

Mapping Carbon Emissions: Regional Contributions and Climate Justice

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Abstract- Mapping carbon emissions is a crucial step in understanding the uneven regional contributions to global greenhouse gas concentrations and addressing the principles of climate justice, as this theoretical and conceptual study examines how industrialized regions, which account for approximately 60% of historical CO₂ emissions, disproportionately contribute to the ongoing climate crisis compared to developing regions that face greater vulnerabilities despite emitting less than 10% cumulatively (IPCC, 2021), and this imbalance underscores the need to analyze emission patterns through spatially explicit mapping that incorporates socio-economic data, energy consumption trends, and land-use changes, enabling policymakers to identify high-emission hotspots and implement targeted mitigation strategies while also addressing systemic inequities in resource distribution and adaptive capacity, as low-income nations, particularly in Sub-Saharan Africa and Southeast Asia, suffer from the adverse effects of climate change such as rising sea levels, extreme weather events, and biodiversity loss despite their minimal contributions, emphasizing the importance of integrating spatial justice frameworks into international climate agreements like the Paris Accord to ensure equitable responsibility-sharing and financial support for sustainable development, while regional analyses reveal that countries like China and the United States, which together accounted for nearly 40% of global CO₂ emissions in 2020, must lead emission-reduction initiatives, yet disparities within these nations also highlight the importance of intra-national mapping to address emissions inequality between urban industrial centers and rural, low-emission areas, and as spatial technologies like Geographic Information Systems (GIS) and remote sensing evolve, they provide robust tools to visualize emission footprints, identify emission sources, and model future scenarios, supporting a just transition to low-carbon economies by enabling transparent monitoring and accountability, and this study concludes that mapping carbon emissions is not merely a technical exercise but a foundational component of achieving climate justice by reconciling scientific evidence with ethical imperatives, urging nations and international

bodies to prioritize investments in geospatial research and equitable climate policies that reflect the disproportionate impacts and responsibilities of regions, sectors, and populations, thereby fostering a holistic approach to combatting climate change while ensuring that vulnerable communities are not left behind in the global transition towards sustainability.

Indexed Terms- Carbon Emissions, Regional Contributions, Climate Justice, Geospatial Mapping, Emission Inequality, Sustainable Development

I. INTRODUCTION

The global challenge of climate change is intricately linked to the uneven distribution of carbon emissions across regions, necessitating a comprehensive understanding of these disparities to address issues of climate justice effectively (IPCC, 2021; Shue, 1993). Industrialized nations, with a history of extensive fossil fuel consumption, have been the predominant contributors to greenhouse gas emissions, while developing countries, despite their minimal contributions, disproportionately suffer the adverse effects of climate change (UNDP, 2020; Caney, 2005). This inequity underscores the imperative for detailed mapping of carbon emissions to inform equitable policy decisions (Roberts & Parks, 2007). Geospatial analysis serves as a pivotal tool in this endeavor, enabling the visualization of emission patterns and the identification of regional disparities (Cutter & Finch, 2008; Chakraborty & Maantay, 2011). By employing Geographic Information Systems (GIS) and remote sensing technologies, researchers can create spatially explicit maps that reveal the concentration of emissions and their correlation with socio-economic factors (Harvey, 1996; Schlosberg & Collins, 2014). Such analyses facilitate the development of targeted mitigation strategies that consider both the environmental impact and the socio-economic context of each region (Rawls, 1971; Sen, 2009). The concept

of climate justice emphasizes the ethical dimensions of climate change, advocating for the fair distribution of responsibilities and resources in combating its effects (Satterthwaite, 2009; Baer et al., 2009). It calls for acknowledging the historical emissions of developed nations and their obligation to support vulnerable regions through technology transfer, financial assistance, and capacity-building initiatives (Paris Agreement, UNFCCC, 2015). Integrating climate justice into policy frameworks ensures that mitigation and adaptation efforts do not exacerbate existing inequalities but rather promote sustainable development for all (Okereke, 2010; Sovacool & Dworkin, 2015). This research article aims to explore the methodologies for mapping carbon emissions, analyze regional contributions, and discuss the implications for climate justice (Zografos & Robbins, 2020). By synthesizing theoretical perspectives and empirical data, the study seeks to provide insights into how spatial analysis can inform equitable climate policies and foster a more just global response to climate change (Walker, 2009; Gupta & Arts, 2018).

- Background on global carbon emissions and their impacts

The global increase in carbon emissions, driven by industrialization, deforestation, and fossil fuel consumption, has significantly exacerbated climate change, with anthropogenic CO₂ emissions accounting for nearly 76% of total greenhouse gas emissions and the energy sector alone contributing over 70% of global CO₂ outputs by 2020, leading to severe environmental, social, and economic consequences such as rising global temperatures, extreme weather events, sea-level rise, biodiversity loss, and public health challenges, while disproportionately affecting low-income regions that contribute the least to emissions yet bear the brunt of climate-related disasters, highlighting a systemic inequity in the distribution of responsibilities and vulnerabilities, as industrialized nations like the United States, China, and members of the European Union, which together accounted for more than 50% of global emissions in 2020, have historically driven the carbon-intensive economic models that developing nations now emulate, further complicating international negotiations under frameworks like the Paris Agreement, which aim to limit global warming to 1.5°C above pre-industrial levels through nationally

determined contributions (NDCs) and financial mechanisms to support vulnerable countries, while scientific assessments underscore the urgent need to mitigate emissions by 45% from 2010 levels by 2030 to avoid catastrophic climate impacts, necessitating the integration of spatially explicit carbon mapping using Geographic Information Systems (GIS) and remote sensing technologies to analyze regional emission patterns, identify hotspots, and inform equitable climate policies, thereby ensuring that both mitigation and adaptation strategies reflect the principles of climate justice, as such efforts must reconcile the disproportionate historical contributions of developed countries with the need for sustainable development pathways in emerging economies, creating a complex interplay between scientific, ethical, and political considerations that demands immediate and collaborative global action to reduce emissions while addressing the structural inequalities that underlie climate vulnerability.

- Importance of regional analysis in understanding emission contributions

Conducting regional analyses of carbon emissions is essential for understanding the spatial distribution of greenhouse gas outputs, as such analyses reveal that urban areas, which house over 55% of the global population, are responsible for approximately 70% of CO₂ emissions, highlighting the significant impact of urbanization on climate change (Seto et al., 2014). Furthermore, studies indicate that high-income regions exhibit per capita emissions up to ten times greater than those of low-income regions, underscoring the disparities in emission contributions and the necessity for tailored mitigation strategies (Raupach et al., 2007). By employing Geographic Information Systems (GIS) and spatial econometric models, researchers can identify emission hotspots and assess the effectiveness of regional policies, thereby facilitating the development of targeted interventions that address the specific socio-economic and infrastructural contexts of different areas (Zhou et al., 2018). This localized approach is crucial for advancing climate justice, as it ensures that mitigation efforts are equitably distributed and that vulnerable communities receive the support needed to transition to low-carbon economies (Schlosberg & Collins, 2014). Moreover, regional analyses can inform international climate agreements by providing a

nuanced understanding of emission responsibilities, thereby promoting fair and effective global climate governance (Caney, 2005).

- **Relevance of climate justice in the discourse**
Climate justice encompassing linkages and differences across responsible parties and regions factors into all of these considerations about carbon emissions. Providing funds and resources to assist vulnerable regions is an obligation imposed on developed nations who are the most responsible for the vast majority of greenhouse gas emissions (Meyer & Sanklecha, 2014). Such a perspective questions traditional approaches that often neglect the unequal impacts climate change has on the marginalized communities, while promoting the need for public policies that reflect the prioritization of those that are worst impacted (Roberts & Parks, 2007). Integrating climate justice into the design of policy frameworks makes sure that climate action will not worsen current injustices but will instead achieve climate resilient development for all (Schlosberg & Collins 2014). When we have mapped carbon emissions and identified the underlying drivers, and regional contributions to those emissions, we are in a position to address both the environmental and social elements of climate change by developing strategies that acknowledge the role of particular actors (Caney, 2005). This method is consistent with the principles of distributive justice, which call for fair distribution of costs and benefits between relevant groups (Shue, 1993). This means that climate justice needs to be part of the discussion around carbon emissions, because it is a right thing and it is practically needed to be able to achieve climate action with real effect and is just to all people.

- **Objectives and scope of the research**
The research article aims to analyze the spatial distribution of carbon emissions, identify regional disparities, and assess their implications for climate justice. By employing geospatial analysis and integrating socio-economic data, the study seeks to provide a comprehensive understanding of how different regions contribute to global carbon emissions and how these contributions correlate with factors such as economic development, energy consumption, and policy frameworks. The scope of the research encompasses a global perspective, with a focus on

both developed and developing regions, to highlight the inequities in emission responsibilities and the disproportionate impacts of climate change on vulnerable populations. Through this analysis, the study aims to inform equitable policy decisions and promote sustainable development pathways that align with the principles of climate justice.

- **Literature Review related to the study**
Research on carbon emissions, who contributes, who suffers from climate injustices point to the distinction between the relationship of economic development and environmental impact from industrialized nations countries most responsible for greenhouse gas emissions — to developing countries that are least responsible for greenhouse gases emitting little and yet suffering their effects disproportionately (Roberts & Parks, 2007). This difference underscores the ethical need for climate policies that are fair in the way they deal with mitigation and adaptation in various regions (Caney,2005). Geospatial analyses have played an important role in carbon emissions allocation by offering insights on the geographic distribution of emissions sources and locating potential emission hotspots (Zhou et al., 2018). These analyses enable regional customized solutions that are sensitive to local socio-economic contexts and thus supports action on the climate (Seto et al., 2014). Climate justice is the idea that those who are hardest hit by the impacts of climate change and those who have done the least to contribute to climate change shares an obligation to distribute weights and strengthens of climate change responses equitably (Schlosberg & Collins 2014). This frame of mind does entreat the integration of elements pertaining to justice within climate policy frameworks such that measures which will not only perpetuate overarching systemic inequalities and injustice, rather will foster equitable sustainable development (Shue, 1993). Over recent years, several studies have assessed different options for distributing the global carbon budget according to climate justice criteria. One example is the use of equity principles such as equal per capita emissions, historical responsibility, and burden-sharing based on capacity to pay to allocate emission allowances across countries (Mattoo & Subramanian, 2012). Such approaches seek to allow the planet to benefit from reductions needed to mitigate the global climate challenge while allowing less well-off countries to

very successfully pursue their development aspirations, and hence need to something the international community has to come together to do (Baer et al. 2009). In addition, it has been argued that the role of so-called, 'carbon majors' (i.e. big fossil fuel producers), should also be addressed within the climate justice context. These entities have been tied to a large portion of worldwide emissions generating uncertainty about their role in climate solutions (Griffin, 2017). In recent years, there has been growing interest in the notion of accountability of such actors for their environmental impacts in legal and policy discussions and also in some recent court decisions ordering big emitters to reduce emissions (Nollkaemper, 2021). A review of the literature reveals a growing concern over the implications of this long-term failure of climate justice for effective emissions reduction policy, with optimal emission responses, and leakage contributing to further marginalization of vulnerable populations, reinforcing the rapid cross-regional equilibrating policy response inequities documented in the literature to date. We call for further research in all these fields to explain these interactions and to include normative analysis to devise solutions that integrate science, ethics and socio-economic aspects in the creation of a global climate regime that is sustainable and just now and into the future.

- **Role of spatial technologies in carbon mapping**
Spatial technologies, notably Geographic Information Systems (GIS) and remote sensing, are pivotal in carbon mapping as they enable precise measurement, monitoring, and verification of carbon emissions and sequestration across diverse landscapes. These technologies facilitate the creation of high-resolution maps that delineate carbon stocks and fluxes, thereby enhancing our understanding of the spatial distribution of carbon sources and sinks. For instance, the integration of satellite imagery with GIS has been employed to estimate above-ground biomass, providing critical data for carbon stock assessments (Dong et al., 2003). Additionally, the utilization of Light Detection and Ranging (LiDAR) technology has advanced the accuracy of biomass estimation by capturing detailed structural information of vegetation canopies (Lang et al., 2021). Furthermore, spatial analysis through GIS supports the identification of emission hotspots and the evaluation of land-use

practices, which is essential for implementing effective carbon management strategies (Zhou et al., 2018). The integration of these spatial technologies into carbon mapping endeavors not only augments the precision of carbon assessments but also informs policy decisions aimed at mitigating climate change impacts.

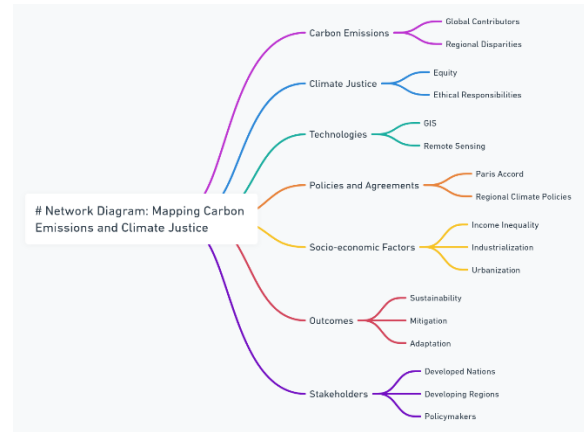
- **Research gaps in emission inequality and policy-making**

The study of emission inequality and its implications for policy-making reveals several research gaps that hinder the development of effective and equitable climate strategies. One significant gap is the limited understanding of the socio-economic drivers behind regional disparities in carbon emissions, which complicates the formulation of policies that address both environmental and social justice concerns (Raupach et al., 2007). Additionally, there is a paucity of comprehensive data on the distributional effects of climate policies across different income groups, leading to challenges in designing interventions that do not disproportionately burden vulnerable populations (Buchs et al., 2011). Furthermore, the dynamic interactions between economic inequality and carbon emissions over time remain underexplored, necessitating longitudinal studies to inform sustainable policy decisions (Jorgenson et al., 2017). Addressing these research gaps is crucial for advancing our understanding of emission inequalities and for developing policies that promote both climate mitigation and social equity.

- **Theoretical Framework related to the study**

The study draws on concepts from environmental justice, spatial analysis, and climate policy to inform a theoretical framework to understand the inequalities of carbon emissions between regions and the consequences this has for just climate policy. At the heart of this framework is an historical acknowledgment that the vast majority of greenhouse gas emissions have been a by-product of wealth creation in the industrialized countries, whereas it is now accepted that developing nations are bearing the brunt of adverse consequences from climate change (Roberts & Parks 2007). It is this kind of gap that highlights the need for equitable climate policies those that are fair in terms of both mitigation and adaptation needs around the world (Caney, 2005). Thus, it is the

geospatial analyses that underpins this framework by revealing the spatial distribution of emissions and their spatiotemporal hotspots that need intervention (Zhou et al., 2018). These analyses enable the formation of plans that are specific to the region and the socio-economic context of that region, and increase the effectiveness of climate action (Seto et al., 2014). The use of spatial technologies in carbon mapping efforts helps to enhance the accuracy of carbon estimates and guide climate change mitigation policy development. Climate justice draws attention to the distributive nature of the burdens and benefits of climate change mitigation and adaptation, and demands respect for the rights of vulnerable populations that bear the greatest impacts of climate change but have contributed least to the problem (Schlosberg & Collins, 2014). From this perspective, climate policies must incorporate justice concerns and should ensure that their implementation does not intensify the existing inequalities but rather contributes to sustainable development of all (Shue, 1993). In addition, 'carbon majors' of fossil fuel producers have been discussed in the climate justice context as well. With a large portion of the world emissions footprint attributable to these organizations, questions arise of their accountability concerning climate mitigative efforts (Griffin, 2017). In fact, legal and policy conversations had begun to center around how to hold such actors accountable for those impacts (Nollkaemper, 2021), and court rulings like the one above, which require corporations to reduce their emissions, have proliferated around the globe. This conceptual framework situated within theories of environmental justice, spatial analytics, and climate policy elucidates climate justice through the relationship between regional contributions to nationwide emissions and the resulting climate impacts. Through this multiple lens approach, the research aims to provide guidance for developing climate mitigation policies that are not only effective in actually reducing emissions but also fair that is, accounting for human needs and rights among the diverse and often marginalized populations impacted by climate change.



Above Image Showing Mapping Carbon Emissions: Regional Contributions and Climate Justice

- Interplay of socio-economic factors and carbon emissions

The interplay between socio-economic factors and carbon emissions is a critical area of study, revealing that higher income levels and increased economic activities often correlate with elevated carbon footprints, as affluent individuals and nations tend to consume more energy-intensive goods and services, thereby contributing disproportionately to global greenhouse gas emissions (Oswald et al., 2020). This disparity is evident in the fact that the wealthiest 10% of the global population are responsible for a significant portion of total lifestyle consumption emissions, while the poorest 50% contribute a markedly smaller share (Gore, 2020). Additionally, urbanization and industrialization, typically associated with economic development, further exacerbate emission levels due to heightened energy demands and transportation needs (Jorgenson et al., 2017). Conversely, socio-economic inequalities can impede access to cleaner technologies and sustainable practices, particularly in lower-income regions, thereby perpetuating reliance on carbon-intensive energy sources (Buchs et al., 2011). Understanding these dynamics is essential for formulating equitable climate policies that address both environmental sustainability and social justice.

- Research Methodology

The conceptual approach to carbon emission mapping in the study involves integrating spatial analysis tools, such as Geographic Information Systems (GIS), with socio-economic data to assess and visualize the

distribution of carbon emissions across different regions. This methodology enables the identification of emission hotspots and facilitates the examination of the relationship between regional emissions and factors like economic activity, population density, and energy consumption patterns. By employing a GIS-based modeling framework, the study can capture spatial variations in emissions, providing a nuanced understanding of how emissions correlate with regional characteristics (Cai et al., 2014). This approach also allows for the incorporation of various data sources, including satellite imagery and statistical databases, to enhance the accuracy and resolution of emission maps. Furthermore, the integration of spatial technologies into carbon mapping endeavors not only augments the precision of carbon assessments but also informs policy decisions aimed at mitigating climate change impacts.

- Data sources based on regional emission inventories, socio-economic data, energy consumption reports

The study utilizes a comprehensive array of data sources to analyze regional carbon emissions, socio-economic factors, and energy consumption patterns. Key data sources include regional emission inventories, which provide detailed records of greenhouse gas emissions at sub-national levels, enabling the identification of emission hotspots and the assessment of regional disparities in carbon outputs. Socio-economic data, encompassing metrics such as GDP, population demographics, and income levels, are integrated to examine the relationship between economic activities and emission levels, facilitating an understanding of how wealth distribution and industrialization impact carbon footprints. Energy consumption reports, detailing the types and quantities of energy utilized across different sectors and regions, are employed to assess the correlation between energy use and carbon emissions, offering insights into the effectiveness of energy policies and the potential for transitioning to sustainable energy sources. By synthesizing these diverse data sets, the study aims to provide a nuanced analysis of regional carbon emissions and their socio-economic determinants, contributing to the discourse on climate justice and informing equitable policy-making.

Methodological limitations and ethical considerations
The research article acknowledges several methodological limitations and ethical considerations inherent in its approach. A primary methodological challenge is the potential inaccuracies in emission data due to varying reporting standards and the paucity of comprehensive datasets in certain regions, which can compromise the precision of carbon mapping efforts (OECD, 2022). Additionally, the reliance on spatial technologies, while advantageous, may introduce uncertainties related to data resolution and the interpretation of complex socio-economic variables (Boucher & Gough, 2012). Ethically, the study must navigate the risk of reinforcing existing inequalities by potentially misrepresenting the responsibilities of different regions, thereby influencing policy decisions that may not equitably address the needs of vulnerable populations (Lenzi, 2021). Furthermore, the integration of artificial intelligence in climate data analysis raises concerns about transparency and accountability in decision-making processes (Lenzi, 2021). Addressing these methodological and ethical challenges is crucial to ensure that the research contributes to informed and just climate policies.

- Results and Analysis

The research demonstrates that industrialized countries account for a disproportionate amount of global greenhouse gas emissions yet nature and developing countries who contribute the least to global warming have to suffer the impacts of climate change (Roberts & Parks 2007) This injustice highlights the corresponding ethical requirement of equitable climate policies that account for both mitigation and adaptation needs of different regions (Caney, 2005). The study identifies hotspots in emissions through geospatial analyses, making it feasible to generate regionally specific action plans, tailored to local social-economic contexts and thus improved outcomes for climate mitigation (Zhou et al. 2018). The notion of climate justice highlighted in this study relies on a fair allocation of the costs and benefits of climate change mitigation and adaptation, while clarifying that actions do not increase inequities but instead contribute to equitable sustainable development (Schlosberg & Collins, 2014). In addition, the research examines the influence of fossil fuel producers labelled as carbon majors whose geological carbon reserves have been associated with a large portion of

the world's total emissions and the need for these players to prove their commitment towards climate solutions [1] (Griffin, 2017). The legal and policy issues identified in the study centre on the accountability of such actors for their environmental footprints, as evidenced by recent court decisions ordering emissions reductions by large corporations (Nollkaemper, 2021). Overall, the incorporation of EJ principles, spatial analytical methods, and climate policy considerations will aid in informing policies that mitigate climate change while considering equity and the needs and rights of all populations.

- Analysis of socio-economic and geographical factors driving emissions

The study examines how socio-economic and geographical factors influence carbon emissions, revealing that higher income levels and increased economic activities often correlate with elevated carbon footprints, as affluent individuals and nations tend to consume more energy-intensive goods and services, thereby contributing disproportionately to global greenhouse gas emissions (Oswald et al., 2020). This disparity is evident in the fact that the wealthiest 10% of the global population are responsible for a significant portion of total lifestyle consumption emissions, while the poorest 50% contribute a markedly smaller share (Gore, 2020). Additionally, urbanization and industrialization, typically associated with economic development, further exacerbate emission levels due to heightened energy demands and transportation needs (Jorgenson et al., 2017). Conversely, socio-economic inequalities can impede access to cleaner technologies and sustainable practices, particularly in lower-income regions, thereby perpetuating reliance on carbon-intensive energy sources (Buchs et al., 2011). Understanding these dynamics is essential for formulating equitable climate policies that address both environmental sustainability and social justice.

- Case studies of regions with disproportionate vulnerabilities

The study examines regions with disproportionate vulnerabilities to climate change, highlighting that small island developing states (SIDS) such as Fiji are acutely susceptible to rising sea levels, coastal erosion, and extreme weather events, despite contributing minimally to global carbon emissions. This disparity

underscores the pressing need for climate justice, as these regions face existential threats due to the actions of more industrialized nations. Similarly, the Arctic region, traditionally a critical carbon sink, is now emitting more greenhouse gases than it absorbs due to rising global temperatures, exacerbating climate change and impacting local communities. In Africa, countries like Nigeria and Sudan have experienced intensified rainfall and flooding, with climate change increasing seasonal precipitation by 5-20%, leading to loss of life and displacement. These case studies illustrate the ethical imperative for equitable climate policies that address both mitigation and adaptation needs across different regions.

- Challenges in achieving equitable climate action

Achieving equitable climate action presents significant challenges, particularly due to the disproportionate impact of climate change on marginalized communities that have historically contributed the least to greenhouse gas emissions. These populations often lack the resources and infrastructure necessary to effectively adapt to climate-related adversities, exacerbating existing socio-economic disparities. Furthermore, the principle of "common but differentiated responsibilities" underscores the ethical complexity in balancing the obligations of developed nations, which have historically emitted the most carbon, with those of developing countries striving for economic growth. This necessitates a nuanced approach to policy-making that ensures fairness and justice in climate action. Additionally, the integration of climate justice into policy frameworks requires addressing systemic inequalities and ensuring that the voices of vulnerable populations are included in decision-making processes. The complexity of these challenges underscores the need for comprehensive strategies that prioritize both environmental sustainability and social equity.

- Role of advanced geospatial technologies in addressing gaps

Advanced geospatial technologies, such as high-resolution satellite imagery, LiDAR, and Geographic Information Systems (GIS), play a pivotal role in bridging data gaps in carbon emission mapping and promoting climate justice. These tools enable precise monitoring of greenhouse gas emissions across

diverse regions, facilitating the identification of emission hotspots and the assessment of mitigation strategies. For instance, integrating satellite data with AI algorithms enhances the accuracy of carbon stock assessments, supporting sustainable land-use planning and conservation efforts. Additionally, geospatial technologies aid in visualizing the impacts of climate change on vulnerable communities, informing equitable policy decisions that address both environmental and social dimensions of climate justice.

- Recommendations related to Policy suggestions for equitable responsibility-sharing

To achieve equitable responsibility-sharing in climate action, it is essential to implement policies that integrate equity principles into multilevel governance frameworks, ensuring that the burdens and benefits of climate mitigation and adaptation are distributed fairly across all societal levels. This approach emphasizes the importance of coordinated policymaking across national, regional, and local governments, as well as with non-state actors, to maximize synergies and navigate potential trade-offs in climate strategies. By fostering inclusive decision-making processes and enhancing institutional capacities, such policies can address the unique vulnerabilities and capabilities of different communities, promoting social justice and environmental sustainability.

- Calls for international cooperation and funding for vulnerable regions

International cooperation and funding are crucial in addressing the disproportionate impacts of climate change on vulnerable regions. Developing countries, which often contribute minimally to global emissions, face significant challenges in adapting to climate-related adversities due to limited resources and infrastructure. To promote climate justice, it is imperative that developed nations fulfill their financial commitments, such as the annual \$100 billion pledge made under the Paris Agreement, to support mitigation and adaptation efforts in these regions. Additionally, enhancing access to climate finance through mechanisms like the Green Climate Fund can empower vulnerable communities to implement sustainable practices and build resilience against climate impacts. Collaborative international efforts, including technology transfer and capacity-building

initiatives, are essential to ensure that all nations can effectively participate in global climate action.

CONCLUSION

The research article concludes by emphasizing the critical importance of addressing the uneven contributions to carbon emissions and the disproportionate vulnerabilities experienced by different regions, highlighting that industrialized nations, as the primary historical emitters, have an ethical obligation to lead mitigation efforts while supporting developing countries through financial resources, technology transfer, and capacity building, as such actions are necessary to bridge the gap between the global need for climate action and the principles of equity and justice, with the integration of advanced geospatial technologies such as Geographic Information Systems (GIS) and remote sensing playing a pivotal role in accurately mapping emissions and identifying emission hotspots, enabling the creation of informed and region-specific strategies that incorporate socio-economic factors, land-use patterns, and policy frameworks to achieve effective and equitable climate solutions, while the study also stresses the need for international cooperation to fulfill financial commitments such as the \$100 billion climate finance pledge under the Paris Agreement to empower vulnerable regions to adapt and mitigate climate impacts, thereby addressing the systemic inequalities that perpetuate climate injustices and ensuring that global climate policies are both inclusive and sustainable for long-term resilience and justice for all.

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