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Sacred Groves and Degraded Forests under Climate Stress: Comparative Biodiversity and Non-Timber Forest Product Dynamics in Chhatarpur District, Madhya Pradesh

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ABSTRACT

Sacred groves (SGs) in Bundelkhand represent community-based conservation systems where biodiversity is sustained through cultural taboos and restricted exploitation, while degraded forests in the same region reveal ecological vulnerability under climate stress and livelihood pressures. This study compared plant diversity and resilience between SGs (Jatashakar, Bhimkund) and degraded forest (Bijawar, Bajna) in Chhatarpur district, Madhya Pradesh. Vegetation sampling using quadrats and transects documented species composition, and diversity indices were applied to assess richness, evenness, and dominance. SGs retained 70-72 species per site, including medicinal herbs (*Curcuma caesia*, *Chlorophytum borivilianum*), native trees (*Shorea robusta*, *Madhuca longifolia*), and climbers (*Abrus precatorius*, *Tinospora cordifolia*). Degraded forest supported only 40-51 species per site, with sensitive herbs absent and hardy or invasive taxa (*Lantana camara*, *Saccharum munja*) dominating. Shannon-Wiener Values were higher in sacred groves (H′ = 3.0–3.2) than degraded forests (H′ = 1.8–2.0), while Simpson's Index confirmed stronger ecological stability in sacred groves (D = 0.88–0.92) compared to degraded forests (D = 0.65–0.72). The findings highlight sacred groves as biodiversity reservoirs, conserving medicinal plants and maintaining ecological balance through cultural practices. In contrast, degraded forests, lacking socio-cultural protection, are more vulnerable to erratic rainfall, prolonged droughts, grazing, and unsustainable extraction of non-timber forest product (NTFPs). Overharvesting of medicinal roots, fruits, and fodder grasses weakens regeneration cycles and accelerates ecological decline. This comparative analysis underscore the ecological and cultural significance of sacred groves and calls for restoration measures in degraded forests, including sustainable NTFP management, to counteract species loss and enhance resilience under semi-arid climate stress.

1. Introduction

Sacred groves in India are culturally protected forest patches that have historically functioned as biodiversity refuges. Rooted in faith, taboos, and traditional management practices, these landscapes preserve native species and microhabitats even amidst extensive land-use change (Mishra et al., 2004; Nayak et al., 2019). They represent living examples of community-based conservation where ecological resilience is sustained through cultural values.

In contrast, degraded forests in semi-arid regions such as Bundelkhand are increasingly vulnerable to climate stress. Erratic rainfall, prolonged droughts, and anthropogenic pressures accelerate biodiversity decline, reducing species richness and weakening ecosystem services (Reshi & Khuroo, 2012; Rath & Ormsby, 2020). Unlike sacred groves, these degraded patches lack socio-cultural protection, making them more susceptible to ecological collapse.

Despite the ecological and cultural importance of sacred groves, comparative studies assessing their resilience against degraded forests under climate stress remain limited in Bundelkhand, particularly in Chhatarpur district. This research addresses that gap by systematically evaluating biodiversity patterns, medicinal plant decline, and community perceptions across sacred groves and degraded forests sites.

The objectives are:

1. To document and compare plant diversity in sacred groves and degraded forests.
2. To analyze the impact of climate stress and anthropogenic pressures on biodiversity.
3. To assess the cultural role of sacred groves in sustaining ecological resilience.

2. Study Area

Chhatarpur district in Bundelkhand, Madhya Pradesh, lies between 23°45′–25°20′ N and 78°10′–80°00′ E, with elevations of 300–450 m. The terrain is dominated by rocky plateaus, shallow valleys, and seasonal streams, while sandy loam soils support vegetation adapted to drought. The semi-arid monsoonal climate brings hot summers, mild winters, and 800–1000 mm of rainfall, though variability has led to prolonged dry spells and water scarcity.

Within this landscape, sacred groves such as **Jatashankar Dham** and **Bhimkund** are culturally protected through rituals and taboos, conserving native medicinal plants and enhancing ecological resilience. In contrast, degraded forest patches like **Badamalhera** and **Bijawar** face pressures from grazing, logging, fuelwood collection, and overharvesting of non-timber forest products, leading to reduced species richness, soil erosion, and weakened regeneration. Sacred groves thus embody ecological and spiritual significance, while degraded forests highlight the impacts of anthropogenic stress.

Fig. 1 Map showing study area sites

3. Methodology

This study adopted a comparative design to evaluate biodiversity patterns, ecological resilience, and non-timber forest product (NTFP) dynamics between sacred groves and degraded forest patches in Chhatarpur district, Madhya Pradesh. The sacred groves selected were Jatashankar Dham and Bhimkund, while the degraded forest sites included Badamalhera and Bijawar.

Sampling Strategy Vegetation sampling was conducted using stratified random quadrats (5 × 5 m) across each site to record species composition, abundance, and diversity. A minimum of ten quadrats were laid per stratum to ensure representative coverage. In addition, line transects (100 m) were established along pilgrimage paths, forest edges, and grazing zones to capture invasive spread and regeneration status. Separate species inventories were prepared for sacred groves and degraded forest sites.

Socio-Cultural Data Collection Semi-structured interviews and questionnaires were administered to local communities, including temple priests, forest staff, and residents. These explored perceptions of biodiversity change, medicinal plant decline, and cultural practices associated with sacred groves. Interviews were conducted in Hindi and local dialects to ensure inclusivity and cultural sensitivity. Importantly, the survey also investigated community dependence on non-timber forest products (NTFPs), such as medicinal roots, fruits, and fodder grasses, to assess livelihood pressures contributing to forest degradation.

Analytical Tools Quantitative analysis employed diversity indices:

- Shannon–Wiener Index (H′) for species richness and evenness:

$$H' = -\sum(p_i \cdot \ln\ p_i)$$

where p_i is the proportion of individuals belonging to the i^{th} species.

- Simpson's Index (D) for dominance patterns:

$$D = 1 - \sum(p_i^2)$$

where p_i is the proportion of individuals belonging to the i^{th} species.

Qualitative responses were thematically coded into categories such as species decline, anthropogenic drivers, NTFP dependence, and cultural practices. Triangulation of ecological and socio-cultural data provided an integrated understanding of biodiversity resilience in sacred groves compared to degraded forests.

Table 1 Comparative Species Composition in Sacred Grove (Jatashankar) and Degraded Forest (Bijawar)

S. No.	Botanical Name	Family	Growth Form	SGs (J)	Degraded Forest (B)
1.	*Abrus precatorius*	Fabaceae	C	✓	✗
2.	*Acacia catechu*	Fabaceae (Mimosoideae)	T	✓	✓
3.	*Acacia nilotica*	Fabaceae (Mimosoideae)	T	✓	✓
4.	*Achyranthes aspera*	Amaranthaceae	H	✓	✓
5.	*Aegle marmelos*	Rutaceae	T	✓	✗
6.	*Anogeissus latifolia*	Combretaceae	T	✓	✗
7.	*Azadirachta indica*	Meliaceae	T	✓	✓
8.	*Biophytum reinwardtii*	Oxalidaceae	H	✓	✗
9.	*Biophytum sensitivum*	Oxalidaceae	H	✓	✗
10.	*Boswellia serrata*	Burseraceae	T	✓	✓
11.	*Buchanania lanzan*	Anacardiaceae	T	✓	✗
12.	*Butea monosperma*	Fabaceae	T	✓	✗
13.	*Calotropis procera*	Apocynaceae	S	✓	✓
14.	*Carissa carandas*	Apocynaceae	S	✓	✓
15.	*Cassia tora*	Fabaceae (Caesalpinioideae)	H	✓	✗
16.	*Chlorophytum borivilianum*	Asparagaceae	H	✓	✗
17.	*Citrus limon*	Rutaceae	S/T	✓	✗
18.	*Cocculus hirsutus*	Menispermaceae	C	✓	✓
19.	*Colocasia esculenta*	Araceae	H	✓	✗
20.	*Commiphora wightii*	Burseraceae	S	✓	✗
21.	*Curcuma caesia*	Zingiberaceae	H	✓	✗
22.	*Dalbergia sisso*	Fabaceae	T	✓	✓
23.	*Dendrocalamus stictus*	Poaceae	T	✓	✗
24.	*Dendrocalamus stictus*	Poaceae	T	✓	✗
25.	*Desmodium gangeticum*	Fabaceae	S	✓	✗

26.	*Diospyros melanoxylon*	Ebenaceae	T	✓	✓
27.	*Eulaliopsis binate*	Poaceae	G	✓	✗
28.	*Grewia asiatica*	Malvaceae	S	✓	✗
29.	*Grewia tiliifolia*	Malvaceae or Tiliaceae	T/S	✓	✗
30.	*Helicteres isora*	Malvaceae	S/T	✓	✗
31.	*Imperata cylindrica*	Poaceae	G	✓	✓
32.	*Indigofera tinctoria*	Fabaceae	S	✓	✓
33.	*Jatropha curcas*	Euphorbiaceae	S	✓	✓
34.	*Lantana camara*	Verbenaceae	S	✓	✗
35.	*Lawsonia inermis*	Lythraceae	S	✓	✗
36.	*Limonia acidissima*	Rutaceae	T	✓	✗
37.	*Limonia elephantum (correa)*	Rutaceae	T	✓	✗
38.	*Linum usitatissimum*	Linaceae	H	✓	✗
39.	*Madhuca longifolia*	Sapotaceae	T	✓	✓
40.	*Malvastrum coromandelianum*	Malvaceae	H	✓	✗
41.	*Mangifera indica*	Anacardiaceae	T	✓	✓
42.	*Morus alba*	Moraceae	T	✓	
43.	*Musa paradisisaca*	Musaceae	H	✓	✓
44.	*Nelumbo nucifera*	Nelumbonaceae	H	✓	✓
45.	*Nyctanthes arbor-tristis*	Oleaceae	S	✓	✓
46.	*Oxalis corniculate (L.)*	Oxalidaceae	H	✓	✗
47.	*Panicum maximum*	Poaceae	G	✓	✗
48.	*Papaver somniferum*	Papaveraceae	H	✓	✓
49.	*Pithecellobium dulce*	Fabaceae (Mimosoideae)	T	✓	✓
50.	*Ricinus communis*	Euphorbiaceae	S	✓	✓
51.	*Rorippa indica (L.)*	Brassicaceae	H	✓	✗
52.	*Saccharum munja*	Poaceae	G	✗	✓
53.	*Saccharum officinarum*	Poaceae	G	✓	✓
54.	*Shorea robusta*	Dipterocarpaceae	T	✓	✓
55.	*Sida acuta (Brum.)*	Malvaceae	H	✓	✗
56.	*Sterculia urens (Roxb.)*	Malvaceae	T	✓	✗
57.	*Strychnos potatorum*	Loganiaceae	T	✓	✗
58.	*Syzygiym cumini*	Myrtaceae	T	✓	✓
59.	*Tectona grandis*	Lamiaceae	T	✓	✓
60.	*Temarindus indica (L.)*	Fabaceae (Caesalpinioideae)	T	✓	✓
61.	*Terminalia bellirica*	Combretaceae	T	✗	✓
62.	*Terminalia chebula*	Combretaceae	T	✗	✓
63.	*Thespesia populnea (L.)*	Malvaceae	T	✓	✗
64.	*Tinospora Cordifolia (willd.) s*	Menispermaceae	C	✓	✓
65.	*Ventilago denticulata (Willd.)*	Rhamnaceae	T	✗	✓
66.	*Vitex negundo*	Lamiaceae	S	✓	✓
67.	*Waltheria indica (L.)*	Malvaceae	S	✓	✗
70.	*Yucca aloifolia*	Asparagaceae	S	✓	✓
71.	*Ziziphus mauritiana (Lam.) T*	Rhamnaceae	T	✓	✓
72.	*Zizipus xylopyrus (Retz.)*	Rhamnaceae	S/T	✓	✓

Sacred groves conserve diverse medicinal herbs, native trees, and climbers due to cultural protection, while degraded forests host fewer species dominated by hardy or invasive taxa. Climate stress and unsustainable pressures reshape vegetation, reducing sensitive plants. Thus, sacred groves act as resilient biodiversity reservoirs, whereas degraded forests reflect ecological vulnerability and selective survival under semi-arid conditions.

Table 2 Comparative Species Composition in Sacred Grove (Bhimkund) and Degraded Forest (Bajna)

S. No.	Botanical Name	Family	Growth Form	Sacred Grove (B)	Degraded Forest (Ba)
1.	*Abrus precatorius*	Fabaceae	C	✓	✗
2.	*Acacia catechu*	Fabaceae (Mimosoideae)	T	✓	✓
3.	*Acacia nilotica*	Fabaceae (Mimosoideae)	T	✓	✓
4.	*Achyranthes aspera*	Amaranthaceae	H	✓	✓
5.	*Aegle marmelos*	Rutaceae	T	✓	✗
6.	*Azadirachta indica*	Meliaceae	T	✓	✓
7.	*Biophytum sensitivum*	Oxalidaceae	H	✓	✗
8.	*Boswellia serrata*	Burseraceae	T	✓	✓
9.	*Buchanania lanzan*	Anacardiaceae	T	✓	✗
10.	*Butea monosperma*	Fabaceae	T	✓	✗
11.	*Calotropis procera*	Apocynaceae	S	✓	✓
12.	*Carissa carandas*	Apocynaceae	S	✓	✓
13.	*Cassia tora*	Fabaceae (Caesalpinioideae)	H	✓	✗
14.	*Chlorophytum borivilianum*	Asparagaceae	H	✓	✗
15.	*Cocculus hirsutus*	Menispermaceae	C	✓	✓
16.	*Colocasia esculenta*	Araceae	H	✓	✗
17.	*Commiphora wightii*	Burseraceae	S	✓	✗
18.	*Curcuma caesia*	Zingiberaceae	H	✓	✗
19.	*Dalbergia sisso*	Fabaceae	T	✓	✓
20.	*Dendrocalamus stictus* (Bamboo)	Poaceae	T	✓	✗
21.	*Desmodium gangeticum*	Fabaceae	S	✓	✗
22.	*Diospyros melanoxylon*	Ebenaceae	T	✓	✓
23.	*Eulaliopsis binate*	Poaceae	G	✓	✗
24.	*Grewia asiatica*	Malvaceae	S	✓	✗
25.	*Imperata cylindrica*	Poaceae	G	✓	✓
26.	*Indigofera tinctoria*	Fabaceae	S	✓	✓
27.	*Jatropha curcas*	Euphorbiaceae	S	✓	✓
28.	*Lantana camara*	Verbenaceae	S	✓	✓
29.	*Lawsonia inermis*	Lythraceae	S	✓	✓
30.	*Madhuca longifolia*	Sapotaceae	Tree	✓	✓
31.	*Malvastrum coromandelianum*	Malvaceae	H	✓	✗
32.	*Musa paradisiaca*	Musaceae	H	✓	✓
33.	*Nelumbo nucifera*	Nelumbonaceae	H	✓	✓
34.	*Nyctanthes arbor-tristis*	Oleaceae	S	✓	✓
35.	*Panicum maximum*	Poaceae	G	✓	✗
36.	*Papaver somniferum*	Papaveraceae	H	✓	✓
37.	*Pithecellobium dulce*	Fabaceae (Mimosoideae)	T	✓	✓
38.	*Ricinus communis*	Euphorbiaceae	S	✓	✓
39.	*Rorippa indica*	Brassicaceae	H	✓	✗
40.	*Saccharum munja*	Poaceae	G	✗	✓
41.	*Saccharum officinarum*	Poaceae	G	✓	✓
42.	*Shorea robusta*	Dipterocarpaceae	T	✓	✓
43.	*Sida acuta*	Malvaceae	H	✓	✗
44.	*Strychnos potatorum*	Loganiaceae	T	✓	✓

45.	*Syzygium cumini*	Myrtaceae	T	✓	✓
46.	*Tectona grandis*	Lamiaceae	T	✓	✓
47.	*Tamarindus indica*	Fabaceae (Caesalpinioideae)	T	✓	✓
48.	*Terminalia bellirica*	Combretaceae	T	✓	✓
49.	*Terminalia chebula*	Combretaceae	T	✓	✓
49.	*Thespesia populnea*	Malvaceae	T	✓	✗
50.	*Vitex negundo*	Lamiaceae	S	✓	✓
51.	*Ziziphus jujuba*	Rhamnaceae	S/T	✓	✓

Bhimkund sacred grove sustains diverse medicinal herbs, native trees, and climbers, while Bajna degraded forest is dominated by hardy and invasive species. Cultural protection fosters resilience in groves, whereas climate stress and NTFP pressures reduce ecological stability in degraded forests.

Table 3 Comparative Biodiversity and Stress Indicators (Sacred Groves: Jatashankar, Bhimkund (JB) vs Degraded Forests: Bijawar, Bajna (B.Ba)

S. No.	Parameter	SGs (J, B)	Degraded Forests (B.Ba)
1.	Species Richness	Very high (70–72 species recorded per site)	Moderate (40–51 species recorded per site)
2.	Medicinal Plant Presence	Strongly retained (*Curcuma caesia*, *Tinospora cordifolia*, *Boswellia serrata*, *Chlorophytum borivilianum*)	Declined; many herbs absent, invasives (*Lantana camara*, *Saccharum munja*) dominate
3.	Shannon Index (H′)	3.0–3.2 (high richness and evenness)	1.8–2.0 (lower diversity, uneven distribution)
4.	Simpson Index (D)	0.88–0.92 (low dominance, balanced communities)	0.65–0.72 (higher dominance, fewer species prevail)
5.	Climate Resilience	Moderate to high; cultural protection supports regeneration	Low; prolonged droughts and grazing reduce recovery
6.	Community Concern	Strong cultural attachment; rituals restrict exploitation	Weak cultural link; overharvesting and fuelwood collection common

Sacred groves exhibit high species richness, medicinal plant retention, and ecological stability, while degraded forests show reduced diversity, invasive dominance, and weak resilience. Diversity indices confirm cultural protection sustains balanced communities, whereas climate stress and unsustainable pressures accelerate ecological decline in unprotected forest patches.These results highlight how cultural protection enhances biodiversity conservation.

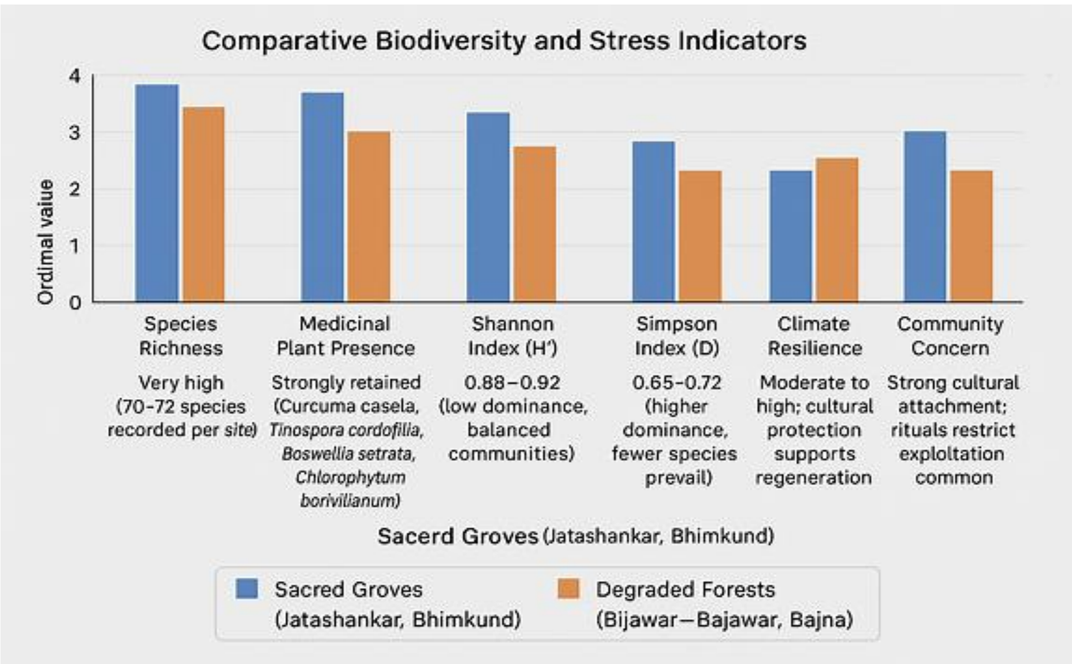

Fig. 2 Comparative Biodiversity and Stress Indicators across Sacred Groves (Jatashankar, Bhimkund) and Degraded Forests (Bijawar, Bajna)

Fig. 3 Images showing a vegetation degraded forest and sacred groves

Table 4 Diversity Indices Comparison (Based on Field Data from SGs and Degraded Forests)

Index / Parameter	Sacred Groves (J, B)	Degraded Forests (B, Ba)	Reference
Species Richness	70–72 species per site (high diversity)	40–51 species per site (moderate)	Field Analysis
Shannon–Wiener (H′)	3.0–3.2 (high richness and evenness)	1.8–2.0 (lower diversity, uneven distribution)	Field Analysis (current dataset)
Simpson's Index (D)	0.88–0.92 (low dominance, balanced communities)	0.65–0.72 (higher dominance, fewer species prevail)	Calculated from species abundance; cf. Reshi & Khuroo, 2012
Evenness	High (species well distributed)	Low (few species dominate)	Derived from field observations; cf. Pappa Rani et al., 2019
Ecological Resilience	Moderate to high; cultural protection supports regeneration	Low; grazing and drought reduce recovery	Field Assessment

This table synthesizes the raw species composition data into diversity indices. Sacred groves consistently show higher Shannon values and Simpson's stability, reflecting balanced communities and medicinal plant retention. Degraded forests, by contrast, exhibit lower diversity and higher dominance, confirming ecological vulnerability under climate stress and anthropogenic pressure.

4. Result and Discussion

The comparative study of sacred groves (Jatashankar, Bhimkund) and degraded forests (Bijawar, Bajna) revealed clear contrasts in biodiversity and resilience. Sacred groves supported 70–72 species per site, including medicinal herbs (*Curcuma caesia*, *Chlorophytum borivilianum*), native trees (*Shorea robusta*, *Madhuca longifolia*), and climbers (*Abrus precatorius*, *Tinospora cordifolia*). Degraded forests contained only 40–51 species, dominated by hardy or invasive taxa such as *Lantana camara* and *Saccharum munja*. Diversity indices confirmed richer, more stable communities in sacred groves (Shannon H′ = 3.0–3.2; Simpson D = 0.88–0.92) compared to degraded forests (H′ = 1.8–2.0; D = 0.65–0.72). Cultural taboos in sacred groves restrict exploitation, sustaining regeneration, while degraded forests face climate stress and unsustainable harvesting of non-timber forest products, leading to ecological vulnerability.

5. Conclusion

Sacred groves in Bundelkhand, such as Jatashankar and Bhimkund, sustain higher biodiversity, medicinal plant retention, and ecological resilience compared to degraded forests like Bijawar and Bajna. Diversity indices confirm balanced communities in sacred groves, while degraded forests show reduced richness, invasive dominance, and weakened regeneration. Climate stress and unsustainable extraction of non-timber forest products (NTFPs) accelerate decline in degraded patches, whereas cultural taboos in sacred groves restrict exploitation and support ecological stability. Future restoration must integrate sustainable NTFP management with community-based conservation to balance livelihood needs and biodiversity protection under semi-arid conditions.

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