International Institute for Applied Systems Analysis
IIASA www.iiasa.ac.at

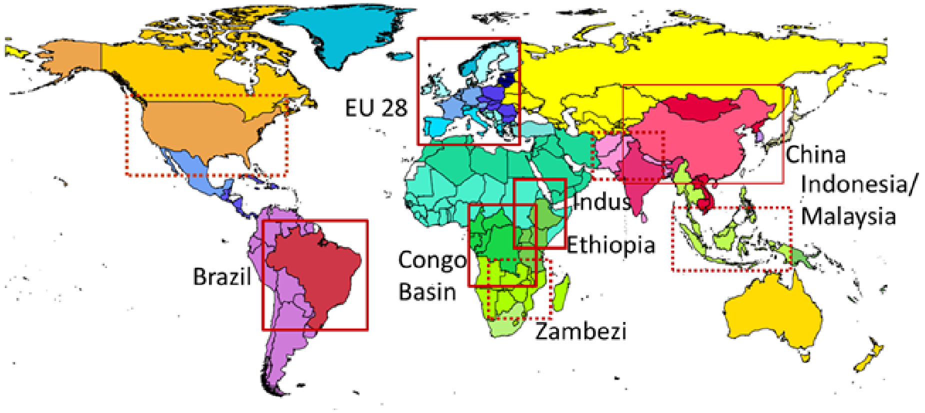
The Global Biosphere Management Model (GLOBIOM)

Stefan Frank, Petr Havlík, Hugo Valin and many others…

Background - GLOBIOM

- **Developed at International Institute for Applied Systems Analysis** in Austria since the early 2000s
- **Partial Equilibrium Model** - offspring of US FASOM model developed by Bruce McCarl
    - Global bottom-up supply side coverage (>10,000 Simulation Units)
    - Agriculture: major agricultural crops and livestock products
    - Forestry: managed forests for sawnwood, and pulp and paper production
    - Bioenergy: 1st, 2nd generation biofuels, solid biomass
- **Optimization model** (maximize consumer & producer surplus)
    - Runtime ~1 hour up to 2050
    - Computational cluster at IIASA allows up to 200 scenarios to be run in parallel
- **Data sources -** FAOSTAT, complemented with spatially explicit bottom-up sectoral models (EPIC, G4M etc.) for production parameters and land cover information
- GLOBIOM is developed and maintained at IIASA in the Integrated Biosphere Future Research Group by around **25 interdisciplinary scientists -** on access strategy under development
- However, **many national collaborators/users** that develop regional model versions such as in Argentina, Brazil, China, Colombia, India, Indonesia, Mexico, Russia, US, …

Bridging geographical and temporal scales



2000 2010 2020 2030 2040 2050 2060 2070 2080 2100

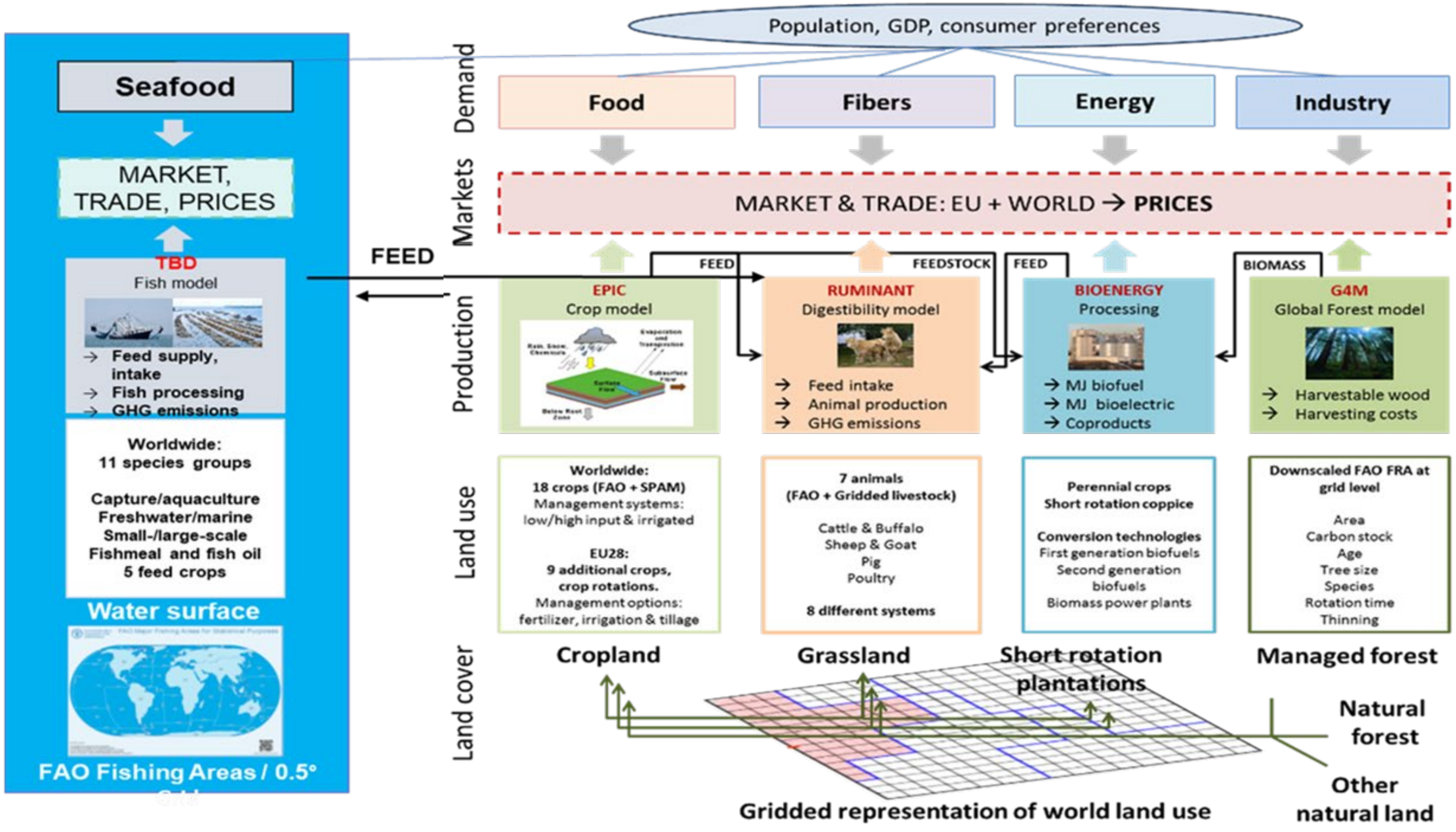
Validation period

Policy Impact Assessment

Long-Term Outlook

Climate stabilization pathways

Global Biosphere Management Model (GLOBIOM)



- 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

Key model features for biofuel assessments

Detailed representation of land

- Associated uses (and non-uses)
- Carbon stocks
- Marginal yield values from biophysical model

Yield endogenous response

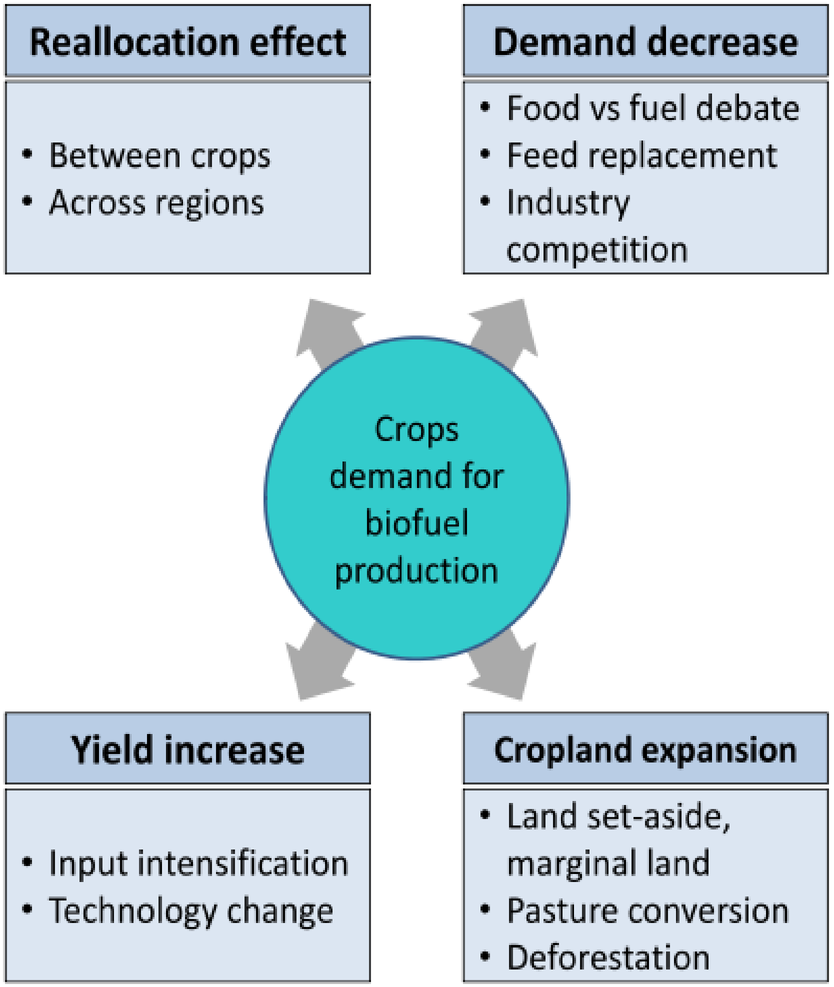
- Intensification (change in management systems)
- Irrigation
- Intra-regional reallocation

Endogenous demand response & substitution effects (e.g. vegetable oils)

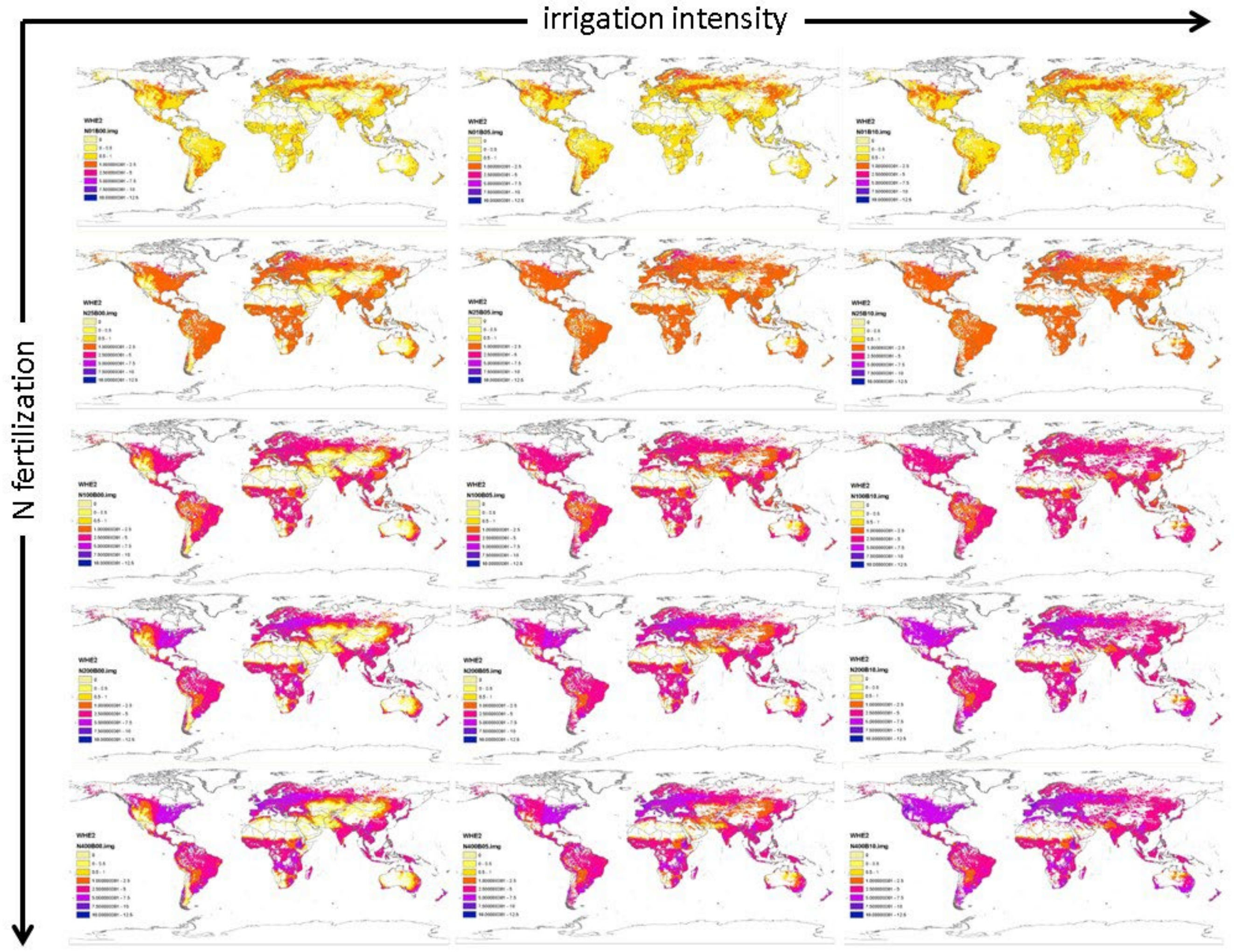
AFOLU GHG emission sources and globally consistent accounting

Detailed representation of biofuel processing technologies

Bilateral trade



Crop production systems: EPIC



Balkovic et al. (2014)

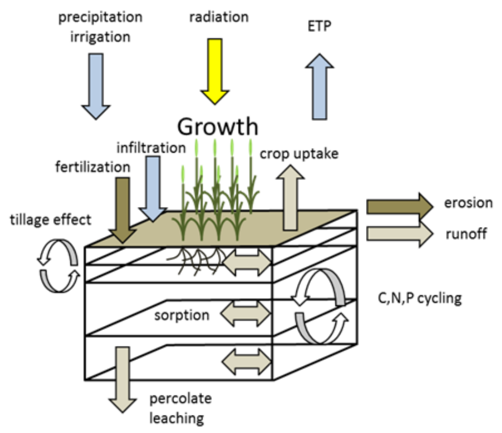
wheat yield [tDM/ha]

	0
	0 - 0.5
	0.5 - 1
	1.000000001 - 2.5
	2.500000001 - 5
	5.000000001 - 7.5
	7.500000001 - 10
	10.00000001 - 12.5

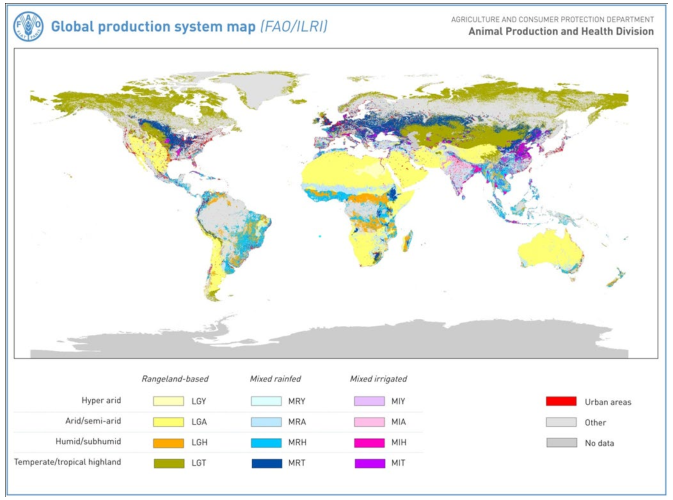
Spatially explicit production functions

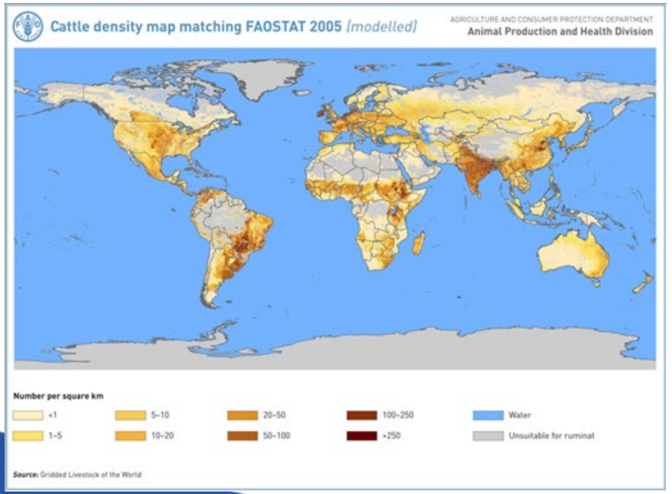
In every SimU:

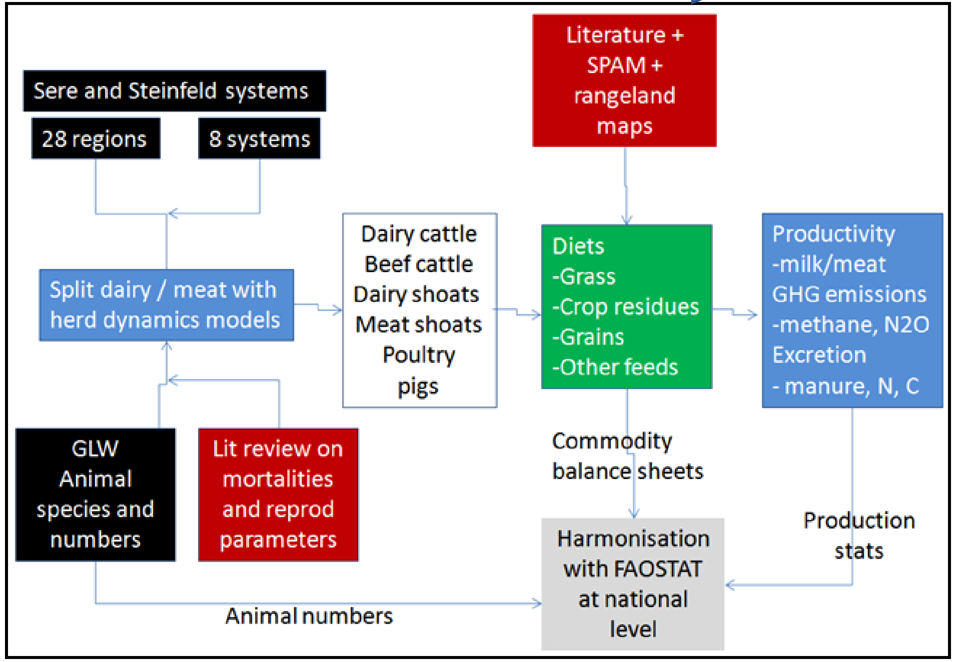
- Up to 18 possible crops in the global model version & 4 crop managements
- Parameters (yield, fertilizer and irrigation input requirement) estimated with biophysical models
  e.g., EPIC model (Izaurralde et al., 2006)



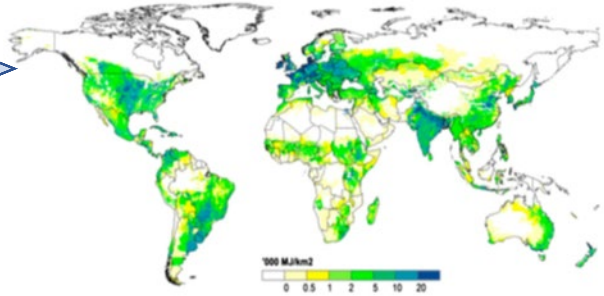
Livestock Production Systems: RUMINANT



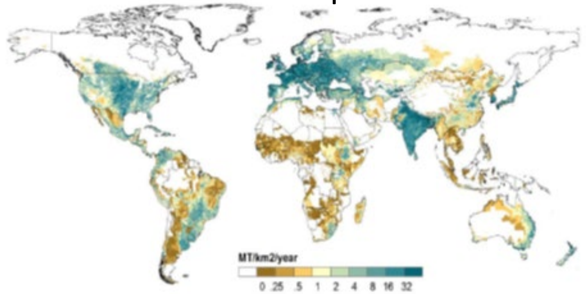




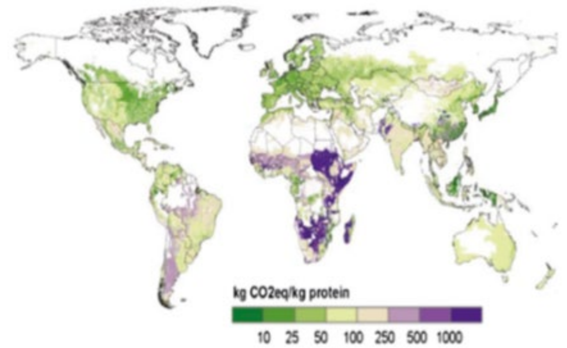
Metabolizable energy intake



Milk production



Non-CO2 emissions

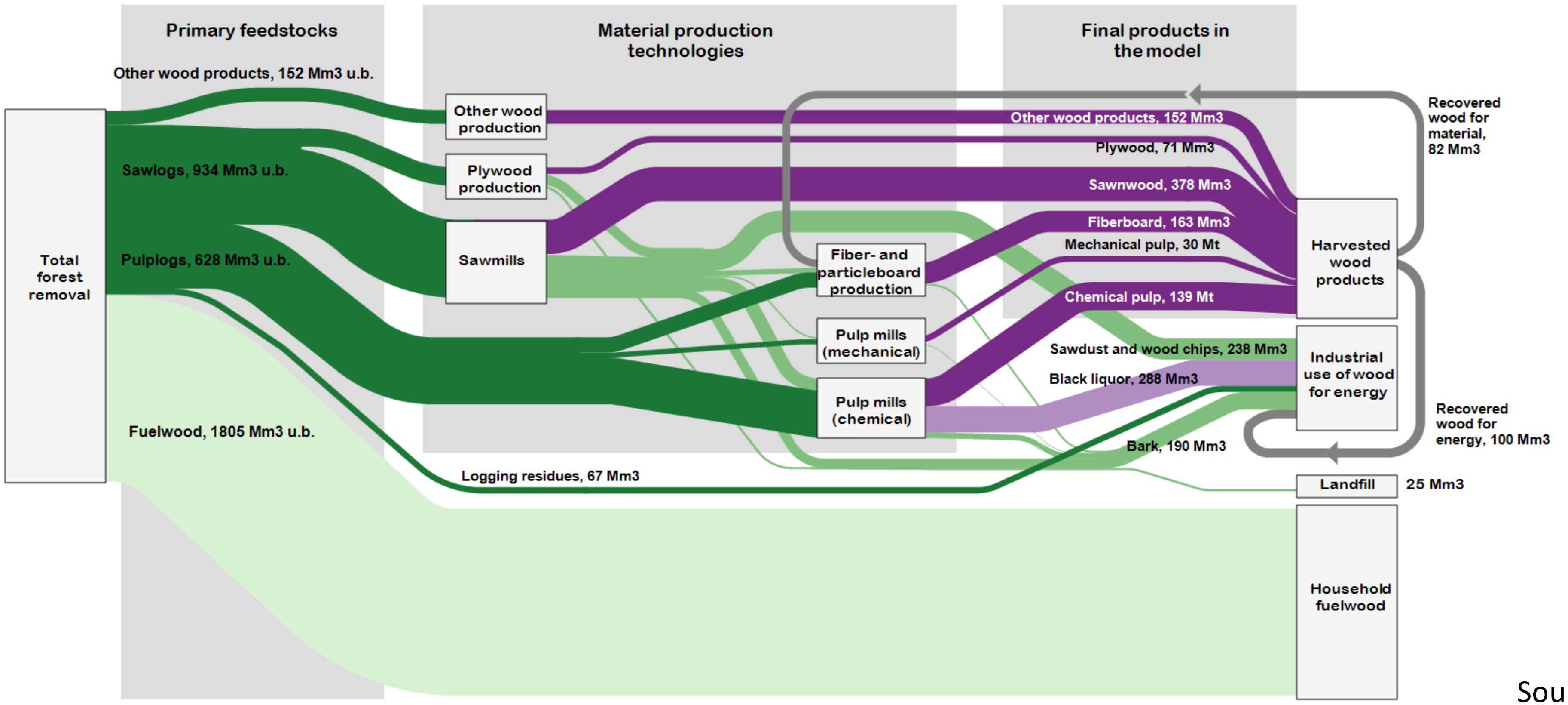


Source: Herrero et al. 2013, PNAS

Forest industries - GLOBIOM

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

GLOBIOM woody biomass use in 2010

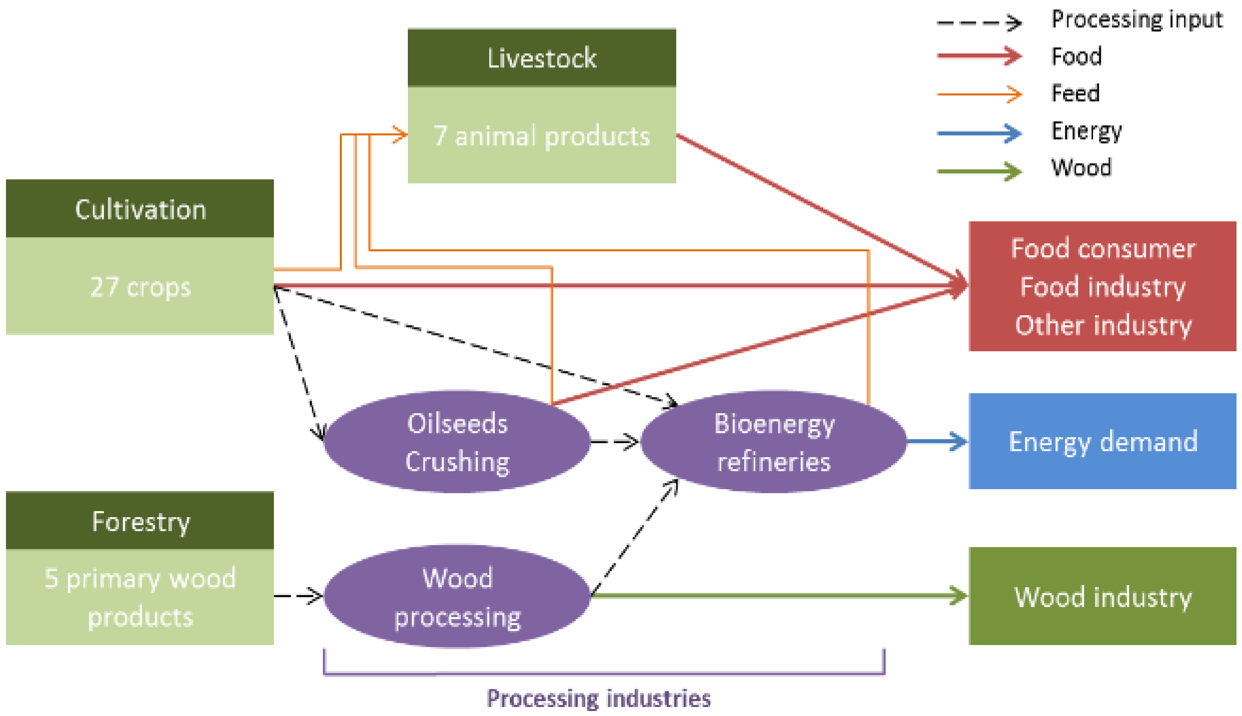


Source: Lauri et al., 2017

Biofuel processing chains

Food crop-based biofuels

- Starch crops: barley, corn & wheat
- Sugar crops: sugar cane & sugar beet
- Oil crops: rapeseed, soybean, oilpalm & sunflower

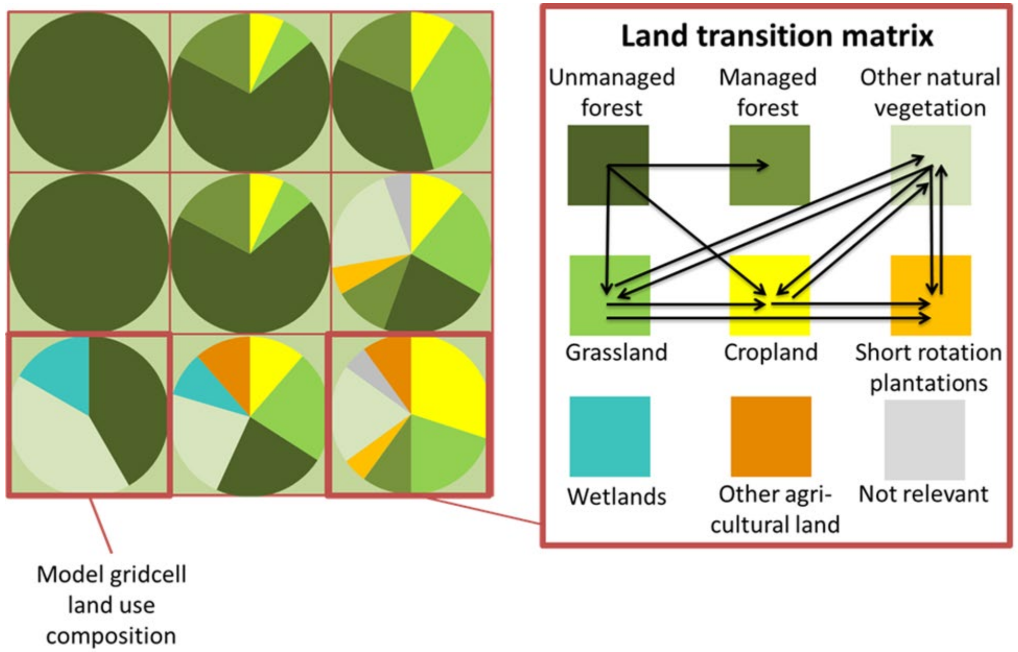


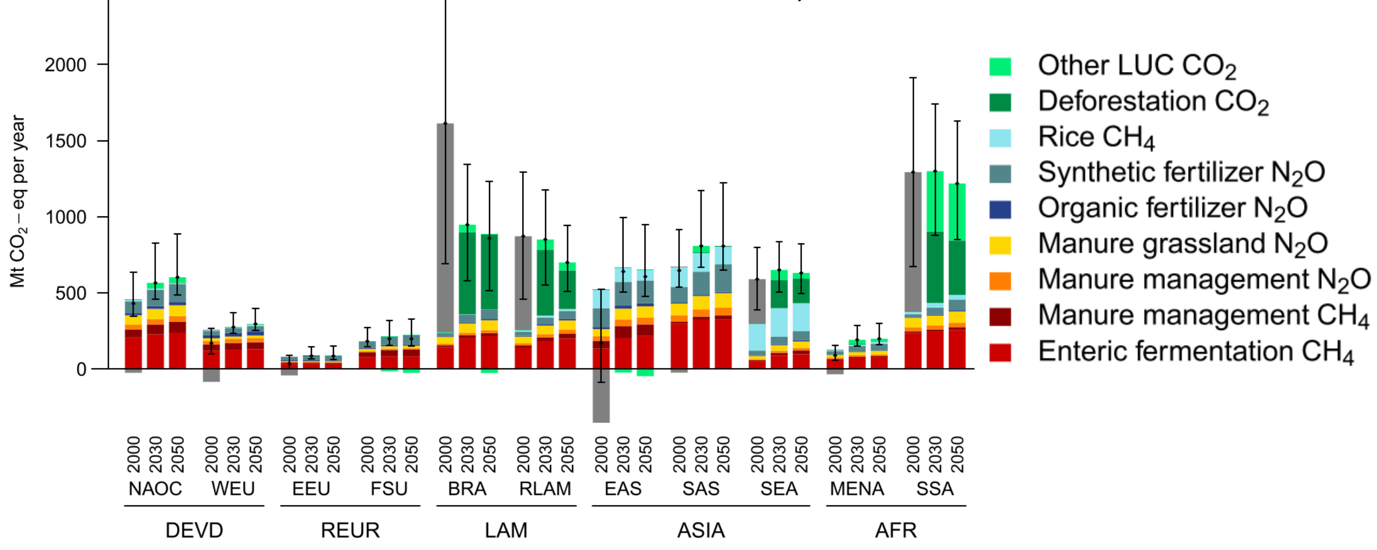
Advanced biofuels

- Residues: cereal straw & forest residues
- Short rotation coppices: poplar, willow & eucalyptus
- Grassy crops: miscanthus & switchgrass

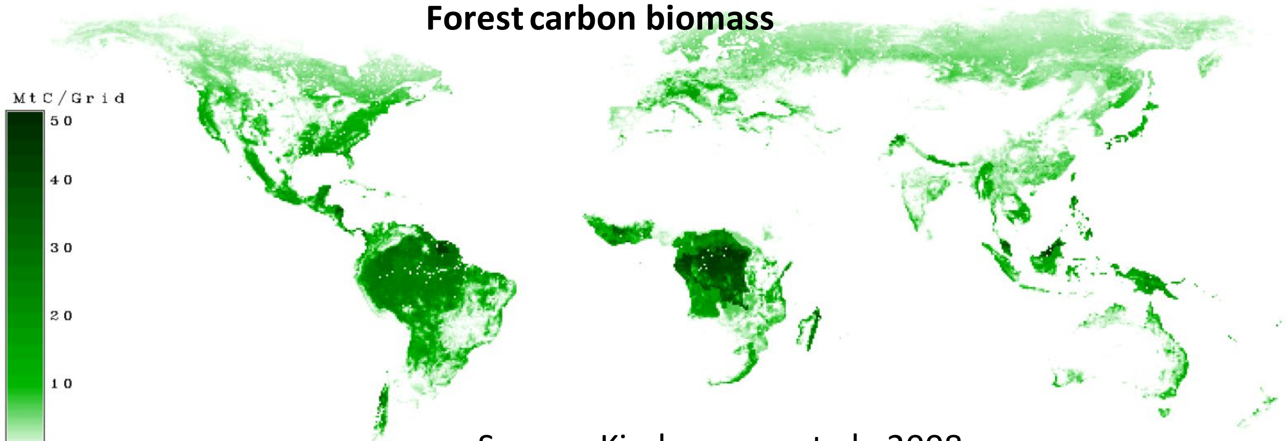
Land cover change

Full AFOLU GHG accounting





Source: Valin et al., 2013



Source: Kindermann et al., 2008

- Land cover change endogenous depending on relative profitability

Policy assessments

Biofuels Assessments

- EU ILUC & ILUC2 assessment
- ICAO CORSIA biofuel modelling

EU Energy & Climate Policies

- EU Reference scenarios 2013, 2016, 2020
- 2020 & 2030 Climate and Energy Package
- 2050 Long Term Strategy - A Clean Planet for All
- Fit for 55 package
- …

Providing modelling support to EC - DG ENE, CLIMA & ENV, US-EPA, OECD, Worldbank, FAO, UNEP-WCMC…

Land-use related sustainability assessments

nature sustainability
ARTICLES
https://doi.org/10.1038/s41893-019-0287-1

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

A. V. Pastor[1,2,3]*, A. Palazzo[1], P. Havlik[1], H. Biemans[4], Y. Wada[1], M. Obersteiner[1], P. Kabat[2,5] and F. Ludwig[2]

ARTICLES
https://doi.org/10.1038/s43016-021-00366-x
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Jinfeng Chang[1,2]✉, Petr Havlík[2], David Leclère[2], Wim de Vries[3], Hugo Valin[2], … Michael Obersteiner[2]

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David Leclère ✉, Michael Obersteiner ✉, … Lucy Young

Nature **585**, 551–556 (2020) | Cite this article

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China's future food demand and its implications for trade and environment

Hao Zhao[1,2,3], Jinfeng Chang[3,4], Petr Havlík[3]✉, Michie… Charlotte Janssens[3,6], Lin Ma[1]✉, Zhaohai Bai[1], Mario H… Michael Obersteiner[3,9]

ARTICLES
https://doi.org/10.1038/s41893-019-0371-6
nature sustainability

Tackling food consumption inequality to fight hunger without pressuring the environment

Tomoko Hasegawa[1,2,3]*, Petr Havlík[2], Stefan Frank[2], Amanda Palazzo[2] and Hugo Valin[2]

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Charlotte Janssens[1,2]✉, Petr Havlík[2], Tamás Krisztin[2], Justin Baker[3], Stefan Frank[2], Tomoko Hasegawa[2,4], David Leclère[2], Sara Ohrel[5], Shaun Ragnauth[5], Erwin Schmid[6], Hugo Valin[2], Nicole Van Lipzig[1] and Miet Maertens[1]

Thank you!

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