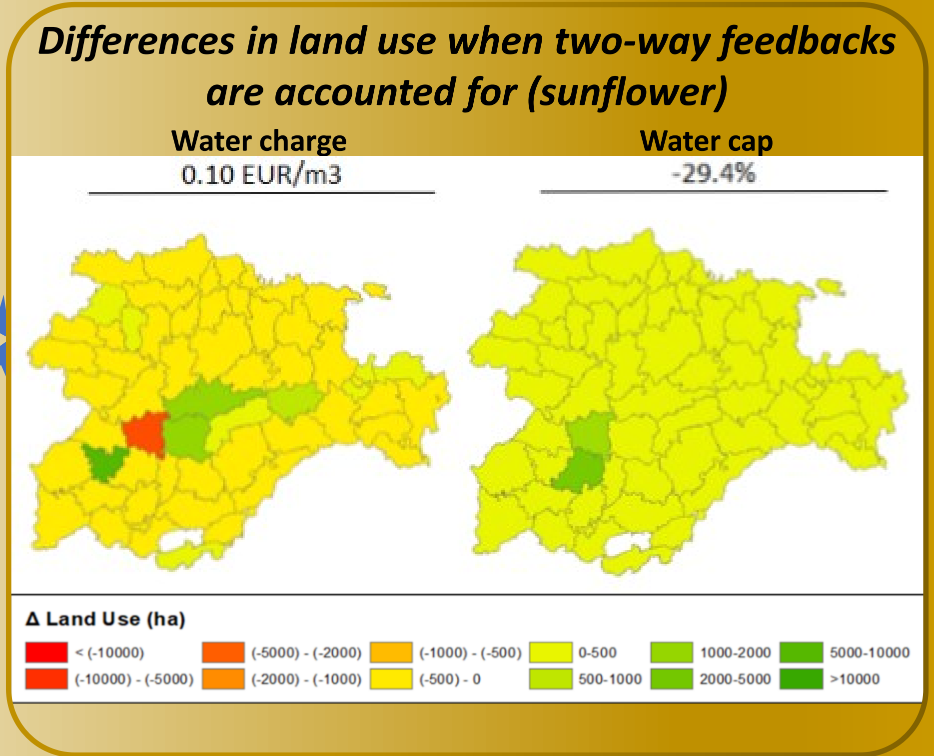
Integrating the micro- and macro-economic scales to assess water management policies

ANTHROPOSPHERE

HYDROSPHERE

(1) Conventional stand-alone agro-economic model assessments without two-way feedbacks tend to overestimate economic losses and water conservation.





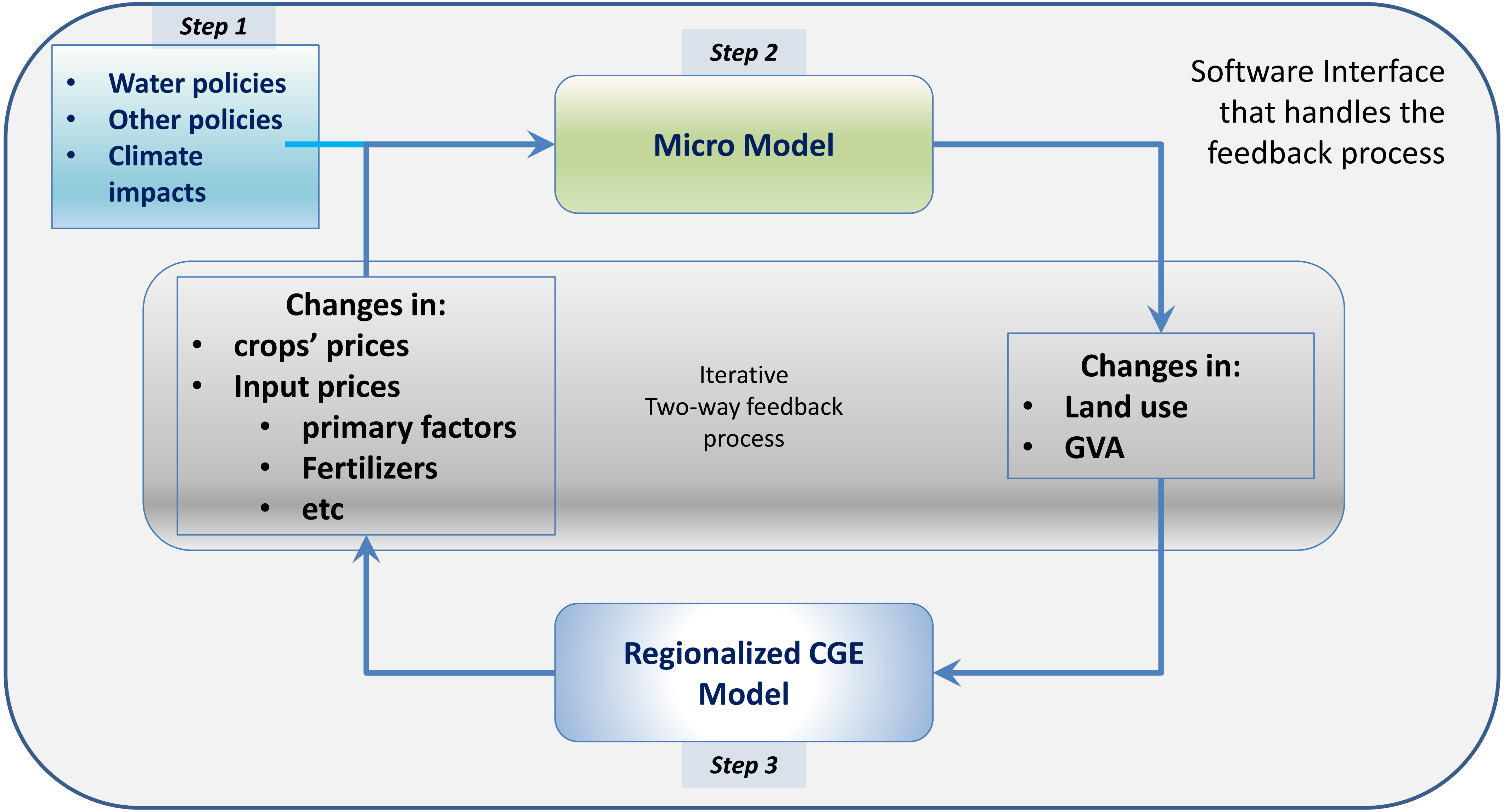
(2) Disregarding two-way feedbacks can lead to biased assessments in land use and water conservation policies affecting regional and local water use estimates.

Source: Parrado et al. (2020)

Thanks!

Centro Euro-Mediterraneo sui Cambiamenti Climatici

Data exchange in TALANOA-WATER



Source: Parrado et al. (2019)

Data exchange in TALANOA-WATER

Micro scale model outputs	Macro-economic model outputs

Changes in:
• Land use
• GVA
	Changes in:
	• crops’ prices
	• Input prices
	    • primary factors
	    • Fertilizers
	    • etc

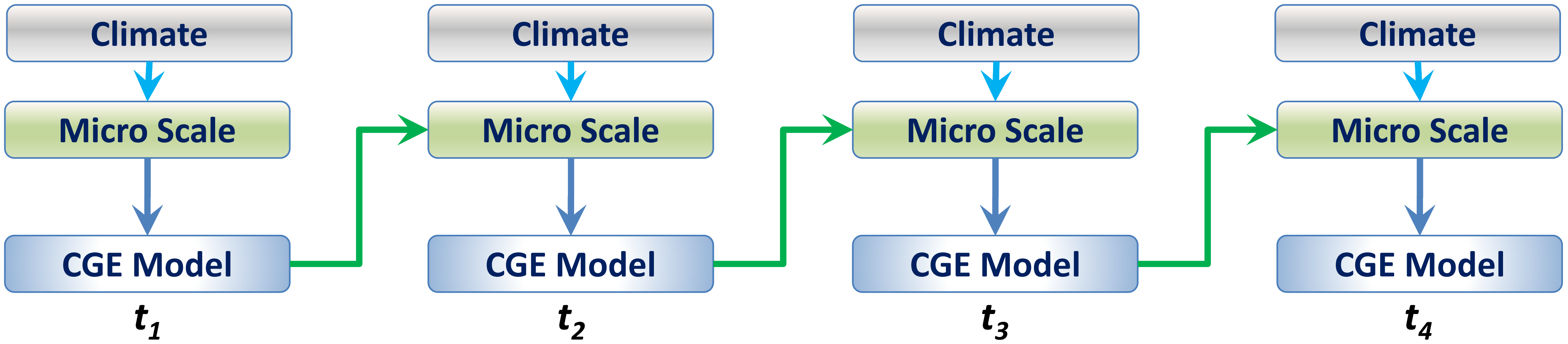
Additional considerations

- Static setup (laboratories)
  - Short-term horizon (1-year or less)
  - Policy assessments
  - Easier to implement

- Dynamic setup (selected cases)
  - Medium- to Long-term horizon
  - Climate change impact assessment
  - Should also consider including dynamics in model-linking:
    - Convergence in each year before advancing to the next year.
    - Recursive linking: no convergence in each year.

Including dynamics

- Recursive linking: no convergence in each year.



- Convergence in each year before advancing to the next year.