A Global Integrated Modelling Framework for Assessing Mitigation Options in the Land Use Sector

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Abstract

Global historical GHG emissions from land use are currently considered to be the second largest sources of emissions. Future potentials of global mitigation options in the land use sector depend inter alia on land availability and product supply and demand in different regions. The IIASA Forestry Program has developed a multi-model toolbox in a coupled modelling framework (Fig. 1) that allows assessing interactions between different land use related mitigation measures in an integrated way. As an example we show the impact of biofuel expansion on crop prices and deforestation and the role of international trade (Fig. 2).

The Basic Framework

The framework establishes linkages between biophysical resource modelling and economic optimisation designed at two levels: Model simulations (forestry G4M and agriculture EPIC) quantify the **biophysical implications** of land management as well as mitigation strategies as a basis of the **economic optimisation** in the global model (GLOBIOM, EU-FASOM).

Additionally, a regional economic optimisation model (BEWHERE) assesses the **cost competitiveness** of bioenergy options. With this framework land use options and direct and indirect implications of land use change can be analysed including cropland, grassland and livestock management as well as afforestation, deforestation, forest management and bioenergy production.

The application of the entire model cluster is essential to fully evaluate **trade-offs** of different land uses. Also **conflicts** between alternative management options that are promoted in national and international policy programmes (climate policy, land use, biofuels, etc.) with respect to environmental criteria, the full GHG balance, impacts on food security, and development can be assessed.

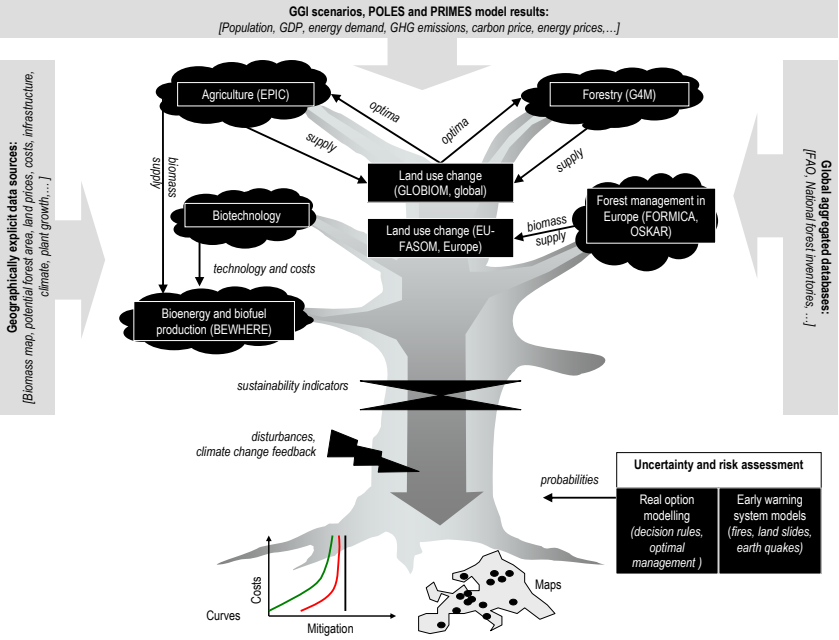

Fig. 1: The multi-model toolbox is a major step to a comprehensive understanding of the impacts of economically optimised mitigation strategies considered. For description of single models see right.

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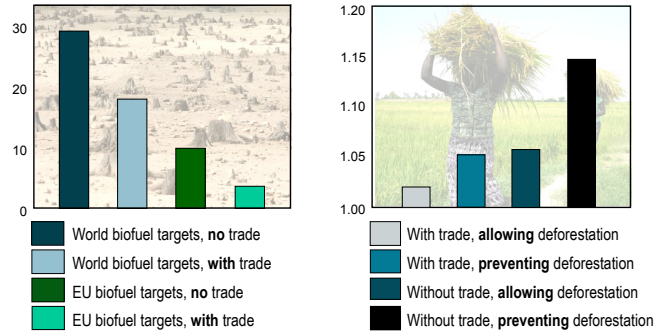
Scenarios and first results

Scenario 1: Deforestation is not prevented — A- Free trade in biofuels; B- No trade in biofuels

Scenario 2: Deforestation is prevented — A- Free trade in biofuels; B- No trade in biofuels

- **Indirect land use effects** can be large: if bioenergy is only produced domestically (no trade), food production is reallocated to other areas leading to deforestation (Fig. 2 a) and an increase in the crop price index (Fig. 2 b).
- **Avoiding deforestation** reinforces the increase in crop prices.
- **Free trade mitigates the negative impacts** of biofuel expansion: about 10 million hectares of forest are lost when trade of bioenergy is not allowed.

Fig. 2 a) Deforestation: million hectares *b) Food security: crop price index*



IIASA FOR Models

G4M Model
The Global Forest Model (G4M) provides spatially explicit estimates of annual aboveground wood increment, development of aboveground forest biomass and costs of forestry options such as forest management, afforestation and deforestation by comparing the income of alternative land use.

EPIC Model
The Environmental Policy Integrated Climate (EPIC) integrates a large number of biophysical processes and is used to compare land management systems and their effects on water, nitrogen, phosphorus, and green house gas emissions.

GLOBIOM Model
GLOBIOM is a global static partial equilibrium model integrating the agricultural, bioenergy and forestry sectors with the aim to give policy advice on global issues concerning land use competition between the major land-based production sectors.

EU-FASOM Model
EU-FASOM is a partial equilibrium model used for long term assessment of the economic, technical and environmental potentials of land use options in Europe under different market and environmental conditions and policies.

BEWHERE Model
The BEWHERE model calculates the optimal spatial distribution and size of bioenergy plants, pulp and paper mills and sawmills given the spatial biomass supply distribution from biophysical models to assess economies of scale and scope under poly-production.

FORMICA Model
The model FORMICA calculates carbon pool trajectories under current and changing forest management in existing forests at a regional scale.

OSKAR Model
OSKAR estimates biomass, dead wood, harvest yields and costs for different forestry scenarios (thinning, species, climate change) at plot level to regional scale.

GBPM – Growth and Biological Production Models
A spatially distributed set of four different types of growth and biological production models for major forest forming species of Northern Eurasia has been developed by IIASA FOR Program.

Disaster Models
Disaster models developed for the GEO-BENE project (www.geo-bene.eu) include forest fires, earthquakes, landslides, and tsunamis. The purpose of the models is to quantitatively assess the value of observations/measurements for the reduction of disaster's impact on society and environment.

Real Options Models
Real options analysis is a tool for decision-making under uncertainty when there is flexibility to postpone decisions and when irreversibility is involved. Examples of applications within FOR include optimal forest rotation models in the face of fire risk, investment and operational decisions concerning biomass-fired power plants, etc.

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