Modelling European Agriculture with Climate Change for Food Security

Integrated assessment of climate change mitigation and adaptation trade-offs in Austria

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Adaptation Futures 2016
Wednesday 11th of May 2016, Rotterdam, NL

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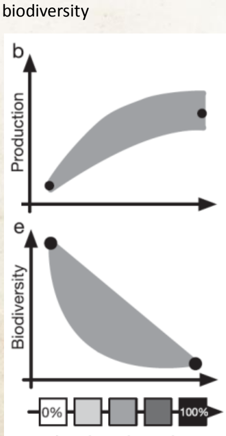
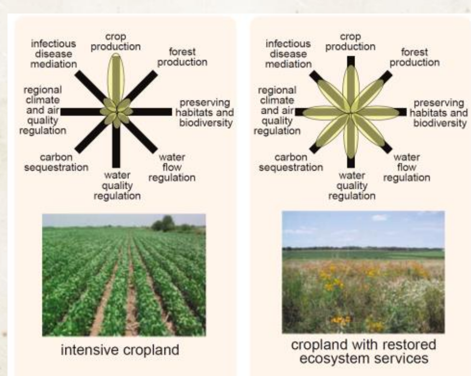
Trade-offs: common to land use

Hypothesized relationships of agricultural production and biodiversity



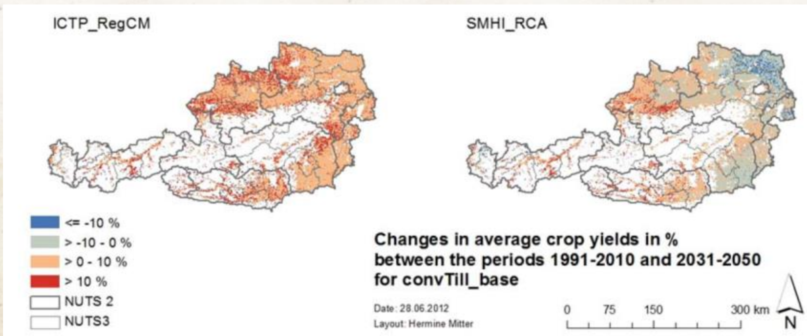
Seppelt et al., 2016. BioScience (in press).

Conceptual framework for comparing land use and trade-offs of ecosystem services.



Foley et al., 2005, Science 309, 570–574.

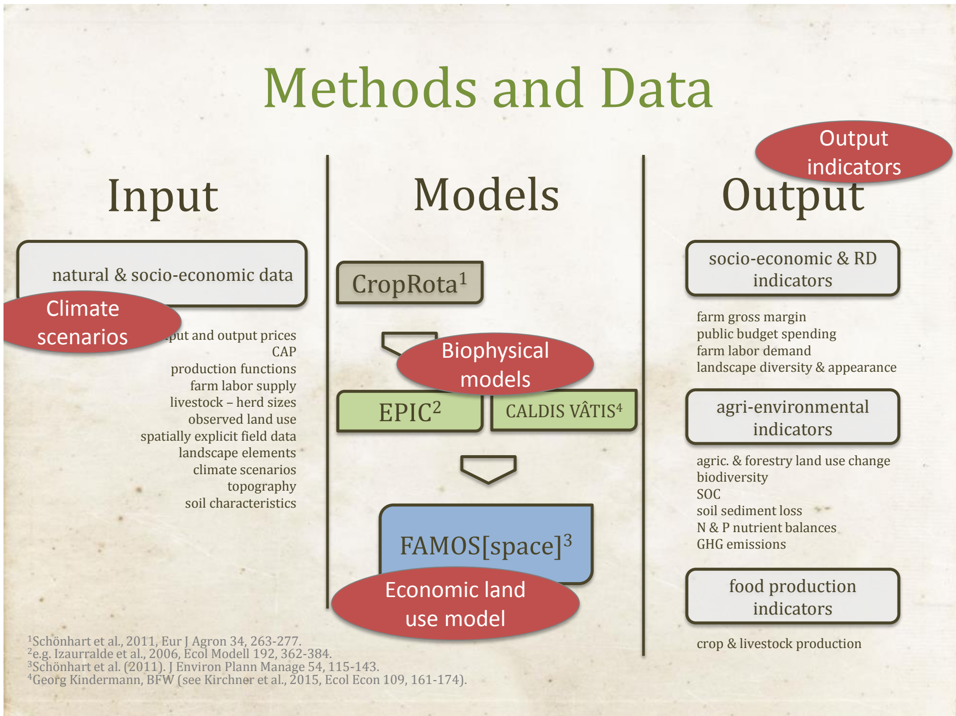
Climate change impacts: scenarios & location matters

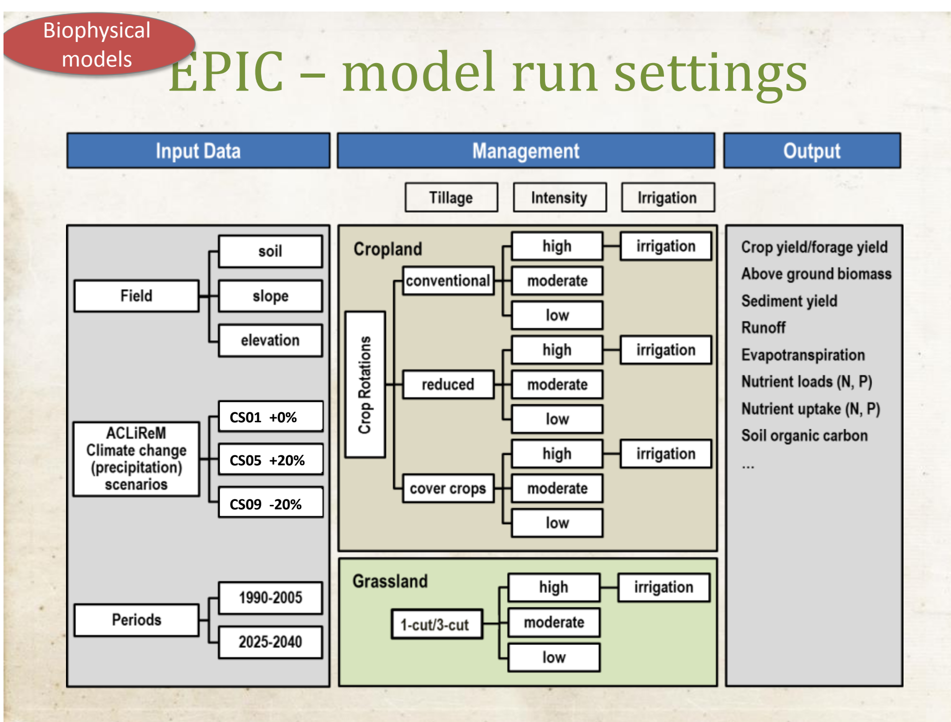


Schönhart et al., 2014. Ger. J. of Agric. Econ. 63, 156–176.

Key research questions

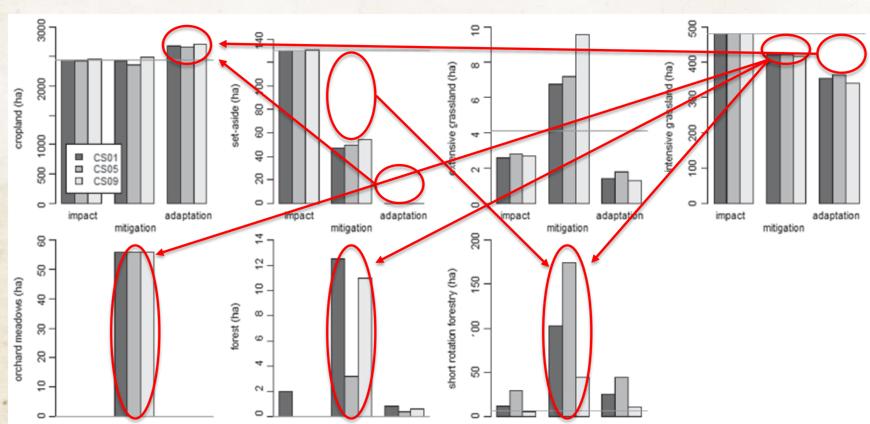
- How may climate change and related policies impact land use at national to landscape level?
  - Addressed by integrated model application
  - Role of heterogeneity among farms and climates
  - Adaptation -> profit-driven farm management choices
- What are the environmental and landscape effects from combined climate and land use change?
  - Synergies and trade-offs impacted by policies


Methods and Data
Input
Models
Output
Output indicators
natural & socio-economic data
Climate scenarios
put and output prices
CAP
production functions
farm labor supply
livestock – herd sizes
observed land use
spatially explicit field data
landscape elements
climate scenarios
topography
soil characteristics
CropRota1
Biophysical models
EPIC2
CALDIS VÂTIS4
FAMOS[space]3
Economic land use model
socio-economic & RD indicators
farm gross margin
public budget spending
farm labor demand
landscape diversity & appearance
agri-environmental indicators
agric. & forestry land use change
biodiversity
SOC
soil sediment loss
N & P nutrient balances
GHG emissions
food production indicators
crop & livestock production
1Schönhart et al., 2011, Eur J Agron 34, 263-277.
2e.g. Izaurralde et al., 2006, Ecol Modell 192, 362-384.
3Schönhart et al. (2011). J Environ Plann Manage 54, 115-143.
4Georg Kindermann, BFW (see Kirchner et al., 2015, Ecol Econ 109, 161-174).


Biophysical models
EPIC – model run settings
Input Data
Management
Output
Tillage
Intensity
Irrigation
Field
soil
slope
elevation
ACLiReM Climate change (precipitation) scenarios
CS01 +0%
CS05 +20%
CS09 -20%
Periods
1990-2005
2025-2040
Cropland
Crop Rotations
conventional
reduced
cover crops
high
moderate
low
irrigation
Grassland
1-cut/3-cut
Crop yield/forage yield
Above ground biomass
Sediment yield
Runoff
Evapotranspiration
Nutrient loads (N, P)
Nutrient uptake (N, P)
Soil organic carbon
...

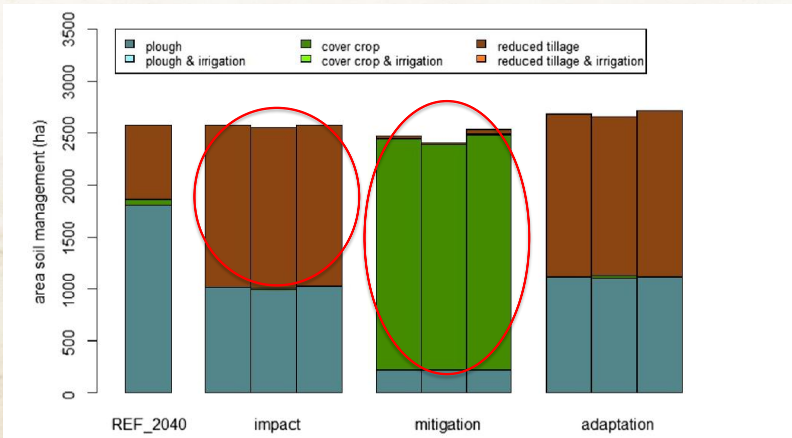
Case study: Central Europe, Austria, Mostviertel landscape
Model driver: climate, mitigation and adaptation policies
Results: compared to a reference policy scenario

Land use change at landscape level



Schönhart et al., 2016, Agric Syst 145, 39–50.

Soil management change at landscape level

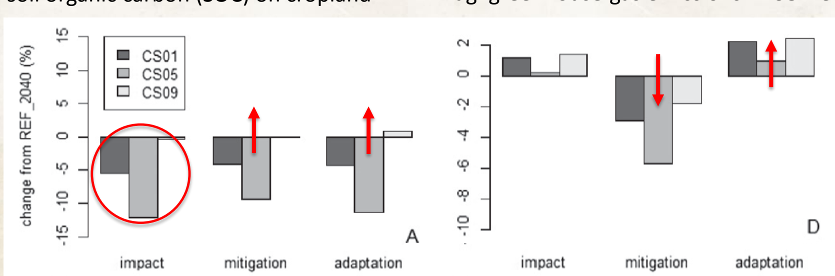


Schönhart et al., 2016, Agric Syst 145, 39–50.

Abiotic environmental indicators

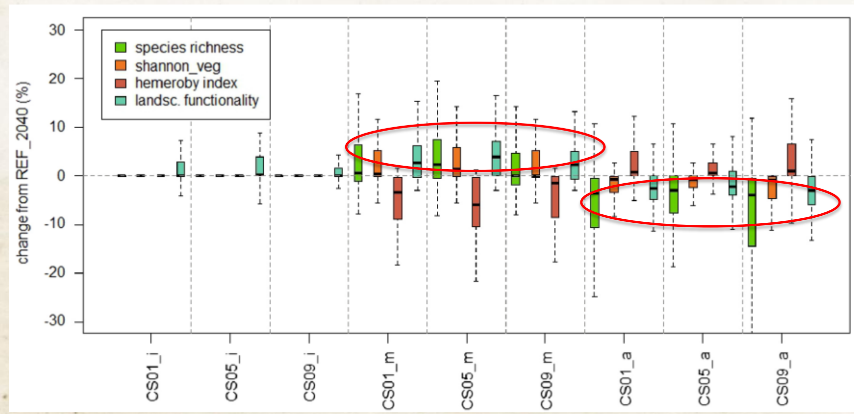
soil organic carbon (SOC) on cropland

ag. greenhouse gas emissions in CO2-eq.



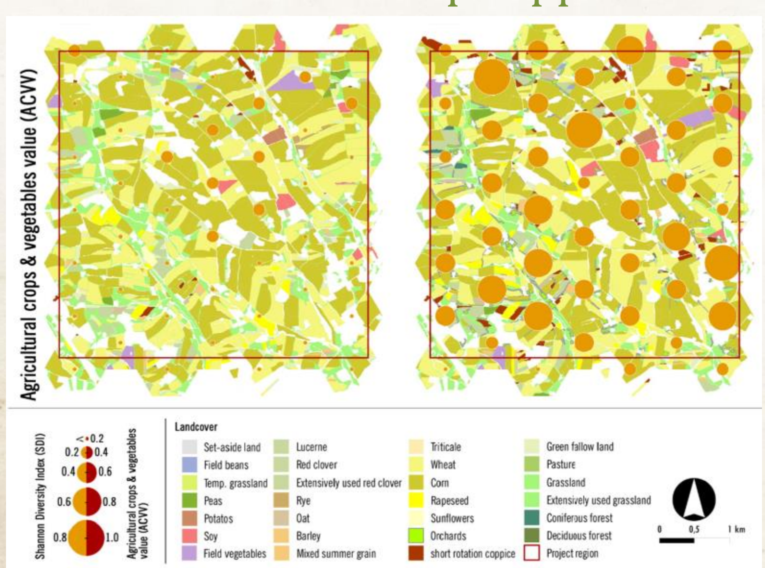
Schönhart et al., 2016, Agric Syst 145, 39–50.

Results - farm land biodiversity indicators from climate change and policies

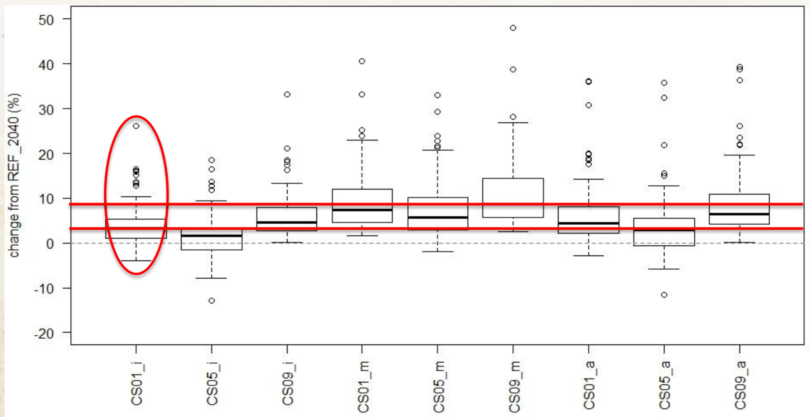


Schönhart et al., 2016, Agric Syst 145, 39–50.

Agricultural crops and vegetables value – indicator for landscape appearance



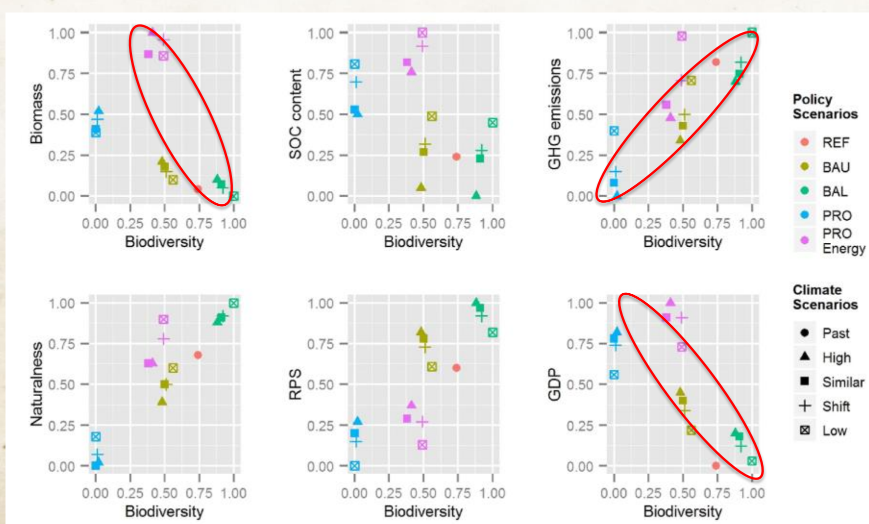
Changes in gross margins at farm level



Schönhart et al., 2016, Agric Syst 145, 39–50.

Gross margin: + product sales (plant, livestock) + subsidies + annuities for long-term investment
- variable costs (machinery, inputs and services, off-farm labor)

National level: trade-offs and synergies between biodiversity and selected indicators



Kirchner et al., 2015, Ecol Econ 109, 161-174

Discussion

- Increasing productivity from climate change on average
  - In line with some of the literature, but not all -> uncertainty
  - What about extreme weather events and variability?
  - How to communicate mitigation needs? cf. Egan and Mullin, 2016, Nature 532, 357–360.
- Increasing farm incomes on average from assumed policies
  - Mitigation policy increases environmental quality at the cost of public budgets and agricultural production -> leakage not considered
  - Flexibility from adaptation shows trade-offs between ag. production and env. protection
- Location determines impacts
  - Heterogeneous climate change impacts among regions and farms
  - Not only latitude but altitude to be considered as well in impact studies

Conclusions

- Increasing productivity increases intensification pressures
  - Threatened permanent grasslands and landscape elements, but
  - subject to resource constraints, costs and prices
  - Future RDP and environmental policy design (e.g. WFD) should take changing productivity into account
- What next steps are needed? Analyze uncertainties
  - Heterogeneity among climate scenarios -> climatologists
  - Extreme events and variability -> economists
  - Available adaptation options -> agronomists, economists
  - Ensembles of crop and grassland models -> crop modellers
  - Expert survey on observed and expected changes to complement modelling -> ongoing work
  - Improve data quality -> government

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This presentation has been supported by the Austrian the Federal Ministry of Agriculture, Forestry, Environment and Water Management of Austria within the FACCE-JPI Knowledge Hub MACSUR.