Achieving Multiple Socio-Economic Targets

Angelo Gurgel

Together with work by: Sergey Paltsev, Adam Schlosser, Jennifer Morris, Henry Chen, Mei Yuan, Mustafa Babiker, John Reilly, Eloide Blanc, Bryan Mignone, Haroon Kheshgi and other CS3 researchers and partners

Center for Sustainability Science and Strategy

Global Change Forum 48

Connecting Climate and Sustainability: Synergies and Tradeoffs

MIT Samberg Conference Center
50 Memorial Drive, Cambridge, MA

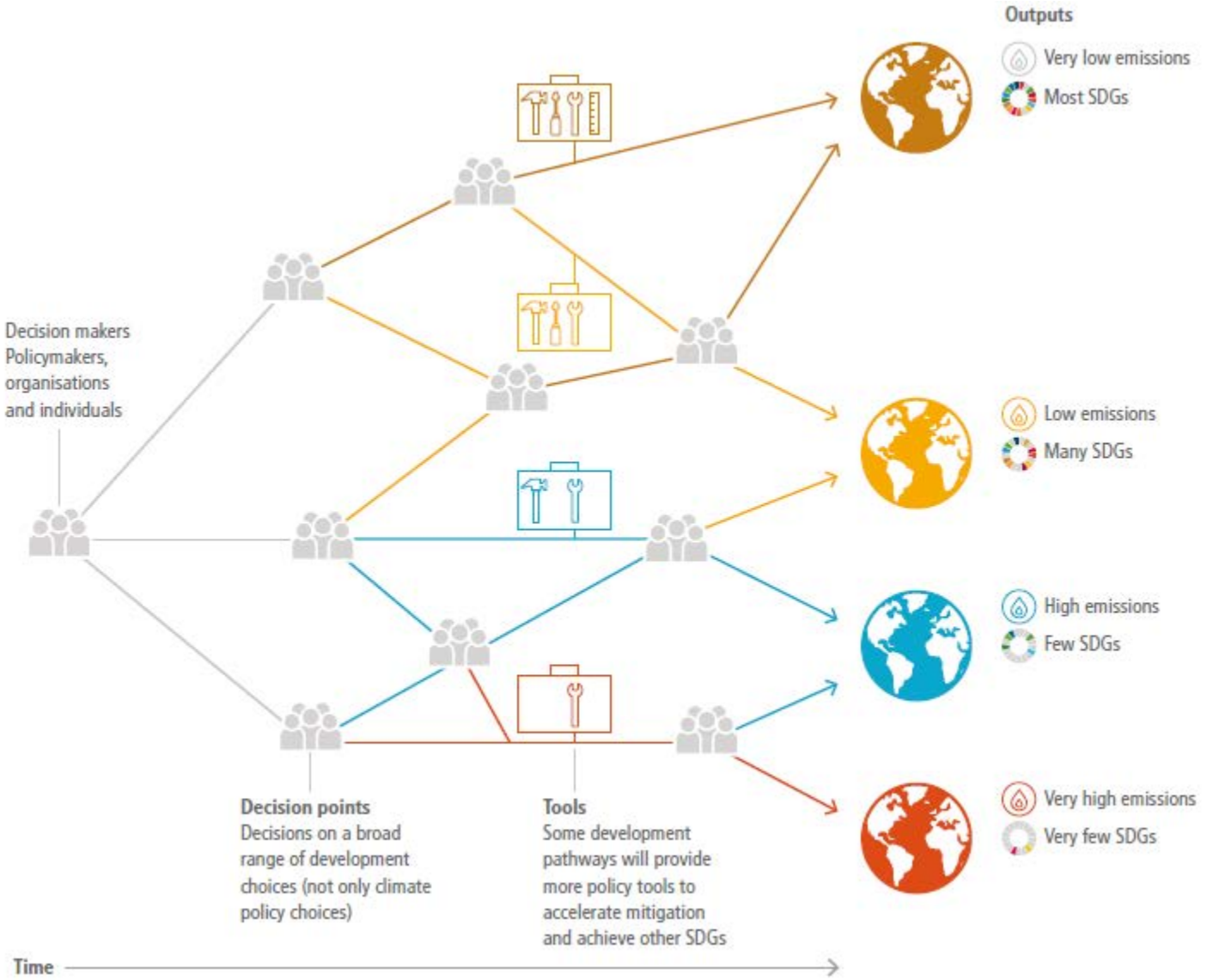
Image : https://www.azocleantech.com/article.aspx?ArticleID=1692

Achieving Multiple Socio-Economic Targets

- Why should we deal with multiple socio-economic targets?
- Knowledge on multiple socio-economic targets is evolving
- Sustainable Development Goals: a framework to guide socio-economic targets?
- Assessing multiple socio-economic goals
  - Tools
  - Climate Change Impacts on Agriculture
  - Energy Transition in Africa
  - Carbon Dioxide Removal (CDR) and Climate Justice
  - Bioenergy

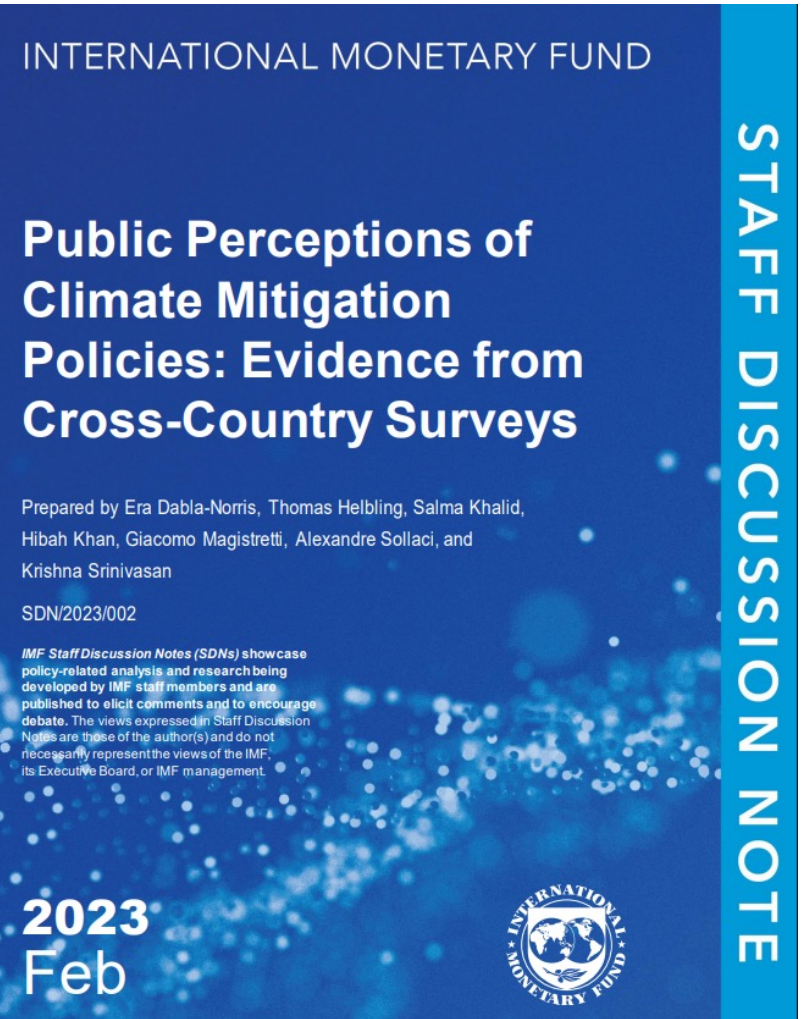
Why should we deal with multiple socio-economic targets?

- Achieve societal and political support
- Have stakeholders on board
- Achieve international agreement/collaboration
- Sustainability challenges are highly interconnected



Source: IPCC AR6 WGIII

Why should we deal with multiple socio-economic targets?

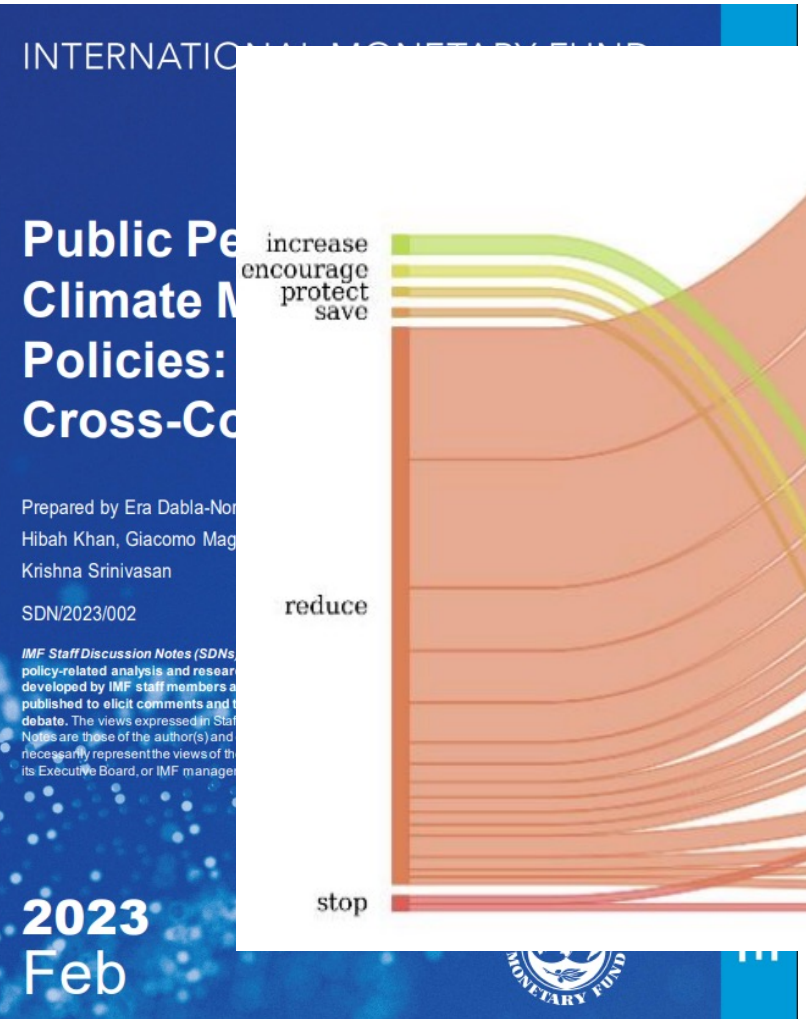


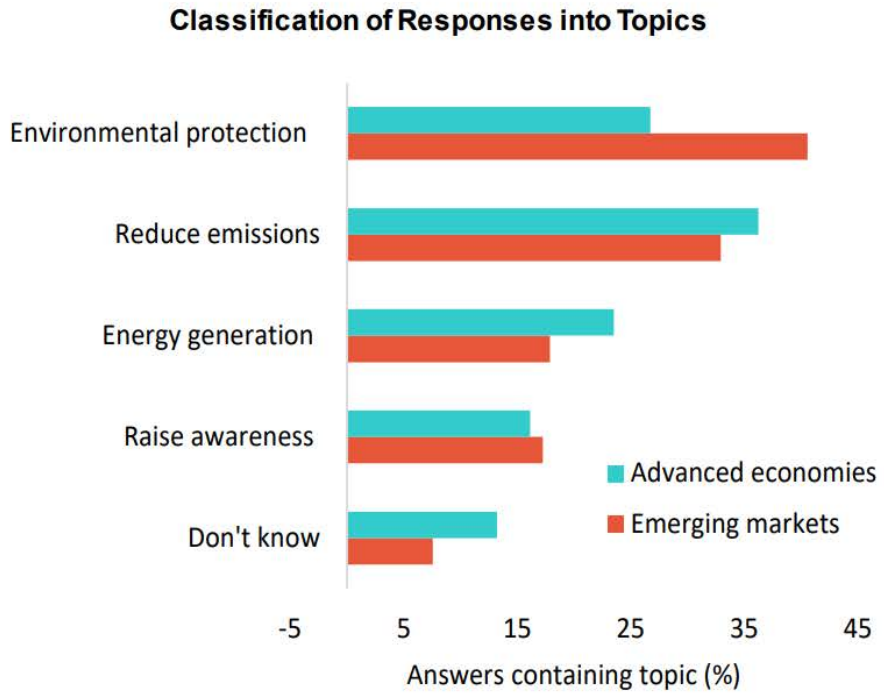
"… three key policy attributes are major predictors of whether people support carbon pricing:

(1) Perceived effectiveness in reducing emissions
(2) Perceived fairness or distribution burden
(3) Perceived **other co-benefits of improved air quality, health outcomes and new jobs**"

Why should we deal with multiple socio-economic targets?

“What do you think a good climate policy should aim to achieve?”





Source: IMF staff calculations based on IMF-YouGov survey.
Note: This figure shows the share of answers that contain at least one word related to each of the four broad topics, plus the share of answers that relate that they do not know what a climate policy should do. Note that responses can be classified into more than one topic.

Knowledge on multiple socio-economic targets is evolving … *but it is still far from our needs*

- Energy, greenhouse gas emission, economic growth usually are assessed together.
- Societies care about many other outcomes: employment, health, equity, poverty reduction, energy access, food security, water security, biodiversity, etc.

Ng *Discover Sustainability* (2026) 7:29
https://doi.org/10.1007/s43621-025-02343-x

Discover Sustainability

REVIEW Open Access

A global bibliometric review of climate change and energy policy research: insights for sustainable development and international collaboration

Sai-Leung Ng[1*]

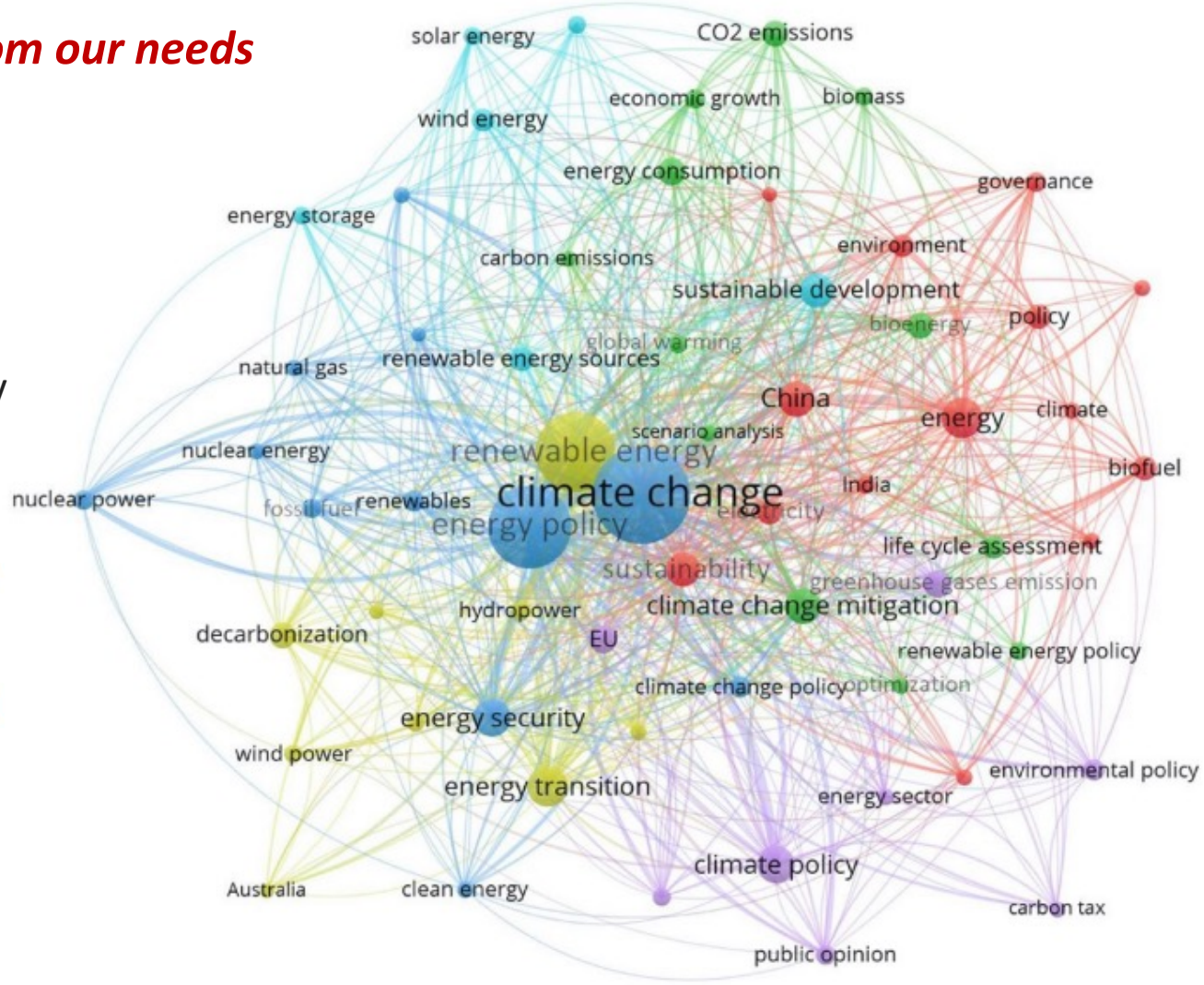


Fig. 3 The network map of co-occurrence showing keyword clusters on climate change and energy policy

Sustainable Development Goals: a framework to guide multiple socio-economic targets?

ipcc
INTERGOVERNMENTAL PANEL ON climate change

Climate Change 2022
Mitigation of Climate Change

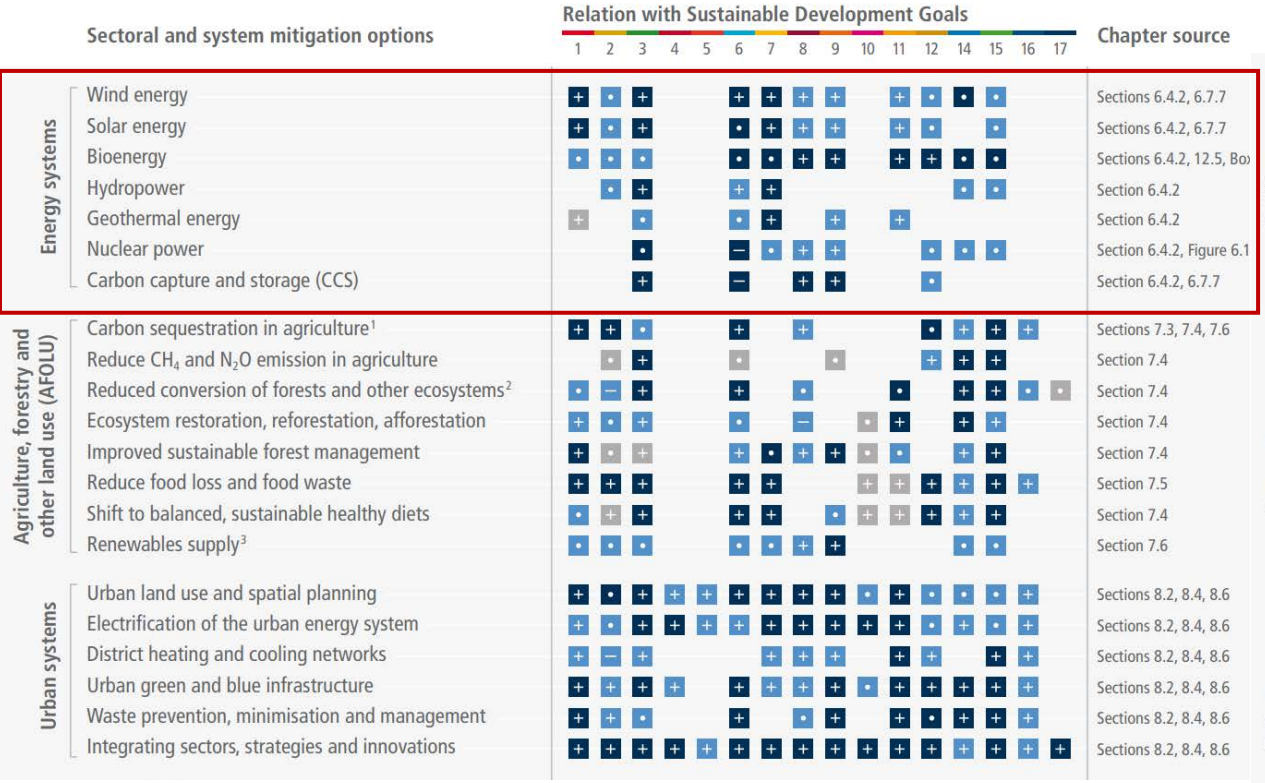
D. Linkages between mitigation, adaptation, and sustainable development

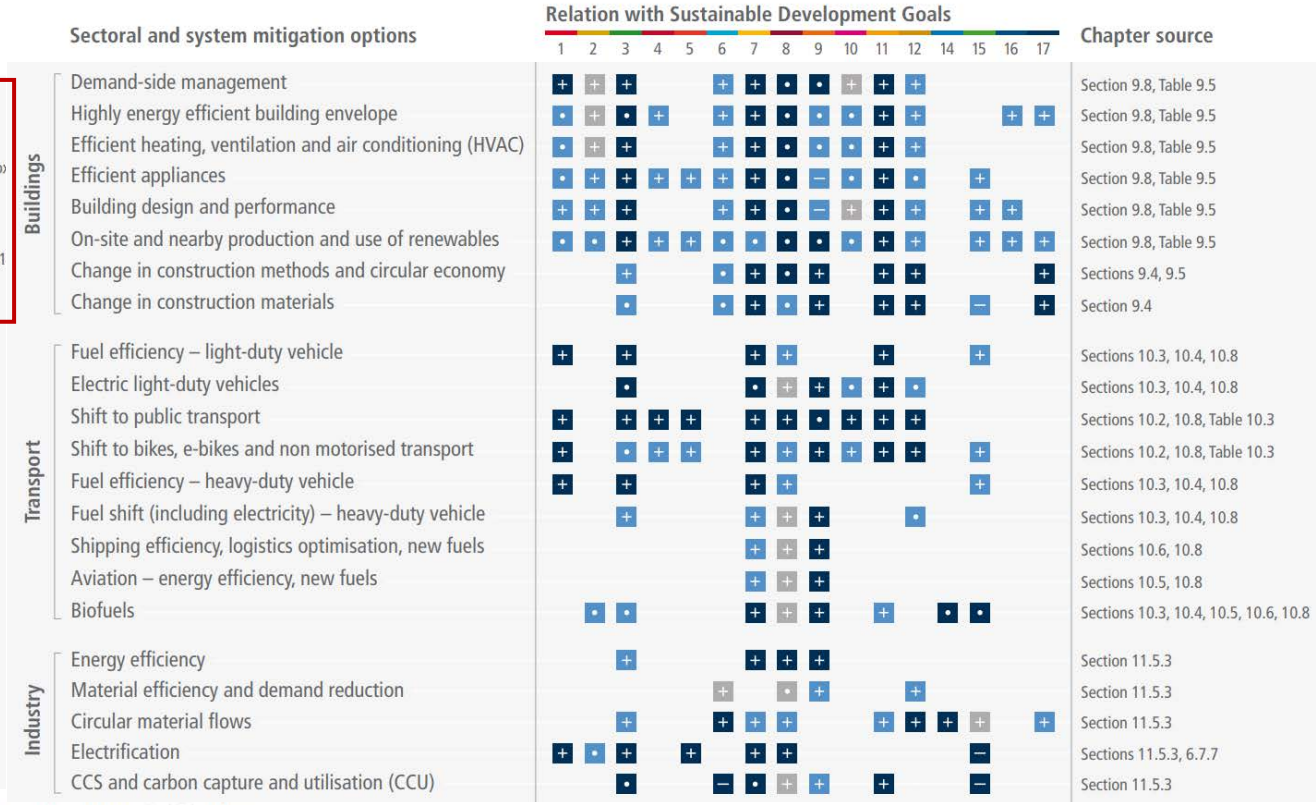
D.1 Accelerated and equitable climate action in mitigating, and adapting to, climate change impacts is critical to sustainable development. Climate change actions can also result in some trade-offs. The trade-offs of individual options could be managed through policy design. The Sustainable Development Goals (SDGs) adopted under the UN 2030 Agenda for Sustainable Development can be used as a basis for evaluating climate action in the context of sustainable development. (*high confidence*) (Figure SPM.8) {1.6, 3.7, 17.3, Figure TS.29}

WGIII
Working Group III contribution to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change
WMO UNEP

IPCC AR6 WGIII

Sustainable Development Goals: a framework to guide sustainable development?





Type of relations:

- \+ Synergies
- − Trade-offs
- • Both synergies and trade-offs[4]

Blanks represent no assessment[5]

Confidence level:

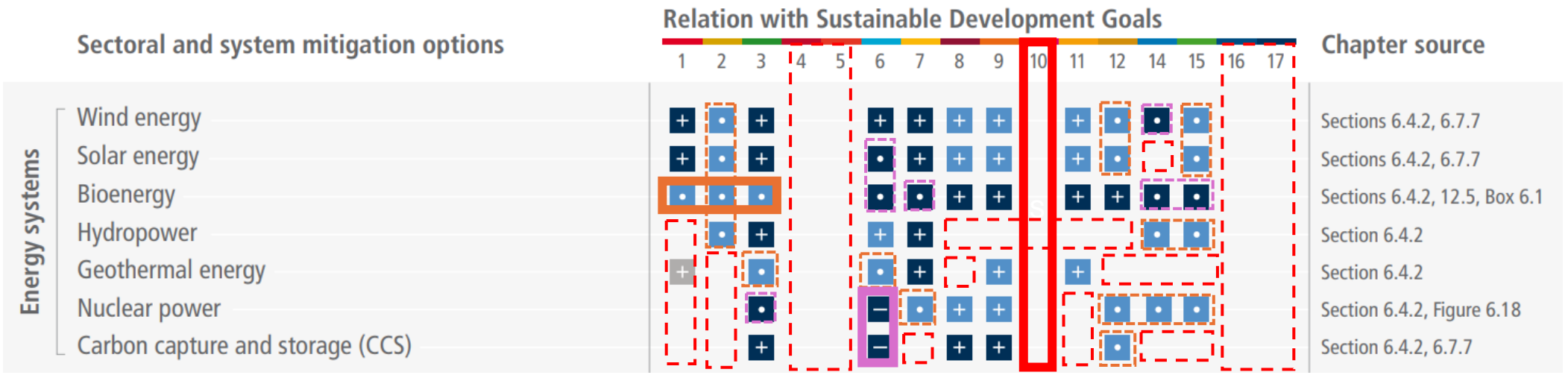
- *High confidence*
- *Medium confidence*
- *Low confidence*

Related Sustainable Development Goals:

- 1 No poverty
- 2 Zero hunger
- 3 Good health and wellbeing
- 4 Quality education
- 5 Gender equality
- 6 Clean water and sanitation
- 7 Affordable and clean energy
- 8 Decent work and economic growth
- 9 Industry, innovation and infrastructure
- 10 Reduced inequalities
- 11 Sustainable cities and communities
- 12 Responsible consumption and production
- 13 Climate action
- 14 Life below water
- 15 Life on land
- 16 Peace, justice and strong institutions
- 17 Partnership for the goals

Source: IPCC AR6 WGIII

Sustainable Development Goals: a framework to guide sustainable development?



Knowledge on multiple socio-economic targets is quite narrow!

Limited knowledge
Challenges
Gaps

Issues to be investigated by integrated modeling approaches!

Type of relations:
- \+ Synergies
- − Trade-offs
- • Both synergies and trade-offs[4]

Blanks represent no assessment[5]

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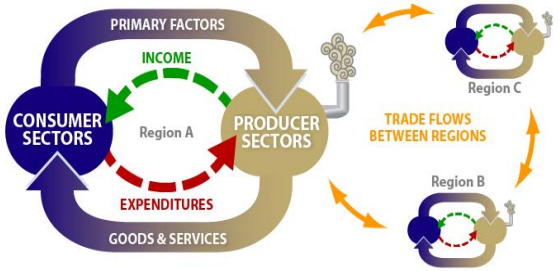
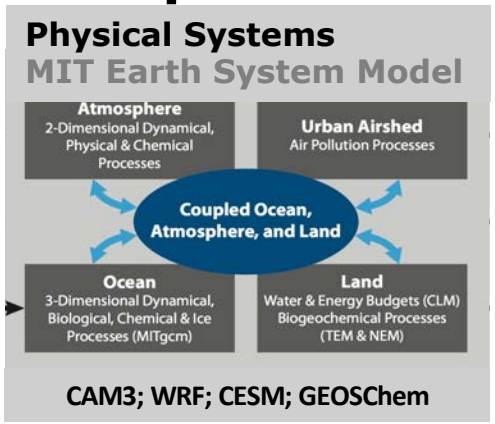
Source: IPCC AR6 WGIII

CS3 Toolbox for Integrated Modeling across Systems, Sectors, Scales and Uncertainties

Human Systems: *Economy, Trade, Energy, Agriculture, Transport, Industry, Land-Use, Population Dynamics, Infrastructure, Natural Resources* (Global to Regional Scale)

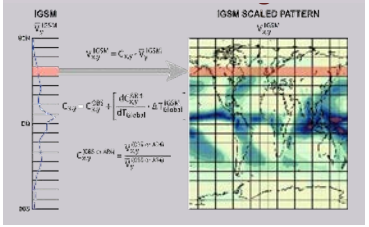


Physical Systems
MIT Earth System Model

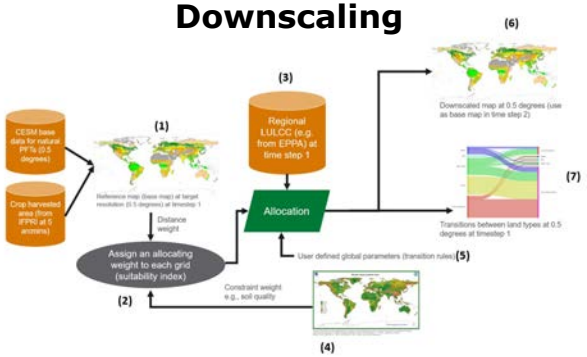


CAM3; WRF; CESM; GEOSChem

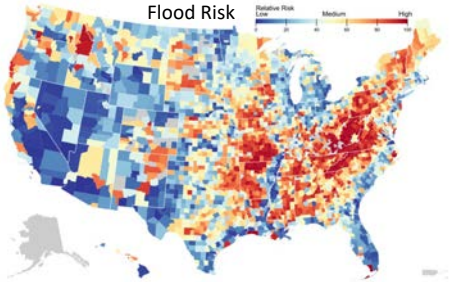
Pattern Scaling & Extreme Events



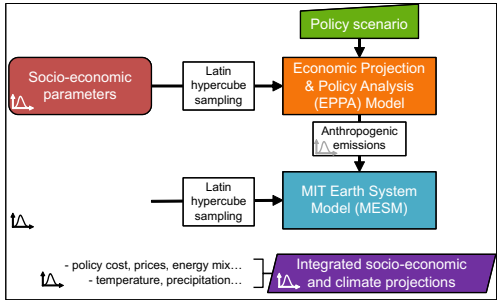
Downscaling



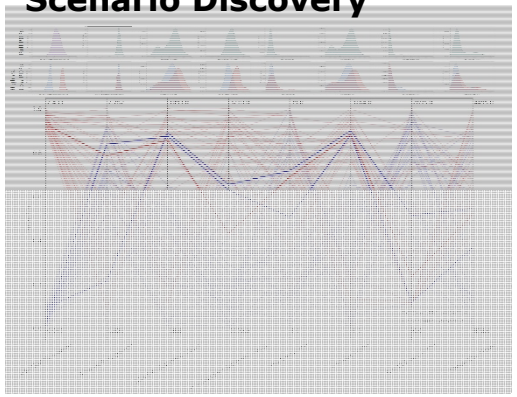
County-Level Multi-Risk Triage



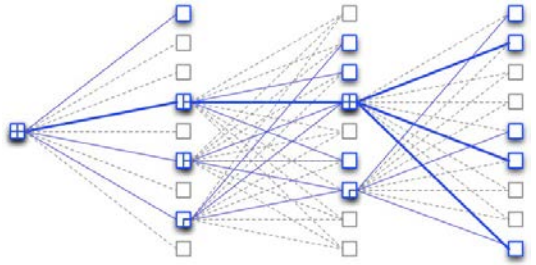
Probabilistic Ensembles & Integrated Projections



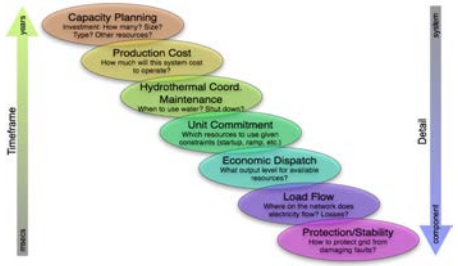
Exploratory Modeling & Scenario Discovery



Decision-Making Frameworks

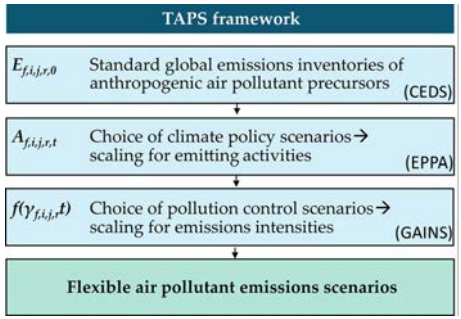


Detailed Electricity Models

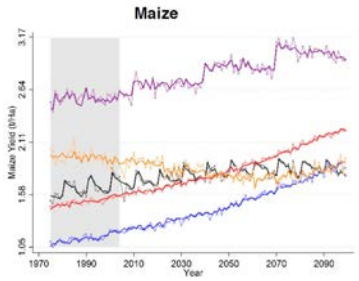


Water Resource System Model

Air Quality & Human Health



Statistical Emulators



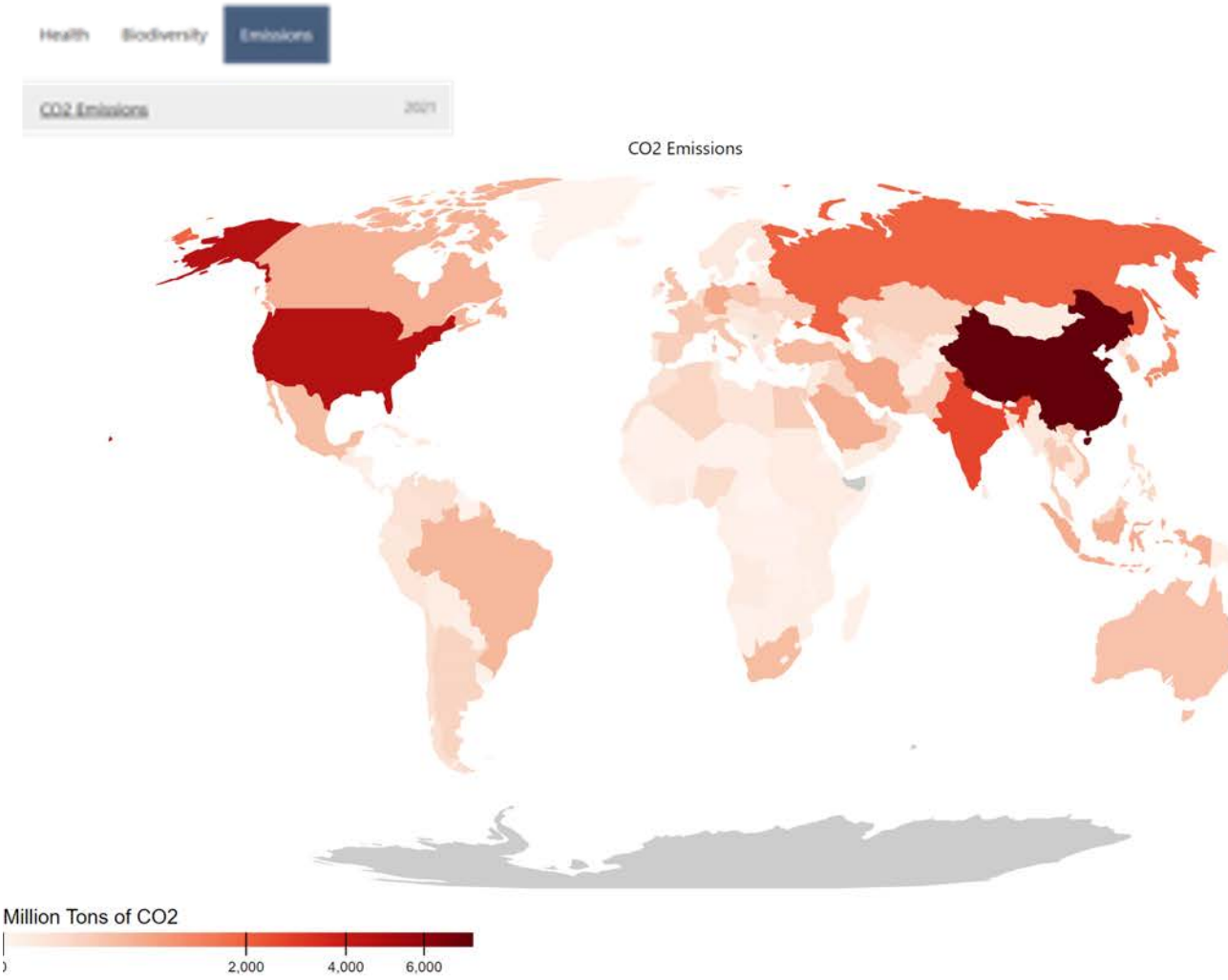
+

Assessing multiple socio-economic goals

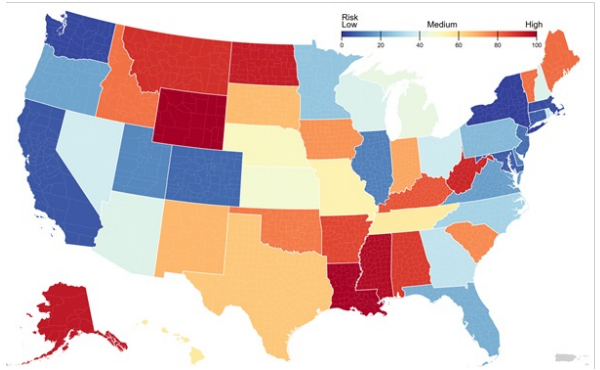
Tools

STRESS Platform https://est.mit.edu/

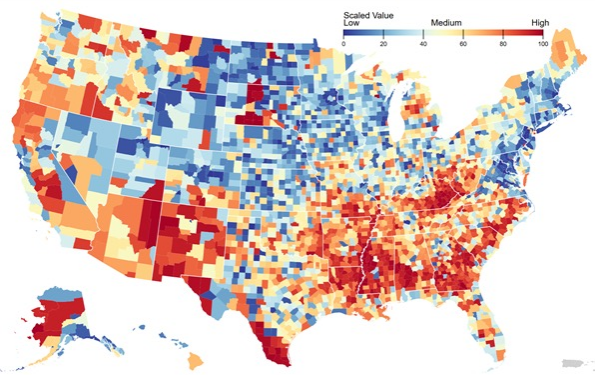
System for the Triage of Risks from Environmental and Socio-economic Stressors

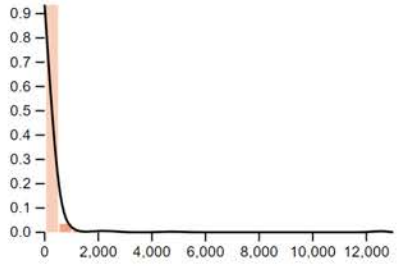


Energy Expenditure as Share of GDP

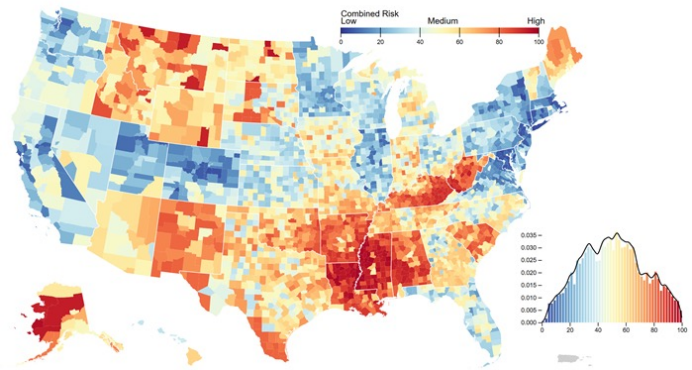


Population Below Poverty Level



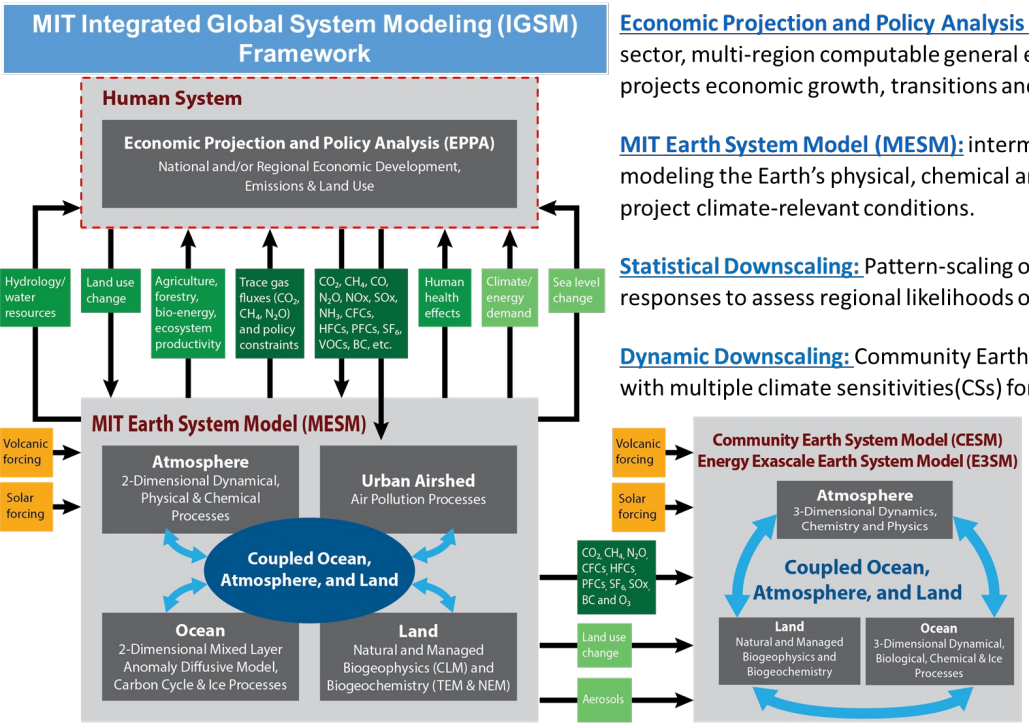


Combined



Assessing multiple socio-economic goals

Tools

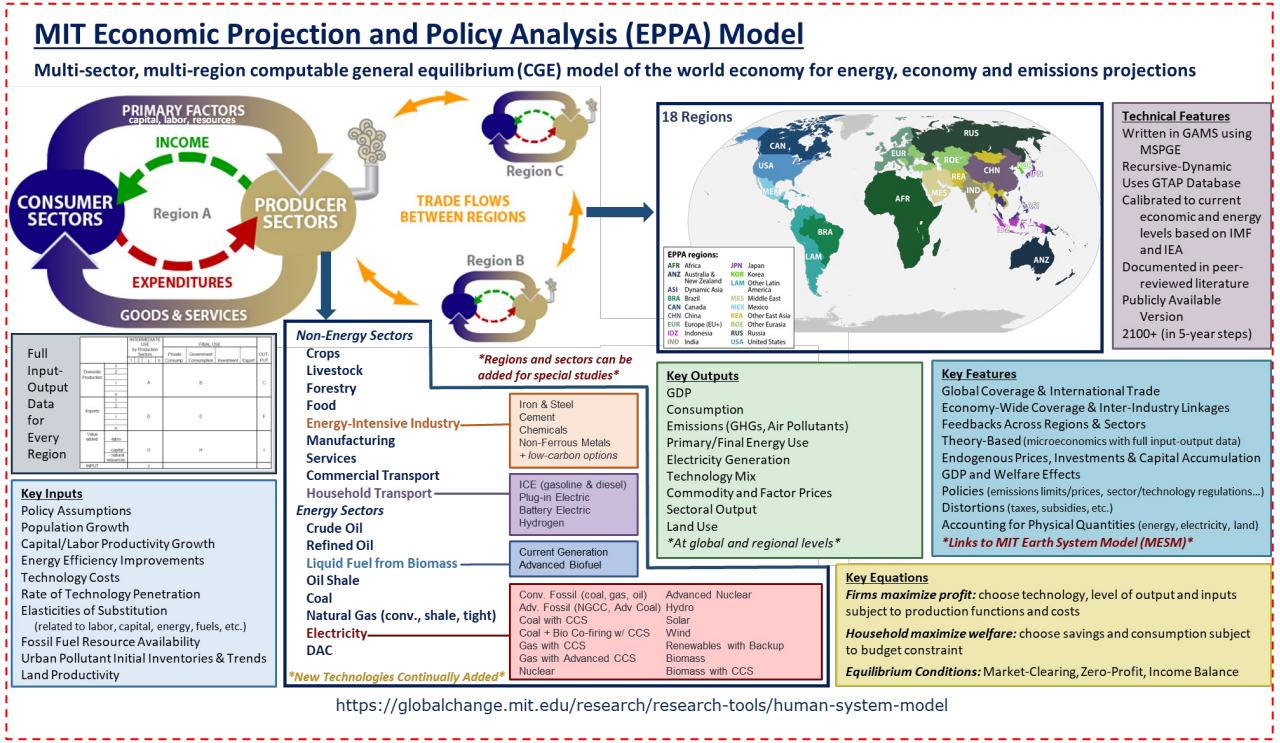


Economic Projection and Policy Analysis (EPPA) model: multi-sector, multi-region computable general equilibrium (CGE) model projects economic growth, transitions and human emissions

MIT Earth System Model (MESM): intermediate complexity, modeling the Earth's physical, chemical and biological systems to project climate-relevant conditions.

Statistical Downscaling: Pattern-scaling of MESM based on CMIP6 responses to assess regional likelihoods of change.

Dynamic Downscaling: Community Earth System Model (CESM) with multiple climate sensitivities(CSs) for full range of response.



Existing tools can be used to overcome limited knowledge, challenges and gaps on multiple socio-economic impacts,
and must be enhanced and integrated with others towards that direction!

Assessing multiple socio-economic goals

Climate Change Impacts on Agriculture

Climatic Change (2021) 166:29
https://doi.org/10.1007/s10584-021-03119-8

Challenges in simulating economic effects of climate change on global agricultural markets

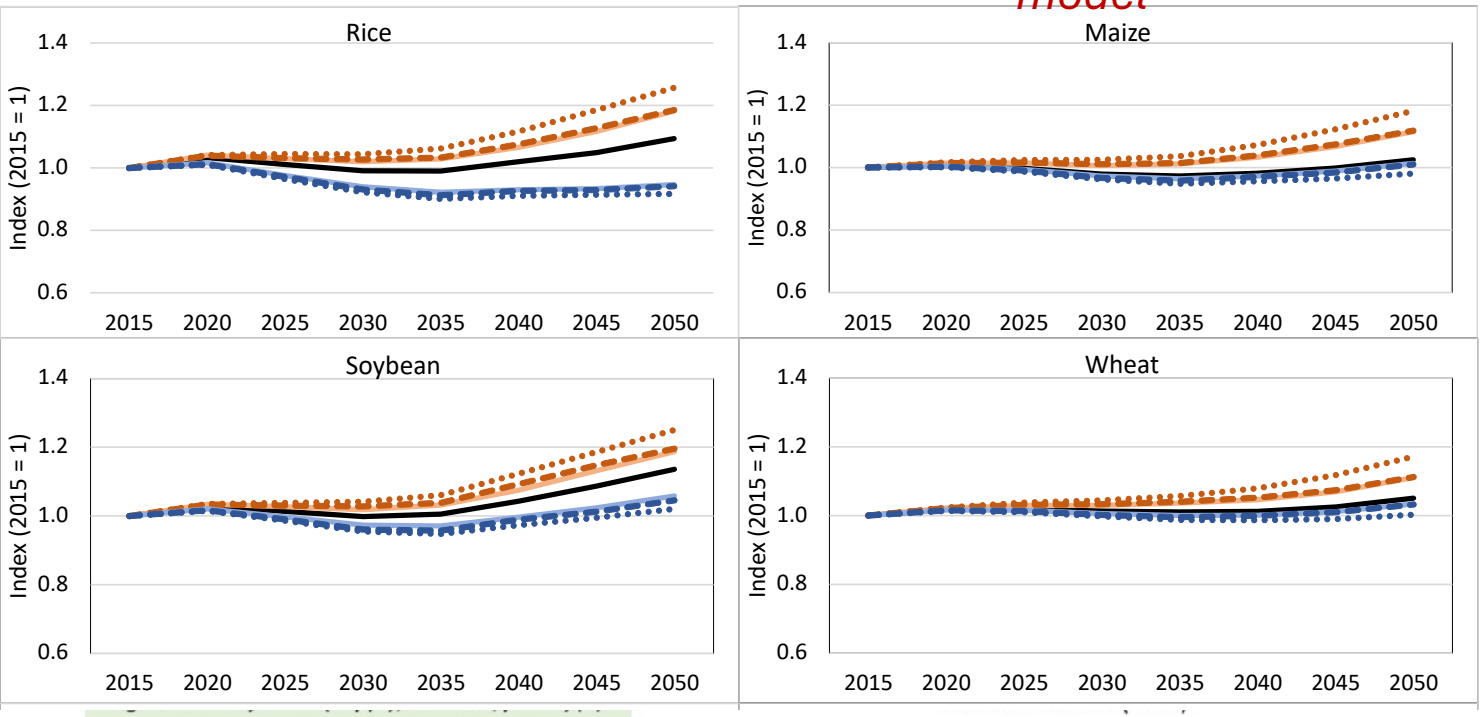
Angelo C. Gurgel[1] · John Reilly[1] · Elodie Blanc[1]

Received: 29 May 2020 / Accepted: 10 May

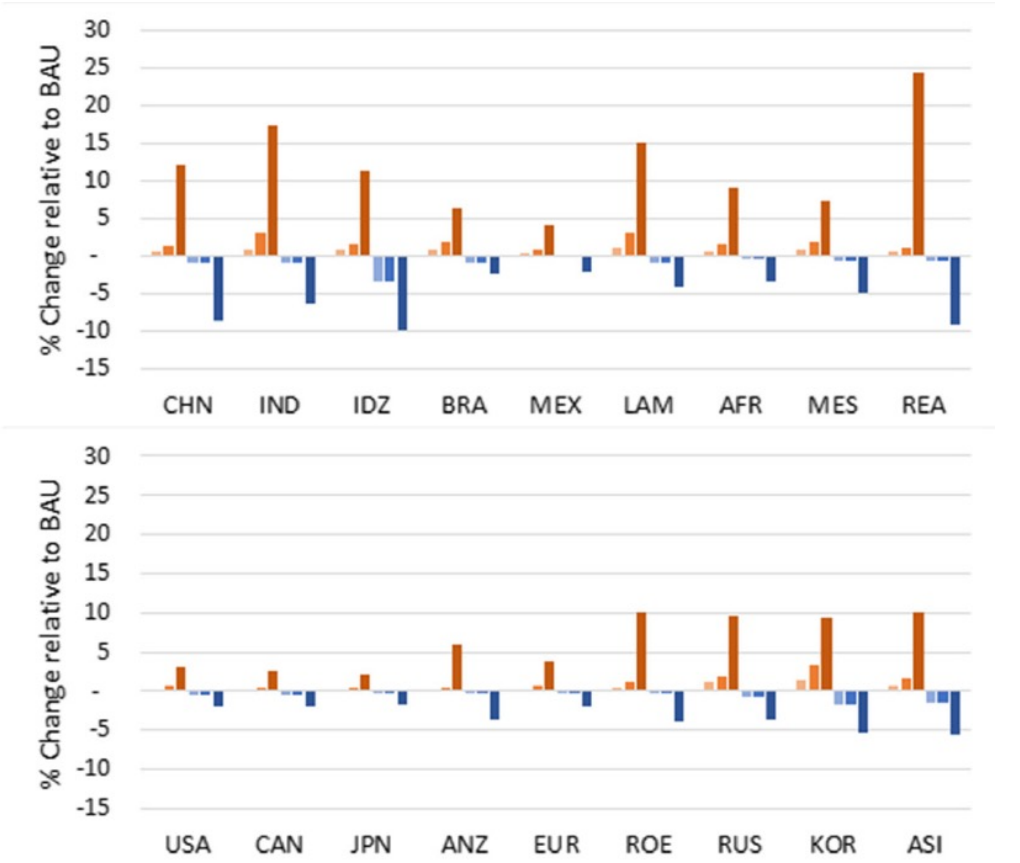
How will changes in agriculture prices impact other socio-economic goals, such as food security?

MIT EPPA-Agri model

Global price indexes for crops



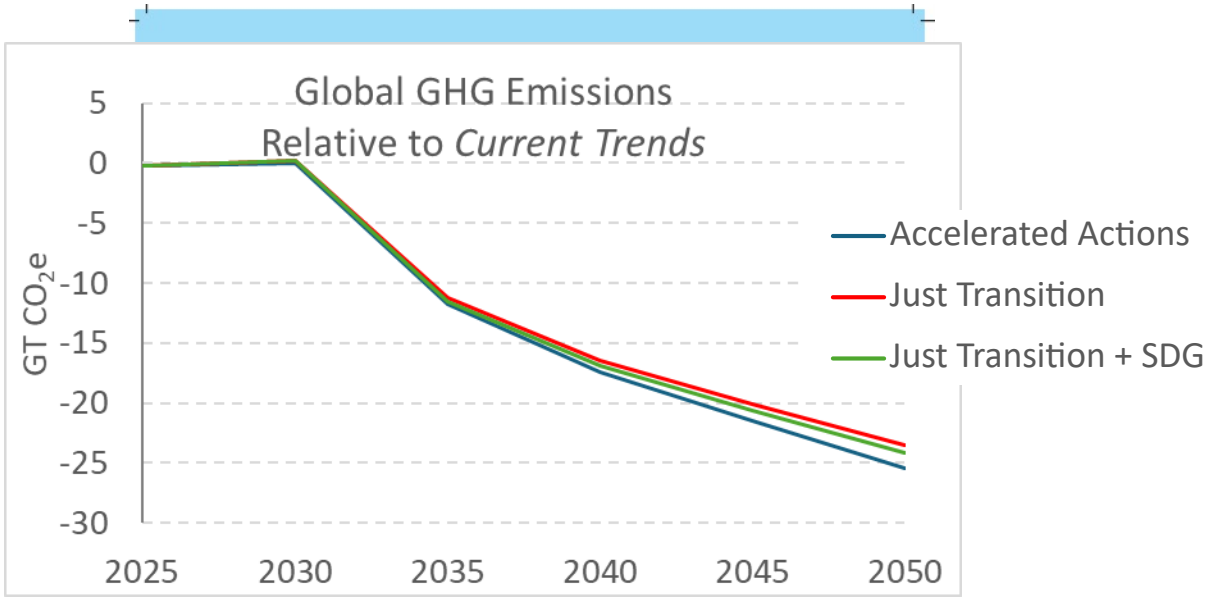
Change in food budget share in 2050 relative to BAU



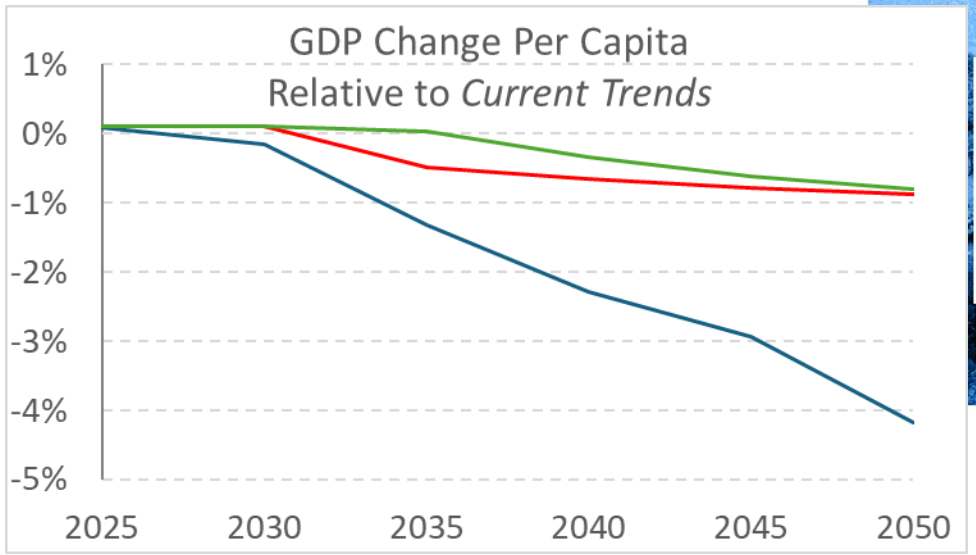
Assessing multiple socio-economic goals

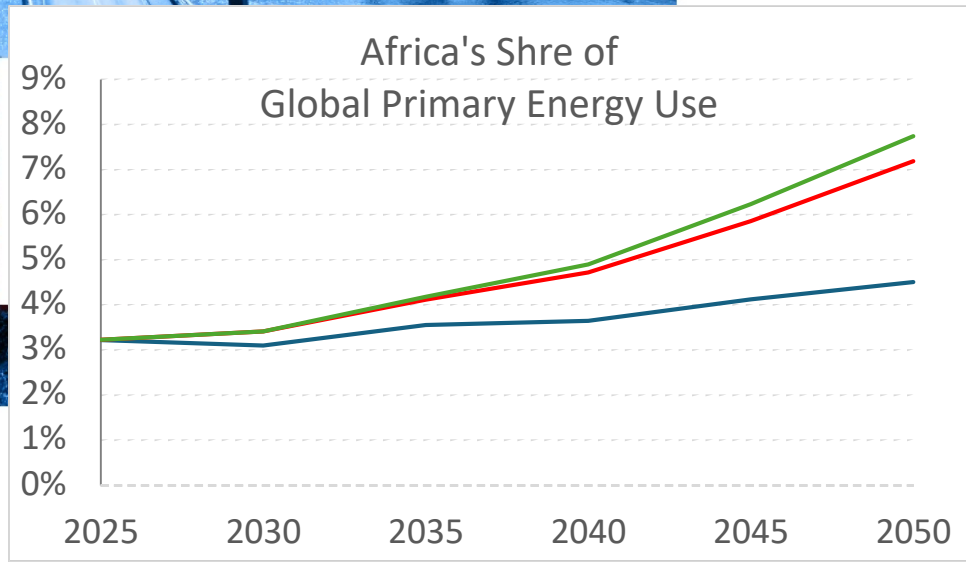
Energy Transition in Africa

- Sustainable development challenges, rich in natural resources, highly vulnerable to climate change, risks associated with low-carbon transition
- t transition scenarios for Africa:
  - negligible impact on global GHG
  - avoids impacts on economic growth
  - reduces energy access gap
  - reduce deforestation and protect ecosystems
  - replace biomass with cooking gas (health benefits)



Enhanced MIT EPPA model: Africa sub-regions

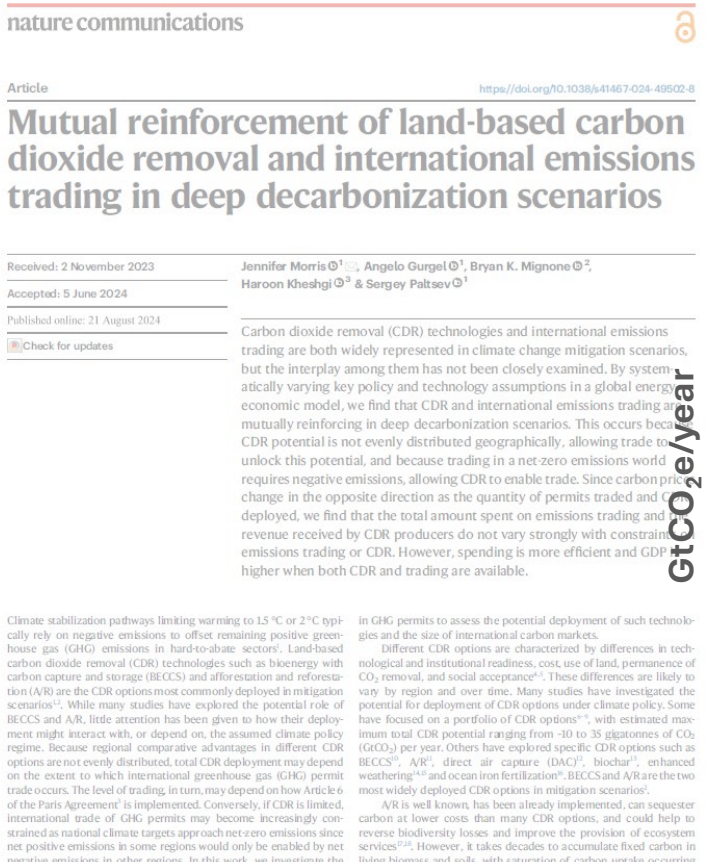




Assessing multiple socio-economic goals

Carbon Dioxide Removal (CDR) and Climate Justice

2°C climate stabilization scenario: global carbon markets and international trade in GHG permits and offsets from afforestation and bioenergy with CCS



nature communications

Article

https://doi.org/10.1038/s41467-024-49502-8

Mutual reinforcement of land-based carbon dioxide removal and international emissions trading in deep decarbonization scenarios

Received: 2 November 2023

Accepted: 5 June 2024

Published online: 21 August 2024

Check for updates

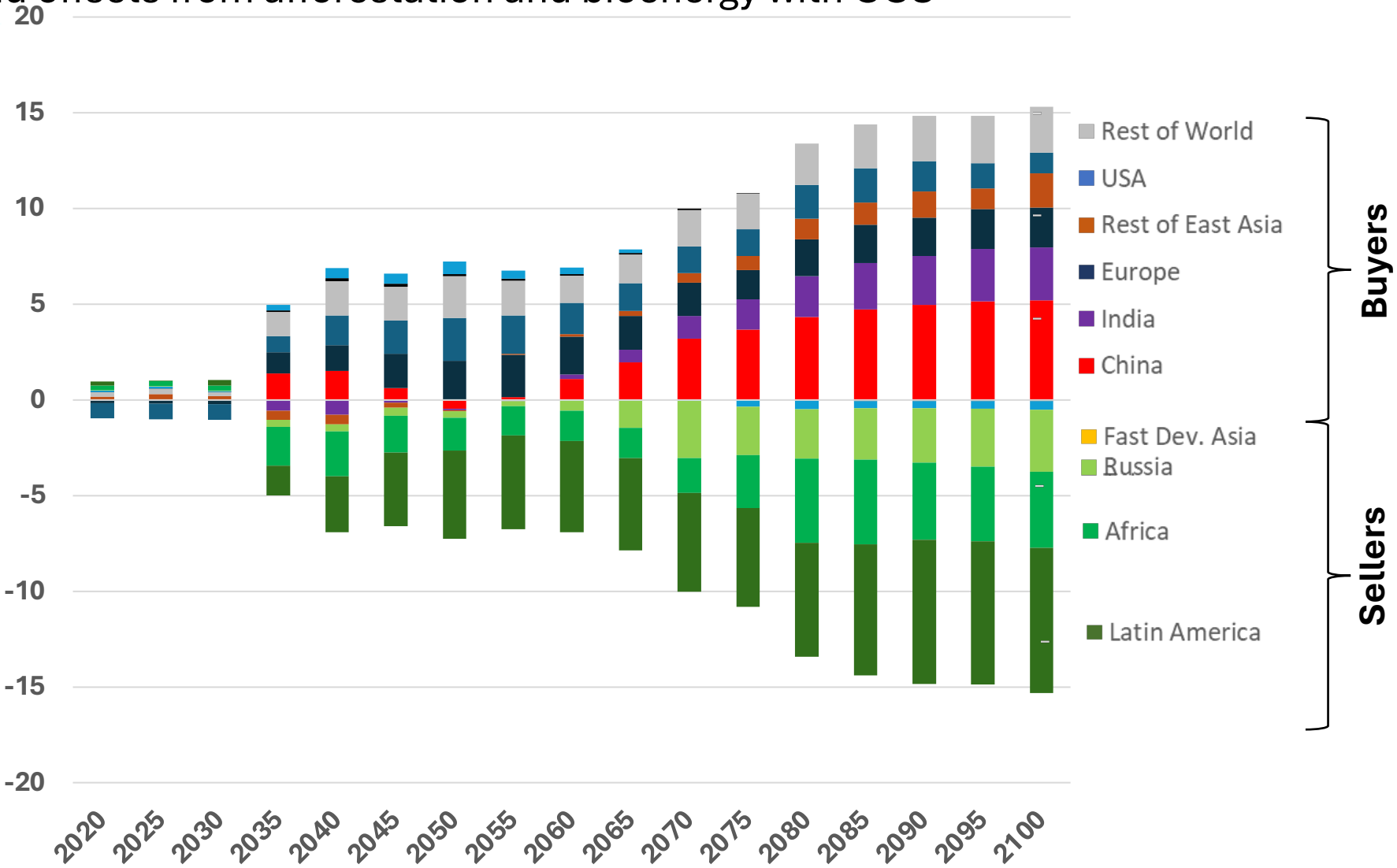
Jennifer Morris[1], Angelo Gurgel[1], Bryan K. Mignone[2], Haroon Kheshgi[3] & Sergey Paltsev[1]

Carbon dioxide removal (CDR) technologies and international emissions trading are both widely represented in climate change mitigation scenarios, but the interplay among them has not been closely examined. By systematically varying key policy and technology assumptions in a global energy-economic model, we find that CDR and international emissions trading are mutually reinforcing in deep decarbonization scenarios. This occurs because CDR potential is not evenly distributed geographically, allowing trade to unlock this potential, and because trading in a net-zero emissions world requires negative emissions, allowing CDR to enable trade. Since carbon price change in the opposite direction as the quantity of permits traded and CDR deployed, we find that the total amount spent on emissions trading and the revenue received by CDR producers do not vary strongly with constraints on emissions trading or CDR. However, spending is more efficient and GDP is higher when both CDR and trading are available.

Climate stabilization pathways limiting warming to 1.5 °C or 2 °C typically rely on negative emissions to offset remaining positive greenhouse gas (GHG) emissions in hard-to-abate sectors[1]. Land-based carbon dioxide removal (CDR) technologies such as bioenergy with carbon capture and storage (BECCS) and afforestation and reforestation (A/R) are the CDR options most commonly deployed in mitigation scenarios[1,2]. While many studies have explored the potential role of BECCS and A/R, little attention has been given to how their deployment might interact with, or depend on, the assumed climate policy regime. Because regional comparative advantages in different CDR options are not evenly distributed, total CDR deployment may depend on the extent to which international greenhouse gas (GHG) permit trade occurs. The level of trading, in turn, may depend on how Article 6 of the Paris Agreement[3] is implemented. Conversely, if CDR is limited, international trade of GHG permits may become increasingly constrained as national climate targets approach net-zero emissions since net positive emissions in some regions would only be enabled by net negative emissions in other regions. In this work, we investigate the role in GHG permits to assess the potential deployment of such technologies and the size of international carbon markets.

Different CDR options are characterized by differences in technological and institutional readiness, cost, use of land, permanence of CO_2 removal, and social acceptance[4,5]. These differences are likely to vary by region and over time. Many studies have investigated the potential for deployment of CDR options under climate policy. Some have focused on a portfolio of CDR options[6–9], with estimated maximum total CDR potential ranging from ~10 to 35 gigatonnes of CO_2 ($GtCO_2$) per year. Others have explored specific CDR options such as BECCS[10], A/R[11], direct air capture (DAC)[12], biochar[13], enhanced weathering[14,15] and ocean iron fertilization[16]. BECCS and A/R are the two most widely deployed CDR options in mitigation scenarios[2].

A/R is well known, has been already implemented, can sequester carbon at lower costs than many CDR options, and could help to reverse biodiversity losses and improve the provision of ecosystem services[17,18]. However, it takes decades to accumulate fixed carbon in living biomass and soils, with saturation of carbon uptake occurring



Assessing multiple socio-economic goals

Carbon Dioxide Removal (CDR) and Climate Justice

IOP Publishing Environ. Res. Lett. 20 (2025) 024002 https://doi.org/10.1088/1748-9326/ada4c

ENVIRONMENTAL RESEARCH
LETTERS

LETTER

Integrated assessment of carbon dioxide removal portfolios: la
energy, and economic trade-offs for climate policy

Solene Chiquier[1,2,3,*], Angelo Gurgel[1,2], Jennifer Morris[1,2], Yen-Heng Henry Chen[1,2] and Sergey Paltsev[1,2]

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[2] MIT Energy Initiative, Massachusetts Institute of Technology, Cambridge, MA, United States of America
[3] CarMa IFP School Chair, IFP Energies Nouvelles, Paris, France
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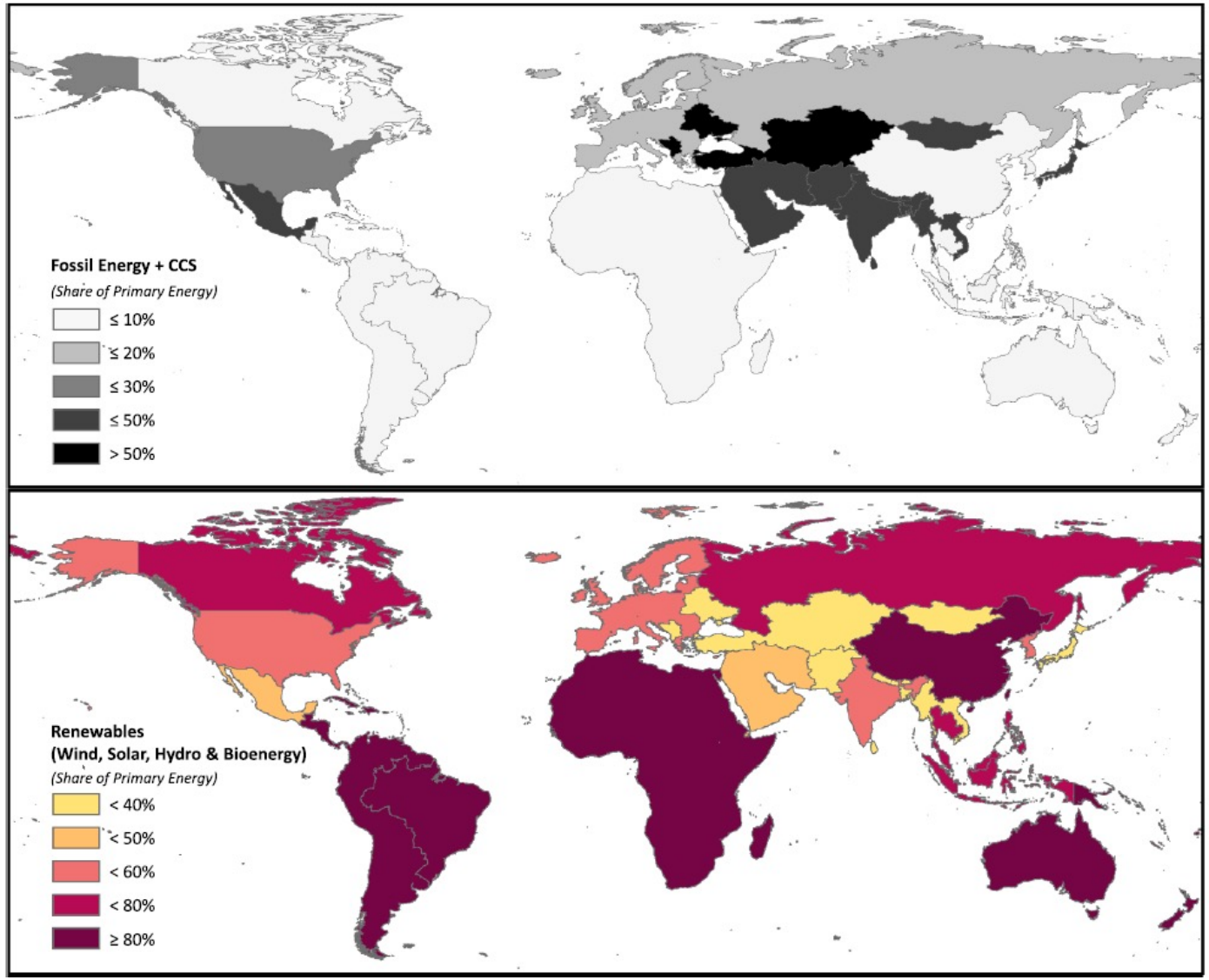
Keywords: carbon dioxide removal, negative emissions technologies, net-zero, scalability, sustainability, mitigation pathway

Supplementary material for this article is available online

Climate justice in a global/regional context: shifts in the world socio-economic "energy/technology/environment" balance?

Share of fossil x renewables (hydro+wind+solar+bioenergy) in total primary energy by 2100 in a CDR portfolio scenario assuming "sustainable biomass"



Assessing multiple socio-economic goals

Bioenergy

MENU ipcc

SPECIAL REPORT

Climate C

An IPCC Special Report on cli
land management, food secur

Table 6.73 | Impacts of integrated response options based on land management on the UN SDGs.

Integrated response options based on land management	GOAL 1: No poverty	GOAL 2: Zero hunger	GOAL 3: Good health and well-being	GOAL 4: Quality education	GOAL 5: Gender equality	GOAL 6: Clean water and sanitation	GOAL 7: Affordable and clean energy	GOAL 8: Decent work and economic growth	GOAL 9: Industry, innovation and infrastructure	GOAL 10: Reduced inequality	GOAL 11: Sustainable cities and communities	GOAL 12: Responsible consumption and production	GOAL 13: Climate action	GOAL 14: Life below water	GOAL 15: Life on land	GOAL 16: Peace, justice and strong institutions	GOAL 17: Partnerships to achieve the goals
Increased food productivity																	
Improved cropland management																	
Improved grazing land management																	
Improved livestock management																	
Agroforestry																	
Agricultural diversification										+ or –							
Bioenergy and BECCS[10]	+ or –		+ or –														

Large positive impacts, strong evidence
Medium positive impacts, some evidence
Small positive impacts or low evidence
Low negative impacts or low evidence
Medium negative impacts, medium evidence
Large negative impacts, high evidence

Assessing multiple socio-economic goals

Bioenergy

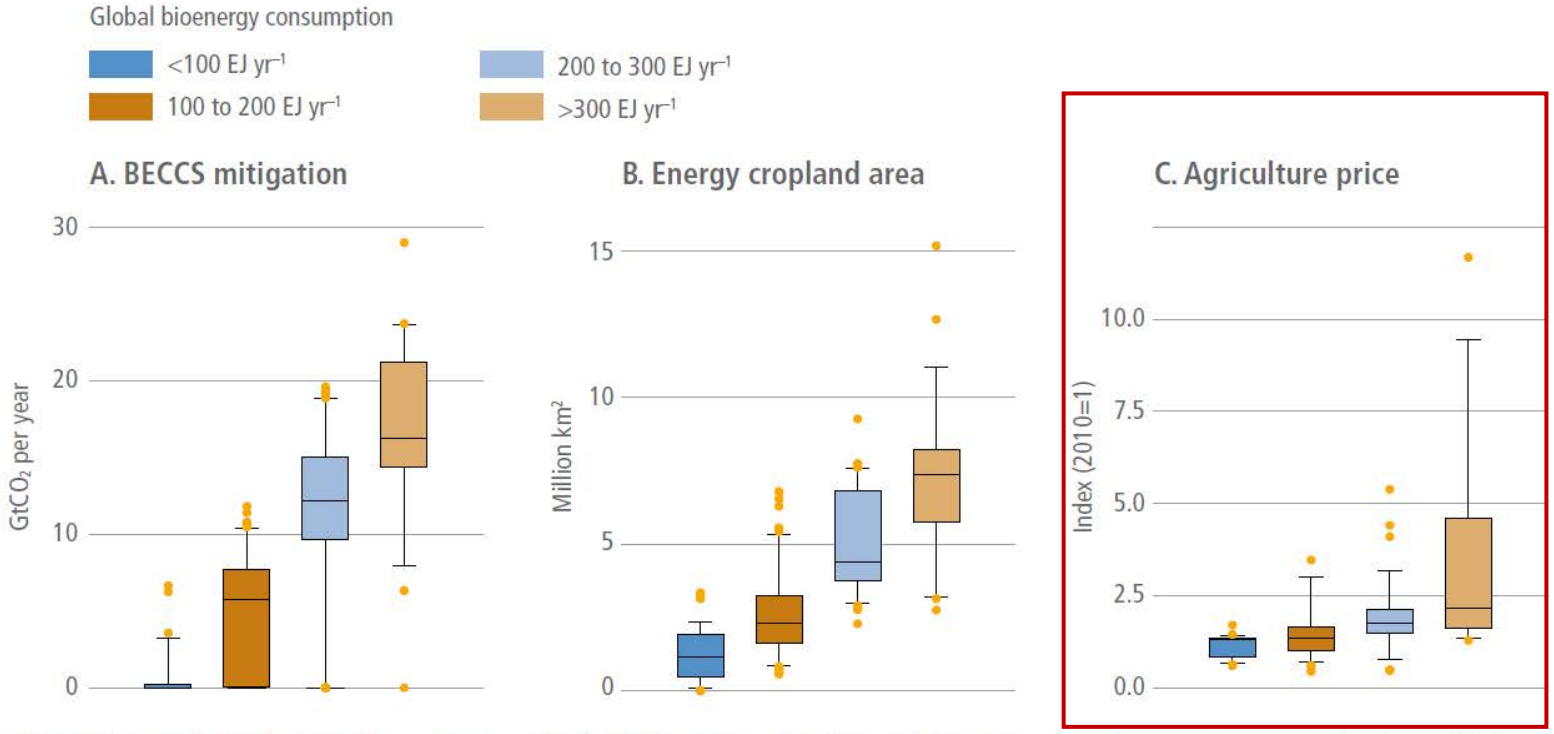


Figure 6.8 | Correlation between bioenergy use and other indicators. Panel A shows global CO_2 sequestration by BECCS in 2100. **Panel B** shows global energy cropland area in 2100. **Panel C** shows agricultural prices in 2100 indexed to 2010. Data are based on the amount of bioenergy used globally in 2100. All scenario data that include bioenergy consumption and the variable of interest are included in the figure; the resulting number of scenarios varies per panel, with 352 in panel A, 262 in panel B, and 172 in panel C. The boxes represent the interquartile range (i.e., the middle 50% of all scenarios). The line in the middle of the box represents the median, and the 'whiskers' represent the 5 to 95% range of scenarios. Data is from an update of the Integrated Assessment Modelling Consortium (IAMC) Scenario Explorer developed for the SR15 (Huppmann et al. 2018; Rogelj et al. 2018b).

How will changes in agriculture prices translate in other socio-economic impacts, such as changes in household income and in food security?

Are there regional/local/sectorial or context-specific opportunities?

ipcc

SPECIAL REPORT

Climate Change and Land

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nature sustainability

Article

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Contribution of double-cropped maize ethanol in Brazil to sustainable development

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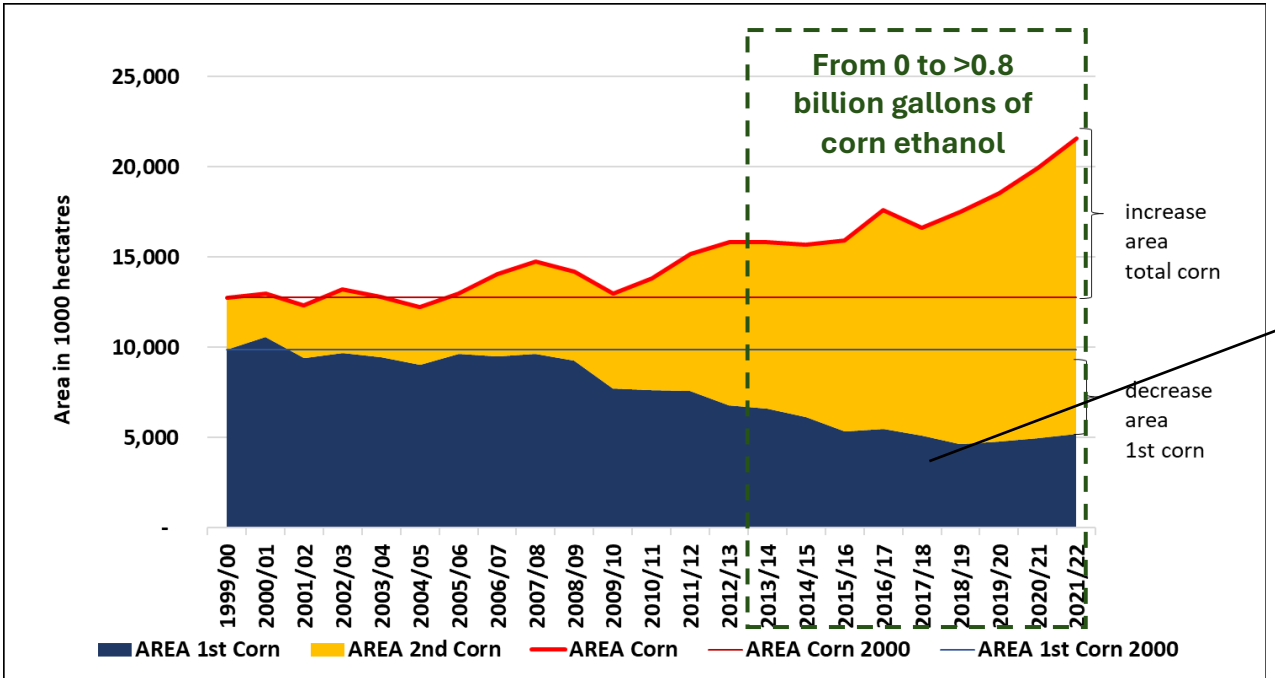
Evolution of Corn Area in Brazil

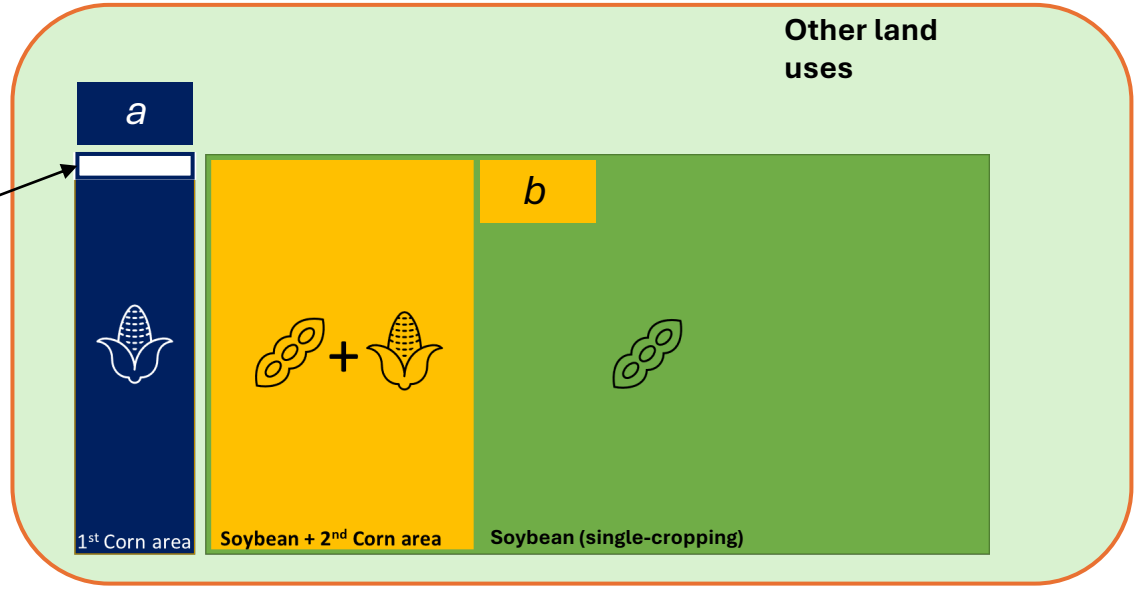


Alternative Farmers' response to an additional demand for corn:

a) *Expanding single-cropping corn area, leading to land use competition with other uses*

b) *Expanding corn as double cropping on soy area*

Enhanced two socio-economic CGE models: multicropping and multiple households



Assessing multiple socio-economic goals

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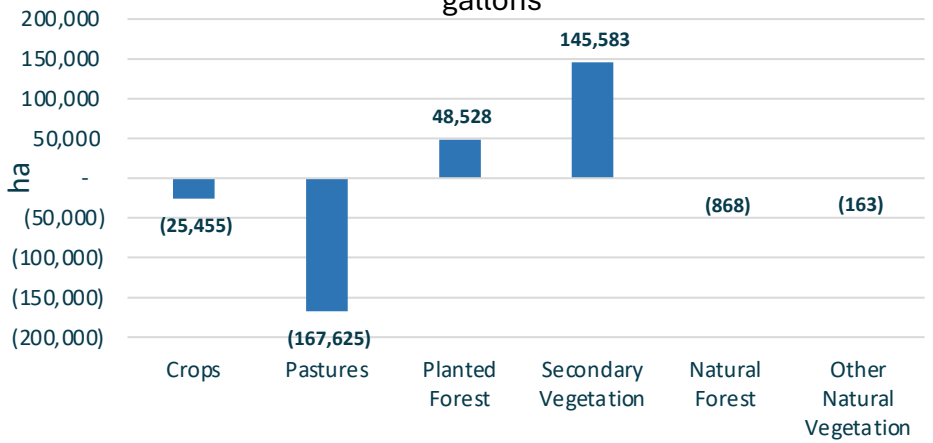
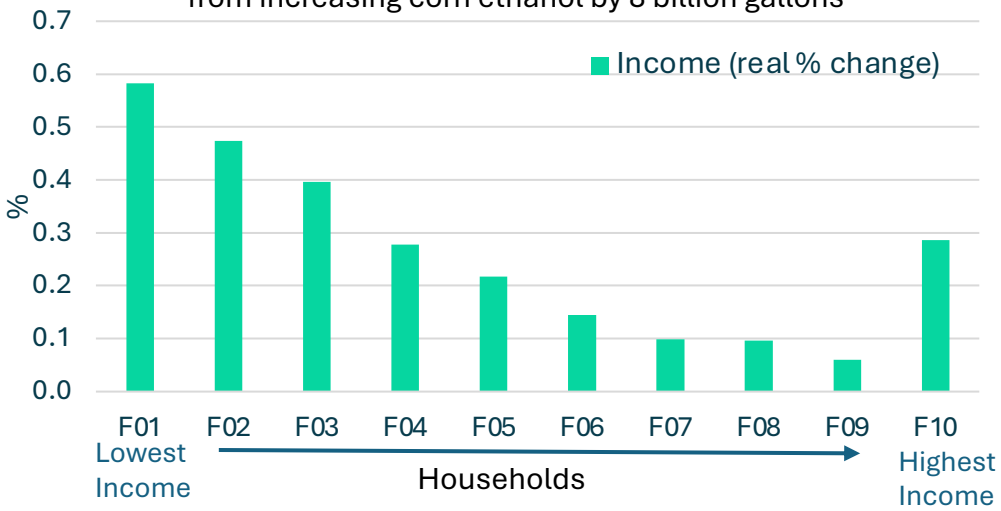
Multicropping maize-based production system contributions to SDGs.

Land use changes in Brazil from increasing corn ethanol by 8 billion gallons



Changes in household income in Center-West Brazil from increasing corn ethanol by 8 billion gallons



b Results from socio-economic models

Indicator	Geography	Metric
Food production	Local	%
Food production	National	%
Food production	Global	%
Food price	Local	%
Food price	National	%
Food price	Global	%
Income of the poorest families	Local	%
Consumption by the poorest families	Local	%
Utility index of poorest families	Local	%
Renewable fuel production	Local	billion l
Power generation	Local	MWh
Fuel and chemicals prices	Local	%
Electricity and utility services prices	Local	%
Price of transport services	Local	%
Liquid fuel price	National	%
Electricity price	National	%
Price of transport services	National	%
Electricity and utility services prices	Global	%
Fuel and chemicals prices	Global	%
Greenhouse gas emissions	National	$MtCO_2e$
Greenhouse gas emissions	Global	$MtCO_2e$
Cropland area	National	million ha
Pasture area	National	million ha
Planted forest area	National	million ha
Natural (secondary) vegetation regrowth area	National	million ha
Natural forest area	National	million ha
Non-forest natural vegetation area	National	million ha
Cropland area	Global	million ha
Pasture area	Global	million ha
Planted forest and secondary vegetation area	Global	million ha
Natural forest area	Global	million ha
Non-forest natural vegetation area	Global	million ha
Economic growth	National	%
Economic growth	Global	%

Final Remarks

Socio-economic co-benefits are key to achieve public support and stakeholder engagement

"Just transition" may facilitate international discussions and sustainability agreements, but it requires better understanding and framing

There are several context-specific challenges and opportunities to align multiple environmental and socio-economic positive outcomes

Need to advance knowledge on multiple socio-economic targets
(overcame gaps, deal with trade-offs, find and enhance synergies)

Thank you

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Center for Sustainability Science and Strategy

Global Change Forum 48

Connecting Climate and Sustainability: Synergies and Tradeoffs

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Image :