DECARBONIZATION AND ENERGY SECURITY

Security beyond energy: land use

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MIT Joint Program on the Science and Policy of Global Change

March 23, 2023

** Based on work in collaboration with: Sergey Paltsev, Jennifer Morris, Andrei Sokolov, Henry Chen, Howard Herzog, Florian Allroggen, Bryan Mignone, Haron Kheshgi, Martin Haigh, David Hone, Bonnie Waring, Alexandre Köberle, Joeri Rogelj, Steven Rose, Marcelo Moreira and Sofia Arantes*

Outline

- Security beyond energy: land use
- Sustainable bioenergy
- Nature Climate Solutions (NCS)
- Bioenergy x NCS
- Bioenergy + NCS
- Final remarks

Security beyond energy: land use

Energy Security: **Reliable, affordable access to all fuels and energy sources**

"The IEA defines energy security as the uninterrupted availability of energy sources at an affordable price."

Energy security has many aspects:

- long-term: timely investments to supply energy in line with economic developments and environmental needs.

- short-term: the ability of the energy system to react promptly to sudden changes in the supply-demand balance.

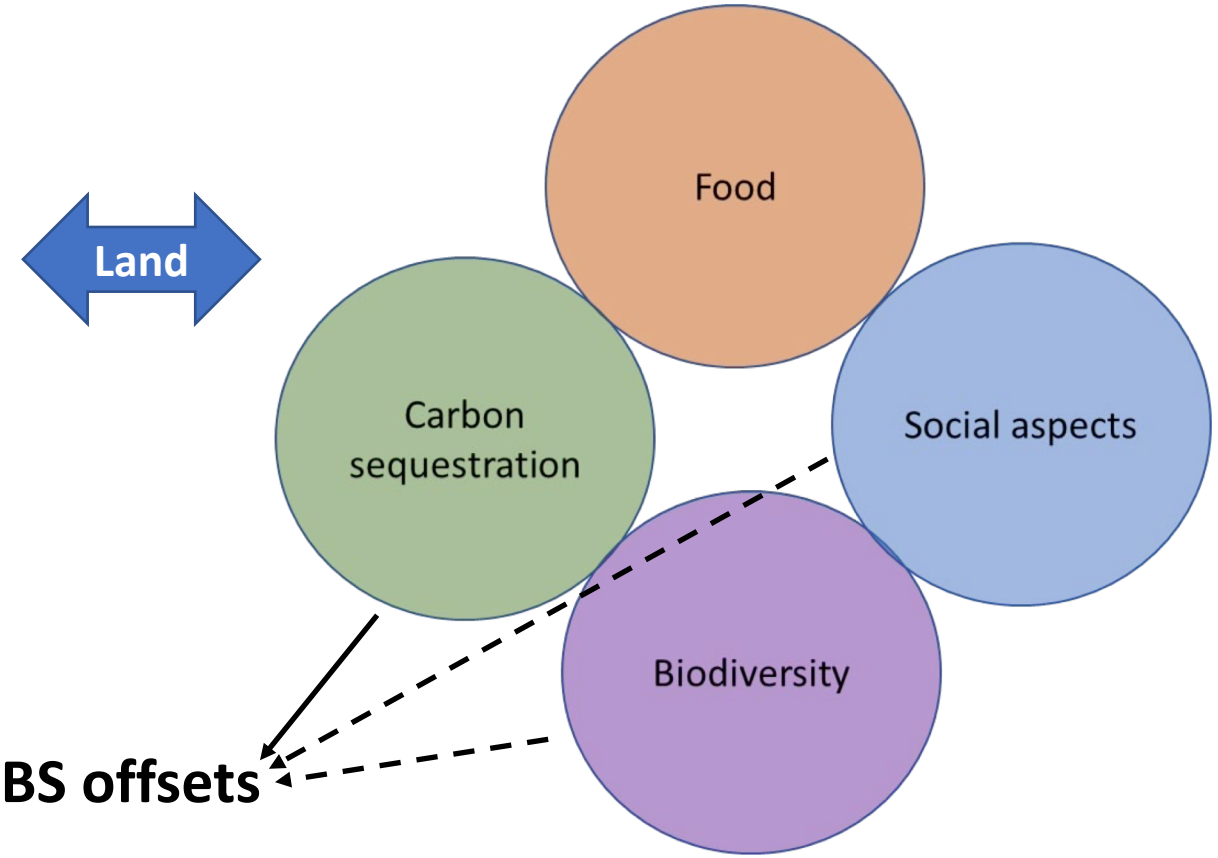
Security beyond energy: land use

Bioenergy:

- size of bioenergy markets (how much)
- where
- when

Sustainable bioenergy

Other land use demands and constraints:



Sustainable Bioenergy

Pathways

Feedstock

e.g., corn, sugar cane, soybean, switchgrass, landfill biogas

Production Process

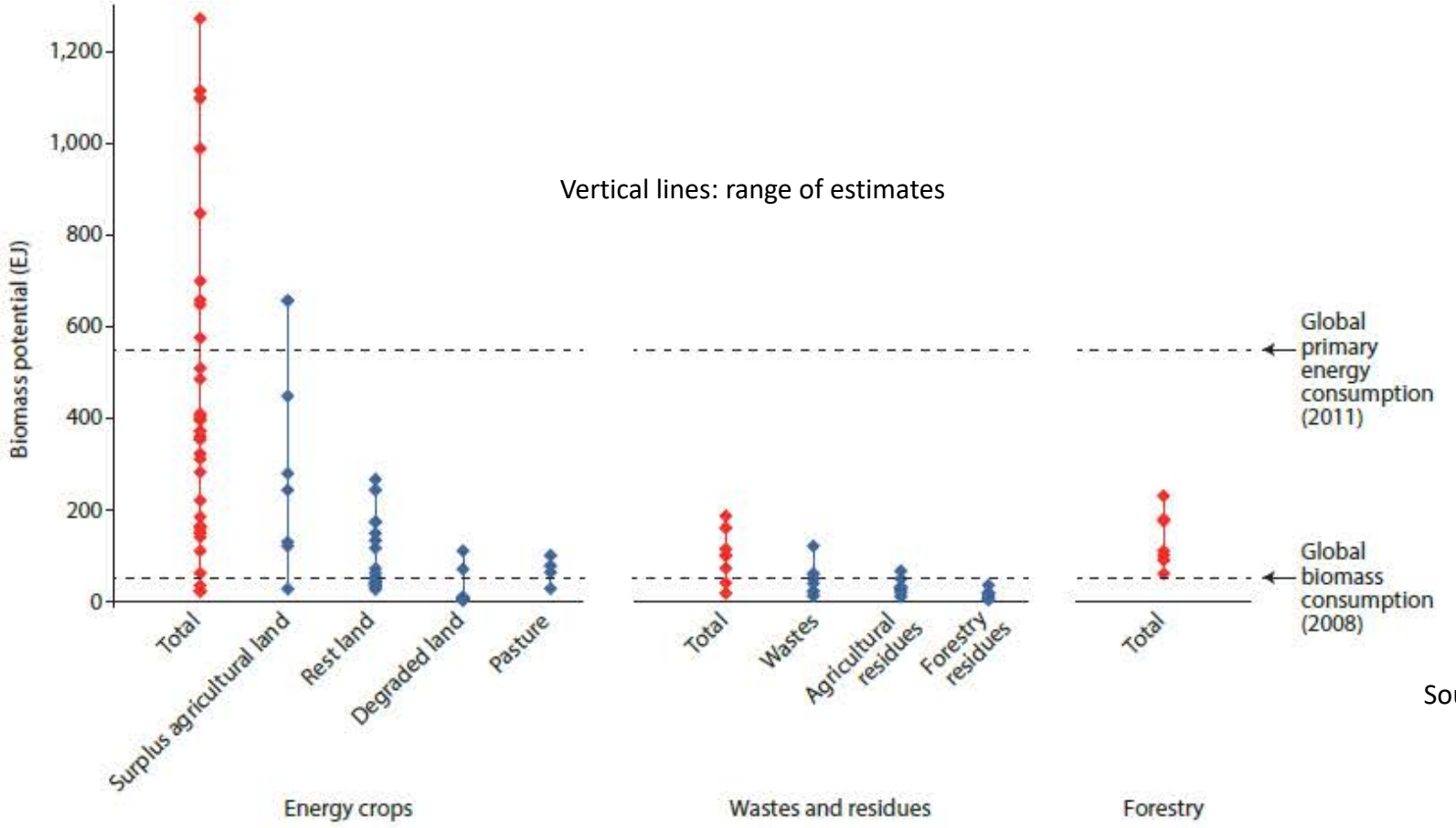
e.g., hydrotreating, gasification and upgrading, transesterification

Fuel Type

e.g., ethanol, biodiesel, biojet kerosene, cellulosic fuels

Sustainable Bioenergy

Potential contribution of energy crops, wastes and forest biomass to future energy supply



Source:

nature climate change
REVIEW ARTICLE
PUBLISHED ONLINE: 29 JANUARY 2014 | DOI: 10.1038/NCLIMATE2097

Global bioenergy resources

Raphael Slade*, Ausilio Bauen and Robert Gross

Sustainable Bioenergy

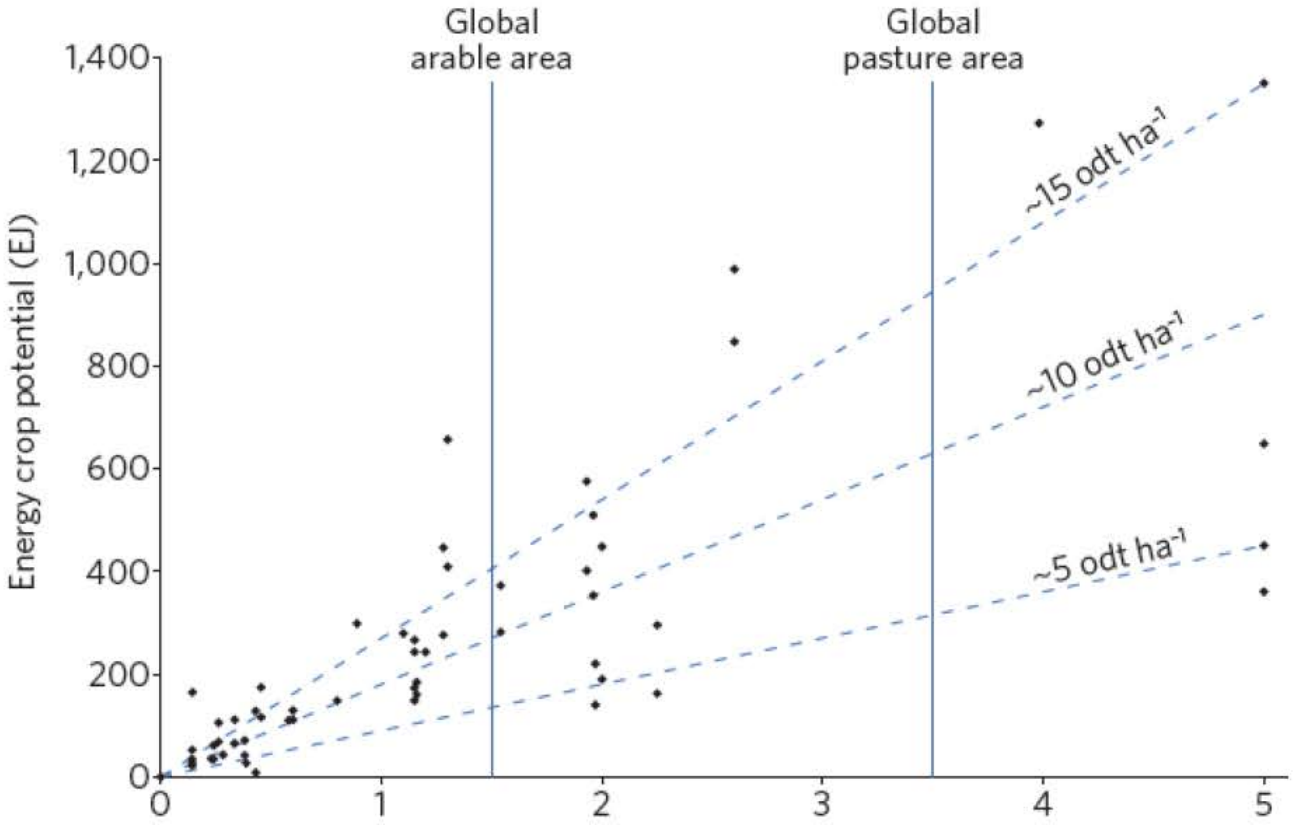


Figure 4. Estimated land area for energy crops (Gha) Source: Slade et al., 2014).

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Global bioenergy resources

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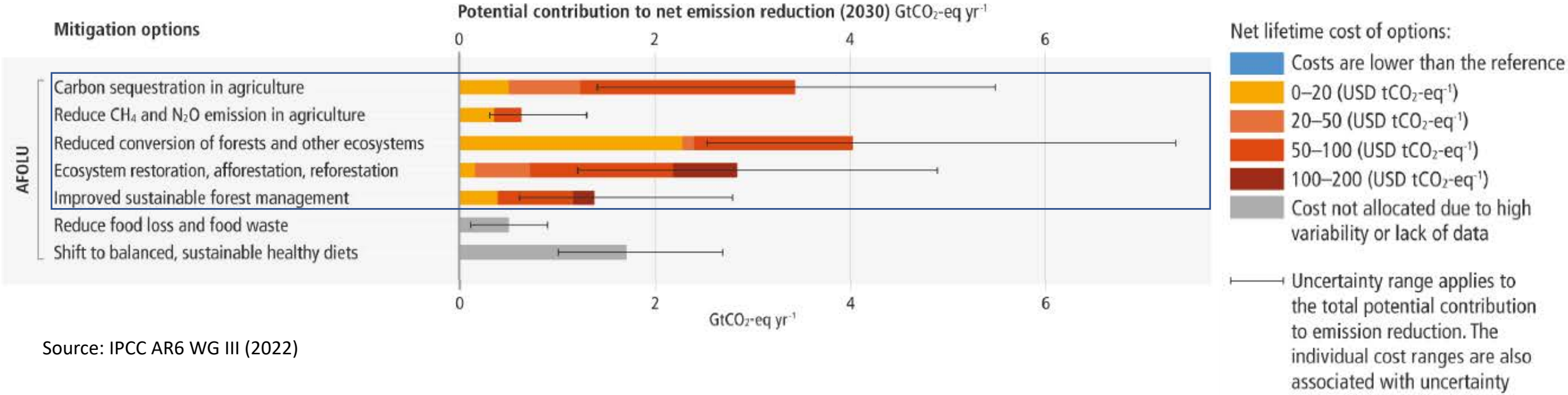
Sustainable paths for expanding biofuels:

- *Boosting crop yields and residues;*
- *Freeing up farmland (yield improvements);*
- *Reducing losses and waste in the food chain;*
- *Freeing up pastureland (livestock management);*
- *Afforestation using fast-growing trees;*
- *Algae cultivation.*

IRENA
International Renewable Energy Agency

Nature Climate Solutions

Many options available now in all sectors are estimated to offer substantial potential to reduce net emissions by 2030. Relative potentials and costs will vary across countries and in the longer term compared to 2030.



Source: IPCC AR6 WG III (2022)

High expectations: NCS can deliver CO_2 reduction, conservation, restoration, or altered management of natural ecosystems ('win-win-win' outcomes for climate, nature and society)

Nature Climate Solutions

However:

- *Current demand for offsets does not find enough supply of high-quality NCS projects;*
- *Complex set of interacting ecological, social, and financial constraints;*
- *Requires multiple stakeholders involvement;*
- *Potential unintended consequences of large-scale habitat transformation;*
- *Scaling up is hard due to the absence of a 'one size fits all' approach to NCS;*
- *Several challenges to 'monitor, report, and verify' (MRV)*

  (baseline assumptions, leakage risks, measurement of carbon sequestration in different pools, lack of standards and rigor in methodologies, over-statement of carbon benefits, uncertainty on permanence, lack of metrics to assess biodiversity co-benefits, …)

- *Limits on carbon emissions avoidance/sequestration (saturation);*

Bioenergy x Natural Climate Solutions (NCS)

Bioenergy:

- Implemented already
- Multiple sources and uses
- Easily adapted or copied to other regions
- Several pathways generate co-benefits
- …
- High costs to build negative pathways
- Challenges to attend environmental and social goals (biodiversity, inequalities)
- Land competition, food prices, biodiversity
- …

NCS/NBS:

- Higher public acceptance (more “natural”)
- Some cheap options (avoided deforest. and reforest.) being implemented already
- Several countries and private-sector entities committed to forest conservation
- May generate environmental co-benefits
- …
- Local and context specific (costs, mitigation, consequences)
- Regions with high potential: structural and institutional challenges
- Measurement, standards and protocols are far from adequate
- Climate impacts may compromise projects
- Saturation
- Limited discussions on implementation, equity and governance
- …

Bioenergy x Natural Climate Solutions (NCS)

Public perception:

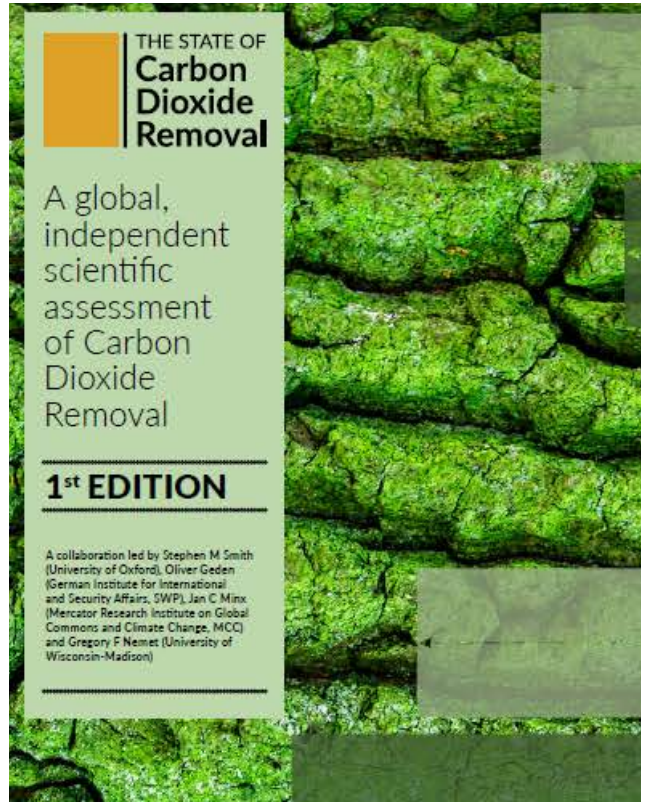


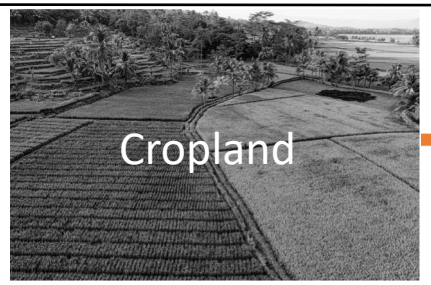
Figure 4.5. *Share of original tweets on Carbon Dioxide Removal (CDR) that express either a positive or negative sentiment (2010-2021); trends in sentiment (positive - green arrow; negative - red arrow) over time; tweet counts for different CDR methods (2010-2021). Definitions: Bioenergy with Carbon Capture and Storage (BECCS), Direct Air Carbon Capture (DAC) and Direct Air Carbon Capture and Storage (DACCS).*

Bioenergy x Natural Climate Solutions (NCS)

To proper evaluate land use aspects, mitigation potentials and possible consequences and trade-offs we need an integrated analysis, considering interactions and connections among:

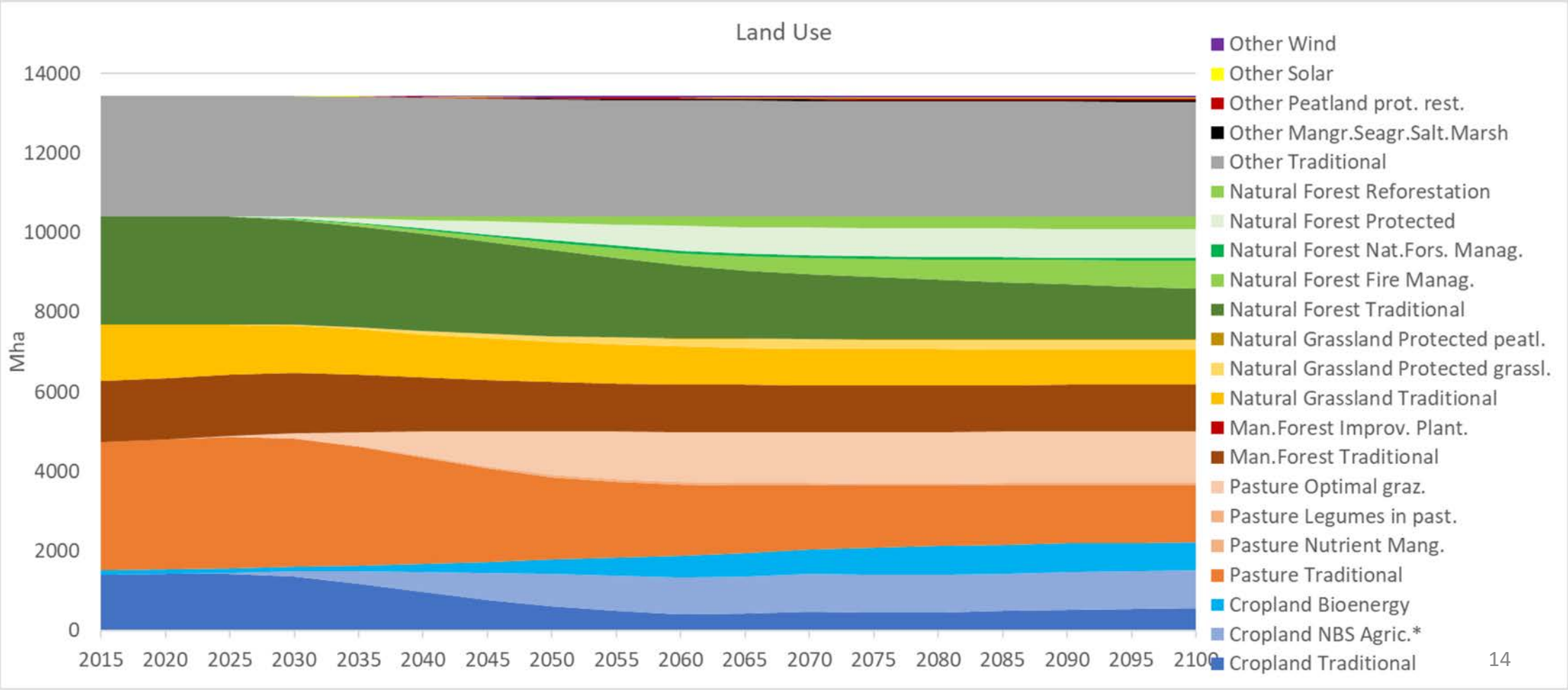
- energy markets
- agricultural markets
- land markets
- natural resources
- environmental impacts

Environmental Resources - Land



Bioenergy x Natural Climate Solutions (NCS)

How may land be distributed to accommodate bioenergy and NBS/NCS in high mitigation pathways (1.5°C "Sky" scenario)?



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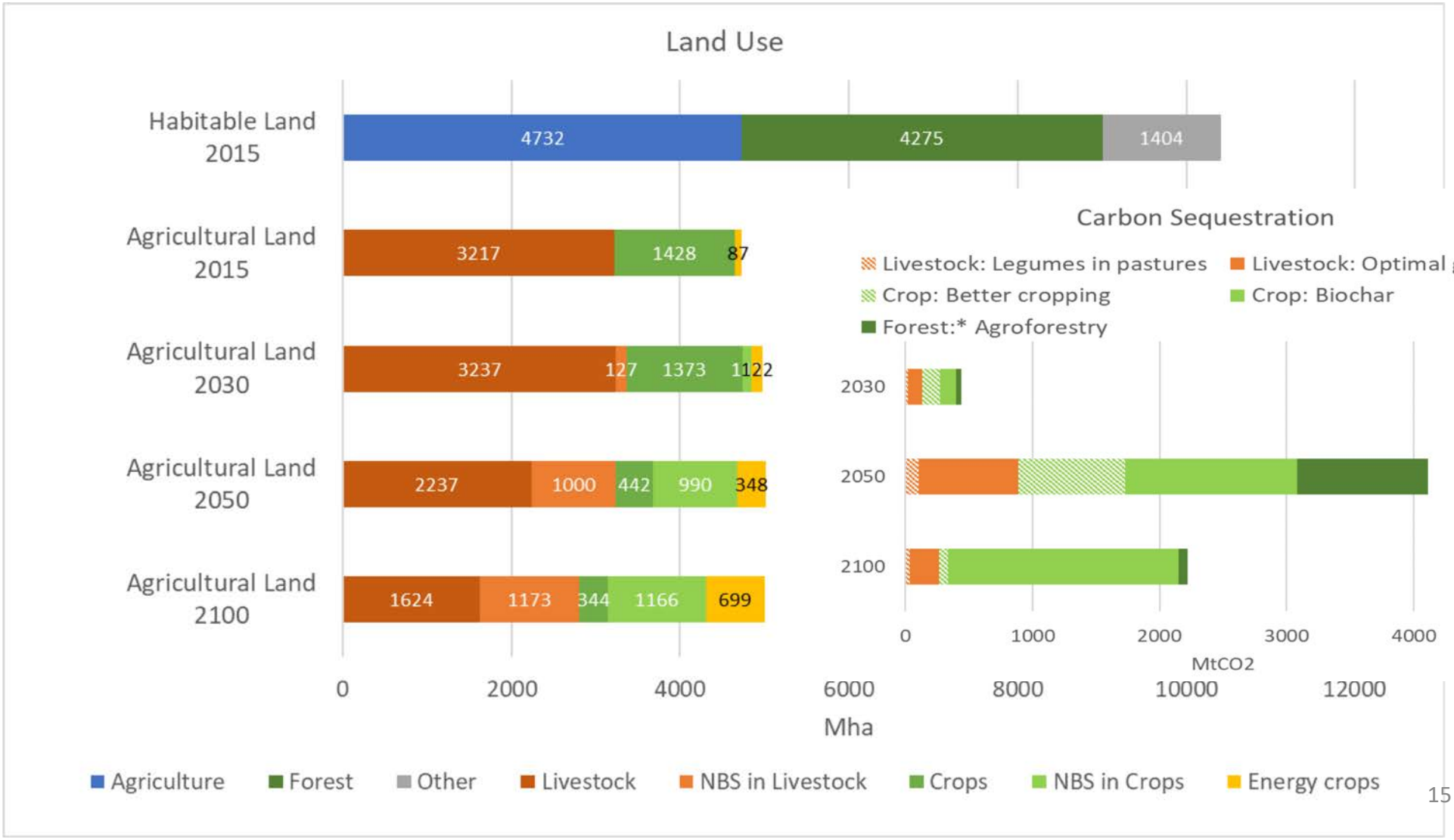
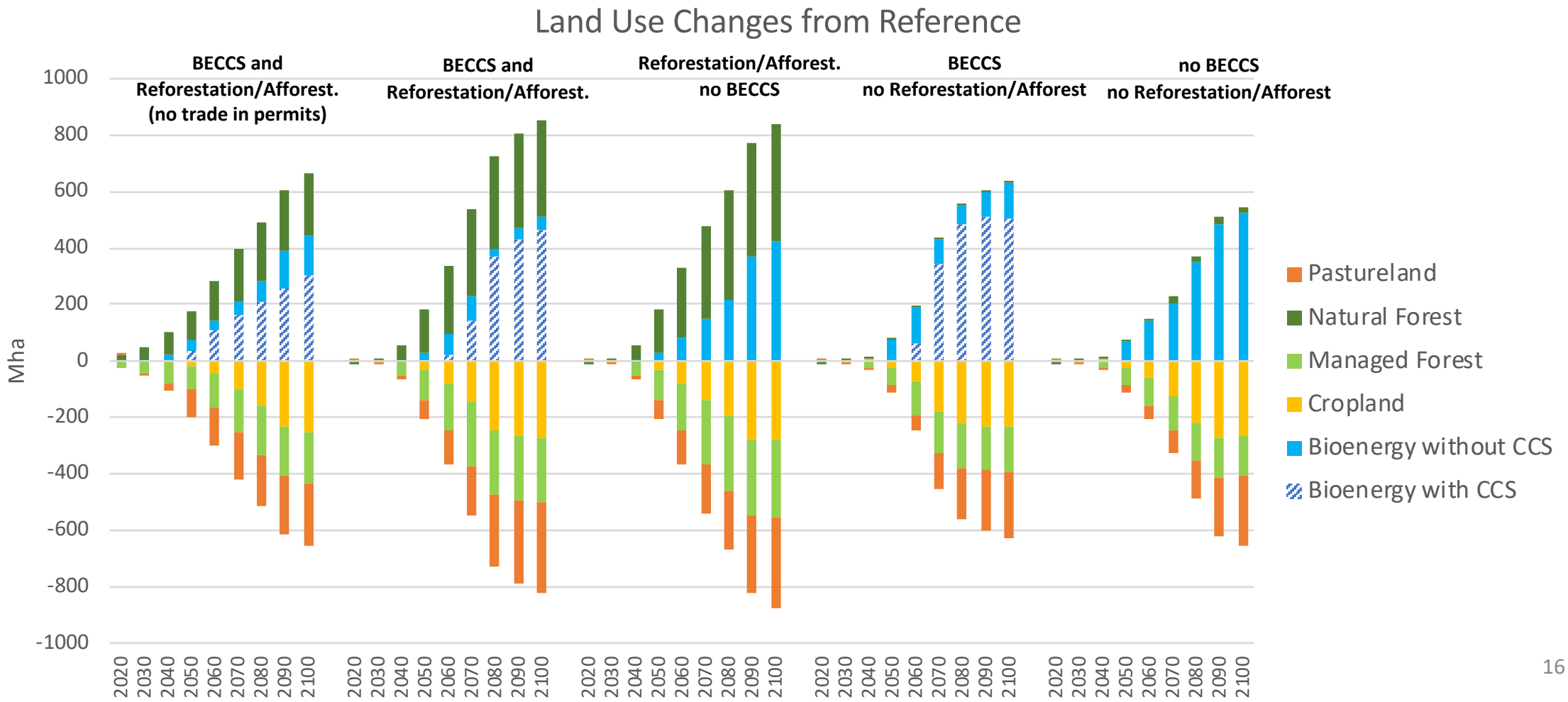


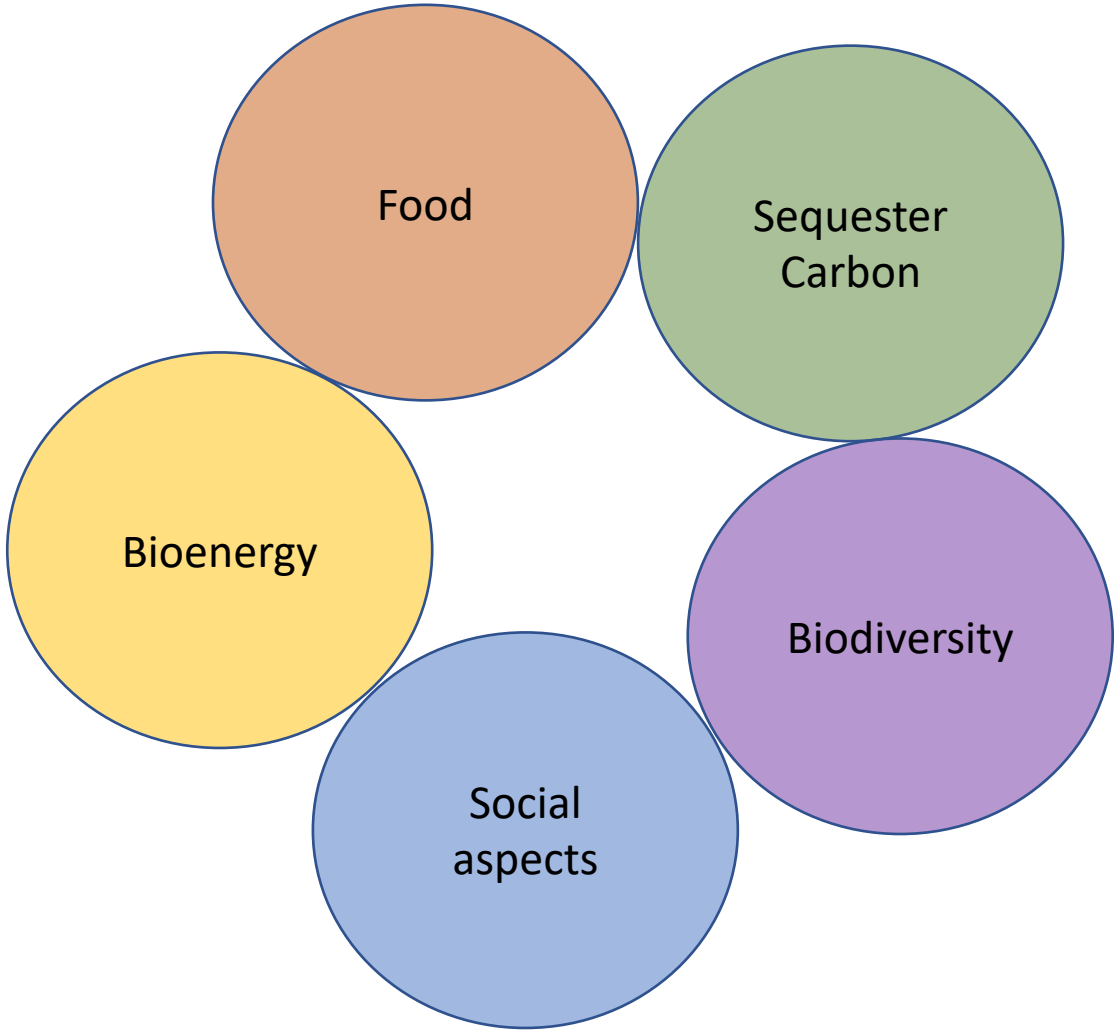
Bioenergy x Natural Climate Solutions (NCS)

How land use would change under alternative stabilization scenarios (2°C) of bioenergy and NBS/NCS (afforestation/deforestation)?



Bioenergy + Natural Climate Solutions (NCS)

Land use allocation will need to consider multiple goals and several constraints



- Bioenergy and NCS may be local and context specific (costs, mitigation, consequences);
- Scaling up is hard due to the absence of a ‘one size fits all’ approach;
- Potential unintended consequences of large-scale adoption;

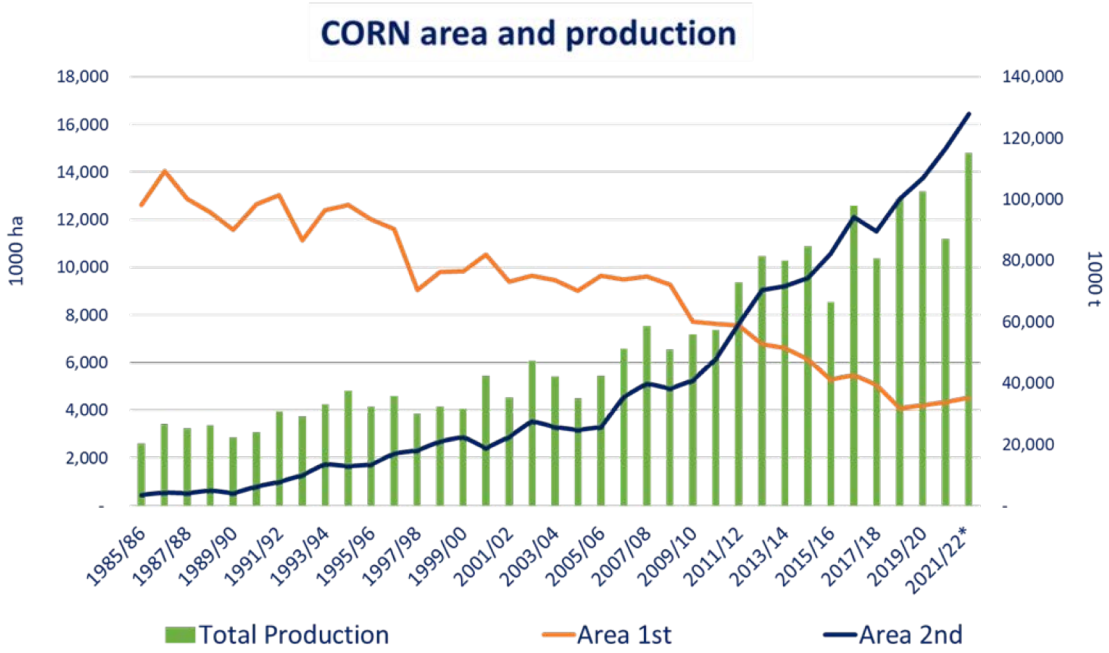
Can we find complementarities and synergies between bioenergy and NCS?
How to evaluate such pontentials?

Bioenergy + Natural Climate Solutions (NCS)

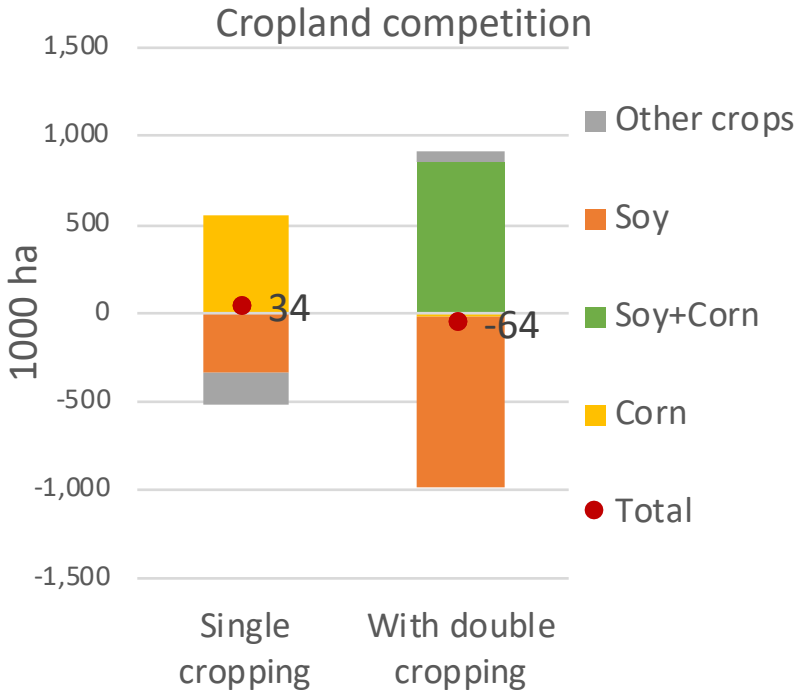
Corn ethanol in Brazil from 2nd cropping

From 2013/14 to 2020/21:

- Corn ethanol production has grown from 0.1% to 8.5% of total ethanol output



Increase corn ethanol in Brazil by 5 billion liters



Under double cropping approach:

- *Corn expands as double-crop on area previously occupied by soy under single cropping*
- *Total cropland area decreases*

Final Remarks

- Land use changes, bioenergy and Nature Climate Solutions:
  - Many challenges and uncertainties (yields, social impacts, local conditions, …)
  - Some complementarity (Afforestation “now”, BIOCCS later)
  - Some competition (Afforestation x 1st generation biofuels)
  - NCS has many unknowns (soil carbon, monitoring, permanence, leakage, …)

➢Socio-economic-environmental modeling needed to assess potentials, impacts, trade-offs

- Climate stabilization will be hardly achieved without NBS and bioenergy

Develop synergies between bioenergy and NBS practices and principles!

Thanks!

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