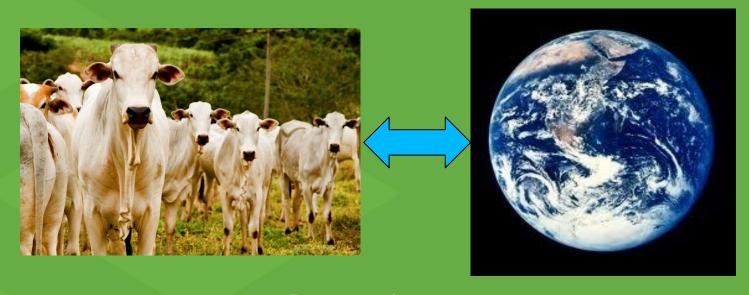
Modelling sustainable intensification in Brazilian agriculture





June 2016

Rafael Silva, SRUC and The University of Edinburgh **Supervisors:**

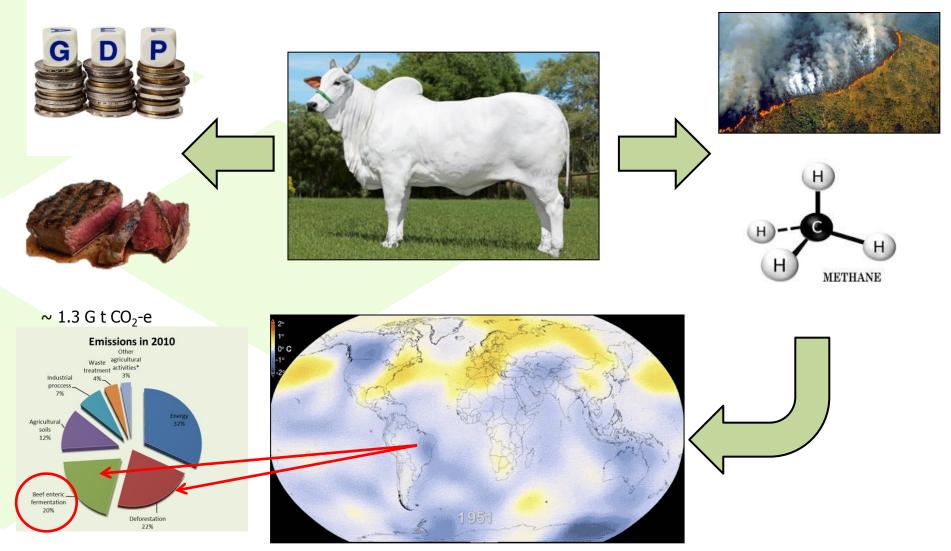
Dominic Moran (SRUC) Julian Hall (Edi Uni)

Luis Barioni (Embrapa)

Leading the way in Agriculture and Rural Research, Education and Consulting

Brazil's "Grand Challenge": the livestock-deforestation-climate Nexus (aka Sustainable Agricultural Intensification - SAI)





Sustainable Agricultural Intensification (SAI)

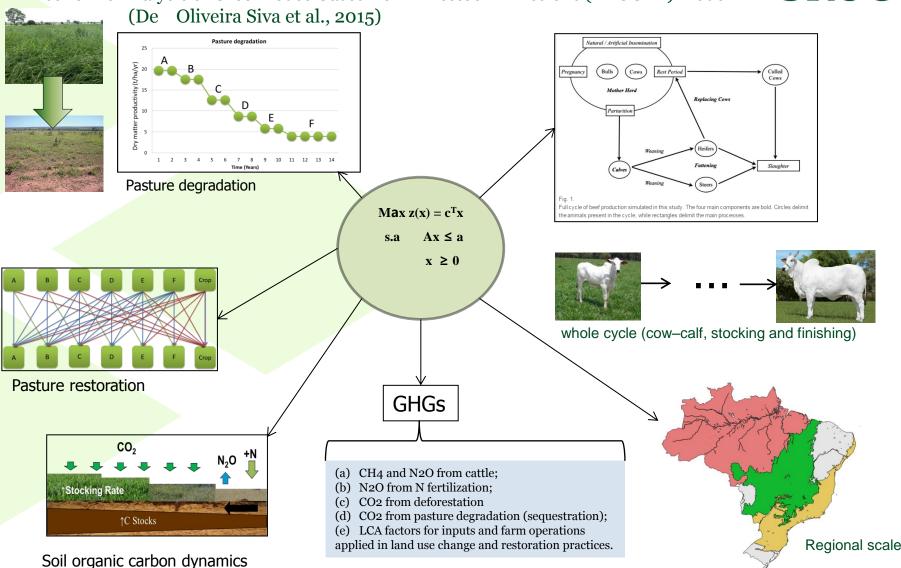


- A key premise is: increase food production from existing farmland in ways that put less pressure on the environment and that do not undermine our capacity to continue producing food in the future.
- Much conceptual literature (e.g., Garnett et. al, 2013; Godfray et al, 2014; Tunner, 2011; Loos et al., 2014), but hardly any convincing empirically-based modelling.

Modelling Sustainable Agricultural Intensification



Economic Analysis of Greenhouse Gases from Livestock Emissions (EAGGLE) model



Policy (hence research) questions

- 1) What are the most promising sustainable agricultura SRUC intensification (SAI) measures in Brazil?
- 2) What is their mitigation potential incl. from avoided deforestation?
- 3) What is their cost?
- 4) Is it possible to reduce deforestation while increasing production? How?
- 5) Which measures to adopt to meet GHG reduction targets? What levels of adoption?
- 6) What happens if we reduce beef consumption?

SAI measures identified in Brazil

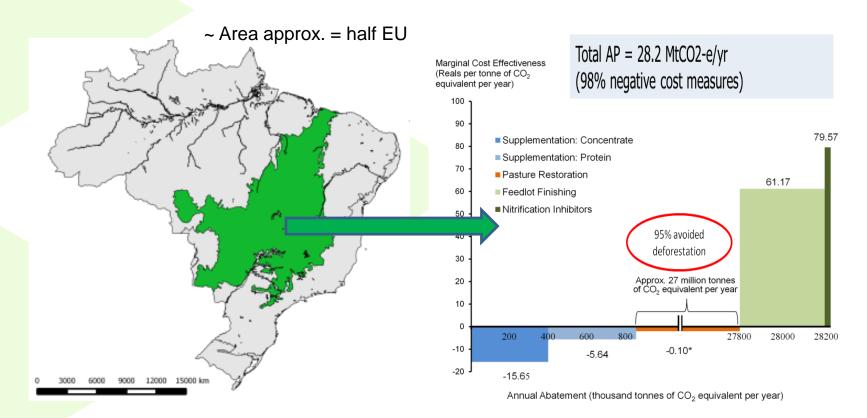


Mitigation Measure	Consists of:	Reduces emissions by:
Supplementation: Concentrates	Feeding cattle via grazing and a ration with a high energy content	Shorter animal life cycle by increasing weight gain
Supplementation: Protein	Feeding cattle via grazing and a ration with a high protein content	Shorter animal life cycle by increasing weight gain
Pasture Restoration	Improving pasture forage productivity by soil chemical and mechanical treatment	Avoiding the need for additional pasture land and increasing organic carbon sequestration
Feedlot Finishing	When cattle weight is around 80% of the slaughter weight it is removed from pasture and grass to feedlot on a diet with ration of balanced protein and energy content	Shorter animal life cycle by increasing weight gain
Nitrification Inhibitors	Applying nitrogen fertilizers coupled with nitrification inhibitors	Reduced conversion of nitrogen to the GHG nitrous oxide (nitrification)

Research questions: some answers...



- 1) What is the mitigation potential?
- 2) What is the cost?



De Oliveira Silva, R. et al. (2015) Developing a nationally appropriate mitigation measure from the greenhouse gas GHG abatement potential from livestock production in the Brazilian Cerrado. *Agricultural Systems* 140, 48–55.

COP21 - Brazil's Intended Determined National Contribution (INDC) as an example of sustainable agricultural intensification



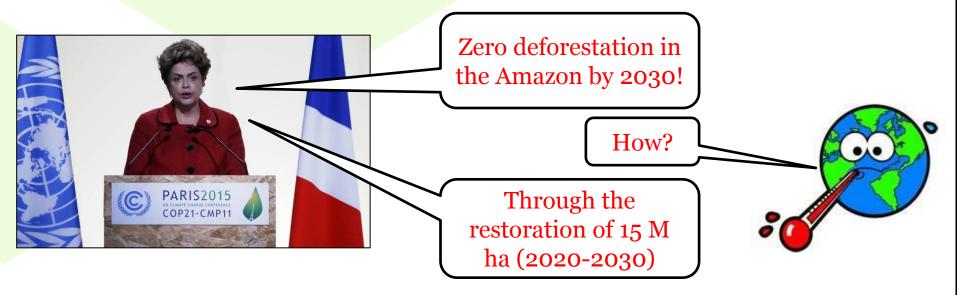


COP21, also known as the 2015 Paris Climate Conference \overline{SRUC}

To achieve a legally binding and universal agreement on climate, with the aim of keeping global warming below 2°C.

INDCs: Mitigation targets and actions to reduce GHG emissions by 2030 (2020-2030)

reduction of GHGs by 37% below 2005 levels by 2025 and 43% by 2030.



Brazil's Intended Determined National Contribution as an example of sustainable agricultural intensification



But where did the 15 Mha come from?

$$R = \frac{\left(\frac{\alpha_D}{\alpha_C} - 1\right) N_i - \lambda_d \Delta A}{\lambda_r - \lambda_d}$$



How is restoration defined? (EAGGLE model)

Table 1: Description of pasture type formation (level of technology) and productivity (dry matter per area).

Pasture	Pasture formation (short description) ¹	Cost (US\$ 2012 per hectare)	Productivity (tonnes of dry matter per hectare) ¹	Soil carbon equilibrium (tonnes per hectare)
А	mowing+dolomitic limestone + single phosphate + brachiaria seeds + micronutrients + 90kg of N	767	19.6	84.3
В	mowing+dolomitic limestone + single phosphate + brachiaria seeds + micronutrients + 45kg of N	617.1	17.6	82.7
С	mowing+dolomitic limestone + single phosphate + brachiaria seeds	367.7	12.6	62.3
D	mowing +dolomitic limestone + single phosphate	137.1	8.7	45.2
E	Mowing	42.5	5.8	32.4
F	No intervention	0	3.9	26.1

Results:



- 4) Is it possible to reduce deforestation while increasing production? how?
- 5) Which measure to adopt to meet GHG reduction targets? What level of adoption?

Table 2: Area and demand (main models inputs) and results comparing DCRA and EAGGLE models.

		Main mo	odel inputs ¹		Result	
	Area 2020	Area 2030	Demand 2020	Demand 2030	Recovered area (M ha) from	2020-
Model	(Mha)	(Mha)	(Mt)	(Mt)	2030	
DCRA	157.5	146.5	11.43	13.15		15.2
EAGGLE	157.5	146.5	11.43	13.15		18.2
		•	•			

The mitigation potential of the zero deforestation target by 2030:

630 Mt CO₂-e

But other authors have suggested managing demand ...







Importance of food-demand management for climate mitigation

Bojana Bajželj¹*, Keith S. Richards², Julian M. Allwood¹, Pete Smith³, John S. Dennis⁴, Elizabeth Curmi¹ and Christopher A. Gilligan⁵

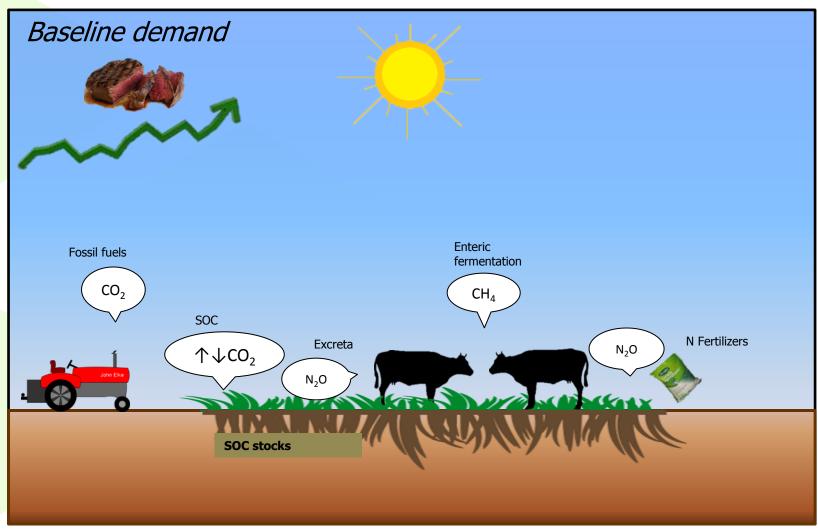
Recent studies show that current trends in yield improvement will not be sufficient to meet projected global food demand in 2050, and suggest that a further expansion of agricultural area will be required. However, agriculture is the main driver of losses of biodiversity and a major contributor to climate change and pollution, and so further expansion is undesirable. The usual proposed alternative—intensification with increased resource use—also has negative effects. It is therefore imperative to find ways to achieve global food security without expanding crop or pastureland and without increasing greenhouse gas emissions. Some authors have emphasized a role for sustainable intensification in closing global 'yield gaps' between the currently realized and potentially achievable yields. However, in this paper we use a transparent, data-driven model, to show that even if yield gaps are closed, the projected demand will drive further agricultural expansion. There are, however, options for reduction on the demand side that are rarely considered. In the second part of this paper we quantify the potential for demand-side mitigation options, and show that improved diets and decreases in food waste are essential to deliver emissions reductions, and to provide global food security in 2050.

Others: Fiala et al. (2008), Hedenus et al. (2013), Popp et al, (2010)

But they assume fixed emissions per kg of meat..

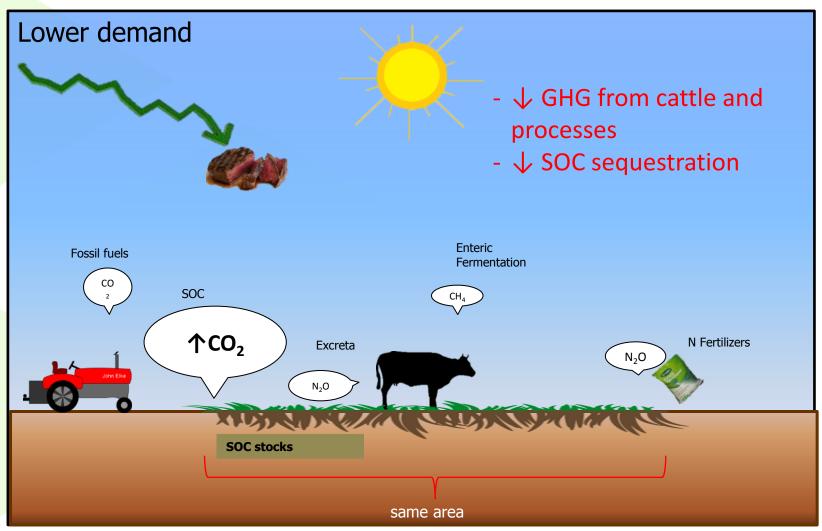
Decoupled Livestock-Deforestation





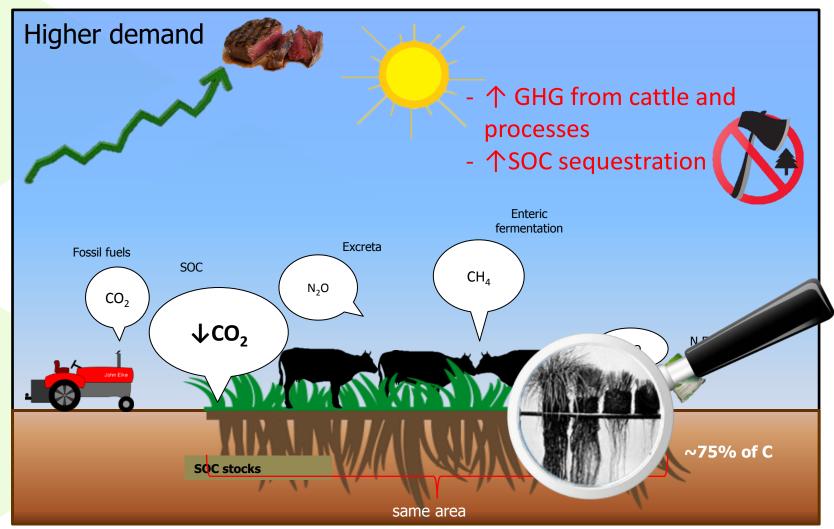
Decoupled Livestock-Deforestation





Decoupled Livestock-Deforestation



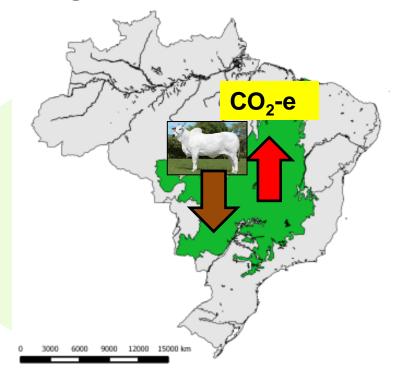


Results:

SRUC

7) What happens if we reduce beef consumption?

"Grass is greener with higher demand"



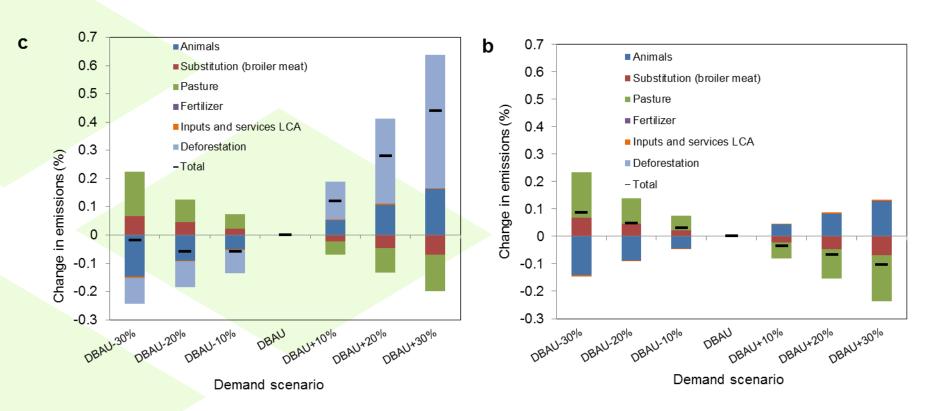
Demand 30% lower by 2030 → net GHG 10% higher

Demand 30% higher by 2030 → net GHG 10 % lower

Results:



7) What happens if we reduce beef consumption?



Percentage changes in accumulated emissions (2006-2030) as a function of demand scenarios under CLD and DLD.

Conclusions



- In the Brazilian *Cerrado*, reduced consumption could actually remove the incentive for grassland improvement and therefore lead to higher emissions.

- Shifting to less meat-dependent diets would help curb climate change, but it is important to understand the nature of different production systems before concluding that reduced consumption will have the same effects in all systems.

Chapters





Minderung von Treibhausgasen durch nachhaltige Intensivierung der Tierhaltung im brasilianischen Cerrado

Rafael de Oliveira Silva, Luis Gustavo Barioni and Dominic Moran

central to Brazil's National Plan on Cirrate Change. At the Conference of the Parties to the United Nations Framework Convention on Climate Change in 2009 (UNFCOC COP 15), Brazil proposed Nationally Appropriate Mitigation Actions NAMAs) as part of its commitment. For the period 2010-20, the NAMAs establish targets for the reduction of deforestation in the Amazon by 80 per cers, and by 40 per cent in the ional pressure on producers as management (or intensification)

Global demand for livestock

2050 (Gerber et al., 2013). This is

ciency in existing ruminant pro-tion of land used for food and

rvices, including mitigation

Tropical regions are implica

(Cerber et al., 2013; Soussana et

The Cerrado (central Brazilian savannah) is a key livestock production area and the adoption of usture restoration (recovery of degraded pastures by chemical and schanical treatment), and integrated crop-livestock-forestry systems (aggregation of different production systems in the same property, such as grain, timber, meat, milk and energy) are also targeted in order to reduce greenhouse gas (GHG) ons. Because such measures increase productivity (output per hectare), they avoid the need for p://dx.doi.org/10.1016/j.agsy.2015.06 88-5213/40 2015 Elsevier Ltd. All right more land to increase production Due to the land-saving effect of these restock-related measures, Brazil expects to reduce net emissions by between 101 and 126 million tonnes (CO₂ eq.) by 2020, compared to baseline projections (i.e. assuming a

ess as usual scenario). This

La remise en état des terres dégradées offre l'opportunité la plus grande de réduire les émissions de gaz à effet de serre dans le Cerrado.

agricultural contribution. The NAMA proposal is enacted as part of the ambitious ABC (Agricultura de Baixo Carbono - Low Carbon Agriculture) programme, which offers low interest loans to farmers adopting mitigation measures. ABC has identified specific mitigation or abatement measur (Table 1). To date there has been no analysis to assess the costeffectiveness of these measures relative to other ways of reducing

over 9 million tonnes per year it accounted for roughly 15 per cent of global production in 2012-13 (FAO, 2014). Brazilian production is predominantly pasture-based on a grassland area of approximately 170 million hectares (IBGE, 2014), mostly with a humid or sub-humid tropical climate. But this production can entail significant external costs i.e. costs borne by wider society such as environmental impacts. To meet increasing domestic and export demand, the government recogn the need to foster methods for sustainable agricultural intensification (SI). This implie increasing resource productivity. while minimising impacts related to conversion of biodiversity-rich habitats to pasture and the

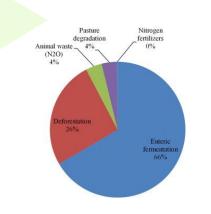
Brazil is the world's second largest

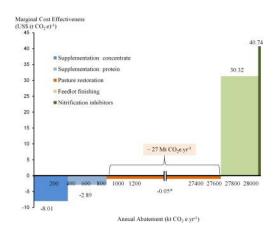
beef producer. With an output of

able 1: The ABC plan: Brazil's po	ril's policy to develop a low carbon emission Mitigation potential		
griculture Measure	Commitment (area increase/use)	(million tonnes of CO ₂ eq.)	
Pasture restoration Croplivestock-forest integration Notifings system Biological Nirogen (N) fixation Reforestation Treatment of animal waste	15 million bectares (ha) 4 million ha 8 million ha 5.5 million ha 3 million ha 4.4 million cubic metres	83 to 104 18 to 22 16 to 20 10 - 6.9	
CHARGE MOZZET (2011).			

De Oliveira Silva et al. **Developing a nationally appropriate** mitigation measure from the greenhouse gas GHG abatement potential from livestock production in the Brazilian Cerrado. Agric. Syst. 140, 48-55.

De Oliveira Silva, R., Barioni, L.G., Moran, D., 2015b. **Greenhouse Gas Mitigation through Sustainable** Intensification of Livestock Production in the Brazilian Cerrado. EuroChoices 14, 28–34.





would account for 61 per cent of the 2015 Agricultural Economics Society and European Association of Agricultural Economicts (EAAS) otal reduction and 73 per cent of the

Chapters





climate change





Nature Climate Change May 2016

Increasing beef production could lower greenhouse gas emissions in Brazil if decoupled from deforestation

R. de Oliveira Silva¹²⁴, L. G. Barioni², J. A. J. Hall³, M. Folegatti Matsuura⁴, T. Zanett Albertini⁵,

F. A. Fernandes⁶ and D. Moran²

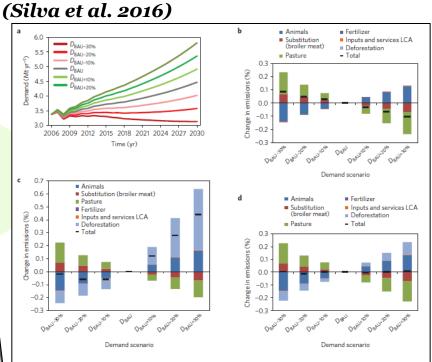
contributes to sustainable interestriction in Communication of the Commu

provisions other valuable ecosystem services.⁴ A counter signament suggests that grass fied bed systems have significantly lower engagest that grass fied bed systems have significantly lower engages by the province of th

GIRCL animas emissions supersistent deforestation, and life-cycle sassessment (LCA) data covering inputs and farm operations to maintain and recover pasture, and crop production, the latter to maintain and recover pasture, and crop production, the latter to maintain and recover pasture, and crop production.

*School of Manhamatex, The University of Edwardy, Mayded Road, Edwardy Elifo 312, UK, *Research Division, 2021.*C, West Mans Stool, Technology State Company, Agriculture Company, CEP (1930) 586. Company, Sept. May Company, CEP (1930) 500.
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Increasing beef production could lower greenhouse gas emissions in Brazil if decoupled from deforestation



mand scenarios and sensitivity analysis. a, Cerrado baseline demand (DBAU) and varied demand projections that correspond to per 2030 in relation to DBAU. b-d, Percentage changes in accumulated emissions (2006-2030) as a function of demand scenarios under , the CLD scenario (c), and an intermediate scenario with k=0.1 (d). The analysis assumes that beef consumption is substituted by b lementary Table 5) and accounts for the net change in production emissions arising from this substitution.

Chapters: proposed papers



- Brazil's Intended Determined National Contribution (INDC) as an example of sustainable agricultural intensification. (PNAS)

- Optimizing pasture restoration for sustainable beef production systems in Brazil. (American Journal of Agricultural Economics)



Thanks!

Acknowledgements:

Brazilian government for the PhD scholarship through the Science Without Borders Program (Ciência Sem Fronteiras).





Deforestation and Demand



Decoupled Livestock-Deforestation (DLD) scenario:

The same deforestation projections irrespective of consumption levels.

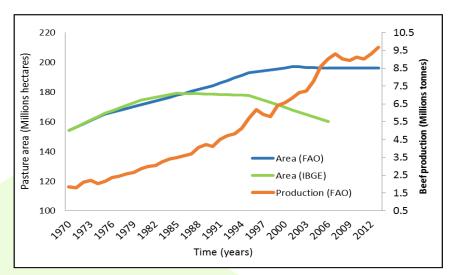
Coupled Livestock-Deforestation (CLD) scenario:

Deforestation projections are sensitive to variations in beef demand.

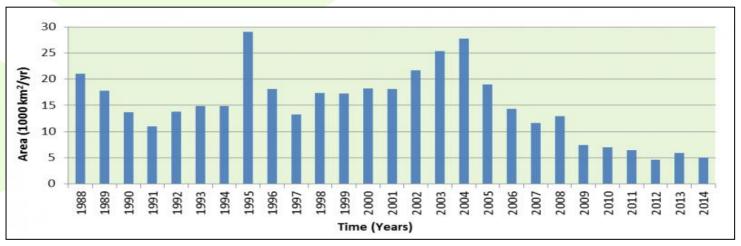


But is it feasible? What does empirical data show?





Pasture area and production estimates (FAO, IBGE).



Source: PRODES (INPE)

Cerrado: The Brazilian savannah

SRUC

Responds for at least 34% of national beef production

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Fig. 1: Brazilian Central Cerrado (green)

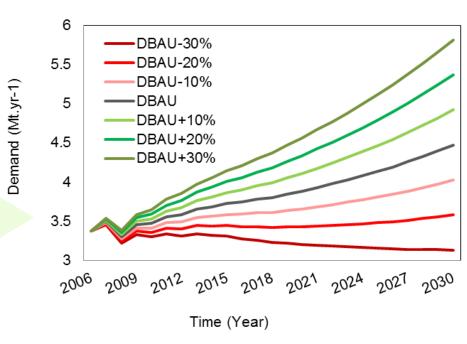
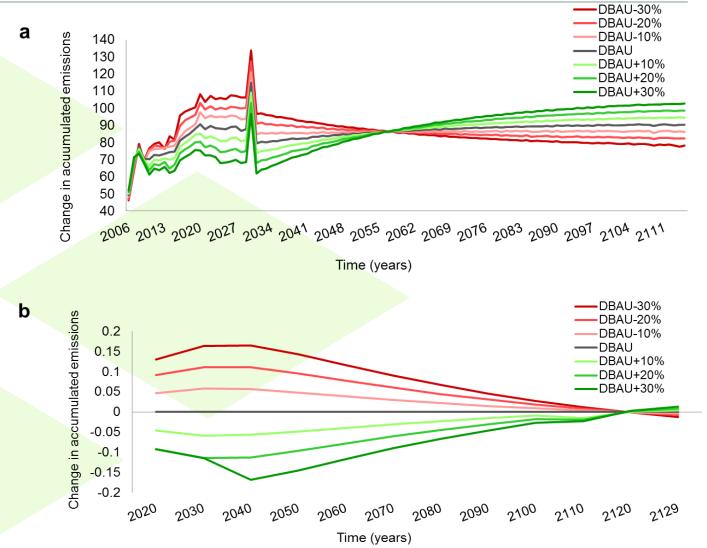


Fig.2: Cerrado baseline demand (DBAU) and varied demand projections that correspond to percentage variation by 2030 in relation to DBAU.

But soil organic carbon saturates ...

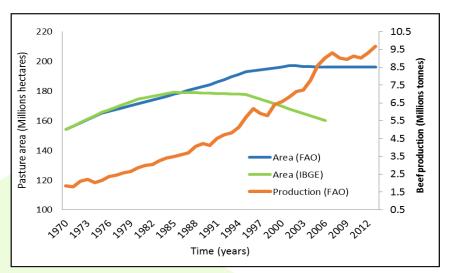




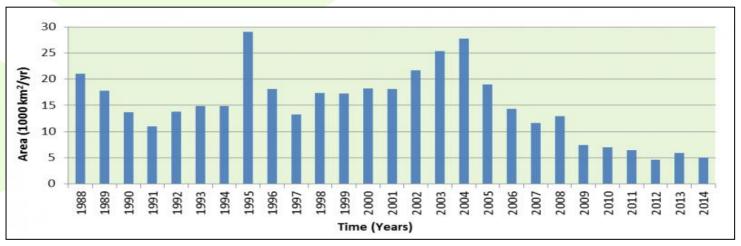
Long term GHG emissions analysis for the demand scenarios. (A) annual net GHG emissions and (B) percentage changes in accumulated GHGs.

But is it feasible? What does empirical data show?





Pasture area and production estimates (FAO, IBGE).



Source: PRODES (INPE)