Modelling European Agriculture with Climate Change for Food Security

Analysis of climate change adaptation with bio-economic farm models: lessons from MACSUR regional pilot studies

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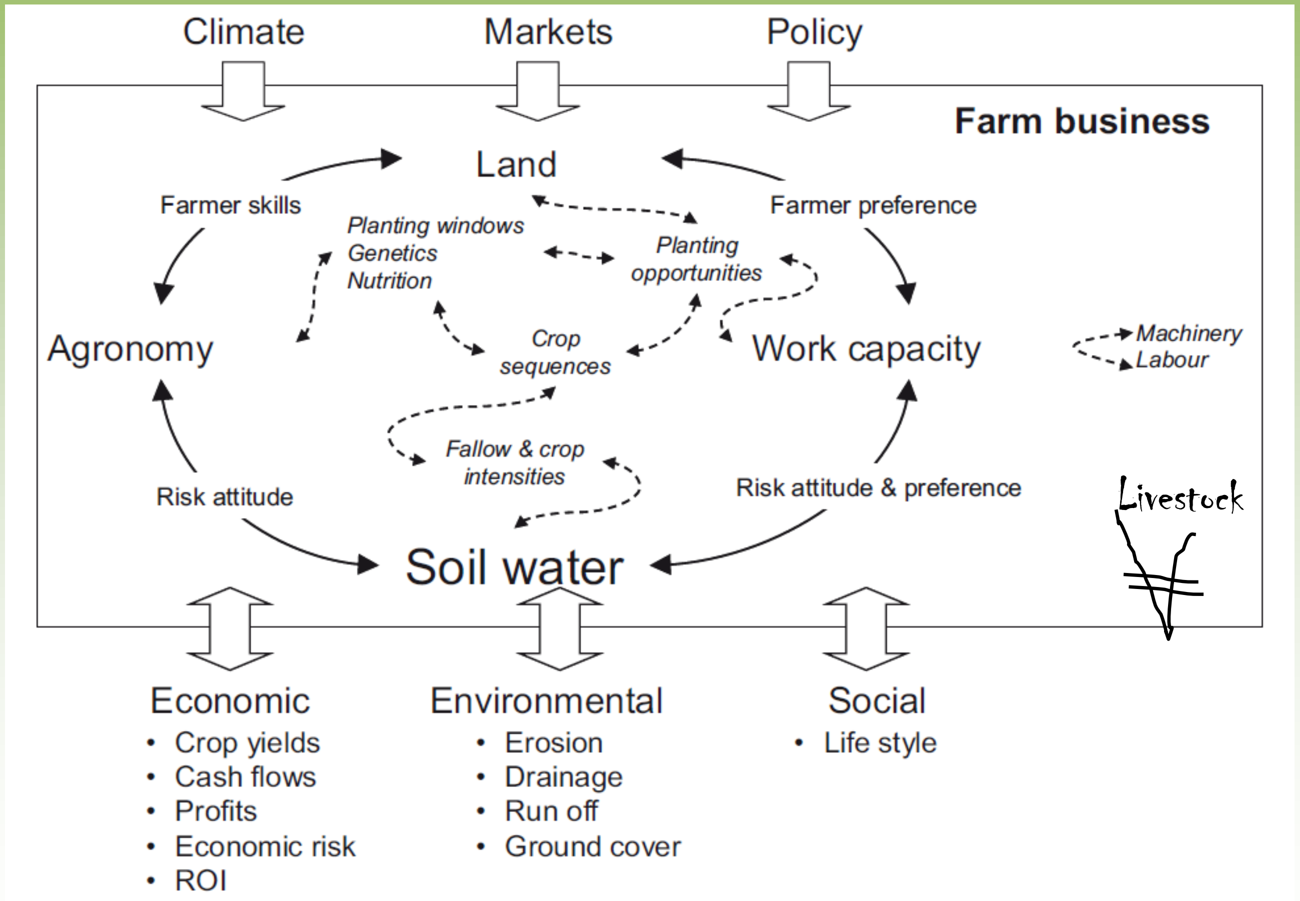
Farming System Perspective



Rodriguez et al. (2011):

Sketch of a farm:
external variables and internal interactions determining the economic, environmental and social impacts of the system.

Farming System Perspective (II)

- farmers adapt continuously…
- to changes in markets, policies, technologies and natural conditions…
- based on their preferences, expectations, risk behavior and adaptive capacity.
- farmers are constrained by their
  - resource endowments & natural production conditions
  - market access
  - policies,
  - knowledge & skills

Climate change is different…

- A multidimensional global change phenomenon that impacts (global) markets, (national) policies and (local) natural production conditions
- Impacts on livestock, plant production and natural resources
- Regional heterogeneity creates winners and losers
- Changes are outside the ranges observed in the past
- Changes are not continuous and difficult to detect for farmers (-> noise of weather variability)
- Impacts are uncertain

-> Business as usual decision making may no longer be viable

Need for integrated modelling with bio-economic farm models

- Link climate signal to farm management and land use decision
- Model economic, environmental and social impacts of adaptation
- Consider spatial scales at high resolution
  - Large spatial aggregation may overestimate flexibility and
  - Neglect spatial heterogeneity of climate change impacts
- Consider dynamics
  - Increasing variability increases the effectiveness of inter-seasonal management
- Communicate results to stakeholders

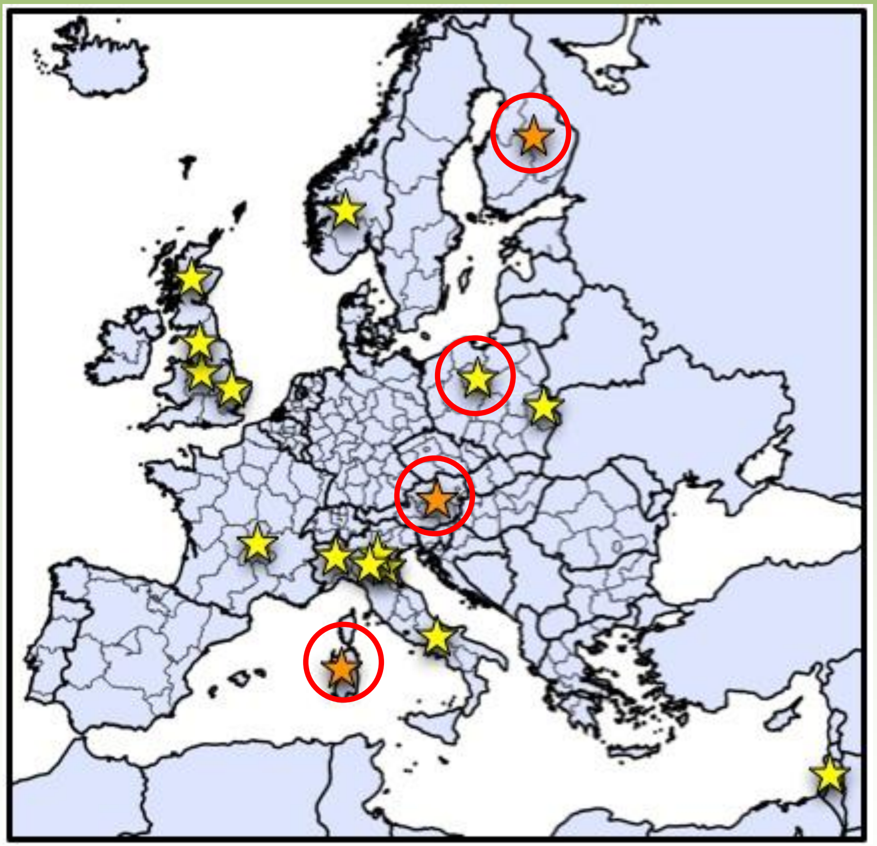
Research objectives

- Enhance the understanding of climate change compared to other drivers of farm level management
- Derive good practices to model farm level adaptation in bio-economic farm models (BEFM)

Adaptation
What should be considered?

- representation of farm level decision making
- high spatial resolution
- representation of intra-farm interactions (e.g. livestock & plant production, labor organization, mechanization schedule)
- climate change signals transformed to farm level drivers
- representation of policies on adaptation and mitigation
- availability of adaptation options
- farm resource constraints are related to adaptation options
- consideration of uncertainties

Case studies (I)



Models are applied in four regional case studies over major climate zones in Europe

www.macsur.eu/index.php/regional-case-studies/

Case studies (II)

Bio-economic farm model	Origin	Type	Optimization	Representation
MODAM	DE	LP	multi-objective (e.g. gross margin)	typical farms
FAMOS[space]	AT	MIP	max. gross margin	all farms in landscape
Demcrop	FI	NLP	max. profits (dynamic), risk considered	representative farms
Hybrid TRF	IT	NLP	max. gross margin (inter-annual dynamic), PMP	territorial with representative farms (TRF)

Results (I)

Model	Climate signals as drivers in farm decision making
MODAM	crop production data from expert knowledge including future yields and water demand, scenarios on GHG impact of legumes, linking with crop model HERMES planned
FAMOS[space]	EPIC models crop and forage yields based on daily-resolution climate data; impacts on soil resource base (erosion, SOC) considered,
Demcrop	DREMFIA models crop and forage yields taking into account development of water limited crop yield potential weather data and pest and disease pressure
Hybrid TRF	EPIC and DSSAT model crop and forage yields based on daily-resolution climate data, observed and generated by climatological models (RAMS); livestock impacts are considered

Results (II)

Model	Representation of adaptation options: *Design process*
MODAM	defined by modelers based on expert information and literature
FAMOS[space]	defined by modelers based on expert information and literature
Demcrop	defined by modelers, experts, extension services, and farmers
Hybrid TRF	defined by modelers based on expert information and literature

Results – Adaptation options

Option	MODAM	FAMOS[space]	Demcrop	Hybrid TRF
Crop rotation choices	y	y	y	y
Cultivar choice	n	n	y	y
Cover crops	y	y	y	y
New crops and cultivars	y	n	y	n
Tillage options	y	y	n	y
Fertilization options	y	y	y	y
Liming	n	n	y	n
Weed & pest management	n	n	y	n
Irrigation	y	y	n	y
Landscape elements	n	y	y	y
Buffer strips and catch crops	y	n	n	n
Afforestation/Deforestation	n/n	y/n	n/n	n/n
Grassland conversion	n	y	n	y
Livestock herd size, dietary choices	y	y	n	y

Results (IV)

Model	Representation of mitigation policies
MODAM	mitigation policies considered
FAMOS[space]	adaptation and mitigation policies are considered to analyse trade-offs: energy crops and short rotation forestry allowed on ecological focus areas, agri-environmental program, subsidy for afforestation, irrigation premium, abolishment of greening
Demcrop	fertilisation limits and extensification incentives in CAP pillar 2, specific conditions of CAP pillar 1, protein crop subsidies
Hybrid TRF	integration of adaptation and mitigation policies; feedbacks between energy crops, greening and pastures; agri-environmental programs; irrigation water pricing; extension of collective irrigation systems

Discussion (I)

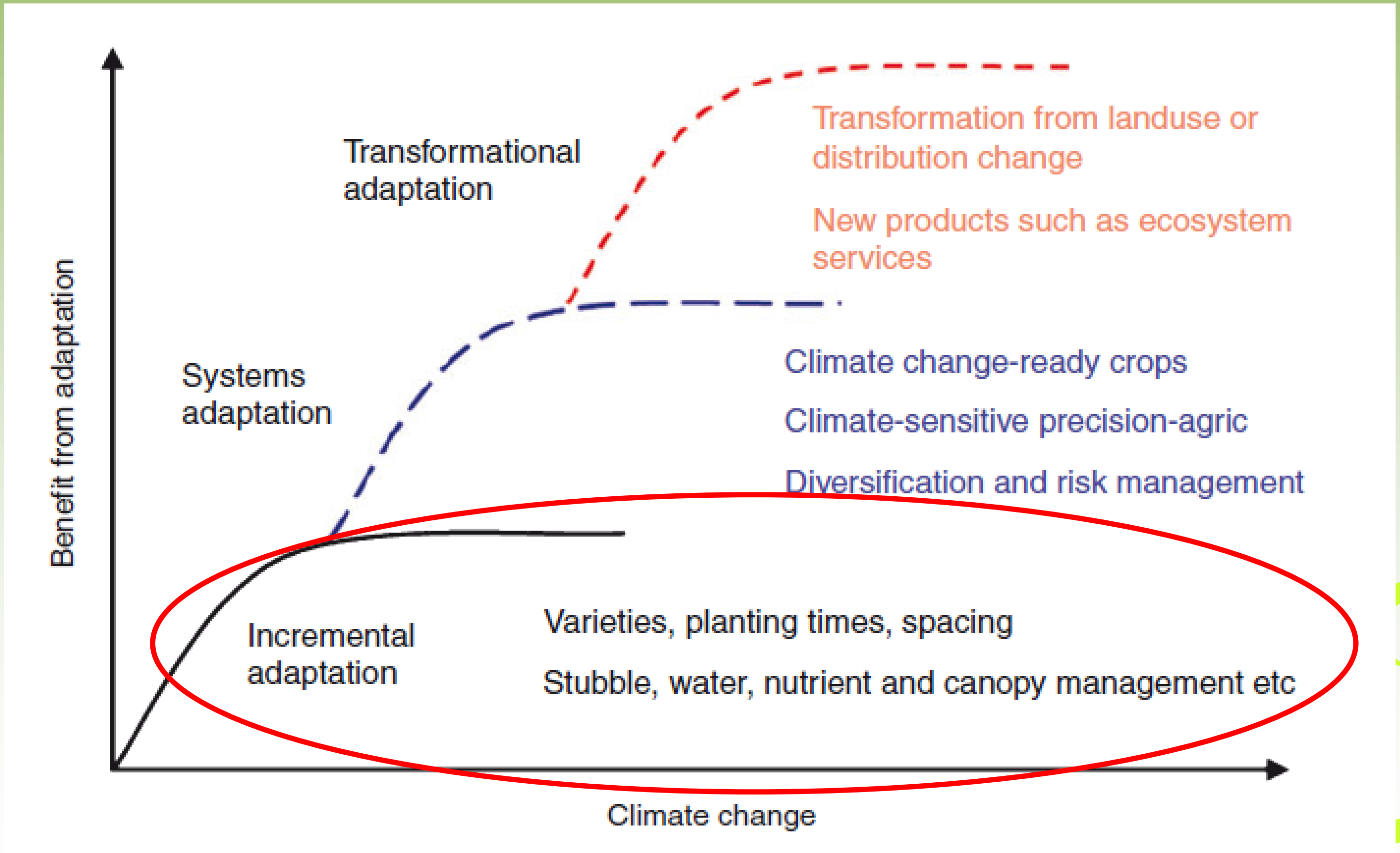
- Climate change is different from other farm level land use drivers considered so far
- There is high information demand by farmers, industry, administration, and policy makers on farm level adaptation
- Climate change impacts and adaptation behavior is uncertain
- BEFM show optimal adaptation behavior under strict assumptions on preferences and risk
- Criteria need to be defined on the transferability of model results to larger spatial aggregates.

Discussion (II)

- All are programming models optimizing more or less elaborated forms of utility (gross margin – multi-criteria)
- All consider or plan to consider crop yield impacts from bio-physical crop models based on daily-resolution climate data
- Some models include pest and diseases or livestock impacts. Non consider climate change impacts on market prices or interactions among farms (see Berger and Troost, 2014)
- All models are spatially explicit and integrated but only some consider multiple spatial or temporal scales as well as dynamics (Gibbons and Ramsden, 2008)
- Adaptation options determine the solution space and are mainly expert-based in the regional case studies.
- Modelling of adaptation requires interaction with stakeholders (Schaap et al., 2013).

Hierarchy of adaptation options

Rickards and Howden (2012)



Outlook

- Next research steps:
  - develop a full list of adaptation specificities and compare to models
  - reveal the advantages and disadvantages of the models
  - define an ideal-type BEFM for climate change adaptation studies
  - define supplementary methods to BEFM to holistically describe farm adaptation

Thanks for your attention

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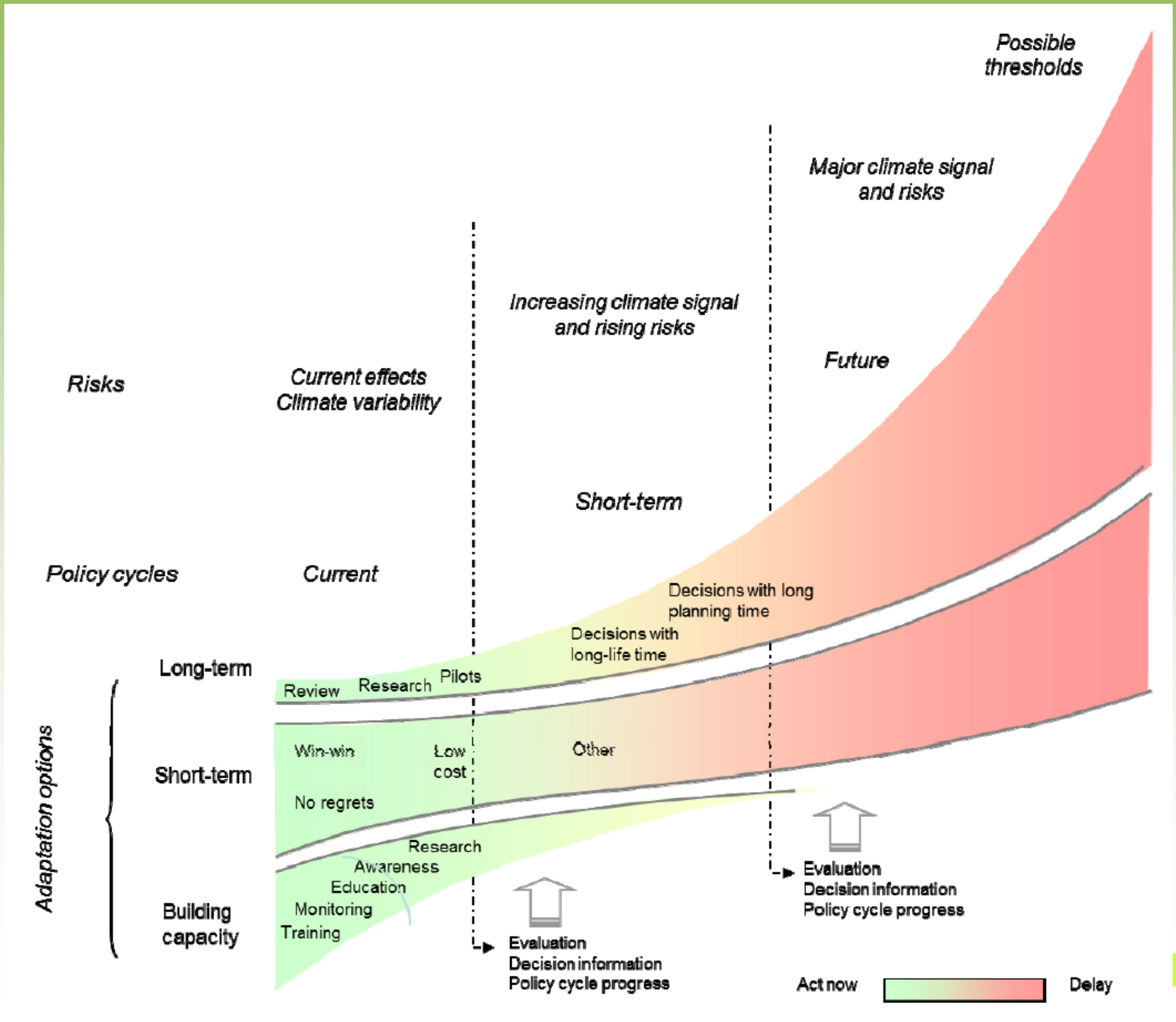
Knowledge demand on adaptation

- Farmers
  - Adaptation options and adaptation schedule to secure farm income and resource base while minimizing the social impacts of farming
- Society (i.e. administration/policy makers)
  - Design of policies to facilitate beneficial adaptation and mitigate mal-adaptation
  - Decision support on the allocation of research funds for adaptation options (e.g. breeding, new technologies)
  - Development of farm advisory strategies and facilitating planned farm level adaptation
  - Public planning on future food security

Adaptation pathway Wattkiss et al. 2010



What do we have to know and what to do when?

Results (III)

Model	Representation of adaptation options: *Available options*
MODAM	Irrigation and crop rotations
FAMOS[space]	farm and region-specific crop rotations, fertilizer intensity, mowing frequency, irrigation, tillage options and cover crops, land use change (crop – grassland – landscape elements - forestry), livestock numbers and feeding,
Demcrop	dynamic (field parcel specific) crop rotation choices, fertilizer intensity, crop protection, liming, fungicide use,
Hybrid TRF	farm and region-specific crop rotations, irrigation intensity and frequency, land use change (crops – grassland – landscape elements), change in livestock feeding and replacement, insurance