MANAGING THE GLOBAL CARBON BUDGET: THE ROLE(S) OF BIOENERGY IN SUSTAINABLE DEVELOPMENT

(LAND AS THE KEY MEDIATOR OF MITIGATION AND ADAPTATION)

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(land as the key mediator of mitigation and adaptation)

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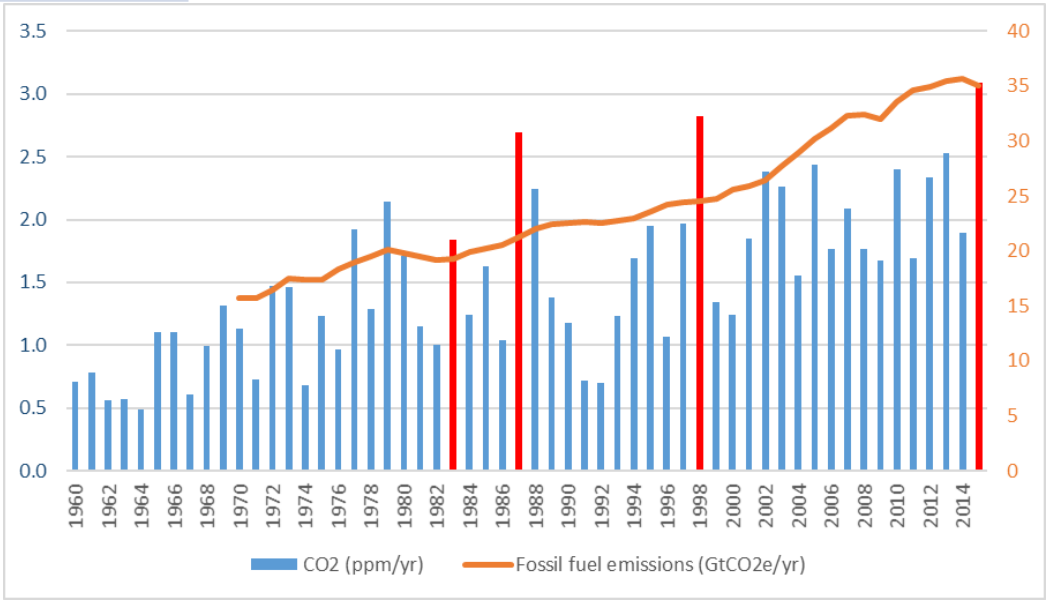
The Global Carbon Budget
Avoiding the ‘cliff edge’ - time to act is limited

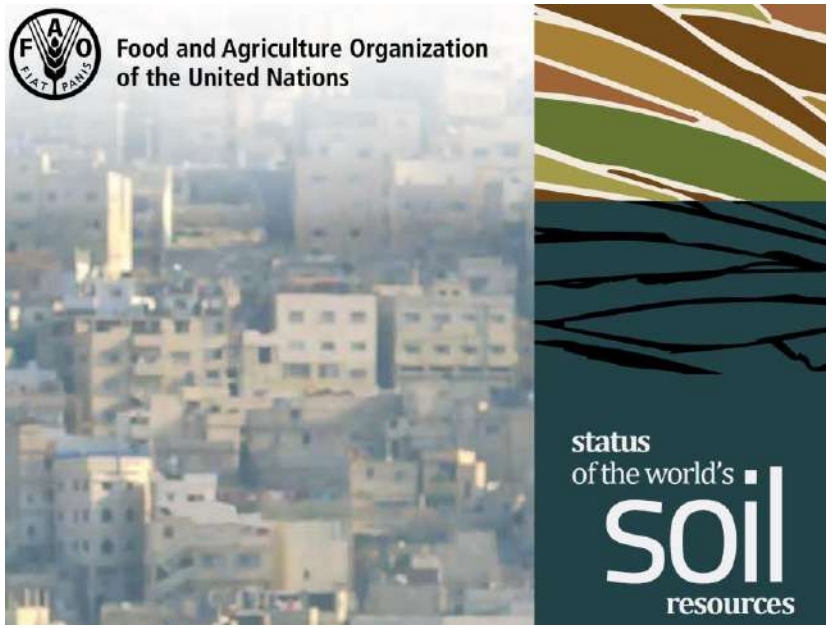
	$GtCO_2e$ (cumulative)	Temperature anomaly	Sources
1870 to 2015	2800		Den Elzen et al (1870 to 1990) + EDGAR (1990 to 2012)
1870 to 2100 – RCP 8.5	11400	+6.2 to +1.7°C	FT – Climate Change Calculator
1870 to 2100 – RCP 2.6	4660	+2.8 to +0.7°C	FT – Climate Change Calculator
Remaining budget	1990		FT – Climate Change Calculator
Current rate of emissions	49	per year	IPCC AR5



Based on Financial Times Climate Change Calculator (2015)

Need to enhance carbon in soils and vegetation

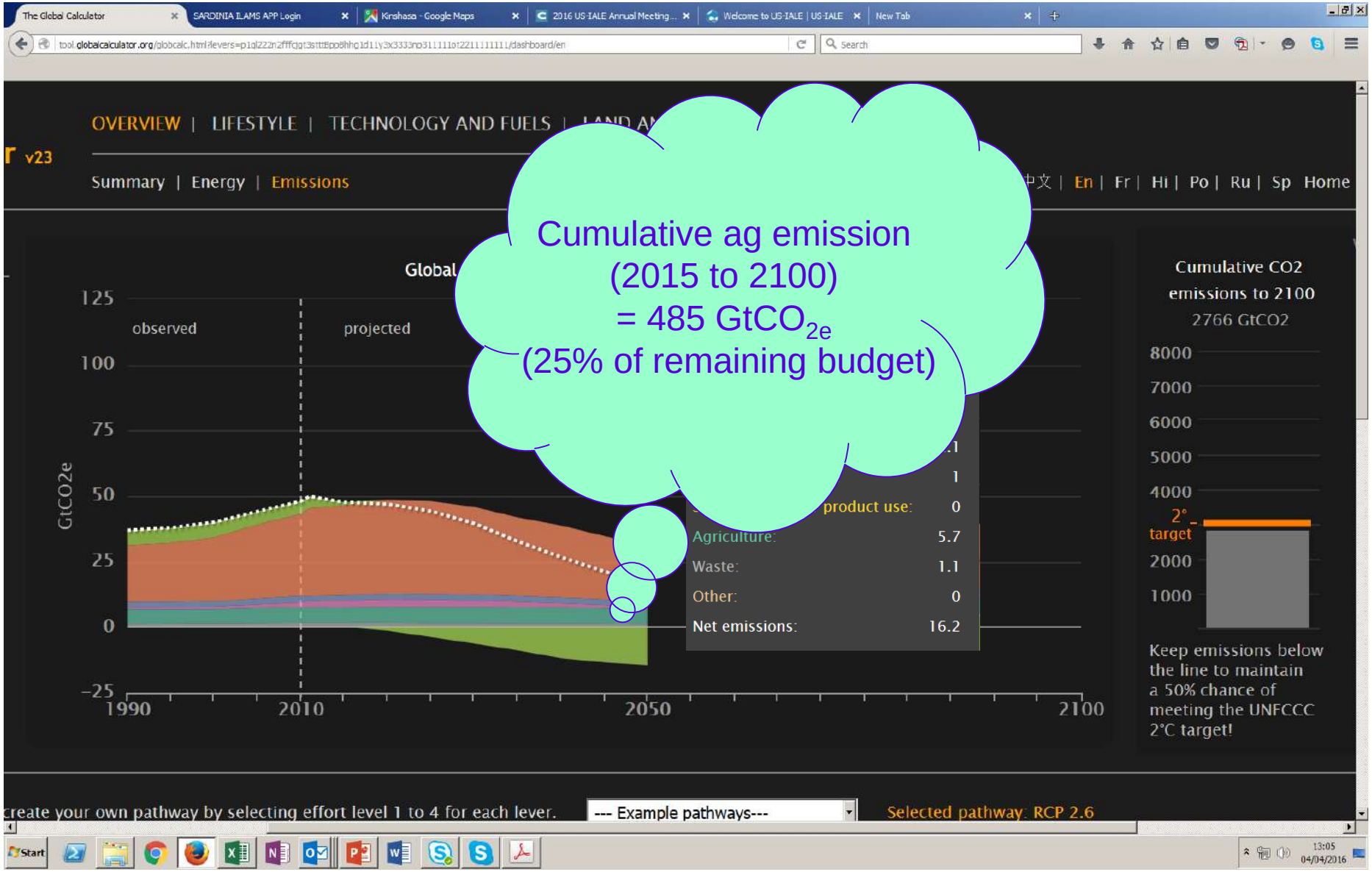
- Soil degradation is a critical issue for Sustainable Development
- Key components are:
  - Soil degradation
  - Water availability
  - Soil organic matter = soil carbon
  - Above ground vegetation carbon stocks and fluxes = yields



Whilst controversial and contested, there is a growing recognition of the importance of soil organic matter (soil carbon) in the management of agricultural soils for resilience and enhanced / sustained productivities.

Should bioenergy play a role in enhancing soil carbon stocks for intensive agriculture for food production? Is this possible / probable?

Global Emissions Trajectory (RCP 2.6)



Cumulative ag emission
(2015 to 2100)
= 485 $GtCO_{2e}$
(25% of remaining budget)

Source: tool.globalcalculator.org, 2015

Global economic consequences of deploying BECCS

Muratori, Calvin, Wise, Kyle and Edmonds (2016)

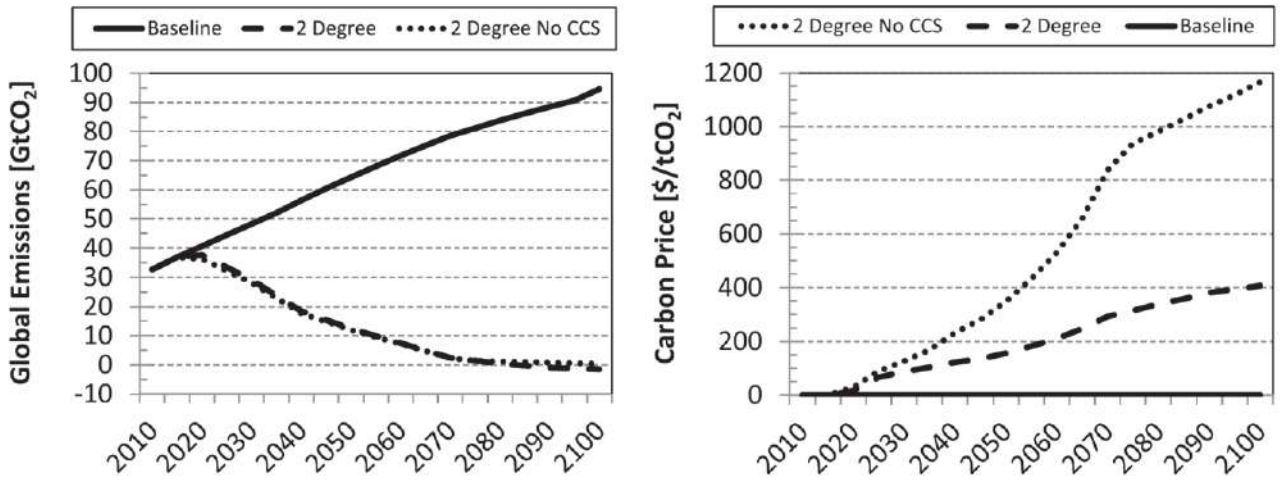


Figure 2. Global CO_2 emission (left pane) and related carbon price (right pane) pathways for the three scenarios considered in this paper. Note that the 2 *Degree* scenario reaches net negative emissions by the end of the century.

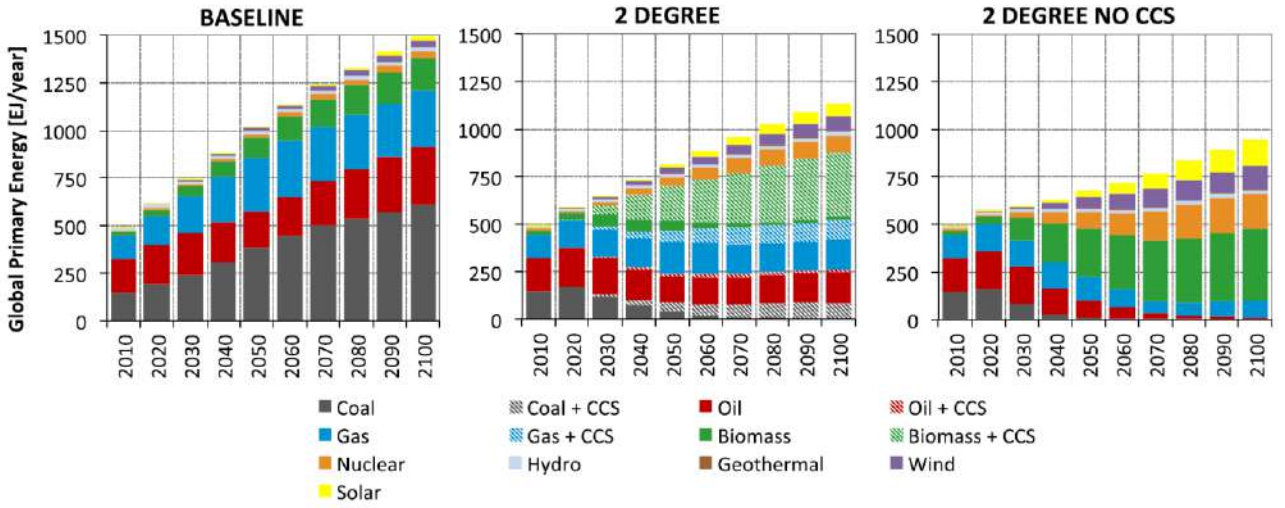


Figure 4. Global primary energy consumption for three scenarios.

Natural Climate Solutions

Griscombe et al. '[Natural Climate Solutions](#).' PNAS, 2017

- The green area shows cost-effective NCS (aggregate of 20 pathways), offering:
- 37% of needed mitigation through 2030,
- 29% at year 2030,
- 20% through 2050, and
- 9% through 2100.

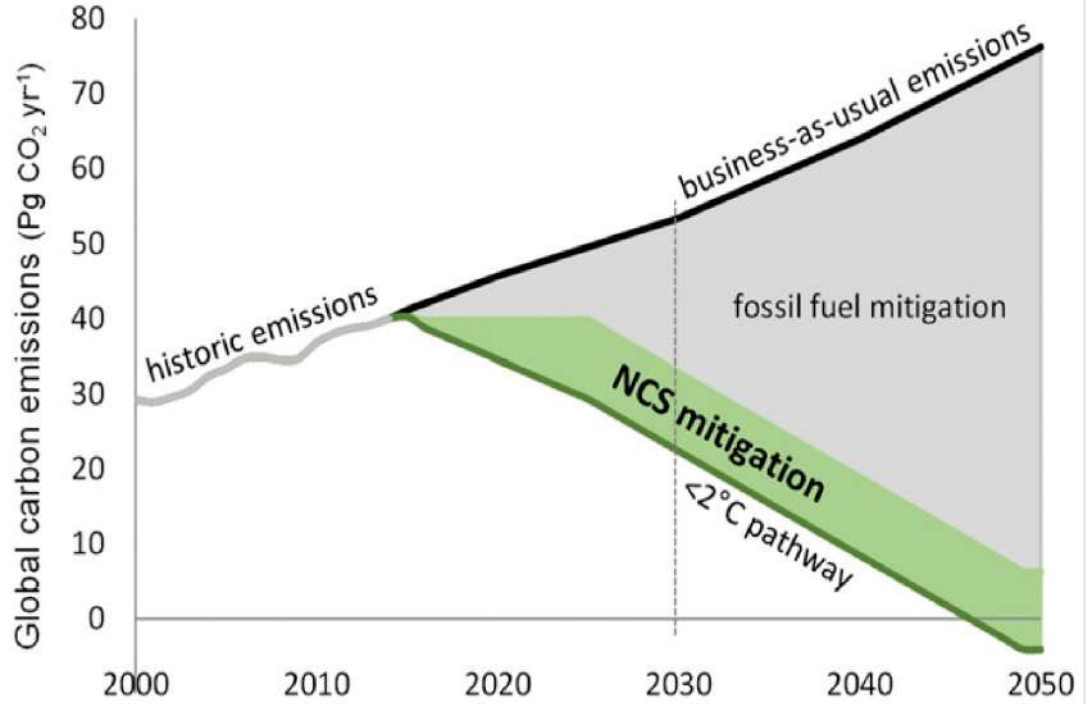
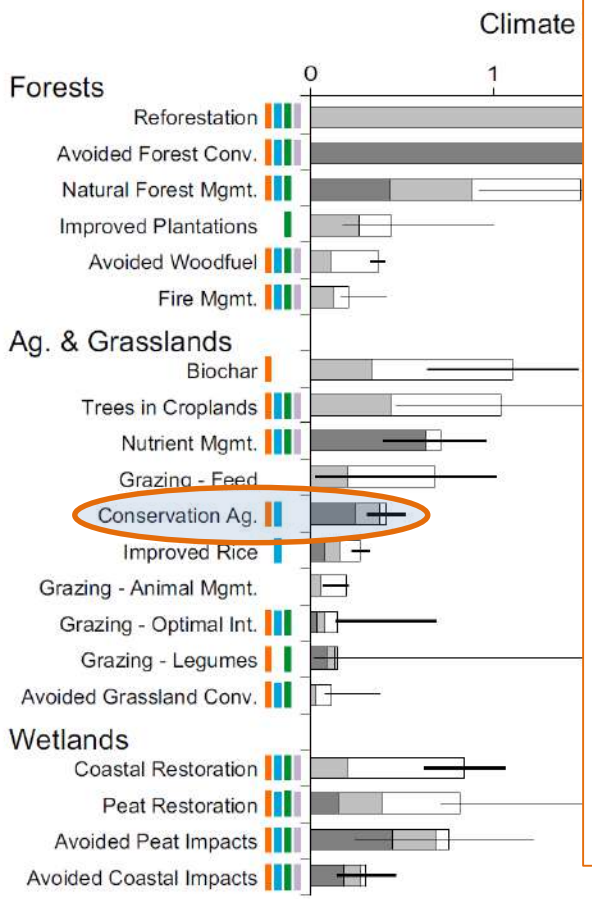


Fig. 2. Contribution of natural climate solutions (NCS) to stabilizing warming to below 2 °C. Historical anthropogenic CO_2 emissions before 2016 (gray line) prelude either business-as-usual (representative concentration pathway, scenario 8.5, black line) or a net emissions trajectory needed for >66% likelihood of holding global warming to below 2 °C (green line). The green area shows cost-effective NCS (aggregate of 20 pathways), offering 37% of needed mitigation through 2030, 29% at year 2030, 20% through 2050, and 9% through 2100. This scenario assumes that NCS are ramped up linearly over the next decade to <2 °C levels indicated in Fig. 1 and held at that level (=10.4 $PgCO_2$ y^{-1}, not including other greenhouse gases). It is assumed that fossil fuel emissions are held level over the next decade then decline linearly to reach 7% of current levels by 2050.

Natural Climate Solutions
Griscombe et al, 2017



BDR is an enhancement of 'Conservation Agriculture' synergistically linking the energy and agricultural systems.

A substantial carbon offset by substituting fossil energy emissions + a large soil-carbon sink:

Overall Natural Climate Solutions could provide:

- 11.3 $PgCO_{2e}$ y^{-1} of max NCS potential meets a cost-effectiveness threshold.
- 23.8 $PgCO_{2e}$ y^{-1} max additional mitigation potential (95% CI 20.3–37.4); 2030 reference year

Defines a '<2°C (limiting warming to below 2°C) "cost-effective" level of mitigation as a marginal abatement cost not greater than ~100 USD $MgCO_2^{-1}$ as of 2030.

Fig. 1. Climate mitigation potential of 20 natural pathways. We estimate maximum climate mitigation potential with safeguards for reference year 2030. Light gray portions of bars represent cost-effective mitigation levels assuming a global ambition to hold warming to <2 °C (<100 USD $MgCO_2e^{-1}$ y^{-1}). Dark gray portions of bars indicate low cost (<10 USD $MgCO_2e^{-1}$ y^{-1}) portions of <2 °C levels. Wider error bars indicate empirical estimates of 95% confidence intervals, while narrower error bars indicate estimates derived from expert elicitation. Ecosystem service benefits linked with each pathway are indicated by colored bars for biodiversity, water (filtration and flood control), soil (enrichment), and air (filtration). Asterisks indicate truncated error bars. See *SI Appendix*, Tables S1, S2, S4, and S5 for detailed findings and sources.