Integrating agent-based modelling and behavioural data analytics: A case study of climate change farmers' perception in Italy.

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Abstract

Climate change is arguably the most severe and complex challenge facing today's society, a cross-cutting issue affecting many sectors and connected to other global challenges, such as ensuring sustainable water management and food security. Agricultural systems are adversely influenced by climate change through increased water stress, change in run-off patterns, seasonality fluctuation, and temperature variations. Farmers are, hence, a valuable source of first-hand observations of climate change as they may provide a deeper understanding of their manifestation, relevance, and effects. Social and behavioural sciences have investigated the influence of farmers' experiences in increasing climate change adaptation capability and improving decision-making processes at the system level. The conclusion is that local perceptions provide sufficient baseline information for understanding individual and collective exposure to climate risks, an essential element for effective policy formulation and implementation. Traditional management approaches based on simple, linear growth optimization strategies, overseen by command-and-control policies, have proven inadequate for effective adaptation to climate change. Conversely, accurate bottom-up approaches focused on social learning can complement the system transformation by building collaborative problem solving among individuals, stakeholders, and decision-makers. In this context, deepening social perception becomes fundamental for two main reasons: i) it is a key component of the socio-political context, and ii) it is an essential step for behaviour transformation and attitude change. In this line, associative processing methods, such as interviews and surveys, have been discussed for their ability to monitor the nature, extent, significance, and influence of personal experience on climate change adaptation. Also, modelling techniques have been recognized in social sciences as effective mechanisms to simulate the social influence in decision-making processes. System dynamics (e.g., causal loop diagrams, CLD) and Agent-Based Models (ABM) can include feedback between social and physical environments, define individuals' and stakeholders' narratives, and map the social network with agents' interactions. This proposal aims at testing how qualitative data can enable policy-makers and managers to understand and re-think water management and climate change policies at the local level, which is essential to address agricultural risks. From a system dynamics approach, we examine how ABMs can most effectively integrate behavioural data collected from semi-structured interviews and surveys to increase robustness in decision-making processes while attending to farmers' behaviour on climate change adaptation. We surveyed 460 farmers and semi-structured interviews with 13 irrigation consortiums from northern Italy to deepen a triple loop analysis on climate change awareness, perceived impacts, and adaptive capacity.

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Track 1

Using qualitative data to inform behavioural rules in agent-based models

INTRODUCTION

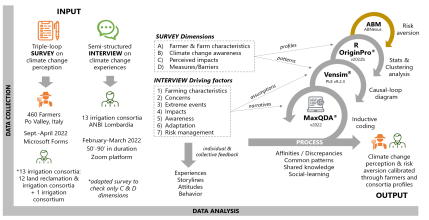
- **Agricultural systems** are adversely influenced by **climate change** through increased **water stress, change in run-off patterns, seasonality fluctuation, and temperature variations.**
- **Farmers and irrigation consortia are valuable sources of first-hand observations** of climate change as they may provide a deeper understanding of their manifestation, relevance, and effects, but also promote adaptation measures.
- **Perception is a complex process** that encompasses a range of **psychological constructs** such as previous knowledge, beliefs, attitudes, and concerns about if and how climate changes.
- **Social learning from bottom-up approaches and tools** (survey, interviews) can **reinforce system dynamics** and Agent-Based Models (ABM) through individuals' and stakeholders' narratives, and map the social network with agents' interactions.

CASE STUDY: THE LOMBARDY REGION

- **An agricultural cluster:** ≈52,000 farms distributed in less than 600,000ha (25% of the irrigated area at the national level).
- **An intricate system** of rivers, lakes, regulated reservoirs, and channels.
- **Subalpine hydrometeorological regime:** dry periods in winter/summer & peaks in late spring/autumn fed by snowmelt and rainfall.
- **Extreme events:** hydrological (flash floods), climatological (convective storms, droughts) & meteorological (cold and heat waves).

AIM & METHODS

To analyse **behavioural data on climate change from farmers' and irrigation consortia's perceptions** as the first step **to build risk aversion profiles** for coupling an agent-based model with a distributed agrohydrological model (ABNexus) that covers the irrigation district of the **Adda river, Lombardy region, Italy.**



RESULTS

Farmer dominant profile

Man, 45-64y, higher education, experience >30y, union farm and consortia membership, non off-farm activity, no succession intention

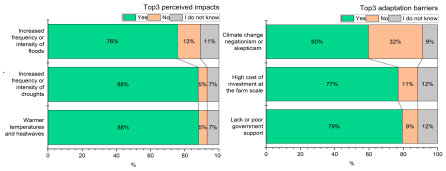
Farm dominant characteristics

Size >20ha, irrigated, conventional crops (maize), livestock, fertilizers use, irrigation canal as water source, non renewable energy use

CLIMATE CHANGE AWARENESS

- Climate change is the single most **serious problem** (85%)
- **Multifunctionality** is slightly **more exposed** to climate change than rainfed and irrigated **crops & livestock**
- **Individuals are more responsible** than EU and economic sectors for tackling climate change adaptation

CLIMATE CHANGE PERCEPTION AND ADAPTATION

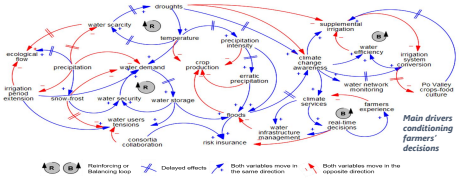


Most promoted adaptation measures
1) Weather services (79%)
2) Reduce fertilizers' use or improve their efficiency (70%)
3) Crop diversification and rotation (67%)

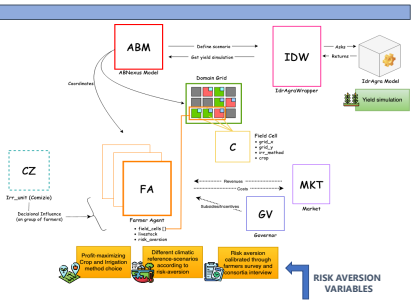
Irrigation consortia's perspectives – Farmers heuristics

- **A neighbourhood effect:** small farmers (**C4**) in proximity exhibit similar risk adaptation preferences, especially by introducing water-saving practices or supplying supplementary irrigation.
- **Farmers are conservative**, and their **attitudes tend to change depending on** personal **experiences** through the **years**, and notably after suffering economic losses in a mid-term period.
- Young farmers (**C2-C4**) lead the **modernisation and innovation process**, eminently in water efficiency techniques.

FEEDBACK *reinforcing*



Main drivers conditioning farmers' decisions



Social focus
- Education, age & farming experience
- *Succession intention (no consensus)*
- *Consortium membership (no consensus)*

Agricultural focus
- Farm size, production system, fertilizers use & irrigation method
- *Crops/Livestock (no consensus)*

SURVEY CLUSTERING

- **C1 Medium farms** (46%) old, low education, high experience
- **C2 Rainfed** (16%) young, high education, low experience
- **C3 Big farms** (31%) old, low education, high experience
- **C4 Small farms** (7%) young, high education, low experience

- **C1/C3**: annual forages
- **C2**: vineyards & grasslands
- **C4**: vineyards & vegetables
- *Maize + livestock (all)*

- **AWARENESS: C4** is the most concerned / small differences between clusters
- **PERCEIVED IMPACTS**: **C4** highest perception / **C1-C4** more floods / **C3-C4** pest infection
- **ADAPTATION MEASURES**: **C3-C4** highest application / **C2** asking for cooperation
- **ADAPTATION BARRIERS**: **C3-C4** highest barriers / **C4** negationism-skepticism
- *"I do not know" answer:* **C2** (the 'doubtful' cluster) / **C4** (the 'self-confident' cluster)

REMARKS AND FUTURE RESEARCH

- **Surveys** & **interviews** recap qualitative data to **reinforce ABMs.**
- **Farmers and consortia's heuristics** can be used to determine **risk aversion** in ABMs.
- Farmers and consortia are **aware of climate change**, **perceiving similar impacts** (↑ increase and extreme events), **but differing about adaptation strategies**: **soft measures by farmers** (e.g., crops, insurance, weather services) or **hard measures by the consortia** (e.g., water storage).
- **Causal Loop Diagrams** can be used to **identify drivers and interactions** between climate change impacts and adaptive capacity.
- **Future research** should target how **farmers' imitation attitudes** can increase adaptive capacity and how consortia, together with farmers' unions, can serve as peer groups for **social-learning and knowledge transfer.**

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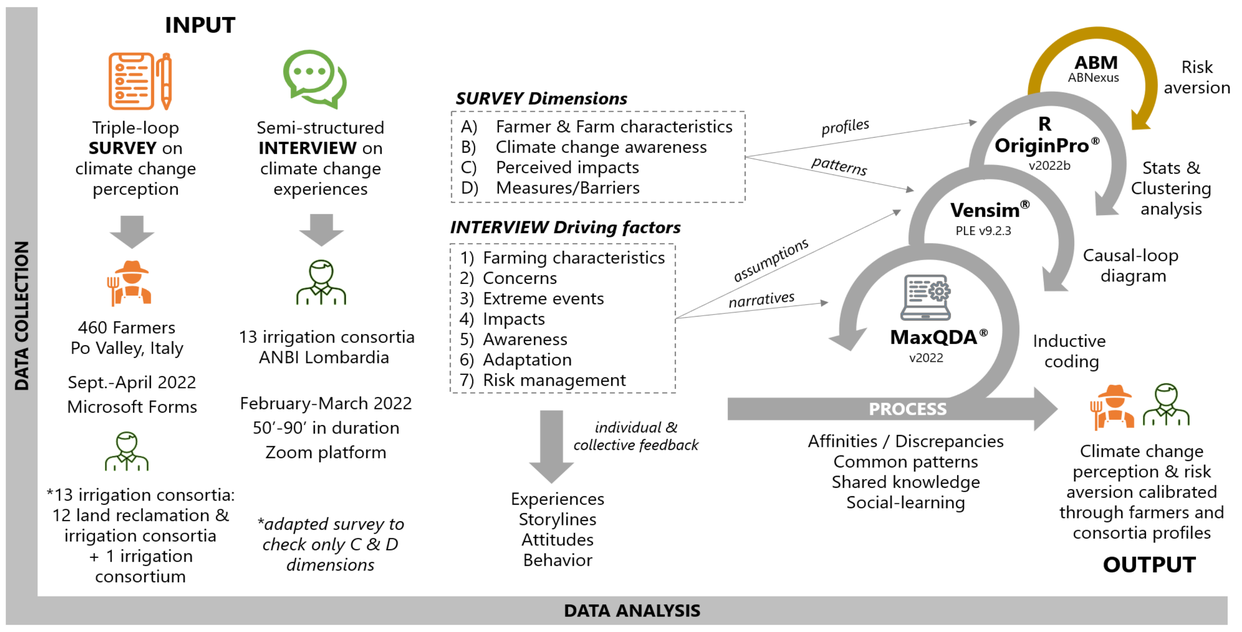

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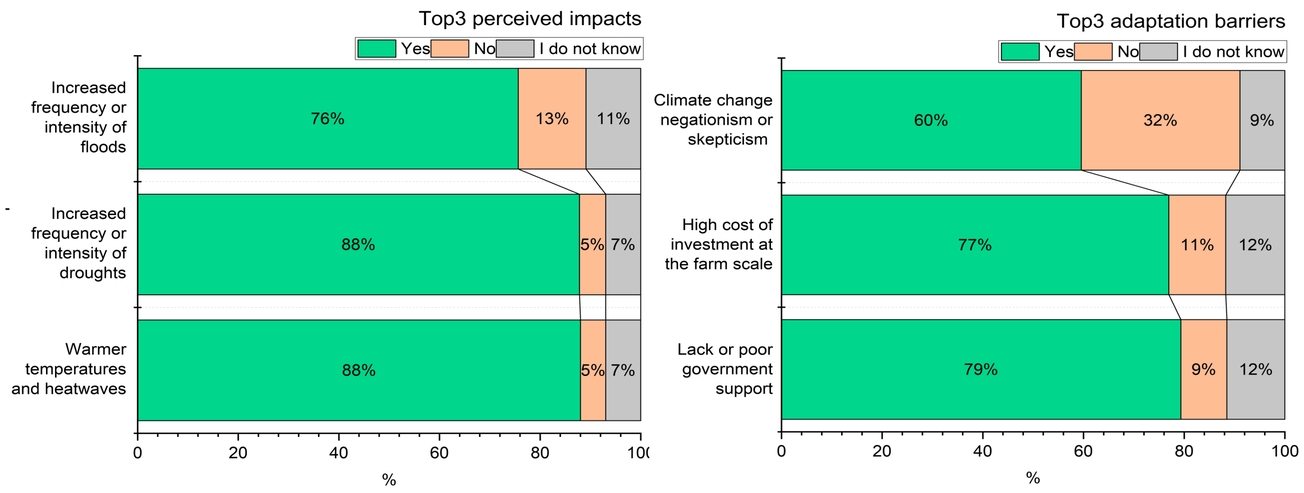

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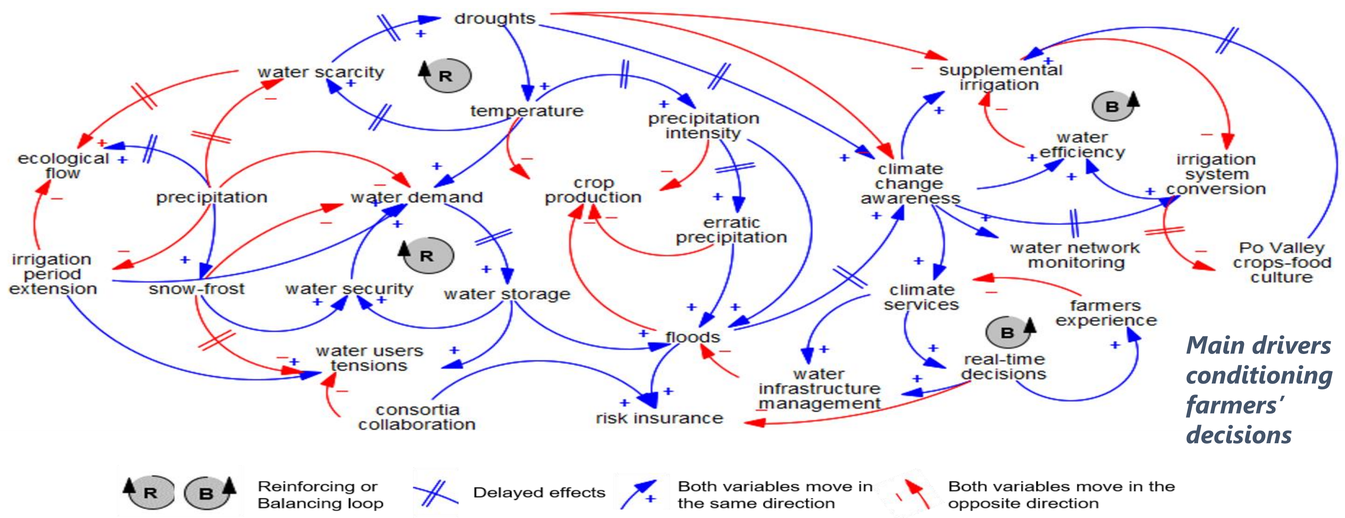

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