Research on Agriculture and Climate Change

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1. Agriculture and Climate Change

Agriculture has a significant impact on the environment as it requires large amounts of fresh water, emits greenhouse gases and uses massive land. Food production accounts for 26% of global greenhouse gas emissions [1]. Half of the world's habitable land is used for agriculture. 70% of global freshwater withdrawals are used for agriculture. 78% of global ocean and freshwater eutrophication is caused by agriculture.

Food production is a significant contributor to climate change. Addressing the adverse effects of agriculture while simultaneously feeding an expanding global population presents a formidable challenge. Scientific studies indicate that climate change will exacerbate the existing negative impacts of agriculture by diminishing crop yields, reducing the effectiveness of synthetic inputs such as fertilizers, and increasing damage from crop pests and soil erosion [2]. The decline in crop yields and fertility may consequently lead to further land clearance for food production, resulting in the destruction of wildlife habitats and loss of biodiversity. This situation necessitates an increased application of fertilizers and pesticides to sustain productivity, which can have cascading effects on surrounding ecosystems.

2. Climate-Smart Agriculture

The Food and Agriculture Organization of the United Nations (FAO) first proposed to develop "climate-smart agriculture" at the Hague Conference in 2010, aiming to achieve the multi-win goals of food security, climate change mitigation and adaptation.

Through relentless efforts, researchers have established a substantial scientific foundation for climate-smart agriculture. Across the globe, farmers, civil societies, non-governmental organizations (NGOs), and governments are collaborating to implement various practices that enhance the sustainability and resilience of agricultural systems while simultaneously mitigating climate change. For instance, practices aimed at improving soil health—such as cover cropping, no-till farming, and crop diversification—can significantly enhance the capacity of agricultural soils to sequester carbon [3]. Agroforestry not only diversifies income streams for farmers but also provides shade for livestock and serves as windbreaks, all while facilitating additional carbon sequestration. Moreover, optimizing fertilizer application can reduce water pollution and emissions of nitrous oxide—a greenhouse gas with a global warming potential 300 times greater than that of CO2.

However, numerous challenges persist in achieving effective climate-smart agriculture. Firstly, methodologies for carbon monitoring and accounting in agriculture require further standardization and unification [4]. The potential for greenhouse gas (GHG) emission reduction and carbon storage within agricultural contexts remains ambiguous. Precise methods are essential to forecast how climate change will impact agriculture accurately. Additionally, indicator systems and assessment standards are crucial components of climate-smart agriculture initiatives. Furthermore, current technologies often lack multi-objective synergy; thus coordination is necessary to enhance agricultural output while sequestering carbon, reducing greenhouse gas emissions, and improving adaptation strategies to changing climatic conditions. There is also a notable deficiency in creativity regarding technological integration and systematic solutions; many technologies remain nascent or lack clear regulatory frameworks or affordability for large-scale adoption. Finally, there is an urgent need for the development of a global agri-carbon market alongside mechanisms promoting equitable inclusion in climate-smart agriculture initiatives.

3. US Governments and CSA

The U.S. government has intensified its efforts to promote CSA. The Biden administration's 2022 climate legislation allocated $19.5 billion to the USDA's Natural Resources Conservation Service, primarily aimed at supporting "climate-smart agriculture." For fiscal year 2025, the U.S. Department of Agriculture is providing up to $7.7 billion in assistance to help agricultural and forestry producers implement conservation practices on working lands. This funding includes up to $5.7 billion designated for climate-smart practices, made possible by the Inflation Reduction Act. In an emailed statement, a USDA spokesperson writes that federal climate legislation "provided needed funding to help us drive measuring, monitoring, reporting and verification efforts … to quantify the impact of [farming] practices on greenhouse gas emissions and carbon sequestration, and ensure that future resources are directed to the most effective practices."

However, many farming practices endorsed by the U.S. government may not significantly reduce climate pollution as claimed. For example, an emphasis on certain regenerative farming techniques can detract from solutions that could achieve more rapid and substantial reductions in greenhouse gas emissions. The USDA incentivizes farmers to adopt regenerative practices under the premise that increasing soil carbon content can contribute toward the U.S.'s goal of reducing greenhouse gas emissions by 50-52% relative to 2005 levels by 2030. While corporations and governments are making ambitious commitments regarding the potential benefits of regenerative agriculture, there exists insufficient scientific evidence to substantiate these claims [4]. Researchers have identified three major concerns regarding assertions that regenerative practices enhance soil carbon sequestration. First, inconsistencies in farm soil carbon measurements pose a significant challenge. Second, the concept of "permanence" introduces another complication; factors such as droughts, heat waves, and crop rotation can lead soils to release stored carbon back into the atmosphere—thereby exacerbating global warming—even if certain farming methods increase initial soil carbon levels.

Furthermore, it remains uncertain whether some regenerative farming techniques—such as no-till cultivation—truly enhance soil's inherent capacity for carbon storage.

References

[1] Ritchie, H., Rosado, P., & Roser, M. (2022, December 2). Environmental impacts of food production. Our World in Data. https://ourworldindata.org/environmental-impacts-of-food

[2] Yang, Y., Tilman, D., Jin, Z., Smith, P., Barrett, C. B., Zhu, Y., Burney, J., D'Odorico, P., Fantke, P., Fargione, J., Finlay, J. C., Rulli, M. C., Sloat, L., Van Groenigen, K. J., West, P. C., Ziska, L., Michalak, A. M., Lobell, D. B., Clark, M., . . . Zhuang, M. (2024). Climate change exacerbates the environmental impacts of agriculture. Science, 385(6713). https://doi.org/10.1126/science.adn3747

[3] Lou, Y., Feng, L., Xing, W., Hu, N., Noellemeyer, E., Cadre, E. L., Minamikawa, K., Muchaonyerwa, P., AbdelRahman, M. A., Pinheiro, É. F. M., De Vries, W., Liu, J., Chang, S. X., Zhou, J., Sun, Z., Hao, W., & Mei, X. (2024). Climate-smart agriculture: Insights and challenges. Nature, 1(1), 100003. https://doi.org/10.1016/j.csag.2024.100003

[4] Simon, J. (2024, September 10). Regenerative agriculture is sold as a climate solution. Can it do all it says? NPR. https://www.npr.org/2024/09/10/g-s1-17179/regenerative-agriculture-climate-change-soil-carbon