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Editorial: Finding paths to net-zero carbon in climate-smart food systems

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Editorial on the Research Topic
Finding paths to net-zero carbon in climate-smart food systems

This Research Topic (Finding Paths to Net Zero Carbon in Climate-Smart Food Systems), aimed at analyzing the balance between carbon (C) emission and C storing per unit of time in agriculture and the food systems.

Global emissions of carbon (CO_2eq) have increased about 40% between 1990 and 2021 (Statista, 2023), so transitioning to a net-zero world is a major challenge for humanity. Setting aside natural sources of C emissions, the energy sector accounts for around 75% of anthropogenic emissions, and the full food system for the remaining 25%. On-farm primary production, which explains about 12% of the food system (Crippa et al., 2021) includes methane (54%), nitrous oxide (28%), and carbon dioxide (18%). Whereas, carbon dioxide may last hundreds of years in the atmosphere, methane is a short-lived gas that last around 10–12 years (FAO, 2023). According to Rosa and Gabrielli (2023), while primary production would explain about 42% of C emitted by the full food system, land-use change would accounts for 31%, food processing, transport, retail, and packaging 20%, and food-waste disposal 7%. Therefore, the food system will inevitably be subjected to scrutiny in any climate-stabilization program.

The notion of net-zero carbon (NZC) in agriculture refers to the balance between the carbon (C) amount released to, and the amount of C removed from the atmosphere per unit of time. Some practices are recommended to facilitate the path to NZC: (i) use of biofuels in farm operations (Flammini et al., 2022), (ii) use of improved rice cultivation methods (Yuan et al., 2021), (iii) management of nitrogen fertilizers (Maaz et al., 2021) and use of grass-legume mixtures for fixing nitrogen and replace nitrogen fertilizers in tropical and subtropical regions (Jensen et al., 2012; Boddey et al., 2020), (iv) use of feed additives to reduce methane production in ruminants (Hegarty et al., 2021), (v) genetic selection that aims at low methane emission in cattle (Manzanilla-Pech et al., 2022), (vi) biological C storage in biomass and soil to improve C balance in farms (Chiquier et al., 2022) and (vii) rock weathering coupled to tilling operations (Searchinger et al., 2021). Rosa and Gabrielli (2023) suggest that a smart combination of techniques could mitigate C emissions by up to 45%.

The massive use of biomass as renewable energy in a NZC strategy is still an unresolved question. The large-scale need of land for biomass production could lead to deforestation, habitat alteration, biodiversity loss and soil degradation. The competition between grain- and biomass-crops for land and water will affect food production to feed about 10 billion people by 2050 (Rosa et al., 2021).

Assuming uncertainties for accounting the C-stocktaking in the path to NZC, current research methods differ depending on whether bottom-up (IPCC, 2021) or top-down (Byrne et al., 2023) approaches are used. In either approach, the estimation of C storage is still another unresolved question. The calculation of C storage is more controversial than that of C emission (Smith, 2004). Beyond discussions, several studies (Lal, 2004; Navak et al., 2019; Viglizzo et al., 2019; Chen et al., 2020) focused on the C captured by plant through photosynthesis, which in turn accumulates as above-ground (AGB), below-ground-biomass (BGB) and soil organic carbon (SOC). Two published articles in this Research Topic addressed the issue C storing: by combining biogeochemical simulation models and remote-sensing data, Baldassini et al. proposed a novel methodology to estimate on-farm C accumulation in Uruguayan soils. On the other hand, Hyman et al. demonstrated that improved pastures have stored up to 10 Mg ha^{-1} more SOC than degraded pastures or native savannas in acid soils of Colombia.

Beyond the biological options, there is an increasing interest on enhanced rock weathering to store C in cropping. Beerling et al. (2020) analyzed the impact of a technique that looks at capturing C by modifying the soil properties with calcium and magnesium-rich crushed silicate rocks. The improved meteorization of silicate rocks through cropping operations seems to have a significant potential to remove C from the atmosphere (Joppa, 2020; Terlouw et al., 2021). The difference between biological and geological store of C is rather clear: while biomass and SOC behave as ephemeral C sinks, rocks tend to be permanent.

Amid speculations about NZC, well-known scientists and leading climate experts like Dyke et al. (2021) have harshly criticized the notion of NZC, especially when such concept is associated with carbon-credit purchase. They argue that the application of NZC strategies allows heavy-polluting industries to "neutralize" their emissions by buying carbon-emission permits, which simply means a "greenwashing" tactic to avoid responsibilities with no net benefit to climate. They denounced the idea of NZC as a fraud and a trap because it pushes the problem onto future generations, emphasizing that the goal should be zero emissions, rather than emissions counterbalanced by carbon credits. NZ balance is for them a distraction to hide a business-based climate-change mitigation. To get an effective C removal, they argue that C capture and store would need to remove 12 billion ton of C dioxide each year, which seems to be too good to be true. In line with this thinking, the 2021 Report of the International Energy Agency (IEA, 2021) states that the massive deployment of C-removal strategies is costly and uncertain, and so the international community should stop putting it in a first place.

Beyond C emissions and C storing, some scientists and policy-makers are looking at geo-engineering as an emergency solution to limit temperature rising. However, geo-engineering, which connotes a broad-scale control on solar radiation entry, will not resolve the problem of C emissions. It is just a temporary solution with no definitive effect on the true cause of climate change (Saeed et al., 2018).

Skeptic views about the Paris Agreement, C offsetting alternatives, C sequestration, geo-engineering and NZ options are inevitable. However, if an optimistic vision tends to prevail, significant investment, policies support, financial incentives, education and training programs would inevitably be required at a global scale.

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References

Beerling, D. J., Kantzas, E. P., Lomas, M. R., Wade, P., Eufrasio, R. M., Renforth, P., et al. (2020). Potential for large-scale CO2 removal via enhanced rock weathering with croplands. *Nature* 583, 242–248. doi: 10.1038/s41586-020-2448-9

Boddey, R. M., Casagrande, D. R., Homem, B. G. C., and Alves, B. J. R. (2020). Forage legumes in grass pastures in tropical Brazil and likely impacts on greenhouse gas emissions: a review. *Grass For. Sci.* 75, 357–371. doi: 10.1111/gfs.12498

Byrne, B., Baker, D. F., Basu, S., Bertolacci, M., Bowman, K. W., Carroll, D., et al. (2023). National CO2 budgets (2015-2020) inferred from atmospheric CO2 observations in support of the global stocktake. *ESSD* 15, 963–1004. doi: 10.5194/essd-15-963-2023

Chen, R., Zhang, R., Han, H., and Jiang, Z. (2020). Is farmers' agricultural production a carbon sink or source? Variable system boundary and household survey data. *J. Clean. Product.* 266, 122108. doi: 10.1016/j.jclepro.2020.122108

Chiquier, S., Patrizio, P., Bui, M., Sunny, N., and Mac Dowell, N. (2022). A comparative analysis of the efficiency, timing, and permanence of CO2 removal pathways. *Energy Environ. Sci.* 15, 4389–4403. doi: 10.1039/D2EE01021F

Crippa, M., Solazzo, E., Guizzardi, D., Monforti-Ferrario, F., Tubiello, F. N., and Leip, A. (2021). Food systems are responsible for a third of global anthropogenic GHG emissions. *Nat. Food* 2, 198–209. doi: 10.1038/s43016-021-00225-9

Dyke, J., Watson, R., and Knorr, W. (2021). *Climate Scientists: Concept of Net Zero Is a Dangerous Trap*. The Conversation. Available online at: https://theconversation.com/climate-scientists-concept-of-net-zero-is-a-dangerous-trap-157368 (accessed September 29, 2023).

FAO (2023). *Methane Emissions in Livestock and Rice Systems. Sources, Quantifications, Mitigation and Metrics*. Rome.

Flammini, A., Pan, X., Tubiello, F. N., Qiu, S. Y., Souza, L. R., and Quadrelli, R., et al. (2022). Emissions of greenhouse gases from energy use in agriculture, forestry and fisheries: 1970-2019. *Earth Syst. Sci. Data* 14, 811–821. doi: 10.5194/essd-14-811-2022

Hegarty, R. S., Cortez Passetti, R. A., Dittmer, K. M., Wang, Y., Shelton, S., Emmet-Booth, J., et al. (2021). *An Evaluation of Emerging Feed Additives to Reduce Methane Emissions from Livestock. Edition 1.* A report coordinated by Climate Change, Agriculture and Food Security (CCAFS) and the New Zealand Agricultural Greenhouse Gas Research Centre (NZAGRC) initiative of the Global Research Alliance (GRA).

IEA (2021). *Net Zero Emissions by 2050: A Roadmap for the Global Energy Sector*. International Energy Agency. Available online at: https://www.iea.org/reports/net-zero-roadmap-a-global-pathway-to-keep-the-15-0c-goal-in-reach (accessed July 19, 2023).

IPCC (2021). *Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change.* Cambridge: Cambridge University Press.

Jensen, E. S., Peoples, M. B., Boddey, R. M., Gresshoff, P. M., Hauggaard-Nielsen, H., Alves, B. J. R., et al. (2012). Legumes for mitigation of climate change and the provision of feedstock for biofuels and biorefineries - a review. *Agron. Sustain. Dev.* 32, 329–364. doi: 10.1007/s13593-011-0056-7

Joppa, L. (2020). *Progress on Our Goal to be Carbon Negative by 2030*. Microsoft on the Issues. Available online at: https://blogs.microsoft.com/on-the-issues/2020/07/21/carbon-negative-transform-to-net-zero/ (accessed September 29, 2023).

Lal, R. (2004). Soil carbon sequestration to mitigate climate change. *Geoderma* 123, 1–22. doi: 10.1016/j.geoderma.2004.01.032

Maaz, T. M., Sapkota, T. B., Eagle, A. J., Kantar, M. B., Bruulsema, T. W., and Majumdar, K. (2021). Meta-analysis of yield and nitrous oxide outcomes for nitrogen management in agriculture. *Glob. Change Biol.* 27, 2343–2360. doi: 10.1111/gcb.15588

Manzanilla-Pech, C. I. V., Stephansen, R. V., Difford, G. F., Løvendahl, P., and Lassen, J. (2022). Selecting for feed efficient cows will help to reduce methane gas emissions. *Front. Genet.* 13, 885932. doi: 10.3389/fgene.2022.885932

Navak, A. K., Rahman, M. M., Naidu, R., Dhal, B., Swain, C. K., Nayak, A. D., et al. (2019). Current and emerging methodologies for estimating carbon sequestration in agricultural soils: a review. *Sci. Tot. Environ.* 665, 890–912. doi: 10.1016/j.scitotenv.2019.02.125

Rosa, L., and Gabrielli, P. (2023). Achieving net-zero emissions in agriculture: a review. *Environ. Res. Lett.* 18, 014008. doi: 10.1088/1748-9326/aca815

Rosa, L., Sanchez, D. L., and Mazzotti, M. (2021). Assessment of carbon dioxide removal potential via BECCS in a carbon-neutral. *Eur. Energy Environ. Sci.* 14, 3086–3097. doi: 10.1039/D1EE00642H

Saeed, F., Schleusmer, C.-F., and Hare, W. (2018). *Why Geoengineering is Not A Solution to the Climate Problem*. Climate Analytics. Available online at: http://www.climateanalytics.org/

Searchinger, T., Zionts, J., Peng, L., Wirsenius, S., Beringer, T., and Dumas, P. (2021). *A Pathway to Carbon Neutral Agriculture in Denmark*. World Resources Institute (WRI). doi: 10.46830/wrirpt.20.00006

Smith, P. (2004). Soils as carbon sinks: the global context. *Soil Use Manag.* 20, 212–218. doi: 10.1079/SUM2004233

Statista (2023). *Annual Greenhouse Gas Emissions Worldwide from 1990 to 2021.* Available online at: https://www.statista.com/statistics/1285502/annual-global-greenhouse-gas-emissions/# (accessed October 23, 2023).

Terlouw, T., Bauer, C., Rosa, L., and Mazzotti, M. (2021). Life cycle assessment of carbon dioxide removal technologies: a critical review. *Energy Environ. Sci.* 14, 1701–1721. doi: 10.1039/D0EE03757E

Viglizzo, E. F., Ricard, M. F., Taboada, M. A., and Vázquez-Amábile, G. (2019). Reassessing the role of grazing lands in carbon-balance estimations: meta-analysis and review. *Sci. Tot. Environ.* 661, 531–542. doi: 10.1016/j.scitotenv.2019.01.130

Yuan, S., Linquist, B. A., Wilson, L. T., Cassman, K. G., Stuart, A. M., Pede, V., et al. (2021). Sustainable intensification for a larger global rice bowl. *Nat. Commun.* 12, 7163. doi: 10.1038/s41467-021-27424-z