Combining modelling and stakeholder involvement to build community adaptive responses to climate change

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Structure of the presentation

- How do we understand **climate change**
- How do we understand **adaptive responses** to CC
- Lessons from the Agroscenari-Macsur **case study**
    - Expected climate scenarios
    - Expected impacts on farming systems
    - Community perspectives and response-abilities
- **Implications** for researching and policy making

Living in a CC world

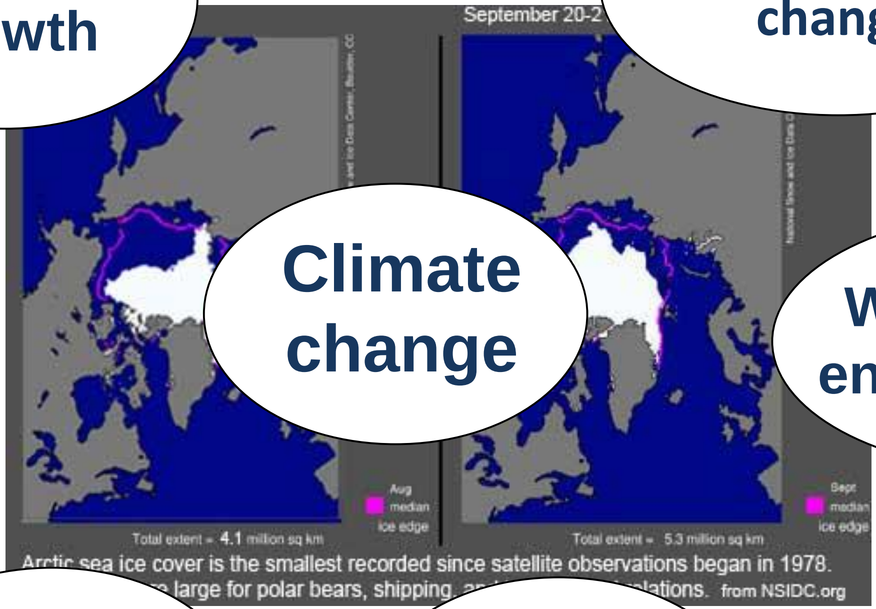
Population growth

Technological change

Climate change

Globalisation
(India, China)

Water, food & energy security



Poverty alleviation

Infectious diseases

Living in a CC world

Innovation to create low carbon economies

Innovative learning pathways are key

Unprecedented challenges to ecosystems & human systems

Adaptation to more frequent heat waves, floods & droughts

More imaginative approaches

New ways of working together

More collaborative approaches

Hypotheses

- Human-induced climate change is a totally new challenge to the human kind
  - It requires **changes in the way of thinking and acting**

- How to develop an effective strategy to respond to CC in an adaptive way?
  - **Key words**: **reflection, learning**
  - **Stakeholders**: actors, owners, customers…
    - what role for researchers, engineers, policy makers, consumers…?

- Structural coupling and science/policy interfaces

How we understand climate change?

- Complex
- Unintended consequences
- Multiple stakeholding
- Multiple scales
- Highly contested

(Collins et al 2011 Env Pol Gov)

'Do we have a shared conceptual understanding of what global warming is?'
(Brooks, 2005)

CC situations as wicked issues

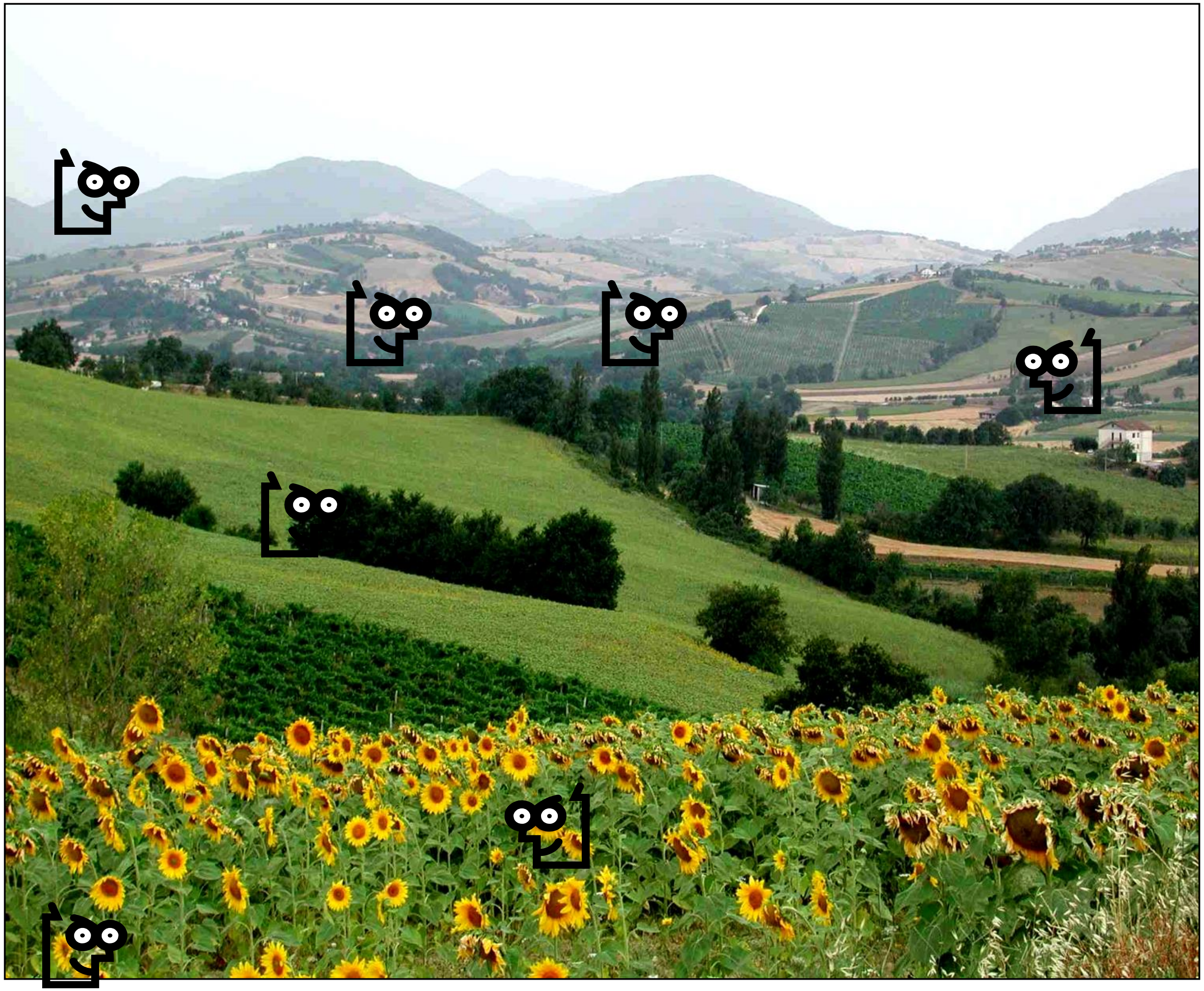
(Australian Public Service Commissioner, 2007)

Tame problem	Wicked issue
Stable, **well defined** problem clear when a **solution** is reached, targeted actions can be designed	No definitive **formulatio** actions relying on perceived evidence are late and ineffective
Solutions can be objectively evaluated as **right or wrong** depending on targeted achievements	Contextualized "**better**" or "**worse**" solutions (actions) emerging from **process quality** assessment
solutions can be **tried and abandoned**	Every action is "**one-shot operation**":
Can be **classified** and approached with tools already tested elsewhere	Every problem is **unique** and symptom of other problems in specific contexts
	The **choice of explanation modalities** determines the nature of the problem's and the response pathways

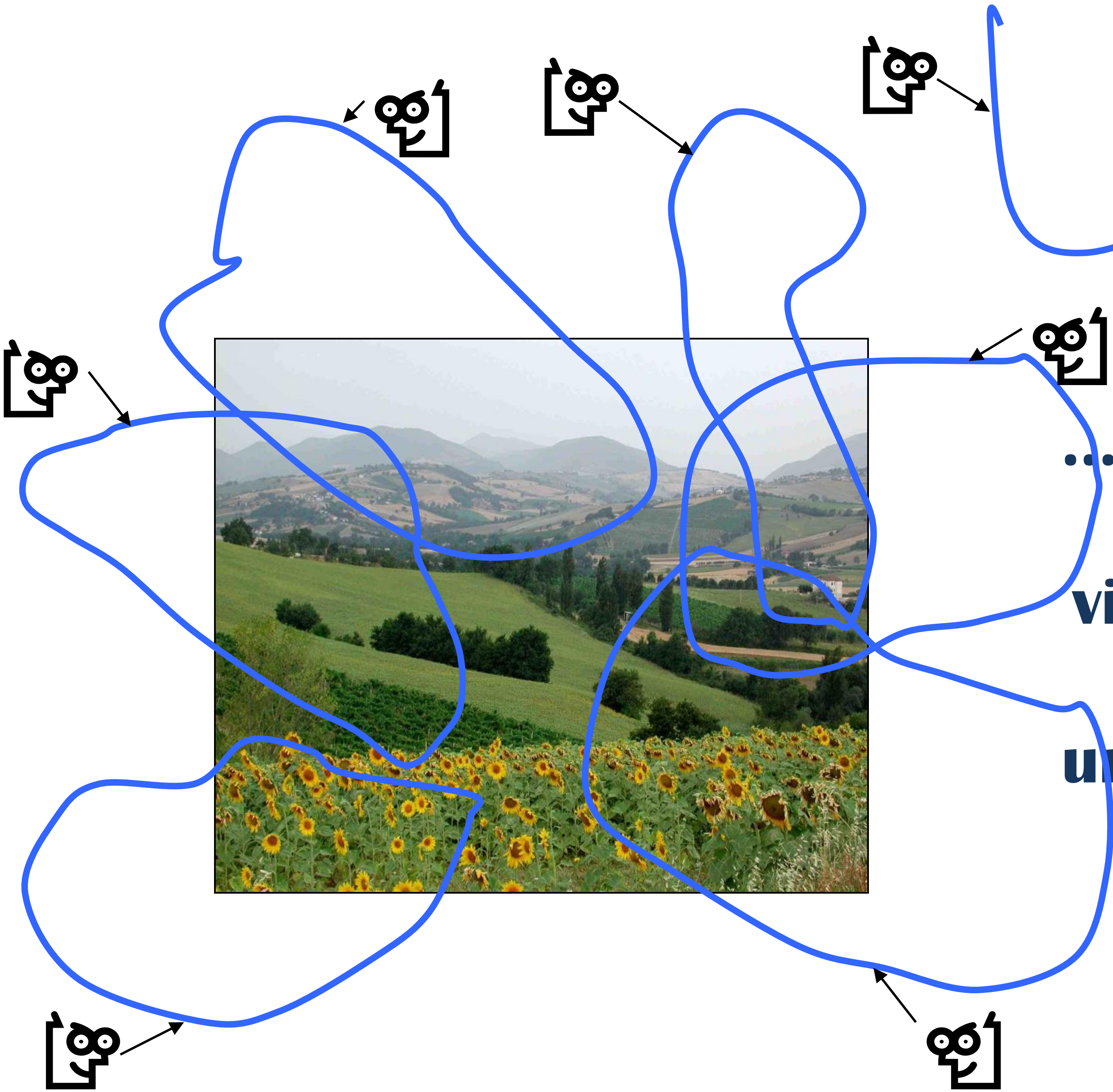
Systems view of CC in agriculture

- **Complexity** emerging from multiple perspectives:
  - variety of time and space scales, cropping systems, environmental socio-economic contexts
  - variety of actors, responsibilities,systems' perspectives
- **Sharing** the nature of the issue is crucial for concerted actions towards sustainability
  - Quantitative tools essential, but not sufficient to address the challenge of adaptive responding to CC
- Research results to provide tools for learning

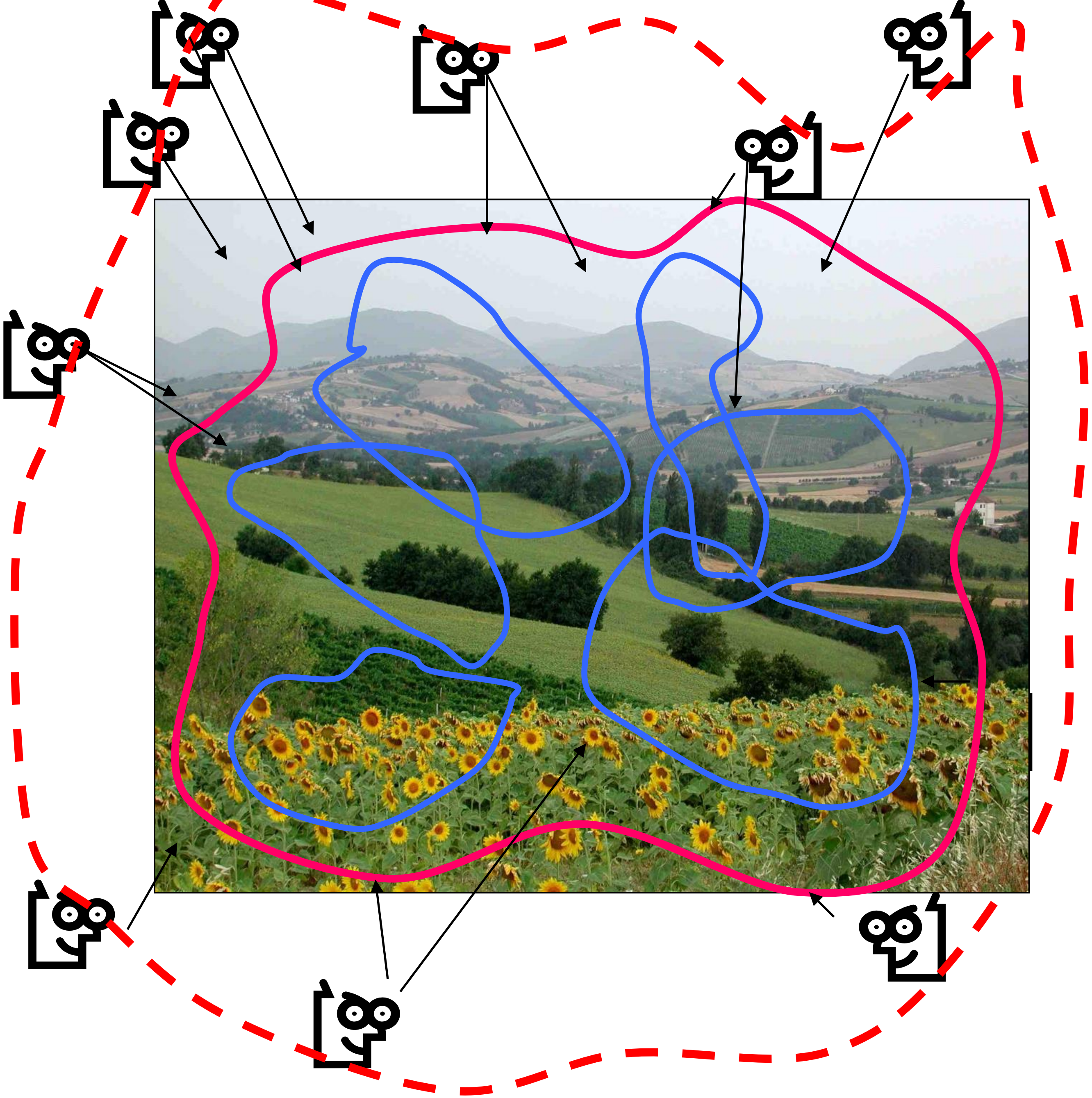
A systems view of a situation….



...recognises multiple stakeholders which means....



...recognising multiple viewpoints and partial understandings of the 'situation'



A well designed social learning process can be effective in integrating multiple perspectives for understanding issues and designing concerted actions

How we understand CC adaptation

- **Not a route towards a fixed destination, but a changing pathway without clear future direction**

Adapting TO *vs* WITH CC

- "Fitting to" (jigsaw) vs co-evolution (feet-shoes)

Ison, 2010, Systems practice: how to act in a climate change world, Springer

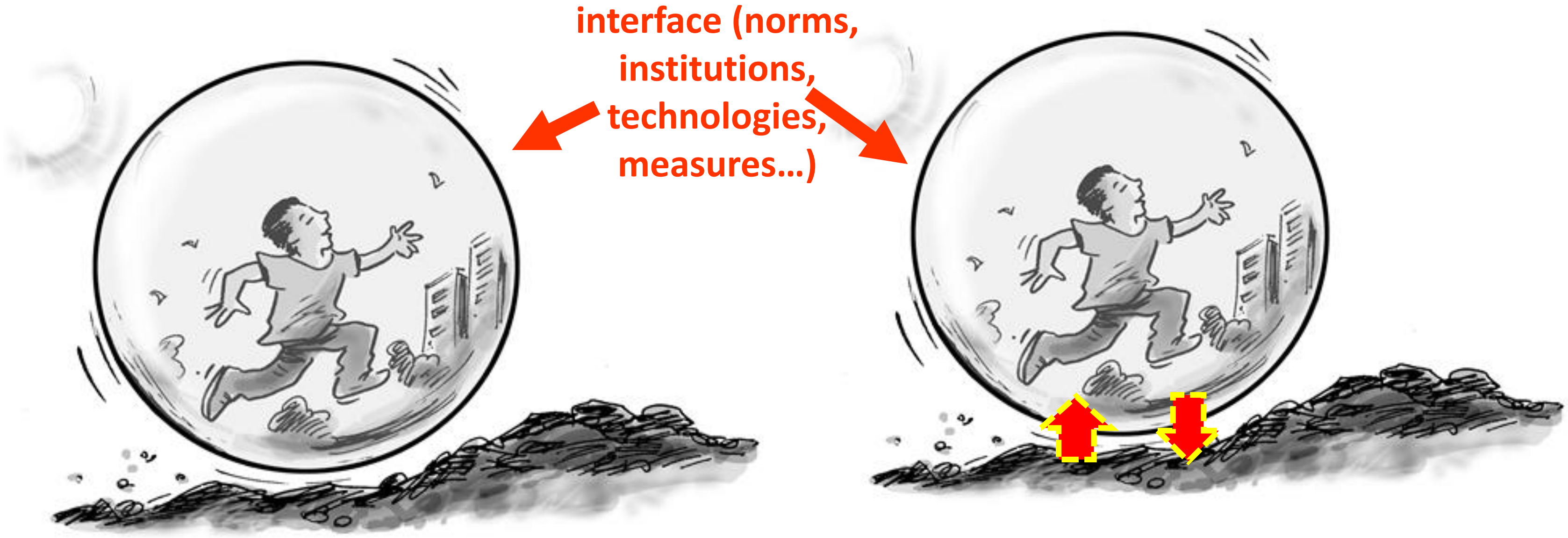
Adapting WITH change

- A concerted action for a desirable performance
  - …changeing with players under the same sheet music
  - As in a jazz orchestra, the band continuously adapts to soloists…


Ison, 2010, Systems practice: how to act in a climate change world, Springer

Adapting WITH CC

- In agriculture, the performance emerges from the interaction of three components:
  - The biophysical system's dynamics (eg climate, soil, crops)
  - The social system's dynamics (eg farmers practice)
  - The structural coupling of the two that co-evolve and influence each other



Ison, 2010, Systems practice: how to act in a climate change world, Springer

Framing research on CC

Business as usual	Strategic change
Set targeted states to be achieved through best practices under "command and control" regulation	Contextualize actions and tools towards improved performance under changing contexts and address self-organized systems
Delegate targeted projects to experts to design effective solutions through rules and incentives	Invest on co-learning spaces, remove barriers, promote volunteer habits and response-ABILITIES
Farmers as users of scientific knowledge produced by researchers	Farmers and researchers as co-producers of "hybrid knowledge" (Nguyen et al 2013)

Adapting to CC

- When dealing with CC, business as usual at different levels will not allow acceptable performance

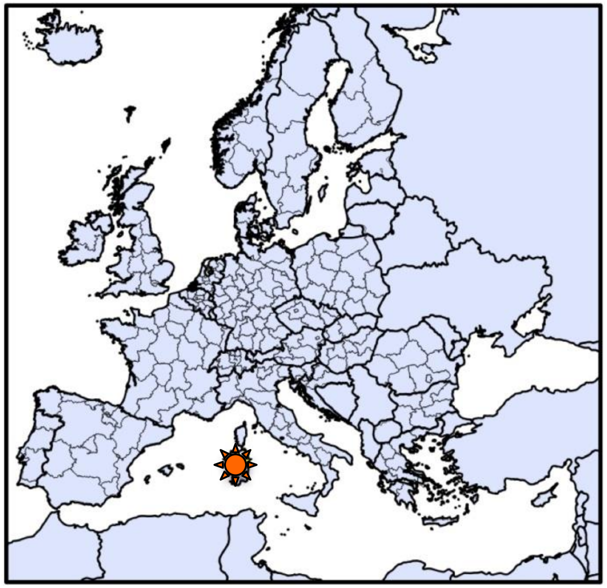
Ison, 2010, Systems practice: how to act in a climate change world, Springer

Case study "Oristanese", Italy

(www.macsur.eu – www.agroscenari.it)

Combining modeling and stakeholder involvement to build community adaptive responses to climate change in a Mediterranean agricultural district

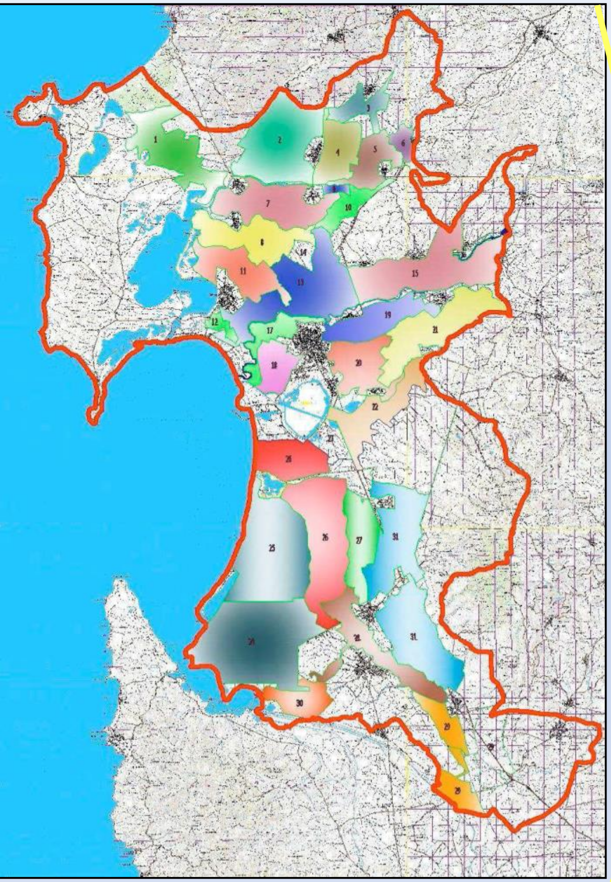
Pier Paolo Roggero, Giovanna Seddaiu, Luigi Ledda, Luca Doro, Paolo Deligios, Thi Phuoc Lai Nguyen, Massimiliano Pasqui, Sara Quaresima, Nicola Lacetera, Raffaele Cortignani, Gabriele Dono

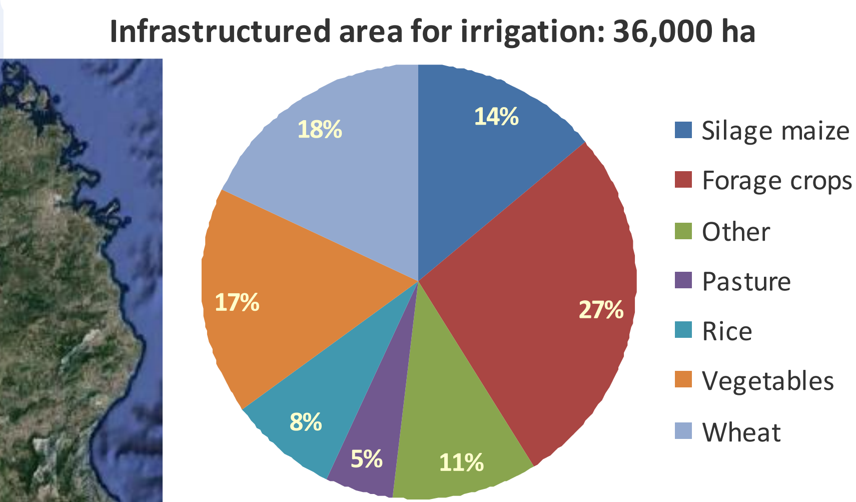


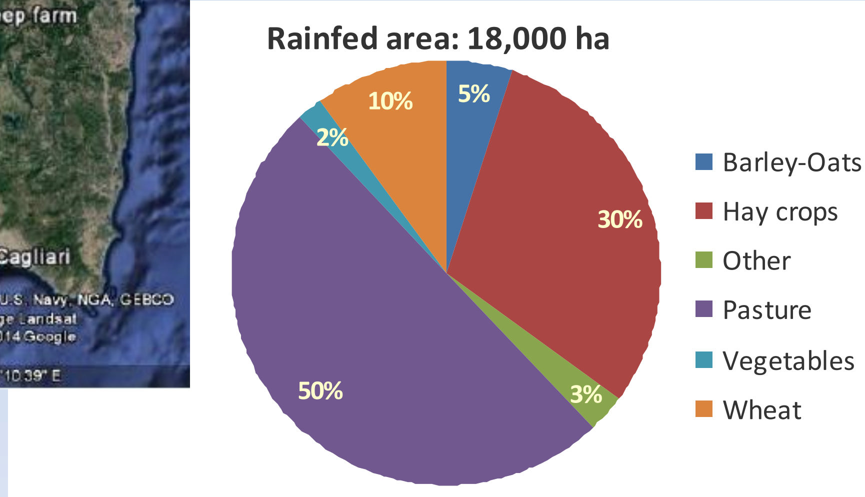
MACSUR meta-question

What would be the different contributions of different European adaptation strategies to ensure global food security until 2050 at different scales [farm to EU] while keeping the GHG targets?

Case study area







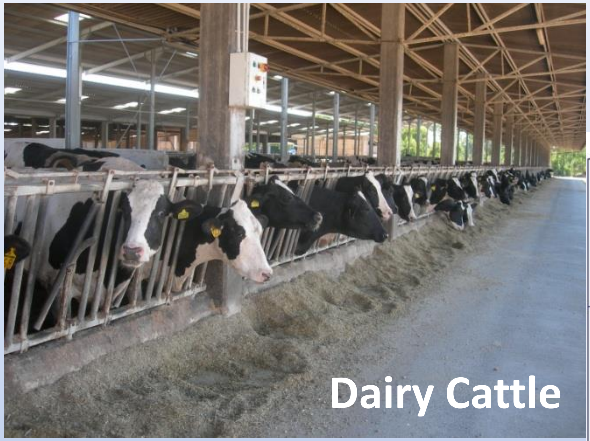
Context

Interdisciplinary team already @work
Context data available

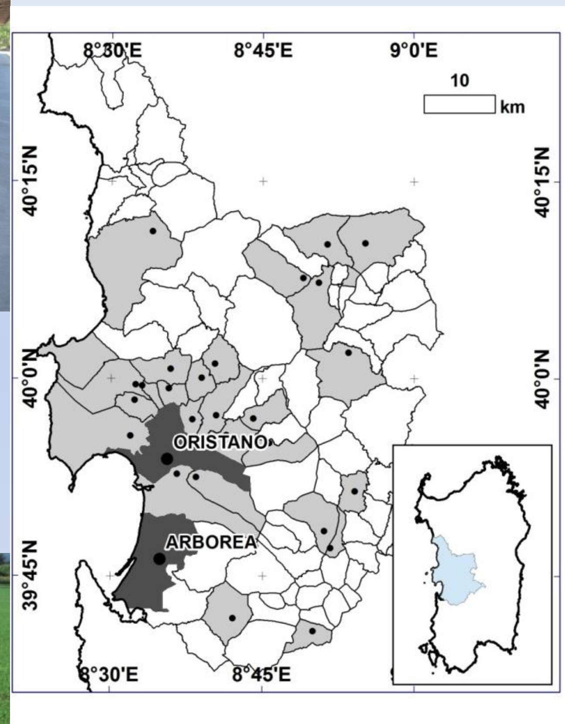
Very **diversified Mediterranean** agricultural district
- Irrigated and rainfed farming systems
- Variety of cropping systems, intensity levels, farm sizes

Multiple stakeholders
- Cooperative agro-food system
- Producers' organizations (rice, horticulture)
- Variety of extensive pastoral systems

Main farming systems



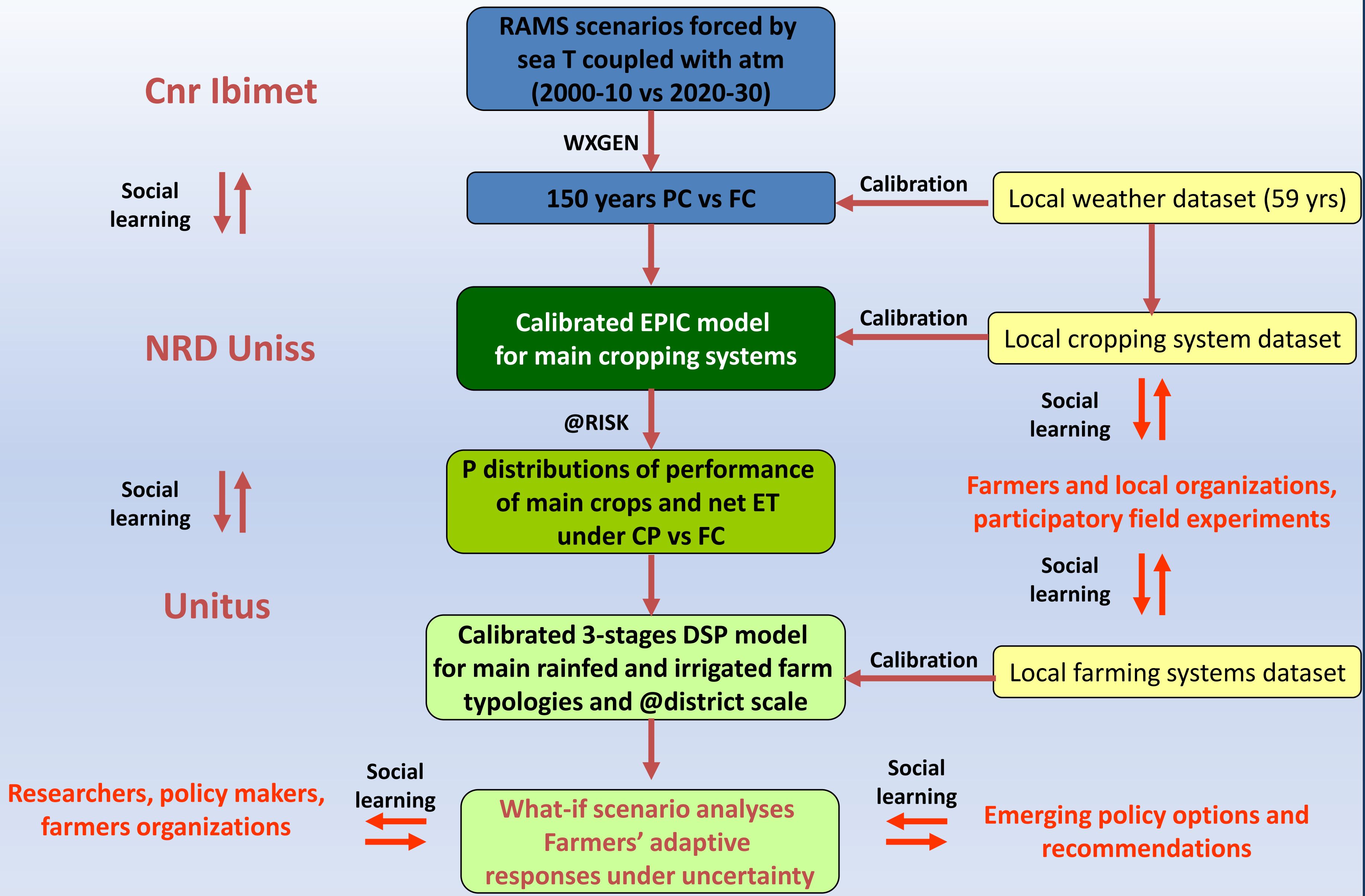
Irrigated forage systems :
- silage maize, Italian ryegrass, triticale, alfalfa



Permanent or temporary pastures in rotation with autumn-winter forage (winter pasture and hay or grain production)

Farm typologies

Farm typologies	Represented farms (n)	Farm land size (ha)	Typology % total land area	Net Income per farm (NI - € 000)	Typology % total NI
Irrigated farms	**1025**	**30,546**	**58**	**65,496**	**83**
Rice	24	115	**5**	140	**4**
Citrus	68	13	**2**	46	**4**
Dairy cattle A	130	31	**8**	199	**33**
Dairy cattle B	40	32	**2**	113	**6**
Greenhouse	46	13	**1**	30	**2**
Vegetables - Cereals	562	22	**24**	34	**24**
Cereals - Forages	55	146	**15**	126	**9**
Tree and arable crops	100	6	**1**	12	**2**
Rainfed farms	**556**	**22,371**	**42**	**13,933**	**17**
Vegetables - Fruit	100	4	**1**	18	**2**
Cereals - Forages	94	25	**4**	17	**2**
Sheep A	45	87	**7**	44	**3**
Sheep B	188	41	**15**	16	**4**
Sheep C	129	62	**15**	43	**7**



Cnr Ibimet
RAMS scenarios forced by sea T coupled with atm (2000-10 vs 2020-30)
WXGEN
Social learning
150 years PC vs FC
Calibration
Local weather dataset (59 yrs)
NRD Uniss
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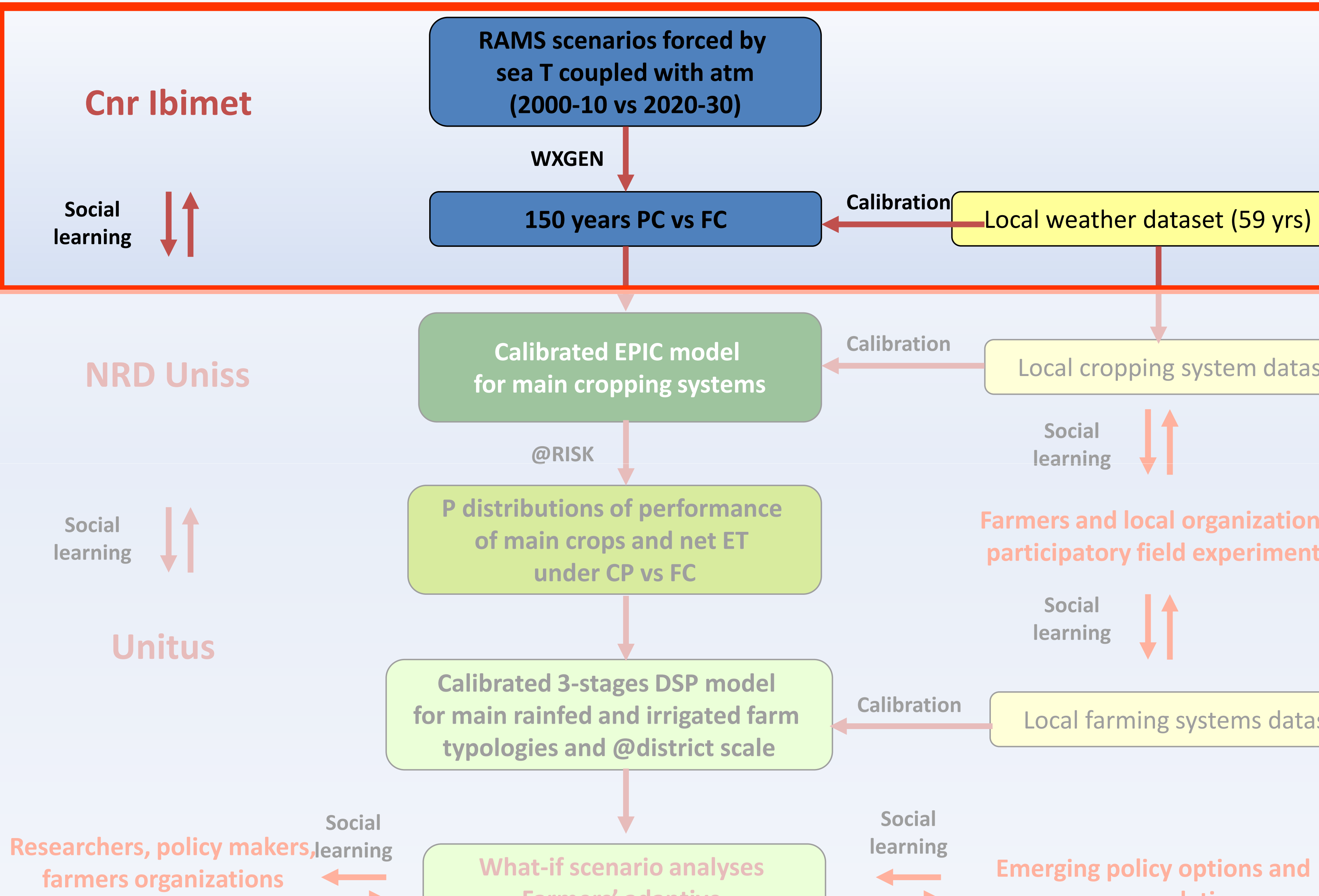
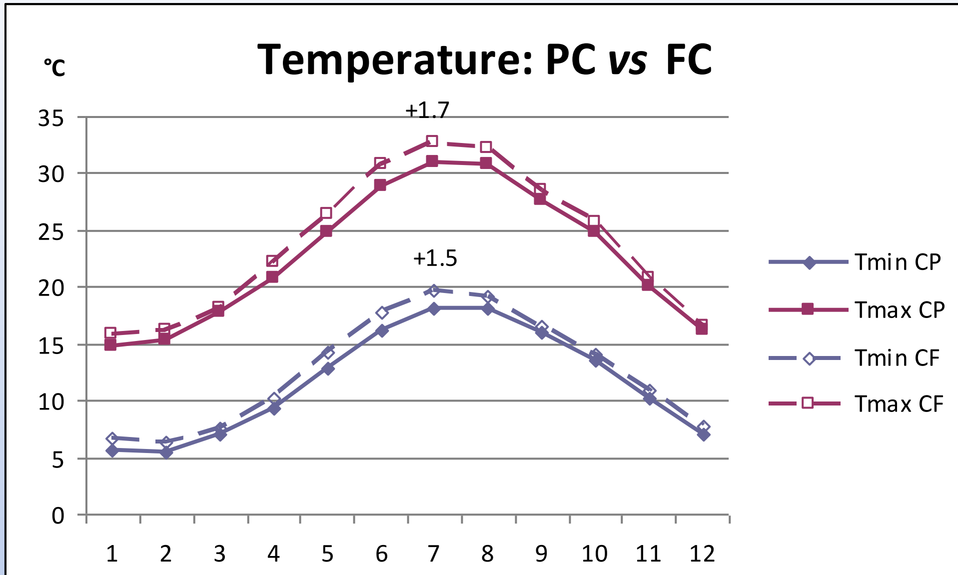
Researchers, policy makers, farmers organizations
What-if scenario analyses Farmers' adaptive responses under uncertainty
Social learning
Emerging policy options and recommendations

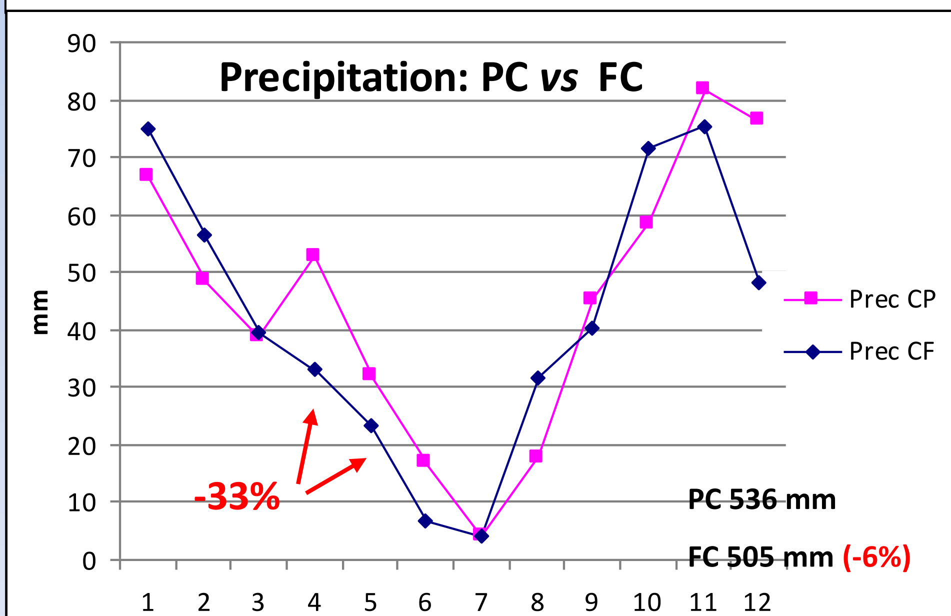


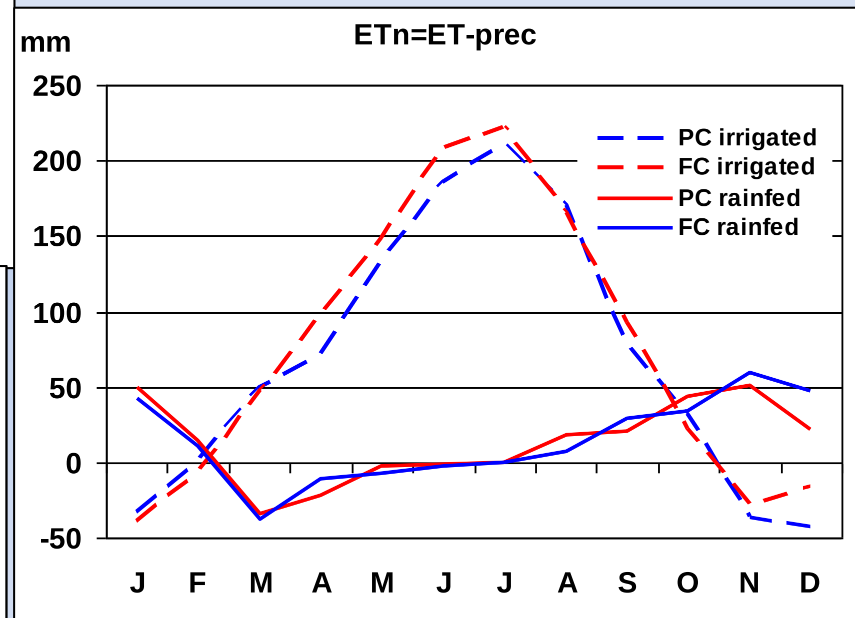
desertification and its relations to climate, environment and agriculture

Climate change scenarios

Climate change signals







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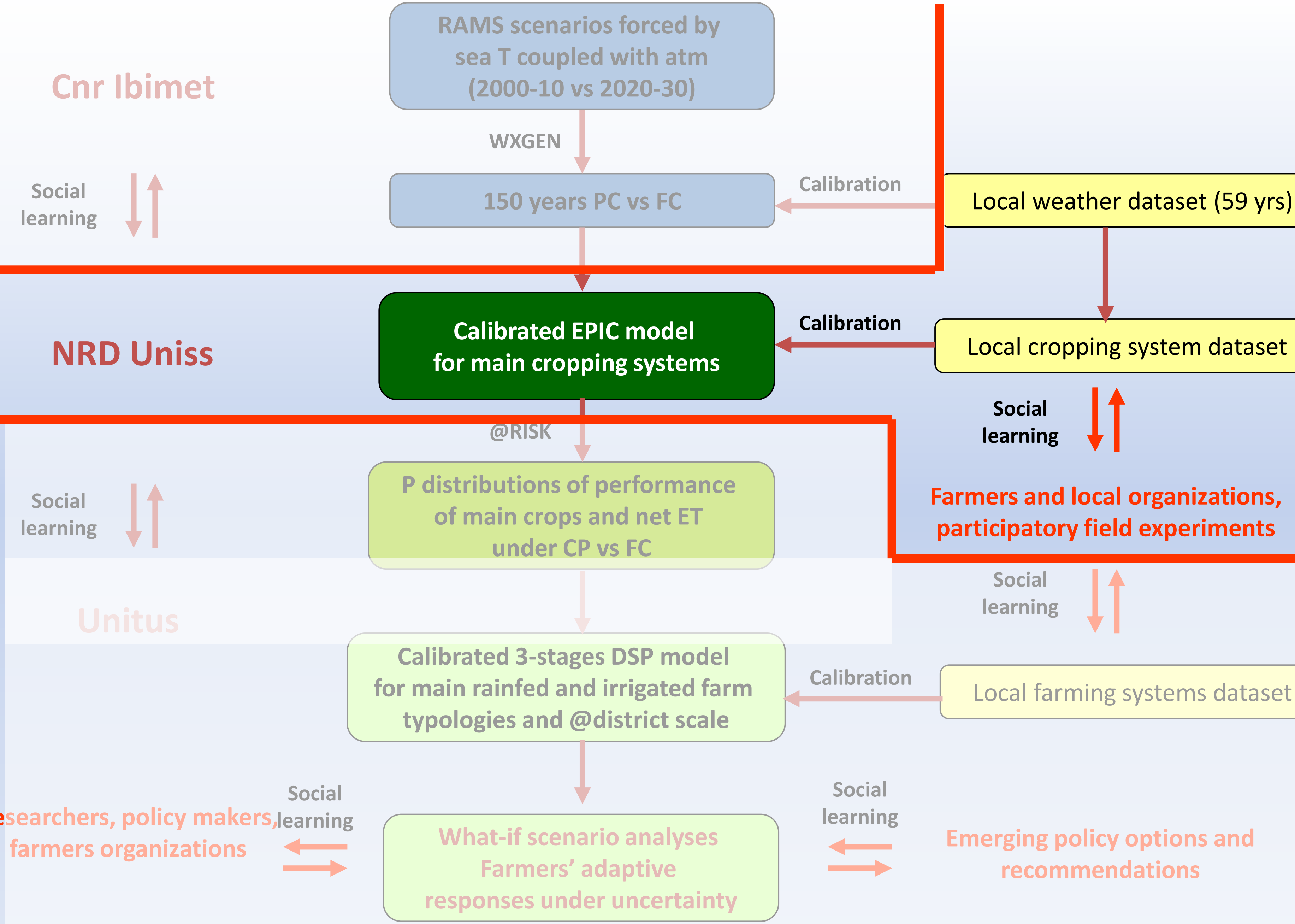
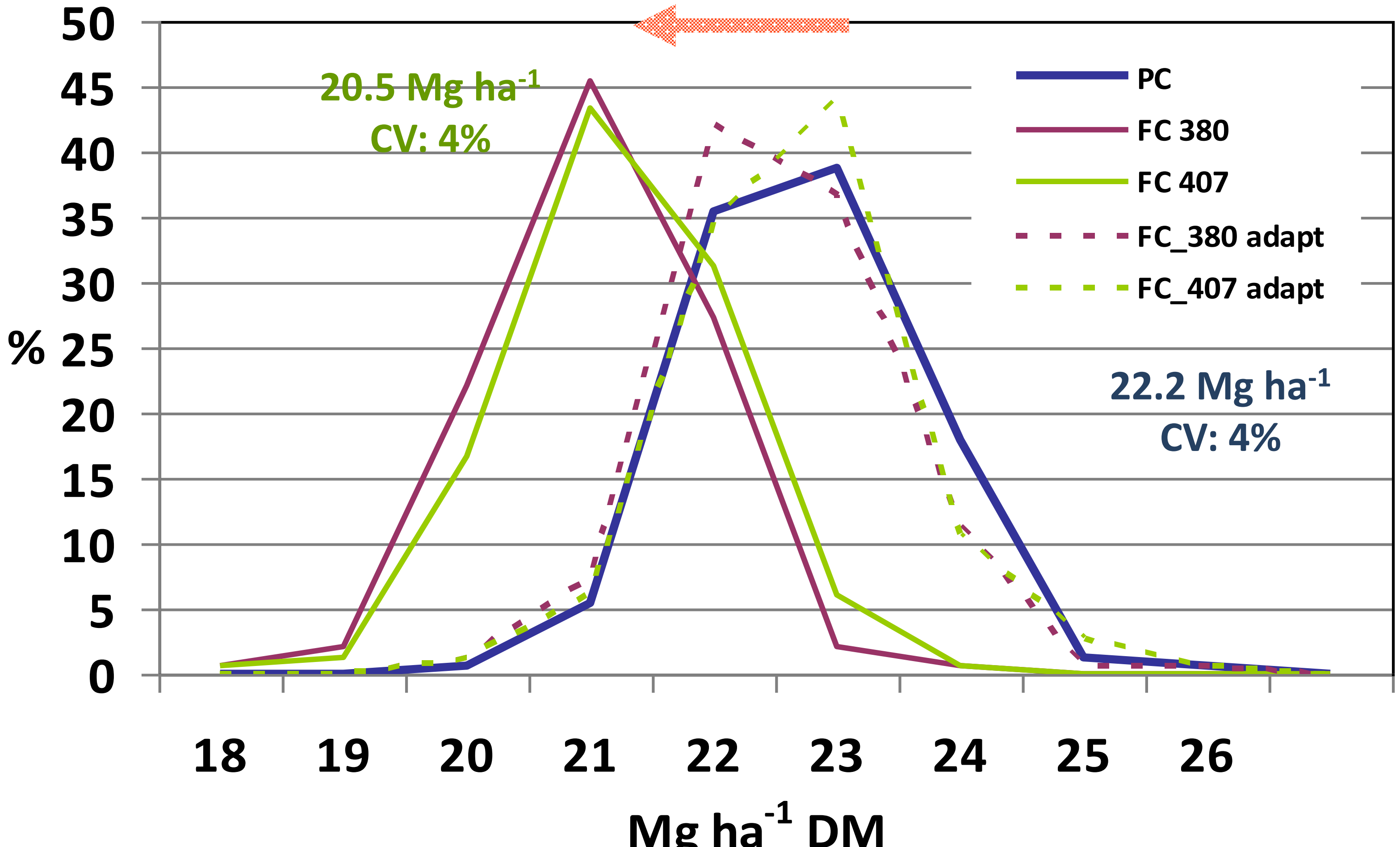


Combining modelling and social learning for CC adaptation – PP Roggero

Silage maize



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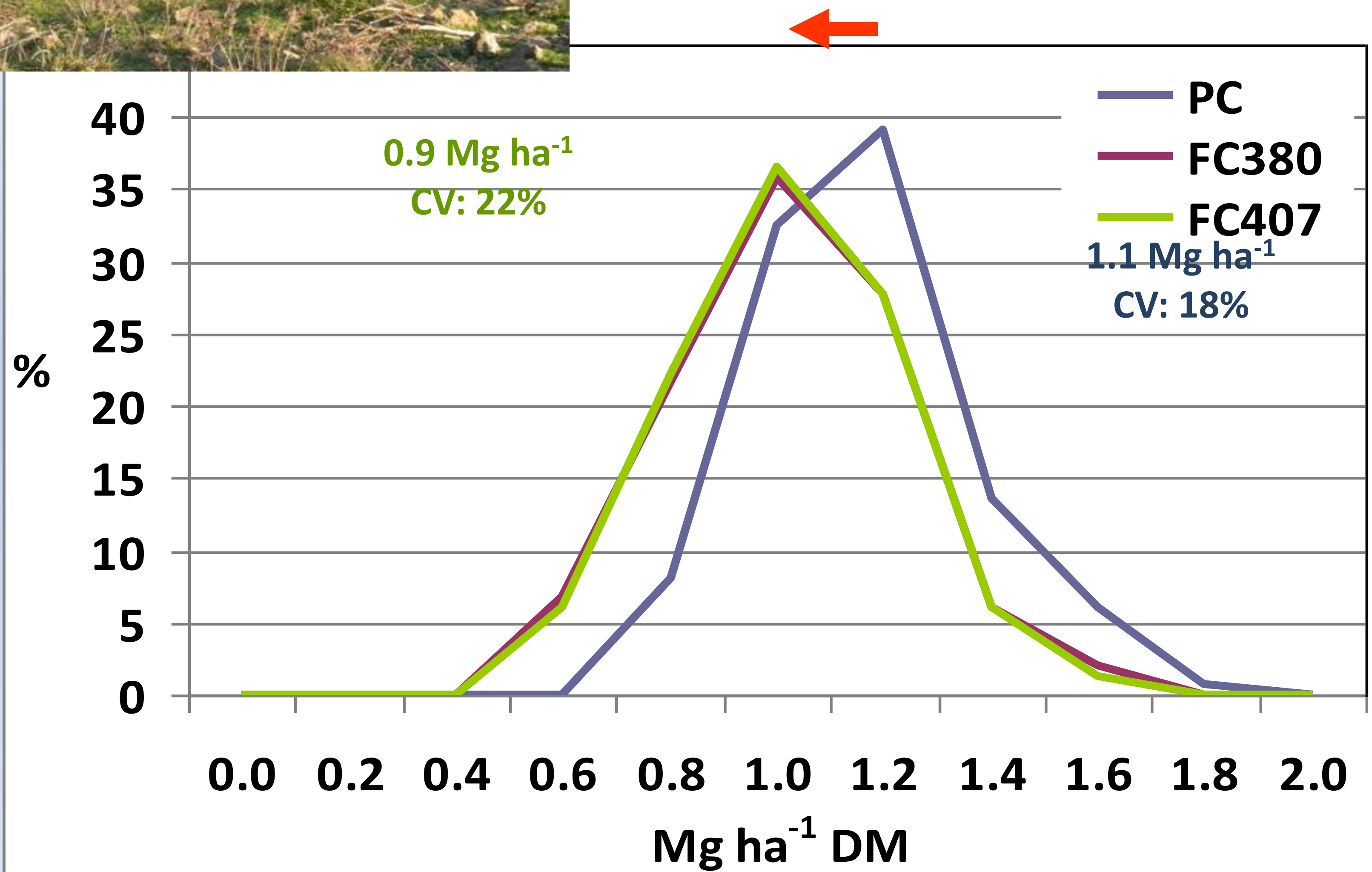
Rainfed grassland



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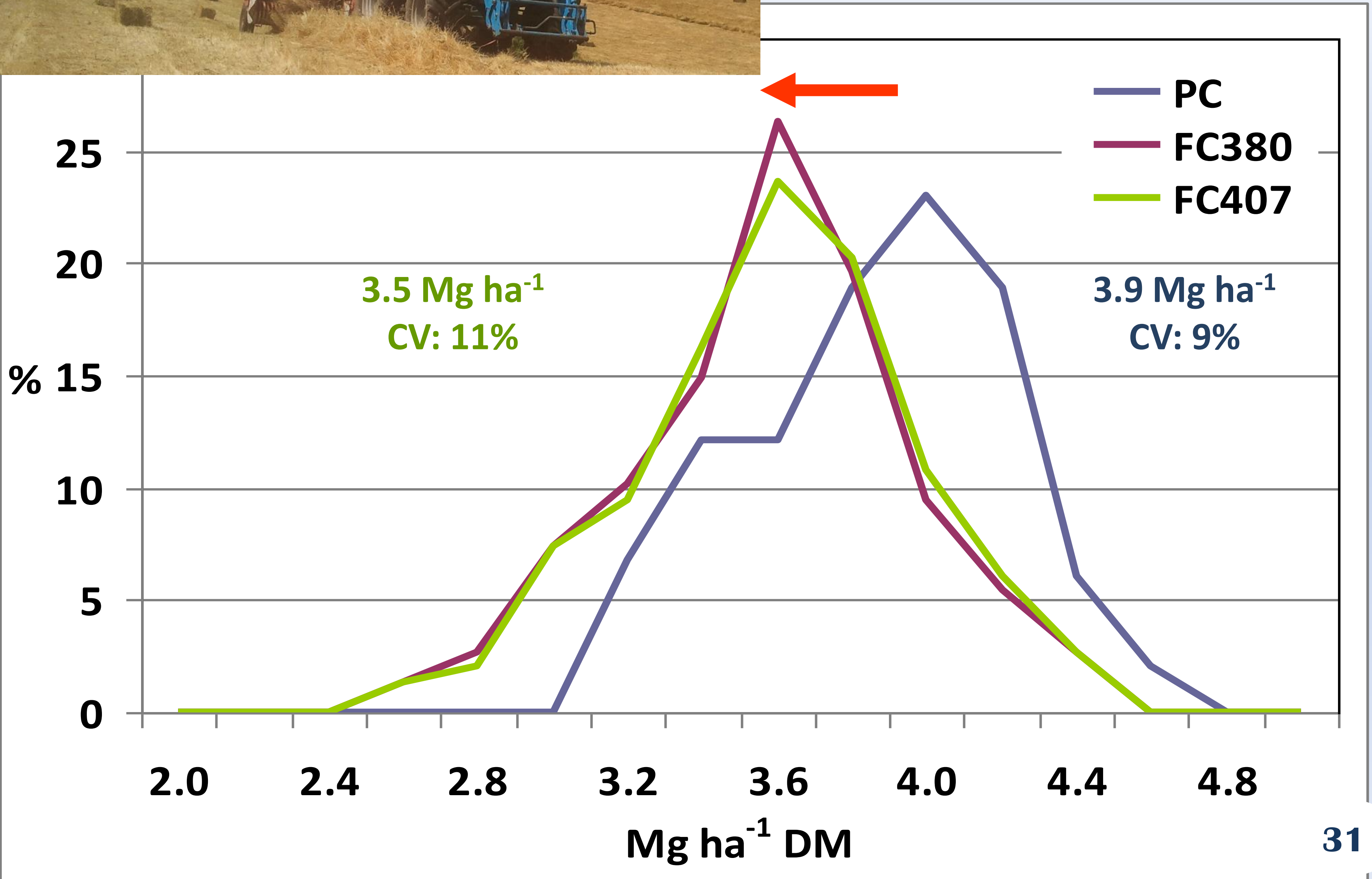
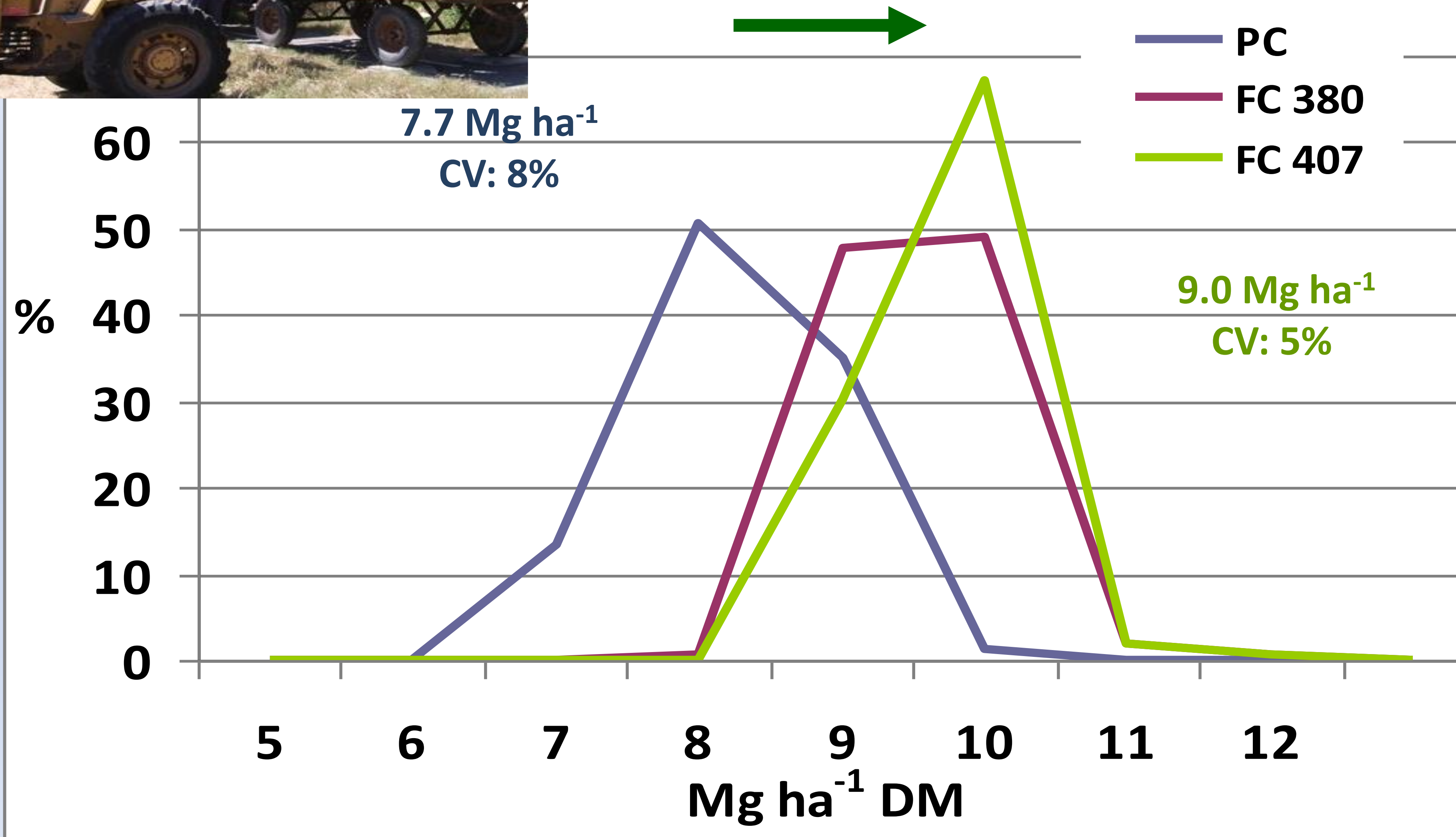
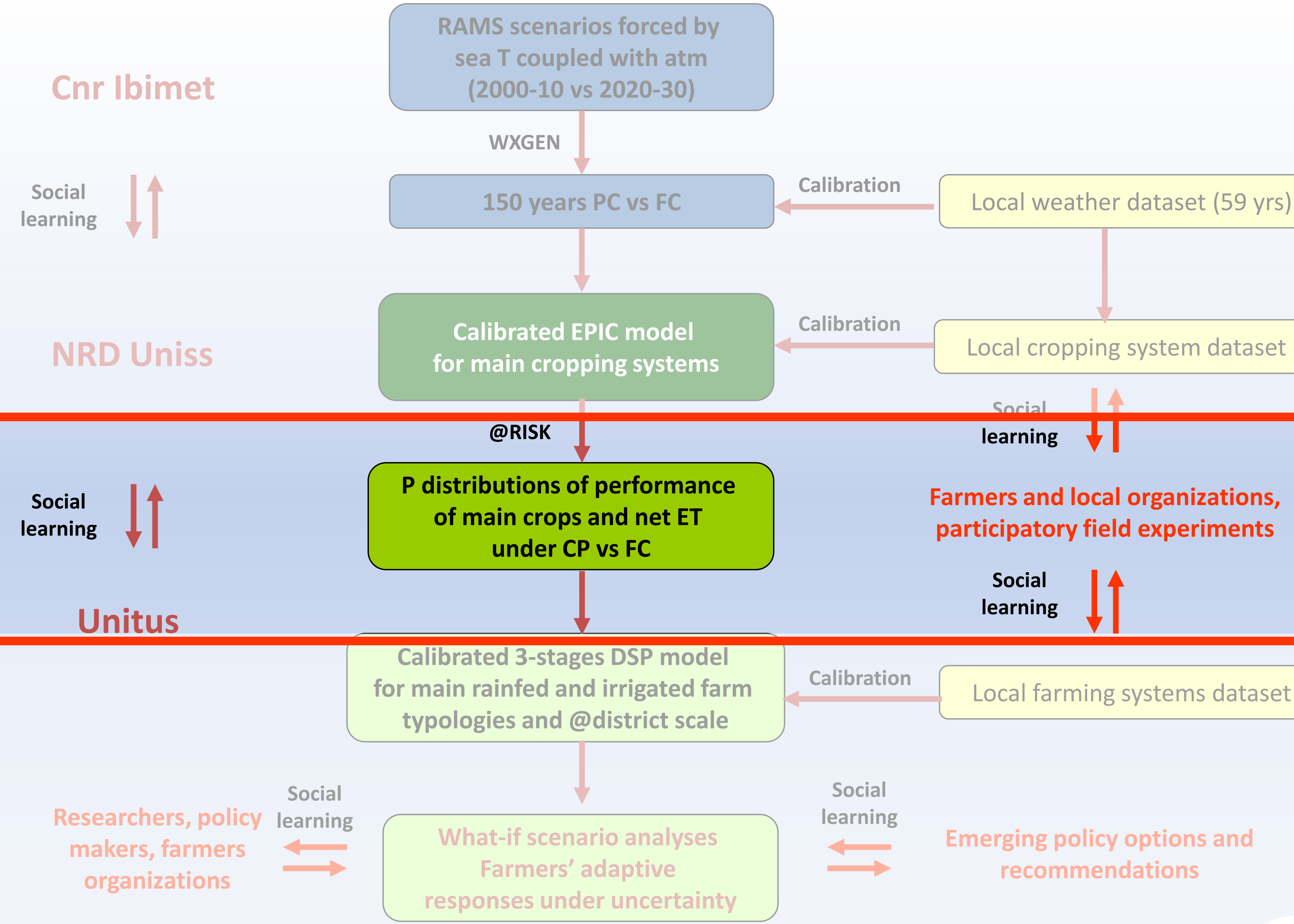
Rainfed haycrop



Irrigated haycrop





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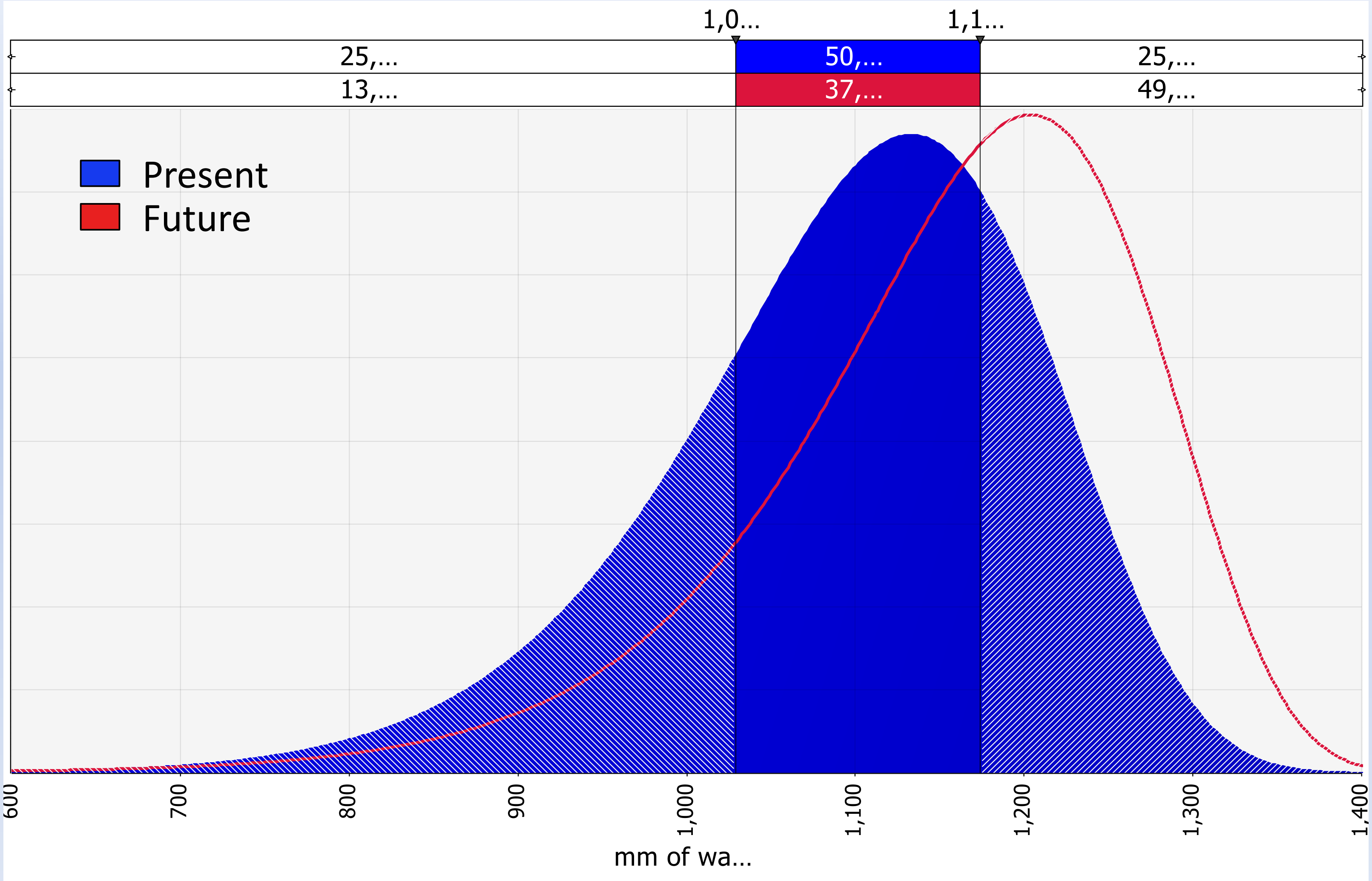
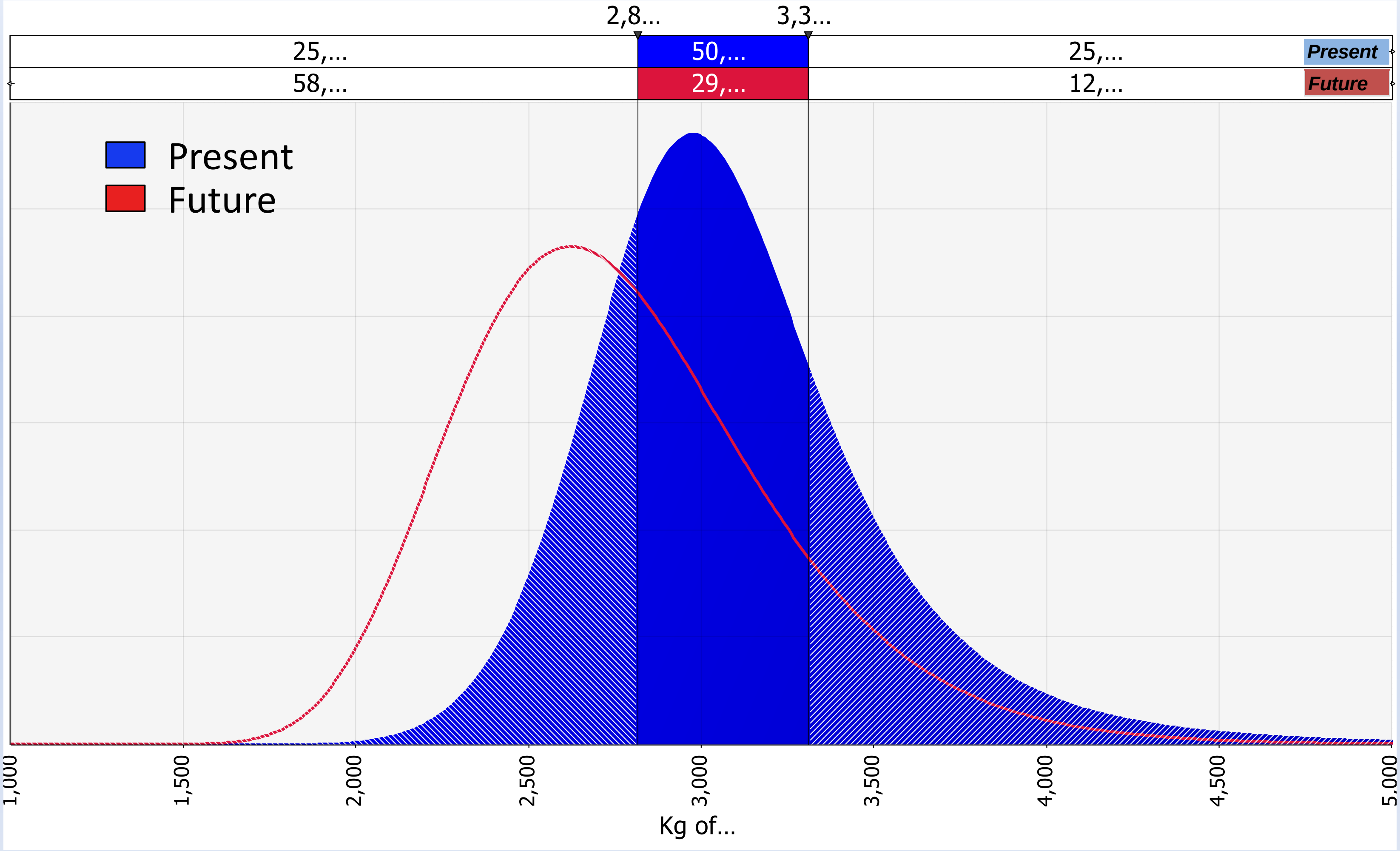
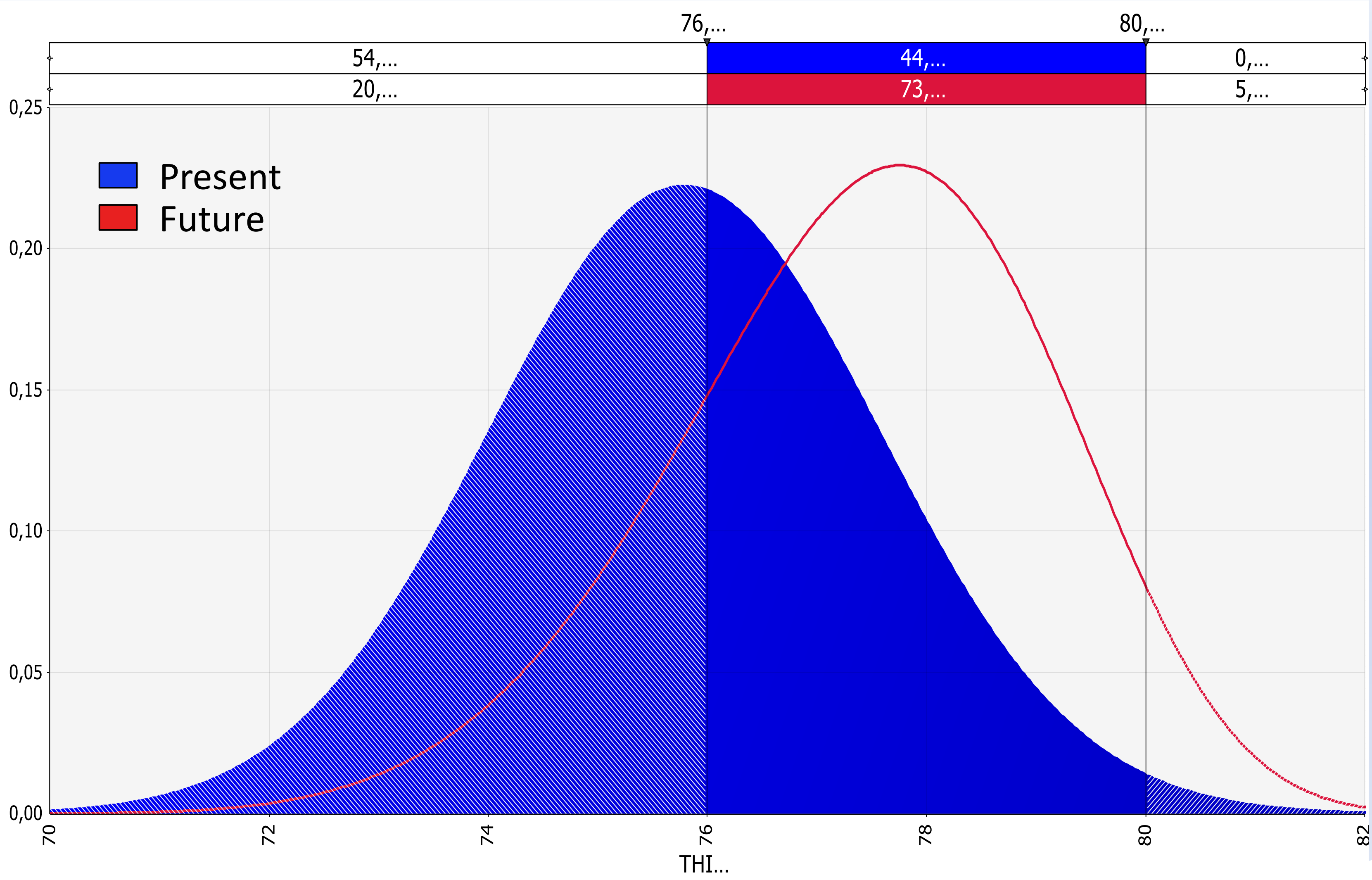
Cumulative ETn in April-October

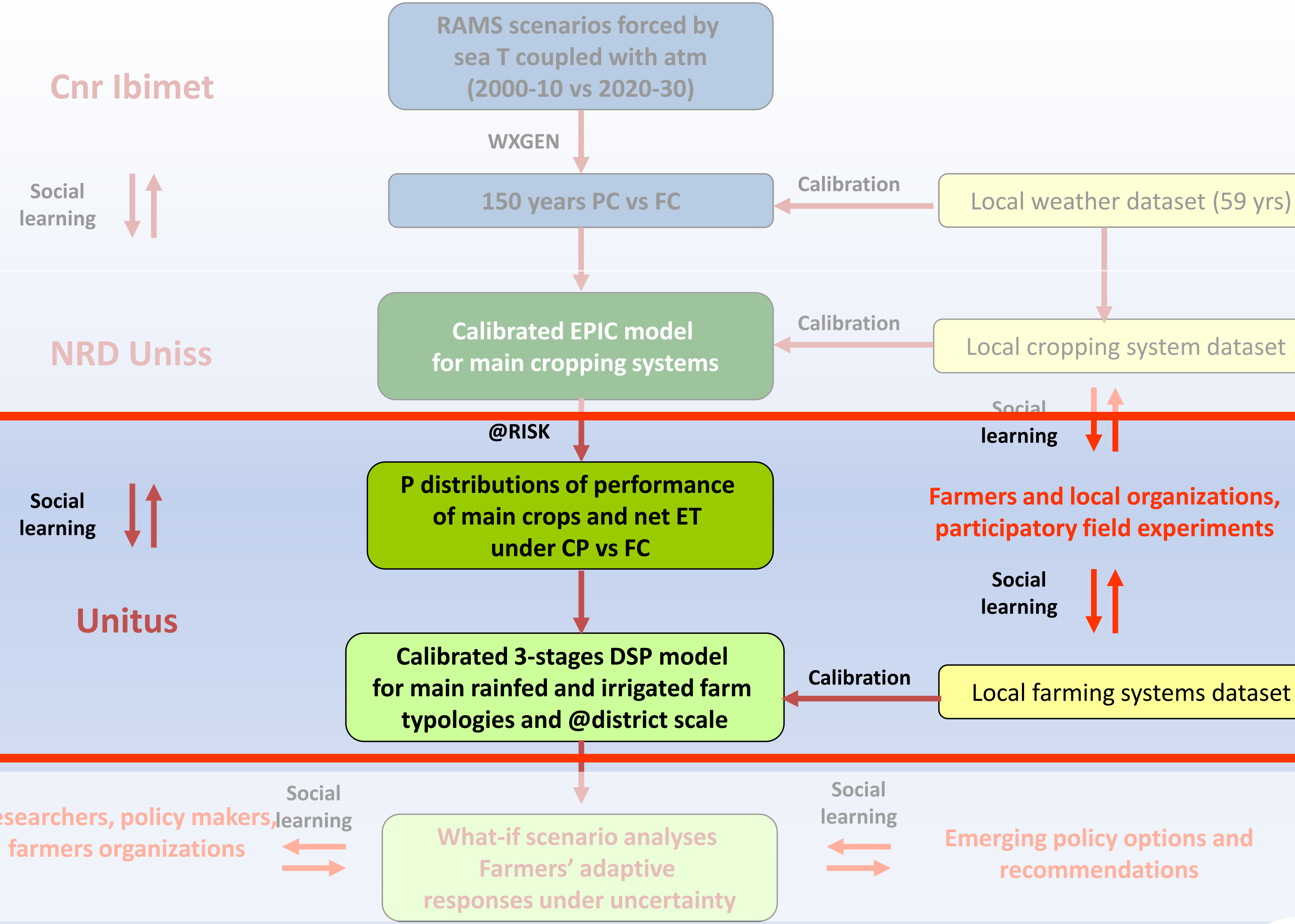


Spring Hay yield from rain-fed crops



THI max in May-September

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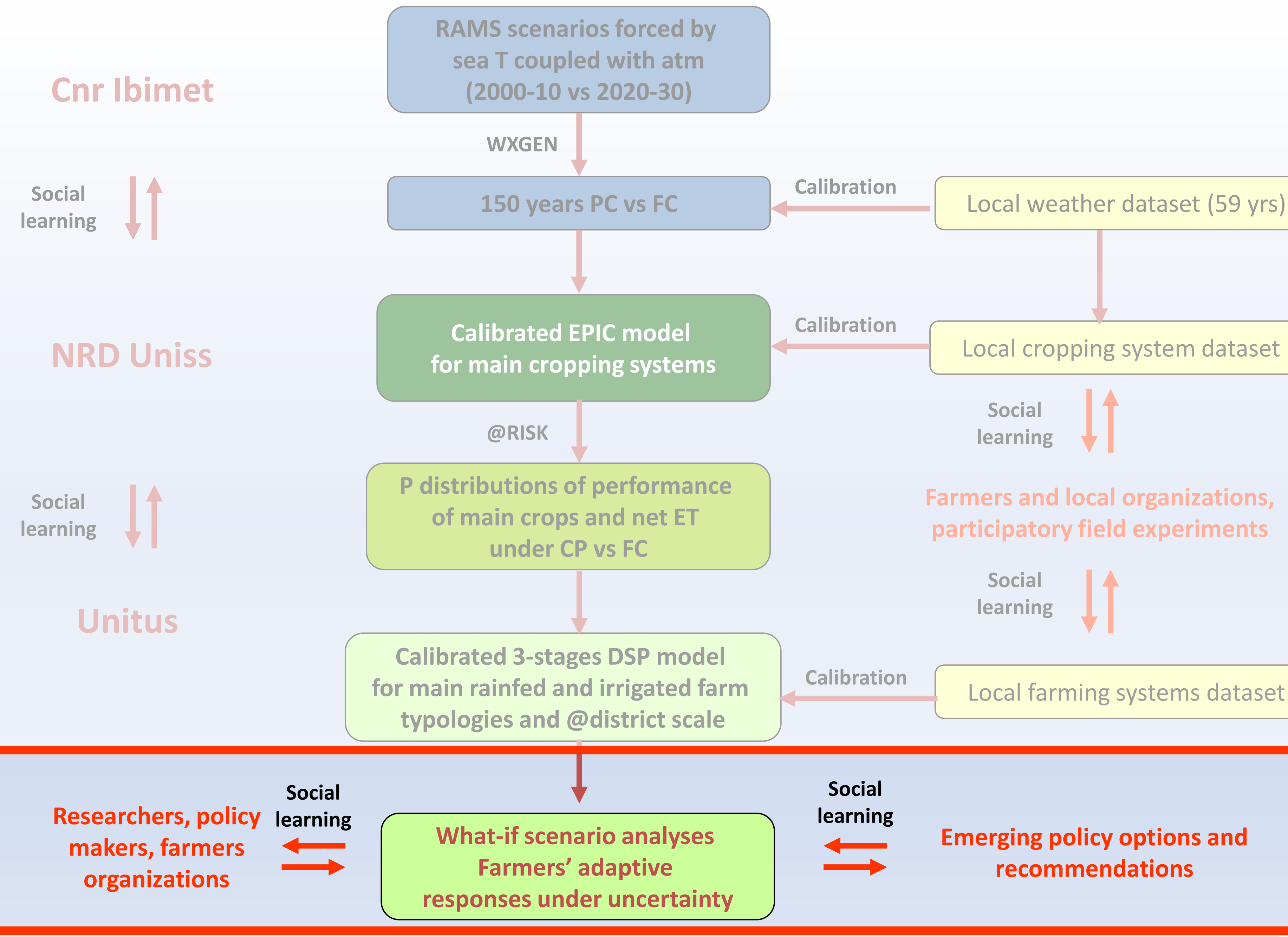
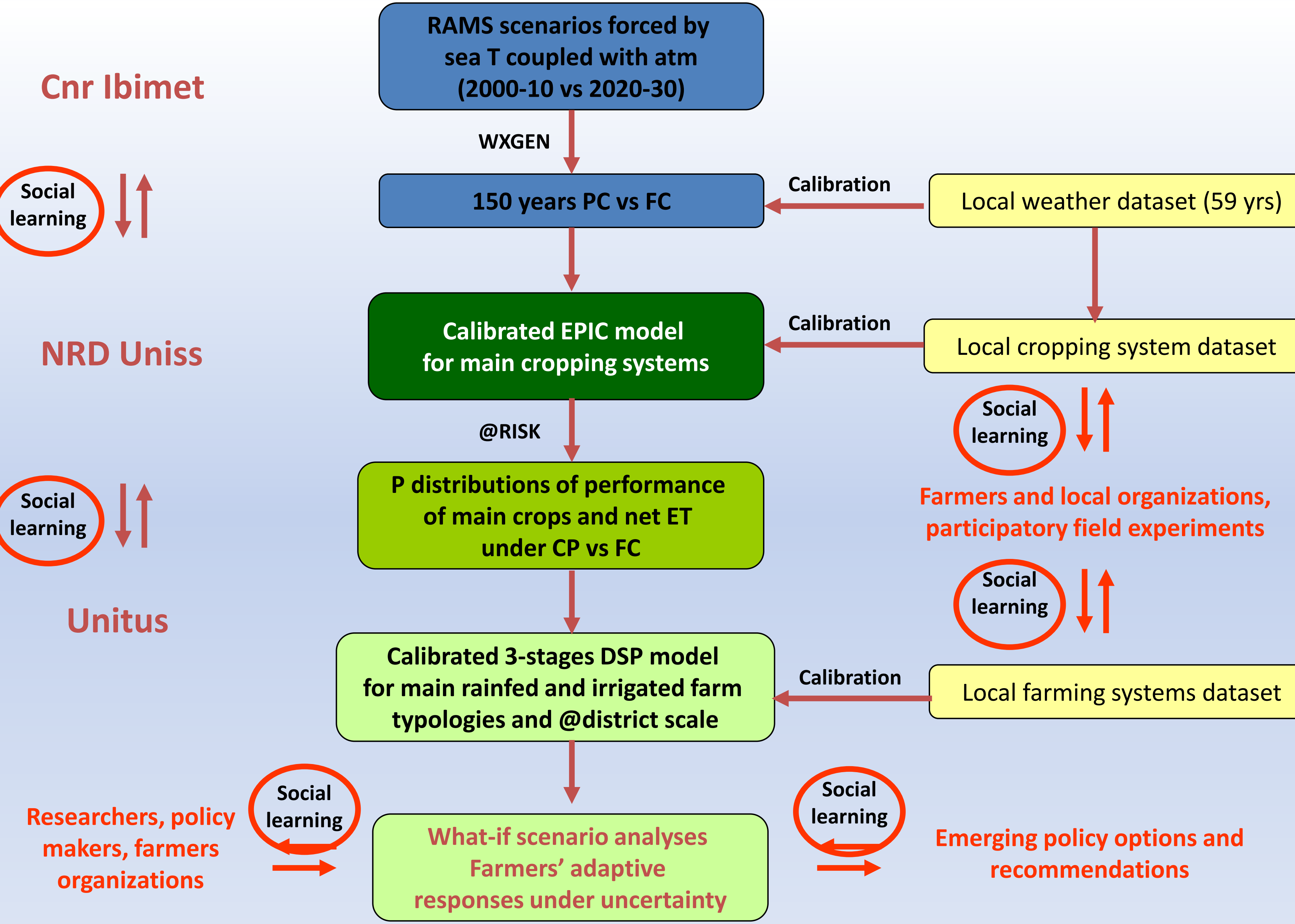
Farm typologies	Represented farms (n)	Farm land size (ha)	Typology % total NI	Near future vs Present climate	
				% per farm	Total area
Irrigated farms	1025	30,546	83		-6.1%
Rice	24	115	4	-0.7	
Citrus	68	13	4	-7.1	
Dairy cattle A	130	31	33	-6.4	
Dairy cattle B	40	32	6	-6.1	
Greenhouse	46	13	2	+0.3	
Vegetables – Cereals	562	22	24	-1.2	
Cereals – Forages	55	146	9	+1.0	
Tree and arable crops	100	6	2	-0.9	
Rainfed farms	556	22,371	17		-8.8%
Vegetables - Fruit	100	4	2	-0.1	
Cereals - Forages	94	25	2	+0.0	
Sheep A	45	87	3	-9.0	
Sheep B	188	41	4	-5.1	
Sheep C	129	62	7	-7.4	
					-6.5%

desertification and its relations to climate, environment and agriculture

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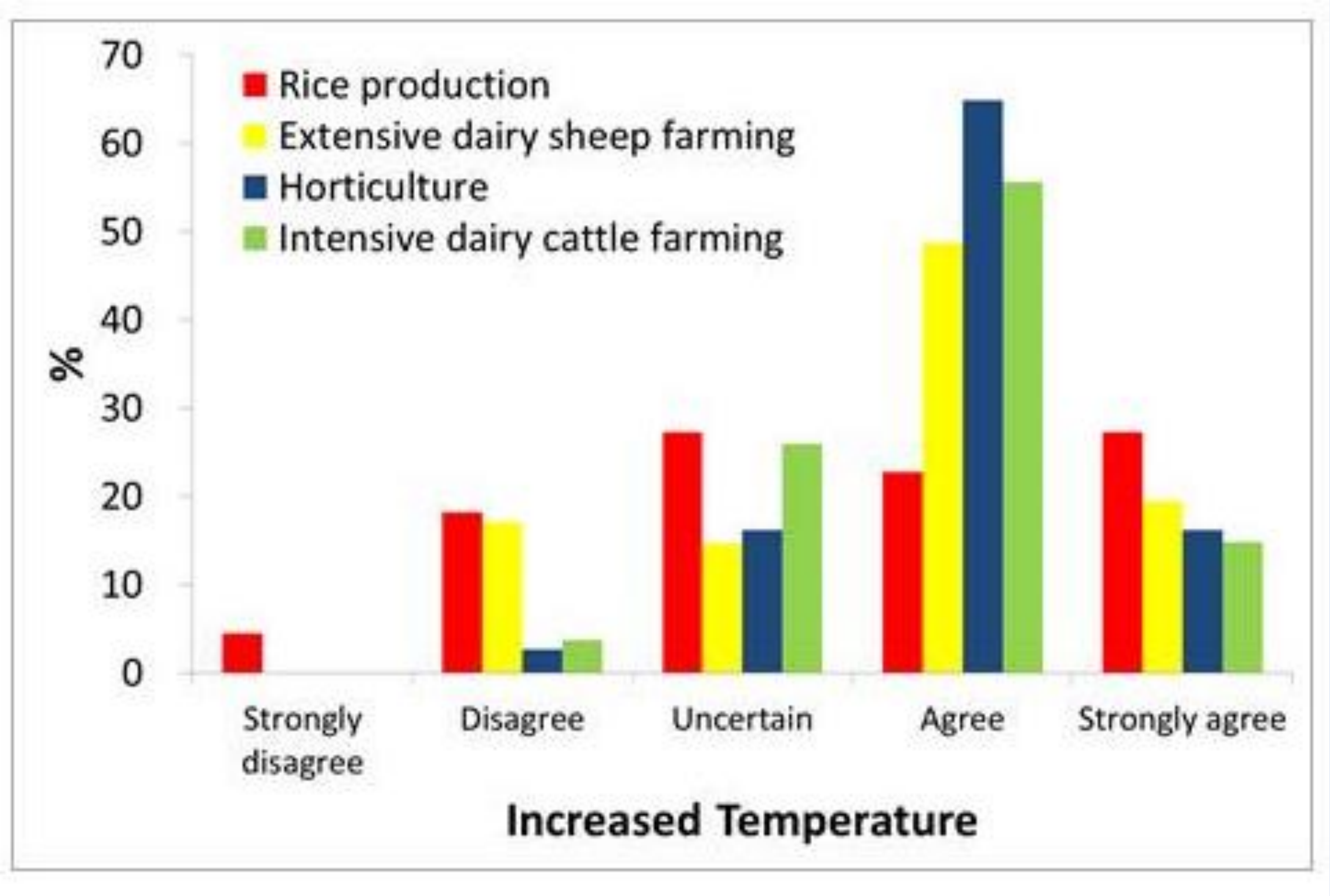
Farmers' CC perception

Perceptions	% of interviewees	n. agreem/total respondents
Unpredictable seasons	88%	22/25
Increased temperatures	68%	17/25
Increased rain variability	52%	13/25
Climate is not changing	8%	2/25

Analysis of Farmers' Perceptions and

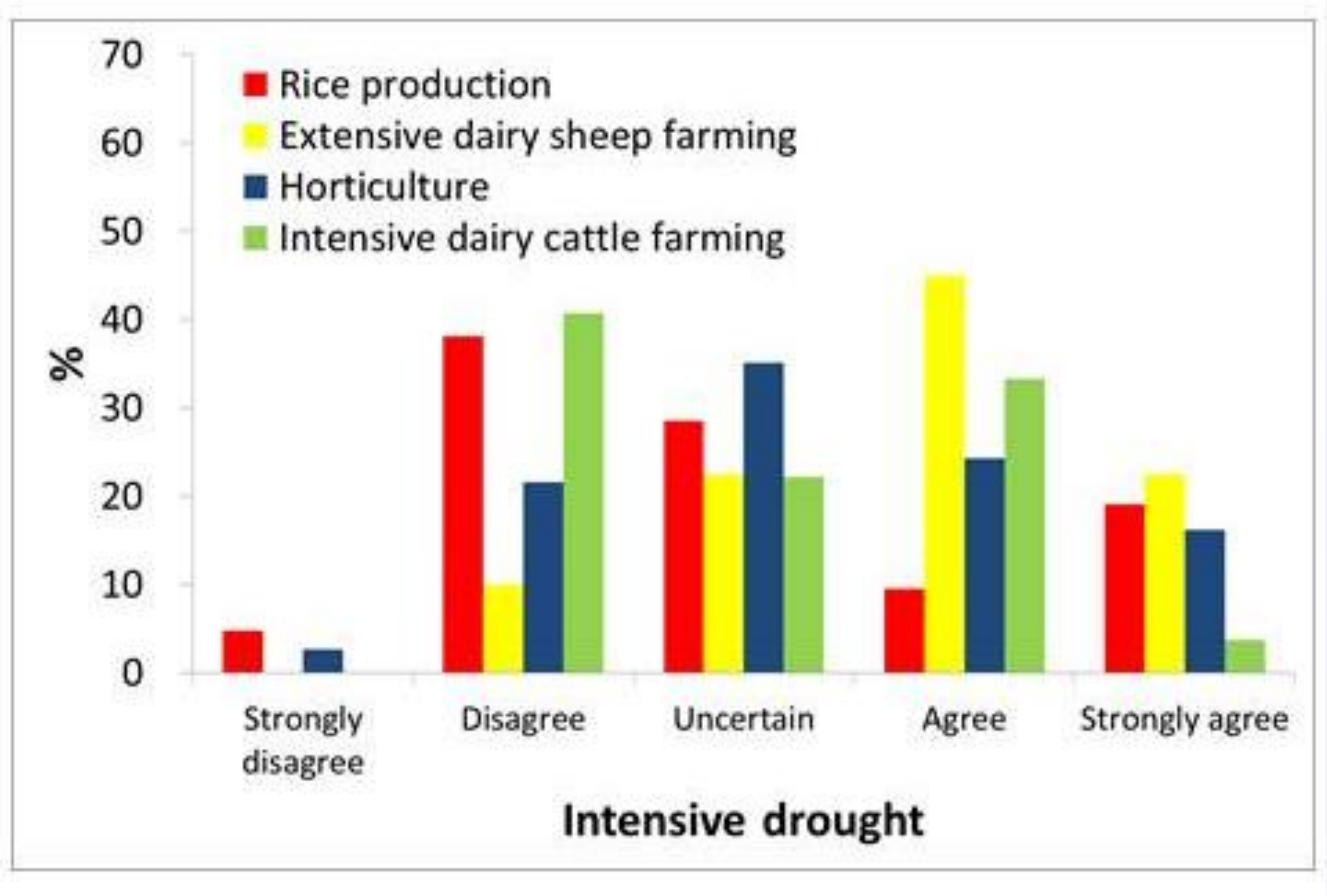
Results

- Likert-type questionnaires



Results

- Results from LikertType questionnaires



Dairy sheep farmers' perceptions of climate impacts

- Indicator of winter temperature: **daily milk production**
  - Winter less cool now than in the past (less frost)

- Uncertainty of **autumn pasture** availability
  - date of the first rainfall after summer
  - difficulties in seed bed preparation for the annual forage crop cultivation in rainy autumn (mainly with high stocking rate)

- Uncertainty of complementary forage resources availability from annual forage crops
  - **spring rainfall** is critical to hay production to address autumn pasture uncertainty

Farmers' response to climate variability

The majority of farmers have already responded to perceived CC

Actions already taken	Actions farmers think to take
• Change/**diversify** crops • Improve **irrigation** systems • Improve **animal health:** veterinary services, hygiene in stables • Change/improve the animal **diet** • Follow daily **weather forecast** to support actions on the spot • Do nothing (8%)	• Improve **infrastructure** (farm structure, stables, barns, sheds) • Adopt new **technologies** (i.e. air conditioning systems for animals) • Improve water use **efficiency** at farm scale • Interact with technical **advisors**, researchers, neighbors • Participate to **social networks** to enhance adaptive capacity

Farm level adaptation options and agenda for RDP as identified by SH

	Farm level possible adaptation strategies	Adaptation agenda for rural development
Extensive farming systems	- Reduce **water** consumption - Use **conservation tillage** - Improve **new grazing areas** - Improve forage **self-supply** - Change forage system: more **grassland** less arable crops - Strengthen integrated **agro-forestry-pastoral system** - Recognize the role of graziers as **landscape managers**	- Support maintainamce of permanent **grasslands** - Support to **farms' structure improvement** - Improve advisory **services** - **Link complementary districts** to exploit forage resources: encourage pro-active farmers, participatory approaches - Investment in **co-research with farmers** on CC adaptation practices

Discussion

- Emerging frames informing scenarios:
  - **Type 1 - Individual adaptation**
  - **Type 2 - Collective adaptation**

Discussion

Type 1 scenario: Individual adaptation (each farmer for himself)	
1.1. "Proactive"	**1.2. "Passive"**
Self-establishment of adaptation practices: Increase farm size, invest on hi-tech (e.g. dairy cattle farms)	Increased **uncertainty** (e.g. because of no anticipated adaptive responses) **Few investment** in technologies and improved farming practices (eg sheep)
Risks Environmental **pollution** Costs of water and energy are perceived as additional pressures	**Risks** **Abandonment** of large grazing districts

Discussion

Type 2 scenario: collective adaptation (all SH for all farmers)

2.1: "Bottom-up"

Collective adaptive responses,

Hi-tech farms (e.g. dairy cattle) will continue to develop (e.g. increase farm size, diversify crops, investment in technologies…);

Low-tech farms (e.g. some dairy sheep) can be also sustained and improved.

Opportunities:

more **investments in research** on specific farm-level adaptation practices e.g. bio-fuels, waste water treatment, irrigation mgt...

2.2. "Top-down "

a. **Effective policy measures**:

Hi-tech farms will grow

Low-tech farms sustained, no changes

b. **Inadequate policy measures** :

Hi-tech farms rely on endogenous adaptive capacity

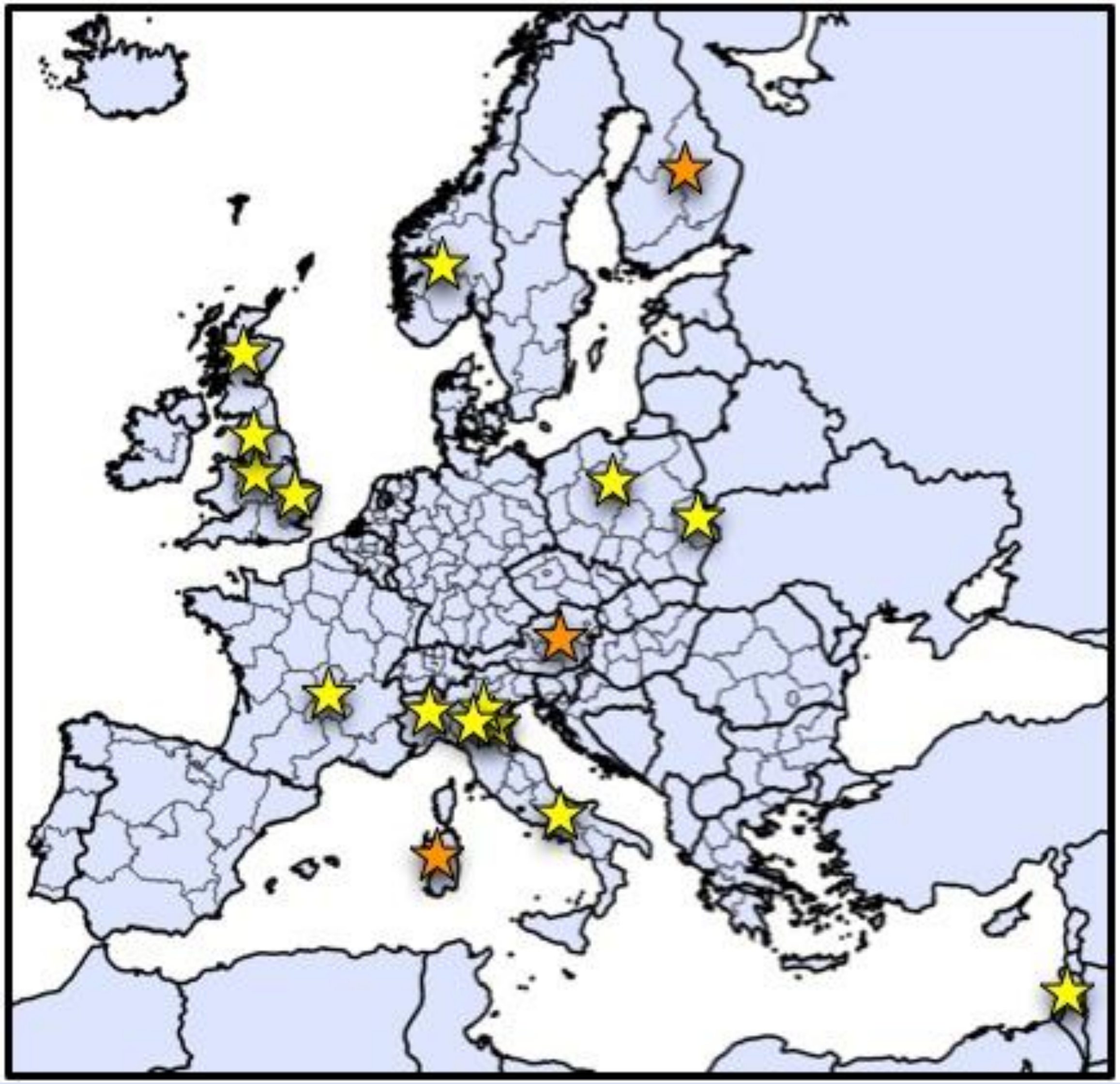
Low-tech farms risk to **disappear**.

Assumptions:

No long-term adaptation developed, no multi-stakeholder participation to the design of RDP measures

Conclusions and Implications

- Adaptation scenarios depend on different ways and attitudes in looking into the future
  - **Perceptions** of CC and impacts
  - Investments on endogenous **adaptive capacity** (lay knowledge, skills, experiences, etc.) and exogenous **driving forces** (science, incentives, resources, etc.)
- Combining modelling with social learning was effective in generating credible scenario analysis (Nguyen et al 2013)



http://macsur.eu/index.php/regional-case-studies/

Some refs

- Allan et al 2013 Ital J Agron
- Collins & Ison 2012 Env Pol Governance
- Colvin et al 2014 Res Pol
- Dono et al 2013 Agric Sys
- Dono et al 2013 Water Res Manage
- Ison et al 2007 Environ Sci Policy
- Ison et al 2011 Water Res Manage
- Nguyen et al 2012 Ital J Agron
- Nguyen et al 2013 Int J Agric Sustain
- Steyaert & Jiggins 2007 Environ Sci Policy
- Toderi et al 2007 Environ Sci Policy