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

SUPREMA GLOBIOM-MAGNET Training

December 4, 2020

GLOBIOM - Introduction

Center for Environmental Resources & Development, Presenter: Petr Havlík

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 773499 SUPREMA.

suprema

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

- Miroslav Batka
- Esther Boere
- Albert Brouwer
- Sophie-Charlotte Bundle
- Andre Deppermann
- Tatiana Ermolieva
- Neus Escobar Lanzuela
- Fulvio Di Fulvio
- Nicklas Forsell
- Stefan Frank
- Mykola Gusti
- Petr Havlík
- Tamás Krisztin
- Pekka Lauri
- David Leclère
- Michael Le Gohebel
- Amanda Palazzo
- Frank Sperling
- Hugo Valin
- Michael Wögerer

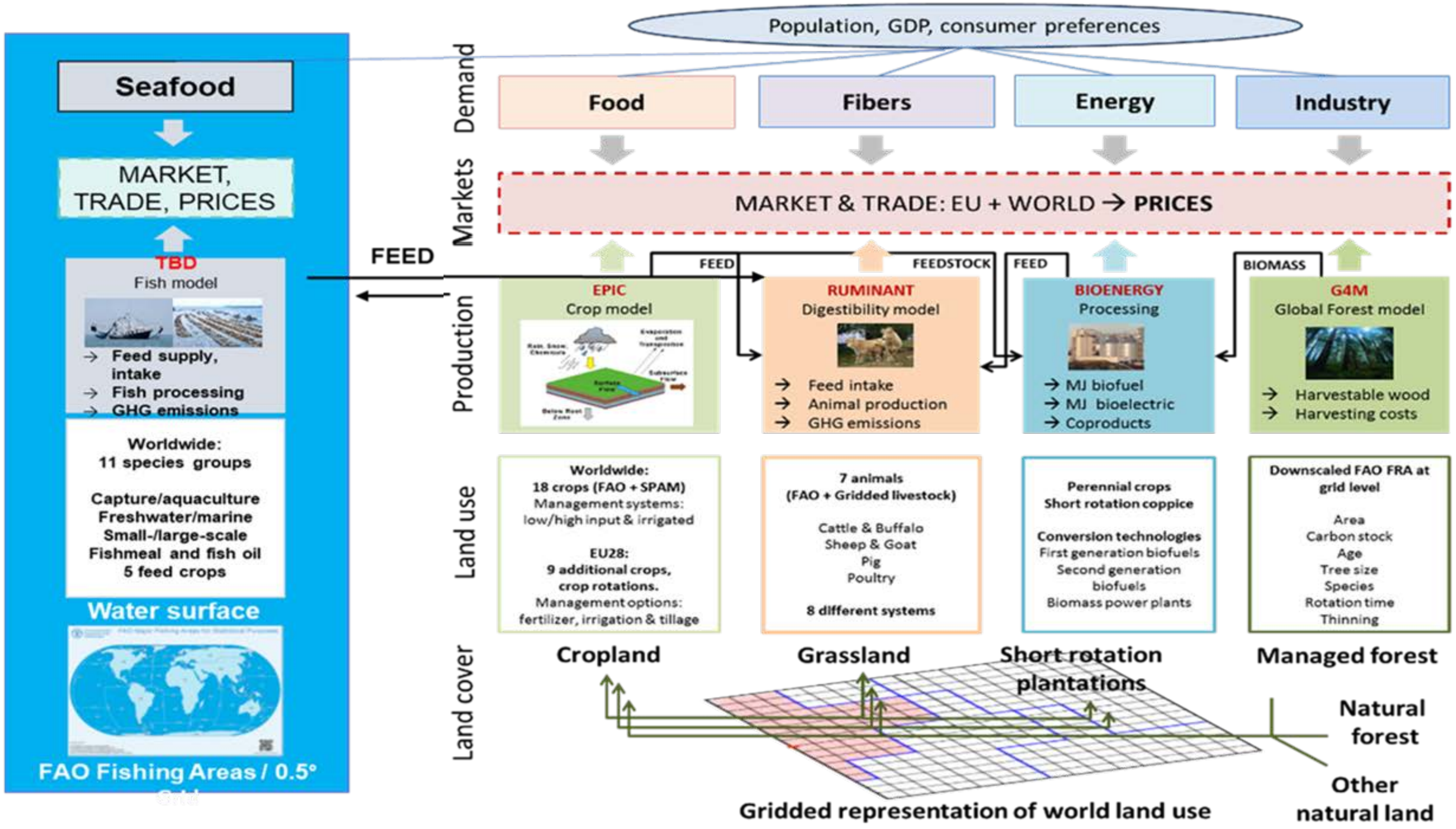
Guest researchers

- Juliana Arbelaez Gaviria
- Justin Baker
- Jinfeng Chang
- Sabine Fuss
- Charlotte Janssens
- Philipp Piribauer
- Aline Soterroni
- Michiel van Dijk
- Hao Zhao

IIASA Postdoc fellows

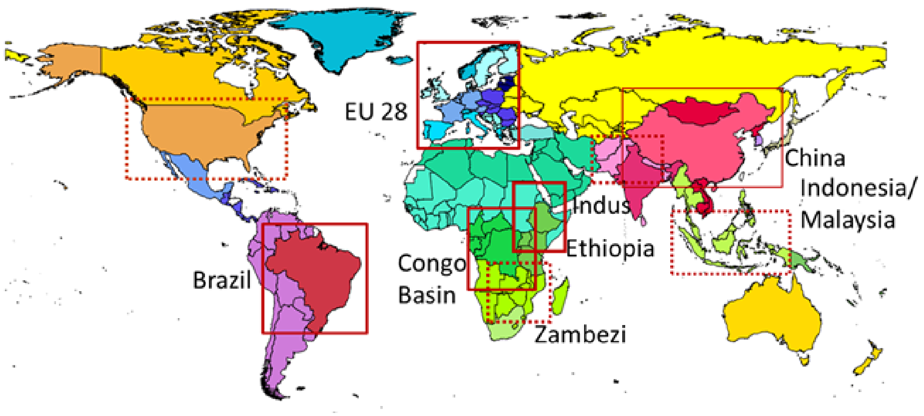
- Ren Ming, PKU-IIASA
- Bai Minghao, PKU-IIASA with WAT
- Yixin Guo, PKU-IIASA with AIR
- Eleanor Warren-Thomas, NERC-IIASA

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
- Open access strategy under development

Bridging geographical and temporal scales



2000 2010 2020 2030 2040 2050 2060 2070 2080 2100

Validation period

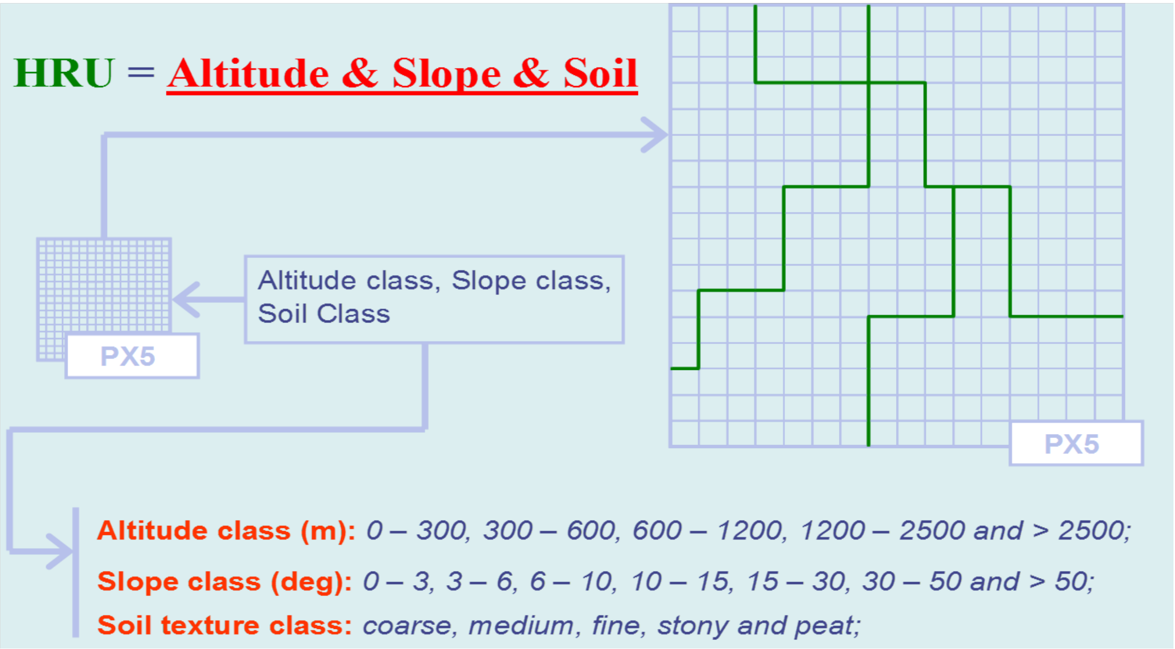
Policy Impact Assessment

Long-Term Outlook

Climate stabilization pathways

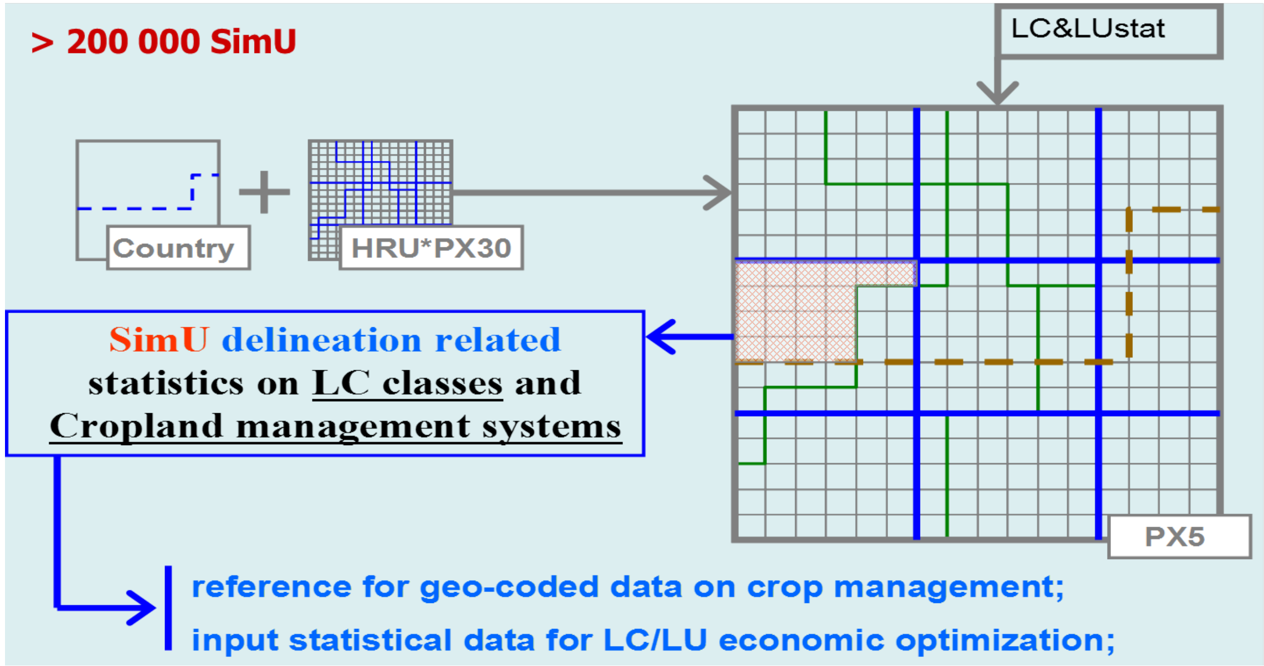
Spatial resolution

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



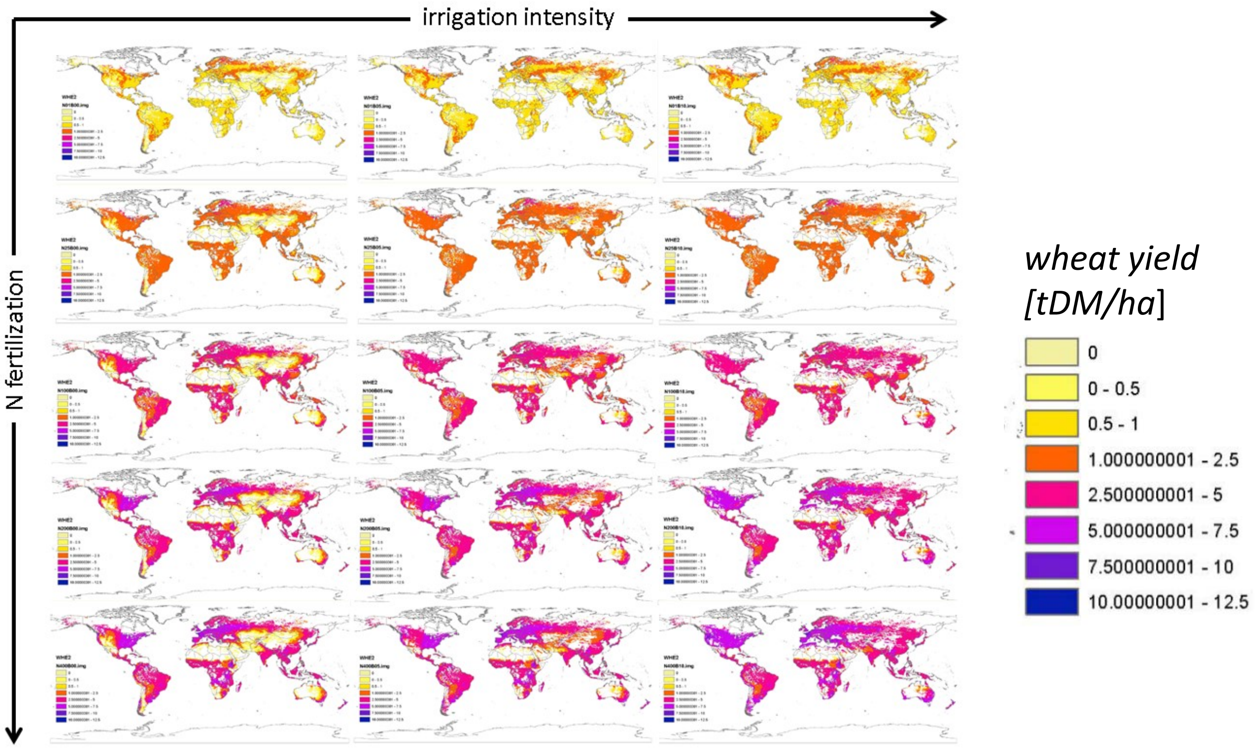
Source: Skalský et al. (2008)

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



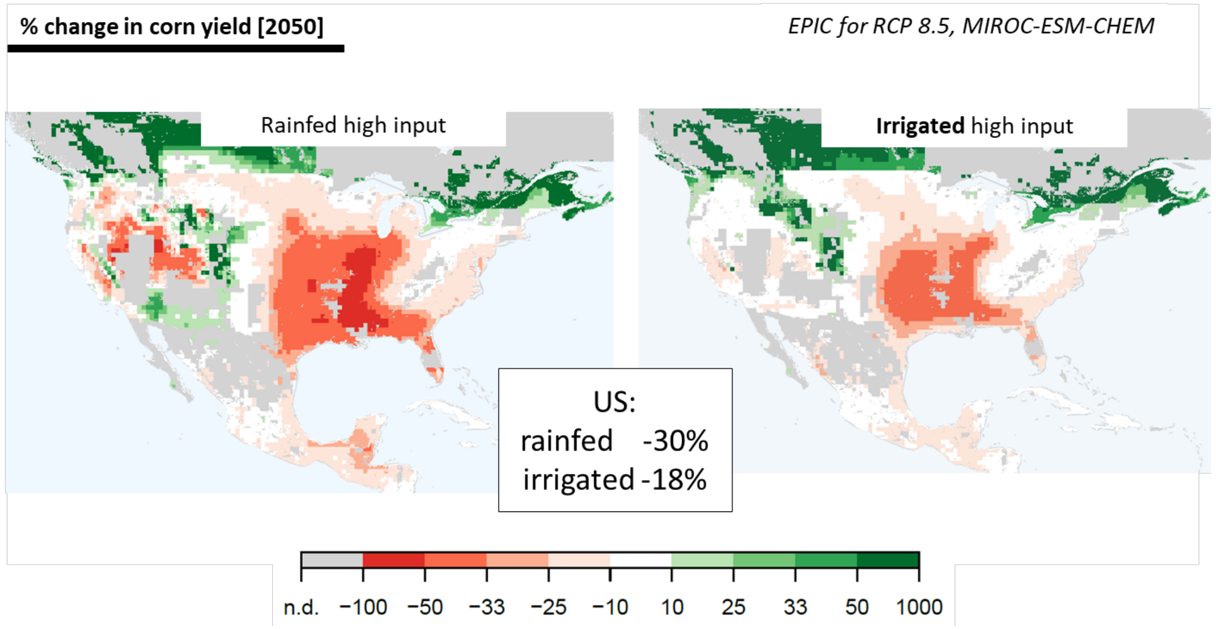
Crops: EPIC

- Spatially explicit production functions



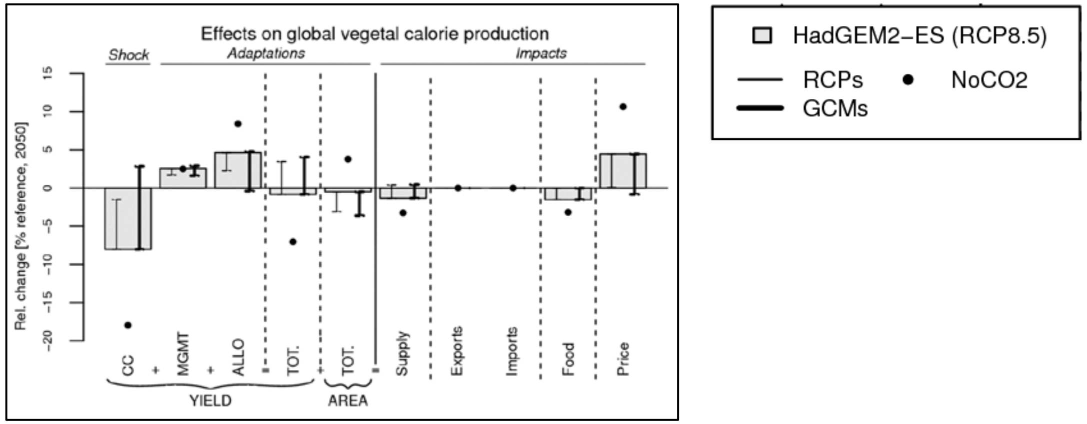
Source: Balkovič et al.

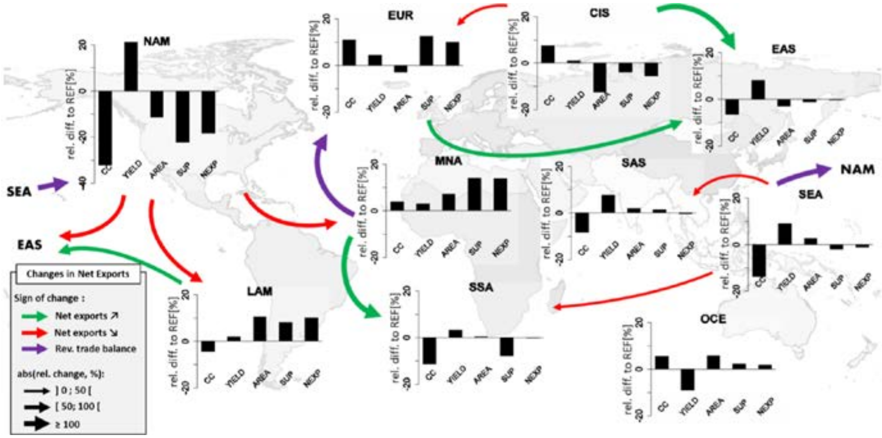
- Climate change impacts



Climate change impacts, adaptation and extremes

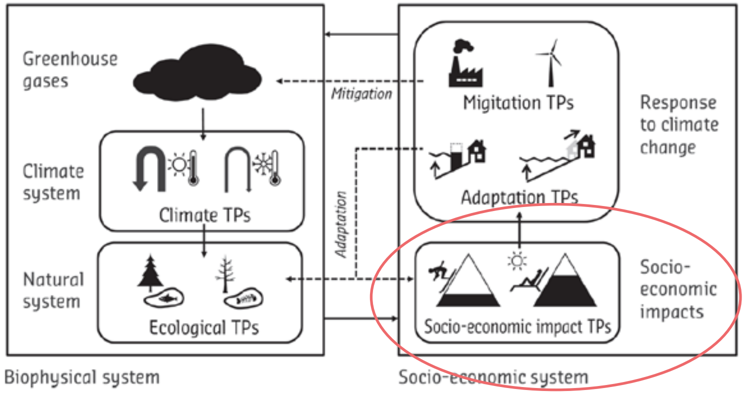
Impacts and adaptation





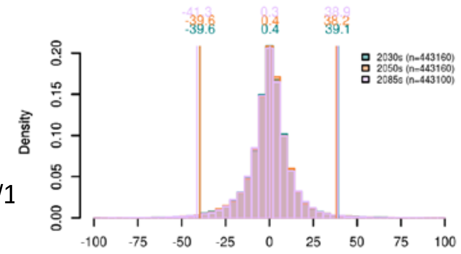
Leclere et al. 2014. Climate change induced transformations of agricultural systems: insights from a global model. *Environmental Research Letters.* (9):12

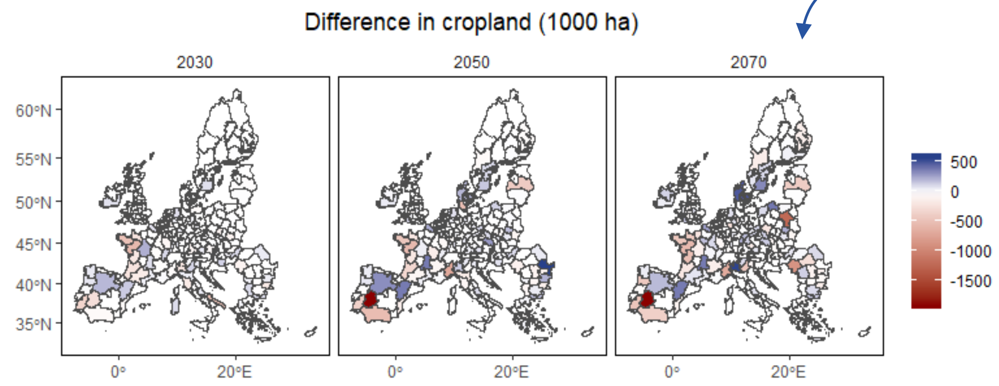
Extreme events



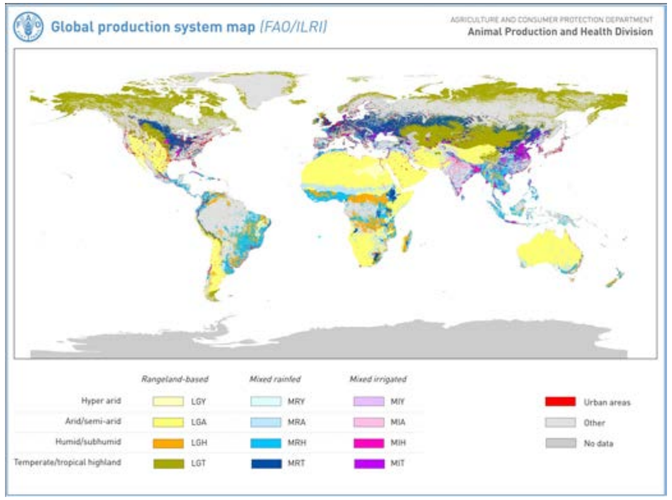
van Ginkel et al. 2019 Environ. Res. Lett. (2020) https://doi.org/10.1088/1748-9326/ab6395

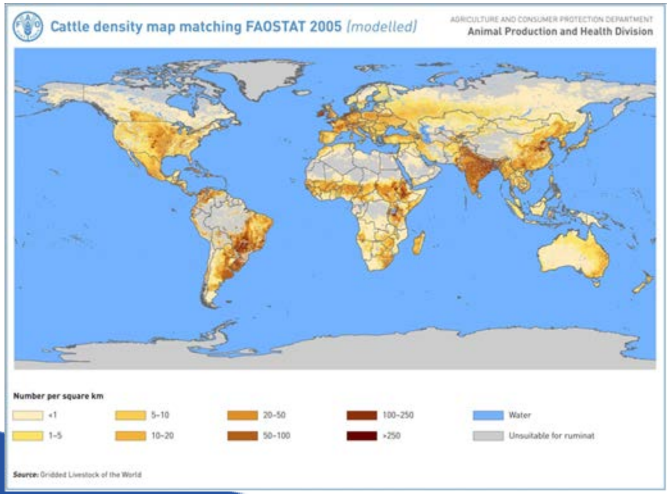
Study magnitude and frequency of yield losses

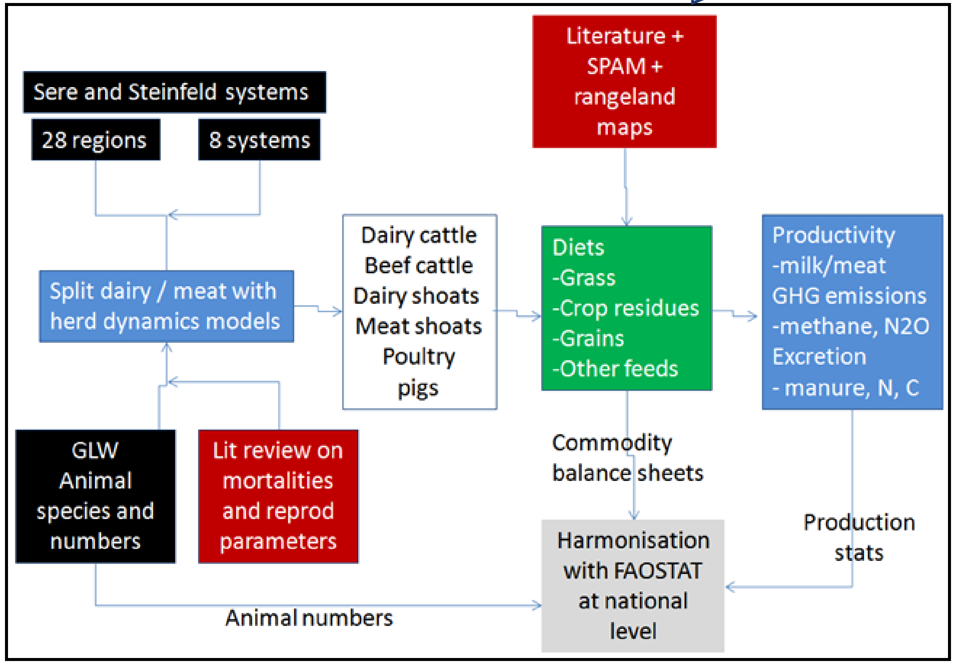




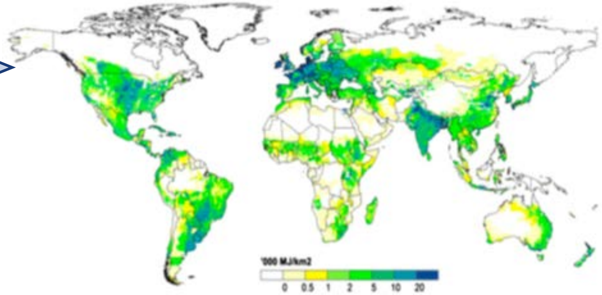
Livestock Production Systems: RUMINANT



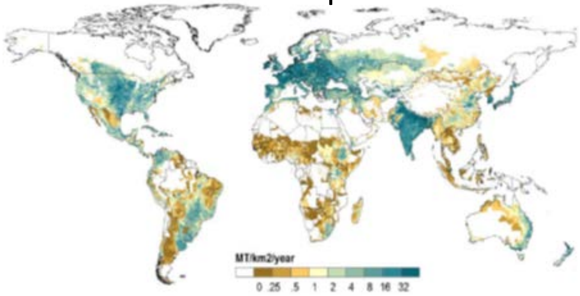




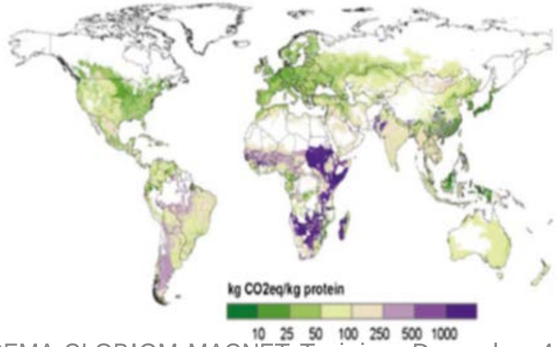
Metabolizable energy intake



Milk production



Non-CO2 emissions



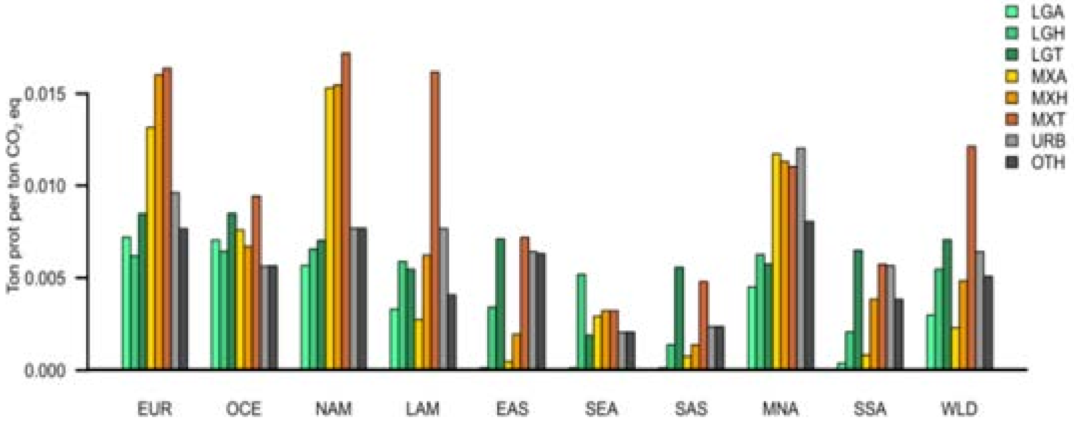
Source: Herrero et al. 2013, PNAS

Heterogeneity of farm systems matters

Large efficiency gaps prevail between production systems and regions

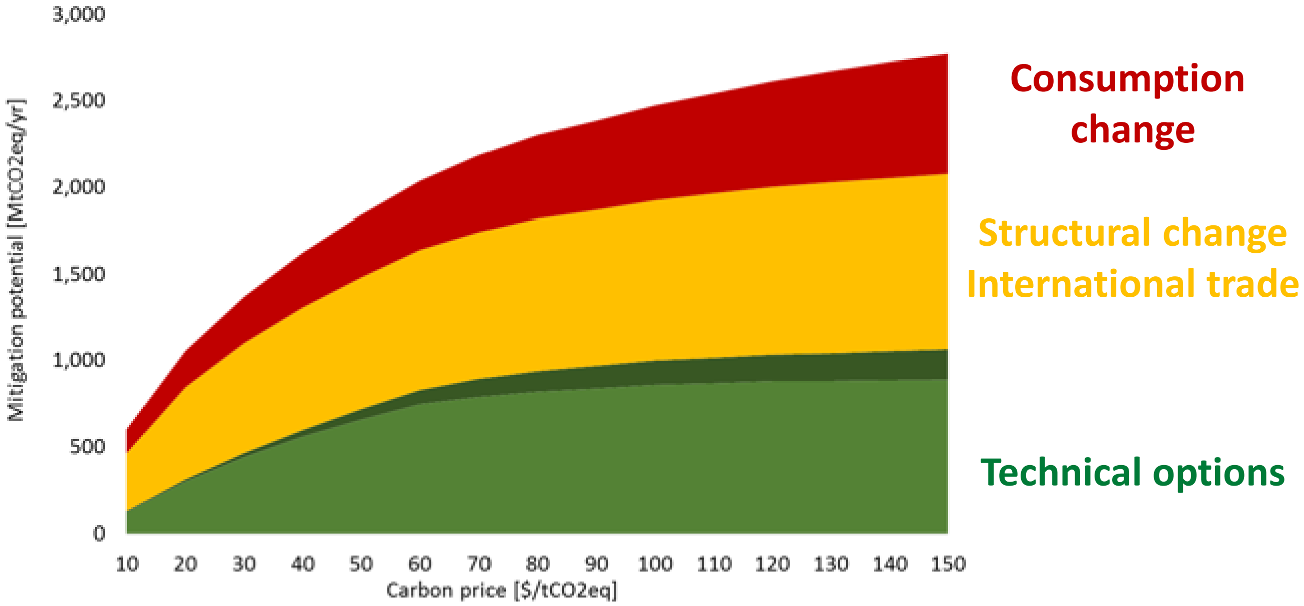
Reallocation of production across systems and regions would reduce GHG emissions, nitrogen pollution, and water scarcity

GHG efficiency of beef production by system and regions



Herrero et al. PNAS 2013

Annual non-CO_2 abatement potential by 2050 Water & nitrogen



Frank et al. NCOMM 2018

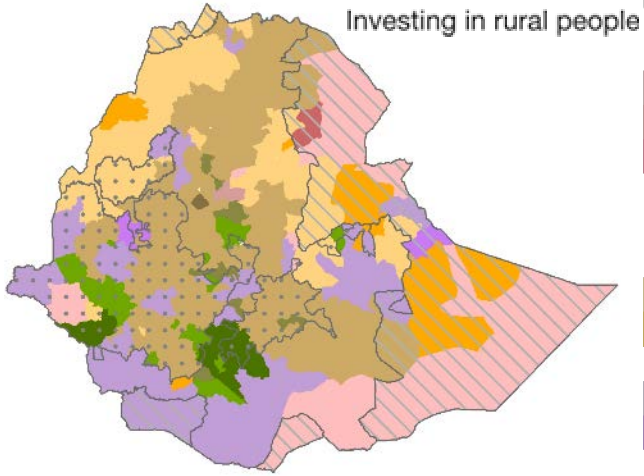
Flexible production systems definition: Smallholder farmers

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**

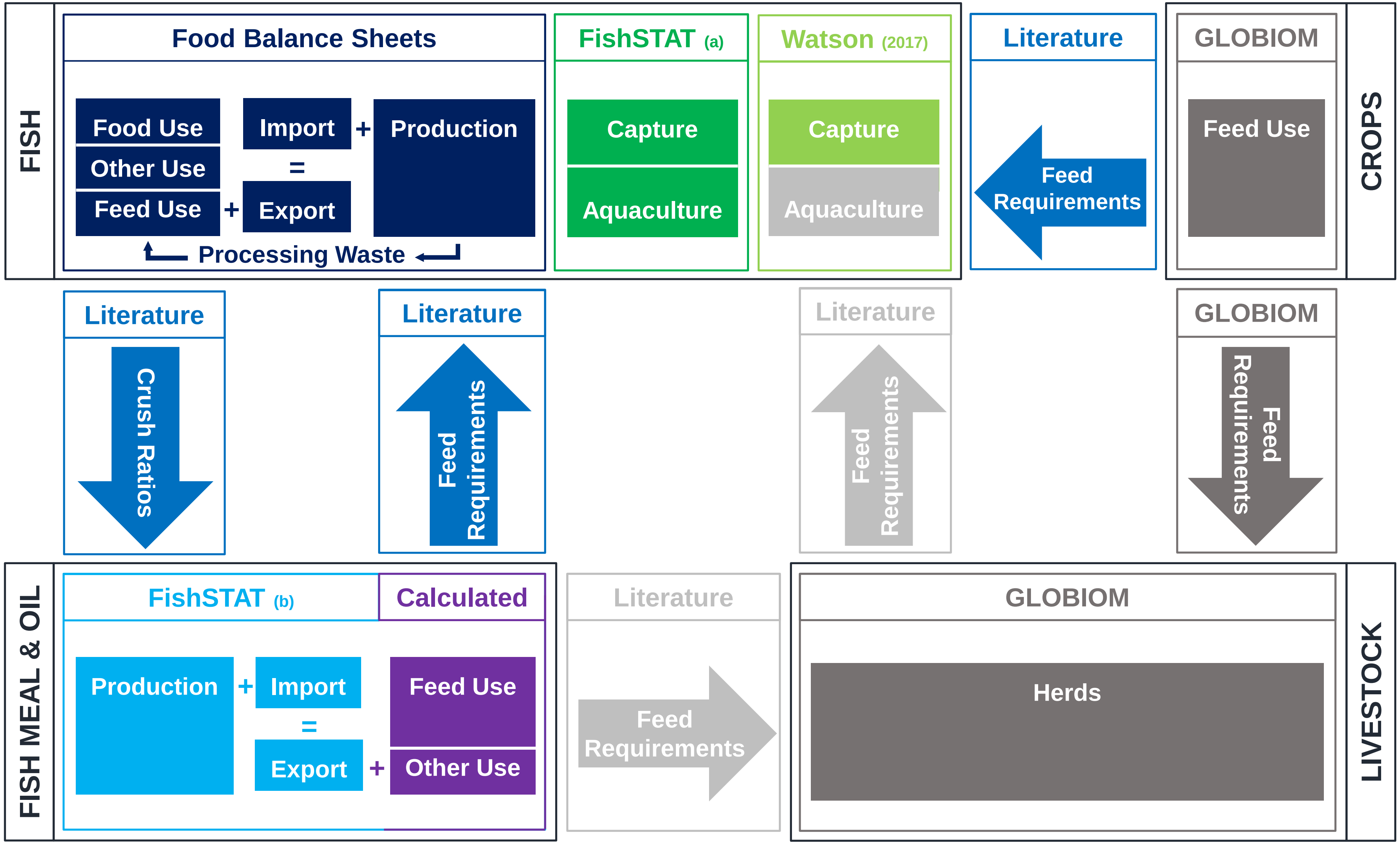


New typology built on 3 criteria:

- AEZ
- Main production
- Market integration

Source: Boere et al. 2019

Fisheries & Aquaculture

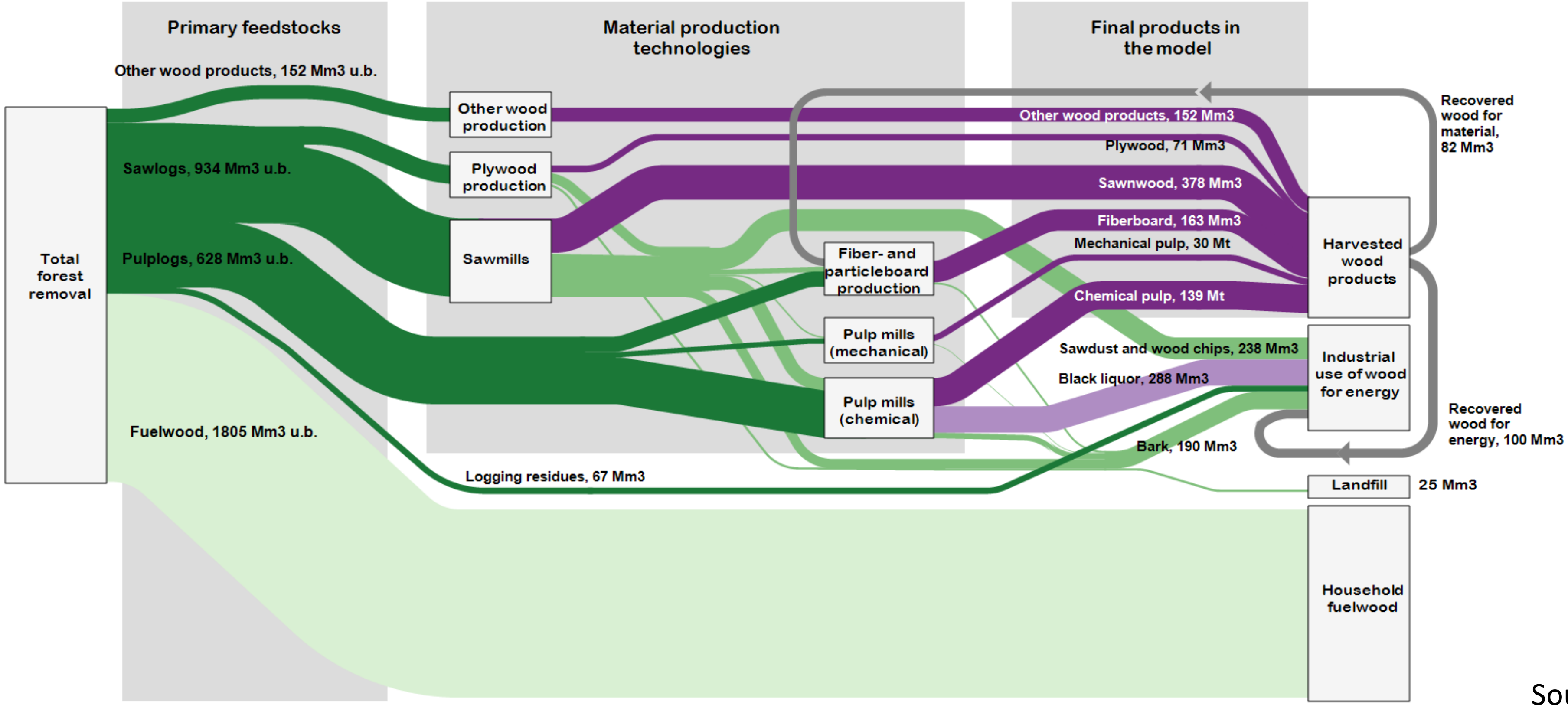


Source: Batka et al., in preparation

Forestry

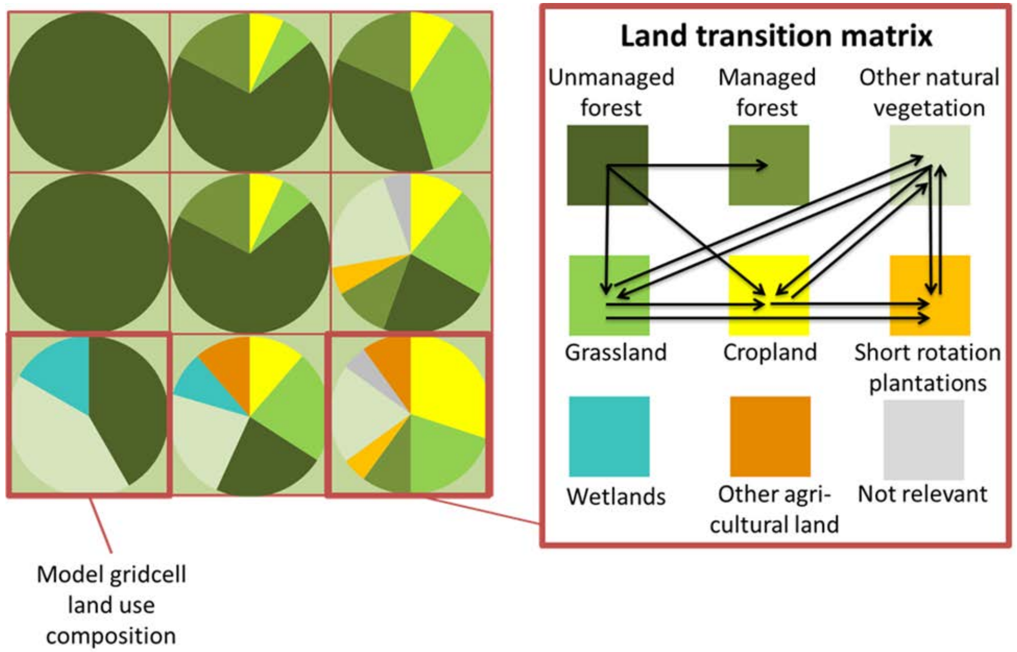
- GLOBIOM covers the main primary feedstocks, by-products, and semi-finished HWP products.
- Wood flows as of 2010 is calibrated according to FAOSTAT.

GLOBIOM woody biomass use in 2010



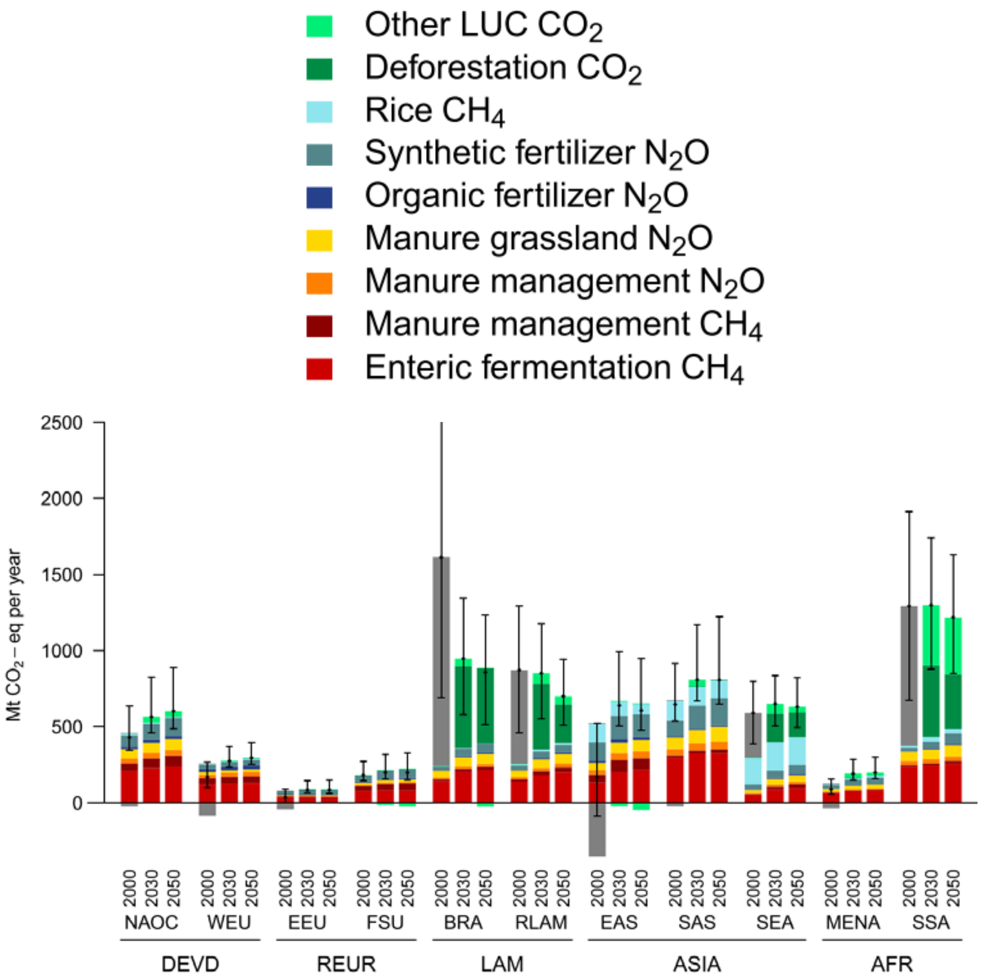
Source: Lauri et al., 2017

Land cover change



- Land cover change endogenous depending on relative profitability

Full AFOLU GHG accounting



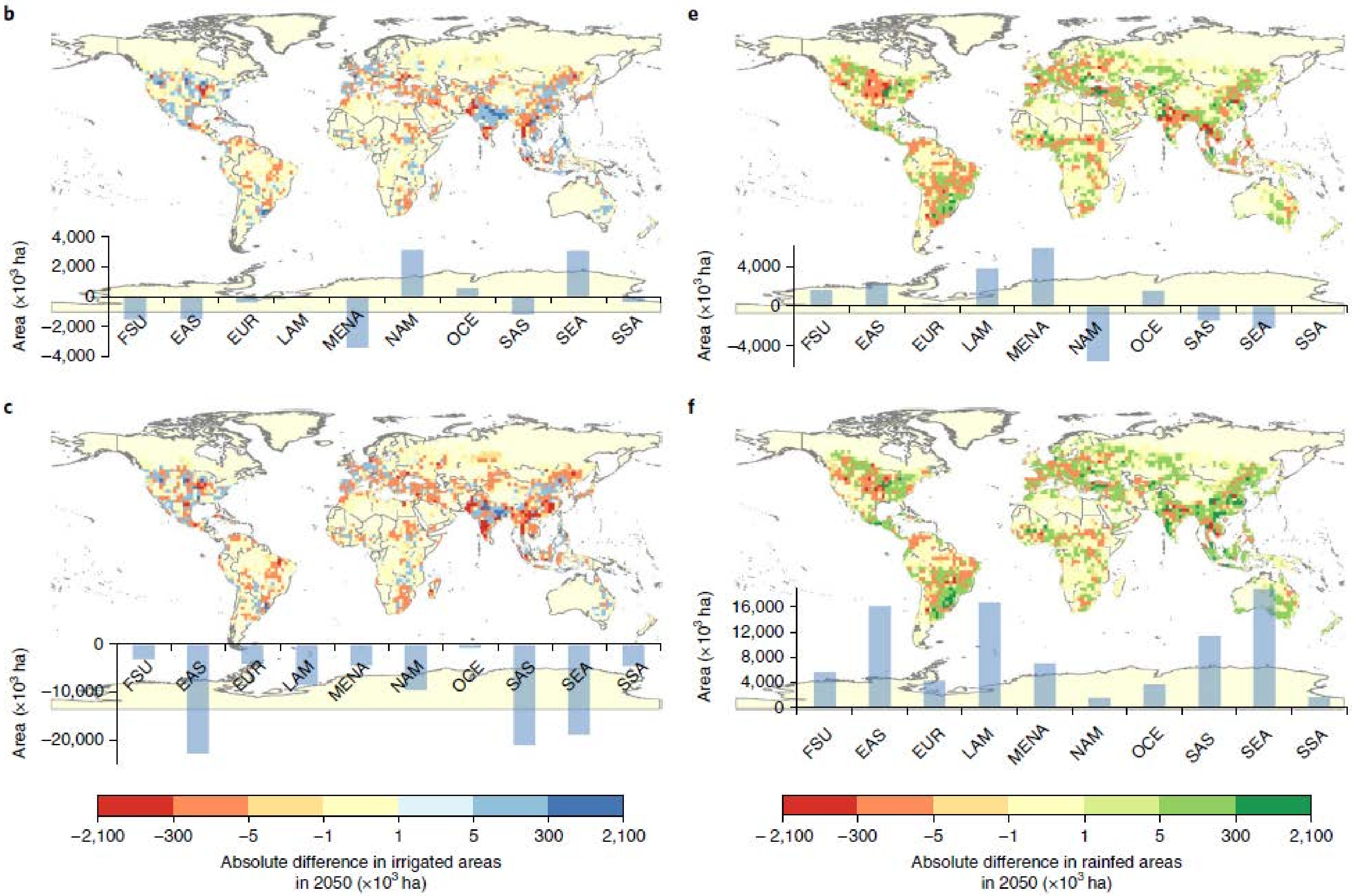
Source: Valin et al., 2013

Water balance

Net change in irrigated (left) and rainfed areas (right)

climate change impacts
on irrigation water
requirements
and water availability

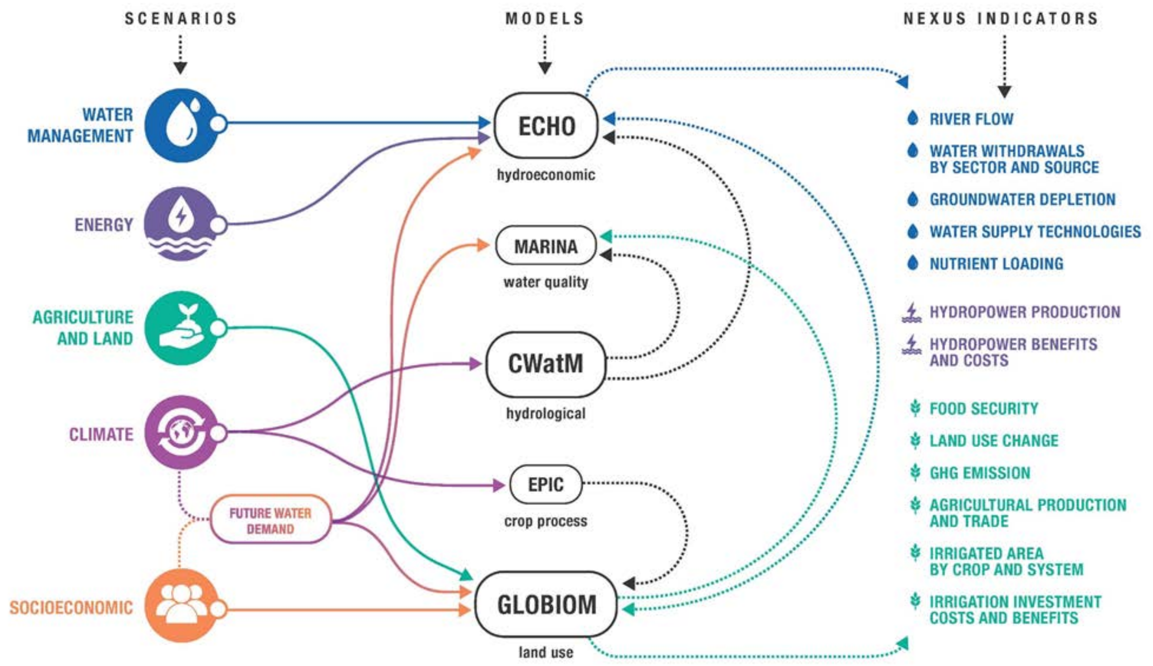
climate change impacts
and protections
for environmental flow
requirements



Pastor et al. (2019). The global nexus of food–trade–water sustaining environmental flows by 2050. Nature Sustainability. DOI: https://doi.org/10.1038/s41893-019-0287-1

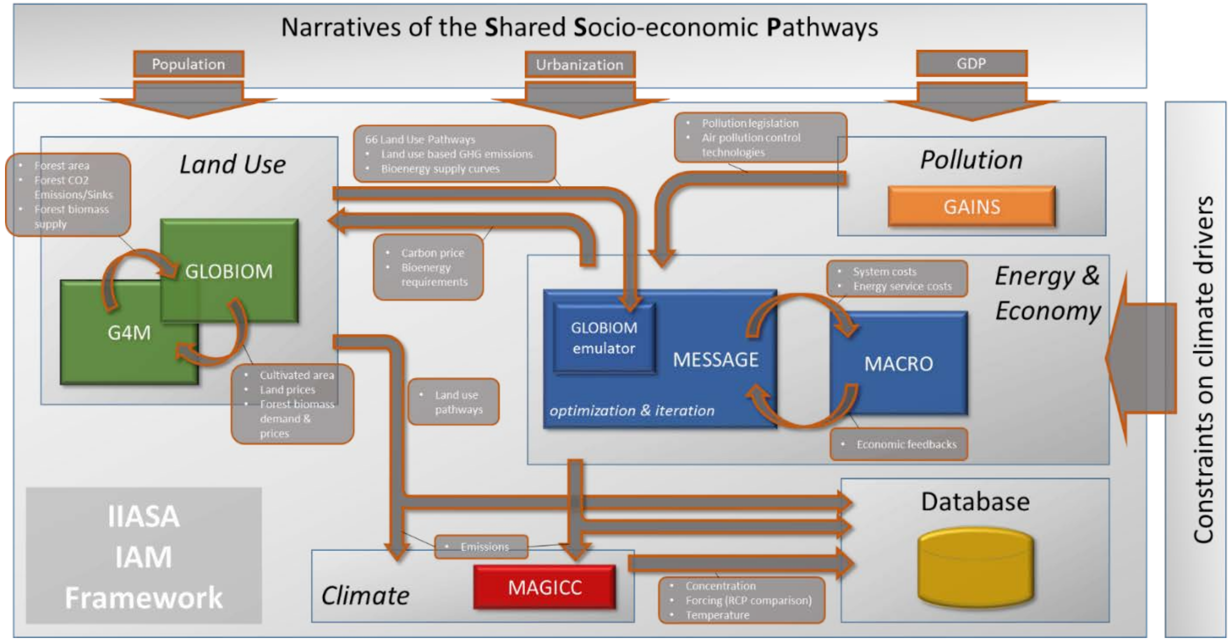
Interlinkages with other sectors and feedback effects

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)

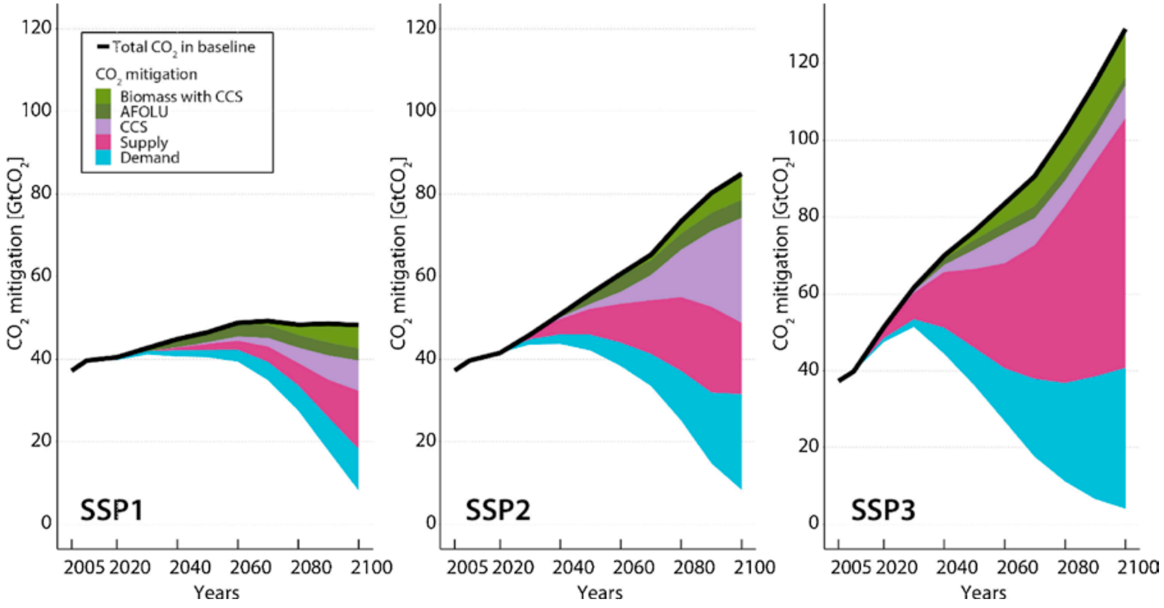


Source: Fricko et al., 2017

Scenario analysis at the global and local scale

Global

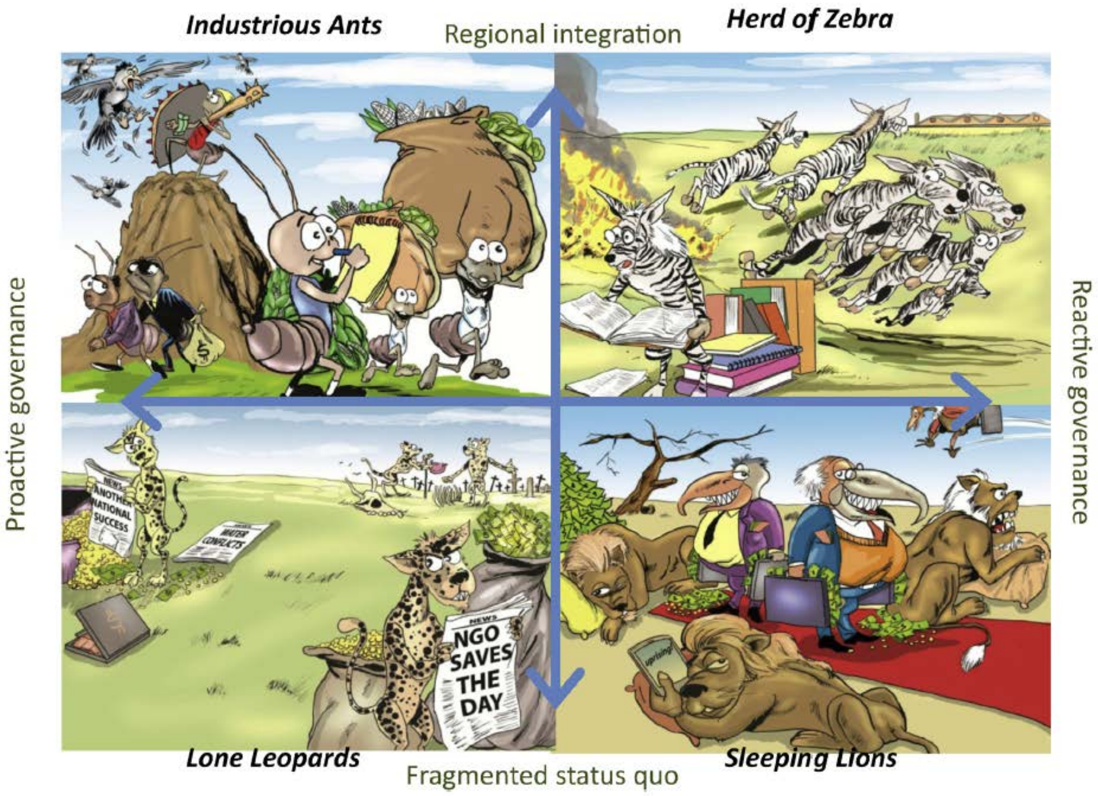
To assess potential futures and their consequences for the agriculture and forestry sectors



Fricko et al. (2017). The marker quantification of the Shared Socioeconomic Pathway 2: A middle-of-the-road scenario for the 21st century. *Global Environmental Change* 42: 251-267. DOI:https://doi.org/10.1016/j.gloenvcha.2016.06.004

Local

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



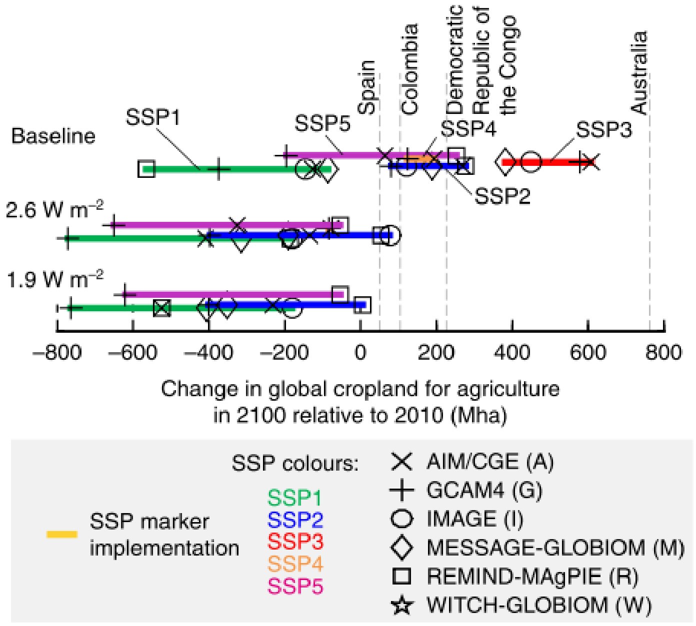
Palazzo et al. (2017). Linking regional stakeholder scenarios and shared socioeconomic pathways: Quantified West-African food and climate futures in a global context. *Global Environmental Change* 45: 227-242. DOI:10.1016/j.gloenvcha.2016.12.002

Climate change mitigation

nature climate change
ARTICLES
https://doi.org/10.1038/s41558-018-0091-3

Scenarios towards limiting global mean temperature increase below 1.5 °C

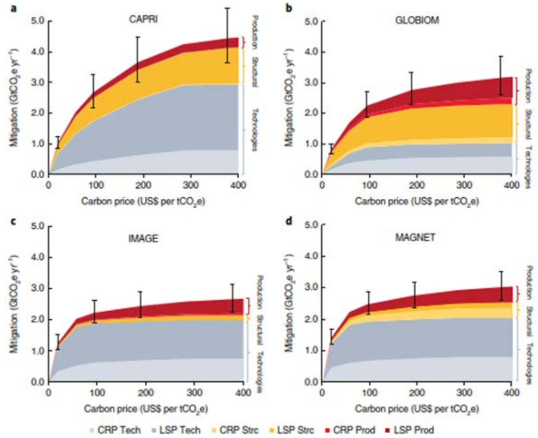
Joeri Rogelj[1,2]*, Alexander Popp[3], Katherine V. Calvin[4], Gunnar Luderer[3], Johannes Emmerling[5,6],



ARTICLES
https://doi.org/10.1038/s41558-018-0358-8
nature climate change

Agricultural non-CO_2 emission reduction potential in the context of the 1.5 °C target

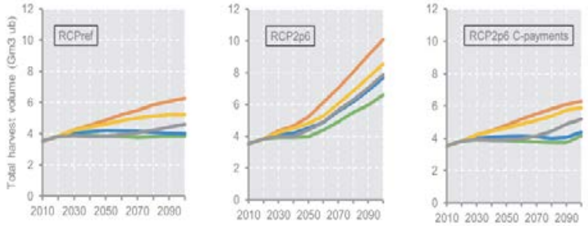
Stefan Frank[1]*, Petr Havlík[1], Elke Stehfest[2], Hans van Meijl[3], Peter Witzke[4], Ignacio Pérez-Domínguez[5], Michiel van Dijk[1,3], Jonathan C. Doelman[2], Thomas Fellmann[5], Jason F. L. Koopman[3], Andrzej Tabeau[3] and Hugo Valin[1]



Journal of Forest Economics, 2019, 34: 285–309

Global Woody Biomass Harvest Volumes and Forest Area Use Under Different SSP-RCP Scenarios

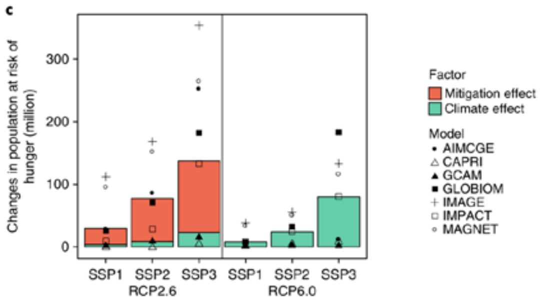
Pekka Lauri, Nicklas Forsell, Mykola Gusti, Anu Korosuo, Petr Havlík and Michael Obersteiner*



nature climate change
LETTERS
https://doi.org/10.1038/s41558-018-0230-x

Risk of increased food insecurity under stringent global climate change mitigation policy

Tomoko Hasegawa[1,2]*, Shinichiro Fujimori[1,2,3], Petr Havlík[2], Hugo Valin[2], Benjamin Leon Bodirsky[4], Jonathan C. Doelman[5], Thomas Fellmann[6], Page Kyle[7], Jason F. L. Koopman[8], Hermann Lotze-Campen[4,9], Daniel Mason-D'Croz[10,11], Yuki Ochi[12], Ignacio Pérez Domínguez[6], Elke Stehfest[5], Timothy B. Sulser[10], Andrzej Tabeau[8], Kiyoshi Takahashi[1], Jun'ya Takakura[1], Hans van Meijl[8], Willem-Jan van Zeist[5], Keith Wiebe[10] and Peter Witzke[13]

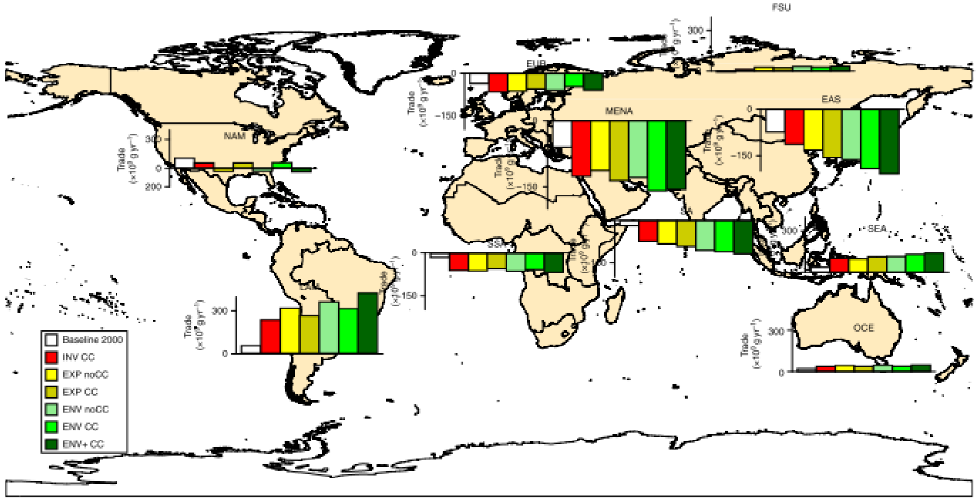


Climate change impacts, international trade policies, and food security

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

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

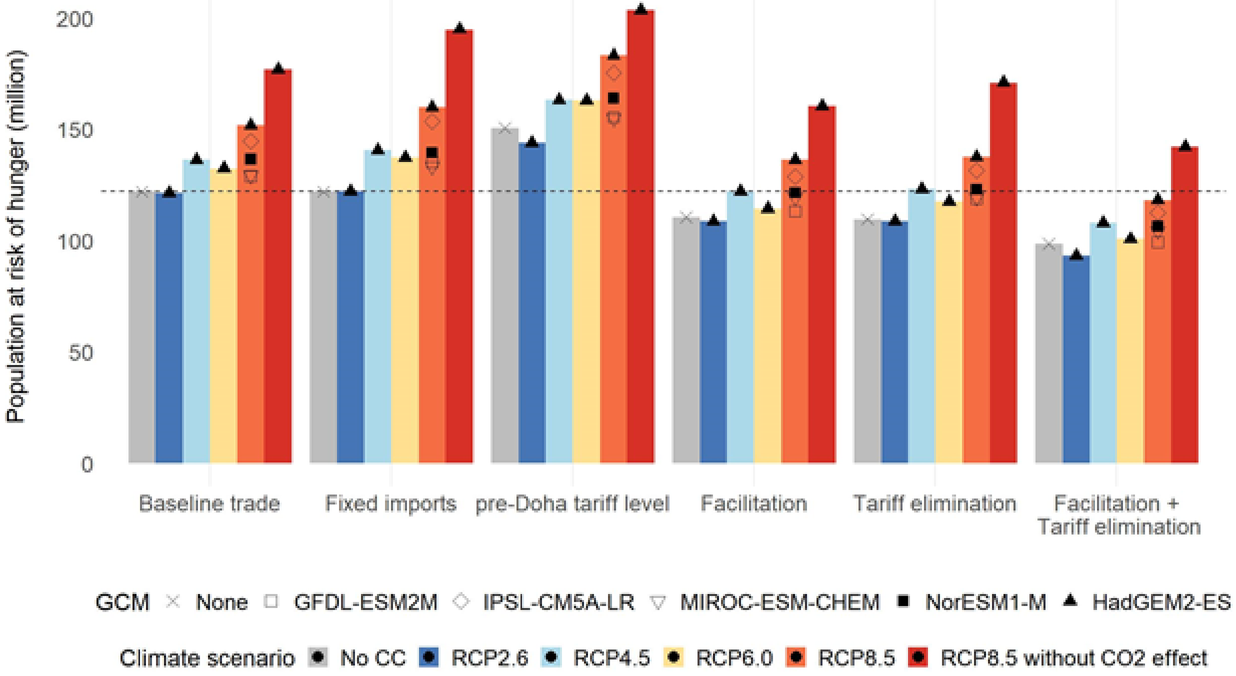
A. V. Pastor[1,2,3*], A. Palazzo[1], P. Havlik[1], H. Biemans[4], Y. Wada[1], M. Obersteiner[1], P. Kabat[2,5] and F. Ludwig[2]



nature climate change | ARTICLES
https://doi.org/10.1038/s41558-020-0847-4
Check for updates

Global hunger and climate change adaptation through international trade

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]



Biodiversity and the need for wholistic strategies

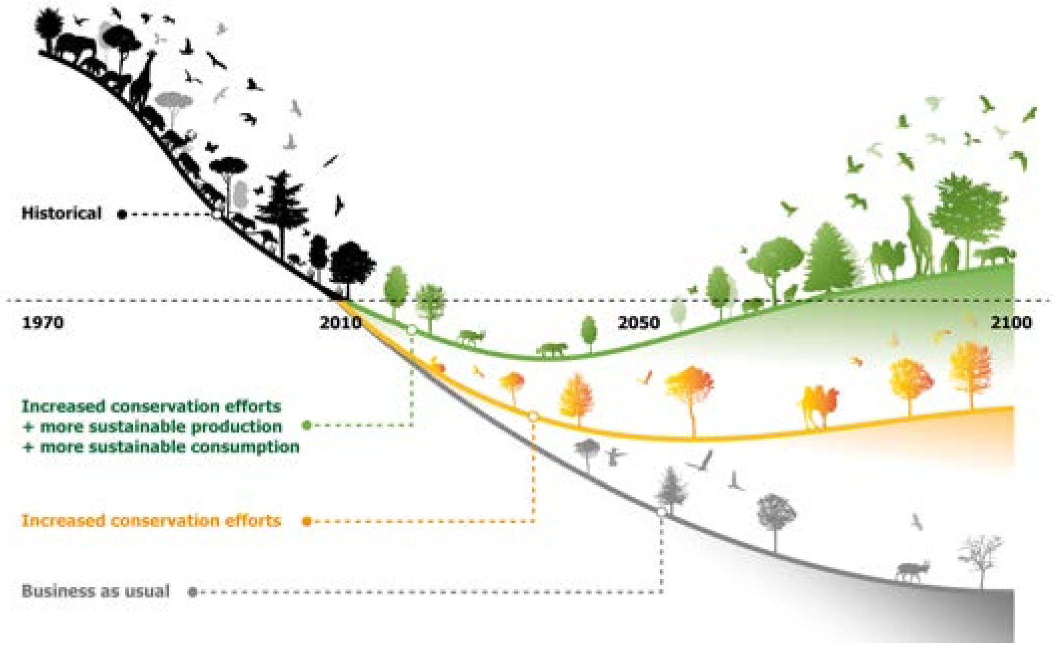
Article

Bending the curve of terrestrial biodiversity needs an integrated strategy

nature

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, …)



Connecting social and environmental sustainability

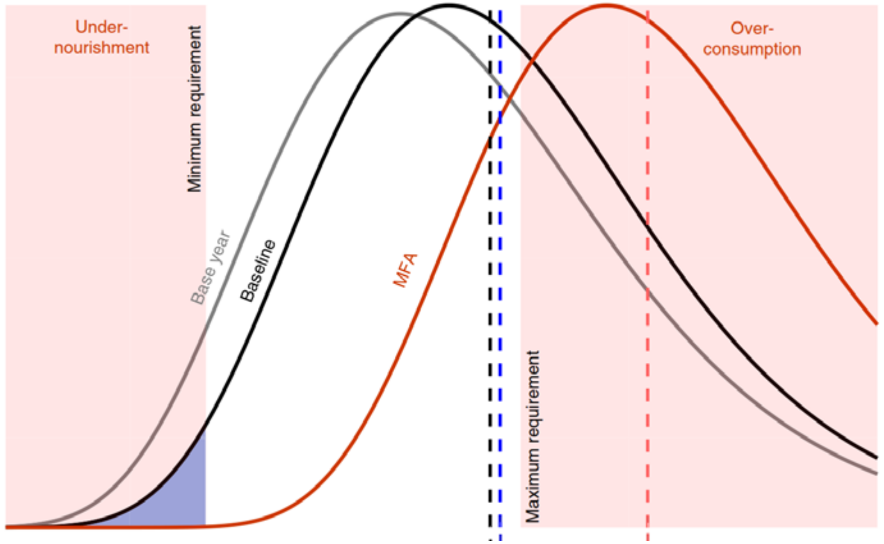
ARTICLES
https://doi.org/10.1038/s41893-019-0371-6
nature sustainability

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]

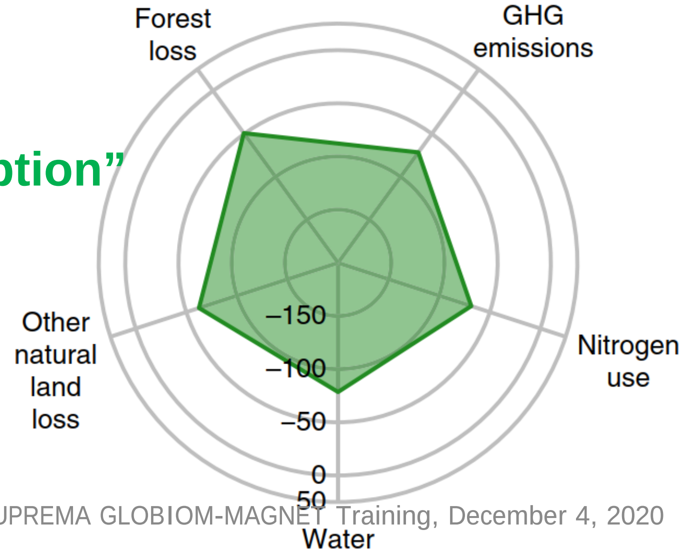
NIES JAPAN

Food availability distribution across the individuals in the population



"More Food for All"

"Food for Poor & No Overconsumption"



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

References

Balkovič J, van der Velde M, Skalský R, Xiong W, Folberth C, Khabarov N, et al. Global wheat production potentials and management flexibility under the representative concentration pathways. Global and Planetary Change. 2014;122:107-21.

Boere, E., Mosnier, A., Bocquého, G., Garbero, A., Krisztin, T., Havlik, P. , & Elhaut, T. (2018). Developing country-wide farming system typologies: An analysis of Ethiopian smallholders' income and food security. IFAD.

Frank S, Beach R, Havlík P, Valin H, Herrero M, Mosnier A, et al. Structural change as a key component for agricultural non-CO2 mitigation efforts. Nature Communications. 2018;9(1):1060.

Fricko O, Havlik P, Rogelj J, Klimont Z, Gusti M, Johnson N, et al. The marker quantification of the Shared Socioeconomic Pathway 2: A middle-of-the-road scenario for the 21st century. Global Environmental Change. 2017;42:251-67.

Herrero M, Havlík P, Valin H, Notenbaert A, Rufino MC, Thornton PK, et al. Biomass use, production, feed efficiencies, and greenhouse gas emissions from global livestock systems. Proceedings of the National Academy of Sciences. 2013;110(52):20888-93.

Lauri P, Forsell N, Korosuo A, Havlík P, Obersteiner M, Nordin A. Impact of the 2°C target on global woody biomass use. Forest Policy and Economics. 2017;83(Supplement C):121-30.

Leclère D, Havlík P, Fuss S, Schmid E, Mosnier A, Walsh B, et al. Climate change induced transformations of agricultural systems: insights from a global model. Environmental Research Letters. 2014;9(12):124018.

Skalský, R., Z. Tarasovičová, et al. (2008). GEO-BENE global database for bio-physical modeling v. 1.0 - concepts, methodologies and data. The GEO-BENE database report., International Institute for Applied Systems Analysis (IIASA), Austria: 58.

Valin H, Havlík P, Mosnier A, Herrero M, Schmid E, Obersteiner M. Agricultural productivity and greenhouse gas emissions: trade-offs or synergies between mitigation and food security? Environmental Research Letters. 2013;8(3):035019.

van Ginkel KCH, Botzen WJW, Haasnoot M, Bachner G, Steininger KW, Hinkel J, et al. Climate change induced socio-economic tipping points: review and stakeholder consultation for policy relevant research. Environmental Research Letters. 2020;15(2):023001.

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

For further information: www.globiom.org

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 773499 SUPREMA.

suprema