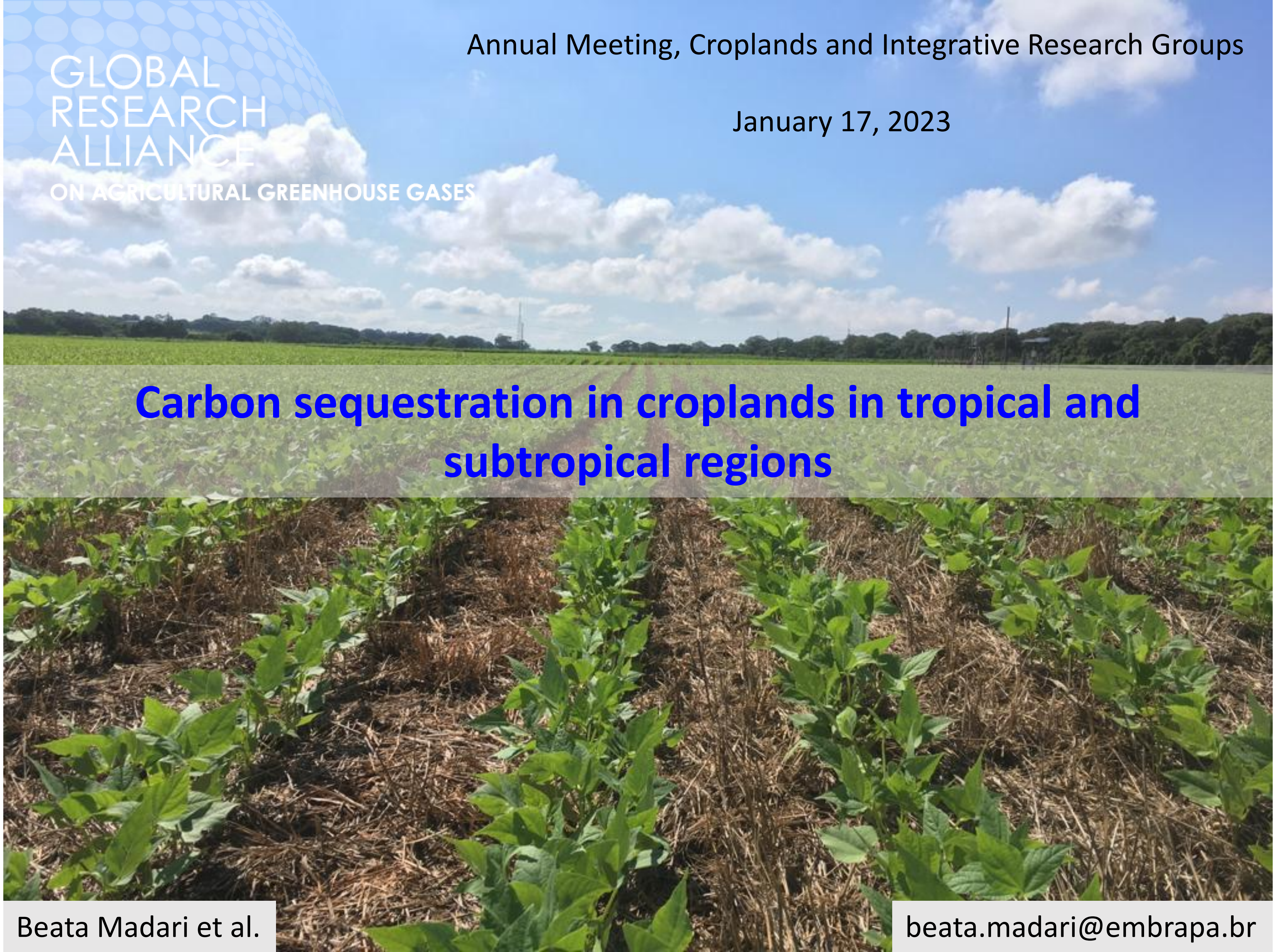

GLOBAL RESEARCH ALLIANCE ON AGRICULTURAL GREENHOUSE GASES

Annual Meeting, Croplands and Integrative Research Groups

January 17, 2023

Carbon sequestration in croplands in tropical and subtropical regions

Beata Madari et al.

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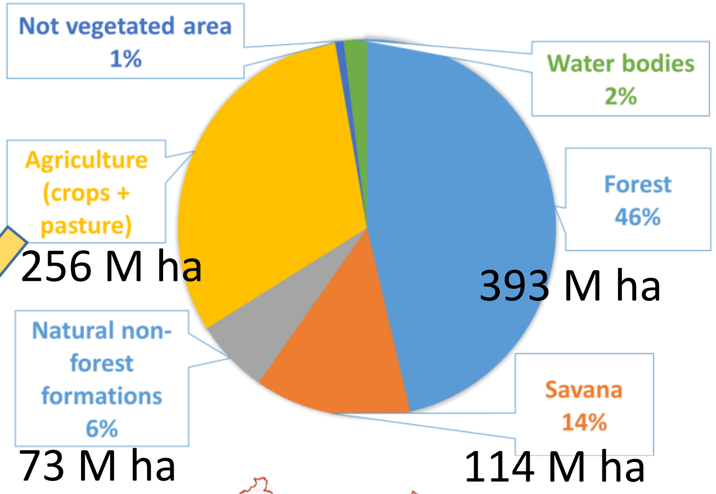
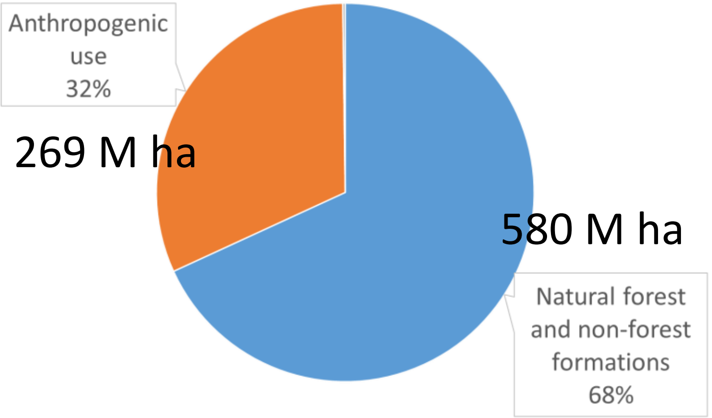
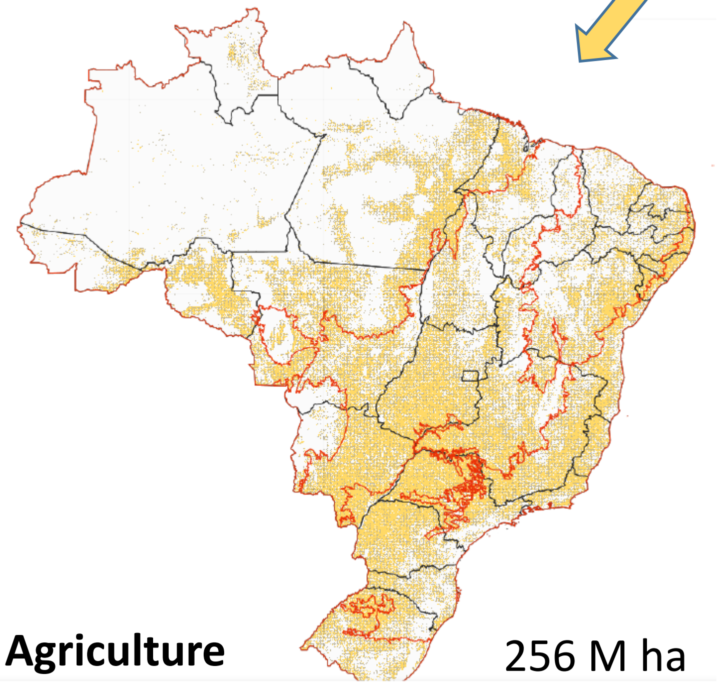
Embrapa

Land Use in Brazil - 2021

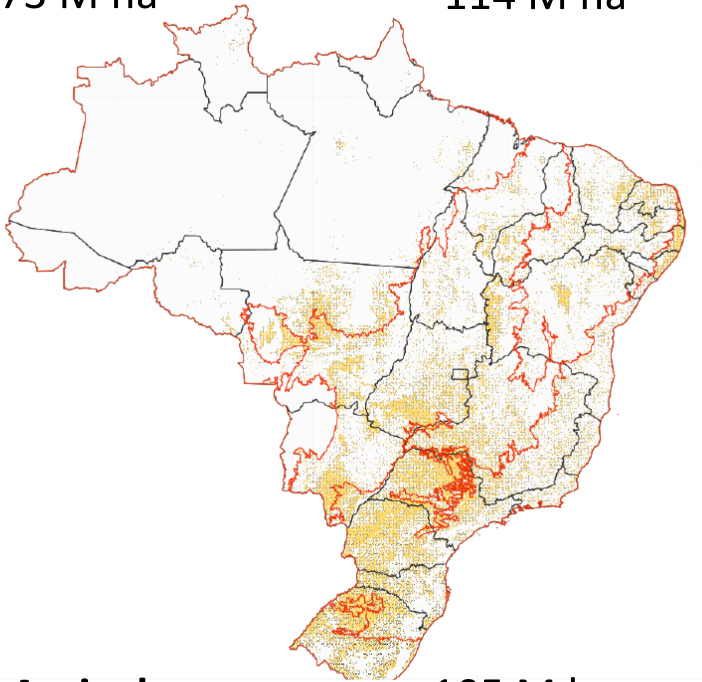
Projeto MapBiomas – Coleção v.7 da Série Anual de Mapas de Cobertura e Uso de Solo do Brasil, acessado em 13/01/2023 através do link: https://plataforma.brasil.mapbiomas.org



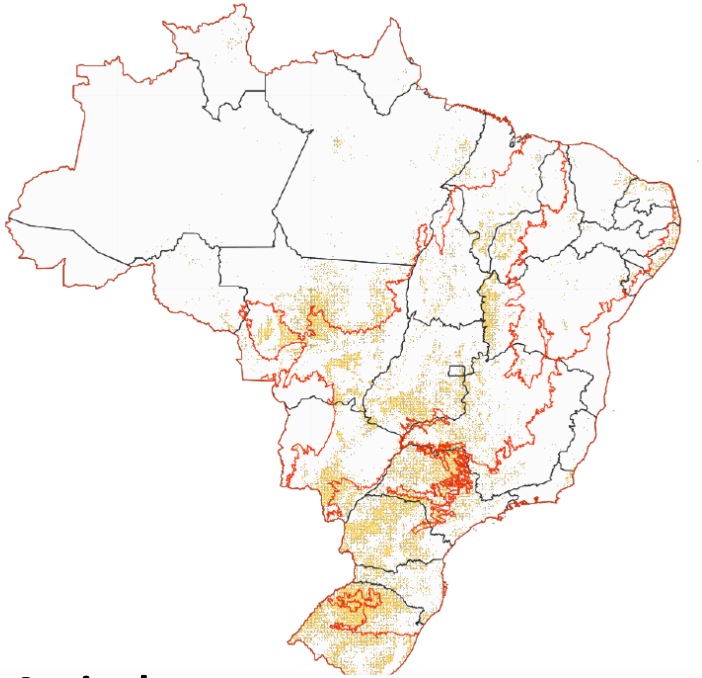




Agriculture 256 M ha
- anual + permanent crops, including fiber (cotton) and energy (sugarcane)
- pasture



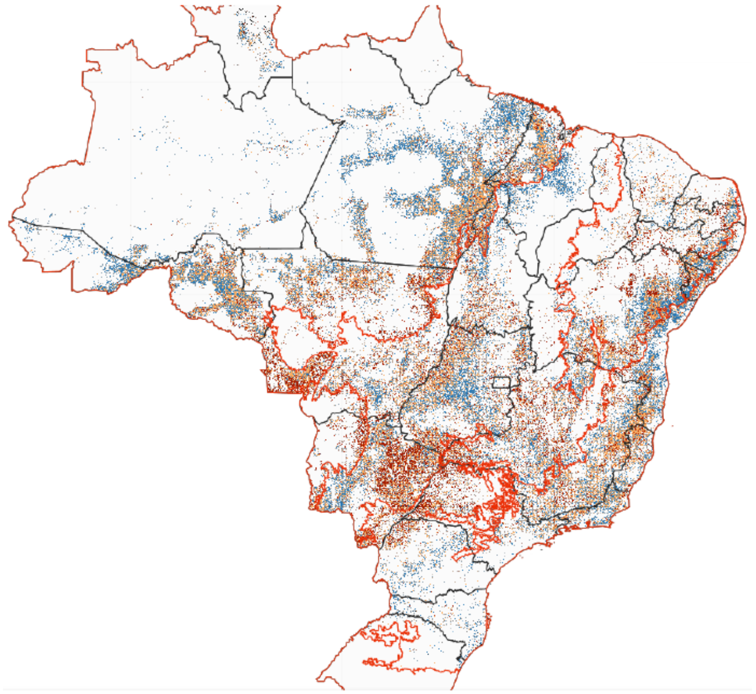
Agriculture 105 M ha
- anual crops, including fiber (cotton) and energy (sugarcane),
- mosaic

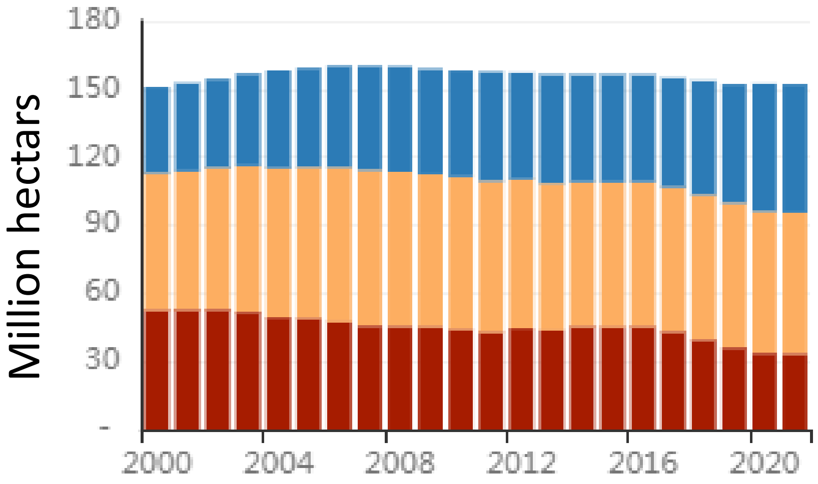


Agriculture 63 M ha
- anual crops, including fiber (cotton) and energy (sugarcane)

Land Use in Brazil - 2021

Projeto MapBiomas – Coleção v.7 da Série Anual de Mapas de Cobertura e Uso de Solo do Brasil, acessado em 13/01/2023 através do link: https://plataforma.brasil.mapbiomas.org





Pasture

Severly degraded	33 M ha 27%
Moderately degraded	62 M ha 42%
Not degraded	57 M ha 31%
Total	151-160 M ha

Earlier: Plano ABC 2010 – 2020

Currently:

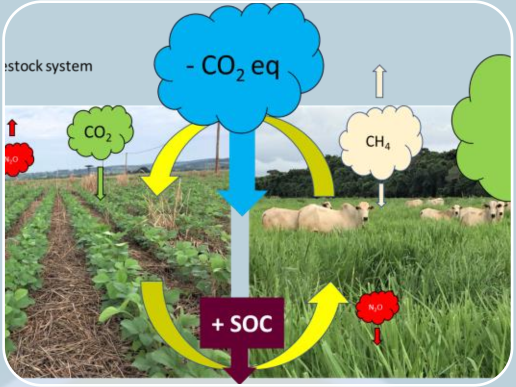
ABC+

Policy for *Adaptation to Climate Change* and for *Low C Emission Agriculture*

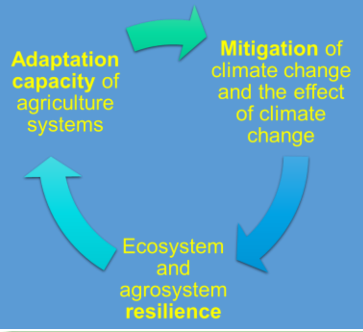
2020 - 2030

Integrated **Landscape** Management

(Forest Code)



Adaptation to Climate Change and **Mitigation**



Encouraging the **Adoption and Maintenance** of Systems, Practices, Products and Processes of **Sustainable Production**

Embrapa

Main Technologies (Sustainable Production Systems) of Plano ABC+ (2020 – 2030) – SPS_{ABC+}

Restoration / Recovery of Pastures (+30 M ha)
Mitigation potential[1]: 113.7 M tons CO_2eq
Soil C sequestration potential*: ~ 0.3 – 1 tons ha^{-1} yr^{-1} C

[1]Considering default emission/removal factor of 3.79 tons $CO_2eq/ha/yr$ (IPCC, 2006)

* Available literature

Zero Tillage System (crop rotation with cover crops) (+12.6 M ha)
Mitigation potential[3]: 13 M tons CO_2eq
Soil C sequestration potential*: ~ 0.53 to 1.75 tons ha^{-1} yr^{-1} C

[3]Considering sequestration rates of C of 1.75 tons/ha/year for ZTS and of 0.53 tons/ha/yr for ZT, and a conversion factor 3.67 for CO_2eq

* Available literature

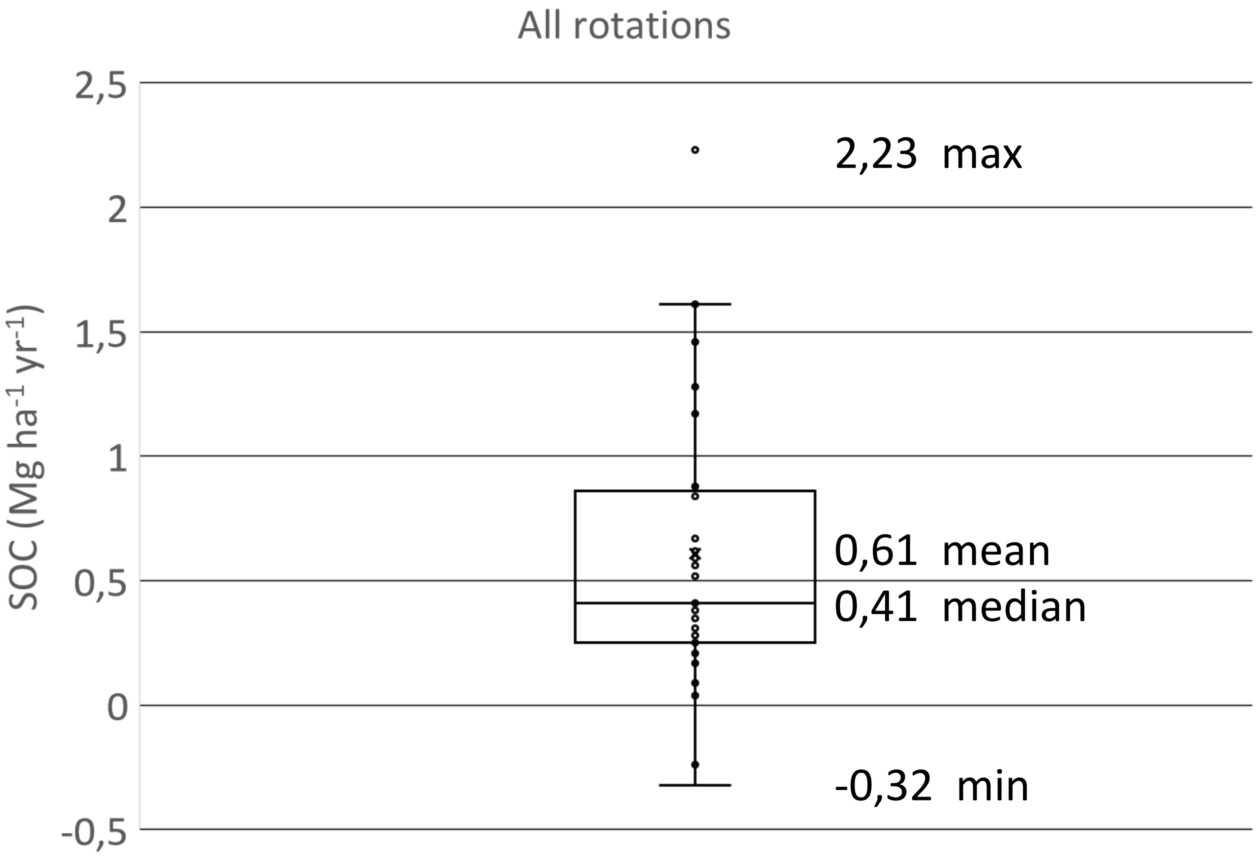
Integrated Crop-Livestock-Forestry and Agroforestry (+10.1 M ha)
Mitigation potential[2]: 72.1 M tons CO_2eq
Soil C sequestration potential*: -0.04 to 2.85 tons ha^{-1} yr^{-1} C

[2]Considering an emission/removal factor of 33.79 tons $CO_2eq/ha/yr$ for ICLF (Carvalho et al., 2010); and 3.79 tons $CO_2eq/ha/yr$ for AF
* Available literature

Brasil. Ministério da Agricultura, Pecuária e Abastecimento. Plano Setorial para Adaptação à Mudança do Clima e Baixa Emissão de Carbono na Agropecuária 2020-2030 : Plano Operacional / Ministério da Agricultura, Pecuária e Abastecimento. Secretaria de Inovação, Desenvolvimento Rural e Irrigação. – Brasília : Mapa/DEPROS, 2021. 133p.

Embrapa

Soil organic carbon accumulation rates from CT to NT system in crop production



Sagrilo et al. Soil Organic Matter as Affected by Green Manure at Brazilian Conditions. Dynamic Soil, Dynamic Plant (2011) 5:7-11. + all other cited articles

Soil organic carbon accumulation potential in crop-livestock int. (ICL)

Pasture | Soy | Fallow | Beans
1040 days | 128 | 178 | 79

Total days 1425 (3 years and 3 months)

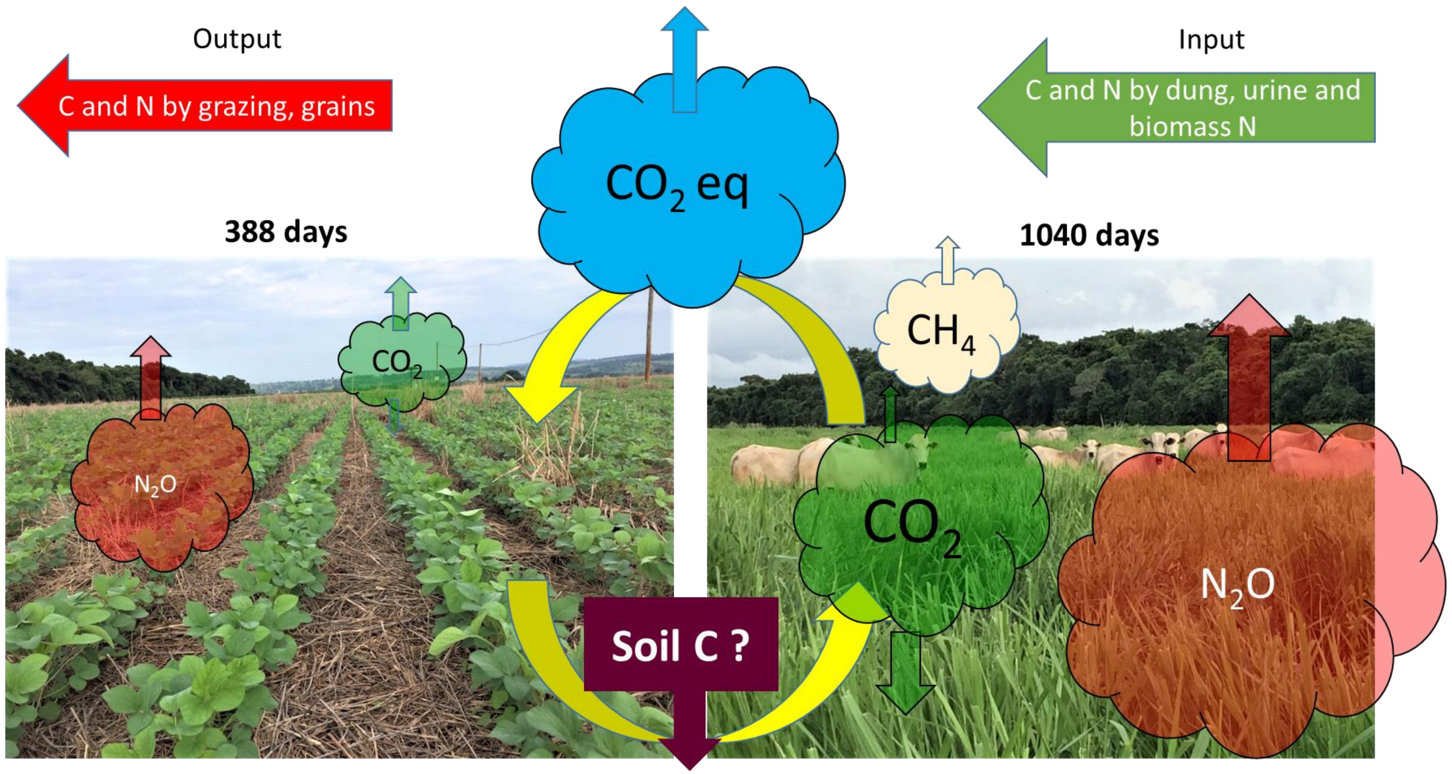
	Paddock 4	
Season Year	Summer	Winter
1990/91	Co. bean[†] CT[‡]	Fallow
1991/92	Corn CT	Fallow
1992/93	Corn CT	Fallow
1993/94	Soybean NT	Fallow
1994/95	Fallow	Co. bean CT
1995/96	Corn NT	Fallow
1996/97	Corn NT	Fallow
1997/98	Corn NT	Fallow
1998/99	Soybean NT	Fallow
1999/00	Corn NT	Fallow
2000/01	Corn+U (C)[§] NT	U (C)[¶]
2001/02	Soybean NT	Millet NT
2002/03	Corn+U (C) NT	U (C)
2003/04	Rice CT	Fallow
2004/05	Corn+U (P) NT	U (P)
2005/06	U (P)	U (P)
2006/07	U (P)	U (P)
2007/08	U (P)	U (P)
2008/09	U (P)	U (P)
2009/10	Corn+U (P) NT	U (P)
2010/11	U (P)	U (P)
2011/12	U (P)	U (P)
2012/13	U (P)	U (P)
2013/14	Soybean NT	Fallow
2014/15	Rice NT	Sorgh+U (P)[‡‡] NT
2015/16	Corn+U (P) NT	U (P)
2016/17	U (P)	U (P)
2017/18	U (P)	U (P)
2018/19	Soybean NT	Fallow
2019/20	Co. bean/ Rice+U (P) NT	U (P)
2020/21	U (P)	U (P)
2021/22	Co. bean/ Rice+U (P) NT	U (P)

Crop (and land use) rotation in a integrated crop-livestock (ICL) system

Case study

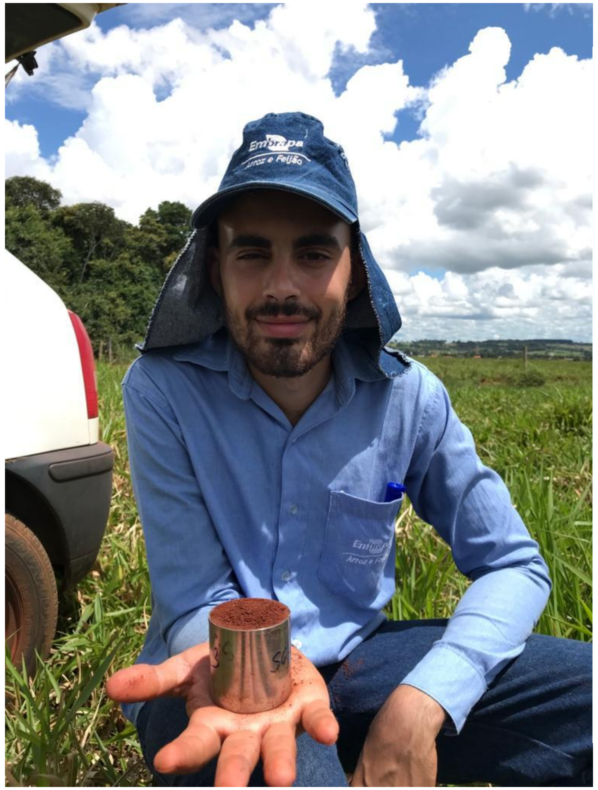
8 ha

Carbon balance of ICL



Components of ICL	Implementation	Harvest
Brachiaria grass (*Urochloa brizantha* cv Marandú)	10/11/2015	--------------
Soybean (*Glycine max* L. BRS 7755RR)	21/12/2018	27/04/2019
Fallow	28/04/2029	--------------
Common bean (*Phaseolus vulgaris* L. BRS FC 104)	23/10/2019	11/01/2020

Embrapa



Chemical properties and particle size distribution of the **Rhodic Ferralsol** (Typic Acrustox; Latossolo Vermelho acriférrico típico) at 0-10 cm under ICL and an adjacent forest in Santo Antônio de Goiás, Goiás State, Brazil

Area	pH H_2O	Ca	Mg	Al	H + Al	K	Clay	Silt	Sand
		----- mmol$_c$ dm^{-3} -----				mg dm^{-3}	----- g kg^{-1} -----		
Paddock 4	6.3	14.6	8.5	0.0	22.0	296.5	534	144	321
Forest	5.2	0.81	1.0	8.0	62.8	36.3	449	114	436

Embrapa

Li-Cor GHG-1 (LI-7550 e LI-7700)

Method

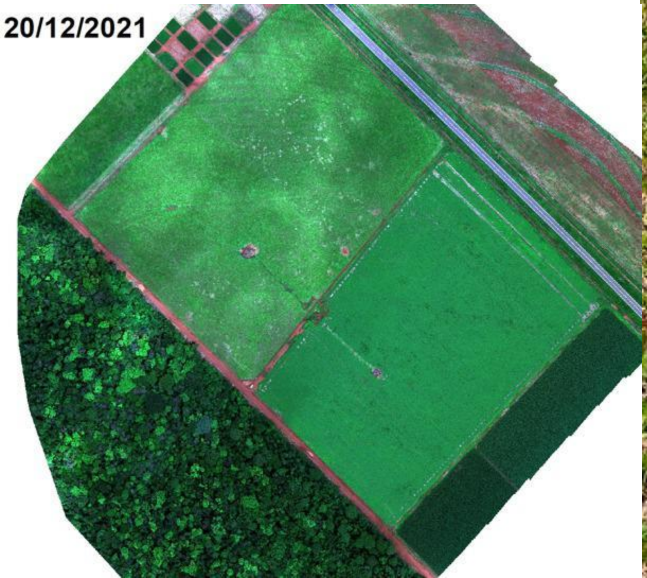
Eddy-covariance

NPP = GPP - R_{ECO}

Reichstein et al. (2005)

Lloyd & Taylor (1994)

20/12/2021

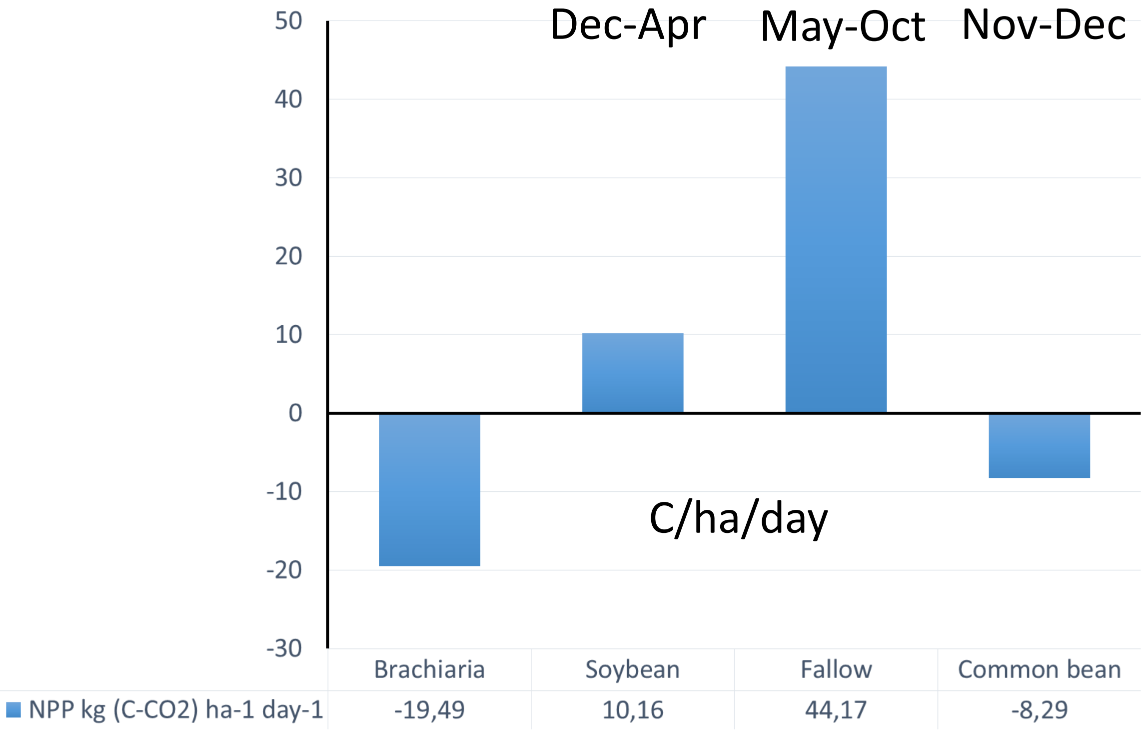


Unit (µmol m^{-2} s^{-1}) Net Primary Production (NPP), Gross Primary Production (GPP), Ecosystem Respiration (Reco) quantified with the eddy-covariance method, representing the measurement periods for each component of the ICL rotation.

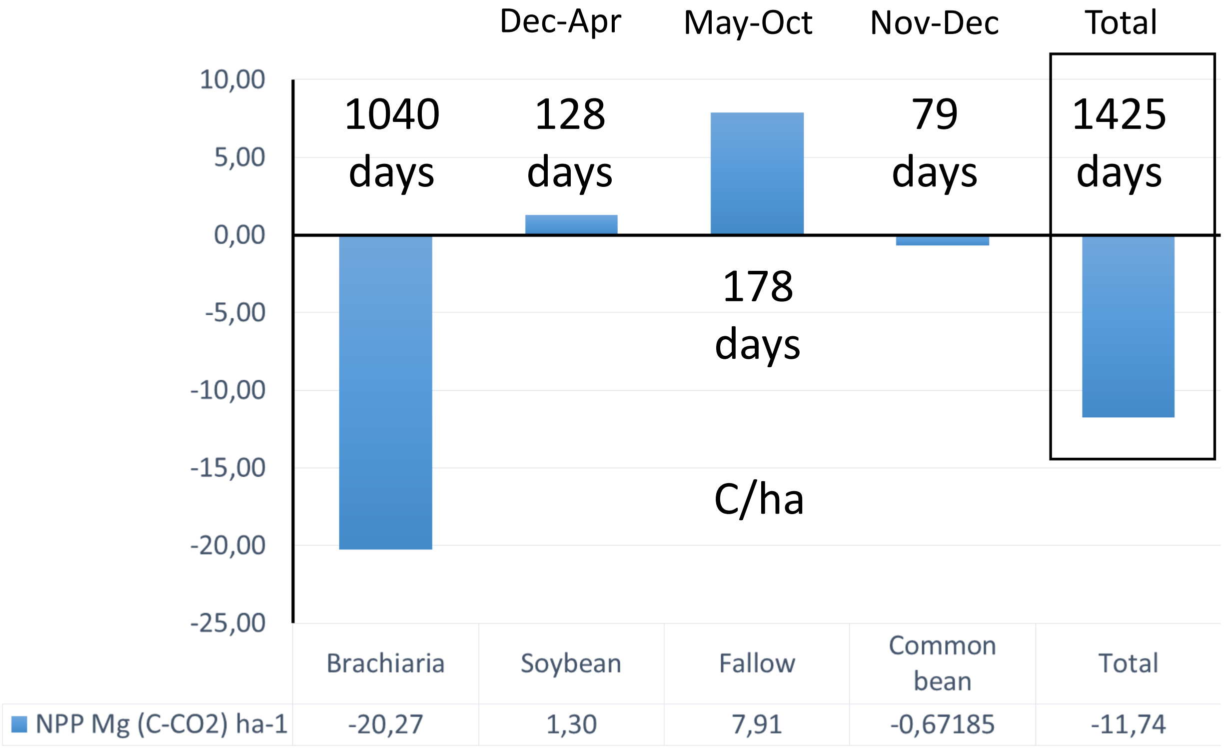
Results

Species	NPP	GPP	Reco
	CO_2 (µmol m^{-2} s^{-1})		
Brachiaria	-1,88 (±3,2)	-7,49 (±3,8)	6,96 (±2,2)
Soybean	0,98 (±1,9)	-6,24 (±2,7)	7,85 (±1,6)
Fallow	4,26 (±1,6)		4,26 (±1,6)
Common bean	-0,80 (±3,6)	-7,51 (±3,0)	7,84 (±1,2)

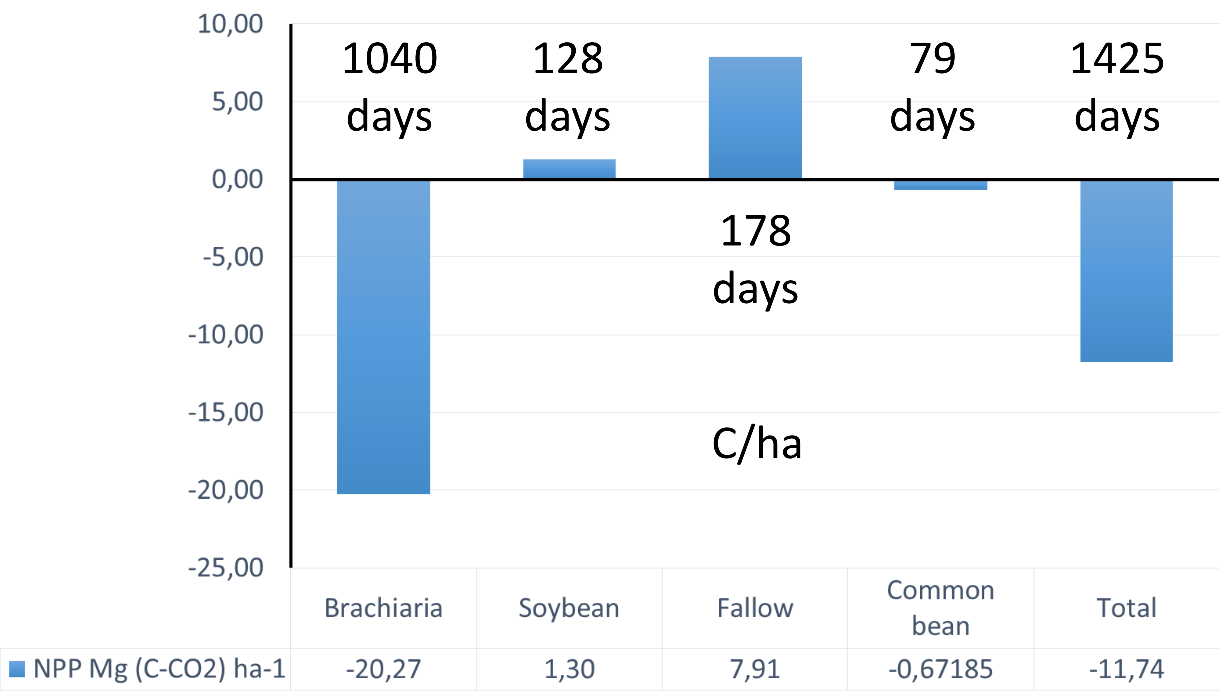
NPP: Net Primary Production; GPP: Gross Primary Production; Reco: Ecosystem respiration



Daily carbon ($C\text{-}CO_2$) fluxes in ICL in Santo Antônio de Goiás, GO



Carbon (C-CO2) fluxes in ICL components



Carbon (C-CO2) fluxes in ICL components in Santo Antônio de Goiás, GO

Results

Yearly C input into the system by NPP:
3 Mg ha^{-1} year^{-1}

Measured anual C accumulation rate:
~0.57 Mg ha^{-1} year^{-1} between 2010 and 2020

Estimated anual C accumulation rate:
0.6 – 0.9 Mg ha^{-1} year^{-1} between 2019 and 2039
(CQESTR; Oliveira et al., 2022 doi: 10.3389/fenvs.2022.826786)

19 to 30% of the anual NPP of this ICL is accumulated as SOC

Soil bulk density and soil organic carbon (SOC) content of each soil depth at Santo Antônio de Goiás, Goiás State, Brazil (Oliveira et al., 2022 doi: 10.3389/fenvs.2022.826786)

Soil depth	Year							Bulk density
	1970	1999	2007	2010	2013	2015	2020	
	Soil Organic Carbon (g kg^{-1})							(g/cm^{-3})
Paddock 4								
0-10 cm	70.68	19.00	23.59	28.25	32.40	32.37	31.60	1.34
10-30 cm	37.64	-	18.27	20.25	-	19.83	23.80	1.35

Conclusions – final remarks

- ✓ In tropical and subtropical agriculture crop-livestock integration is a possible way for enhancing soil C sequestration; brachiária grass has great potential for C input into the production system of crops
- ✓ Knowing the potential contribution of each component of ICLs helps designing the production system to achieve soil C accumulation; eliminate fallow, permanent living soil cover, enhancing C inputs
- ✓ Besides, increasing SOC contributes to better soil health, to the regeneration of soil functions; soil organic C is fundamental for building soil fertility, especially in soils of tropical and subtropical regions where soil minerals have very low CEC
- ✓ Soil C sequestration alone does not necessarily lead to C neutral systems, but contributes to lower C emissions
- ✓ Combining SOC sequestration with circularity measures potentially leads to further reduce GHG emissions

THANK YOU

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