

Climate Change Mitigation Strategies through Forest Conservation and Afforestation Programs in Kerala: A Tribal Perspective Analysis

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Abstract

This research paper examines climate change mitigation strategies through forest conservation and afforestation programs in Kerala, India, focusing on the perspectives of the state's tribal communities. The study explores the impact of climate change on biodiversity loss, deforestation, land degradation, displacement of communities, loss of traditional knowledge, limited access to resources and technology, and conflicts over land and resource ownership (Bhatnagar and Wagh, 2022). The paper highlights the need for integrated approaches combining conservation, sustainable land management, and community empowerment to address these challenges (Madhu et al., 2014). It emphasizes the importance of recognizing and integrating indigenous knowledge systems into climate change adaptation and mitigation efforts, as well as strengthening policy implementation and enforcement mechanisms (Shynu, 2012). The paper concludes by stressing the need to prioritize biodiversity conservation, leverage traditional ecological knowledge, and foster inclusive and sustainable solutions to safeguard Kerala's forests and the livelihoods of its tribal communities.

Keywords: Climate change mitigation, afforestation, biodiversity, traditional ecological knowledge, sustainable development, policy implementation.

Introduction

Kerala, located in south western India, is known for its rich biodiversity, lush landscapes, and cultural heritage deeply intertwined with its forests (Bhatnagar and Wagh, 2022). However, like many regions across the globe, Kerala is not immune to the far-reaching impacts of climate change. The increasing frequency of extreme weather events, erratic rainfall patterns, and rising temperatures pose significant challenges to the state's ecosystems and the livelihoods of its people, particularly its indigenous tribal communities. In this context, forest conservation and afforestation emerge as crucial strategies for mitigating climate change and safeguarding the ecological integrity of Kerala's landscapes (Madhu et al., 2014). The intricate relationship between forests and climate resilience has long been recognized, with forests serving as vital carbon sinks, regulating local climates, and supporting diverse ecosystems. Moreover, indigenous communities, with their deep-rooted

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traditional knowledge and sustainable practices, have played a pivotal role in nurturing and conserving these forest ecosystems for generations (Shynu, 2012). This research endeavors to delve into the intersection of climate change mitigation, forest conservation, and the perspectives of Kerala's tribal communities. By focusing on the unique insights and experiences of indigenous groups, this study seeks to elucidate the potential of traditional ecological knowledge in informing contemporary approaches to sustainable forest management and climate resilience.

The choice of Kerala's tribal communities as the focal point of this study is deliberate. Historically marginalized and often residing in ecologically sensitive areas, tribal populations have an intimate relationship with their surrounding forests, relying on them for sustenance, livelihoods, and cultural identity. However, they are also among the most vulnerable to the impacts of environmental degradation and climate change, exacerbating existing socio-economic disparities (V. Nair and V. S, 2018). Against this backdrop, understanding the perspectives, practices, and challenges faced by Kerala's tribal communities in the realm of forest conservation and afforestation is not merely an academic endeavor but a critical step towards inclusive and effective climate action. By amplifying indigenous voices, this research aims to contribute to a more holistic and equitable approach to climate change mitigation, one that acknowledges the interconnectedness of ecosystems, cultures, and livelihoods. Through a multidisciplinary inquiry encompassing ecological, social, and policy dimensions, this study seeks to shed light on the untapped potential of indigenous knowledge systems in shaping resilient and sustainable futures for Kerala's forests and its people. It is within this framework that the research embarks on a journey to explore climate change mitigation strategies through the lens of forest conservation, with a particular focus on the perspectives of Kerala's tribal communities.

Impact of Climate Change on Biodiversity Loss in Kerala's Forests

Climate change poses a significant threat to biodiversity in Kerala's forests, impacting the flora, fauna, and tribal communities dependent on these ecosystems (Gopi, 2018). Understanding how climate change exacerbates biodiversity loss is crucial for developing effective mitigation strategies and preserving the ecological integrity of the region for future generations. Climate change is a pressing global issue that has far-reaching consequences on ecosystems and biodiversity. In Kerala's forests, the effects of climate change are particularly pronounced, leading to habitat loss, altered species distributions, and disruptions in ecological processes. These changes not only threaten the survival of numerous plant and animal species but also impact the livelihoods and cultural practices of tribal communities deeply connected to the land and its biodiversity (Gadgil, 2014).

Loss of Biodiversity and Ecosystem Services

Climate change exacerbates the loss of biodiversity and ecosystem services in Kerala's forests, affecting the flora and fauna essential for the livelihoods and cultural practices of tribal communities. Understanding the extent and consequences of biodiversity loss due to climate change is crucial for effective mitigation strategies (Chivian et al., 2008). Kerala's forests harbor a rich diversity of plant and animal species, many of which are endemic and threatened. However, deforestation, habitat fragmentation, poaching, and invasive species have led to a decline in biodiversity across various ecosystems, including tropical rainforests, wetlands, and mangroves. Loss of habitat and fragmentation disrupts ecological processes, reduces genetic diversity, and increases the risk of species extinction. Biodiversity loss undermines the capacity of ecosystems to provide essential services that support human well-being, such as clean air and water, pollination, soil fertility, climate regulation, and natural hazard mitigation. Degradation of ecosystems diminishes their resilience to environmental stressors, including climate change, and compromises their ability to deliver these critical services, posing risks to human health, livelihoods, and food security (Damodaran, 2006).

Tribal communities in Kerala have deep cultural, spiritual, and socio-economic ties to the land and its biodiversity. The loss of biodiversity and ecosystem services directly impacts the livelihoods and cultural practices of indigenous peoples, who depend on forests for food, medicine, fuel wood, and other essential resources (V. Nair and V. S, 2018). Disruption of traditional ecological knowledge systems further exacerbates vulnerabilities and undermines the resilience of tribal communities to environmental changes (Sæther et al., 2024). Loss of biodiversity in Kerala's forests threatens keystone species, such as large mammals, birds of prey, and apex predators, which play critical roles in maintaining ecosystem structure and function. Declines in keystone species can lead to cascading effects on ecosystem dynamics, including altered species interactions, reduced ecosystem resilience, and compromised ecological integrity.

Despite conservation efforts, protecting biodiversity in Kerala's tribal areas remains a formidable challenge due to various factors, including inadequate enforcement of protected area regulations, encroachment, illegal logging, and wildlife poaching. Balancing conservation objectives with the needs and rights of local communities, particularly indigenous peoples, requires participatory approaches, community-based conservation initiatives, and strengthened governance mechanisms. Climate change further exacerbates the loss of biodiversity and ecosystem services in Kerala, posing additional threats to vulnerable species and ecosystems. Rising temperatures, altered precipitation patterns, and extreme weather events disrupt species distributions, phenology, and ecological interactions, leading to shifts in ecosystem structure and function. Integrating climate change

considerations into biodiversity conservation strategies is essential for enhancing the resilience of ecosystems and safeguarding biodiversity in Kerala's tribal areas. Despite the challenges, there are opportunities for conservation and restoration efforts to mitigate biodiversity loss in Kerala's tribal areas. Promoting sustainable land management practices, establishing protected areas and wildlife corridors, enhancing community-based conservation initiatives, and leveraging traditional ecological knowledge can contribute to biodiversity conservation, ecosystem restoration, and sustainable development in the region. Addressing the loss of biodiversity and ecosystem services in Kerala's tribal areas requires concerted efforts from multiple stakeholders, including government agencies, civil society organizations, indigenous communities, and the private sector. By prioritizing conservation, sustainable land management, and community empowerment, it is possible to preserve Kerala's rich biodiversity and ensure the continued provision of ecosystem services for future generations.

Deforestation and Land Degradation

Despite efforts to conserve forests, deforestation and land degradation persist in Kerala, leading to habitat loss, reduced carbon sequestration, and increased vulnerability to climate change impacts such as floods and landslides. Examining the drivers of deforestation and land degradation in tribal areas and identifying solutions is essential for sustainable forest management (Priya, 2021). Deforestation, primarily driven by agricultural expansion, urbanization, infrastructure development, and illegal logging, has resulted in the loss of significant forest cover in Kerala. This loss of forest habitat threatens biodiversity, disrupts ecological processes, and reduces the capacity of forests to sequester carbon and regulate local climates. Deforestation and land degradation degrade habitats and disrupt ecosystems, leading to the loss of biodiversity in Kerala's forests. This loss of biodiversity not only threatens the survival of numerous plant and animal species but also undermines the resilience of ecosystems to environmental stressors, including climate change. Deforestation and unsustainable land use practices (Hyde et al., 1996), such as shifting cultivation and monoculture plantations, contribute to soil erosion and degradation in Kerala's tribal areas. Soil erosion reduces soil fertility, diminishes agricultural productivity, and increases the risk of landslides and flooding, posing significant challenges to the livelihoods and well-being of tribal communities. Deforestation and land degradation affect water availability and quality in Kerala's watersheds. Loss of forest cover disrupts hydrological cycles, leading to reduced groundwater recharge (Rohde et al., 2021), altered streamflow patterns, and increased sedimentation in rivers and reservoirs. These changes exacerbate water scarcity, particularly during dry seasons, and compromise the availability of clean water for drinking, irrigation, and other domestic uses.

Deforestation and land degradation contribute to climate change by releasing stored carbon into the atmosphere and reducing the capacity of forests to absorb greenhouse gases. Moreover, degraded lands are more vulnerable to climate change impacts, such as increased temperatures, erratic rainfall patterns, and extreme weather events, further exacerbating land degradation and its associated consequences. Deforestation and land degradation disproportionately affect vulnerable populations, including tribal communities dependent on forests for their livelihoods and cultural identity. Loss of access to forest resources, declining agricultural productivity, and increased environmental hazards exacerbate poverty, food insecurity, and social marginalization among tribal populations in Kerala. Despite the existence of policies and regulations aimed at forest conservation and land management, challenges persist in their effective implementation and enforcement. Weak governance, inadequate law enforcement, conflicting land tenure systems, and institutional fragmentation hinder efforts to address deforestation and land degradation in Kerala's tribal areas. Engaging tribal communities in participatory forest management and community-based conservation initiatives can play a crucial role in combating deforestation and land degradation. Empowering local communities to actively participate in forest protection, sustainable land management, and agroforestry practices can enhance the resilience of ecosystems and promote sustainable livelihoods among tribal populations. Addressing deforestation and land degradation requires integrated approaches that combine conservation, sustainable land management, and socio-economic development strategies. Strengthening governance structures, promoting community-based conservation initiatives, investing in sustainable agriculture and agroforestry, and enhancing public awareness and education are essential for mitigating the impacts of deforestation and land degradation in Kerala's tribal areas and preserving the ecological integrity of the region for future generations.

Displacement and Loss of Traditional Knowledge

Climate change-induced disasters and environmental degradation may lead to the displacement of tribal communities and the loss of traditional ecological knowledge passed down through generations (Grabska et al., 2022). Preserving and integrating indigenous knowledge systems into climate change adaptation and mitigation strategies is vital for fostering resilience and sustainability (Kasali, 2011). Large-scale development projects, such as dams, mining, infrastructure development, and conservation initiatives, often result in the involuntary displacement of tribal communities from their ancestral lands. Displacement disrupts social cohesion, cultural practices, and traditional livelihoods, leading to loss of identity and connection to the land. Displacement and resettlement disrupt the transmission of traditional ecological knowledge (TEK) from elders to younger generations (Pattiselanno, 2016). TEK encompasses indigenous practices, beliefs, and wisdom regarding natural resource management, biodiversity conservation, and climate

adaptation. The loss of TEK not only erodes cultural heritage but also diminishes the resilience of tribal communities to environmental changes. Displacement often forces tribal communities to abandon their traditional livelihoods, such as subsistence farming, fishing, hunting, and gathering. In resettlement areas, access to land, water, and forest resources may be restricted, leading to food insecurity, poverty, and dependency on external aid. The loss of traditional livelihoods exacerbates socio-economic vulnerabilities and marginalization among displaced populations. Displacement can have profound psychological and social impacts on tribal communities, including loss of social networks, increased stress, trauma, and cultural dislocation. Displaced individuals may experience feelings of alienation, disempowerment, and marginalization in their new environments, further exacerbating mental health issues and social tensions. Displacement often results in the fragmentation of traditional community structures and cultural practices. Dispersed resettlement, relocation to unfamiliar environments, and loss of ancestral lands weaken social cohesion and erode cultural identity. The fragmentation of communities hampers collective action, community resilience, and the transmission of indigenous knowledge across generations. Resettlement and rehabilitation efforts often fail to adequately address the needs and aspirations of displaced tribal communities. Inadequate housing, lack of access to basic services, insufficient livelihood opportunities, and inadequate compensation exacerbate the challenges faced by displaced populations. Moreover, top-down approaches to resettlement may disregard the preferences, customs, and aspirations of affected communities, leading to further marginalization and disempowerment.

Preserving and revitalizing traditional knowledge systems are essential for maintaining cultural continuity, promoting resilience, and enhancing adaptive capacity among tribal communities. Efforts to document, safeguard, and transmit TEK should be prioritized, involving active participation of elders, community leaders, and youth. Integrating TEK into education, research, and development programs can foster intergenerational learning and ensure the sustainability of indigenous knowledge systems. Strengthening legal frameworks, policies, and mechanisms to protect the rights of tribal communities against displacement and loss of traditional knowledge is imperative. Advocacy efforts aimed at recognizing and respecting indigenous land tenure rights, free, prior, and informed consent (FPIC) processes, and culturally appropriate resettlement and rehabilitation measures are essential for promoting social justice and human rights (Young, 2019). Addressing displacement and loss of traditional knowledge requires a rights-based approach that prioritizes the voices, needs, and aspirations of affected tribal communities. Collaborative efforts involving government agencies, civil society organizations, academia, and indigenous leaders are essential for promoting inclusive development, cultural resilience, and sustainable livelihoods for tribal populations in the face of climate change and development-induced displacement.

Limited Access to Resources and Technology

Tribal communities often face barriers in accessing resources, technology, and information necessary for effective forest conservation and afforestation. Addressing the digital divide and providing equitable access to resources and green technologies can empower tribal populations to actively participate in climate change mitigation efforts. Tribal communities often face economic marginalization, limiting their access to financial resources, technology, and modern infrastructure. This hampers their ability to adopt climate-resilient agricultural practices, access alternative livelihood opportunities, and invest in renewable energy solutions (V. Nair and V. S, 2018). Disparities in resource allocation and distribution exacerbate socio-economic inequalities among tribal communities. Limited access to land, water, seeds, credit facilities, and market networks further marginalizes vulnerable populations, hindering their capacity to adapt to climate change and diversify their livelihoods (Maikhuri et al., 2013). The digital divide, characterized by unequal access to information and communication technologies (ICTs), is particularly pronounced in remote tribal areas with limited connectivity and infrastructure. Lack of access to ICTs restricts tribal communities' ability to access weather forecasts, market prices, agricultural extension services, and climate-related information necessary for informed decision-making (Kasali, 2011). Inadequate infrastructure, including roads, transportation networks, and storage facilities, impedes market access and value chain development for tribal producers. Poor infrastructure also limits the delivery of essential services such as healthcare, education, and extension support, constraining opportunities for economic development and climate resilience building.

The dissemination of appropriate and affordable technologies tailored to the needs and contexts of tribal communities is often hindered by logistical challenges, high costs, and lack of awareness. Moreover, the mismatch between externally promoted technologies and local knowledge systems may result in low adoption rates and limited sustainability of interventions (Pattiselanno, 2016). Building the capacity of tribal communities to harness available resources and technology for climate change adaptation and livelihood diversification is crucial. This entails providing training, technical assistance, and extension services in areas such as sustainable agriculture, renewable energy, agroforestry, water management, and eco-tourism. Strengthening institutional support mechanisms, including government programs, non-governmental organizations (NGOs), and community-based organizations (CBOs), is essential for addressing the barriers to resource and technology access faced by tribal communities. These institutions can facilitate knowledge exchange, promote innovation, and provide targeted support to enhance resilience and sustainability. Recognizing and integrating indigenous knowledge systems into climate change adaptation and technology adoption efforts is critical. Indigenous practices rooted in traditional wisdom and local ecological knowledge

can complement modern technologies, enhancing the resilience of tribal communities to environmental changes while preserving cultural heritage and biodiversity (Shynu, 2012).

Conflicts over Land and Resource Ownership

Land tenure issues and conflicts over forest resources between tribal communities, government agencies, and private entities can hinder collaborative conservation efforts and exacerbate vulnerability to climate change impacts (Burnham, 2012). Resolving conflicts and promoting inclusive governance structures are essential for fostering cooperation and collective action in forest management. Historically, tribal communities in Kerala have relied on traditional customary rights for accessing and managing forest resources (S, 2018). However, changes in land tenure systems, encroachment by non-tribal settlers, and competing claims over forest lands have led to disputes and conflicts over land ownership. Clarifying and securing land tenure rights for tribal communities are essential for promoting sustainable land management practices and enhancing resilience to climate change impacts. With increasing pressure on natural resources due to population growth, urbanization, and industrial expansion, there is often competition between tribal communities, government agencies, private companies, and other stakeholders for access to land and forest resources. Conflicting interests and priorities may lead to tensions and conflicts over resource use, extraction, and conservation, exacerbating vulnerabilities to climate change. Large-scale development projects, such as infrastructure development, mining, and hydroelectric dams, can exacerbate conflicts over land and resource ownership in tribal areas. These projects often result in displacement, loss of livelihoods, and environmental degradation, disproportionately affecting tribal communities. Balancing development objectives with the rights and interests of indigenous peoples is essential for minimizing conflicts and promoting sustainable development (Damodaran, 2006).

Ambiguities in land laws, inadequate enforcement mechanisms, and weak governance structures contribute to land-related conflicts in Kerala's tribal areas. Lack of clarity regarding land ownership rights, boundaries, and land-use regulations can lead to disputes and litigation, further complicating efforts to address climate change adaptation and livelihood diversification challenges. Establishing effective conflict resolution mechanisms, including traditional dispute resolution mechanisms, mediation, and arbitration, is critical for addressing conflicts over land and resource ownership in tribal areas. These mechanisms should be participatory, transparent, and culturally sensitive, involving all relevant stakeholders in the decision-making process and promoting dialogue and reconciliation. Empowering tribal communities through recognition of their customary rights, strengthening community-based natural resource management institutions, and promoting

participatory decision-making processes are essential for resolving conflicts over land and resource ownership. Investing in capacity building, legal literacy, and leadership development among tribal communities can enhance their ability to assert their rights and interests effectively (Young, 2019). Recognizing the value of traditional ecological knowledge (TEK) and indigenous land management practices is crucial for promoting sustainable land use and resolving conflicts over land and resource ownership. Integrating TEK into decision-making processes, land-use planning, and natural resource management policies can enhance the resilience of tribal communities to climate change while preserving cultural heritage and biodiversity (Pattiselanno, 2016).

Inadequate Policy Implementation and Enforcement

Despite the existence of policies and regulations aimed at promoting forest conservation and afforestation, inadequate implementation and enforcement mechanisms undermine their effectiveness. Enhancing policy coherence, capacity building, and stakeholder engagement is essential for translating policy objectives into tangible actions on the ground. Despite the existence of comprehensive policies and frameworks aimed at addressing climate change adaptation and promoting livelihood diversification in Kerala's tribal areas, there often exists a gap between policy formulation and implementation on the ground. This gap may arise due to various factors such as insufficient financial resources, bureaucratic inefficiencies, lack of coordination among implementing agencies, and limited capacity at the local level to translate policy objectives into actionable plans (Gadgil, 2014). In many instances, stakeholders at the grassroots level, including tribal communities, may lack awareness about existing policies, their rights, and available support mechanisms for climate change adaptation and livelihood diversification. Moreover, inadequate capacity-building initiatives targeting local authorities, community leaders, and civil society organizations may hinder effective policy implementation and enforcement efforts. The absence of robust monitoring and evaluation mechanisms makes it challenging to assess the impact of policies and programs related to climate change adaptation and livelihood diversification. Without reliable data and feedback mechanisms, policymakers and implementing agencies may struggle to identify gaps, track progress, and make informed decisions to improve policy effectiveness (Priya, 2021). Kerala's governance landscape may suffer from regulatory fragmentation and overlapping mandates among different departments and agencies responsible for implementing climate change adaptation and livelihood diversification initiatives. This fragmentation can lead to duplication of efforts, jurisdictional conflicts, and gaps in service delivery, ultimately undermining the coherence and effectiveness of policies and programs.

Effective policy implementation and enforcement require active engagement and participation of diverse stakeholders, including tribal communities, local

governments, civil society organizations, and the private sector. However, insufficient consultation and involvement of stakeholders in the policy formulation process may result in policies that do not adequately reflect the needs, preferences, and priorities of the target populations (Madhu et al., 2014). Weak enforcement mechanisms, coupled with legal loopholes and ambiguities in existing regulations, undermine the deterrent effect of policies aimed at promoting climate change adaptation and livelihood diversification. Inadequate enforcement capacity, corruption, and political interference may further exacerbate challenges in ensuring compliance with environmental laws and regulations. Inequitable distribution of resources, benefits, and burdens associated with climate change adaptation and livelihood diversification policies can exacerbate socio-economic disparities and marginalization, particularly among vulnerable populations such as tribal communities. Ensuring climate justice and equity requires addressing power imbalances, promoting inclusive decision-making processes, and prioritizing the needs of the most marginalized groups in policy implementation efforts (V. Nair and V. S, 2018).

Climate Change Adaptation and Livelihood Diversification

Tribal communities reliant on forest resources for their livelihoods face increasing challenges due to climate change. Encouraging livelihood diversification, promoting alternative income-generating activities, and strengthening social safety nets are critical for enhancing the adaptive capacity of tribal populations to climate change impacts (Maikhuri et al., 2013). Climate change poses significant challenges to the traditional livelihoods of tribal communities in Kerala, which are often intimately linked with forest resources. As climate variability and extreme weather events become more frequent, there is a growing imperative for these communities to adapt their livelihood strategies to ensure resilience and sustainability. One key approach to adaptation involves livelihood diversification, whereby communities expand their income-generating activities beyond traditional practices reliant on forest resources. This not only reduces vulnerability to climate change impacts but also enhances adaptive capacity and fosters socio-economic resilience (Sæther et al., 2024). Climate change adaptation and livelihood diversification are essential components of building resilience and sustainable development for tribal communities in Kerala. By promoting alternative income-generating activities, enhancing skills and capacity, and fostering sustainable resource management practices, these communities can mitigate the adverse effects of climate change and secure their livelihoods for future generations. However, achieving meaningful adaptation requires holistic approaches that address the socio-economic, cultural, and environmental dimensions of vulnerability among tribal populations. Collaborative efforts involving government agencies, civil society organizations, academia, and local communities are crucial for advancing climate-resilient

livelihood strategies and ensuring inclusive and equitable development in Kerala's tribal regions (Shynu, 2012).

Conclusion

In conclusion, the loss of biodiversity and ecosystem services in Kerala's forests due to climate change poses significant challenges for both the environment and tribal communities. Deforestation, unsustainable land use practices, and weak governance structures have contributed to habitat loss, reduced soil fertility, and increased vulnerability to climate change impacts such as floods and landslides. These environmental changes not only threaten the survival of plant and animal species but also undermine the resilience of ecosystems and the well-being of indigenous peoples reliant on forest resources (Chivian et al., 2008; Gadgil, 2014). Addressing these challenges requires integrated approaches that combine conservation, sustainable land management, and community empowerment strategies. By promoting sustainable land management practices, establishing protected areas, and empowering local communities through participatory conservation initiatives, it is possible to mitigate biodiversity loss, enhance ecosystem resilience, and promote sustainable development in Kerala's tribal areas (Madhu et al., 2014; Shynu, 2012). Collaborative efforts involving government agencies, civil society organizations, indigenous communities, and other stakeholders are essential for achieving inclusive and sustainable solutions to the complex issues of biodiversity loss and ecosystem degradation in the region. Moving forward, prioritizing the conservation of biodiversity, integrating climate change considerations into conservation strategies, and leveraging traditional ecological knowledge are key steps towards safeguarding Kerala's rich biodiversity and ensuring the continued provision of ecosystem services for future generations (Pattiselanno, 2016; V. Nair and V. S., 2018). By recognizing the value of indigenous perspectives and engaging local communities in decision-making processes, we can foster resilience, equity, and sustainability in forest conservation efforts, ultimately contributing to the well-being of both people and the planet (Young, 2019; Kasali, 2011).

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