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BIODIVERSITY AND ECOLOGICAL ASSESSMENTS: WITH SPECIAL REFERENCE TO COMMUNITY CONSERVED SACRED GROVES IN BIODIVERSITY CONSERVATION AND CLIMATE RESILIENCE

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ABSTRACT

Forest remnants that have been kept for their spiritual and religious importance are called sacred groves. The practise became more important as agriculture spread, resulting in extensive deforestation that negatively impacted watersheds and biodiversity. Although they may be less prominent today, sacred groves are nonetheless important in rural Indian landscapes home to traditional people. Despite having a pan-Indian distribution, this tradition has recently attracted more attention, leading scientists to concentrate their research on India's northeast, Western Ghats, and east coast either for their global/regional significance or unique habitats. Lower life forms were badly disregarded while the majority of studies focussed on flora, primarily angiosperms, and vertebrates in the faunal studies. Despite the fact that there are observations, there are little studies on how ecosystems function.

Keywords: biodiversity conservation, climate change, ecosystem service, sacred grove

1 INTRODUCTION

Sacred groves are areas of the landscape that are marked off and protected by human societies because it is thought that keeping them in a largely untouched state is an expression of a significant connection with the divine or with nature. These areas typically contain trees as well as other types of life and geographical features. International organisations like UNESCO and the World-Wide Fund for Nature are showing an increasing amount of interest in the significance of these natural sacred sites. Sacred groves are considered sacred natural sites (SNS) by the International Union for Conservation of Nature and Natural Resources (IUCN), which is defined as "natural places of great spiritual significance to peoples and communities. They consist of both natural regions acknowledged by institutionalised religions or faiths as sites of worship and commemoration as well as those recognised by indigenous and traditional peoples as sacred.[1]

Since the beginning of time, forests have satiated human wants. Being in a tropical climate, India has a vast variety of forest types and is home to a great biological diversity, as evidenced by the fact that four of the world's 34 biodiversity hotspots are found here.[2] In India's Western Ghats, sacred groves are one of the forest habitats that local communities protect because of their strong religious ties to the area. Sacred groves are an illustration of effective human intervention in forest conservation.[3] The federal government owns and jointly manages the sacred groves with the local communities. Local communities primarily contribute to the management of sacred groves by providing protection and tree enlargement.[4] This has made a significant contribution to the growth and maintenance of sacred groves, as well as to the provision of several intangible advantages like the preservation of biodiversity, the sequestration of carbon, the preservation of water and soil, and aesthetic and recreational services. Given the major land cover changes and socioeconomic changes causing biodiversity loss and a drop in related ecosystem services in semi-arid tropical nations, these ecosystems are crucial. Sacred groves are also common in a variety of forms throughout China, Eastern Africa, Europe, North America, and a few Arab nations.[5] The advantages of forests are largely dependent on how well the ecosystem functions and how vulnerable it is to

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invasions, droughts, floods, and other climatic anomalies.[6] Early nineteenth-century research indicates that ecosystem functioning grows as biodiversity rises. As time went on, this theory gained more support. It is hypothesised that the more species there are in an ecosystem, the more interactions there will be between them that will strengthen the ecosystem's capacity for function. Combinations of species can make full use of the available resources thanks to changes in physiological processes, morphological distinctions, and life histories of plant species, which also aid in maximising plant output.[7]

There will therefore be more alternative paths for the internal cycling of nutrients and flow of energy, which helps to support the ecosystem's stability and productivity, since there are more plant species present in a community. Understanding functional ecosystem response has become more important under the current scenario for climate change in order to offer solid interpretations and generalisations that aid in tackling climate mitigation.[8] One of the primary issues caused by global climate change is the loss of biodiversity. Unchecked GHG emissions are causing the expected change in the global climate. Due to its affordability and the numerous ecosystem services it provides, carbon sequestration from forest ecosystems is regarded as a possible method of climate mitigation as different approaches adopted to reduce emission levels have not produced the intended outcomes. It has been demonstrated beyond doubt that forest ecosystems are one of the most significant carbon sinks.[9] Reforestation and afforestation combined could lower atmospheric CO2 levels by as much as 30 ppm globally in this century. The biomass buildup in Indian forests has helped to reduce 9.31% of the world's annual emissions since 2000. Estimates also indicate that up until 2020, when emissions will be 95% greater than in 2000, continuous sequestration by forests will be able to offset 4.87 percent of emissions. The great variety of ecosystems like sacred groves, which confers a range of functional capacities in terms of stress tolerance, carbon assimilation, and optimal resource management, makes them particularly important for increasing carbon sequestration.[10]

By solving problems at the regional levels, global climate change can be reduced. Therefore, compiling the carbon stocks of various ecosystems at the regional level is important for making policy decisions that will maintain these ecosystems and the services they provide, in addition to being beneficial for establishing precise estimations. In light of this background, the current study makes an effort to evaluate the sacred groves' contributions to the preservation of biodiversity and carbon sequestration.[11]

1.1 Sacred sites as a global concept

Caves served as homes throughout the Stone Age, and pilgrimages were made to religious locations. Since the beginning of time, practically all of the continents in the world have had access to such areas. In indigenous tales, Mount Kenya in Kenya, Africa, claimed to be the origin of everything. The source of the Blue Nile is revered in Ethiopia; the source of the stream Abady is revered in Egypt; and "Jebel Musa" is thought to be the location of Mount Sinai, which Moses regarded as a holy place of God. Dead souls travel to Ghana's sacred lake "Bosumtwi" to say goodbye to God iwi. A woodland with shrine complexes is considered sacred by the "Yorubu" in Nigeria. Lake Anivorano and Mount Passot, where a sacred volcano is located, are revered places in Madagascar. There are sacred locations on the continent of Australia and in the Pacific. Western Australia's "Yamada Thalu" and Queensland's Lauran are regarded as holy places. The locations of Labasa, Vanua-Levu, "Korolmalama," a cave, and Navatu-Rock, a cliff, are revered as holy places in Fiji. Kilauea is revered as a sacred site in Hawaoo-Kailau, a mountain ridge. Wichon Falls in Micronesia is revered as a sacred location. Mt. Kailash and Mt. Jizu in China are revered by Buddhists as sacred mountain pilgrimage sites. In Tibet, Mount Kailash is revered as a holy mountain from which the Indus, Sutlej, Bhrahmaputra, and Ganges rivers flow. In South Korea, Mt. Taebaeksan, another mountain, and Mt. Hallasan, still another mountain, are revered peaks. Ibusuki, a sacred wood, and Saitobaru Mountain are revered as holy places in Japan.[12]

Mt. Popa is revered as a sacred site in Myanmar (Burma), which located in South East Asia. Sam Mt. Nga Hanh Son, or the live stone hills, are revered by Buddhists in Vietnam. Java cave and Karang Tretes cave are revered in Indonesia. The third-highest mountain in the world, Mount Kanchenjenga, is revered by Buddhists and Hindus in South Asia's Nepal. Buddhists in Sri Lanka regard Mount Mihintale as a holy site.

Guatemala's sacred places include K'umarcaaj, El Baul, and others in South Latin America. Mt. Sore is revered in Venezuela. The lake Guatavita is a holy place in Colombia. Another location is Canada's Mount Mose. Bear Bute,

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a tall ridge in the United States, is revered by Red Indians. Therefore, it can be said that the emergence of sacred sites and the associated deities is relatively prevalent throughout the world.

1.2 Sacred groves - The Indian concept

No matter where you are in India—mountains, rivers, or coastal regions—there are many sacred spots. Respect for environment has been practised through religious beliefs and practises for ages across Africa and the Indian subcontinent of Asia. In numerous communities around the world, the protected refugee or natural ecology in a certain area has existed as "Sacred Groves."[13] The strongest natural conservation areas are sacred groves, where strong cultural and religious traditions centred on conservation help to maintain a rich ecological legacy.

It is a region of fully developed vegetation that includes endemic, uncommon, and endangered plant and animal species in connection with one or more deities. It contains vegetation in its peak phase, forming a "miniforest" ecology, and is dependent on both biotic and abiotic elements directly and reciprocally. Numerous Indian states have sacred groves that go by various names, including "Devarai" in Maharashtra, "Orance" in Rajasthan, "Sidharavanam" or "Devarakadu" in Karnataka, "Sarnas" in Bihar, "Supply forests" or "Safety forests" in the north-eastern state of Mizoram, "Demojong" in Sikkim, "Dev Bhumi" in the Himalaya They are referred to in Tamil Nadu as "Iyarkai kovilkal," "Kaavu," or "Sarpakaavu," and as "Kovilkaadukal" in the northern part of the state.

They also occur in a number of other Indian states.

A sacred grove might have an area under it that ranges from a few square metres to hundreds of square metres or more. The investigation and documentation of sacred groves dates back to 1897, under D. Brandis. He asserts that "very little has been written about a number of groves in India, yet they are, or rather, were, very numerous.[14] The first floristic and ethnobotanical study of these groves after nearly 75 years. They contend that one of the most priceless remnants of early attempts at nature preservation were sacred groves. On the basis of religious convictions, it is assumed that these groves are fully immune to human intervention.

The "Sarguga" district of M. P. State is considered to contain the greatest sacred groves in all of India (Gadgil and Vartak, 1975). Every community in this area has a grove that is around 20 hectares in size. Locally, these groves are referred to as "Sarana" woodlands. The word "Sarana" is likely derived from the Sanskrit word "Sharan," which means "sanctuary." Sacred groves are areas where all local vegetation kinds have been preserved safely and where many forms of living things coexist together.

2. BIOLOGICAL DIVERSITY

Tree diversity is one of the key elements that contribute significantly to an ecosystem's ability to function. According to the findings, 144 tree species have been identified in sacred groves of which 14 were discovered to be indigenous to sacred groves.[15] The sacred groves contain a higher variety of tree species than the (91) species previously reported for this area.[16] The district's unique climatic conditions, which are a result of its location in the steep terrain of the middle Western Ghats, are chiefly responsible for its high tree diversity.

In the lower levels and at higher altitudes, it experiences yearly rainfall ranging from 1500 mm to 5000 mm on average. The range of altitude was 900–1757 m. The district now has different types of dry deciduous, moist deciduous, semi-evergreen, and evergreen forests due to rainfall, altitude, and the corresponding changes in soil and physiographic elements. Since the sacred groves are dispersed around the district in these various forest types, it is expected that a wide variety of species with various climatic requirements would flourish there.

Additionally, religious feelings toward sacred groves have protected them from anthropogenic interference and have significantly contributed to maintaining their diversity over time. The fact that the Shanon's diversity index has stayed high and non-significant across the range of grove sizes shows that tree diversity has not changed with respect to the size of sacred groves.[17] The neutral theory and niche theories contribute significantly to the understanding of the coexistence of species.

2.1 Structural composition of sacred groves

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Photosynthesis is the most significant environmental activity that provides the basic energy needed for life. The effectiveness with which solar energy is used determines how well the ecosystem performs this function. According to niche theory, an important consideration in this situation is the make-up and structure of the ecosystem. As a result, there has been evidence of significant growth-strategies differentiation between species at various light intensities. Thus, the spatial arrangement of trees was examined in order to comprehend the structural composition and its impact on the ability of sacred groves to function. Results showed that among all size classes of the groves, the number of trees remained lowest in the lowest (1–5 m) and highest height classes (>25 m), and the greatest number of trees were found in the height classes between 5.1 and 20 m.[18]

One and five percent of the total population were found in the lowest and highest height classes, respectively, followed by 28, 30, 21 and 13 percent of the population in the other height classes.[19] This pattern was also seen in the mean height distribution of trees in all the size classes of the sacred groves. This implies that compared to species that require moderate light, canopy species and shade-tolerant species are less numerous. A species arrangement based on light saturation would maximise the ecosystem's use of light, resulting in healthy growth.

2.2 Ecosystem functions and services

Less scientific focus was paid to the ecological dynamics and functions of regional ecosystems near sacred groves than to biodiversity assessment. These factors are crucial for managing groves and conserving them, especially in environments that have been altered by humans. Clearly, the location of a sacred grove affects how well and to what extent an ecosystem provides certain benefits.[20] A sizable, unharmed grove is an example of a healthy forest ecosystem, which offers beneficial ecological services such the preservation of soil, water, and biodiversity, nutrient cycling, and temperature regulation.

Small, dispersed groves offer these services at lower costs. Small groves can, however, have significant ecological effects at the local level in terms of pollination, seed dissemination, and the provision of animal passageways; therefore, these issues call for careful examination.

2.3 Soil conservation and nutrient cycling

The grove's unaltered vegetation cover is crucial for the preservation of the soil. Organic material deteriorates when litter builds up, returning nutrients to the earth and to standing biomass. Many microbes, invertebrates, and fungus will flourish as a result, and species that aren't native to secondary forests and ploughed fields can survive in the groves. Rich layers of leaf litter, humus, and intricate root systems play a crucial role in limiting soil erosion and promoting soil development. Village communities regard the water that seeps from sacred woods into the nearby farmed grounds to be nutrient-rich. However, research is required to support such claims.[21]

In certain studies of grove systems, nutrient cycling was covered in great detail. In sacred woods, a direct correlation between species richness and variety and trash output. They came to the conclusion that the grove system's tendencies for trash creation resemble tropical rain forests. The amount of nutrients in the litter and their release into the soil are typically determined by the makeup of the forest species, humidity, temperature, and the soil microbial community. Arunachalam characterise the soil nutritional condition of the grove in northeast India in terms of greater moisture content, soil organic carbon, total nitrogen, and C/N ratio.[22] According to the study, dehydrogenase activity, which aids in the decomposition of litter and assimilation of nutrients into the soil, was highest in the grove region, which was distinguished by a rich litter cover. The production of fine root mass in the grove is governed by conditions like low soil temperature, high tree density, high basal area, and undisturbed state.

By limiting leaching, fine roots play a key role in the efficient recycling of soil nutrients. The role of groves in maintaining tropical ecosystems through leaf litter and root dynamics in Cherrapunji, Meghalaya, demonstrated how effective nutrient cycling through leaf litter and networks of fine roots developed on the soil surface supported the development and stability of a fragile rainforest ecosystem over a nutrient-deficient calcareous landscape.

2.4 Water conservation

It is well recognised that holy woods serve to safeguard enduring water sources. This may be the ecological function that has received the most documentation across all of India. Well-maintained groves in Meghalaya effectively lessen runoff water's erosive strength, minimising soil erosion and nutrient washout. Up to eight streams that provide Shillong, the state's capital, with water originate in the Lum Shyllong-Nongkrim sacred

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groves in Meghalaya. Sacred groves in the Himalayan region-controlled water flow and sedimentation by being situated on rocky, steep slopes that led to ridges. Most sacred woods in the Western Ghats are connected to year-round perennial streams that are vital water sources for nearby people. In Rajasthan, where oran-related water bodies were a lifeline for the region's residents and cattle, sacred groves may have had the greatest impact on water conservation. The Jharan holy grove in Jhalawar maintained the city's water supply and guarded the stream's watershed from siltation.

Some groves have more sensitive, hygrophilous indigenous species because of the groves' ability to retain water.[23] The sacred groves of the Central Western Ghats represent the northernmost limits for the majority of the endemic species found in the Western Ghats. For example, Calophyllum apetalum, Dipterocarpus indicus, Gymnacranthera canarica, Mastixia arborea, Myristica magnifica, Pinanga dicksonii, and Syzygium travancoricum are just a few of the rare hygrophilous species that can be found in India.[24]

3. SACRED GROVE AND LANDSCAPE HETEROGENEITY

The sacred grove is a part of a larger system. These remnant forest areas contribute to the richness and biodiversity of the landscape by existing amidst a patchwork of features such as utility woods, agricultural fields, grazing lands, plantations, and human settlements.[25] Studies published to date frequently assessed groves as singular entities for biodiversity and ecology without highlighting the significance of the landscape level.

The genetic diversity, regeneration, and seed dispersion of uncommon plants are frequently impacted by grove fragmentation, which ultimately results in decreases in plant populations. The loss of mutualistic interactions between plants and animals due to fragmentation has a negative impact on the availability of pollinators and seed dispersers.

3.1 Carbon sequestration

Because of the variety of species present, the density of the trees, and the deposition of leaf litter, well-managed sacred groves can act as carbon sinks. Higher percentages of soil carbon store were found in sacred groves in the Nagoni sacred forest in Himachal Pradesh than in other forest ecosystems conditionally, compared to other forest ecosystems, well-protected sacred forests store much more carbon due to their larger biomass.[26] The future ability of groves to store carbon should, however, be estimated in light of difficulties with fragmentation and degradation so that actions can be done to preserve and restore sacred groves as local climate change mitigation strategies.

3.2 Disturbance over biodiversity

Studies on biodiversity noted grove disturbances, most of which were anthropogenic. Disturbances were divided into four categories: 1) land use change (such as deforestation, land conversion, fragmentation, and encroachment), 2) change in species composition, both intentional and unintentional (such as plantation, disturbance due to land use change, unplanned restoration activities, etc.), 3) construction projects in and around the grove, and 4) modifications to social norms, cultural practises, and religious beliefs.[27]

Due to these dangers, the biodiversity of the grove has been impacted in numerous ways. Reduced grove area due to land use change exposes the interior grove biota to unfavourable environmental conditions. Numerous delicate species suffered damage and extinction, while invasive species like Lantana camara and Chromolaena odorata established themselves in the grove.[28] The groves' original species composition has frequently changed as a result of human involvement (both planned and accidental).

Plantation (such as Acacia and Eucalyptus), horticulture requirements, impromptu restoration activities (such as the establishment of exotic plants in the name of restoration), and landscape disturbance frequently introduce new species into the grove system that affect the grove biota and have an adverse effect on the ecological function of the area. The future survival of grove species is seriously threatened by the decline in regeneration capability. Developmental activities, grazing, open access, and resource exploitation frequently result in damage to understory flora (i.e., seedlings and saplings), raising doubts about the species' chances of surviving locally in the future. Due to their extremely constrained distributions and high spatio-temporal sensitivity, endemic and uncommon species are particularly at risk.

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Grove management is closely correlated with local societies' social, cultural, and religious practises. Ecological profiles can be utilised as markers of grove management, according to studies. A grove that is well managed by the community may have a higher stem density, a larger basal area, and good potential for regeneration. In contrast, heliophilic open space species frequently took up disturbed groves.

4. FUTURE RESEARCH DIRECTIONS

Grove management is closely correlated with local societies' social, cultural, and religious practises. Ecological profiles can be utilised as markers of grove management, according to studies. A grove that is well managed by the community may have a higher stem density, a larger basal area, and good potential for regeneration. In contrast, heliophilic open space species frequently took up disturbed groves. Some of the key ecological processes that maintain the rhythm of the life cycle processes include water conservation, microclimate regulation, carbon sequestration, and plant-animal interactions (such as pollination and seed dissemination). Without a thorough grasp of these elements, developing a successful conservation strategy for grove biodiversity is challenging.[29]

4.1 Landscape dynamics and its conservation importance

All conservation efforts to date have been grove-oriented, taking into account a grove as a single entity. From a landscape perspective, groves that are part of the humanised landscape might need attention. Due to their varied settings, grove biota is reliant on the nearby land use types at various stages of their life cycles. When sufficient conditions for supporting life are available, processes including pollination, seed dispersal, germination, and foraging and nesting among animals typically take place at larger geographical scales. The majority of organisms successfully utilise a variety of landscape features and rely on landscape-level heterogeneity, with the exception of a small number of habitat-specialized species.[30]

Therefore, even if the sustaining grove area is unaltered, any significant alteration in the landscape can have an impact on the life cycles of creatures. Pesticide applications on farmlands (which may have an impact on bee and insect populations), water body diversion (which may have an impact on moisture-sensitive plants and animals), and development activities (which may have an impact on the availability of food for the animals) all have an indirect or direct impact on the ecology as a whole. A wide range of parties with various interests are involved in landscape level conservation. In order to establish sustainable livelihoods and protect biodiversity, it calls for greater community involvement and an efficient management strategy. However, the landscape level approach is still in its infancy due to poor knowledge of complex ecological processes and complicated socio-economic scenarios.

Groves that exist today are the remains of earlier forests. They are isolated areas of forest that are surrounded by different types of land use and are vulnerable to a range of disturbances. When a grove is fragmented, unfavorable conditions like as the edge effect, habitat loss, changes in microclimate, and soil compaction arise on their own and have a variety of effects on the grove biota.[31] Research is still needed to determine how fragmentation affects biodiversity and to develop mitigating strategies.

4.2 Value of ecosystem services

The advantages humans gain from the intricate ecological processes of nature—both tangible and intangible goods—are known as ecosystem services. The primary driving force behind these services is biodiversity. The existence of many creatures and the intricate interactions that result from them produce goods and services that are useful to humans. Only the provisioning service may be evaluated using a market framework out of the four main categories of services (provisioning, regulating, supporting, and cultural).[32]

Even if it is not currently possible to evaluate and quantify all services, efforts might be made to estimate values of the measurable products and services wherever practicable. Groves are an integral component of rural socio-economic life, so it is crucial to assess their value using everyday language so that locals may participate in conservation efforts and advocate for their own interests.

5. CONCLUSION

The variety and variability of living species at all levels of biological organisation on our planet is referred to as biodiversity. It comprises all varieties of living things, such as plants, animals, birds, and microorganisms, as well as their genes, habitats, and ecosystems. There are 1.8 million known species worldwide. Our nation sustains a

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range of habitats and ecosystems while just taking up 2.4 percent of the earth's landmass. India has 97,514 species of animals and 47,513 kinds of flowers recorded. Rajasthan is the largest state in our nation, with a geographical area of roughly 10.41%, yet a significant portion of the state is comprised of desert and semi-arid regions.

The best example of community-based in-situ biodiversity protection is seen in sacred woods. These are beautiful woodland sections of various sizes that are protected by the local religious groups and have a strong religious significance to these groups. These groves are sustained by mystic folklore as well as taboos, rituals, and religious beliefs. These groves are off-limits to hunting, logging, and other types of illicit human intervention. Developmental activities are also not permitted there.

The current study highlights the local flora and faunal species as well as their state of conservation. In this wood, numerous plant and animal species that have vanished from nearby habitats are still well preserved. The plant species and their traditional medical applications are also highlighted in the study. This endeavour demonstrates how knowledgeable the locals are about the therapeutic plants and their applications. The significance of sacred groves to the local populace has also been underlined by the studies. The current investigation has found that this grove serves as a lifeline for the nearby tribal inhabitants.

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