Modelling sustainable intensification in Brazilian agriculture

June 2016

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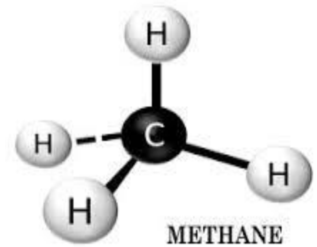
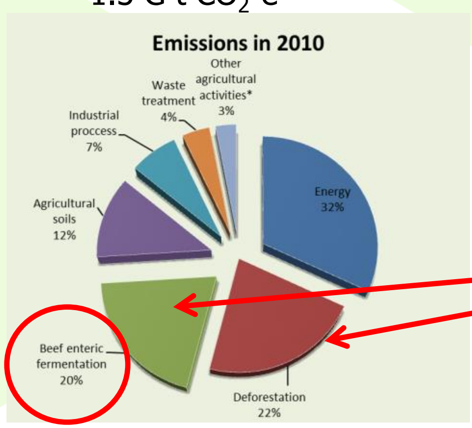
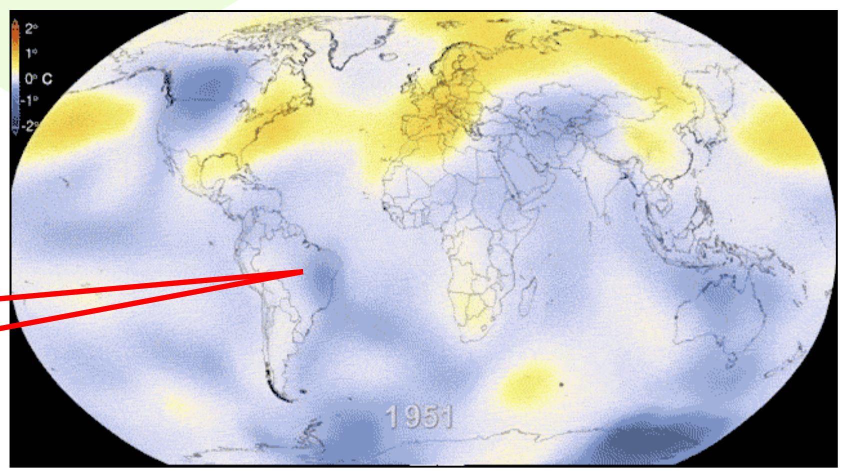
Leading the way in Agriculture and Rural Research, Education and Consulting

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



~ 1.3 G t CO_2-e





Sustainable Agricultural Intensification (SAI)

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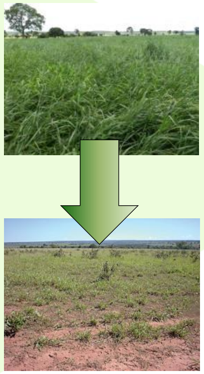
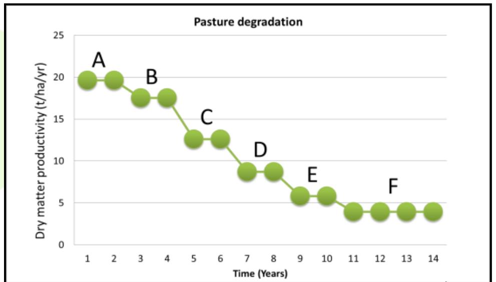
- A key premise is : increase food production from existing farmland in ways that put less pressure on the environment and that do not undermine our capacity to continue producing food in the future.

- 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 (De Oliveira Siva et al., 2015)





Pasture degradation

$$\text{Max } z(x) = c^T x$$
$$\text{s.a} \quad Ax \leq a$$
$$x \geq 0$$

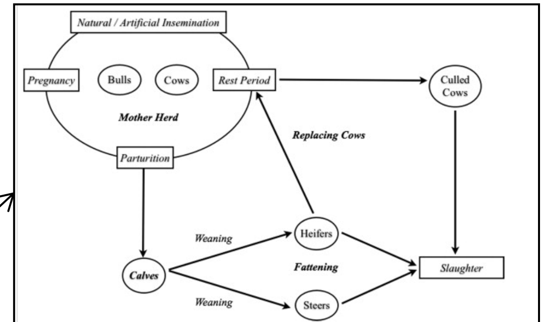
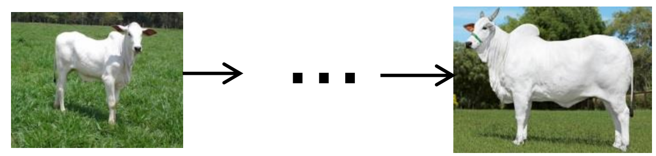
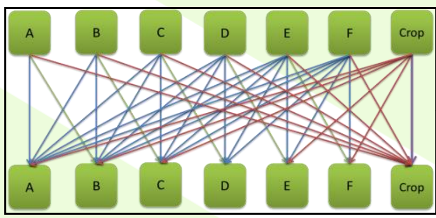


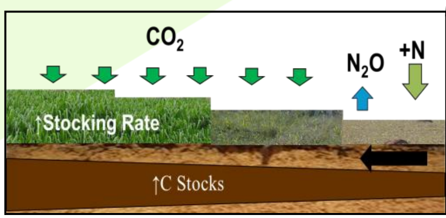
Fig. 1.
Full cycle of beef production simulated in this study. The four main components are bold. Circles delimit the animals present in the cycle, while rectangles delimit the main processes.



whole cycle (cow–calf, stocking and finishing)



Pasture restoration



Soil organic carbon dynamics

GHGs

(a) CH4 and N2O from cattle;
(b) N2O from N fertilization;
(c) CO2 from deforestation
(d) CO2 from pasture degradation (sequestration);
(e) LCA factors for inputs and farm operations applied in land use change and restoration practices.

Regional scale

Policy (hence research) questions

1) What are the most promising sustainable agricultural 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?

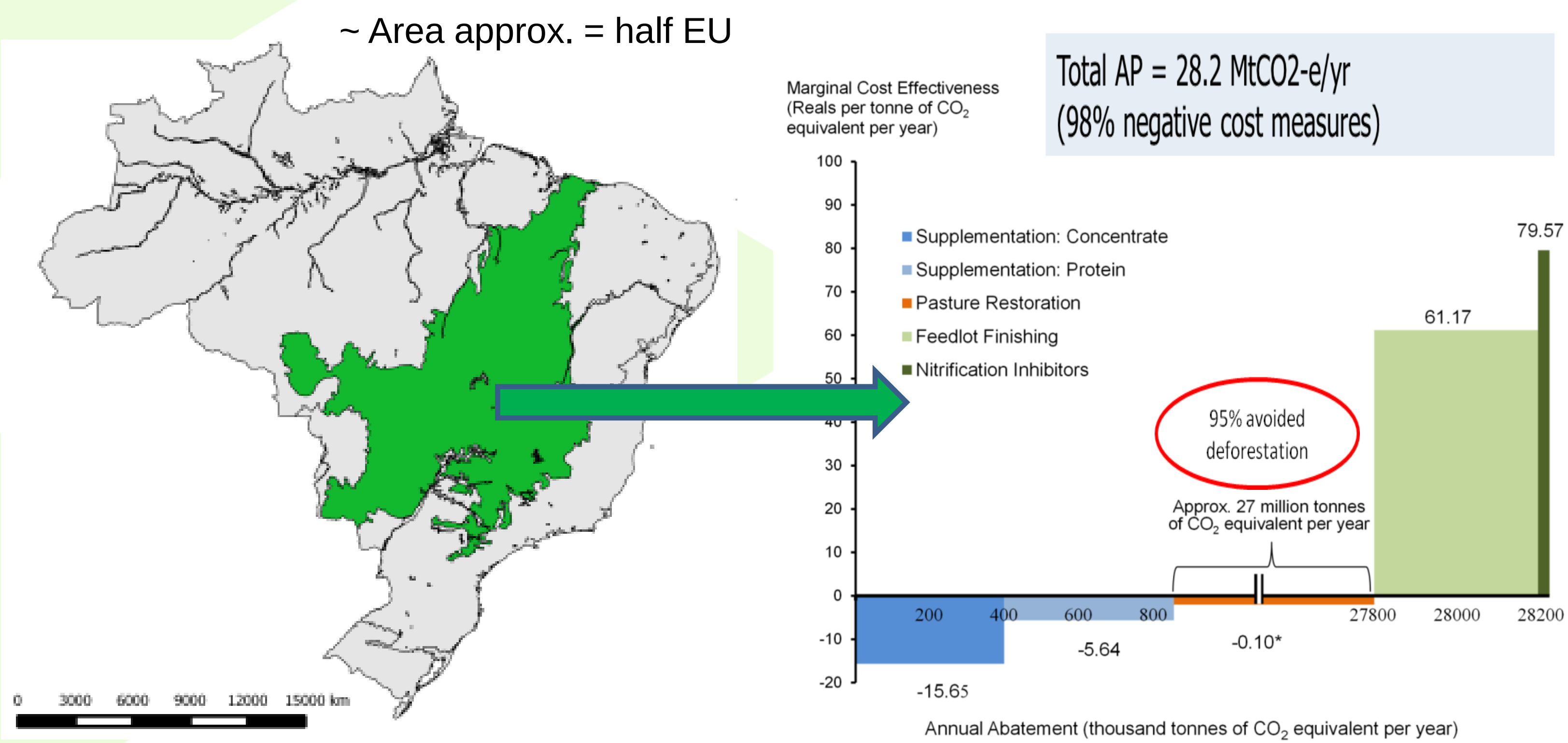
6) What happens if we reduce beef consumption?

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

SRUC

COP21 · CMP11
PARIS 2015
UN CLIMATE CHANGE CONFERENCE

COP21, also known as the 2015 Paris Climate Conference

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.

Zero deforestation in the Amazon by 2030!

How?

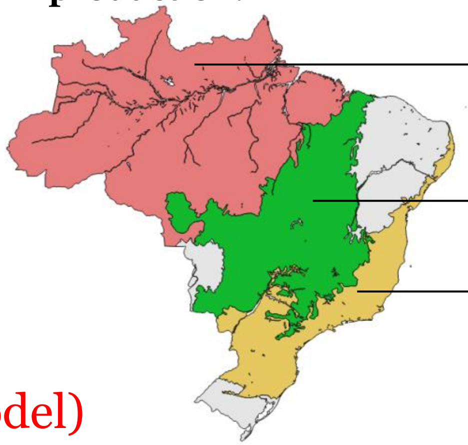
Through the restoration of 15 M ha (2020-2030)

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

But where did the 15 Mha come from?

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

90% of national beef production:



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)
A	mowing+dolomitic limestone + single phosphate + brachiaria seeds + micronutrients + 90kg of N	767	19.6	84.3
B	mowing+dolomitic limestone + single phosphate + brachiaria seeds + micronutrients + 45kg of N	617.1	17.6	82.7
C	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 model inputs[1]				Result
Model	Area 2020 (Mha)	Area 2030 (Mha)	Demand 2020 (Mt)	Demand 2030 (Mt)	Recovered area (M ha) from 2020-2030
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 CO_2-e

But other authors have suggested managing demand …

nature climate change
ARTICLES
PUBLISHED ONLINE: 31 AUGUST 2014 | DOI: 10.1038/NCLIMATE2353

Importance of food-demand management for climate mitigation

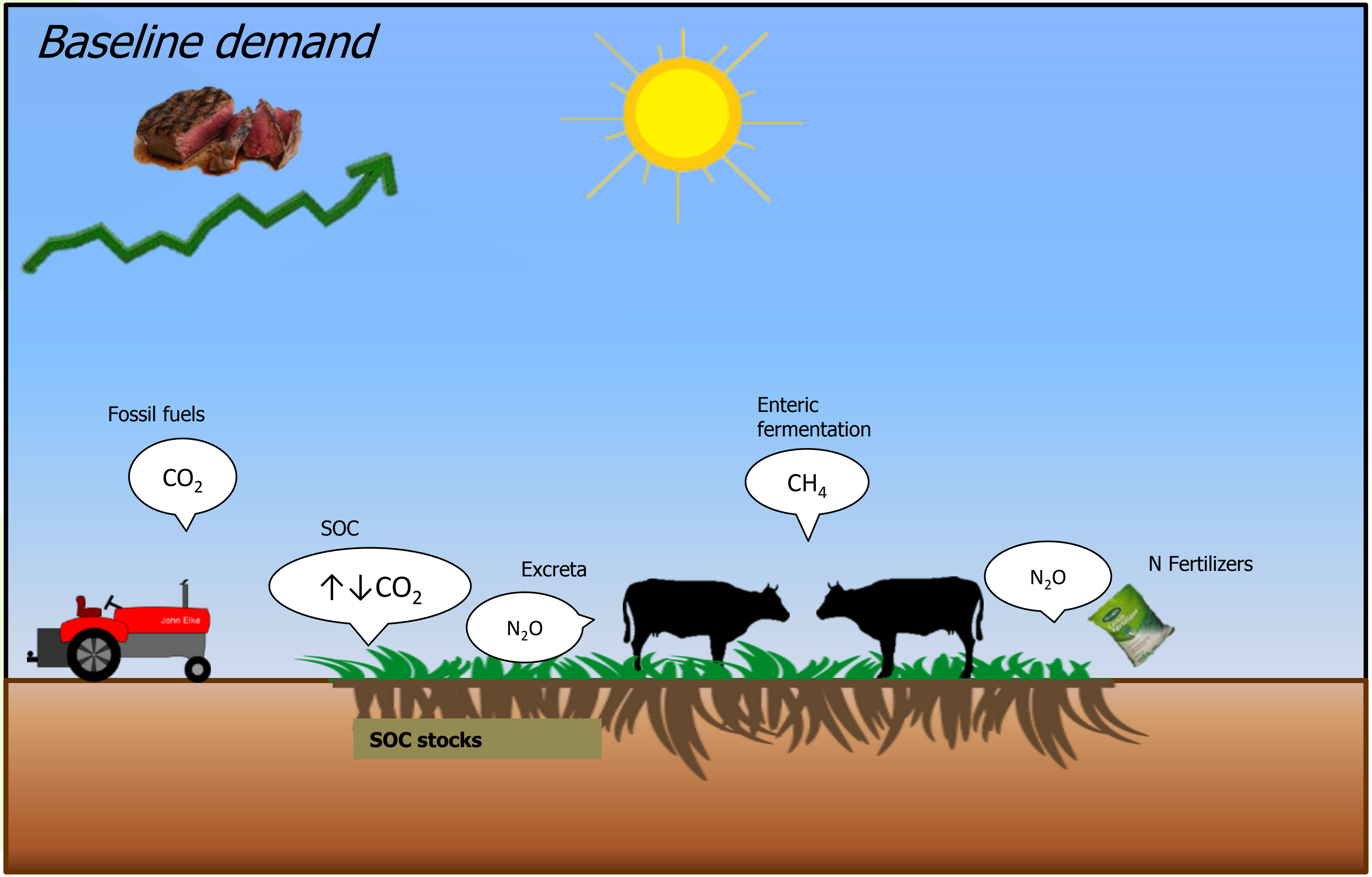
Bojana Bajželj[1]*, Keith S. Richards[2], Julian M. Allwood[1], Pete Smith[3], John S. Dennis[4], Elizabeth Curmi[1] and Christopher A. Gilligan[5]

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.

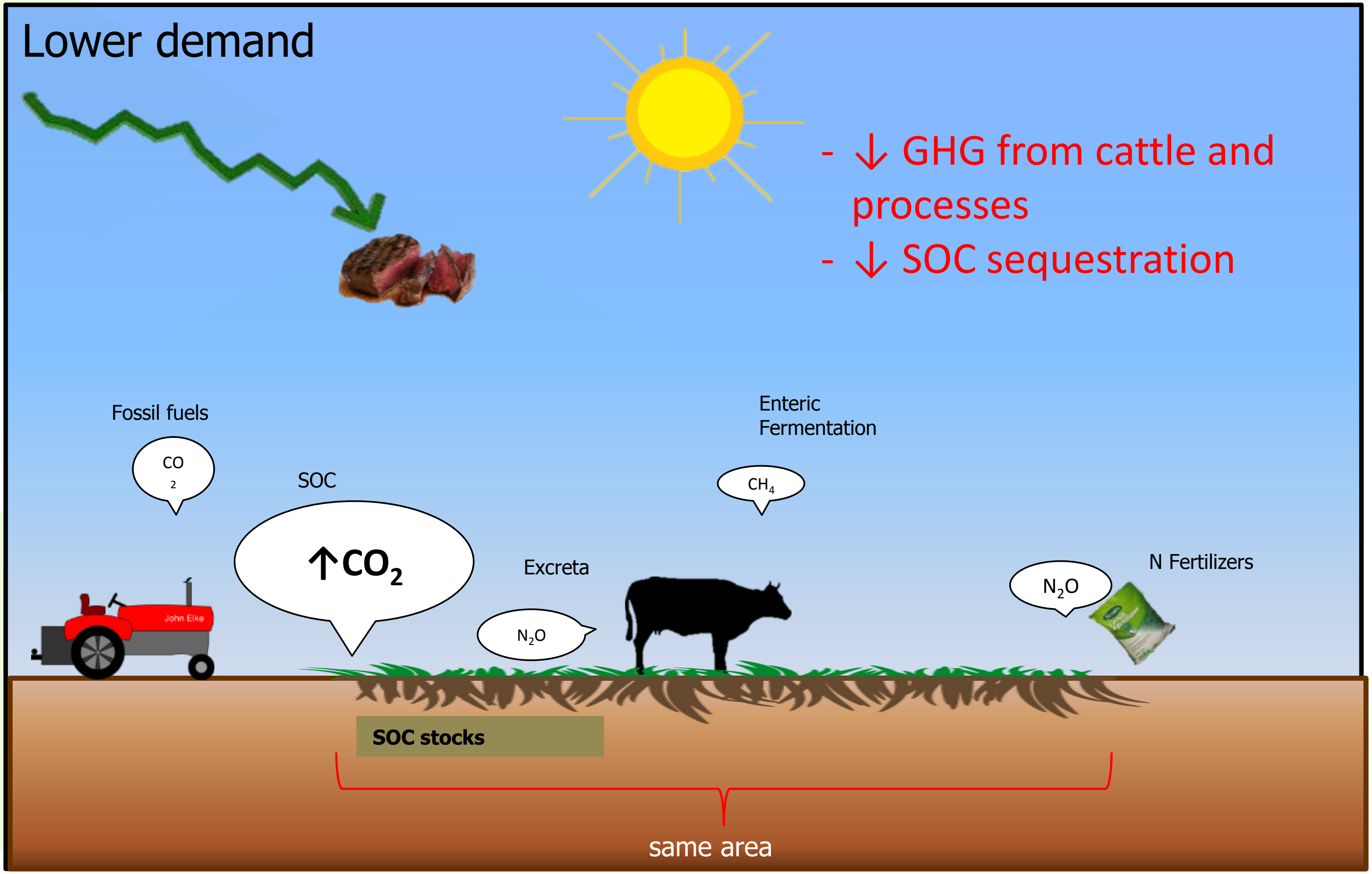
Others: Fiala et al. (2008), Hedenus et al. (2013), Popp et al, (2010)

But they assume fixed emissions per kg of meat..

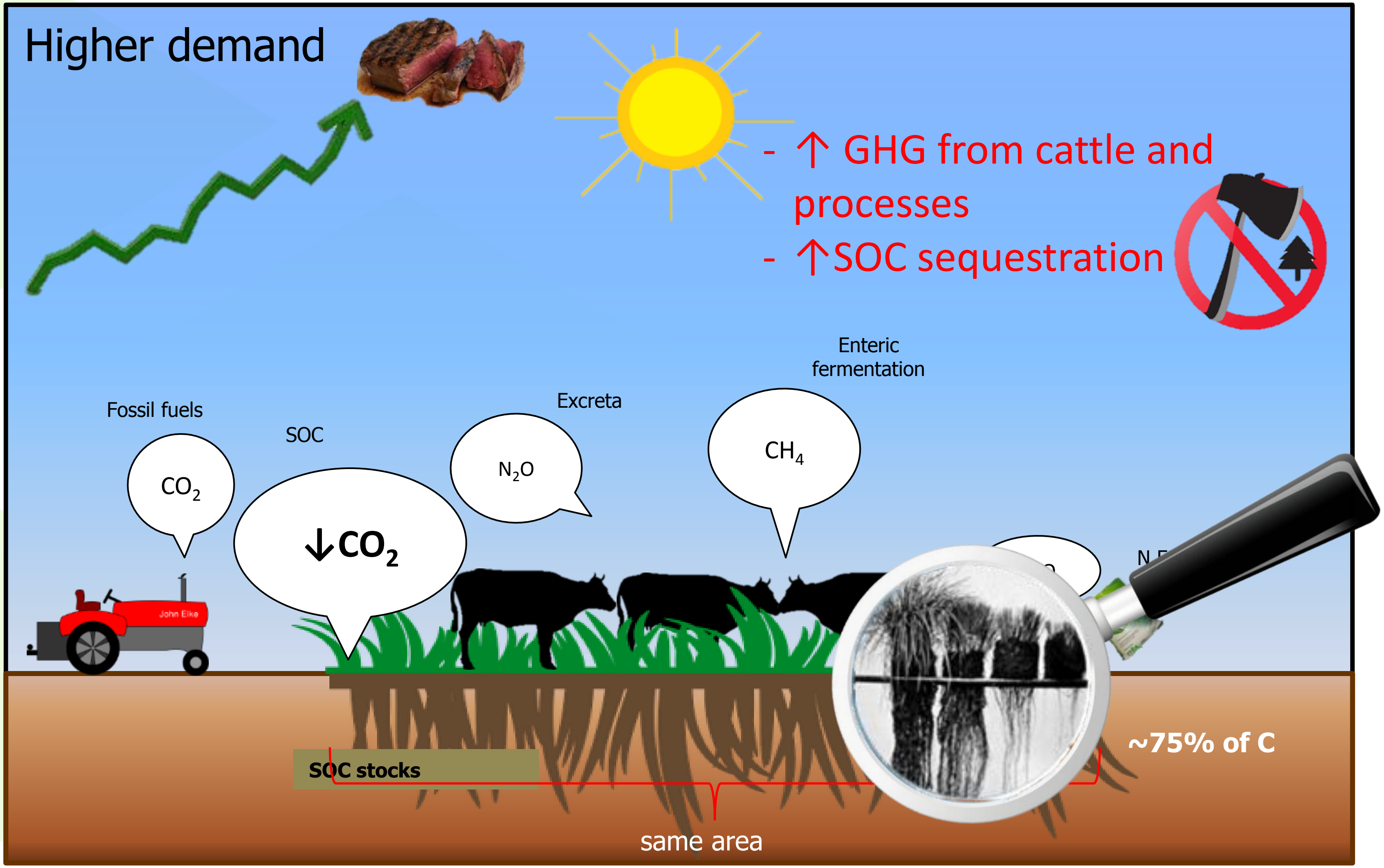
Decoupled Livestock-Deforestation



Decoupled Livestock-Deforestation



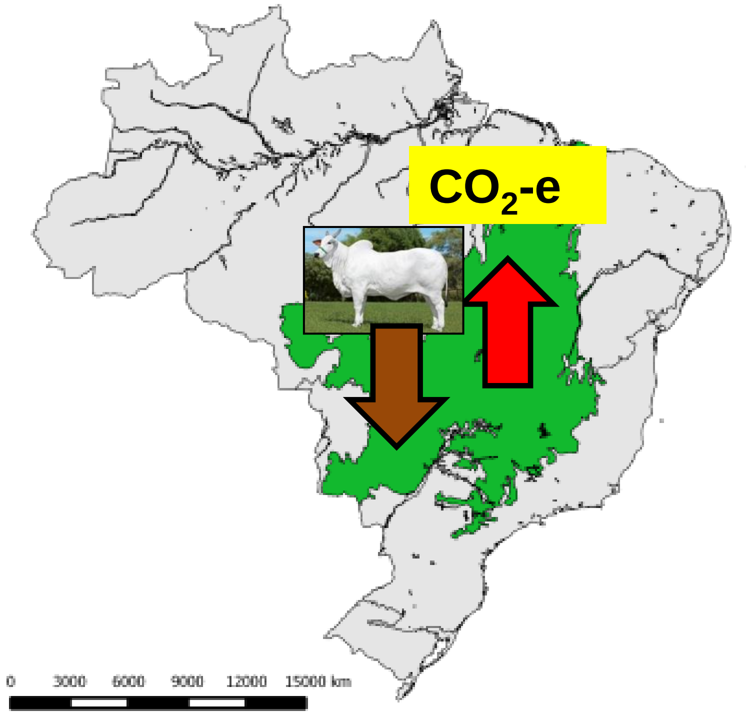
Decoupled Livestock-Deforestation



Results:

7) What happens if we reduce beef consumption?

“Grass is greener with higher demand”



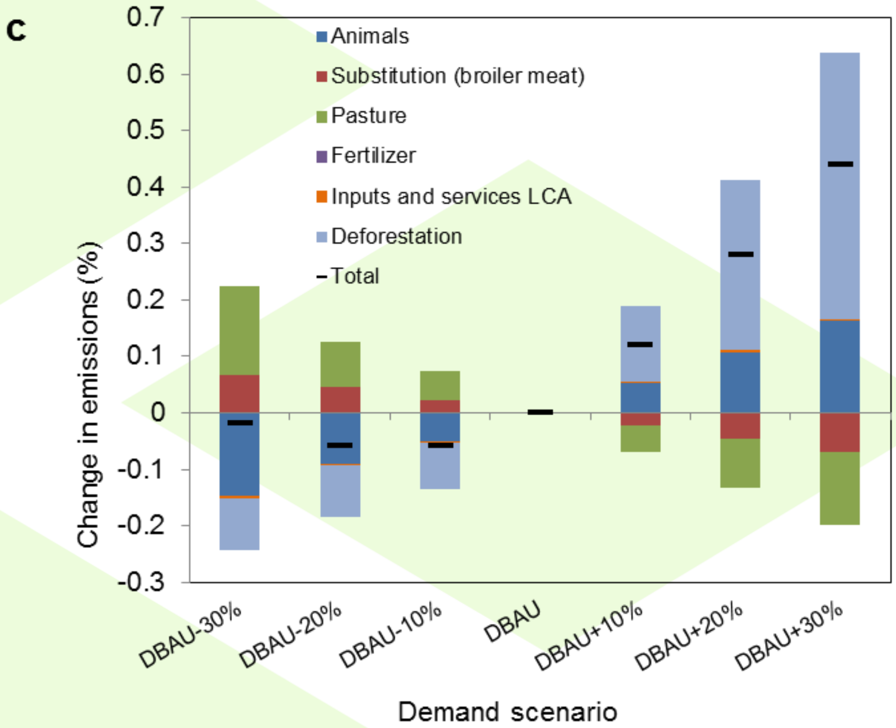
Demand 30% lower by 2030 → net GHG 10% higher

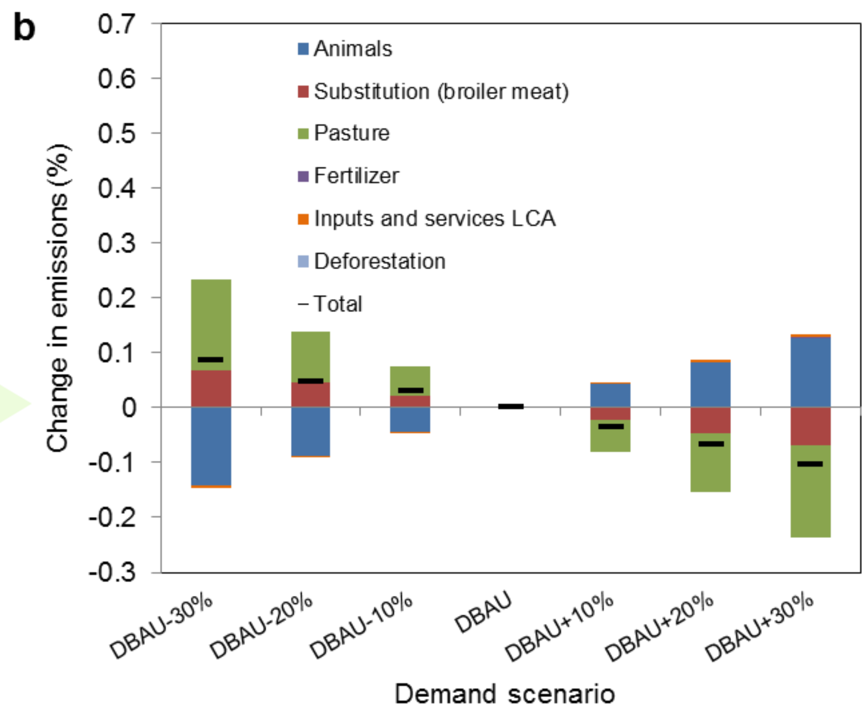
Demand 30% higher by 2030 → net GHG 10 % lower

De Oliveira Silva et al. (2016). Increasing beef production could lower greenhouse gas emissions in Brazil if decoupled from deforestation, *Nature Climate Change*

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

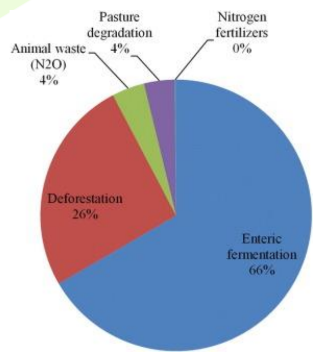
- In the Brazilian *Cerrado*, reduced consumption could actually remove the incentive for grassland improvement and therefore lead to higher emissions.

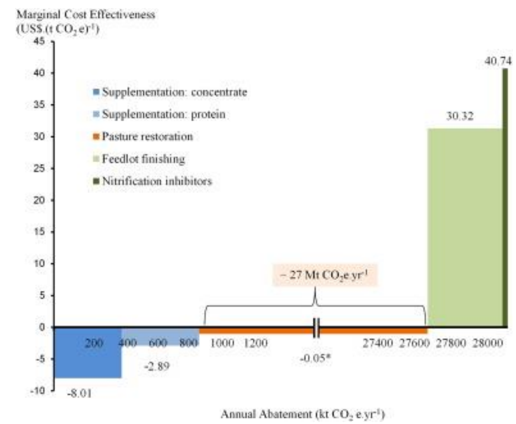
- Shifting to less meat-dependent diets would help curb climate change, but it is important to understand the nature of different production systems before concluding that reduced consumption will have the same effects in all systems.

Chapters

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.

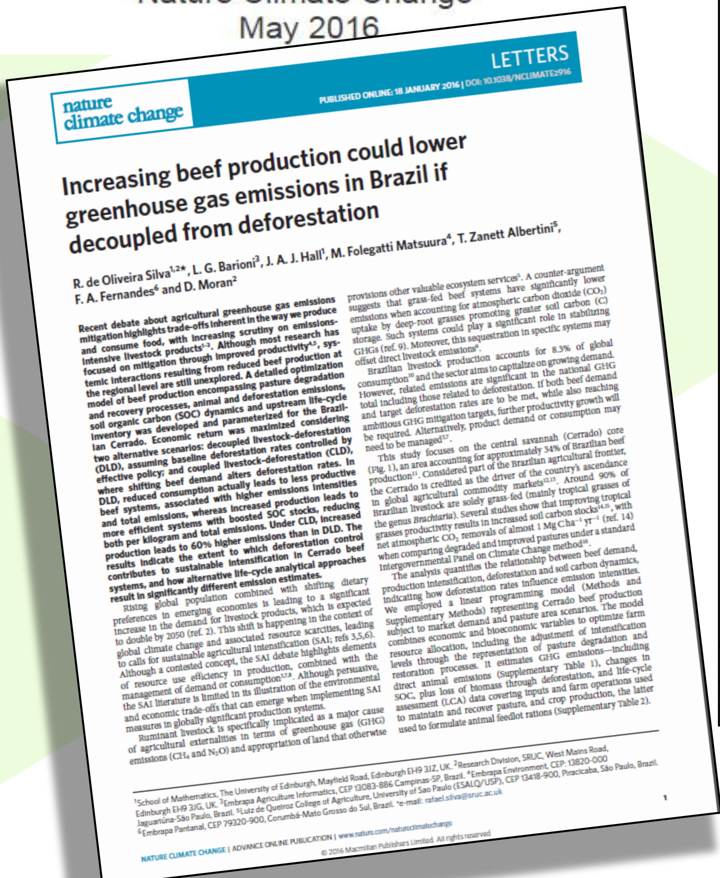
De Oliveira Silva, R., Barioni, L.G., Moran, D., 2015b. **Greenhouse Gas Mitigation through Sustainable Intensification of Livestock Production in the Brazilian Cerrado**. EuroChoices 14, 28–34.





Chapters

Nature Climate Change
May 2016


nature climate change

LETTERS

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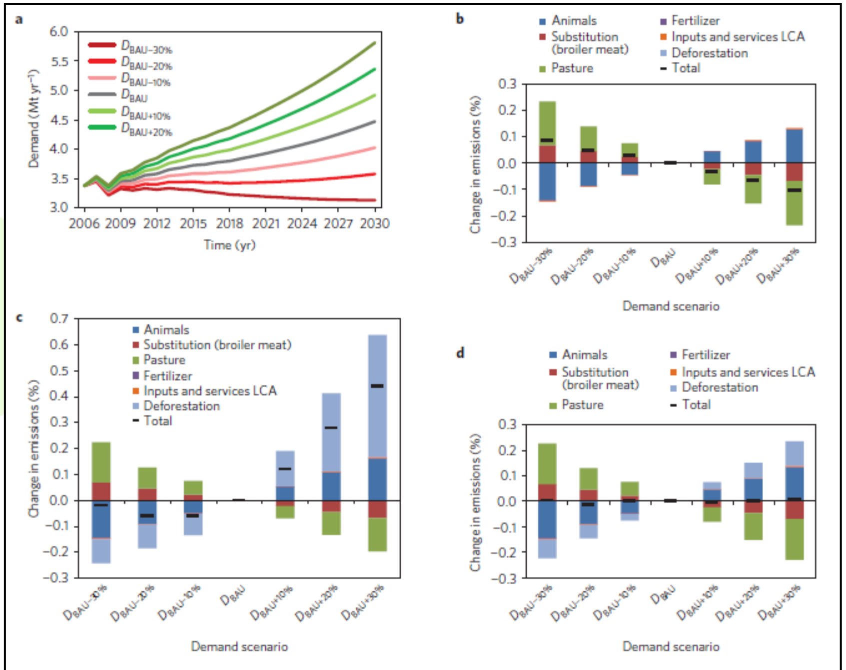
Increasing beef production could lower greenhouse gas emissions in Brazil if decoupled from deforestation

R. de Oliveira Silva[1,2]*, L. G. Barioni[3], J. A. J. Hall[1], M. Folegatti Matsuura[4], T. Zanett Albertini[5], F. A. Fernandes[6] and D. Moran[2]

[1]School of Mathematics, The University of Edinburgh, Mayfield Road, Edinburgh EH9 3JZ, UK. [2]Research Division, SRUC, West Mains Road, Edinburgh EH9 3JG, UK. [3]Embrapa Agriculture Informatics, CEP 13083-886 Campinas-SP, Brazil. [4]Embrapa Environment, CEP: 13820-000 Jaguariúna-São Paulo, Brazil. [5]Luiz de Queiroz College of Agriculture, University of São Paulo (ESALQ/USP), CEP 13418-900, Piracicaba, São Paulo, Brazil. [6]Embrapa Pantanal, CEP 79320-900, Corumbá-Mato Grosso do Sul, Brazil. *e-mail: rafael.silva@sruc.ac.uk

Increasing beef production could lower greenhouse gas emissions in Brazil if decoupled from deforestation (Silva et al. 2016)



…emand scenarios and sensitivity analysis. a, Cerrado baseline demand (D_{BAU}) and varied demand projections that correspond to per… 2030 in relation to D_{BAU}. 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:

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Deforestation and Demand

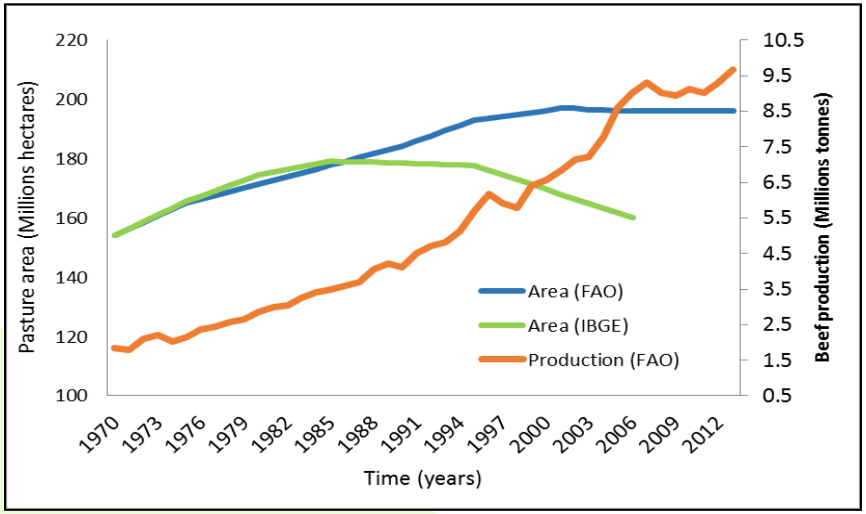
Decoupled Livestock-Deforestation (DLD) scenario:

The same deforestation projections irrespective of consumption levels.

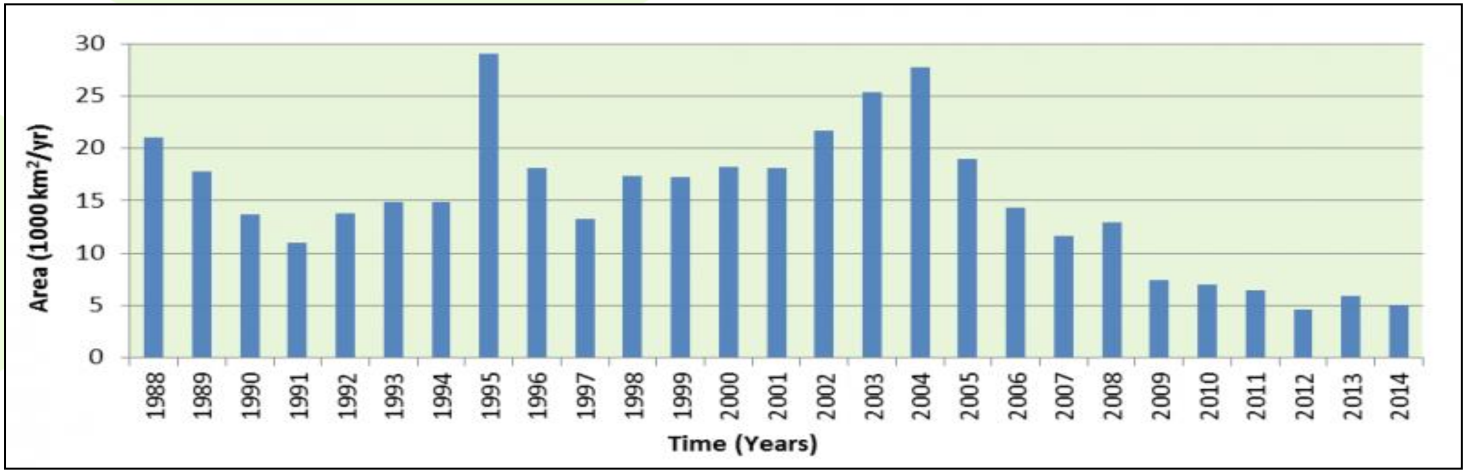
Coupled Livestock-Deforestation (CLD) scenario:

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

Responds for at least 34% of national beef production

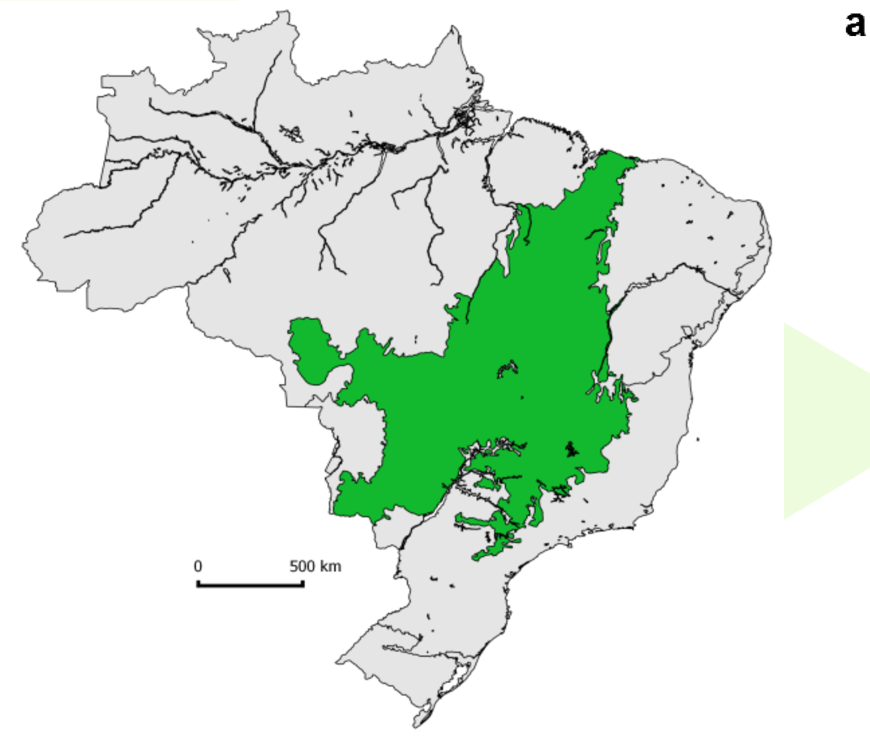


Fig. 1: Brazilian Central Cerrado (green)

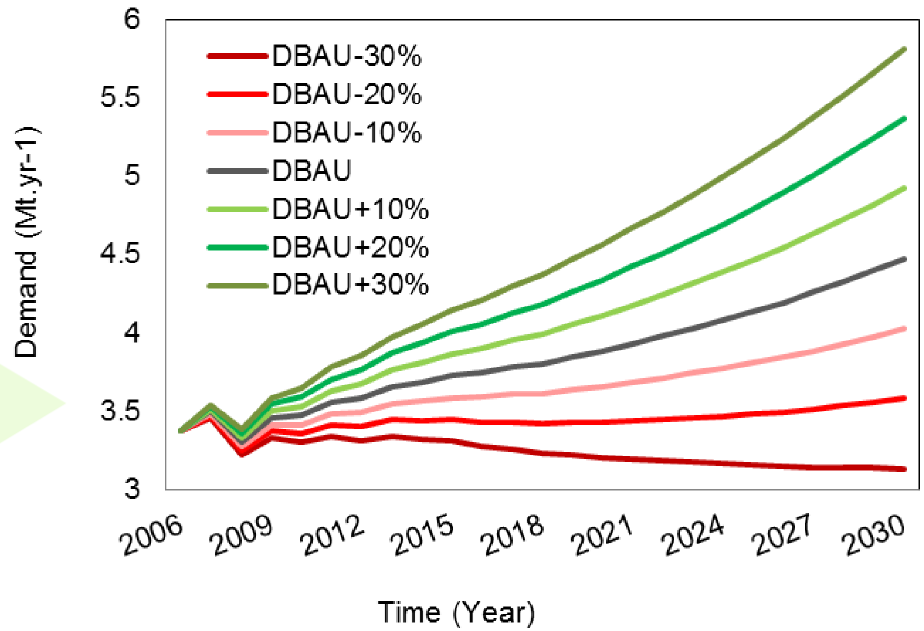
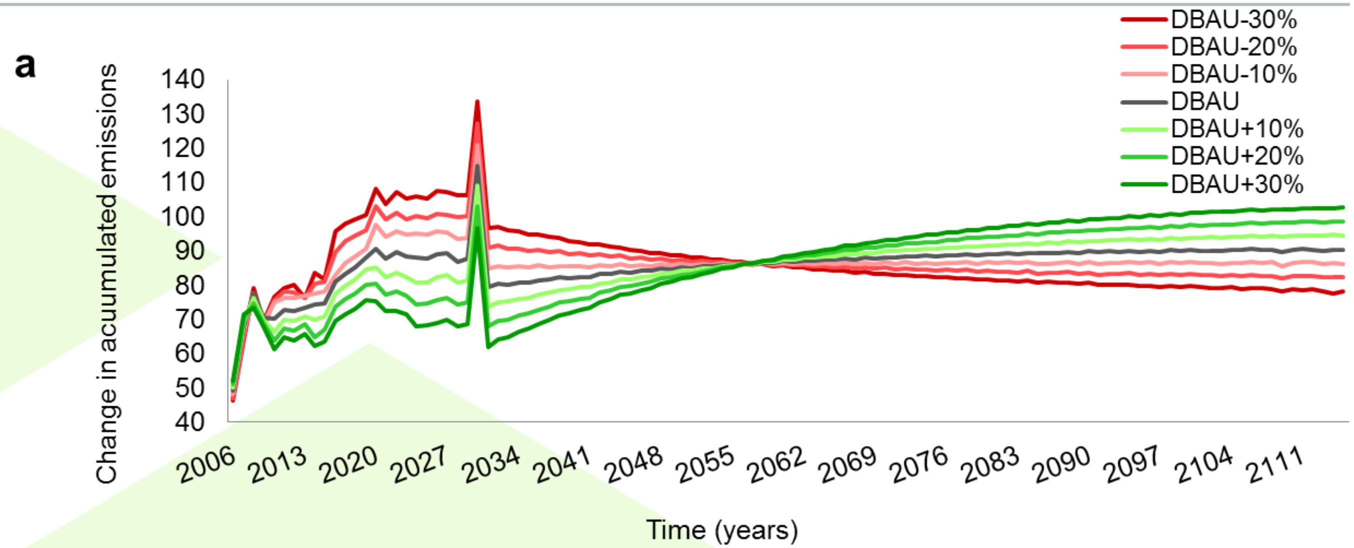
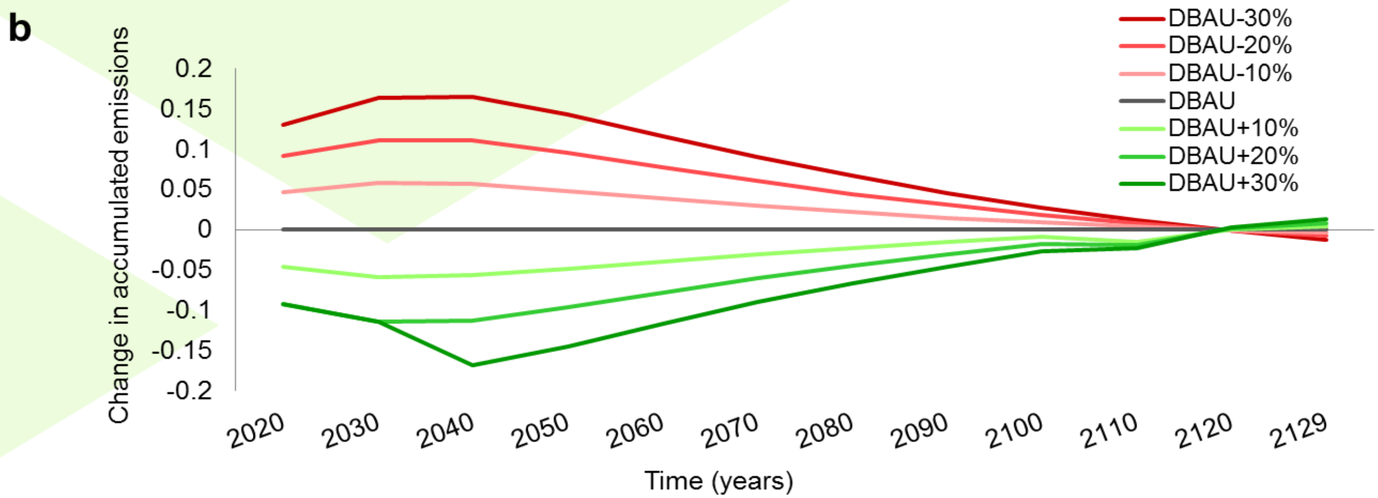


Fig.2: Cerrado baseline demand (DBAU) and varied demand projections that correspond to percentage variation by 2030 in relation to DBAU.

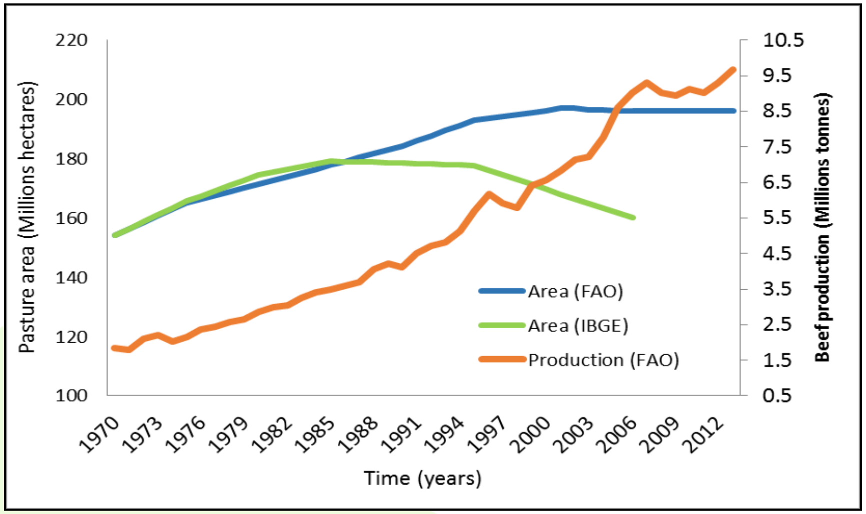
But soil organic carbon saturates …





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?



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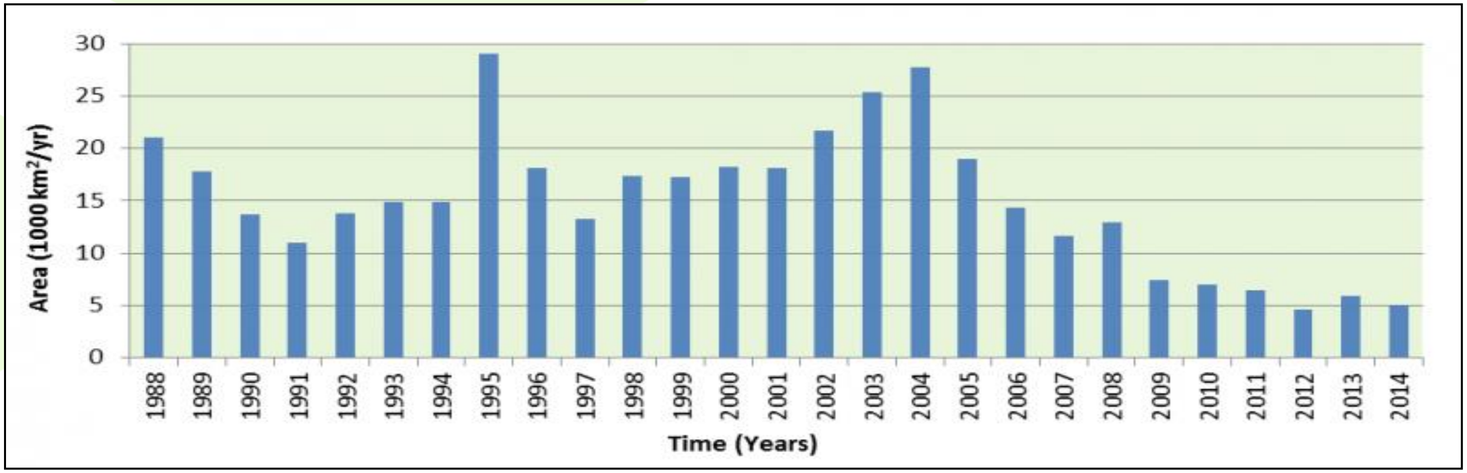

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