

Modeling Agri-Environmental Interactions for Policy Analysis

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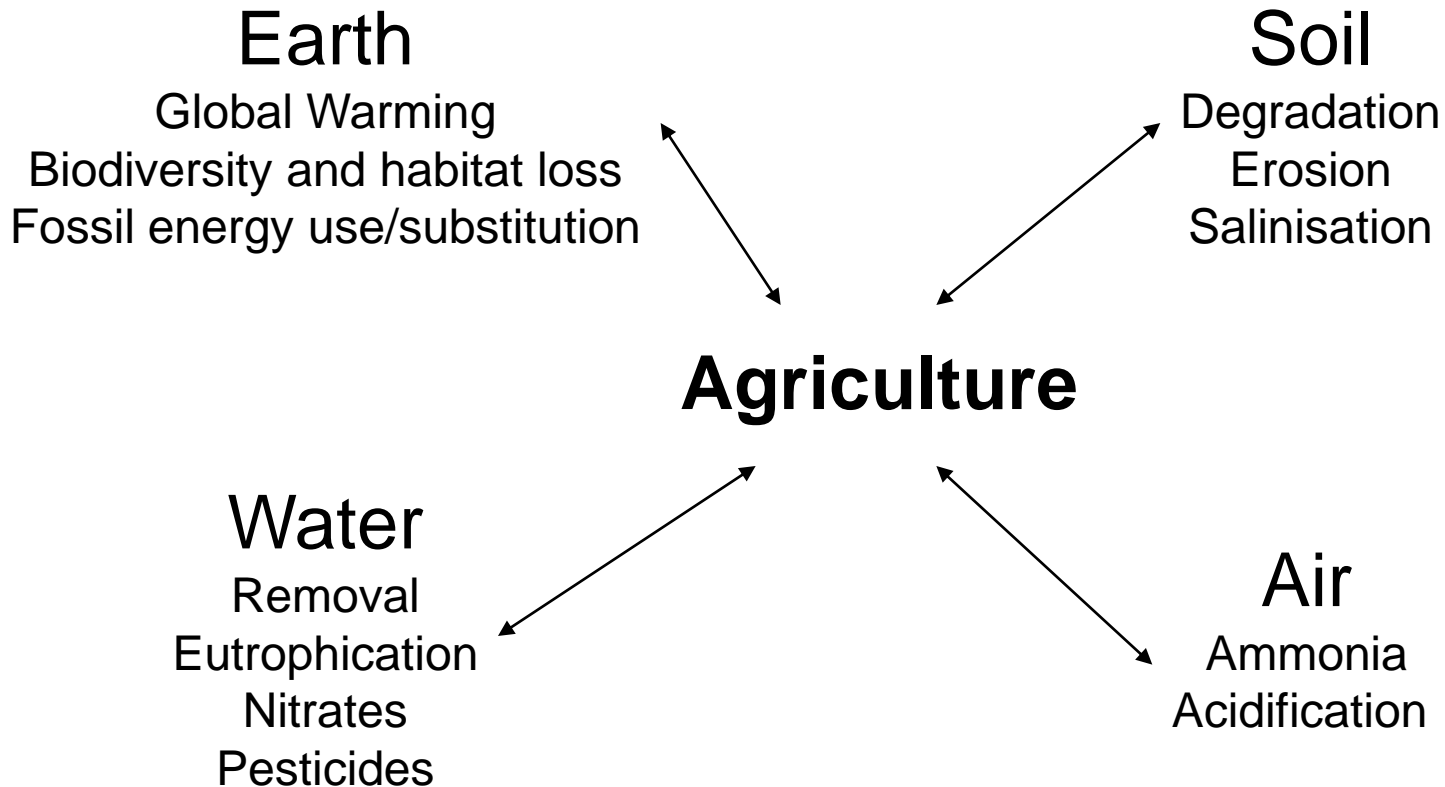
Model based Policy Analysis
in memoriam Prof. Dr. Wilhelm Henrichsmeyer
GEWISOLA Jahrestagung 2010



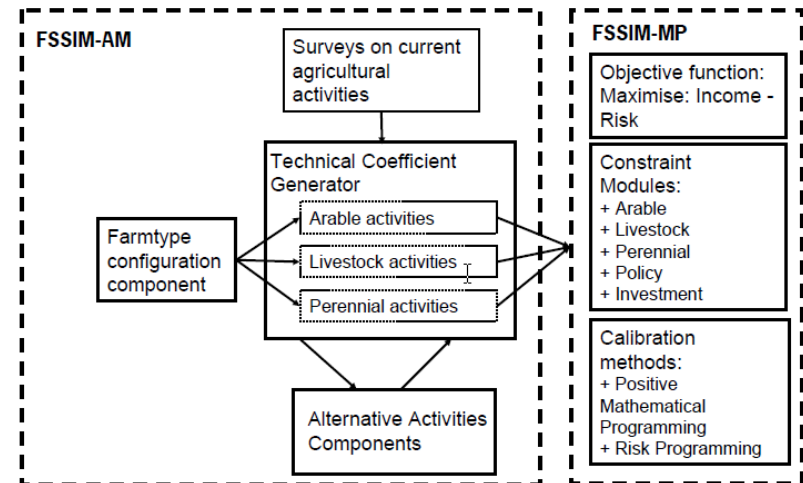
- ❑ Background: Interactions between agriculture and the environment
- ❑ Tools:
 - Bio-Economic Modelling
 - Regional / Farm Type aggregate programming models
 - National / Global land use models
 - Global market models with environmental satellites
 - Spatial down-scaling and post modelling processing
- ❑ Pros and cons, challenges of combined tool usage
- ❑ Summary and conclusions

- Some words of caution:
 - Presentation due to “surprise effect” based on own research agenda and not on systematic literature review
 - Research field certainly broader, but cannot be covered in sufficient detail in one presentation
 - Bio-physical components without behavioral model excluded if not directly linked to economic tools
 - Certain “Henrichsmeyer” bias by focusing on approaches covering all agricultural activities and including market feedbacks

- Growing awareness of **limited global resources** (soil, water, fossil energy, bio-diversity and habitat loss)
- **Agriculture**, despite small GDP share in developed nations, still a **dominating land use activity**, with important positive and negative environmental externalities
- Interaction between (fossil) **energy markets** and agriculture, contribution of agriculture to **climate change** and its mitigation
 - ⇒ Agricultural, energy and environmental policies interact
 - ⇒ Need for quantitative impact assessment (tools)



- ❑ Typical example: FFSIM in SEAMLESS (Louhichi et.al. 2010)
- ❑ (N)LP based **programming models** with exogenous prices
- ❑ Risk behaviour can be integrated
- ❑ Highly **detailed technology description**, covering variants of relevant processes such as tillage, including not adopted ones
- ❑ Distinction by soil types, farming system etc.
- ❑ Parameterization partly based on simulations with **crop-growth models**
- ❑ Many applied in **case-studies** (data availability, resources needed for parameterization/calibration/validation)



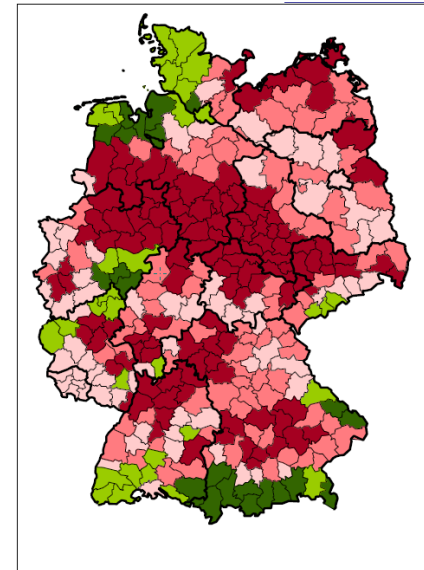
□ Advantages

- **Resource specificity** (soil, climate, farm endowments)
- Excellent interfacing to **agri-environmental policy instruments** (opt-in measures, taxes, regulatory approaches)
- Rich set of **environment related results** from crop growth models

□ Dis-advantages

- Often rather **normative** – necessary observations for calibration/validation scarce
- **Expensive survey** based data acquisition
- Generalization of results challenging
- Missing price feedback

- ❑ Typical examples: RAUMIS (Henrichsmeyer et.al. 1996)
- ❑ Sub-national resolution based on **administrative regions**
- ❑ Calibrated to **observed farming practise**, based on Positive Mathematical Programming and extensions
- ❑ Cover **all of agriculture** (Economic Accounts for Agriculture, Land use, Herds)
- ❑ Some **major environmental processes/indicators** e.g. N/P/K balancing, GHG emissions integrated as constraints



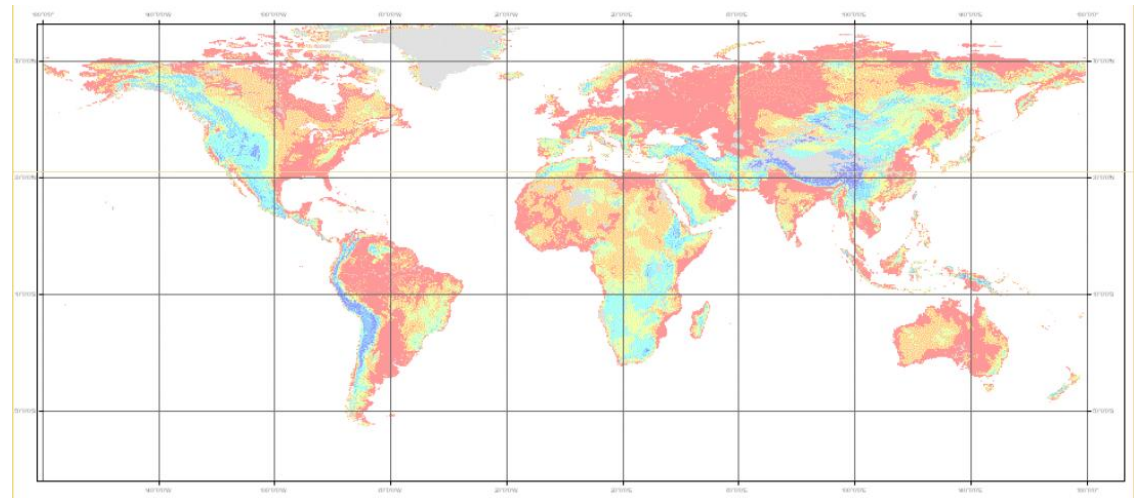
□ Advantages

- Key farm practise **data** such as crop areas, herd sizes & yields readily available from **official statistics** as time series
- Typically higher resource specificity and improved description of farm level processes compared to market level models

□ Dis-advantages

- Less technological detail and resource specificity compared to Bio-Economic modelling, **regions assumed to be homogenous**
- **Input allocation** to processes/regions **challenging** and labour intensive due to data limitations
- Missing price feedback

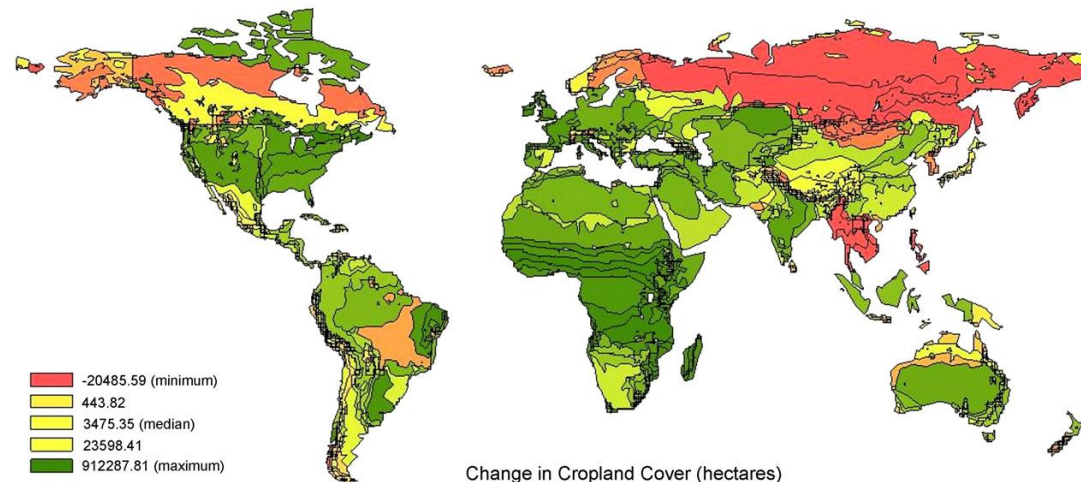
- ❑ Typical example: GLOBIOM (Havlik et.al. 2008)
- ❑ Builds on FASOM (Adams et.al. 1996) model family: **LP** based supply, **spatial**, **endogenous prices** via welfare maximisation, **recursive-dynamic**, agriculture and **forestry** covered
- ❑ Land and water as fixed resources
- ❑ Sourced by EPIC



Homogenous response units underlying GLOBIOM, Skalský et.al. (2008)

- ❑ Advantages:
 - Some resource specificity combined with **global coverage**
 - Major **competing land uses** included
 - Link to **bio-physical model** allows e.g. to capture mitigation options for CO₂ (equivalents)
- ❑ Dis-advantages:
 - Only own-price demand elasticities
 - Parameterization, **calibration/validation**
 - Higher spatial resolutions lead to **very large LP frameworks** (solution time, debugging, quality control)

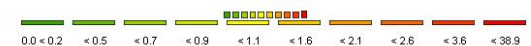
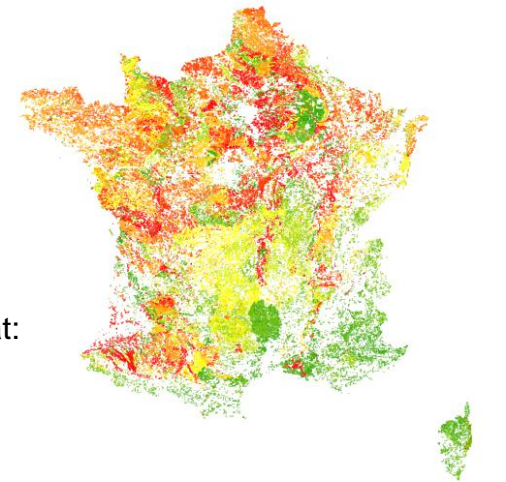
- Extensions of existing (market) models with new endogenous modules
- Examples:
 - Integration of a land-use module in GTAP (GTAP-AEZ, Lee 2005)
 - Integration of 126 river basins in IMPACT (IMPACT-Water Rosegrant et.al. 2008)
- Advantages:
 - Global perspective
 - Market feedback
- Dis-advantages:
 - Highly stylized technology and policy description
 - Regional aggregation quite high



Example from GTAP-AEZ (Britz & Hertel 2009)

- Examples: Land-Use Cover Change (LUCC) modelling (e.g. Verburg and Overmars 2009), CAPRI-Dynaspat (Leip et.al. 2008)
- General approach:
 - Estimate quantitative relations between local factors (soil, climate, topography, existing land cover) and land use resp. agricultural management (crop shares, stocking densities, yields, input use)
 - Dis-aggregate given results on higher regional scale based on estimated relations

Example from CAPRI-Dynaspat:
Ruminants in livestock units
per ha fodder area,
France, Ø2001-2003



□ Advantages:

- Economic models operate on established regional scale (data availability, estimation of behavioural parameters, response time, model size and complexity)
- Independent down-scaling tool can apply **different methodology** (e.g. cellular automaton) and software
- Serves as input into bio-physical models, e.g. FATE (Baraoui and Grizetti 2008, CAPRI-DNDC link (Leip et.al. 2008))

□ Disadvantages:

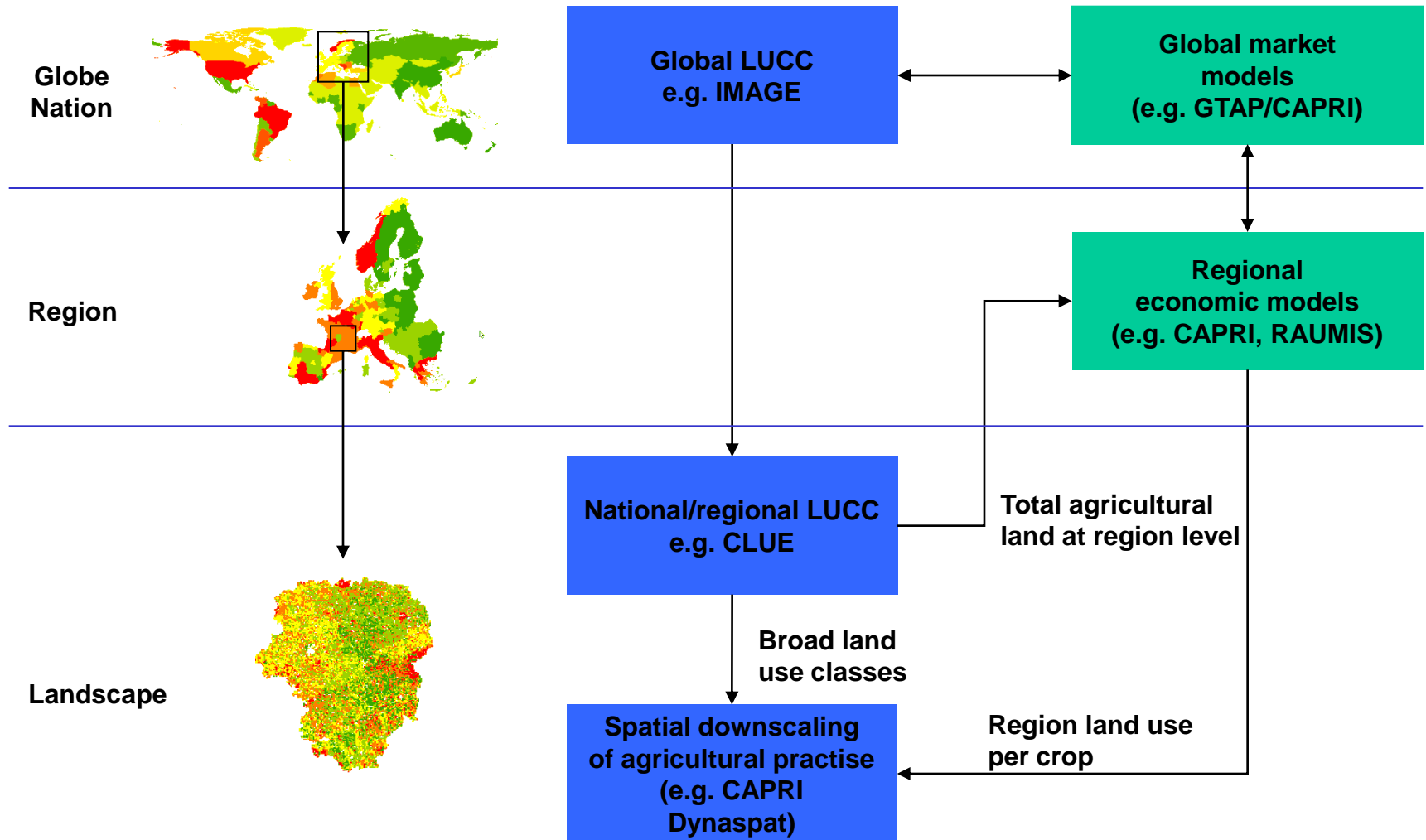
- **Post-model step** – indicator calculators and underlying processes are not integrated in economic models
- Linked bio-physical models may contradict aggregate relationships in economic models

- For any policy instrument where aggregate perspective matters (price feedback, indirect land use change, GE):
 - Tension between **required level of detail** to capture environmental impacts and policy instruments – spatial resolution, process detail – and **enormous data and processing need**
 - Stand-alone use of one specific tool often not promising – tools with the required detail are not sufficiently encompassing, global tools (PE or GE) can hardly be dis-aggregated to appropriate scale
- ⇒ Increasing interest in combined tool use
- ⇒ Large-scale EU framework projects (SEAMLESS, SENSOR)

- Exploit **comparative advantages** by **combining** tools, e.g.
 - Integration of bio-economic or regional models with market models to allow for price feedback while keeping technological detail and spatial resolution
 - Integration of land-use models with agricultural/forestry models to capture land-use dynamics
 - Combination of agricultural and bio-physical models for detailed impact assessment, e.g. on different N-Compartments
- => Major research question: how to ensure matching response e.g. to price/policy changes in different tools?

- Improved consistency in combined tool use:
 - **Sequential calibration:**
 - Models updated and solved iteratively till convergence (CAPRI e.g. Britz 2008, Jansson et.al. 2009 for CAPRI and GTAP)
 - **Response surfaces:**
 - Britz & Hertel 2009 linking CAPRI supply models and GTAP
 - Perez et.al. 2010 extrapolate supply response from bio-economic models FFSIM to regional scale, Adenäuer et.al. calibrate CAPRI regional models to the upscaled response of FFSIM

Example for top-down model chain



- Modelling agri-environmental interactions:
 - currently a **dynamic scientific field** which competing approaches
 - requires data and tools capturing relevant **farm management processes** (tillage, fertilizing and irrigation practise, use of pesticides ..)
 - remains **challenging**, especially if tools operating at appropriate spatial / temporal / process resolution are combined with global models

- ❑ Weakly covered bits such as appropriate **indicators** for **bio-diversity** or **landscape assessment**
- ❑ Robust behavioural models for
 - **Participation rates** for opt-in measures or cheating rates
 - **Adaption of new farm management practises**
- ❑ Appropriate **communication** of **multiple indicators** and multiple **scales** (space, time) – upscaling, indices, choice of social discount rates?
- ❑ How to deal with **uncertainty** and stochastics, e.g. the question of possible catastrophic events?



Thanks for your attention!

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