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THE SOCIAL AND ECONOMIC FACE OF CLIMATE CHANGE: ANALYZING THE BRAZIL CASE

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Abstract: Climate change is intricately linked to the economic, social, and political systems. Therefore, it cannot be treated as an isolated problem but rather as a symptom of an unsustainable development model. By relating and understanding the socioeconomic aspects of this challenge, it is possible to obtain a complete view of the climate crisis. For this reason, understanding climate change as an interconnected phenomenon is essential to finding effective and equitable solutions, especially in countries such as Brazil. This article briefly reviews the topic, seeking to connect the impacts and offer the reader a broader view of this phenomenon.

Keywords: Socioeconomic impacts; Greenhouse gas emissions; Deforestation; Sustainable development; Migration and displacement; Agricultural losses; Public policy

1. Introduction

Climate variations are linked to solar radiation, rain, wind, Earth's orbital movements, and other natural phenomena. However, the climate change phenomena we face are mainly caused by the increase in greenhouse gas (GHG) concentration in the contemporary world [1]. The role of CO_2, as well as the greenhouse effect itself, has been debated extensively in recent decades due to their association with climate variations and the profound impacts caused by the increase in CO_2 and greenhouse gases.

In Brazil, only in 2023, the country emitted approximately 2.3 billion tons of carbon dioxide equivalent ($GtCO_2e$), making it the fifth largest emitter of greenhouse gases globally [2]. This fact represents a threat to economic growth and social development, as it directly affects the climate, natural resources, and populations in different regions of the world. This index helps the public sector identify vulnerabilities and the readiness of efficient responses to the country's challenges associated with climate change impacts [3].

For this reason, climate change is generally treated as an environmental issue that goes beyond ecological limits and is deeply correlated with society. Its impacts must be

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analyzed beyond extreme natural phenomena, such as droughts, floods, fires, and even hurricanes, directly affecting the lives of billions of people. Unfortunately, without a significant reduction in greenhouse gas emissions, natural disasters of greater magnitude are expected, which would bring serious problems to the food supply, public health, commerce, industry, national security, and the general population's life quality [4].

Unfortunately, the last two years in Brazil (2023 and 2024) have been marked by three significant floods in Rio Grande do Sul, including the most extensive one ever recorded in Brazilian history [5]. Also, two consecutive record droughts were observed in the Amazon [6]. The worst drought in the country's record occurred in 2024, leaving 60% of the Brazilian territory covered with smoke and reiterating the urgency of tackling climate change [7].

The social effects caused by climate change are not the same in every society. People considered vulnerable, such as indigenous communities, kids, the elderly, small farmers, and residents of coastal areas, are suffering disproportionate impacts in terms of health, food security, and access to resources. Increases in average temperature are expected throughout the country, with the most severe increases in the central and northern parts [8]. The relationship between social inequalities and climate change is complex and interconnected, forming a vicious cycle that intensifies the challenges the most vulnerable populations face [9].

Brazil has had a harmful relationship with environmental and climate policy by ignoring the effects of climate change and encouraging an exploitative economic model within ecological protection areas. For this reason, this work can contribute to reflections on how climate change affects the general population's lives more than one might imagine. Due to significant political changes that occurred in Brazil, the data presented in this review covered the period from 2020 to 2024 [10].

2. Economic impacts

The relationship between economic growth and carbon emissions is a complex issue, especially in the Brazilian context. The country's economic development has historically been strongly linked to expanding carbon-intensive sectors, such as industry, agriculture, and fossil fuel-based energy generation. Brazil is among the 18 countries with the highest economic losses from climate disasters [11]. On the other side, most countries that emit GHG into the atmosphere have large populations and economies. These countries account for more than 50% of the global population [12].

The Brazilian economy is complex, dynamic, and heavily dependent on the agricultural sector. This dependency generates conflicting demands between environmental priorities and agricultural sector priorities. There is a shared debate about the needs of the

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agricultural sector, the public policies to mitigate greenhouse gas emissions, and the adaptations that this sector should attain to fight climate and environmental changes [4].

Brazilian industrialization, which has driven economic growth in recent decades, has been associated with a significant increase in greenhouse gas emissions, mainly due to burning fossil fuels to generate energy and produce consumer goods. However, unlike other countries that emit GHG, the sector responsible for the most significant emissions in Brazil is related to soil use due to deforestation, mainly from the Amazonia Rainforest [13], and plant burning.

For this reason, Brazil pollutes more than it produces wealth since its GHG emissions are not directly linked to economic growth [1,2]. The greatest greenhouse gas emissions are linked to fires and environmental deforestation. In 2023, all economic sectors, except soil use and change, increased their GHG emissions. This increase was followed by an economic recovery, showing a 2.9% increase in the Gross Domestic Product (GDP) compared to the previous year [2].

Despite the reduction in emissions in the soil use sector (24% lower than in 2022), the devastation of Brazilian ecosystems emitted 1.04 $GtCO_2e$ gross in 2023. According to Tsai and collaborators, if the deforested land in Brazil were a country, it would be considered the eighth most significant emitter of GHGs, behind countries such as Japan and Iran. The intersection of GDP with emissions shows that deforestation is still primarily considered criminal, speculative, and disconnected from the real economy, distorting the GHG's national emissions curve [2].

This fact doubles the amount of carbon per dollar generated in the economy. For example, if the soil use sector were not included in this equation, Brazil would have emitted approximately 0.31 $KgCO_2e$ per dollar in 2023. Including deforestation in the equation raises the GHF emissions by 0.26 Kg per dollar [2].

Brazil, a country of continental proportions, has distinct trajectories and patterns of land use and occupation in each region. Some areas, such as the South and Southeast, achieve higher scores in sustainability. In contrast, regions such as the North and Northeast are hampered by significant socioeconomic limitations, which intensify inequality between these regions [14]. Energy generation and agriculture are key sectors that are at risk, with potential repercussions for the financial sector. In addition, land use patterns amplify the risks of climate change.

The increase in the length of the dry season and the frequency of droughts, for example, have reduced the resilience of the Amazon against shocks and may have already pushed the Amazon close to a critical threshold of rainforest death, which would affect the economies of thousands of people who depend on fishing and tourism in the region [15]. Some estimates, which are subject to significant uncertainty, quantify the loss of production

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in this region if the Amazon critical point is reached for Brazil at only 10% of GDP from 2022 to 2050), which could have serious social consequences for the region [16].

3. Social Impacts: Social inequality and vulnerability

Social and economic inequality exacerbates vulnerability to climate change, which creates a vicious cycle in which the poorest are the ones who have contributed less to the problem but who suffer the most remarkable consequences. Black, indigenous, and Quilombola populations are the most affected in Brazil, as they generally live in more vulnerable areas [17]. Global food production is expected to decrease by up to 2% over the next decade due to climate change, while global demand for food is expected to increase by up to 14% [18].

These changes affect activities such as fishing, navigation, and water collection for consumption. The impacts on agriculture are multiple and significant. Almost 11 million hectares of land available for planting could be lost due to rising temperatures by 2030 [4]. Climate change could also compromise Brazilian production, causing losses of up to R$14 billion by 2070 [19].

Agriculture, especially wheat and corn crops, is also affected by changes in the hydrological and rainfall systems [20]. Soybeans could be the most affected crop. In the most extreme scenario predicted by the Intergovernmental Panel on Climate Change(IPCC), losses of up to R$7.6 billion could be achieved [19]. Like agriculture, the livestock sector is also affected by climate change, increasing the costs of essential or commonly consumed foods. Changes in rainfall patterns and rising temperatures can lead to a decrease in the nutritional quality of pastures, making them less nutritious for livestock. Rising temperatures can cause heat stress in animals, affecting their health, reproduction, and productivity. The impacts of climate change can lead to a reduction in meat and milk production, affecting producers' income and food security [20].

This disparity between supply and demand is accentuated by climate change and can lead to increased food shortages and malnutrition. If climate change is not contained, it is likely that by 2050, 25 billion children under the age of 5 worldwide will be malnourished, especially in low-income countries [18]. As a result, population migrations are likely to become more intense, especially from less developed regions.

Human migration is considered multi-causal and can be caused by a combination of factors, such as prolonged crises, internal conflicts, socioeconomic factors, health crises, and seasonal factors caused by extreme weather events [21,22]. It is important to emphasize that it is established that climate change is considered a displacement factor and that the impact generated by it will be different depending on the location [22].

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According to the United Nations Organization (2017), around 25 million people are forced to leave their countries each year due to environmental problems such as droughts, floods, storms, and forest fires. By 2050, this number will reach 1 billion people [23]. In 2021, 38 million internal displacements occurred, and nearly 24 million were caused by environmental disasters [18,22].

In Brazil, the lack of adequate living conditions in cities and semi-arid regions has changed into arid regions, which can lead to migratory flows to states' capitals or other wealthier regions. According to Oliveira and collaborators [18], the Northeast is the region that contributes most to the increase in migration within the country, mainly if analyzed in the long term, which would also lead to a loss of well-being for the population that remains in the region. Meanwhile, the Southeast region receives the largest contingent of people from all other Brazilian regions. The Brazilian coastline may be directly impacted by climate change with the rise in sea level. According to projections, due to the rise in sea level, most of the Brazilian capitals will suffer severe damage to their coastal infrastructure and sewage systems. The relationship between per capita greenhouse gas emissions and per capita income in Brazil isn't as straightforward as one might imagine.

As we have seen, climate change's economic impacts are vast and varied, affecting sectors such as agriculture, fisheries, tourism, and infrastructure. Crop losses, extreme weather events, and rising sea levels generate significant costs for national and global economies. By analyzing the economic aspects, we need to develop mitigation strategies to reduce the vulnerability that climate change can cause.

Understanding climate change's social and economic aspects is essential for creating public policies that integrate environmental mitigation, social justice, and sustainable economic development. Brazil increased its climate commitments in 2023, returning to the original goal of the Paris Agreement in 2015, which is an important step forward in addressing climate vulnerabilities and seizing the opportunities of a green transition. Investments in practices such as carbon pricing can internalize the environmental costs of greenhouse gas emissions, incentivizing economic sectors to adopt more sustainable practices. Sustainability-oriented agrarian reform promotes the distribution of land with access to credit, technical assistance, and basic infrastructure. Incentives for reforestation and the bioeconomy, and adaptive social protection to support populations vulnerable to climate change, among others, to integrate these policies into a territorialized approach, considering regional specificities, is essential to promote climate justice and sustainable development in Brazil [15].

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4. Conclusions

This work has shown that effective climate policies must consider each region's specific social and economic contexts since climate change is not only an environmental problem but also a social and economic problem. By understanding social, economic, and environmental interactions, we can develop environmentally sustainable and socially just policies. In Brazil, these policies must effectively combat deforestation, encourage clean energy production, and promote energy efficiency. These policies will help the country better reconcile economic development with environmental protection.

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