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Comparative Analysis of Climate Policies in Kerala and Sikkim: Alignment with the IPCC Reports

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Abstract : *Climate change presents a complex and evolving challenge that necessitates region-specific policy responses grounded in global scientific knowledge. This research paper offers a detailed comparative analysis of the climate policies of Kerala and Sikkim, two Indian states with distinct geographical and ecological contexts. The study examines how their climate action plans align with the Intergovernmental Panel on Climate Change (IPCC) guidelines, focusing on mitigation and adaptation strategies. The analysis highlights the strengths and gaps in each state's policy framework and proposes measures to enhance alignment with IPCC recommendations. The study is rooted in a descriptive research methodology, drawing insights from academic articles, government reports, and international research publications.*

Key words: *Climate policies, Kerala, Sikkim, IPCC, Mitigation, Adaptation Strategies.*

Introduction

Climate change is one of the most pressing global crises, affecting ecosystems, human societies, and economies worldwide. While international frameworks like the Paris Agreement and IPCC reports provide a blueprint for climate action, the success of these measures relies heavily on localized implementation. Regional governments must tailor global guidelines to their unique vulnerabilities, natural resources, and socio-economic contexts. India, a country with diverse landscapes and climatic conditions, experiences a wide range of climate-induced challenges. From rising sea levels and extreme weather events to glacial retreat and biodiversity loss, the country's states face unique risks that necessitate state-specific policy responses. Kerala, with its extensive coastline, and Sikkim, nestled in the Eastern Himalayas, face contrasting yet equally severe climate risks. Kerala contends with rising sea levels, extreme rainfall, and coastal erosion, while Sikkim grapples with glacial retreat, water scarcity, and biodiversity loss. Understanding how these states adapt global policy recommendations to local realities provides valuable insights for strengthening sub national climate action.

Objectives

The objectives of this research paper include:

a) To analyze and compare the climate action plans of Sikkim and Kerala in terms of their adaptation and mitigation strategies.

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b) To evaluate the extent to which the state-level climate policies align with the global framework outlined in the IPCC Sixth Assessment Report.

c) To identify the administrative and political barriers that influence the implementation of climate action plans in both states and suggest potential policy improvements.

Locational Setting

Kerala, located in the south-western part of India, is characterized by its lush greenery, tropical monsoon climate, and intricate network of backwaters. The state experiences heavy rainfall, making it susceptible to floods, landslides, and coastal erosion. Its biodiversity-rich ecosystems are under constant threat from deforestation, unregulated tourism, and infrastructure development.

On the other hand, Sikkim, a small state in the eastern Himalayas, is known for its mountainous terrain, dense forests, and glacial landscapes. Sikkim is situated in the eastern Himalaya between 88° 03' – 88°57' E longitudes and 27°03' – 28°07' N latitudes. It is a small mountain state bounded by Tibet on north, Nepal on west, Bhutan on east and West Bengal on south. The state is highly vulnerable to glacial melt, landslides, and unpredictable weather patterns, which threaten its fragile ecosystems and rural livelihoods. The contrasting geographical and climatic conditions of these states shape the nature and focus of their respective climate policies, influencing their approaches to risk management, conservation, and sustainable development.

Literature Review

Bawa and Ingty (2023) synthesize climate change in the Sikkim Himalayas, highlighting significant impacts on biodiversity, water resources, and local livelihoods. Their research emphasizes the importance of integrating local community observations and traditional ecological knowledge with scientific models to build comprehensive adaptation frameworks. The study underscores the need for systematic climate data collection to better understand current and future impacts.

Jogesh and Dubash (2023) analyze the development of Sikkim's climate action plan, noting the role of proactive political leadership and bureaucratic engagement in scaling up adaptation programs. They highlight how the plan leveraged national schemes like MGNREGA to enhance water security and green initiatives. However, the authors stress that ongoing policy evolution and continuous learning are crucial for long-term success.

Azhoni and Goyal (2023) conduct a stakeholder network analysis, unravelling the complexities of perceiving climate impacts and implementing adaptation strategies. Their findings reveal misalignments between policymaker intentions and on-ground realities, highlighting barriers like limited institutional capacity, funding constraints, and knowledge gaps. The study calls for stronger collaboration between government bodies, researchers, and local communities to bridge these divides.

Jogesh and Paul (2023) evaluate state climate action plans across India, noting their value in decentralizing national efforts but criticizing their fragmented implementation. They argue that without stronger integration into state governance and budgetary processes, these plans risk remaining isolated policy exercises rather than dynamic, evolving strategies.

Tambe and Arrawatia (2023) document Sikkim's ongoing initiatives to mainstream climate adaptation into development planning. Their work highlights multi-sectoral institutional mechanisms, village-level consultations, and the state's commitment to continuous capacity building as critical enablers of climate resilience.

Research Methodology

This study employs a qualitative research design with a document-based comparative analysis approach. The research relies exclusively on secondary data sources. Key documents include the official climate action plans of Sikkim and Kerala, the IPCC's Sixth Assessment Report, and policy briefs from national and international climate bodies. Supplementary materials are drawn from scholarly articles, government reports, and credible publications that analyze regional climate vulnerabilities, policy impacts, and adaptation pathways. Comparative analysis is used to contrast the approaches of Sikkim and Kerala, evaluating their policy choices against the global best practices outlined by the IPCC. Such qualitative insights would offer a richer understanding of the community-policy disconnect and inform participatory policy design.

Data Limitations and Implications for Future Research

The study's reliance on secondary data may limit the ability to capture recent, unpublished policy changes or ground-level realities. Additionally, policy effectiveness can be influenced by factors not fully documented in available literature, necessitating cautious interpretation of findings.

a) *Ground-Level Stakeholder Surveys and Interviews*

   Future research could involve conducting structured interviews and focus group discussions with local farmers, forest-dependent communities, and grassroots governance bodies. This would help capture perceptions of climate change, barriers to adaptation, and the efficacy of current state interventions from the community's perspective.

b) *Climate-Resilient Agricultural Practice Assessments*

   Primary data can be collected through farm-level surveys assessing the adoption of climate-resilient crops, organic methods, and water-saving technologies introduced under the Sikkim SAPCC. This can be supplemented with crop yield and income data to evaluate the effectiveness of adaptation strategies.

The qualitative insights in this paper would offer a richer understanding of the community-policy disconnect and inform participatory policy design.

Summary of IPCC Climate Report

Human activities, principally through emissions of greenhouse gases, have unequivocally caused global warming, with global surface temperature reaching 1.1°C above 1850-1900 in 2011-2020. Global greenhouse gas emissions have continued to increase, with unequal historical and ongoing contributions arising from unsustainable energy use, land use and land-use change, lifestyles and patterns of consumption and production across regions, between and within countries, and among individuals. (IPCC AR6)

Mitigation Strategies: The IPCC emphasizes the need for immediate, deep, and sustained greenhouse gas emission reductions to limit global warming to 1.5°C or 2°C. Key mitigation strategies include transitioning to renewable energy, promoting energy efficiency, adopting low-carbon technologies, and protecting natural carbon sinks like forests and wetlands. The report stresses that delaying mitigation increases future costs and the risk of irreversible climate impacts. It highlights the importance of sustainable agriculture, reducing methane emissions, and transitioning to circular economies to lower emissions across sectors.

Adaptation Strategies: Adaptation is essential to protect communities and ecosystems from unavoidable climate impacts. The IPCC recommends ecosystem-based adaptation (like wetland restoration and afforestation), disaster risk reduction (early warning systems, resilient infrastructure), and sustainable water and food systems. The report underscores the value of local and indigenous knowledge in designing effective adaptation strategies and warns against maladaptation, where poorly planned measures can worsen vulnerabilities. Effective adaptation requires integrating climate risks into urban planning, public health systems, and natural resource management.

Policy Frameworks: The IPCC advocates for comprehensive policy frameworks that integrate mitigation and adaptation with sustainable development goals. It recommends cross-sectoral coordination, stakeholder engagement, and science-based decision-making. Policies should promote climate finance, encourage private sector investment, and ensure equitable resource distribution to protect vulnerable populations. The report highlights the need for international cooperation, capacity building, and continuous policy evaluation to keep pace with evolving climate science.

Major Focus in Kerala's Climate Action Plan

Kerala's State Action Plan on Climate Change outlines a comprehensive set of adaptation measures aimed at reducing the state's vulnerability to climate change across various sectors.

Agriculture: The plan focuses on climate-resilient agriculture, promoting sustainable practices and crop diversification to withstand changing rainfall patterns and extreme weather events. Measures include enhancing production practices, minimizing post-harvest losses, and strengthening the capacities of local institutions like Krishi Bhavans, markets, and insurance providers.

Livestock: The adaptation strategies here aim to reduce climate stress on animals through improved nutrition, safe housing, disease management, and breeding programs. These measures not only boost livestock productivity but also help lower the emission intensity of milk production and create circular economy opportunities, like converting waste into animal or fish feed.

Coastal Fisheries: Given Kerala's extensive coastline, adaptation actions target enhancing both coastal and inland aquaculture, building climate-resilient coastal villages, diversifying fisherfolk income sources, and improving post-harvest infrastructure to mitigate losses from extreme weather events and rising sea levels.

Forests and Biodiversity: The plan aims to improve biodiversity, control invasive species, manage forest fires, and mitigate human-wildlife conflicts. It suggests afforestation, conservation of native species, and capacity building for forest management as key components to enhance resilience.

Health: In vulnerable districts, healthcare infrastructure is to be strengthened with early warning systems for disease outbreaks, improved emergency services, and better waste management. This ensures communities can better respond to climate-induced health risks like vector-borne diseases and extreme heat events.

Water Resources: The plan proposes interventions to enhance water storage capacity, improve irrigation coverage, and develop sustainable drainage systems. It also suggests establishing a Water Resource Information System for better monitoring and decision-making.

Disaster Risk Reduction and Local Governance

Embedding disaster risk management into development plans, updating infrastructure standards, and facilitating climate-informed actions at the local government level are critical components. The plan envisions local action plans and community-based climate monitoring programs to bolster resilience at the grassroots level.

Ecosystem-Based Solutions

For coastal and riverbank protection, the plan advocates for nature-based solutions like mangrove afforestation, beach nourishment, and offshore reefs, while minimizing the use of hard infrastructure.

Barriers in Implementation of Climate Policies in Kerala State

Kerala faces several hurdles in implementing its climate action policies, despite its strong commitment to sustainability and resilience.

Administrative Barriers

Funding and Financial Constraints:

The state requires substantial financial resources to implement its adaptation projects

— approximately INR 38,407 crore over eight years. Limited access to funds, competing priorities, and the lack of a fixed percentage of finance dedicated to climate change within existing program budgets hinder progress. While the state can leverage national and international funds (like the Green Climate Fund or the Adaptation Fund), accessing these resources requires complex proposal processes and co-financing arrangements .

Poor Coordination Across Departments:

Successful climate action needs seamless collaboration between multiple government departments, research institutions, and local bodies. The absence of a well-integrated, overarching monitoring and evaluation plan makes it difficult to track policy progress and adapt strategies dynamically.

Data Gaps and Knowledge Barriers:

Kerala lacks a robust climate data infrastructure, making it harder to predict localized climate impacts or tailor adaptation strategies. Limited access to historical climate data hampers the development of precise **Local Action Plans on Climate Change (LAPCC)**. The state would benefit from investing in automatic weather monitoring systems and digital climate databases .

Community Participation and Awareness:

Although Kerala has strong community involvement, maintaining public interest and ensuring grassroots participation remains a challenge. For example, low uptake of health insurance schemes or hesitation to shift towards sustainable farming practices can reduce the impact of adaptation measures. Awareness campaigns and participatory policy design are key to overcoming this hurdle .

Political Barriers

Decentralized Governance—Strength and Barrier: Kerala's three-tier decentralized governance is a democratic strength, but political differences between state and local levels can slow decision-making or create conflicts in climate plan execution. Political misalignment between panchayats and the state can delay project rollouts, especially if local leaders are not politically aligned with the state government.

Limited Climate Mainstreaming in Sectoral Policies: While Kerala has a strong SAPCC (State Action Plan on Climate Change), many line departments (like agriculture, health, water) still view climate action as an "additional" responsibility. Without political will to embed climate priorities across all sectors, implementation remains fragmented and inconsistent across departments.

Major focus area in Sikkim's State Action Plan

The Sikkim State Action Plan on Climate Change (SAPCC) outlines comprehensive adaptive

strategies to tackle the challenges posed by climate change across critical sectors. These strategies aim to enhance resilience, protect vulnerable communities, and ensure long-term sustainability.

Water Security and Spring Recharge:

Sikkim prioritizes securing its water resources through integrated watershed management programs (IWMP) and Catchment Area Treatment Programs (CATP). The goal is to ensure perennial spring flows and groundwater recharge, especially in drought-prone areas. Techniques like rainwater harvesting, staggered contour trenches, and percolation pits are suggested to mitigate seasonal water scarcity .

Agriculture and Livelihood Resilience:

The state aims to introduce climate-resilient crop varieties, promote organic farming, and encourage sustainable agricultural practices. The plan recognizes the need for robust seed banks, better storage infrastructure, and livelihood diversification through non-farm activities like tourism and small-scale enterprises .

Forest and Biodiversity Conservation:

To protect forest ecosystems, Sikkim aligns with the Green India Mission, focusing on enhancing forest health, carbon sequestration, and biodiversity conservation. Measures include planting native species, controlling invasive plants, and establishing wildlife corridors to facilitate species migration under changing climate conditions .

Community-based Adaptation:

The SAPCC emphasizes building adaptive capacity at the community level. Rural communities already employ indigenous coping strategies, such as preserving seeds with traditional methods and storing water in tanks. The state plans to strengthen these practices by integrating them with national programs like MGNREGA to provide climate-proof livelihoods .

Disaster Risk Management:

Given Sikkim's vulnerability to landslides and extreme weather events, the plan includes early warning systems, infrastructure improvements, and ecosystem-based approaches to reduce disaster risks. It also stresses the importance of decentralized, village-specific adaptation strategies tailored to local vulnerabilities.

Barriers to implementation of effective climate policy in Sikkim

The State climate policy of Sikkim is not so much at satisfactory level. There is a large gap in proper coordination between the institution and stakeholders.

Administrative Barriers

Knowledge and Data Gaps

One of the most pressing barriers to effective climate policy implementation in Sikkim is the lack of reliable, high-resolution climate data. Policymakers struggle to make informed decisions because historical climate records are incomplete, and access to national meteorological data is often restricted by bureaucratic processes. Without precise climate projections, it becomes difficult to design forward-looking policies that anticipate the state's unique vulnerabilities, such as glacial melt and changing rainfall patterns (Azhoni & Goyal, 2023).

Limited Research and Scientific Expertise

Sikkim faces a shortage of climate change specialists, especially in critical areas like hydrogeology and biodiversity management. For example, while the state has initiated spring-water rejuvenation programs to combat water scarcity, many of these projects proceed without scientific validation. This reliance on community knowledge, while valuable, means adaptation efforts may not always be scalable or sustainable in the long term. The absence of localized climate models further limits the state's ability to assess future risks and design adaptive policies grounded in scientific evidence (Azhoni & Goyal, 2023).

Fragmented Institutional Coordination

There is limited institutional capacity and over reliance on individual leadership. Different sectors, such as agriculture, forestry, and water management, often operate in silos, resulting in disjointed adaptation strategies. For instance, while the agriculture department promotes drought-resistant crops, the forest department may lack the resources to protect natural water sources that sustain agricultural land. Without structured communication and integrated planning mechanisms, these sectoral disconnects dilute the effectiveness of climate policies (Azhoni & Goyal, 2023).

Community-Policy Disconnect

Local communities, especially farmers and forest-dependent populations, possess invaluable traditional knowledge of their environments. However, many of these communities lack awareness of broader climate change dynamics and policy frameworks. Community knowledge is valued but often disconnected from policy. This disconnect creates a gap between top-down policy design and on-the-ground realities. For instance, farmers may continue using water-intensive practices even as state policies promote conservation agriculture, simply because the long-term benefits of adaptation are not well-communicated or understood (Azhoni & Goyal, 2023).

Limited Monitoring and Evaluation Systems

The absence of dedicated agencies for ongoing policy monitoring means many adaptation

projects are implemented without mechanisms to track their long-term impacts. For example, spring-water conservation initiatives may succeed initially but fail over time due to changing rainfall patterns or inadequate maintenance. Without systematic evaluation, policymakers miss opportunities to refine, scale, or replicate successful adaptation models, limiting the iterative learning process that the IPCC emphasizes as essential for building long-term resilience (Azhoni & Goyal, 2023).

Political Barriers

Weak Integration of Climate Change in Political Agendas

Climate change is not consistently featured as a core issue in political campaigns or party manifestos in Sikkim. This limits political momentum behind climate initiatives and reduces pressure on policymakers to prioritize climate actions over other developmental or populist agendas.

Limited Political Incentives for Long-Term Planning

Politicians often prioritize short-term, visible results for electoral gain, whereas climate policy requires long-term investment with delayed returns. This mismatch discourages consistent funding and political support for projects like afforestation, glacier monitoring, or spring rejuvenation.

Result and Discussion

Adaptation Strategies and IPCC Alignment: Adaptation is a cornerstone of climate resilience, and both states demonstrate thoughtful approaches tailored to their respective geographies. Sikkim's adaptation strategy is deeply rooted in ecosystem-based solutions, reflecting IPCC guidelines that advocate for nature-based adaptation. The state's water security measures, such as spring revival and rainwater harvesting, address the IPCC's emphasis on sustainable water management. Disaster preparedness efforts, including GLOF monitoring and early warning systems, align with IPCC recommendations for proactive risk reduction. However, the state's limited integration of advanced climate modelling hinders its ability to anticipate long-term risks, indicating an area for improvement.

Kerala's adaptation strategies prioritize disaster management, coastal resilience, and public health, aligning well with IPCC guidelines on infrastructure resilience and community-based adaptation. The state's flood management measures, including wetland restoration and mangrove conservation, mirror the IPCC's call for ecosystem buffers against extreme weather events. Public health adaptation, focusing on disease surveillance and healthcare strengthening, aligns with the IPCC's emphasis on climate-resilient health systems. Yet, Kerala could enhance alignment by adopting more technology-driven solutions, such as dynamic flood prediction systems, and expanding marine ecosystem monitoring programs to track climate impacts on coastal biodiversity.

Mitigation Strategies and IPCC Alignment: Mitigation efforts are critical for reducing emissions and limiting global warming, and both states have made commendable strides in this area. Sikkim's reliance on hydropower as a clean energy source and its commitment to organic farming align with IPCC recommendations for renewable energy transitions and sustainable agriculture. The state's afforestation programs contribute to carbon sequestration, further reinforcing alignment with IPCC mitigation pathways. However, Sikkim's plan lacks detailed long-term emission reduction targets and could benefit from expanding its renewable energy portfolio beyond hydropower to diversify its mitigation strategies.

Kerala's mitigation strategies are ambitious and multifaceted, with strong commitments to renewable energy adoption, sustainable waste management, and marine conservation. The state's solar and wind energy projects, along with policies promoting energy efficiency, reflect IPCC priorities for clean energy transitions. Coastal and marine conservation efforts, such as fisheries management and blue carbon initiatives, align with IPCC recommendations for protecting carbon sinks. Yet, Kerala faces challenges in policy scalability and private sector engagement, which, if addressed, could significantly enhance its mitigation potential.

Policy Gaps and Opportunities for Improvement: Despite their policy strengths, both states exhibit gaps that hinder full alignment with IPCC guidelines. Sikkim's lack of advanced climate data infrastructure limits its ability to craft forward-looking policies, while financial constraints impede large-scale resilience projects. Kerala's gaps lie in policy implementation and monitoring, with limited long-term marine ecosystem studies and insufficient integration of smart disaster management technologies. Both states would benefit from enhanced cross-sectoral coordination, greater public-private partnerships, and stronger mechanisms for accessing international climate finance to support large-scale adaptation and mitigation efforts.

Conclusion and Recommendations

Kerala and Sikkim's climate action plans reflect proactive, region-specific strategies that align with many IPCC recommendations. However, achieving full alignment requires continuous policy evolution, with increased emphasis on data-driven decision-making, technology adoption, and knowledge exchange. Key recommendations include investing in advanced climate modelling, establishing inter-state collaboration platforms, expanding climate education initiatives, and fostering public-private partnerships for green innovation. By embedding global climate science into state-level governance and iteratively refining policies based on evolving research, Sikkim and Kerala can strengthen their climate resilience and serve as national exemplars of localized climate action.

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