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Review Article

Sacred Groves as Biodiversity Remnants and Microclimate Regulators in India: A Review

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Abstract: Sacred groves epitomize the synergy between biodiversity conservation and climate mitigation. Their cultural protection has inadvertently safeguarded critical carbon sinks in biomass and soil, making them untapped assets in global carbon budgets. Recognizing and integrating sacred groves into conservation and climate strategies will amplify their role as living laboratories of sustainable forest management. Thus, the paper is an attempt to explore the potential of sacred groves as untapped natural sinks for climate change mitigation and also for biodiversity conservation. The positive connection between biodiversity and carbon density underscores their dual role in climate mitigation and biological conservation. Recognition of sacred groves as integrated biodiversity-carbon hotspots will help to map, protect and restore these microecosystems for long-term carbon sequestration and biodiversity conservation. To sum up, sacred groves represent irreplaceable socio-ecological systems where cultural reverence and ecological integrity converge to safeguard India's biodiversity heritage and microclimate stability, demanding urgent integration of traditional stewardship with contemporary conservation policies to ensure their survival and continued ecosystem service provision for future generations.
Keywords: Sacred Groves, Carbon Sequestration, Biodiversity Conservation, Climate Change, Ecosystem Services

INTRODUCTION

Sacred groves - the pristine remnants of once-widespread forests, function as critical arks for a vast array of flora and fauna (Ray *et al.,* 2014). The sacred groves serve as a treasure trove of endemic, rare and endangered species thereby upholding genetic diversity and affirming complex ecological webs that have been eroded in the surrounding landscapes. A biodiverse, intact forest is characterized by its dense, multilayered canopy structure, massive, old-growth trees with high wood densities, and complex vegetation stratification, all of which directly contribute to significant biomass accumulation. The rich soil biodiversity, fostered by the constant input of diverse organic matter from a variety of plant species, enhances soil organic carbon, locking it away in a stable form. This synergy creates a powerful feedback loop: a biodiverse ecosystem is more productive, resilient and structurally complex, leading to greater carbon sequestration both above and below ground (Hicks *et al.,* 2014). Sacred groves are maintained by indigenous and local communities through spiritual beliefs and taboos which prevent logging, grazing and land-use change, allowing mature forest environments to persist amidst anthropogenically altered landscapes. Beyond the cultural value, sacred groves harbour high species diversity of fauna, flora and microorganisms (Khan *et al.,* 2008). In addition, the structural complexity and continuous canopy cover of sacred groves offer significant carbon stocks in both biomass and soil, rendering them vital but underutilized carbon sinks (Hangarge, 2013).

In an era witnessing massive climate change impacts and biodiversity erosion, the search for effective and conglomerated solutions are the need of the hour for tackling the twin crisis. It should be noted that the global attention often focuses on technological innovations and large-scale policy frameworks, some of the most potent and resilient answers are quietly enduring for centuries, embedded within the cultural and spiritual practices of local communities like the sacred groves, still remains unexplored. The sacred grove ecosystem represents far more than cultural heritage; they are vital, living reservoirs of biological richness and also significant carbon sinks. The complex interlinkage between the biodiversity conserved within these groves and their capacity to store carbon presents a compelling narrative of an innate, natural solution that has been safeguarding planetary health long before the terms “climate mitigation” or “biodiversity hotspot” entered the scientific lexicon. Thus, the paper is an attempt to explore the potential of sacrae groves as untapped natural sinks for climate change mitigation and also for biodiversity conservation.

Sacred groves as biodiversity reservoirs in India

Sacred groves across India are distributed over a broad span of environmental conditions which range from 100,000 to 150,000 (Bhagwat and Rutte, 2006) and called differently in different parts of the country like *Law lyngdhoh* in Meghalaya, *Kovil kadu* in Kanyakumari, *Dev bhumi* in Uttarakhand, *Kavu* in Kerala, *Sarna and Deorai* in Madhya Pradesh, *Oran* in Rajasthan, *Jaherthan and Garamthan* in West Bengal, *Deovan* in Himachal and *Ummanglai* in Manipur. Basu (2000) reported that selected groves in West Bengal showed a size range of 0.04–1 ha harbour 114 species of flowering plants distributed in 52 different families whose ethnobotanical knowledge and use are prominent. In another study, 30 species of medicinal plants are recorded from three small groves (0.6–0.8 ha) in Midnapur district of West Bengal comprising herbs, shrubs, trees and climbers (Bhakat and Sen, 2008). Sukumaran et al. 8,16 highlighted the floristic richness of 201 (13.1 ha area) and 11 (2.6 ha) miniature sacred groves of Kanyakumari district in Tamil Nadu. Collectively, these groves represent a good number of endemics, rare, endangered and economically While Sukumaran and Jeeva (2008) noted the presence of 98 angiospermic species from 87 genera and 43 families from Agastheeshwaram grove in Tamil Nadu. Sujana and Sivaperuman (2008) documented the presence of rare and threatened plants in small sacred groves (0.08–0.33 ha) across Kerala. The species richness, dominance, distribution, rarity and endemism are all well reported in flora of the scared groves in various studies (Parthasarathy and Karthikeyan 1997; Khumbongmayum *et al*. 2005; Kushalappa *et al.,* 2005; Khumbongmayum *et al*. 2006; Upadhaya *et al.* 2003).

The sacred groves also support faunal diversity including reptiles, amphibians, birds and mammals. Das and Chanda (1997) reported the presence of a new frog from the sacred groves of Amarkantak, central India termed *Philautus sanctisilvaticus*. In another study, Das *et al.* (2010) reported a new species of Leptolalax from the sacred groves of Meghalaya. Deb *et al.* (1997) recorded a total of 42 species of resident land birds in sacred groves in Midnapore in West Bengal. Sashikumar (2005) recorded the avifauna of the sacred groves of North Kerala. The bird diversity and abundance in 15 selected sacred groves of northern Kerala yielded a total of 111 bird species coming under 49 families and 16 orders and it is also noted that the sacred groves of northern Kerala support many of the 'forest-birds' (Jyothi and Nameer, 2015). Sinha *et al.* (2003) explored the earthworm diversity and abundance in the Hariyali sacred landscape, Garhwal Himalaya with a total of seven species belonging to four families.

Conservation of medicinal plants through local belief

The sacred groves are a veritable gold mine of fragrant and therapeutic plants. The majority of the native people who live close to the groves have vigorously preserved their ancient practices, ceremonies, rituals and way of life in the forest through folk beliefs. As per Hindu belief, Lord Hanuman utilized *Sanjeevani*, which is located in the Himalayan region, to revive Lakshman, Lord Rama's brother. Thus, medicinal plant conservation is an inherent part of sustainable living for the adjoining community. Bhakat and Sen (2008) reiterated the potential of sacred groves in ethnomedicinal plant conservation. Sharma and Devi (2014) also opined that sacred groves offer the traditional way of conserving plant diversity. With their sociocultural and religious customs, traditional societies and indigenous groups adjoining the groces are protecting it. Due to the prevailing belief and stories, it is forbidden to chop or axe sacred trees unless the wood is required for religious purposes, such as building and repairing temple structures or for worship, funerals and temple rites. As a result, sacred groves have a direct and permanent religious status and help to preserve the social cohesion of society (Kandari *et al.,* 2014). Tribal members of the Bhotiya group are preserving medicinal plants for centuries in Doonagiri hamlet, which is part of the Nanda Devi Biosphere Reserve in Uttarakhand. They firmly believe that it is a sinful conduct that could cause the villagers to suffer greatly if someone from outside the village pluck and remove the healing plants from their community. They believe that when Lord Hanuman visited their hamlet, he uprooted all of the therapeutic plants, which led to the later occurrence of incurable diseases. Therefore, the preservation of medicinal plants is essential a sustainable way of life in harmony with the environment (Asokan *et al.,* 2015). Thus, India's sacred groves are an example of a long-standing custom of communal forest management for cultural purposes.

Microclimate regulation

The transpiration from the sacred groves lowers local temperatures, raises atmospheric humidity and creates a favourable microclimate. Thus, sacred woods are essential to the preservation of soil and local ecosystem balance. The temperature in the grove and the surrounding local area is largely controlled by sacred groves. The dense canopy of sacred groves serves as a protective cover and contributes to the area's cool environment which is due to the huge amount of water vapor that is released through transpiration and the retention of water vapor. Additionally, the ground vegetation covers and a thick layer of litter fall serve as insulation for the ground area, regulating soil temperature and significantly reducing water loss through evaporation which in turn safeguard water supplies and watersheds. Rawat (2014) critically evaluated the role of sacred groves in ameliorating microclimate in and around Nagdev temple forest of Pauri Garhwal, Uttarakhand. Thus, sacred groves are crucial in maintenance of ecological health, prevention of soil erosion and nutrient wash off, biodiversity repositories, refuge for rare and endangered medicinal plants and as a part of community life.

Carbon storage

Sacred groves are increasingly recognized for their profound ecological utility, particularly as significant and often untapped carbon sinks. These pristine patches of forest, protected by local communities through traditional beliefs and taboos, represent a centuries-old model of conservation that aligns seamlessly with contemporary goals of climate change mitigation (Bhagwat and Rutte, 2006; Khan *et al.,* 2008). The very principles that have safeguarded the groves biodiversity have simultaneously fostered ideal conditions for the long-term accumulation and storage of atmospheric carbon. The mechanism through which sacred groves function as carbon reservoirs is multifaceted, rooted in their ecological integrity. Unlike many managed forests or plantations, sacred groves are often old-growth ecosystems characterized by a multi-layered canopy structure, a high density of mature trees, and a rich understory. This complex vertical stratification allows for maximum biomass accumulation, with large, old trees serving as substantial living carbon banks. Furthermore, the minimal disturbance within these groves ensures that the carbon stored in the soil organic matter remains largely undisturbed. The thick layer of leaf litter, slowly decomposing in the shaded, humid microclimate, continuously enriches the soil, locking away carbon for the long term. This combination of high above-ground biomass and stable below-ground carbon stocks makes them exceptionally efficient at sequestration. The interlinkage between their renowned biodiversity and their carbon storage capacity is a key aspect of their effectiveness. In addition, the presence of a variety of plant species with different growth patterns and lifespans ensures continuous carbon capture. Moreover, the intricate web of life within the grove, from microorganisms in the soil to pollinators in the canopy, supports the ecosystem's resilience and health, which in turn sustains its carbon cycling processes. A diverse forest is a robust and productive forest, and this productivity is directly tied to its ability to draw down carbon from the atmosphere. In the global and national context of seeking natural climate solutions, sacred groves are a ready-made, cost-effective and community-managed network of carbon-rich landscapes. In short, sacred groves are the last man-made carbon sink.

Value and threats

In an era of intensifying climate crisis, the bespeak for effective and sustainable mitigation strategies, a powerful and ancient ally exists in the form of sacred groves across the country. These green patches represent a profound, promising living proof to a symbiotic relationship with nature. Their role extends far beyond spiritual sanctuaries; they are vital, yet often overlooked, natural assets in the global effort to mitigate climate change, functioning as robust carbon sinks and bastions of ecological resilience (Vipat and Bharuch, 2014). Sacred groves are excellent at removing carbon dioxide from the atmosphere, which is the basic process of mitigating climate change. The social-ecological systems of sacred groves are highly valued and offer important ecosystem services like pollination, providing medicinal materials etc. (Blicharska *et al.,* 2013). Grove's efficacy comes from the fact that they are often old-growth ecosystems with little disturbance. As hunting, logging and agricultural encroachment are strictly prohibited, these landscapes have developed into intricate, multi-layered woods with significant biomass accumulation. A huge underground carbon deposit is made up of the unaltered soils of sacred trees. By enriching the soil with organic matter and preventing its long-term release back into the atmosphere, the steady, natural cycle of leaf fall and breakdown in a stable environment locks carbon away in a stable form. The inherent stability of scared grove is a critical asset in a changing climate, where the permanence of carbon stocks is as important as their initial volume.

The true power of sacred groves in climate mitigation lies in their community-based, self-sustaining model of conservation (Alison, 2013). Unlike many top-down projects that require continuous external funding and enforcement, these ecosystems are preserved through intrinsic cultural values which makes them a highly cost-effective and durable climate solution. Recognizing and empowering this traditional system is crucial. Integrating sacred groves into formal climate policy, such as through carbon credit mechanisms or payments for ecosystem services, can provide much-needed support to the communities that guard the groves. Thus, these untapped sinks are leveraged not merely as carbon accounting units, but as holistic, living systems that simultaneously cool the planet, preserve biological wealth and uphold the cultural heritage that has protected them for generations.

CONCLUSION

Sacred groves across India have emerged as vital biodiversity reservoirs and microclimate regulators, representing one of the oldest yet scientifically significant forms of community-based conservation that seamlessly integrates cultural reverence with ecological stewardship. The groves in India ranging from sparse clusters in arid Rajasthan to dense tropical patches in the Western Ghats, harbour exceptional species richness including rare, endemic and threatened flora and fauna often extinct in surrounding landscapes. Beyond their biological significance, sacred groves demonstrate remarkable capacity for microclimate regulation through dense canopy cover that moderates temperature extremes, enhances humidity and creates specialized ecological niches supporting diverse biological communities. These microclimatic conditions extend beyond grove boundaries, influencing immediate surrounding areas and contributing to local climate stability during seasonal extremes. Sacred groves further provide critical ecosystem services including water conservation through perennial springs, streams and ponds that serve as dependable sources during drought, groundwater recharge via extensive root systems that absorb water from depth, soil erosion prevention, nutrient cycling, carbon sequestration and pollinator refugia. However, these invaluable socio-ecological systems confront mounting threats from rapid urbanization, developmental activities, invasive species, erosion of traditional belief systems particularly among younger generations, and climate change-induced weather variability. The transformation from primitive nature worship to formal temple worship has paradoxically led to grove clearance for shrine construction. Ultimately, the persistence of sacred groves depends upon revitalizing community engagement, ensuring intergenerational transmission of traditional ecological knowledge, providing tangible benefits to local custodians through benefit-sharing mechanisms and fostering synergies between faith-based stewardship and evidence-based conservation science. By protecting sacred groves through participatory governance that respects both spiritual values and ecosystem service contributions, India can safeguard these living laboratories of biodiversity, stabilize microclimates, secure water resources and maintain the human-nature bond essential for long-term sustainability in an era of unprecedented environmental change.

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