Climate change and policy impacts on protein crop production: a case study on integrated modeling aproaches

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outline

- context of analysis, stakeholders, policy relevance: protein crops
- research problem: integrated assessment and model comparison
- 2 models and 2 data sets
- scenarios and results
- comparison and lessons learned
- conclusions and discussion

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policy context of the analysis:

protein production and use

case study on soy beans in Austria

complementary use of two models on the same region

- **research questions**
  - what is the future of soy bean production in Austria
  - what are different models telling us
  - why are the resuts deviating but nevertheless very useful

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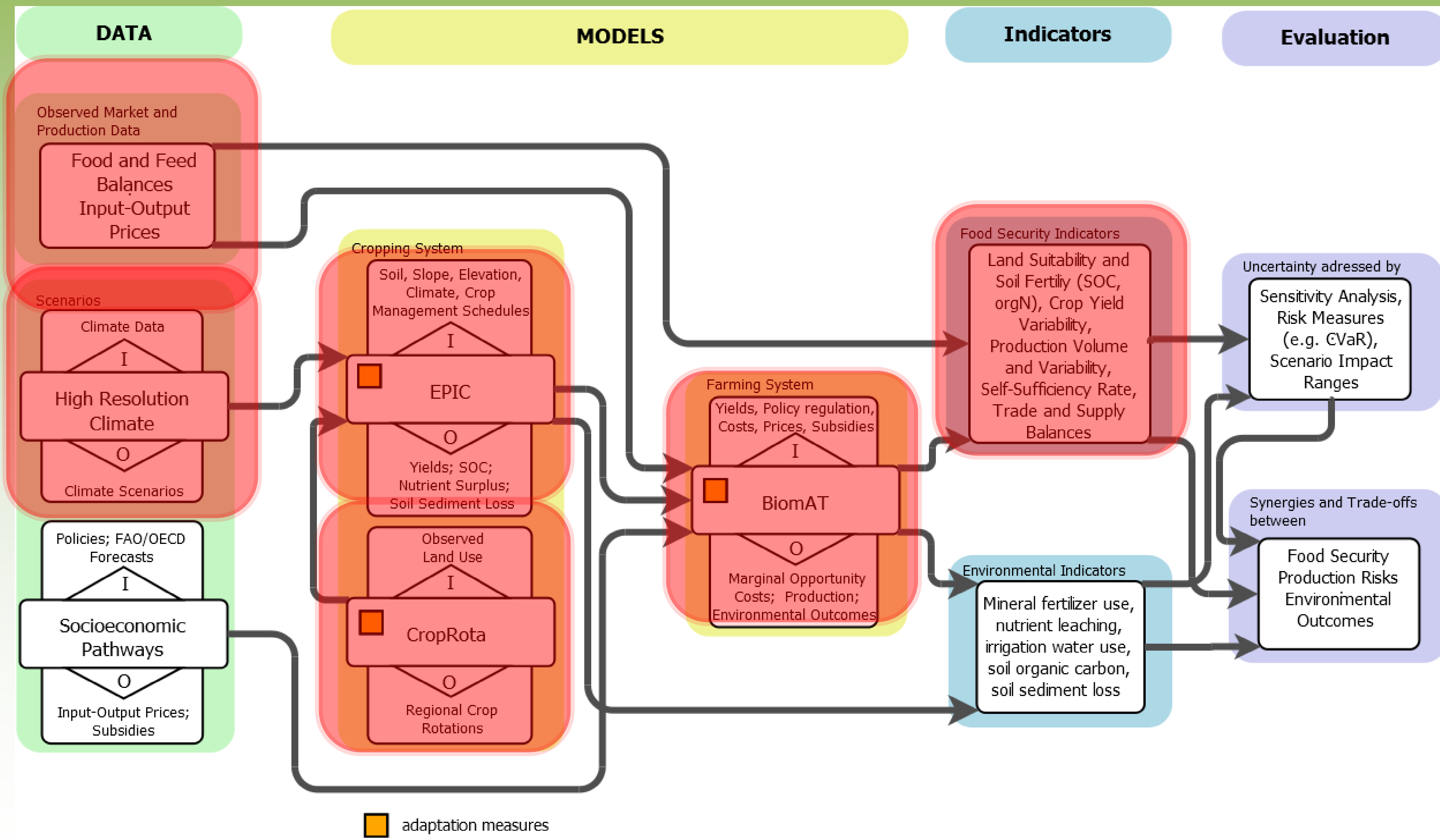
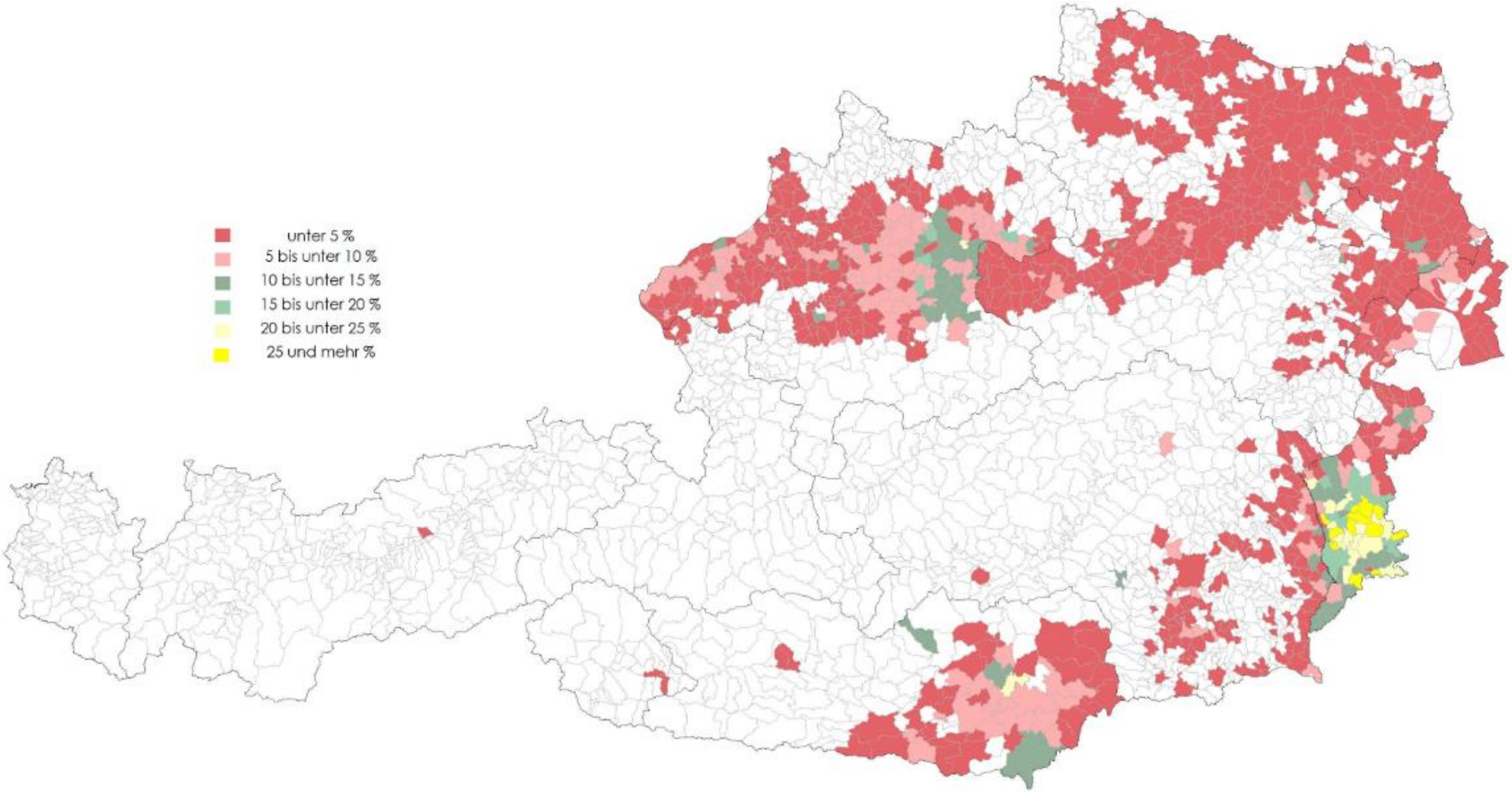
high spatial resolutions approach

integrated assessment modeling framework



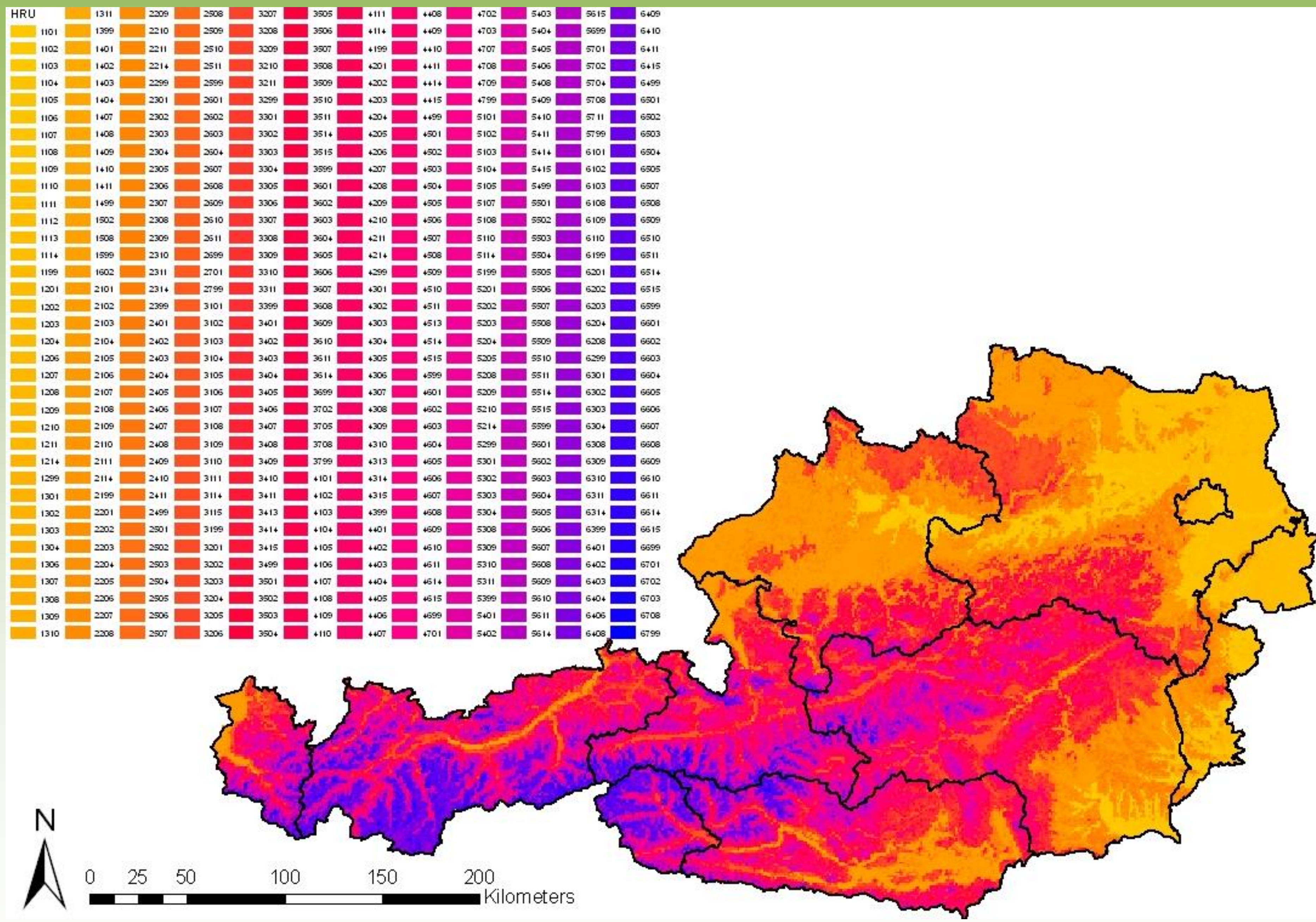
Source: own construction

regional production of soy 2012



Source: STAT, Agrarstrukturerhebung 2012

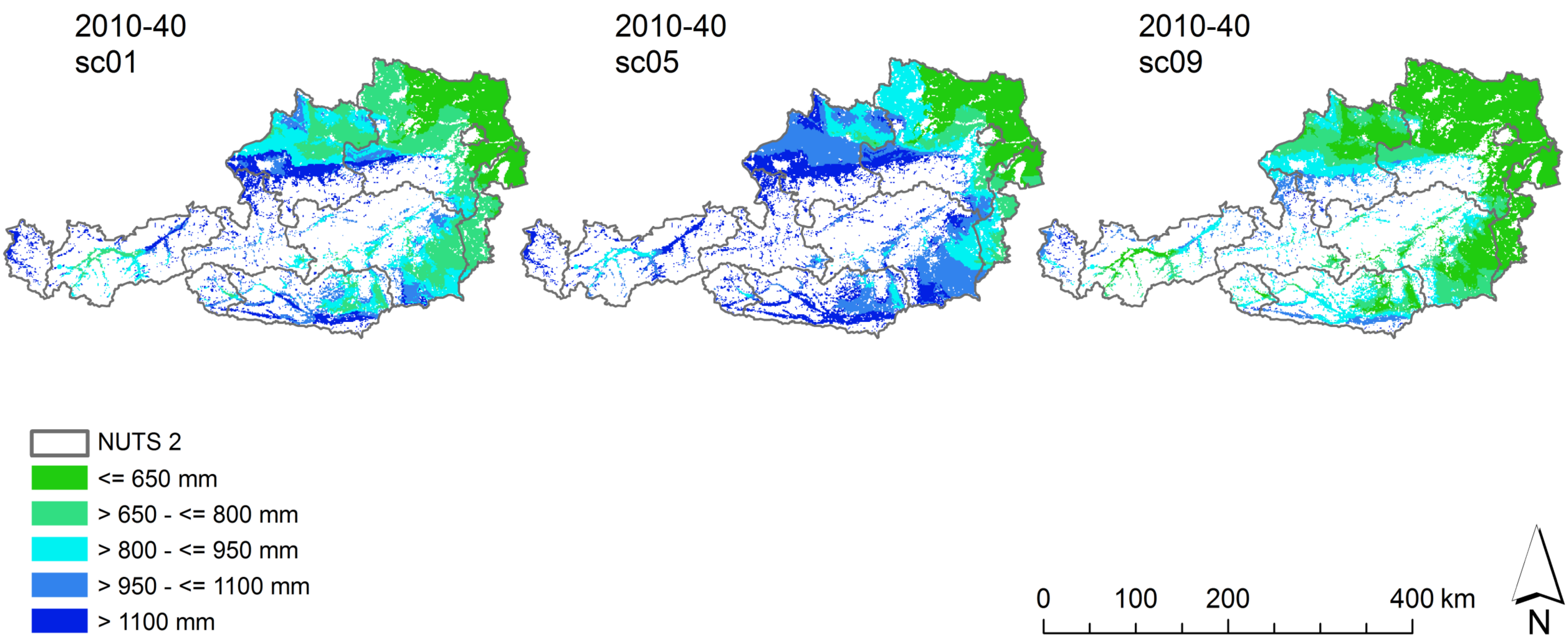
spatial heterogeneity
HRU Homogenous Response Units



Source: own construction

Data: Past and future climates

- **period 1975-2005: observed weather data**
- **period 2010-2040: 5 climate change scenarios (Strauss et al. 2012, 2013): rising trend in temperature (+1.5 °C), different precipitation scenarios**



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policy response:

goal stimulation of protein crops

greening of CAP 2013 reform

protein crops are more competitive

concern about CC

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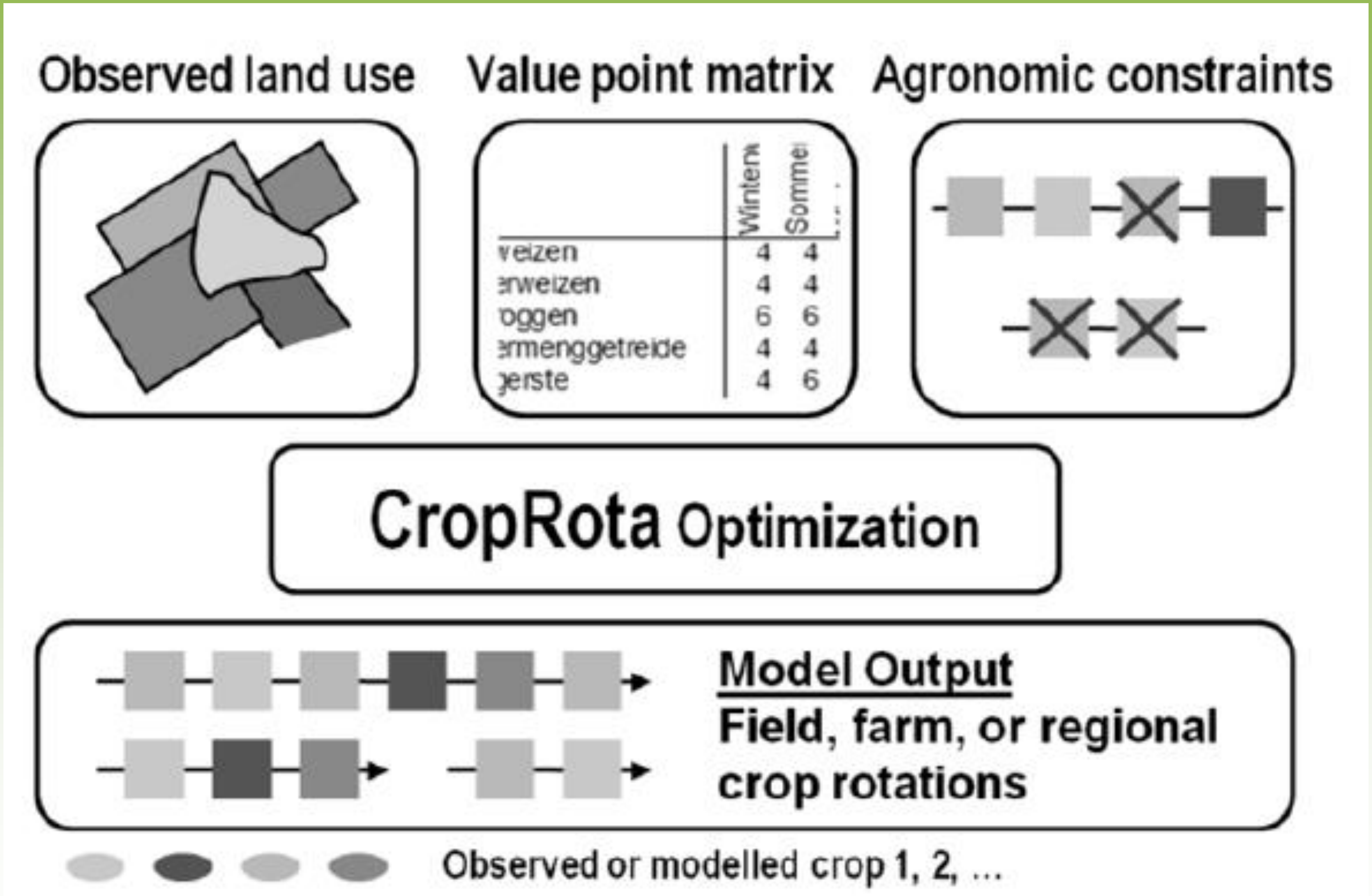
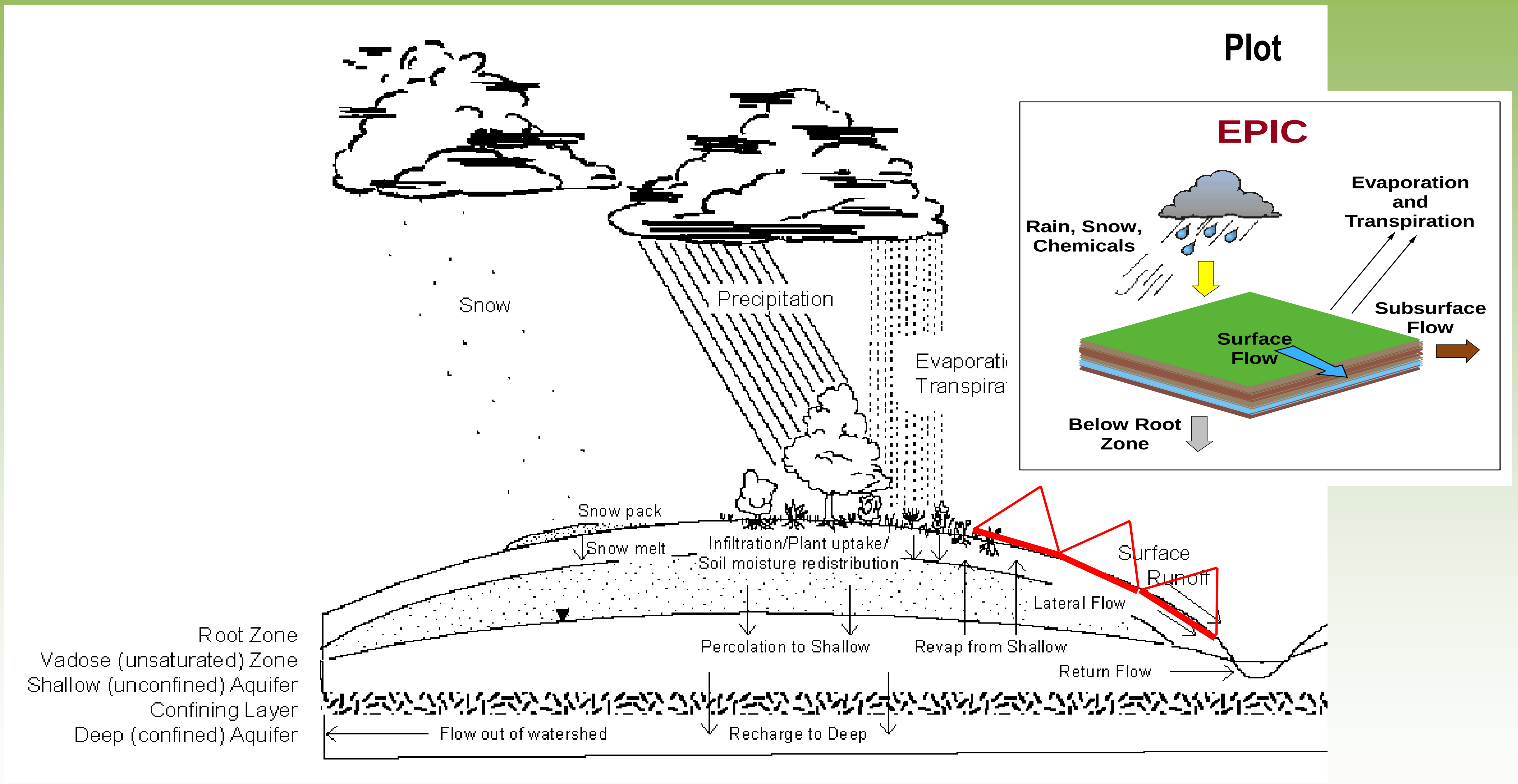
high spatial resolution approach models

CROP ROTA



Source: Schönhart, Schmid, Schneider, 2009

Bio-physical process model EPIC



Source: own construction

BiomAT

$$\max TGM_i = \sum_m \pi_{i,m} x_{i,m} \qquad \forall i$$

$$s.t. \sum_m \left(A_{i,m} x_{i,m}\right) \leq b_i \qquad \forall i$$

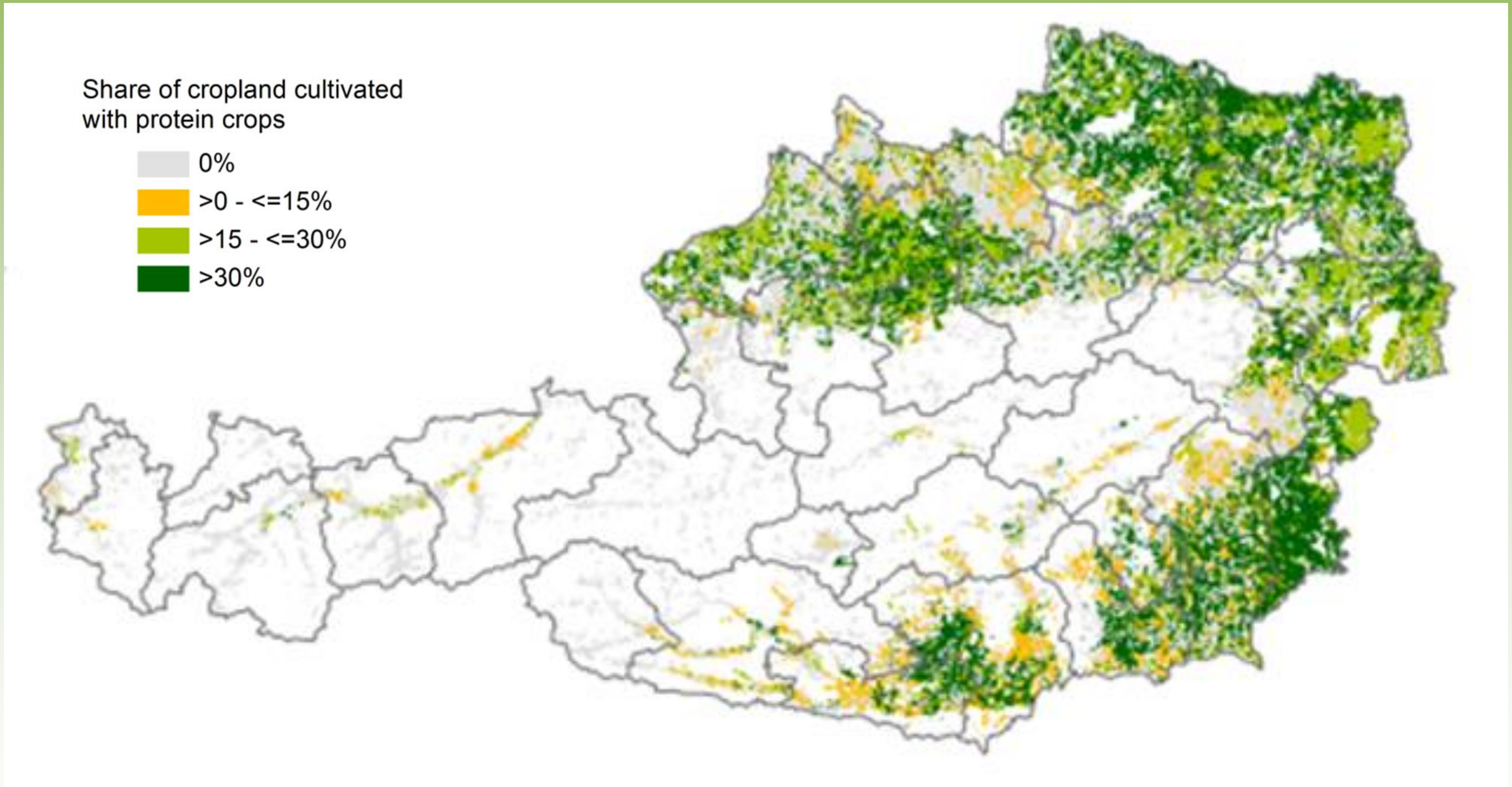
TGM	total gross margin
π	average gross margin in €/ha
i	grid cells (I=40,244)
m	management variants (up to 32 per i)
x	level of crop production in t
A	technical coefficients
b	resource constraints

Source: Asamer, Stürmer, Strauss, Schmid, 2011

BIOMAT: scenarios

- **future CC: 1.5°c +/- 20% precipitation**
- **increasing prices of protein crops**
- **c.p.: other prices/costs (2006/2008)**
- **more land for protein crops (proviously set aside land) for protein crops**
- **management variants *m*:**
  - considered: low/moderate/high intensity, irrigation
  - simulated: **more choices** on crop rotations

extreme scenario S20



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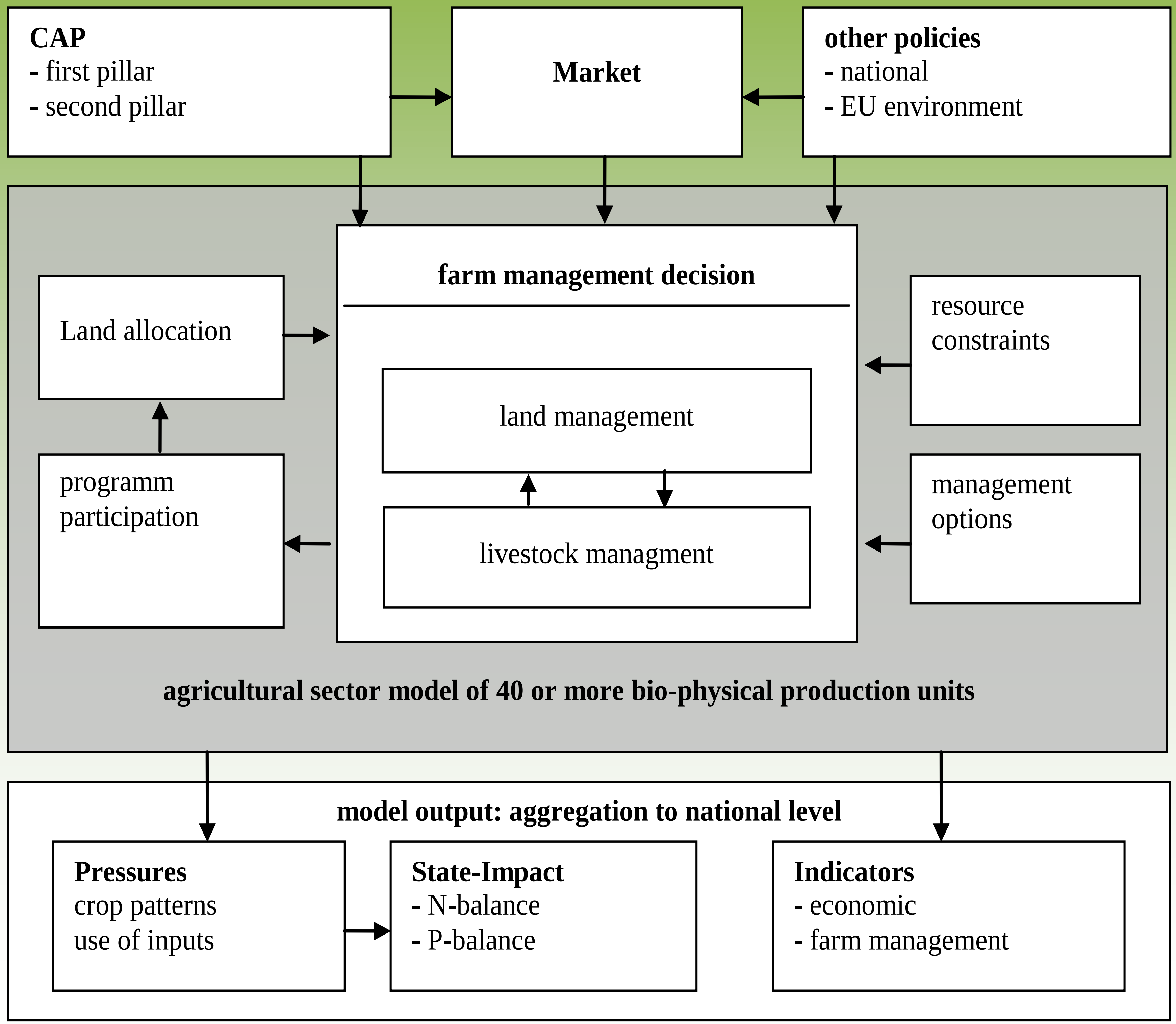
lower spatial resolutions approach

PASMA

PASMA


CAP
- first pillar
- second pillar
Market
other policies
- national
- EU environment
farm management decision
Land allocation
land management
livestock managment
resource constraints
programm participation
management options
agricultural sector model of 40 or more bio-physical production units
model output: aggregation to national level
Pressures
crop patterns
use of inputs
State-Impact
- N-balance
- P-balance
Indicators
- economic
- farm management

PASMA scenarios

- **REF: observed situation**
- **WEM – with existing measures**
- prices / costs OECD-FAO 2014; Energie UBA s.a.
- CAP und PRD after reform 2013
- loss of agricultural land goes on
- technical improvements (e.g. milk until 2050 by 35%)
- **WAM – with additional measures**
- more efficient use of manure, minerals, feed, more productive livestock

climate change mitigation measures

Climate measure	Description
Increase in lactation dairy cows	Increases number of lactations per cow; as a consequence reduced demand of heifers for replacement
Increase in efficiency of livestock	Increases yields of all livestock products except for dairy; assumed to be result of breeding and better (herd) management; no additional feed demand and costs assumed; milk increases are covered by index milk yield per cow
Increase in quality grassland/silage	Increases protein and energy content of all forage products, i.e. forage from permanent and temporary grasslands and silage maize; assumed to be the result of improved crops, better management; no additional costs assumed
Feeding efficiency increase	Reduced protein and energy demand of pig production; no changes in costs and manure production assumed
Reduction of losses manure nutrients	Reduced loss of nitrogen from all livestock manure; assumed to be the result of better management free of additional costs
Reduction of losses of fertilizer	Reduced loss of nitrogen from all mineral fertilizer; assumed to be the result of better management and spreading equipment free of additional costs
Additional energy crops	Model is forced to increase area of short rotation forestry

scenarios assumptions

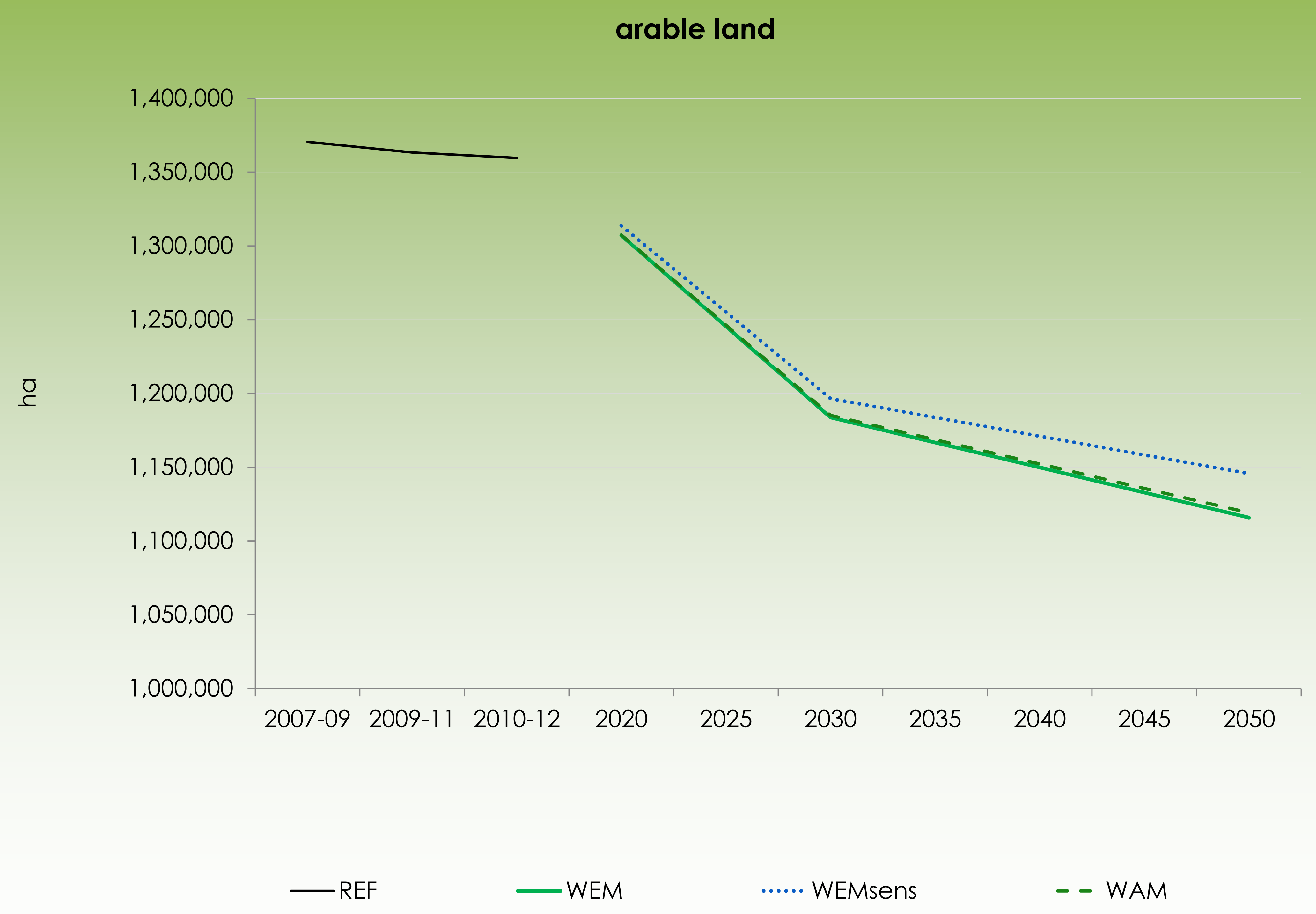
	REF	WEM			WAM			WEM sens
		2020	2030	2050		2030	2050	
market prices								
OECD/FAO 2014 Crops/Livestock		yes			yes			yes
OECD/FAO 2014 Trend Crops/Livestock			yes/yes	yes/yes		yes/yes	yes/yes	
specific price milk		yes	yes	yes		yes	yes	
Energy AT-Forecast		yes	yes	yes	yes	yes	yes	yes
CAP 1st pillar								
milk quota	yes	no	no	no	no	no	no	no
livestock premia	yes	no	no	no	no	no	no	no
regional dircect payments	no	yes	yes	yes	yes	yes	yes	yes
greening (CAP reform 2013)	no	yes	yes	yes	yes	yes	yes	yes
CAP 2nd pillar								
volume mio Euro p.a.	1034	1090	1090	1090	1090	1090	1090	1090
agri-env. payments mio Eur p.a.	527	472	472	472	472	531	590	472
organic farming sheme mio Eur p.a.	89	112	112	112	112	150	150	112
other agri-environmental premia	438	330	330	330	330	330	330	330
organic premium grassland Eur/ha	110-240	70-225	70-225	70-225	70-225	80-250	80-250	70-225
organic premium cropland Eur/ha	110-285	230-450	230-450	230-450	230-450	250-500	250-500	230-450

scenarios - assumptions

	REF	WEM			WAM			WEM sens
		2020	2030	2050		2030	2050	
index farmland hectares	100	98.4	97.1	94.5	100	97.1	94.5	100
index milk yield per cow	100	115	130	135	100	130	135	100
climate measure								
climate act measures 2013/2014	no	1)	1)	1)	yes	yes	yes	yes
increase of lactations dairy cows					no	20.0%	25.0%	no
increase efficieny of livestock (not milk)					no	5.0%	7.5%	no
increase quality grassland/silage					no	5.0%	7.5%	no
feeding efficiency increase (non-ruminants)					no	5.0%	7.5%	no
reduction of losses manure nutrients					5.0%	20.0%	40.0%	
reduction of losses of fertilizer					5.0%	20.0%	40.0%	
additional energy crops								
tax on mineral fertilizer								

PASMA results

arable land



arable land
1,400,000
1,350,000
1,300,000
1,250,000
1,200,000
1,150,000
1,100,000
1,050,000
1,000,000
ha
2007-09
2009-11
2010-12
2020
2025
2030
2035
2040
2045
2050
REF
WEM
WEMsens
WAM

discussion

- heterogeneity has to be accounted for
- integrated model approaches contribute to our understanding
- accounting for management variants helps explain yield ranges
- in Austria: CC impact relatively minor compared to other factors (e.g. management)