



African Journal of Biological Sciences



Assessment of Biodiversity and Conservation Challenges of Prominent Sacred Groves of Punjab: An Overview

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Article History

Volume 6, Issue 4, May 2024

Received: 20 Dec 2023

Accepted: 01 May 2024

doi: 10.33472/AFJBS.6.4.2024.787-811

Abstract

Sacred Groves are biodiversity-rich sites of varied sizes and have been preserved for centuries throughout the world by communities due to their religious and cultural significance. These lesser-known biodiversity hotspots serve as repositories for important plant species and render essential ecosystem services to the surrounding areas. Punjab, a small state in northwestern India, has 84% of its total geographical area under agriculture, while only 5.97% area is under forest cover. A comprehensive study was conducted to assess the floral biodiversity, associated religious & cultural practices, and conservation challenges of prominent sacred groves in Punjab. Nine (9) major sacred groves, spread across 8 Districts with areas ranging from 1.5 to 135 hectares, were identified and studied. The study reported a total of 151 plant species from 54 families, including 63 tree species, 32 shrub species, and 44 herb species, indicating the established and mature nature of these stand-alone ecosystems. However, these sites do not have any statutory protection and are under threat due to habitat fragmentation, anthropogenic pressures, invasive species, cultural & behavioural shifts of new generations, vagaries of time, and climate change. There is an urgent need to adopt various community-led available statutory measures such as recognition as Biodiversity Heritage Sites (BHSs) under the Indian Biological Diversity Act, 2002 or designating as Other Effective Area-based Conservation Measures (OECMs) sites, to ensure the systematic conservation and management of sacred groves of Punjab.

Key words: Sacred Groves, Biodiversity Conservation, BHSs, OECMs, Community Practices, *In-situ* conservation, Ecosystem Services

Introduction

Biological Diversity or Biodiversity encompassing the variety of life within species, between species and across ecosystems, is essential for the health and functionality of ecosystems. It plays a crucial role in providing ecosystem services such as food, water, climate regulation, soil fertility, aesthetic & cultural benefits. The diversity and abundance of genes, species, and ecosystems influence the resilience and sustainability of ecosystems, making the conservation of biodiversity vital for the continued provision of these benefits to humanity. The growth of human population and consumption levels are putting immense pressure on natural resources and ecosystems services.

The ever-increasing demand is contributing to global biodiversity loss and ecosystem degradation, which have far-reaching implications for critical global challenges such as food security, water scarcity, exacerbation of climate change and emergence of zoonotic diseases.

The United Nations has proclaimed period from 2021 to 2030 as the 'UN Decade on Ecosystem Restoration', underscoring the urgency of biodiversity conservation for sustaining life on earth (Singh et al., 2022). This global initiative seeks to galvanize efforts to restore and conserve ecosystems, tackle environmental degradation, and advocate for sustainable practices to protect biodiversity for the well-being of future generations

The 1992 Rio Earth Summit was a turning point for global biodiversity conservation, leading to the creation of the Convention on Biological Diversity (CBD), an international treaty. India, as a signatory, has shown commitment to the CBD's goals through the enactment of the Biological Diversity Act, 2002, which has been now amended as the Biological Diversity Act (Amendment) Act, 2023. This legislation aligns with the CBD's main objectives: conserving biodiversity, sustainable use of its elements, and fair benefit-sharing from the use of biological resources and associated traditional knowledge (Anonymous, 2004). India is one of the 17 mega diverse countries, home to over 45,000 plant species and 91,000 species of animals, reflecting its vast and varied biological richness (Anonymous, 2019).

India, as a party to CBD, has already conserved approximately 27% of its geographic area with 22% as terrestrial and 5% as coastal & marine habitats. This conservation effort exceeds the area-based targets set by Aichi Biodiversity Target 11 and India's own National Biodiversity Target 6 (Anonymous, 2022 a).

The 'Post-2020 Global Biodiversity Framework' (GBF) under CBD has set a worldwide conservation target known as "30 x 30" to protect 30% of the planet's land and sea areas by 2030 (Anonymous, 2022 b). India is actively working towards this goal by extending its conservation initiatives beyond conventional protected areas. This include the preservation of Biodiversity Heritage Sites as per section 37 of the Biological Diversity Act (BDA) and the implementation of "Other Effective Area-based Conservation Measures" (OECMs), which are innovative strategies for safeguarding biodiversity in areas not traditionally protected (Singh et al., 2022). These efforts, which involve local community participation, are designed to bolster *in-situ* conservation and support the broader biodiversity conservation objectives of the GBF.

Punjab, a small state situated in the northwestern region of India, encompasses merely 1.57% of the country's total geographic area (Jerath et al., 2014). Out of the total geographic area of 50,362 sq.km, a significant 84% area is under agriculture, while forest cover is sparse at 5.93%, including 2.26% of trees outside forests and 3.67% within notified forest areas (Anonymous, 2021). The state has a very limited protected area network, making up only 0.69% of its total geographical area, encompassing 13 wildlife sanctuaries, 4 community reserves, 5 conservation reserves, and 5 zoological parks. Punjab is also home to six Ramsar sites, internationally recognized wetlands of importance for biodiversity, namely Harike, Ropar, Kanjli, Keshopur Miani Community Reserve, Nangal and Beas Conservation Reserve (Arora and Singh, 2022).

Prior to the Green Revolution in 1960s, Punjab harbored high genetic diversity in both within agricultural and forest areas. However, over the many decades, this diversity has significantly reduced due to the intensive agricultural practice with a focus on high-yielding crop varieties along with the impacts of habitat loss and fragmentation caused by infrastructure development & anthropogenic activities, spread of invasive species, pollution, and climate change among other reasons (Jerath et al., 2006).

Despite these impending biodiversity conservation challenges, biodiversity hotspots in the form of sacred groves which lie outside the state's protected area network, still exist in the fragile ecosystem of Punjab. These groves have been traditionally preserved and managed by local communities for centuries due to their religious and cultural significance and their associated beliefs about these sites (Singh et al., 2021a). These groves are affectionately called as "Jhidi" (ਝਿੜੀ) by the Punjabi people. In the local Punjabi dialect, "Jhidi" signifies a place with naturally occurring indigenous flora, all thriving within designated areas. These groves consisting abundant native flora and fauna and serving as repositories of genetic diversity, harboring rare and endangered species, valuable medicinal and herbal plants, soil microorganisms, and provide essential ecosystem services such as carbon sequestration and microclimate regulation (Singh et al., 2021b). Sacred groves are also a subset of the broader concept of "Sacred Natural Sites" put forth by the International Union of Conservation of Nature (IUCN) regarding religion and spirituality-based conservation of nature and biodiversity (Verschuuren et al., 2010).

Prominent researchers have made significant contribution for understanding of sacred groves, highlighting their role as religious forests intertwined with human societal evolution and progress (Gadgil and Vartik, 1975). These groves serve as vital reservoirs of genetic diversity, housing rare and endemic species safeguarded by local communities through religious dedication (Kosambi 1962, Vartak & Gadgil, 1973 and Gadgil & Vartik, 1976). Hughes and Chandran (1998) further provided a detailed analysis of the sacred groves' distribution across continents such as Asia, Africa, Europe and America, illustrating their global significance. In various countries, sacred groves are perceived as spiritual or sacred commons, with their management practices deeply rooted in the religious and cultural beliefs of communities venerating deities (Aniah and Yelfaanibe, 2016). These groves are crucial for biodiversity conservation, climate resilience enhancement, and for provision of ecosystem services, along with other tangible and intangible benefits. This significance is attributed to their rich biodiversity, often surpassing that of adjacent areas and even nearby protected sites (Onyekwelu and Olusola, 2014). However, the traditional cultural practices, perceptions, taboos, and conservation methods long associated with sacred groves are reported to be eroding worldwide. This erosion is leading to their fragmentation and degradation (Kent, 2013). This emphasizes to a pressing need to preserve these invaluable ecological and cultural assets, which play a critical role in the biodiversity and heritage of regions around the globe.

The documentation of sacred groves in India began with the work of D. Brandis (1897), who served as the first Inspector General of Forests during the British colonial period and is often referred to as the Father of Indian Forestry. This initial documentation laid the groundwork for subsequent detailed studies on the ecological and cultural aspects of these groves. The first in-depth vegetational analysis and examination of ethnobotanical practices of sacred groves of State of Maharashtra was undertaken by Gadgil and Vartik in 1976. Burman (1992) expanded the geographical scope of research of the sacred groves to include the vast Himalayan region, spanning from Himachal Pradesh

in the northeast to Meghalaya in the far northeast, highlighting the widespread presence of sacred groves across varied ecosystems. The ecological importance, conservation status and diversity of sacred groves in different parts of India, particularly in the northeastern region, have been the focus of numerous researchers (Boojh and Ramakrishnan, 1983; Rodgers, 1994; Khan et al., 1997; Nair et al., 1997; Tiwari et al., 1998; Sunitha and Rao, 1999; Boraish et al., 2003; Kumar and Swamy, 2003; Jerath, 2014 and Amirthalingam, 2016).

India is home to over 100,000 sacred groves, each known by different local names across different regions, representing the highest count of such groves in any country worldwide. This site widely varies in area, from less than a hectare to expanses covering over 100 hectares (Malhotra et al., 2007). This diversity highlights the significant ecological and cultural variations among India's sacred groves. A thorough examination of the status of sacred groves across 25 Indian states was conducted by Warriar et al., 2023, covering distribution, status, and challenges faced by these ecological and cultural keystones.

Despite the widespread recognition and documentation of sacred groves across India, there was a significant research gap in the state of Punjab regarding the sacred groves. Till date, no systematic study has been conducted or reported on the status of sacred groves of Punjab. This omission highlighted the urgent need of an in-depth investigation to get insights into the cultural, ecological, and spiritual dimensions of sacred groves of existing within the landscape of Punjab.

Keeping above in view, for the first time, a comprehensive study was carried to identify major sacred groves of Punjab, assessment of their floral biodiversity with special focus trees, shrubs and herbs, documentation of various social, cultural, and religious practices associated with each site and study their immediate and long-term conservation challenges.

Material and Methods

The identification of significant sacred groves involved extensive exercise of reviewing important literature such as British Era District Gazetteers, Working Plans of various Forest Divisions, State Biodiversity Strategy and Action Plan, biodiversity-related other publications & papers, reports from NGOs and the media to gather initial information on the presence of sacred groves across different agro-climatic zones in the state. This was complemented thorough discussions and interactions with field personnel of relevant department such as Forest & Wildlife Preservation, Agriculture, Horticulture, Rural Development & Panchyats and Animal Husbandry as well as proactive NGOs and university researchers working in area of biodiversity conservation. These efforts were followed by field visits and surveys across all 22 Districts of the state to gather first hand data on the sacred groves.

Besides the extensive biodiversity assessment exercises, the unique social, cultural, religious practices, historical perspective and biodiversity of the surrounding areas, for each site, were also documented. Comprehensive consultation sessions with members of Village Level Biodiversity Management Committees, Gram Panchayats, Head Priest & member of Local Management Committees/Trusts, worshippers, farmers of adjoining fields through structured interviews by preparing a questionnaire, were also conducted to gain insights into the various conservation & management challenges of each site.

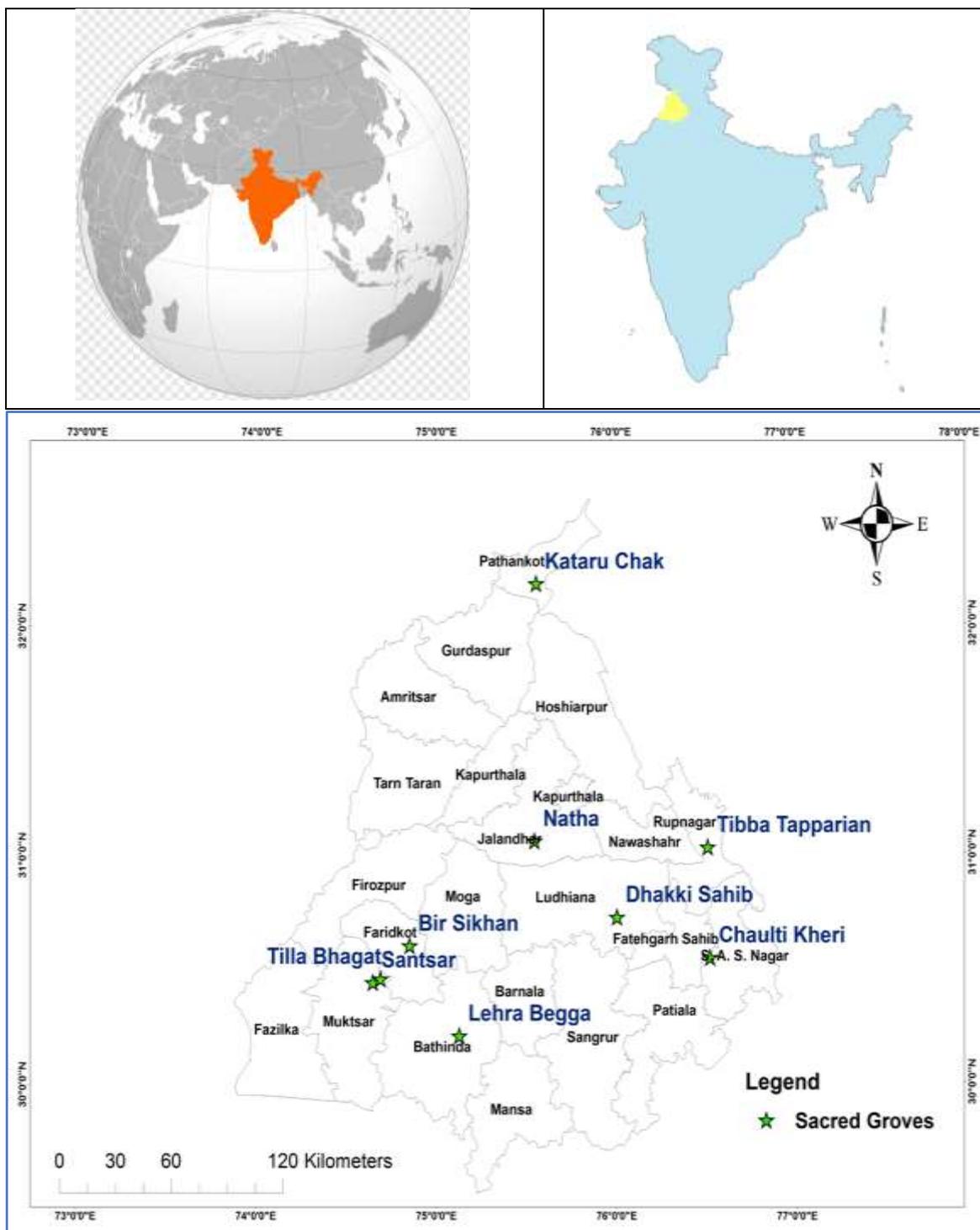
Nine (9) prominent sacred groves from 8 Districts were identified in state based on their popularity in terms of size, vegetation, traditions and all were subsequently studied in detail (**Table 1**). Further, Remote Sensing/GIS Mapping of all the 9 sites was also carried out (**Map 1**).

Table 1: Prominent Sacred Groves of Punjab

Sr. No	Longitude	Latitude	Name & Location	Area (Hectare)
1	74.8498 N	30.6285 E	Bir Sikhanwala, Village Sikhanwala Block Faridkot, District, Faridkot	134.15
2	76.0152 N	30.7463 E	Tapoban Dhakki Sahib, Village Maksudra, Block Payal, District Ludhiana	52.64
3	75.5684 N	32.2042 E	Charpat Bani, Village Kataru Chak, Block Ghorta, District Pathankot	14.65
4	74.6437 N	30.4682 E	Tilla Puran Bhagat, Village Bhuttiwala, Block Gidderbaha, District Mukatsar	11.31
5	75.1248 N	30.2356 E	Derra Baba Mallo Ram Ji, Village Lehra Begga, Block Bathinda, District Bathinda	10.91
6	74.6877 N	30.4805 E	Sant Sar, Village Khokhar & Harike, Block Bariwala, District Muktsar Sahib	3.92
7	76.5274 N	31.0502 E	Dargah Baba Ji, Village Tibba Tapparain, Block Nurpur Bedi, District Roopnagar	3.00
8	76.5344 N	30.5668 E	Kaya Kalp Vriksh, Village Cholti Kheri, Block Khera, District Fatehgarh Sahib	1.15
9	75.5542 N	31.0849 E	Bhairon Jatti, Village Nat/Natha, Block Nurmahal, District Jalandhar	1.62

Throughout the study period from 2018 to 2023, field visits of 9 sites were carried out across various seasons (pre & post-monsoon and winter) on a regular basis for the detailed biodiversity assessment of tree, shrub, and herb species using the quadrat methods (10 m x 10 m for trees and 5 m x 5 m for herbs & shrubs). The morphological characteristics of various plant species reported from various sites were scrutinized and matched with those described in renowned botanical references (Hooker, 1897; Nair, 1978 and Sharma, 2021) to accurately identify and authenticate the species. Additionally, plant voucher specimens were collected for herbarium sheet preparation and off-site species identification using offline and online literature references. The expertise of various taxonomists and plant specialists were availed during the field visits for the on-site identification of species. Documentation of important faunal species were also done. GPS coordinates for all sites were obtained using a Garmin GPS device and GIS mapping was conducted with Arc-GIS software. Photographic documentation (**Plate 1**) of all sites was carried using a standard Canon DSLR Camera and an HD Mobile Camera to gather a visual record of the sites.

Map 1 : Remote Sensing /GIS Mapping of Major Sacred Groves of Punjab



Google Earth imagery was employed to analyze the physical characteristics of the sites over time. Additionally, Remote Sensing/GIS technology, complemented by ground truthing, was utilized to create Normalized Difference Vegetation Index (NDVI) and Land Use & Land Change (LULC) maps. This process on pilot basis was undertaken to monitor changes in vegetation health and land use from 1991 to 2023 for two specific sites namely Bir Sikhanwala, District Faridkot, and Chartpat Bani, District Pathankot, utilizing Landsat 5 satellite data for 1991 to 2011 and Landsat 8 satellite data for 2023.

The summary of salient characteristics of 4 prominent sacred groves of Punjab, has been provided hereunder for representing the religious & cultural connotations and plant diversity being exhibited by these sacred groves along with their conservation challenges:

1. Bir Sikhanwala, District Faridkot: The name "Bir Sikhanwala" derives from "Bir" meaning forest, and "Sikhanwala" indicating its proximity to the village of Sikhanwala. Historical references suggest that Bir Sikhanwala served as a hideout and guerrilla camp for Sikhs during their conflicts with Mughal forces. The site was also reported to be utilized by the Indian army for camps during wartime. A Gurudwara Sahib (Temple) in the name of Baba Marana, also known as "Baba Kala Mehar", has been established at the site. Baba Marana, revered as the ancestor and founder of Sandhwan is a prominent leader of the Sandhu clan of the Sikh religion. Consequently, the site holds significance for Jatt Sikhs of the Sandhu Clan who worship there.

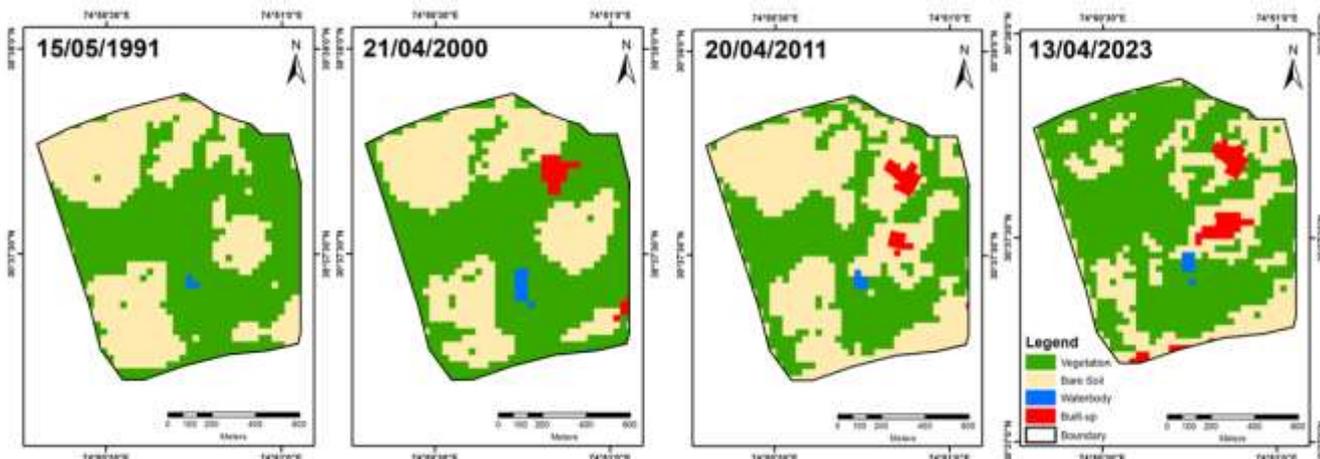
The biggest sacred grove of the state is characterized by a mud wall enclosure in certain areas and features a natural wetland situated in its midst. These unique characteristics, coupled with its historical and religious significance, contribute to the cultural and ecological richness of Bir Sikhanwala. The annual fair held on March 18th includes a tradition, where liquor is offered to the deity as a form of prasad. Additionally, during the annual fair, newlywed couples participate in a ritual where they collect a handful of mud from the pond on the premises. It is believed that taking this mud home with them will bring good fortune and happiness to their married lives. These rituals and customs add cultural significance to the event, contributing to the sense of community and tradition surrounding Bir Sikhanwala. The Google earth image of the site is a given in **Figure 1**.

Figure 1: Google Earth Image of Bir Sikhanwala, District Faridkot

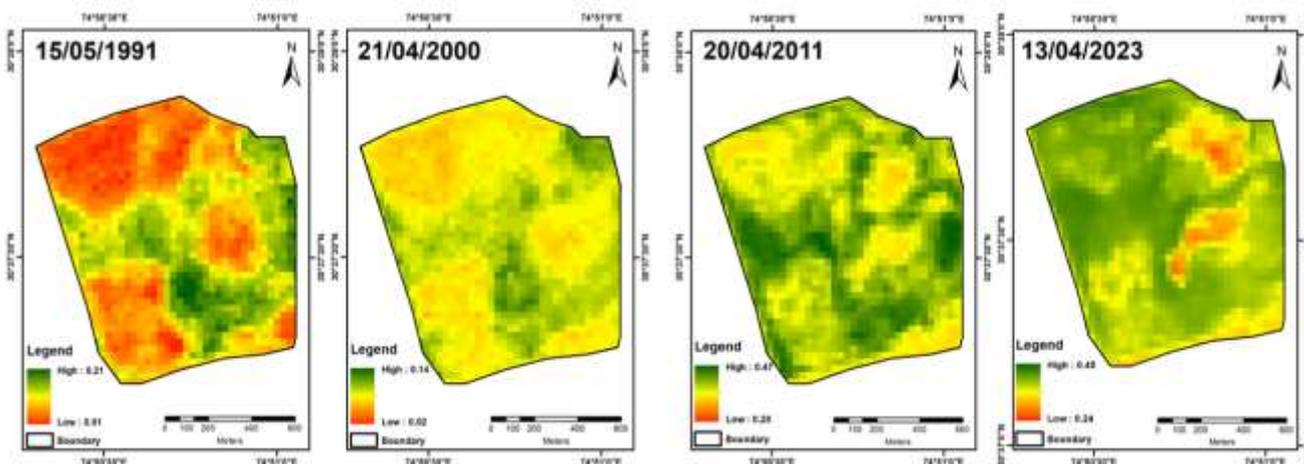


Source: Google Earth, 2024

Map 2: Land Use and Land Cover of Bir Sikhawala Sacred Grove



Map 3: Normalized Difference Vegetation Index of Bir Sikhawala Sacred Grove



The Land Use and Land Cover (LULC) Map of site for period from 1991 to 2023 represents the land use and land cover of site on given dates (**Map 2**). Vegetation and built-up area of site has shown an upward trend and area under bare soil has decreased. The area under water body increased after 1991 and remained consistent after 2001. The vegetation and bare soil areas fluctuation could be attributed to number of factors and natural changes in the environment, which needs to be further investigated.

The Normalized Difference Vegetation Index (NDVI) analysis of the site over the 4 decades from 1991 to 2023 is presented in **Map 3**. NDVI is used to analyze remote sensing measurements from satellite imagery to estimate the density of green cover on a patch of land and is a very useful indicator for assessing vegetation cover. It is calculated from the visible and near-infrared light reflected by vegetation. Healthy vegetation absorbs most of the visible light that hits it and reflects a large portion of the near-infrared light. Unhealthy or sparse vegetation reflects more visible light and less near-infrared light. The NDVI values range from -1 to +1, with higher values indicating greater density and health of vegetation. NDVI is presented in color-coded maps, with red representing lower NDVI values (less vegetation density) and yellow-green representing higher values (greater vegetation density).

There is considerable increase in NDVI values of the site during 2011 ranging from low (0.20) to high (0.47) indicating peak vegetation density as compared to NDVI values for 1991 (0.01 to 0.21), 2002 (0.02 to 0.14) and 2023 (0.24 to 0.45). The NDVI values can also be influenced by a number of factors such as seasonal changes, climatic conditions and land use changes.

The sacred grove has a rich diversity of plant species, with around 60 recorded species including trees, herbs and shrubs. Among these, *Acacia* and *Ziziphus* species dominate the landscape. Several threatened native flora species have been identified within the site, including *Ephedra foliate*, *Tecomella undulata*, *Salvadora oleoides*, *Salvadora persica*, *Capparis decidua* and *Ricinus communis*. Additionally, abundant species such as *Vachellia nilotica*, *Albizia lebbek*, *Cassia fistula*, *Dalbergia sisso*, *Moringa oleifera*, *Prosopis cineraria*, *Azadirachta indica*, *Cordia myxa*, *Calotropis procera*, *Ficus benghalensis*, *Pongamia pinnata*, *Syzygium cumini*, *Boerhavia diffusa*, *Ziziphus mauritiana*, *Ziziphus nummularia*, *Solanum nigrum*, *Tinospora cordifolia*, *Withania somnifera* and *Grewia tenax* contribute to the diverse flora of the site. Bir Sikhawala is a haven for avian life, with around 40 species of birds recorded at the site (Sharma et al., 2023).

The sacred grove is facing significant challenges stemming from the uncontrolled grazing and heavy infestation of invasive species namely *Prosopis juliflora* and *Parthenium hysterophorus*. These invasive plants threaten the native flora and disrupt the ecological balance of the site. Additionally, the concretization of the area surrounding the Gurdwara Sahib, through the construction of additional facilities for visitors, poses a serious threat to the site's integrity due to habitat fragmentation.

2. Tapoban Dhakki Sahib, District Ludhiana: The centuries old revered sacred grove is located outside the village Maksudra, is known as Tapoban or Dhakki Sahib. It is a natural forest area dominated by the *Butea monosperma* species, locally known as Dhakk or Palash, hence the name Dhakki Sahib. *Butea monosperma*, also known as the Flame of the Forest, is a stunning flowering tree native to the Indian subcontinent. The vibrant red or orange flowers of species are a sight to behold. Having such an abundant natural presence of this tree in one location create a breathtaking natural spectacle during its blooming season.

The site boasts a rich variety of all the floral species, reported to be found in the plains of Punjab. It holds significant cultural and religious importance, attracting people from all sections of society. A gurdwara has been constructed in the heart of the site, enhancing its spiritual ambiance. The Google earth image of the site is a given in **Figure 2**.

The locals believe that individuals, who tried to encroach upon and cultivate parts of the site for farming failed miserably. Elders shared the tales of people attempting to gather wood for fire and experiencing various misfortunes, including blindness, leading to heavy losses. With the cooperation and support of devotees, numerous social and welfare activities are conducted at the site. Holy congregations for the recitation of Gurbani Kirtan are held on every full moon (Massya / Purnima), and a grand function is organized annually with lot of religious fervour on 13th April to celebrate Baisakhi.

Figure 2: Google Earth Image of Tapoban, Dhakki Sahib, District Ludhiana



Source: Google Earth, 2024

Beside abundance of natural occurring *Butea monosperma*, the site is rich in various other important dominant species, including *Acacia modesta*, *Aegle marmelos*, *Albizia lebbek*, *Azadirachta indica*, *Ziziphus mauritiana*, and *Prosopis spicigera*. Other notable species present include *Tectona grandis*, *Morus indica*, *Pongamia pinnata*, *Dalbergia sisso*, *Bambusa india*, *Canna indica*, *Cassia occidentalis*, *Ficus bengalensis*, *Ficus religiosa*, *Ficus virens*, *Grewia tenax*, *Moringa Oleifera*, *Jatropha gossypifolia*, *Leucaena leucocephala*, *Murraya koenigii*, *Putranjiva Roxburghii*, *Ricinus communis*, *Syzygium cumini*, *Tinospera cordifolia*, *Tamarix indica*, *Terminalia bellirica*, *Vachellia nilotica*, *Ziziphus mauritiana*, *Ziziphus nummularia*, *Ziziphus jujuba* along with many types of other herbs and shrubs. The site features a natural water pond and boasts rich faunal diversity, including numerous species of birds, mammals, reptiles and amphibians.

The site also harbors an abundance of invasive species such as *Parthenium hysterophorus*, *Cannabis sativa*, *Lantana camara* and *Prosopis juliflora*. Like other biodiversity-rich area within agricultural fields, this site also faces conservation challenges such as habitat fragmentation, farm chemical runoff from surrounding agricultural fields, water stress during dry periods on account intensive agriculture practices in surrounding area, proliferation of invasive species and the impacts of climate change. The increase in built up area within the site over the years also led to loss of habitat for various floral species.

3. Derra Baba Mallo Ram Ji, District Bathinda: The sacred grove spread on 25 acres of privately owned land, graciously set aside by the landowner for Derra, is known as Derra Baba Mallo Ram Ji. According to local belief, Baba Mallo Ram Ji, who dedicated many years to meditation at this site, was a devout follower of the 6th Sikh Guru, Shri Guru Gobind Singh Ji. It's believed that Baba Mallo Ji, harnessing his divine powers, informed Guru Ji's Army about an imminent Mughal invasion, and courageously joined them in the ensuing battle.

The revered site attracts people of all religions seeking blessings. A small Gurdwara Sahib has been established at its heart, serving as a focal point for spiritual activities. Religious congregations are held on every Poornmashi (Full moon), with annual celebrations marking Maghi (Makar Sankranti) and Baisakhi. Additionally, a special annual function on June 18th commemorates the death anniversary of Baba Karam Das Ji, who meditated at this site around 50 years ago. Baba Karam Das ji was a nature lover. To facilitate access for devotees, a small cemented path has been constructed leading to the Gurdwara, as the site is situated on the outskirts of the village. A tranquil pond has been built up to accommodate pilgrims partaking in rituals and seeking solace. The Google Earth image of the site is given in **Figure 3**.

Figure 3: Google Earth Image of Derra Baba Mallo Ram Ji, District Bathinda



Source: Google Earth, 2024

In keeping with tradition, visitors refrain from disturbing fallen wood or harming vegetation at this sacred site due to a deep-rooted belief in potential misfortune. Fallen or damaged wood is repurposed for cooking food in a community kitchen that serves pilgrims, embodying a spirit of resourcefulness and communal support. Moreover, neighboring farmers generously allocate portions of their agricultural land to nurture the vegetation of the site, showcasing a harmonious relationship between the local community and the natural environment. This collective effort

underscores the reverence and stewardship bestowed upon this cherished site. At the grove, an elongated earth mound holds profound significance, revered by locals for its perceived divine powers. Newly married couples or parents of newborns participate in a traditional ritual whereby they gather soil from the surrounding areas and place it upon the mound. This act symbolizes their gratitude for prayers answered and wishes fulfilled, demonstrating the deep spiritual connection shared with the sacred land.

The site is a treasure trove of rare and threatened species, such as *Salvadora oleoides*, *Capparis decidua*, *Clerodendrum phlomidis*, *Ephedra foliata* (both Male and Female plants) & *Prosopis cineraria*, which are not typically found in the surrounding areas. Sadly, these species have faced the brink of extinction due to land consolidation and intensive agricultural practices. The other prominent floral species recorded from site are *Ailanthus altissima*, *Azadirachta Indica*, *Calotropis procera*, *Cordia dichotoma*, *Ficus benghalensis*, *Kigelia africana*, *Maerua oblongifolia*, *Melia azedarach*, *Moringa oleifera*, *Nerium oleander*, *Ricinus communis*, *Tamarix indica*, *Tectona grandis*, *Vachellia nilotica*, *Ziziphus mauritiana* and *Ziziphus nummularia*.

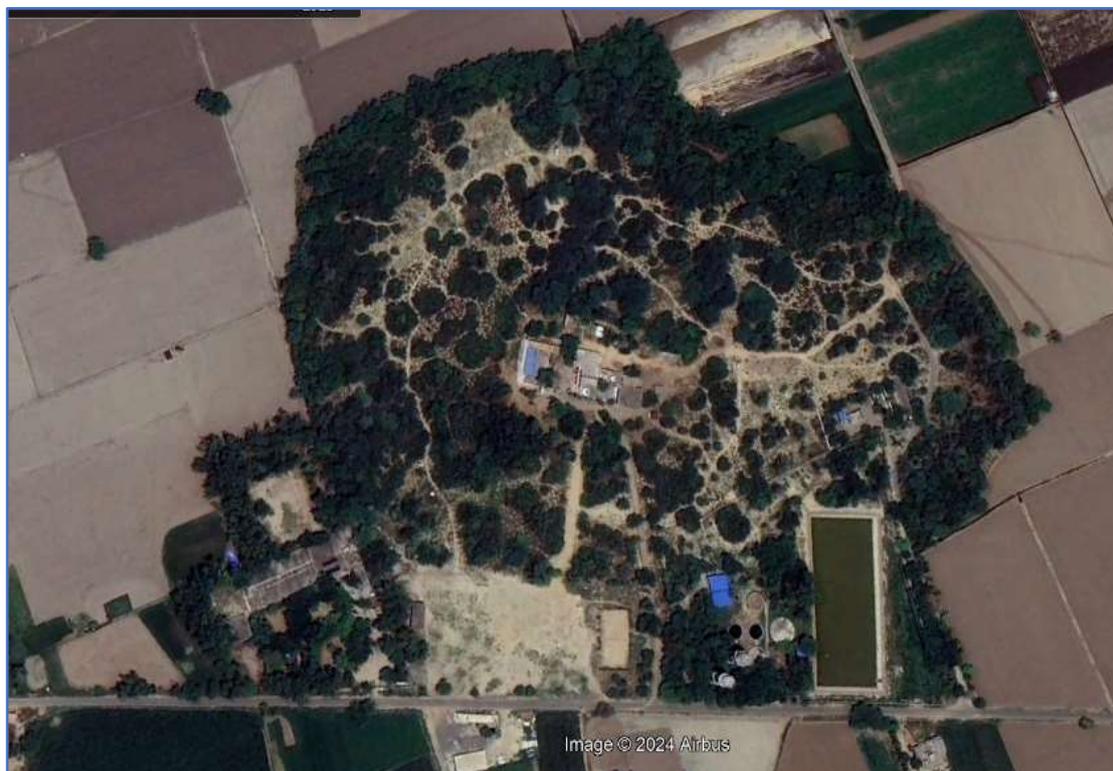
The diverse ecosystem of site also serves as an excellent habitat for Peacock, along with numerous other native bird species. The site also faces several conservation challenges that threaten its delicate ecosystem. Severe water stress during dry months is a pressing issue, exacerbated by the continuously receding groundwater table, which has plummeted to depths of 100 feet. This water scarcity contributes to the drying of many plants each year, jeopardizing the biodiversity of the sacred grove.

Further, the proliferation of invasive species, particularly *Prosopis juliflora*, *Parthenium hysterophorus*, and *Lantana camara* also pose a significant threat to the resident flora and fauna of the grove. The aggressive spread of these species competes with indigenous plants for resources and alters the ecosystem's balance. Agricultural runoff from surrounding fields, especially rainy season introduces pollutants and excess nutrients into the site's ecosystem, further compromising water quality and impacting plant & animal life. The expansion of built areas for religious activities encroached upon the natural habitat, leading to habitat loss and fragmentation. Furthermore, pollution from industries established in the vicinity of the site adds to the environmental strain, degrading air and water quality and disrupting the ecological balance.

4. Tilla Puran Bhagat, District Muktsar Sahib: The sacred grove, nestled atop a sand dune locally referred to as "Tilla," at a height of 35 feet above the village's mainland. It's a place of historical significance, dating back 500 to 700 years, boasting a unique ecosystem akin to the arid zones or desert landscapes typically found in the southwestern region of Punjab. Within this ancient landscape thrives a vegetation rich in character, embodying the hardiness and resilience of desert flora.

The site holds cultural and religious significance as it is dedicated to the worship of the local deity known as "Puran Bhagat". At the heart of the site's main temple, amidst the reverence and devotion of the worshippers, stands a testament to time itself, the centuries-old *Salvadora Oleoides* tree, known locally as Peelu or Van. Despite the passage of years, it stands tall and healthy, a living symbol of endurance and spiritual continuity. The Google Earth image of the site is given in **Figure 4**.

Figure 4: Google Earth Image of Tilla Puran Bhagat, District Muktsar Sahib



Source: Google Earth, 2024

The local legend about these sacred groves is a remarkable event, when Puran Bhagat planted his “Datan” (shoot or stem of branches from the *Acacia nilotica* or *Azadirachta indica* tree, commonly used for dental hygiene in India) and this seemingly ordinary act bore extraordinary fruit, as the Datan miraculously grew into a tree. Over time, this solitary tree multiplied, giving rise to a lush forest of diverse species, each contributing to the vibrant ecosystem of the area. An annual religious fair held during the auspicious occasion of Baisakhi (13th/14th April) amplifies the fervor and devotion of the visitors. Amidst the process of land consolidation after independence, the locals have demonstrated their unwavering commitment for preserving the sanctity of the site by earmarking the land for Puran Bhagat, ensuring the conservation of its precious vegetation and heritage. This act of locals, reflects their deep reverence and respect for the site's religious and cultural significance, reaffirming its status as a cherished place of worship and pilgrimage.

The profound reverence and respect for the sacred site are evident in the locals' actions and traditions. They refrain from taking even the smallest of twig or stem from the site, fearing potential repercussions from nature. Only grazing of cattle, sheep, and goats is permitted at the site. Observations regarding the survival of saplings planted by devotees further underscore the site's unique ecological dynamics. While natural vegetation survives, man-made interventions for planting new saplings seem to struggle to take root, phenomenon that reinforces the site's inherent sanctity and the resilience of its native flora.

The temple was built at the sacred grove in 1962 for enduring devotion and dedication of its worshippers. Over the years, the temple has expanded to accommodate the growing number of devotees. A hall has also been constructed for serving langer (Community Kitchen) to pilgrims.

The site's rich biodiversity is a tribute to its ecological significance as a unique habitat for native plant species. The presence of very old trees, including *Salvadora oleoides*, *Prosopis cinenara*, *Vachellia nilotica*, *Tecomella undulata*, *Ephedra foliata*, *Ziziphus mauritiana*, and *Capparis decidua*, highlights the site's role in preserving botanical treasures that are increasingly becoming very scarce in the surrounding areas. In addition to these venerable specimens, the site boasts a diverse array of other important flora such as *Abutilon indicum*, *Amaranthus viridis*, *Albizia lebbek*, *Argemone Mexicana*, *Azadirachta indica*, *Achyranthes aspera*, *Calotropis procera*, *Clerodendrum phlomidis*, *Chenopodium murale*, *Chenopodium album*, *Ficus benghalensis*, *Ficus religiosa*, *Heliotropium ellipticum*, *Dalbergia sissoo*, *Eucalyptus*, *Grewia tenax*, *Leucaena leucocephala*, *Phyla nodiflora*, *Tribulus terrestris*, and *Ziziphus nummularia*.

The site's diverse ecosystem not only supports a rich array of plant life but also provides a vital habitat for numerous fauna species such as Hare, Snake, Mongoose, Porcupine, Monitor lizards, Squirrels and Jackal and many species of small insects. The site also supports a variety of local bird species, which find food, shelter, and nesting sites among its diverse vegetation. These avian residents contribute to the site's ecological health and serve as indicators of its overall biodiversity.

The site faces many conservation challenges that threaten its ecological integrity and long-term viability. These challenges include uncontrolled grazing, high water stress due to its location on a large sand dune, the impacts of natural processes such as weathering & erosion, the proliferation of invasive species like *Prosopis juliflora* and *Acacia tortilis*, which outcompete native vegetation, and expansion of built infrastructure encroaching upon natural habitats and disrupt ecological processes. Locals have observed degradation of the site's vegetation over the years, which they attribute to drought like conditions in summers and climatic fluctuations, highlighting the urgent need for remedial actions by relevant government agencies to preserve the site.

Results and Discussions

Out of 9 sacred groves, eight are located in the Malwa region, which encompasses the central and south-western districts of the state, while the solitary grove of Charpat Bani is situated in the lower Shiwalik Hills (Kandi Belt) of District Pathankot. A total of 151 plant species from 54 families have been reported from 9 groves (**Figures 5 and 6**). This rich tapestry of plant life includes 63 species of trees, a testament to the well-established and mature nature of these standalone ecosystems. Moreover, the diversity extends to 44 species of herbs that enhance the groves' understory with their medicinal, aromatic and ecological significance and presence of 32 species of shrubs underscores the adaptability and layered structure of the vegetation. Climber and grasses are present as well, with 7 and 5 species respectively, though they are the least abundant.

The dominant presence of tree species highlights the resilience and ecological robustness of these groves, with a high potential to provide a multitude of ecological services and to serve as reservoirs of invaluable genetic stock. Within the range of families represented, Fabaceae recorded the highest species count of 22, followed by Asteraceae (10), Moraceae (9), Euphorbiaceae (7), Amaranthaceae (7) and Lamiaceae (6). Several other families, including Poaceae, Solanaceae, Malvaceae, Rutaceae,

Bignoniaceae, Myrtaceae, Rhamnaceae, Capparaceae, Salvadoraceae, etc. feature less prominently, with species counts ranging from 5 to as few as 2, indicative of their limited and sporadic distribution within the groves. Further, 28 families are represented singularly by one species each, each holding its unique place in the ecosystem. The varied distribution of these families throughout the sacred groves could be the result of a mosaic of ecological and evolutionary factors.

Figure 5: Distribution of Floral Species of 9 Sacred Groves

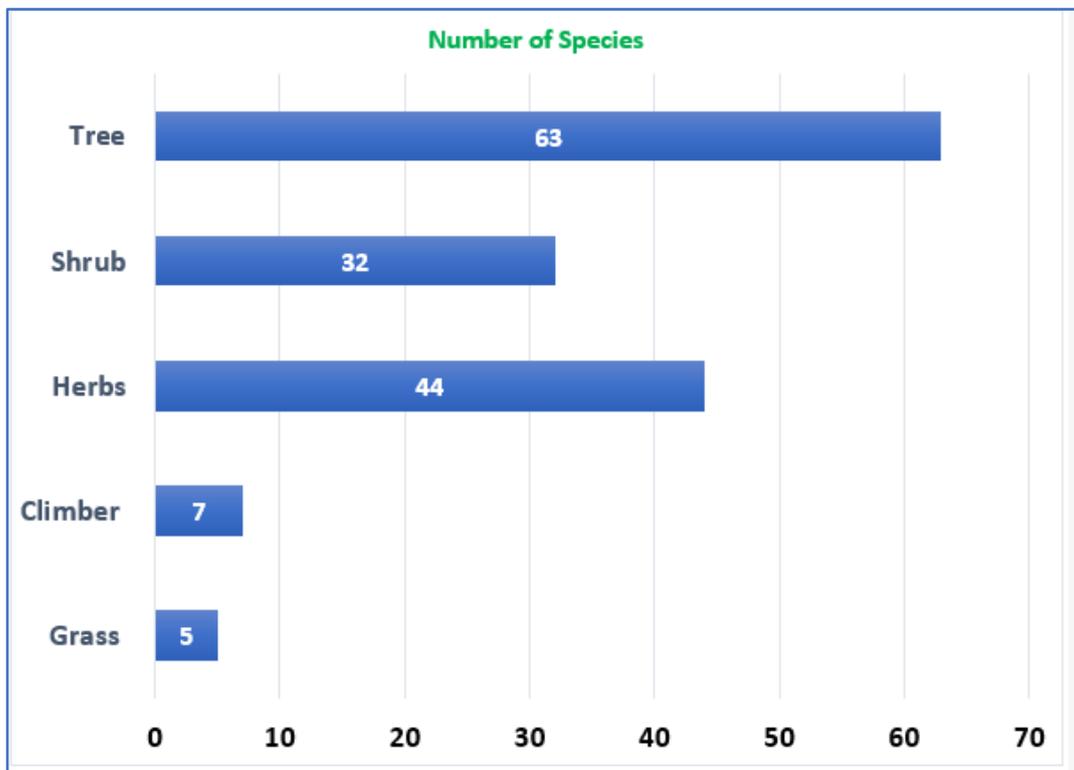
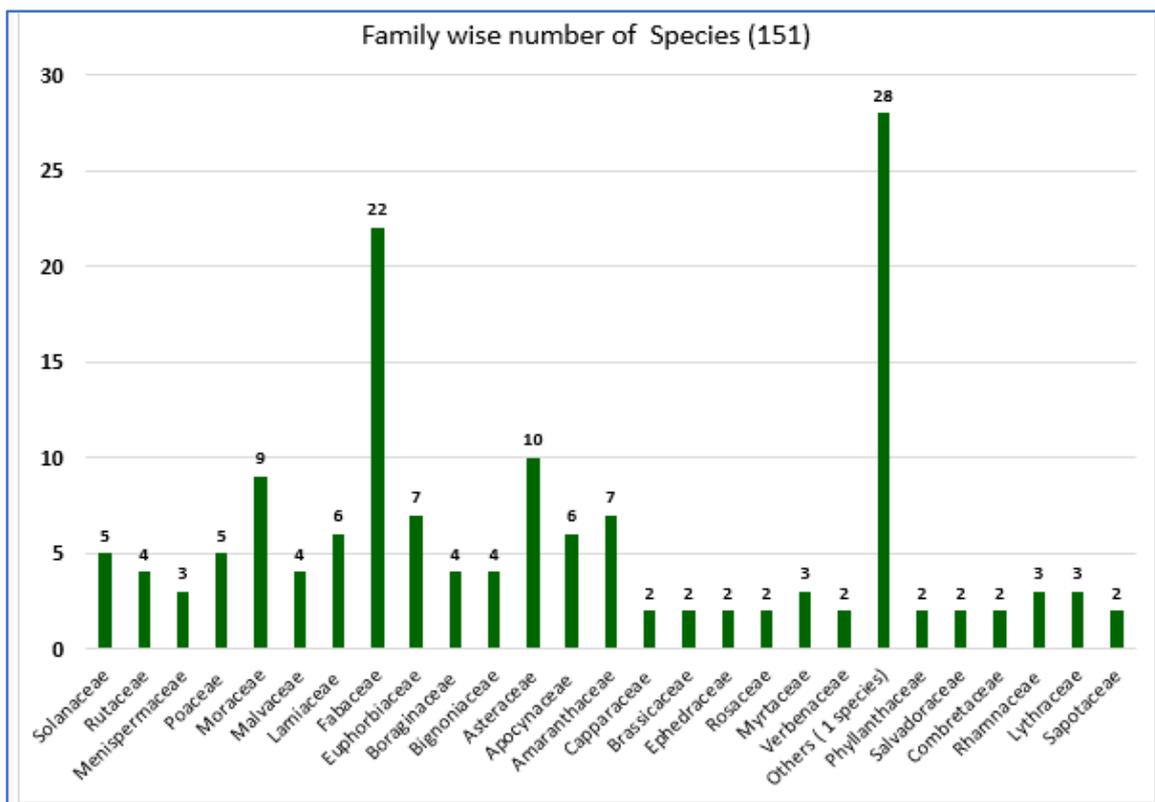


Figure 5: Family wise distribution of Floral Species recorded from 9 Sacred Groves



The sacred groves of the state acting as a crucial habitat for *in-situ* conservation of biodiversity, primarily due to the prevalence of ancient and robust natural populations of certain tree and shrub species. These include *Tecomella undulata*, *Salvadora oleoides*, *Salvadora persica*, *Capparis decidua*, *Ziziphus mauritiana*, *Ziziphus nummularia*, *Butea monosperma*, *Acacia modesta*, *Tamarix indica*, *Terminalia bellirica*, *Ephedra foliate*, *Cordia dichotoma*, *Moringa oleifera*, *Ailanthus altissima*, *Prosopis cinenara*, *Withania somnifera*, *Terminalia chebula*, *Crateva religiosa*, *Ehretia laevis*, *Mallotus philippensis*, *Morus indica* and *Putrinjiva roxburghii*, which are increasingly becoming rare in the surrounding agricultural-dominated ecosystems. The natural occurring population of *Tecomella undulata*, which is notified as a near to extinction species in Punjab, u/s 38 of Biological diversity Act, 2002 (Arora and Singh, 2022) has been reported from 2 groves namely Bir Sikhawala and Tilla Pura Bhagat.

Besides floral species, these groves are also serving as a vital habitat for various faunal species. Their role as a habitat for wildlife underpins the need for further research to understand and reinforce the sacred groves' pivotal function in wildlife preservation within the state. The reverence for sacred groves of state transcends individual faiths, encompassing a multitude of religious beliefs including Sikhism, Hinduism, Islam and Christianity and are integral to cultural and spiritual practices of local communities. However, the traditional commitment to preserving these sacred sites is diminishing over time due to change in attitude of new generations towards the conservation of nature.

The sacred groves in Punjab, akin to those in other parts of India and the world, face numerous conservation challenges. These groves exist as isolated biodiversity hot spots amid expansive agricultural lands characterized by intensive farming practices, since the advent of green revolution in late sixties. The threats to these groves are not uniform but vary in intensity and type from one

site to another. The key conservation challenges include the expansion of built-up areas, particularly around central temples leading to habitat fragmentation and the natural degradation wrought by the passage of time and climate variability. This includes extended dry seasons with soaring temperatures and periods of relentless rainfalls & extreme weather events such hailstorms. Cultural and generational shifts, especially among the youth, are leading to changes in traditional belief systems, which in turn affecting the conservation practices. The introduction of non-native species and the unchecked spread of invasive species like *Prosopis juliflora* and unregulated grazing, especially in the groves having large areas, pose significant ecological threats to sacred groves (Singh et al., 2022).

The conservation of Punjab's sacred groves is also hindered by the reluctance of the trust or management committees of these sites to adopt the existing statutory conservation tool for declaring these as Biodiversity Heritage Sites under section 37 of the Biological Diversity Act, 2002. This hesitance largely stems from misconceptions about losing control over the management of daily affairs and restrictions on further infrastructure development for accommodating the devotees. The lack of synergy and understanding among managing trusts, Village Biodiversity Management Committees and Village Panchayats further compound the conservation challenges and impedes the establishment of effective management and conservation strategies for the sacred groves. All these factors collectively endanger the long-term sustainability of sacred groves in Punjab and thus, warrant urgent and effective conservation measures.

Conclusion

Despite facing various conservation challenges and lack of recognition from local communities for their critical ecological services, sacred groves of the Punjab continue to preserve their biodiversity richness, nurtured over decades by natural processes and the collective faith of the communities, particularly the elder members, who have been holding these sites in high esteem. This enduring resilience of the sacred groves is a powerful testament to the symbiosis of nature and religious reverence, safeguarding these sites over a long period of time.

Addressing the conservation challenges of sacred groves of Punjab requires the adoption of sustainable and scientific management practices as these sites do not have any statutory protection. Strategies such as controlling the spread of *Prosopis juliflora* and other invasive species through manual removal, biological control methods, and targeted herbicide applications, enhancing the biodiversity and ecological resilience of these sites through reforestation in required patches, along with the scientific disposal of disease or termite-infested fallen woods are crucial. Moreover, it is also important to ensure that construction activities near worship areas do not harm the ecological health of the sacred groves. Utilizing environmentally friendly materials and techniques for necessary infrastructure development, alongside effective visitor and waste management and involving the scientific community for regular monitoring, are key steps to address various threats and preserve these natural heritages. The capacity building of local communities, site management committees/ trusts about the significance of these sites, fostering a sense of collective ownership & pride, and promoting collaborative efforts of District Administrations, Local Bodies, and Biodiversity Management Committees are vital for the long-term conservation of these invaluable ecosystems & natural heritage for future generations.

Besides their aesthetic, rejuvenation, and meditation value, these sacred groves can serve as important sites for undertaking nature educational and research activities on various aspects of biodiversity such as plants, birds, reptiles, insects, and fungi. The organization of well-managed nature camps and exploratory visits for students to sacred groves can significantly enhance their learning experiences through understanding the intricacies of these unique ecosystems, fostering a deeper connection with nature and appreciation of the biodiversity these sites support.

These lessors known biodiversity hot spots of the State of Punjab have the potential to be recognized as Biodiversity Heritage Sites under the Indian Biological Diversity Act, 2002, and as Other Effective Area-based Conservation Measures (OECMs) sites, given their contribution to biodiversity conservation, largely as an incidental result of their management goals and beliefs of local communities associated with them. Designating major sacred groves as BHSs or OECMs by adopting various community-led available statutory measures, could pave the way for the systematic conservation and management of sacred groves of Punjab.

Acknowledgments

Authors thankfully acknowledge and appreciate the unstinted technical support and guidance provided by Dr. J. K. Arora, Member Secretary, Punjab Biodiversity Board (PBB); Mr. J. C. Kala, IFS (Retd.), Advisor, Amity Institute of Global Warming and Ecological Studies; Dr. S.P. Singh, IFS (Retd.), Director, Amity School of Natural resources & Sustainable Development, Amity University; Mr. Variender Kumar, Head Teacher, Govt. Primary School, Village Machaki Mal, District Faridkot and Member of Technical Support Group of District Biodiversity Management Committee, Faridkot; Dr. Daljeet Singh, Professor (Rtd), Department of Botany, Government College, Hoshiarpur and Dr. Sangeeta, Scientist, PBB during the entire period of research. Authors also express heartfelt gratitude and are very grateful to Dr. R. K. Setia, Scientist SE, Punjab Remote Sensing Centre, Ludhiana, and Mr. Dharendra Chauhan, Information Officer (EICAP), Punjab State Council for Science & Technology for providing valuable inputs and technical support for preparing Remote Sensing/GIS Maps.

Competing Interests

The authors declare that they have no competing interests.

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Plate 1 : Selected Photographs of Sacred Groves of Punjab



Bir Sikhanwala, District Faridkot



Epidera Foliata at Bir Sikhanwala



Salvadora oleoides at Bir Sikhanwala



Gurdwara Sahib at Tapoban, Dhakki Sahib, District Ludhiana



Butea monosperma at Dhakki Sahib, District Ludhiana



Centuries old *Salwadora oleoides* Tree at Tilla Puran Bhagat, District Mukatsar



Entrerence of Tilla Pura Bhagat, District Mukatsar



Natural Vegetation at Tilla Pura Bhagat, District Mukatsar



Natural Vegetation at Lehra Begga, Distirct Bathinda



Elongated Earth Mound at Lehra Begga, Distirct Bathinda