GLOBIOM - Introduction

Center for Environmental Resources & Development, Presenter: Petr Havlík
IIASA: International Institute for Applied Systems Analysis

**IIASA vision for 2021 to 2030** is to “be the primary destination for integrated systems solutions and policy insights to current, emerging and novel global sustainability challenges, threats, and opportunities”.

**History**
- 1967 initiative of US President Johnson and Prime Minister Kosygin, Soviet Union
- Established as a research center to act as “neutral bridge between east and west”
- Original Charter signed in 1972 by 12 countries
Center for Environmental Resources & Development

Researchers
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- Ren Ming, PKU-IIASA
- Bai Minghao, PKU-IIASA with WAT
- Yixin Guo, PKU-IIASA with AIR
- Eleanor Warren-Thomas, NERC-IIASA
Partial equilibrium model
• Trade: spatial equilibrium
• Homogenous goods
• Flexible demand regions aggregates (37 regions)
• Spatially explicit supply
• Leontief production functions
• Recursively dynamic: 1 to 10 years time step
• Optimization model
• Linear programming
• GAMS
• Open access strategy under development
Bridging geographical and temporal scales
Spatial resolution

Homogeneous response units (HRU) – clusters of 5 arcmin pixels

HRU = Altitude & Slope & Soil

Altitude class (m): 0 – 300, 300 – 600, 600 – 1200, 1200 – 2500 and > 2500;
Slope class (deg): 0 – 3, 3 – 6, 6 – 10, 10 – 15, 15 – 30, 30 – 50 and > 50;
Soil texture class: coarse, medium, fine, stony and peat;

Simulation Units (SimU) = HRU & PX30 & Country zone

> 200 000 SimU

SimU delineation related statistics on LC classes and Cropland management systems

reference for geo-coded data on crop management; input statistical data for LC/LU economic optimization;

Source: Skalský et al. (2008)
Crops: EPIC

- Spatially explicit production functions
- Climate change impacts

Source: Balkovič et al.
Climate change impacts, adaptation and extremes

Impacts and adaptation


Extreme events


Study magnitude and frequency of yield losses
Livestock Production Systems: RUMINANT

Metabolizable energy intake

Milk production

Non-CO2 emissions

Source: Herrero et al. 2013, PNAS
Heterogeneity of farm systems matters

Large efficiency gaps prevail between production systems and regions

Reallocating production across systems and regions would reduce GHG emissions, nitrogen pollution, and water scarcity

GHG efficiency of beef production by system and regions

Annual non-CO$_2$ abatement potential by 2050

Water & nitrogen

Herrero et al. PNAS 2013

Frank et al. NCOMM 2018

Consumption change
Structural change
International trade
Technical options
Flexible production systems definition: Smallholder farmers

IFAD project: Assess the impact of policies on smallholders’ income and food security, and especially the potential for scaling-up IFAD experience

• Main tasks:
  1. Establish a new typology of farming systems based on experts consultation and household survey
  2. Implement them in GLOBIOM
  3. Simulate different policy scenarios in GLOBIOM

• Case study: Ethiopia

New typology built on 3 criteria:
- AEZ
- Main production
- Market integration

Source: Boere et al. 2019
Fisheries & Aquaculture

Food Balance Sheets

FISH

\[
\text{Food Use} + \text{Import} = \text{Production} = \text{Export} + \text{Other Use}
\]

\text{Processing Waste}

FishSTAT (a)

\[
\text{Capture} + \text{Aquaculture}
\]

Watson (2017)

\[
\text{Capture} + \text{Aquaculture}
\]

Literature

GLOBIOM

\[
\text{Feed Use} + \text{Other Use}
\]

Literature

GLOBIOM

\[
\text{Crush Ratios}
\]

\[
\text{Feed Requirements}
\]

Literature

GLOBIOM

\[
\text{Feed Requirements}
\]

Literature

GLOBIOM

\[
\text{Herds}
\]

Source: Batka et al., in preparation
Forestry

- GLOBIOM covers the main primary feedstocks, by-products, and semi-finished HWP products.
- Wood flows as of 2010 is calibrated according to FAOSTAT.

Source: Lauri et al., 2017
Land cover change

- Land cover change endogenous depending on relative profitability

Full AFOLU GHG accounting

- Other LUC CO₂
- Deforestation CO₂
- Rice CH₄
- Synthetic fertilizer N₂O
- Organic fertilizer N₂O
- Manure grassland N₂O
- Manure management N₂O
- Manure management CH₄
- Enteric fermentation CH₄

Source: Valin et al., 2013
Water balance

climate change impacts on irrigation water requirements and water availability

climate change impacts and protections for environmental flow requirements

Interlinkages with other sectors and feedback effects

Land-Water-Energy Nexus

Palazzo et al., (under consideration) “Examining transboundary water-energy-land trade-offs and solutions to achieve sustainable regional development”

Integrated Assessment Modeling (IAM)

Source: Fricko et al., 2017
Scenario analysis at the global and local scale

Global

To assess potential futures and their consequences for the agriculture and forestry sectors

Local

To work together with stakeholders map-out different, plausible futures


Climate change mitigation

Scenarios towards limiting global mean temperature increase below 1.5 °C
Joeri Rogelj\textsuperscript{b,1,2}, Alexander Popp\textsuperscript{3}, Katherine V. Calvin\textsuperscript{4}, Gunnar Luderer\textsuperscript{3}, Johannes Emmerling\textsuperscript{b,4},

Agricultural non-CO\textsubscript{2} emission reduction potential in the context of the 1.5 °C target
Stefan Frank\textsuperscript{a,2}, Petr Havlík\textsuperscript{1}, Diederik Stehfest\textsuperscript{4}, Hans van Meijl\textsuperscript{2}, Peter Witzke\textsuperscript{1}, Ignacio Pérez-Dominguez\textsuperscript{5}, Michielan Dijk\textsuperscript{6}, Jonathan C. Doelman\textsuperscript{7}, Thomas Felsmann\textsuperscript{8}, Jason F. Koopman\textsuperscript{9}, Andrej Tabac\textsuperscript{10} and Hugo Van\textsuperscript{11,12}

Global Woody Biomass Harvest Volumes and Forest Area Use Under Different SSP-RCP Scenarios
Példa Lendi, Nicklas Forsell, Mykola Gusti, Anu Kosonen, Petr Havlík and Michael Obersteiner\textsuperscript{*}

Risk of increased food insecurity under stringent global climate change mitigation policy
Tomoko Hanasegawa\textsuperscript{b,13}, Shinichiro Fujimoto\textsuperscript{b,13}, Petr Havlík\textsuperscript{1}, Hugo Van\textsuperscript{1,12}, Benjamin Leon Bedirsky\textsuperscript{1,12}, Jonathan C. Doelman\textsuperscript{1}, Thomas Felsmann\textsuperscript{8}, Page Kyle\textsuperscript{11}, Jason F. Koopman\textsuperscript{9}, Hermann LOTZE-CAMPEN\textsuperscript{6,14}, Daniel Mason-D’Croz\textsuperscript{6,14}, Yuki Ochi\textsuperscript{15}, Ignacio Pérez-Dominguez\textsuperscript{5}, Diederik Stehfest\textsuperscript{4}, Timothy B. Sillman\textsuperscript{16}, Andrej Tabac\textsuperscript{10}, Kiyoshi Takahashi\textsuperscript{17}, Jun’ya Takakura\textsuperscript{b,18}, Hans van Meijl\textsuperscript{2}, Willem-Jan van Zeist\textsuperscript{1}, Keith Wiebe\textsuperscript{16} and Peter Witzke\textsuperscript{18}
Climate change impacts, international trade policies, and food security

The global nexus of food-trade-water sustaining environmental flows by 2050

A. V. Pastor1,2,3, A. Palazzo1, P. Havlík1, H. Biemans4, Y. Wada1, M. Obersteiner1, P. Kabat2,5 and F. Ludwig2

Global hunger and climate change adaptation through international trade

Charlotte Janssens1,2,3, Petr Havlík2, Tamás Krizsán1, Justin Baker1, Stefan Frank1, Tomoko Hasegawa1,4, David Leclère2, Sara Ohrel1, Shaun Ragnauth4, Erwin Schmid3, Hugo Valin5, Nicole Van Lipzig1 and Miet Maertens1
Biodiversity and the need for wholistic strategies

Article

Bending the curve of terrestrial biodiversity needs an integrated strategy

Leclère et al. 2020

• Feasible only if
• transforming our food systems from farm to fork
• adopting an ambitious conservation & restoration plan
• addressing other threats to biodiversity (climate change, biological invasion, ...)

nature
Connecting social and environmental sustainability

"More Food for All"

"Food for Poor & No Overconsumption"

- Ignoring the heterogeneity → 20% more food production
- Focusing on undernourished → 3% more food


For further information: www.globiom.org