Managing land use in Europe under changing climate and market conditions

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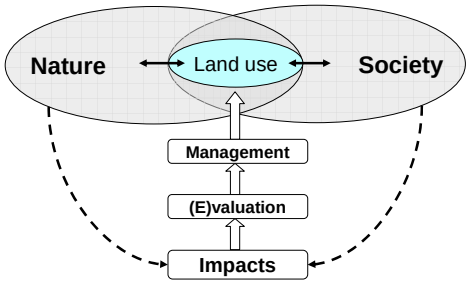
Outline

- Introduction
- Assessing land use change (agriculture)
  - Drivers of land use change
  - Model of (agricultural) land use change
  - Projections of (agricultural) land use change
- Impacts of land use change on ecosystem services
- (E)valuating changes in ecosystem services
- Integrated (sustainability) assessment
- Managing land use
- Concluding remarks

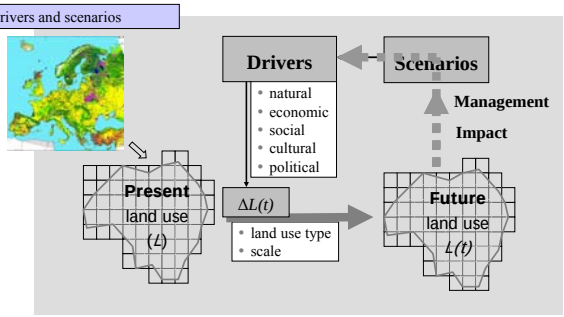
Introduction

Scope of presentation



Assessing land use change

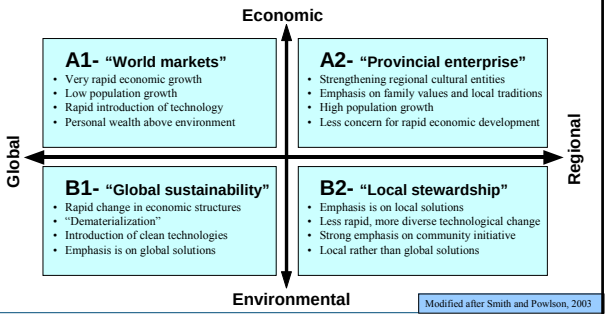
Drivers and scenarios



Assessing land use change

IPCC Special Report on Emission Scenarios (SRES)

Main characteristics of the main SRES marker scenario families



Modified after Smith and Powlson, 2003

Assessing land use change

European agricultural drivers

Policy	Socioeconomics and Environment	
	Demand	Supply
Market intervention (subsidies, quotas)	Population (consumption)	Resource competition (e.g. urban)
Rural development (LFAs)	Consumer preferences (meat, organic)	Climate change (Temp, precip., CO_2)
Environmental policy (NVZs, ESAs)	Market liberalisation (WTO)	Technology & management
	EU enlargement	

Assessing land use change

Modelling agricultural land use change

$$S = D \qquad \frac{S_t}{D_t} = \frac{S_{t_0}}{D_{t_0}} \qquad S = \frac{L \cdot P}{O_r}$$

$$\frac{L_t}{L_{t_0}} = \frac{D_t}{D_{t_0}} \cdot \frac{P_{t_0}}{P_t} \cdot \frac{O_{r,t}}{O_{r,t_0}}$$

S …	Supply of production *[t]*
D …	Demand for production *[t]*
L …	Agricultural land use *[ha]*
P …	Productivity *[t/ha]*
O_r …	Overproduction, relative *[-]*
t …	Time
t_0 …	start moment, baseline

Unknown Parameters to estimate

Ewert et al., 2005

Assessing land use change

$$\frac{L_t}{L_{t_0}} = \frac{D_t}{D_{t_0}} \cdot \frac{P_{t_0}}{P_t} \cdot \frac{O_{r,t}}{O_{r,t_0}}$$

Modelling agricultural land use change

$$P_t = P_{t_0} r(\Delta CO_2, \Delta C, \Delta T)_{t-t_0}$$

P …	Productivity *[t/ha]*
t …	Time
t_0 …	start moment, baseline
r …	Relative change in productivity *[-]*
CO_2 …	Atmospheric CO_2 concentration
C …	Climate
T …	Technology

$$P_t = P_{t_0} + ((P_{t,C} - P_{t_0}) + (P_{t,CO_2} - P_{t_0}) + (P_{t,T} - P_{t_0}))$$

$$\frac{P_{t_0}}{P_t} = \frac{1}{1 + ((P_{t,C}/P_{t_0} - 1) + (P_{t,CO_2}/P_{t_0} - 1) + (P_{t,T}/P_{t_0} - 1))}$$

Assessing land use change

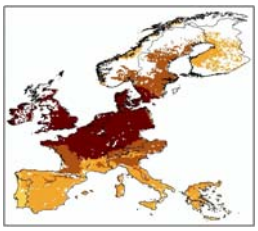
$$\frac{P_{t_0}}{P_t} = \frac{1}{1 + ((P_{t,CI}/P_{t_0} - 1) + (P_{t,CO}/P_{t_0} - 1) + (P_{t,T}/P_{t_0} - 1))}$$

Food crops (wheat) yield changes

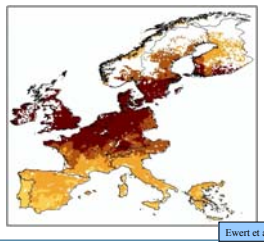
Grain yields (t/ha)

0.00
0.01 - 2.00
2.01 - 4.00
4.01 - 6.00
6.01 - 8.05

Baseline (2000)



A1 (2080), HadCM3



Ewert et al., 2005

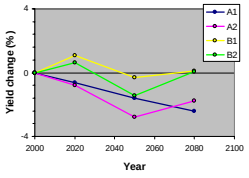
Assessing land use change

$$\frac{P_{t_0}}{P_t} = \frac{1}{1 + ((P_{t,CI}/P_{t_0} - 1) + (P_{t,CO}/P_{t_0} - 1) + (P_{t,T}/P_{t_0} - 1))}$$

Food crops (wheat) yield changes

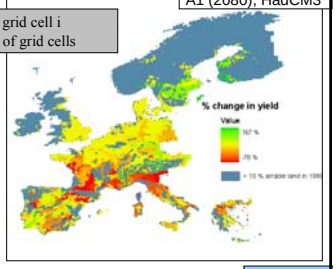
$$\frac{P_{t,C}}{P_{t_0}} = \sum_{i=1}^{n} \frac{Y_{G_i(t)}}{Y_{G_i(t_0)}} / n$$

Y_{Gi} …	Yield in grid cell i
n …	Number of grid cells



Relative yield change (%)

A1 (2080), HadCM3



Ewert et al., 2005

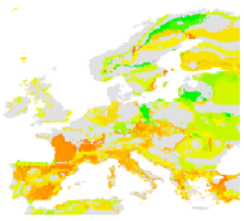
Assessing land use change

Projected yield changes, EU27, 2080, A1 (HadCM3)

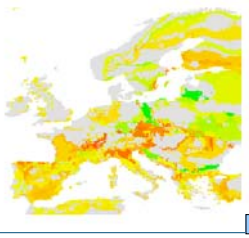
Yield change (%)

Value
High : 100
Low : -100

Wheat



Potatoes



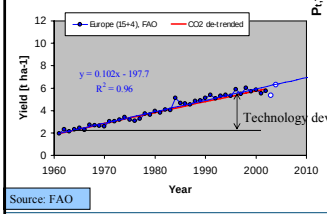
Tor et al., 2007

Assessing land use change

$$\frac{P_{t_0}}{P_t} = \frac{1}{1 + ((P_{t,CI}/P_{t_0} - 1) + (P_{t,CO}/P_{t_0} - 1) + (P_{t,T}/P_{t_0} - 1))}$$

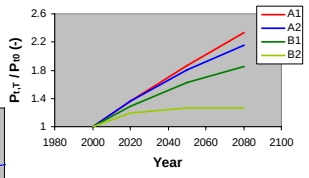
Food crops (wheat) yield changes

Historic yield trends (wheat)



Source: FAO

Assumed future technology effects



Ewert et al., 2005

Assessing land use change

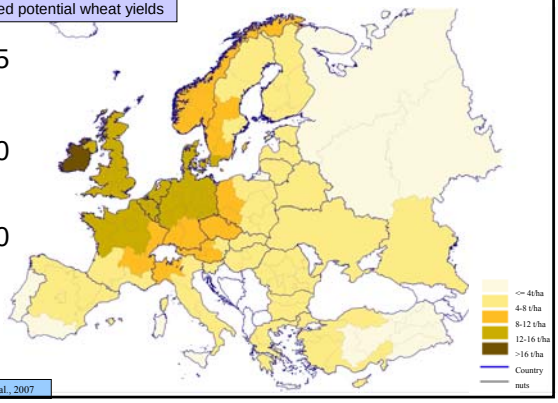
$$\frac{P_{t_0}}{P_t} = \frac{1}{1+((P_{t,CI}/P_{t_0}-1)+(P_{t,CO}/P_{t_0}-1)+(P_{t,T}/P_{t_0}-1))}$$

Projected potential wheat yields

2005

2020

2050



Hermans et al., 2007

Assessing land use change

$$\frac{L_t}{L_{t_0}} = \frac{D_t}{D_{t_0}} \cdot \frac{P_{t_0}}{P_t} \cdot \frac{O_{r,t}}{O_{r,t_0}}$$

Supply vs. demand, wheat, A1

Achievable supply (million ton)	2005	2020	2050
EU-27	113,4	160,5	221,5
EU-Urals	176,8	235,3	345,5

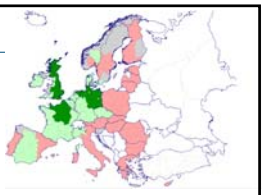
Demand (million tons)	2005	2020	2050
EU-27	113,4	121,1	138,4
EU-Urals	176,8	192,8	261,2

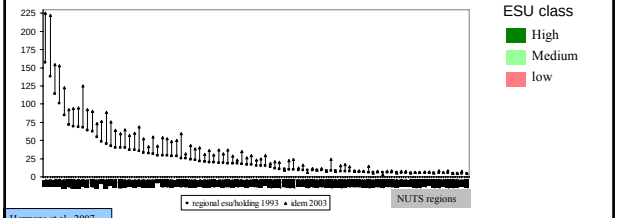
Hermans et al., 2007

Assessing land use change

Allocation of land use change

ESU/holding/region





Hermans et al., 2007

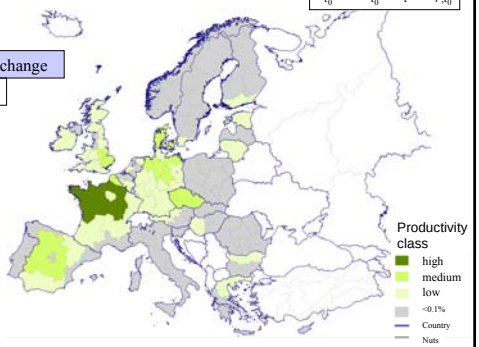
Assessing land use change

$$\frac{L_t}{L_{t_0}} = \frac{D_t}{D_{t_0}} \cdot \frac{P_{t_0}}{P_t} \cdot \frac{O_{r,t}}{O_{r,t_0}}$$

Projected land use change

Wheat, EU27, A1

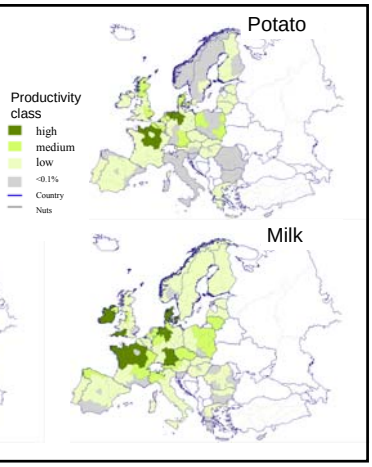
2080



Hermans et al., 2007

Projected land use change

EU27, 2050, A1

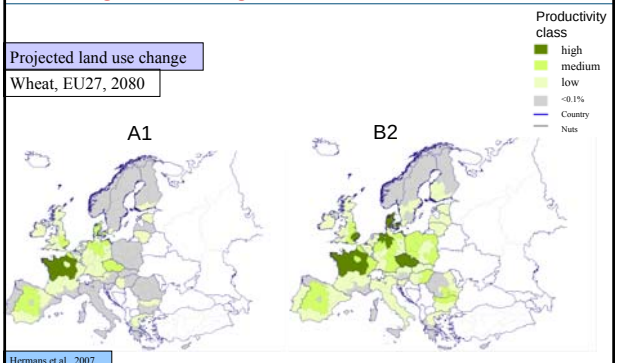


Hermans et al., 2007

Assessing land use change

Projected land use change

Wheat, EU27, 2080



Hermans et al., 2007

Assessing land use change

Surplus land?

Bioenergy production (biofuels,woodland)

GHG emission reduction/mitigation

Biodiversity conservation

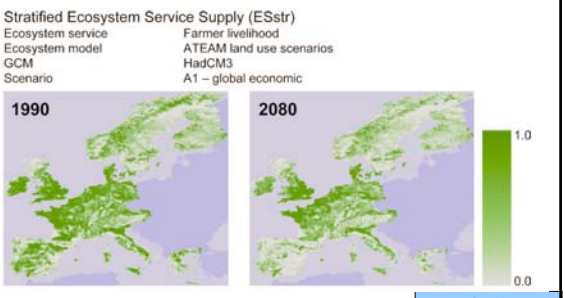
(Organic farming)

Leisure/recreation

Costs and benefits?

Impact on ecosystem services

Farmer livelihood



Metzger et al., 2006

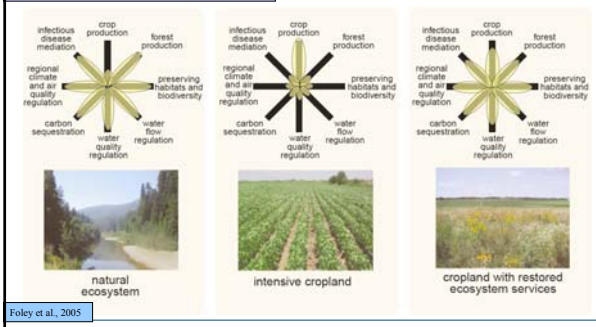
Impact on ecosystem services

Net carbon storage

Metzger and Schroter, 2006

Impact on ecosystem services

Land use and trade-offs of ecosystem services



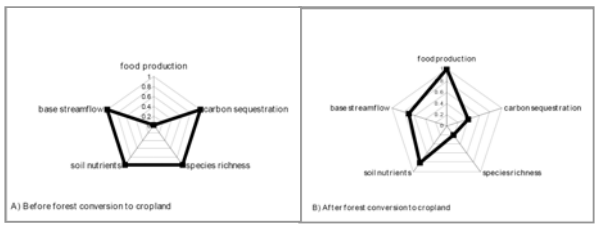
Foley et al., 2005

(E)valuating ecosystem services

Land use and trade-offs of ecosystem services

Expansion of cropland into forested area

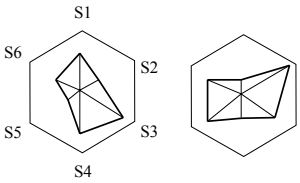
1… High value of service
2… Low value of service



Millennium Ecosystem Assessment, 2006

(E)valuating ecosystem services

Comparing ecosystem services (S) and change



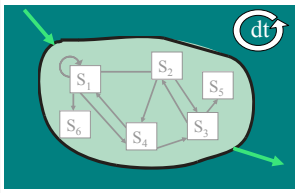
- Consistent unit (%, monetary, -, …)
- Valuing the change of service provision

Critical issues

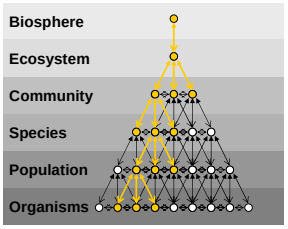
- Importance/value of ecosystem service may change over time
- The stock (capital/functioning) may be more important than flow (change) of a service
- Relationships among services are not considered
- Issues of scale

(E)valuating ecosystem services

Relationships among ecosystem services (S)



Scaling issues



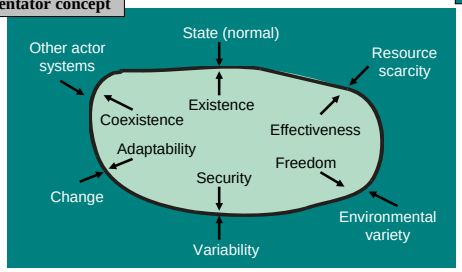
Integrated Assessment

System properties

System

Environment

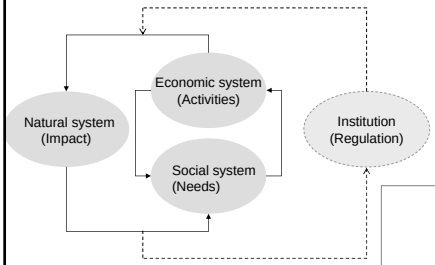
Orientator concept



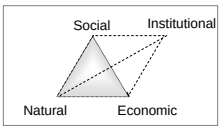
Bossel, 2001

Integrated Assessment

Land use as part of integrated systems

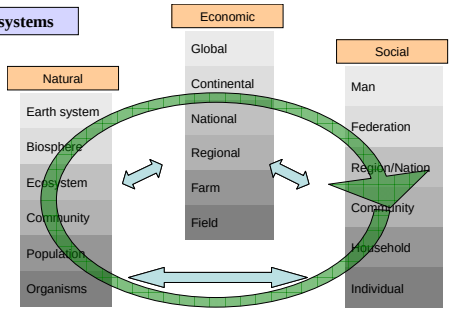


Dimensions of sustainability

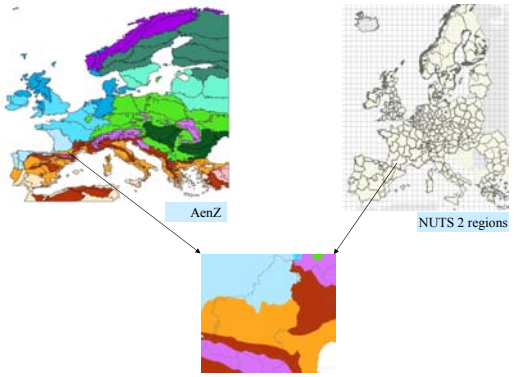


Integrated Assessment

Hierarchical systems



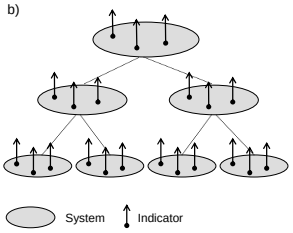
Different delineations of regional typologies



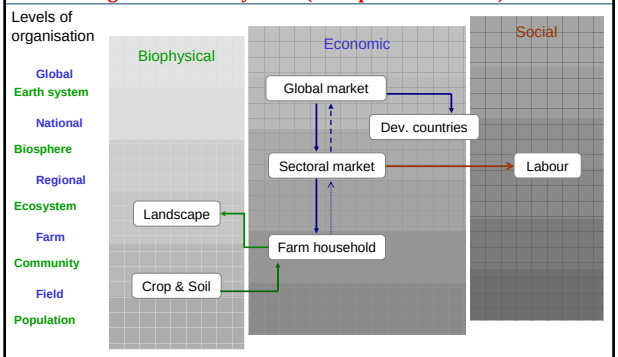
Integrated Assessment

Sustainability indicators

Stakeholder involvement

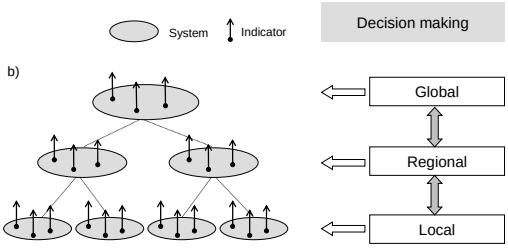


Modelling hierarchical systems (example SEAMLESS)



Managing land use - implications

Scale-dependency of management



Concluding remarks

- High future changes in agricultural land use have been projected which is largely a result of assumption about technology development
- Impacts of LULC change on ecosystem services can be positive or negative
- (E)valuation remains difficult and requires understanding of integrated systems and their behavior
- Integrated assessments provides a means to assess LULC change within a more holistic (sustainability) context
- Approaches and frameworks for IA and modelling are available but need further elaboration
- Need for understanding the scale-dependency (space and time) of land systems management

Scenarios of future land use and implications for sustainability

Thanks for your attention

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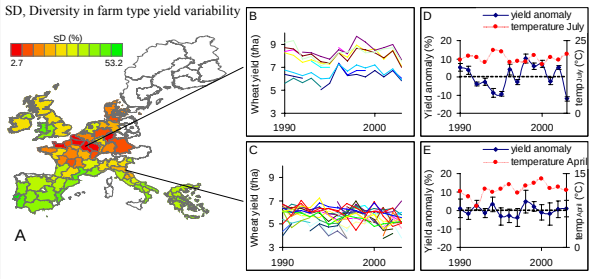
Effects of farm diversity



Reidsma and Ewert, 2007