LAMA CLIMA Land Management for Climate Mitigation and Adaptation

- Exploring and explaining the role of land cover and land management changes on climate and society

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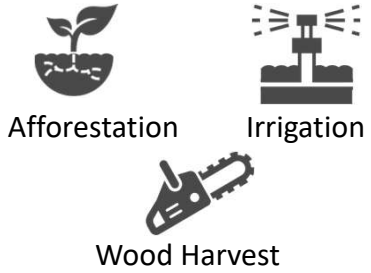
AXIS

AXIS Closing Event
19 June 2023

Project objectives

- Advance the **scientific and public understanding** of the coupled effects between changes in Land Cover and Land Management (LCLM), climate, human and natural systems



- Elaborate **land-based adaptation and mitigation measures** that help achieve the Sustainable Development Goals and the Paris Agreement

- Cross-cutting project to address all 3 AXIS themes:
  - Cross-sectoral and cross-scale climate change impact assessments
  - Integration of biophysical climate change impact estimates with economic models
  - Developing pathways to achieve the long-term objectives of the Paris Agreement, taking into account interactions with SDGs closely linked to SDG13 (climate action)

Bringing together several disciplines and stakeholder engagement

Biophysical responses to changes in land cover and land management (LCLM) using Earth System Models (ESMs)

VU LMU ETH VUB

Stakeholder engagement and scenario co-design

CLIMATE ANALYTICS

Modelling land-use patterns and emissions from co-developed scenarios with MAgPIE

PIK

Investigation of the consequences for macro-economic variables and land-use patterns

CICERO PIK

Development of an Earth System Model emulator including coupled land-use/climate effects

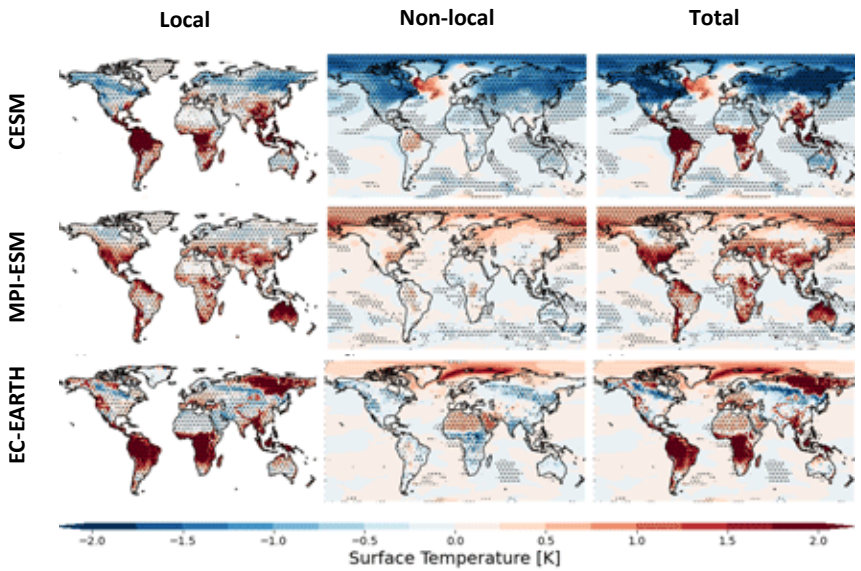
CLIMATE ANALYTICS ETH

Implications of co-developed scenarios for adaptation, mitigation and SDGs using Earth System Models

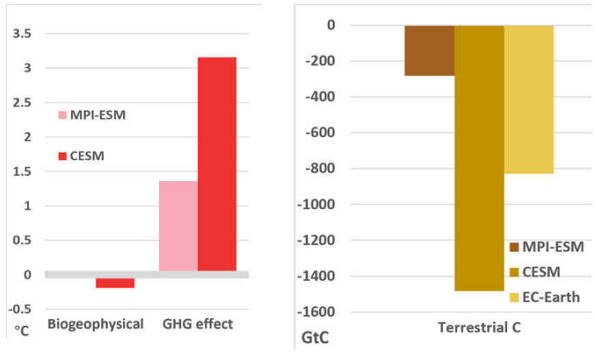
LMU VUB CICERO

Biophysical responses to changes in Land Cover and Land Management using Earth System Models

Biogeophysical impact of deforestation on surface temperature



De Hertog et al. (2023) Earth System Dynamics



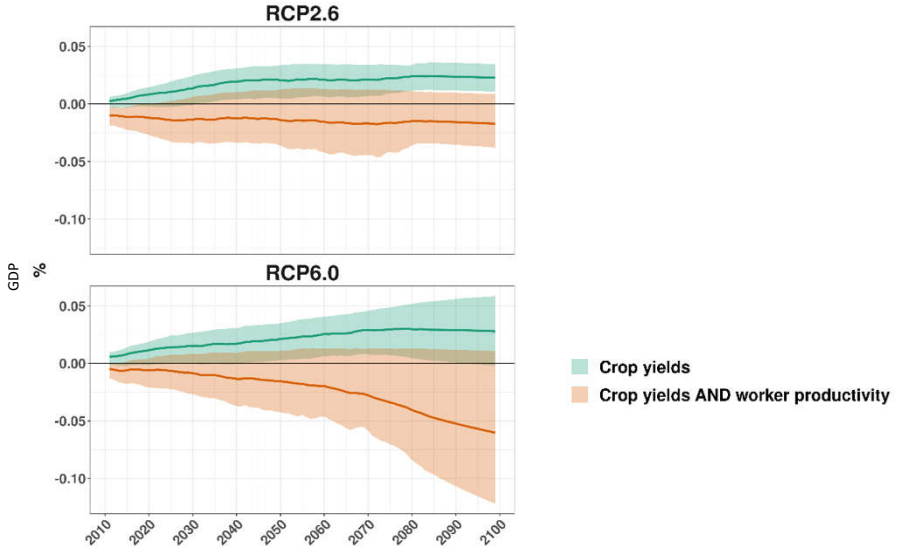
Guo et al. (in prep.)

For the first time, comparison of effects of 3 LCLM options across 3 ESMs using sensitivity experiments

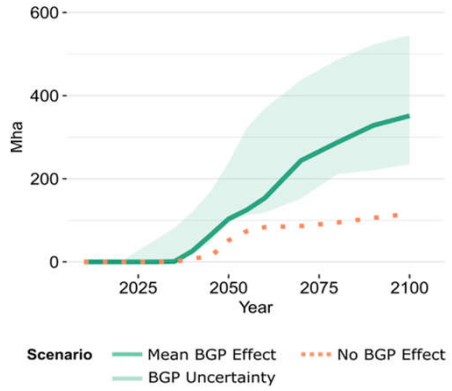
Example of deforestation:

- Both local and non-local temperature effects of the order of 2°C in some regions
- Substantial model differences in terms of non-local effects
- Strong changes in C pool which dominate the global temperature response
- **Deforestation can lead to strong non-local carbon loss**

Investigation of the consequences for macro-economic variables and land-use patterns



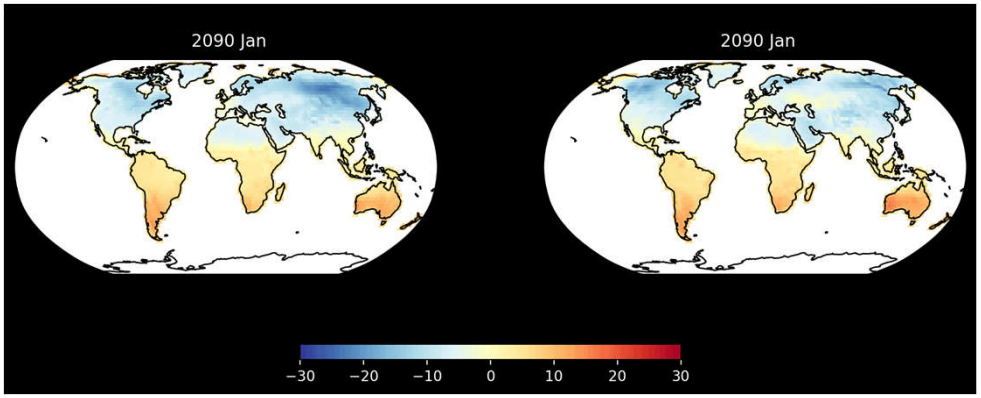
Orlov et al. (2021). Economics of Disasters and Climate Change



Windisch et al. (2022). Environmental Research Letters

- Heat effects on worker productivity implemented in a macro-economic model (GRACE)
- Global economic responses to heat stress impacts on worker productivity in agriculture comparable to those on crop yields
- Changes in LCLM lead to contrasted responses on heat stress thus labour productivity, overall health impacts potentially important but uncertain
- Implementation of local temperature effect of afforestation in the land-use allocation model MAgPIE substantially changes afforestation patterns

Development of an Earth System Model emulator including coupled land-use/climate effects



Monthly emulator with high skill of reproducing complex model output

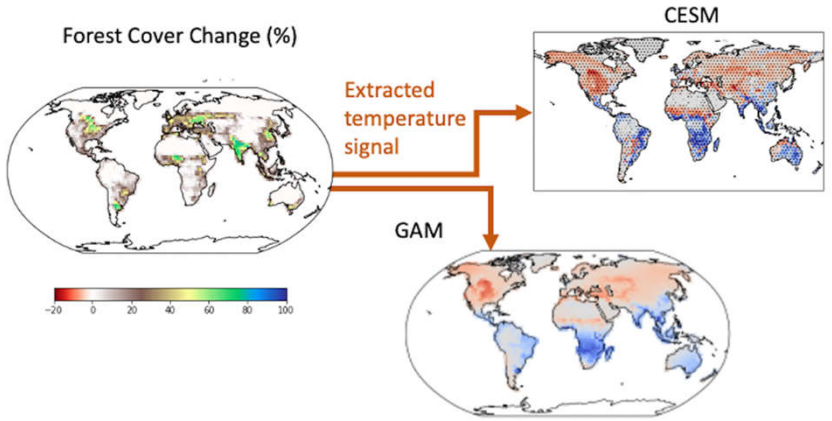
MESMER-M:

- Nath et al. (2022), MESMER-M: an Earth System Model emulator for local monthly temperature
- Basis for emulation of labour productivity decreases from heat stress

Nath et al. (2022). Earth System Dynamics

TIMBER:

- Emulating the temperature response to tree cover changes (Nath et al, in discussion)
- Part of the MESMER ecosystem – integration allows for joint assessment of both



Nath et al. (accepted). Geoscientific Model Development

Stakeholder engagement at its core

Overview of the public webinars, workshops and newsletter	
Public webinar attendees	Around 250, including strong engagement from global south stakeholders
Participants' origin	1. Universities, 2. Research institutes *(many agriculture, development, forestry, technology related)* 3. NGOs 4. Consultants 5. Governments/public offices
Newsletter sign-ups	460+

- Public lectures permanent on YouTube
- Public presentations on project outcomes in a final dissemination workshop
- Further communication through newsletters (including from JPI Climate)
- Targeting key stakeholders for scenario co-development

Scenario co-design with stakeholders – Objectives and process

- **Process**: over February-April 2021, 3 online webinars of 1.5h and a 2-day workshop
- **Objectives**:
  1. identify scenario narratives considered of interest and broad policy relevance to the stakeholders, which reflect different ways to meet climate and environmental policy objectives and would result in different evolutions of land use across the world
  2. identify how the narratives could be implemented in the MAgPIE model

~10 Key Stakeholders

Intergovernmental agencies (EEA, JRC)

Land-use scientists

NGOs

Adaptation practitioners

Environmental consultancies

~10 Consortium scientists

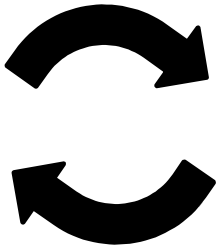
land-use modellers

Earth System modellers

Climate economists

Stakeholder engagement experts

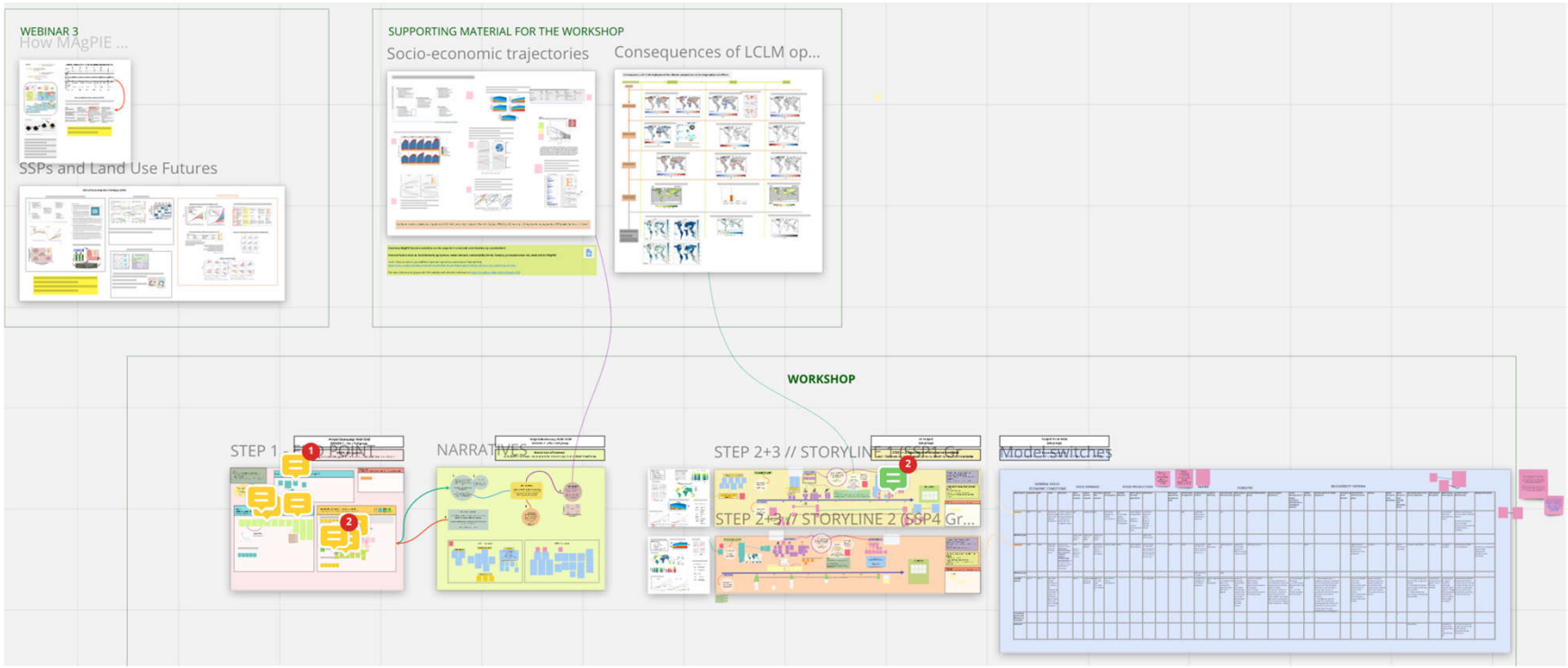
list processes that the models used in the LAMACLIMA project can represent and the types of questions that they can help answer



list aspects that they found of potential interest and policy relevance and worth considering in the scenario narratives

Scenario co-design with stakeholders – Process (continued)

- Extensive online engagement through MIRO board down to the level of specific modelling options
- Very grateful to a highly committed group of key stakeholders
- Two-way learning process



Scenario co-design with stakeholders – Result

The outcomes of the co-development reflect:

- Interest in scenarios compatible with the Paris Agreement, SDGs, other policy objectives (EU-level)
- Focus on Europe & North America (where most stakeholders are from)
- Need to implement these narratives in MAgPIE to model consequences on land-use patterns and emissions

Scenario 1 – Global Sustainability

- extending the SDP/SSP1 narrative
- All countries converge towards sustainability standards wrt to land use and land management at the end of the century
- Socio-economic conditions enable successful deployment of LCLM while respecting sustainability criteria

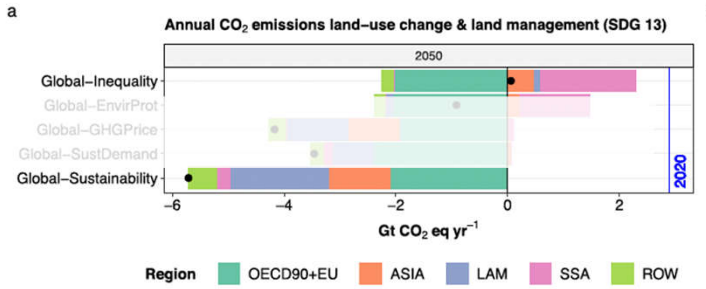
Scenario 2 – Global Inequality

- extending the SSP4 narrative
- OECD countries implement sustainability standards wrt to land (except sustainable consumption) – the rest of the world doesn't → "not in my backyard behaviours"
- Non-converging socio-economic conditions (e.g., governance, GDP) determine a very distinct trajectory for LCLM changes

→ The co-developed scenario narratives were then implemented in the land-use allocation model MAgPIE to model resulting land-use patterns and emissions

→ The results from MAgPIE were used as input for Earth System Model simulations

Modelling land-use patterns and emissions from co-developed scenarios with MAgPIE

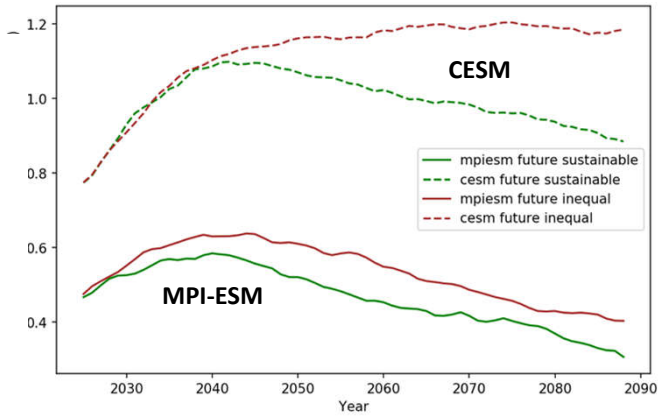


Humpenöder et al. (2022). Nature Communications

- Overcoming global inequality is critical for land-based mitigation in line with the Paris Agreement
- Inclusive socio-economic development in Sub-Saharan Africa and Asia is a key enabling factor for AFOLU GHG mitigation with co-benefits for other Sustainable Development Goals (SDGs)

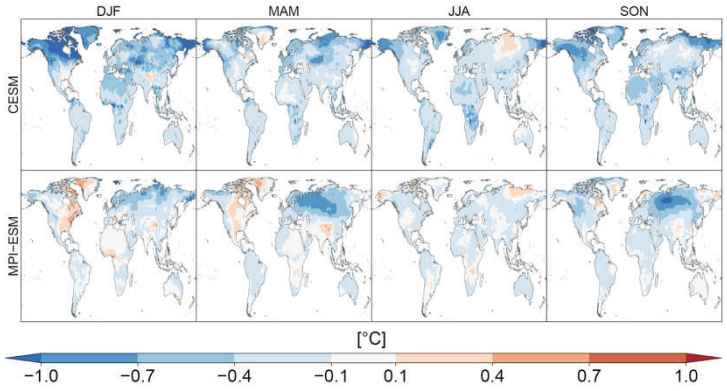
Implications of co-developed scenarios for adaptation, mitigation and SDGs using Earth System Models

Differences in GMT
between Global Sustainability and Global Inequality



Havermann et al. (in prep.)

Differences in Environmental Stress Index
between Global Sustainability and Global Inequality



de Hertog, Orlov et al. (in prep.)

- ESMs simulate that different LCLM scenarios lead to differences in GMT by 0.1-0.4°C between the Sustainability and Inequality scenarios

- Biogeophysical effects of unregulated tropical deforestation enhance the impacts of global warming in Global Inequality vs. Global Sustainability (e.g., for moist heat stress and outdoor labour capacity)

Conclusions

- Land management – climate interactions are of key relevance for broad stakeholder communities but (still) need for improvement representation in climate modelling

- Integrated perspective on land-climate futures underscores the importance of thinking both together

- Scenario stakeholder co-development can trigger mutual learning process and lead to both scientifically and policy relevant outcomes

Thank you for your attention!

Global Economic Responses to Heat Stress Impacts on Worker Productivity in Crop Production Orlov, A. *et al. EconDisCliCha* **5**, 367–390 (2021). https://doi.org/10.1007/s41885-021-00091-6

Accounting for local temperature effect substantially alters afforestation patterns. Windisch *et al* 2022 *Environ. Res. Lett.* **17** 024030

MESMER-M: an Earth system model emulator for spatially resolved monthly temperature Nath, S. et al. *Earth Syst. Dynam.,* 13, 851–877, https://doi.org/10.5194/esd-13-851-2022, 2022.

Overcoming global inequality is critical for land-based mitigation in line with the Paris Agreement Humpenöder, F., Popp, A., Schleussner, CF. *et al. Nat Commun* **13**, 7453 (2022). https://doi.org/10.1038/s41467-022-35114-7

Changes in Land Cover and Management Affect Heat Stress and Labor Capacity Orlov, A. et al. (2023). *Earth's Future*, *11*, e2022EF002909. https://doi.org/10.1029/2022EF002909

Neglected implications of land-use and land-cover changes on the climate-health nexus Anton Orlov *et al* 2023 *Environ. Res. Lett.* **18** 061005

The biogeophysical effects of idealized land cover and land management changes in Earth system models de Hertog, S. et al. 2023 *Earth Syst. Dynam.,* 14, 629–667, https://doi.org/10.5194/esd-14-629-2023, 2023

TIMBER v0.1: a conceptual framework for emulating temperature responses to tree cover change Nath, S., et al. EGUsphere *[preprint],* https://doi.org/10.5194/egusphere-2022-1024, 2022.

Effects of idealised land cover and land management changes on the atmospheric water cycle. de Hertog et al., EGUsphere [preprint], https://doi.org/10.5194/egusphere-2023-953, 2023.

Simulated unintended biogeochemical effects of idealized land cover and land management changes. Guo et al., in prep.

Local and remote impacts of land cover and land management change on the climate and carbon cycle. Guo et al., in prep.

Impacts of future land cover scenarios on heat stress, labour and human health. de Hertog et al., in prep.