Climate change's impact on agriculture increases global inequities

Konstantin Engelmayer

September 29, 2024

Abstract

This paper examines the profound and far-reaching impacts of climate change on global agriculture, highlighting the significant disparities between the global north and south. We explore how the global north, despite its significant contribution to climate change, faces fewer adverse effects compared to the global south, which contributes less to climate change yet bears the main burden of its impacts. The paper emphasizes the vulnerability of the global south to climate change due to its limited adaptive capacity and heavy reliance on agriculture. In line with these findings, we examine the differential responses of staple crops such as wheat and maize to climate change. Wheat, primarily grown in cooler countries in the global north, is projected to benefit from increased yields by 2095, while maize, vital to many countries in the global south, faces substantial yield reductions. This contrast not only exacerbates existing socio-economic disparities but also poses a severe challenge to food security in poorer regions. The paper advocates for equitable climate action and strategies, underscoring the need for a holistic approach that encompasses environmental, economic, and social justice considerations.

Introduction

In an era where climate change is no longer a distant threat but a present reality, its impacts on agriculture are profound and far-reaching [2]. Agriculture is experiencing unprecedented stress due to climatic disruptions. These disruptions manifest in various forms, from shifting precipitation patterns and extreme weather events to the spreading of pests and diseases, all of which challenge traditional agricultural practices and threaten food security [2]. However, the main burden of these changes is not distributed equally across the globe.

The global south finds itself at the frontline of this crisis [3]. These region is already grappling with the consequences of historical injustices and developmental challenges, which are further exacerbated by climate-induced challenges. Conversely, the global north possesses more robust financial structures and technological capabilities, allowing for more effective adaptation and mitigation strategies. This discrepancy in adaptive capacity highlights and intensifies existing global disparities [4], reflecting a notable injustice: the global north, largely responsible for climate change due to its historical and ongoing emissions, faces fewer consequences, while the global south, contributing less to the problem, disproportionately suffers from its impacts [5]. Recent climate patterns have led to significant declines in crop yields especially in the global south [6], further endangering the food sovereignty of vulnerable populations and the economic stability of states that are heavily de-

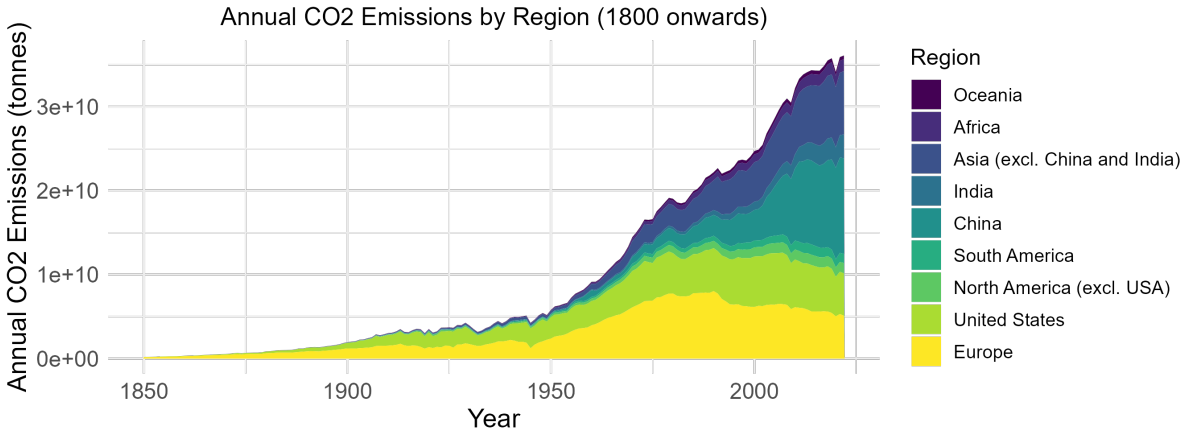

Figure 1: Annual total emissions of carbon dioxide (CO_2), excluding land-use change, measured in tonnes by world region [1]

pendent on agriculture.

The intricate link between climate, agriculture, and injustice forms the core of this research, aiming to shed light on the cascading effects of climate change. The stark contrast in the adaptive capacities of the global North versus the global south, combined with the uneven geographical impacts of climate change [2], highlights the need for equitable climate action. Such action should not only address the environmental challenges but also the underlying socio-economic inequities that are now being magnified by the changing climate.

Climate Change: Contributors and Principal Victims

Since the industrial era, developed nations have been the main Carbon dioxide (CO_2) emitters , as illustrated in Figure 1. CO_2 is the primary greenhouse gas contributing to climate change, primarily due to human activities such as burning fossil fuels and deforestation [2]. Africa, South America and Oceania have emitted the least CO_2. However these regions are most affected by climate change. Noah S. Diffenbaugh and Marshall Burke found that global warming has likely intensified global economic inequality, including an estimated 25 % rise in population-weighted between-country inequality over the last fifty years [7]. This trend results from the influence of warming on annual economic growth, leading to significant declines in economic output in warmer, poorer countries and concurrent increases in cooler, wealthier states, relative to a scenario without anthropogenic warming as shown in Figure 2 [7, 8]. Diffenbaugh and Burke claim that warming in cooler regions moves the countries' mean temperatures closer to the empirical optimum for economic growth, while warming in warmer regions moves the countries' mean temperatures further away from the optimum [7].

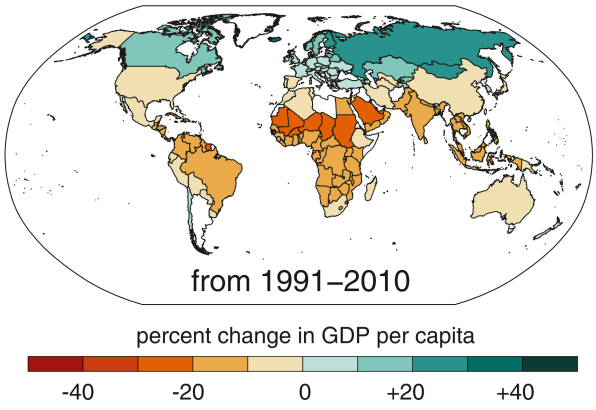

Figure 2: Country-level economic response to global warming. The median impact on country-level per capita GDP across the >20,000 realizations of the world without anthropogenic forcing, calculated for each country over the 1991–2010 period [7]

Agriculture's Sensitivity to Climate and Country Dependencies

It is notable that countries with economies strongly reliant on agriculture are predominantly those experiencing adverse effects on their GDP due to increasing temperatures, as illustrated by Figure 2 and 3. Based on this observation coupled with the fact that agriculture is directly influenced by climate conditions, it is reasonable to conclude that the adverse economic impacts of rising temperatures are predominantly due to the influence of climate change on agricultural sectors. Burke et al. conducted an investigation into the effects of temperature on both agricultural and non-agricultural GDP, claiming that temperature impacts both types of GDP [8]. However, they discovered that the negative impact of rising temperatures is more pronounced on agricultural GDP, further disadvantaging countries in the global south that are often heavily dependent on agriculture as shown in Figure 3 [8].

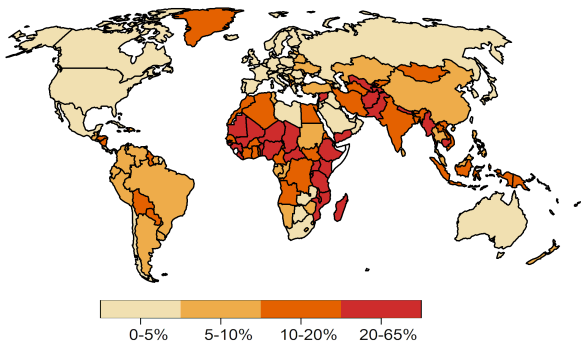

Figure 3: Share of GDP from Agriculture, forestry, and fishing 2022 [9]

When examining how temperature influences the agriculture GDP, the impact of global warming on subsistence farming is neglected, as subsistence farming does not contribute directly to a country's GDP and therefore is not taken into account in that kind of analysis. However subsistence farming plays a crucial role in the livelihoods of many communities in the global south. To respnd to this gap we analysed global warming's impact on key staple crops to determine its potential effects on rural communities.

Global Divide Through Grain: Climate Impacts on Maize and Wheat

Most projections regarding the future yields of staple foods focus on corn, rice, wheat, and soy. Jägermayer et al. found significant changes in wheat and maize yields until the end of the century [6]. Wheat is predominantly cultivated in cooler high-latitude regions, primarily in the global north. Future projections, as illustrated in Figure 4, suggest that wheat yields could increase by up to 40 % by 2095 [6]. Being a C_3 plant, wheat exhibits a relatively strong CO_2 fertilization effect, benefiting from higher CO_2 emissions [10]. The current wheat-growing areas are temperature-limited, implying that global warming might actually lead to an increase in yields [11].

In contrast, maize is grown in a variety of low-latitude regions and is a staple food in many countries in the global south. The same projections that foresee an increase in wheat yields predict a decrease in maize yields by up to 40 % by 2095, as depicted in Figure 4 [6]. As a C_4 plant, maize does not benefit as much from increased CO_2 levels compared to C_3 plants like wheat [10]. Furthermore, many maize-growing areas are already near or at their crop-limiting temperature thresholds [12]. This vulnerability suggests that maize yields will likely suffer significantly due to increasing temperatures, exacerbating food insecurity and economic challenges in many countries in the global south that depend heavily on this crop.

The varying responses of wheat and maize to global warming underscore deepening global inequalities. Maize, a vital staple in poorer countries, is projected to suffer from

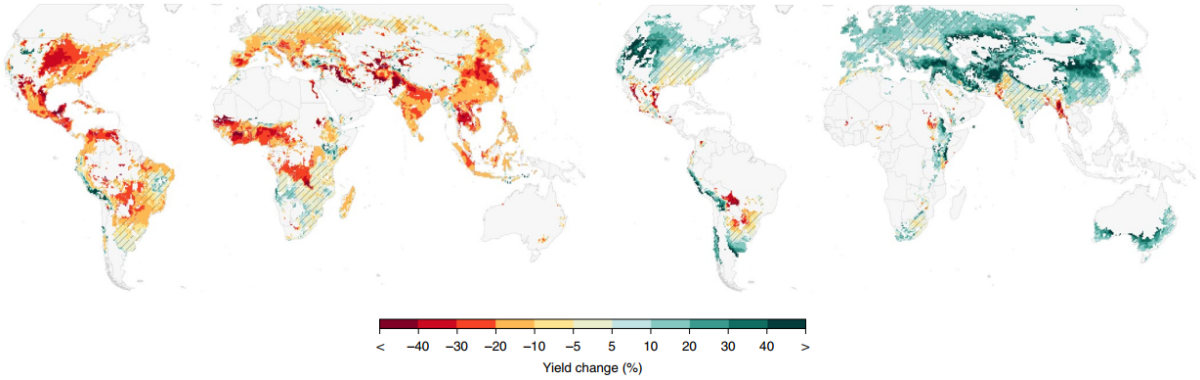

Figure 4: Median changes in yield for wheat and maize projected under the Shared Socioeconomic Pathway 5-8.5 (SSP585) scenario, considering various climate and crop models for the current cultivation areas [6]

decreased yields due to climate change. In contrast, wheat, predominantly consumed in wealthier states, is likely to benefit from increased yields. This stark contrast in the fortunes of these two crucial crops underlines the divide between the global north and south, further exacerbating existing socio-economic disparities on a global scale.

Conclusion

The disproportionate impacts of climate change on agriculture in different regions underscore a critical global inequity. This paper has highlighted how the global south, with its reliance on agriculture and limited adaptive capacity, is disproportionately affected by the climatic changes, especially in terms of food security and economic stability. The global north, despite being a major contributor to the causes of climate change, has been less affected and even benefited in some aspects, thereby widening the gap between the two hemispheres.

Therefore, it is indispensable to acknowledge and address these growing inequalities through global policy and action. Climate change mitigation and adaptation strategies must incorporate equity considerations, ensuring that the needs and challenges of the most vulnerable are prioritized.

This research emphasizes the need for a holistic approach to climate action, one that integrates environmental, economic, and social justice considerations. It is not only a matter of environmental policy but a question of global equity and justice.

References

[1] Our World in Data. *CO2 Emissions Dataset: Our Sources and Methods — ourworldindata.org*. Accessed 02-02-2024. 2022. URL: https://ourworldindata.org/co2-dataset-sources.

[2] Hoesung Lee et al. *IPCC, 2023: Climate Change 2023: Synthesis Report, Summary for Policymakers. Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, H. Lee and J. Romero (eds.)]. IPCC, Geneva, Switzerland.* Technical Report 10.59327/IPCC/AR6-9789291691647.001. Please access report for extended list of writing team, editors, scientific steering committee and other contributing authors. Geneva, Switzerland: Intergovernmental Panel on Climate Change (IPCC), 2023, pp. 1–34.

[3] Laura Pereira. *Climate Change impacts on agriculture across Africa*. Oxford University Press, Mar. 2017.

[4] Melissa Dell, Benjamin F Jones, and Benjamin A Olken. "Temperature shocks and economic growth: Evidence from the last half century". en. In: *Am. Econ. J. Macroecon.* 4.3 (July 2012), pp. 66–95.

[5] Sebastian Bathiany et al. "Climate models predict increasing temperature variability in poor countries". en. In: *Sci. Adv.* 4.5 (May 2018), eaar5809.

[6] Jonas Jägermeyr et al. "Climate impacts on global agriculture emerge earlier in new generation of climate and crop models". In: *Nature Food* 2 (Nov. 2021), pp. 1–13. DOI: 10.1038/s43016-021-00400-y.

[7] Noah S Diffenbaugh and Marshall Burke. "Global warming has increased global economic inequality". en. In: *Proc. Natl. Acad. Sci. U. S. A.* 116.20 (May 2019), pp. 9808–9813.

[8] Marshall Burke, Solomon M Hsiang, and Edward Miguel. "Global non-linear effect of temperature on economic production". en. In: *Nature* 527.7577 (Nov. 2015), pp. 235–239.

[9] World Bank. *Agriculture, forestry, and fishing, value added*. [Accessed 02-02-2024]. 2023. URL: %5Curl %7Bhttps://data.worldbank.org/indicator/NV.AGR.TOTL.ZS/%7D.

[10] Bruce A Kimball. "Crop responses to elevated CO2 and interactions with H2O, N, and temperature". en. In: *Curr. Opin. Plant Biol.* 31 (June 2016), pp. 36–43.

[11] S Asseng et al. "Rising temperatures reduce global wheat production". en. In: *Nat. Clim. Chang.* 5.2 (Feb. 2015), pp. 143–147.

[12] Florian Zabel et al. "Large potential for crop production adaptation depends on available future varieties". en. In: *Glob. Chang. Biol.* 27.16 (Aug. 2021), pp. 3870–3882.