GIS-Based Analysis of Sacred Groves Connectivity and Fragmentation: Landscape Connectivity and Corridor Identification in Khordha District.

Abstract

Sacred groves represent culturally protected forest patches that play a crucial ecological role in fragmented landscapes. In Odisha, rapid land-use transformation due to urbanization, agricultureand infrastructure development has increasingly isolated these groves, threatening their ecological integrity. This study applies a Geographic Information System (GIS)-based approach to analyze the spatial distribution, connectivity, and fragmentation of sacred groves in Khordha District. Using remote sensing data, land-use/land-cover classification, and landscape metrics, the study evaluates the degree of isolation among sacred groves and identifies potential ecological corridors that may enhance landscape connectivity. The results indicate that sacred groves in Khordha function as fragmented ecological islands, with limited structural connectivity. However, remnant vegetation patches, agricultural fallows, and riparian zones present opportunities for corridor development. The study highlights the importance of integrating sacred groves into regional landscape planning and community-based conservation strategies.

Keywords: Sacred Groves, GIS, Landscape Connectivity, Fragmentation, Ecological Corridors, Khordha District

Introduction

Sacred groves are traditionally conserved forest patches protected by religious beliefs and customary laws. Across India, they function as repositories of biodiversity, gene banks of native species and living symbols of human–nature relationships. In many regions, sacred groves persist even where formal forest cover has declined, making them ecologically significant in highly modified landscapes.

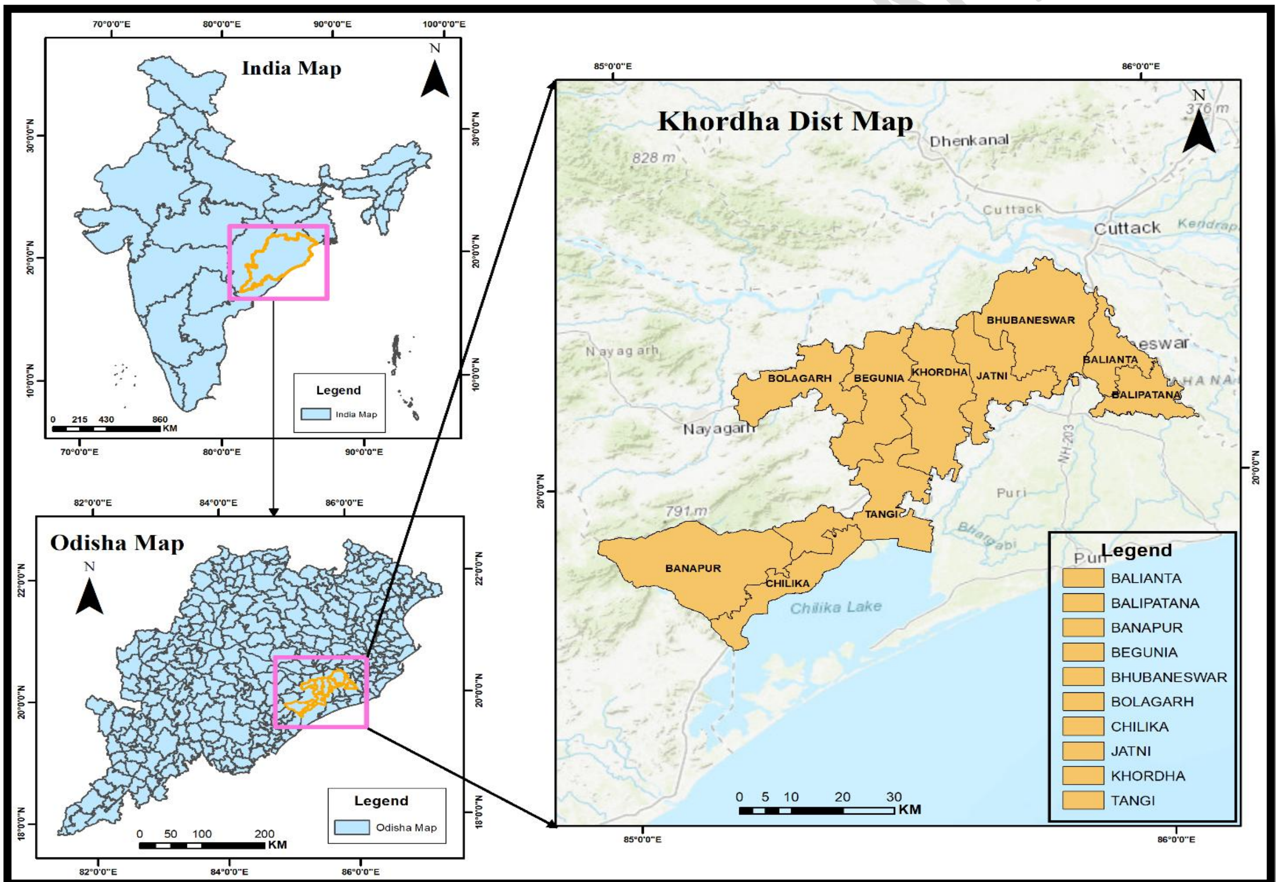
In recent decades, increasing population pressure, agricultural expansion, road construction and urban growth have resulted in severe landscape fragmentation. This fragmentation reduces habitat continuity, restricts species movement, and weakens ecosystem resilience. Landscape ecology emphasizes **connectivity** as a critical factor for maintaining ecological processes, especially in fragmented habitats. Connectivity refers to the degree to which the landscape facilitates or impedes movement among habitat patches.

In Odisha, sacred groves are widely distributed but typically small and spatially isolated. Despite their importance, most studies on sacred groves in the state focus on ethnobotany or biodiversity, while **landscape-level spatial analysis remains limited**. Against this backdrop, the present study applies GIS and landscape ecology tools to assess the connectivity and fragmentation of sacred groves in Khordha District.

Study Area

Khordha District is located in the eastern part of Odisha and forms part of the coastal plain and eastern ghat transitional zone. The district is characterized by undulating terrain, lateritic soils, seasonal streams, and a tropical monsoon climate. Rapid urban expansion around Bhubaneswar, coupled with intensive agriculture, has significantly altered land-use patterns.

Sacred groves in Khordha are locally associated with village deities and ancestral spirits and are typically found near settlements, water bodies, and agricultural fields. These groves vary in size, vegetation composition, and degree of protection, making the district an ideal case for studying fragmentation and connectivity dynamics.



Objectives of the Study

The main objectives of this research are:

1. To map the spatial distribution of sacred groves in Khordha District using GIS.

2. To analyze landscape fragmentation affecting sacred groves through spatial metrics.
3. To assess connectivity among sacred groves within the district.
4. To identify potential ecological corridors that could enhance landscape connectivity.
5. To suggest conservation and planning strategies based on GIS findings.

Data Sources and Methodology

Data Sources

- Topographic maps and administrative boundary data
- Secondary data on sacred grove locations from forest department records and literature
- Field-based verification (where available)

GIS and Remote Sensing Methods

1. **Sacred Grove Mapping**
   Sacred groves were digitized as point or polygon features and overlaid on the map to examine their spatial context.
2. **Fragmentation Analysis**
   Landscape metrics such as patch size, patch density, edge density, and nearest-neighbor distance were used to assess the degree of fragmentation.
3. **Connectivity Assessment**
   Connectivity was evaluated using proximity analysis and network-based approaches, treating sacred groves as habitat patches within a matrix of varying resistance values.
4. **Corridor Identification**
   Least-cost path analysis was applied to identify potential corridors linking sacred groves through low-resistance land-use classes such as agricultural fallows, scrublands, and riparian vegetation.

Results

Spatial Distribution of Sacred Groves

The mapped sacred groves show a scattered distribution across Khordha District, with higher concentrations near rural settlements. Most groves are small in size, often less than one hectare, and embedded within agricultural or semi-urban landscapes.

Fragmentation Patterns

Fragmentation analysis reveals:

- High patch isolation due to built-up expansion
- Increased edge effects caused by agricultural encroachment
- Reduced core vegetation areas within groves

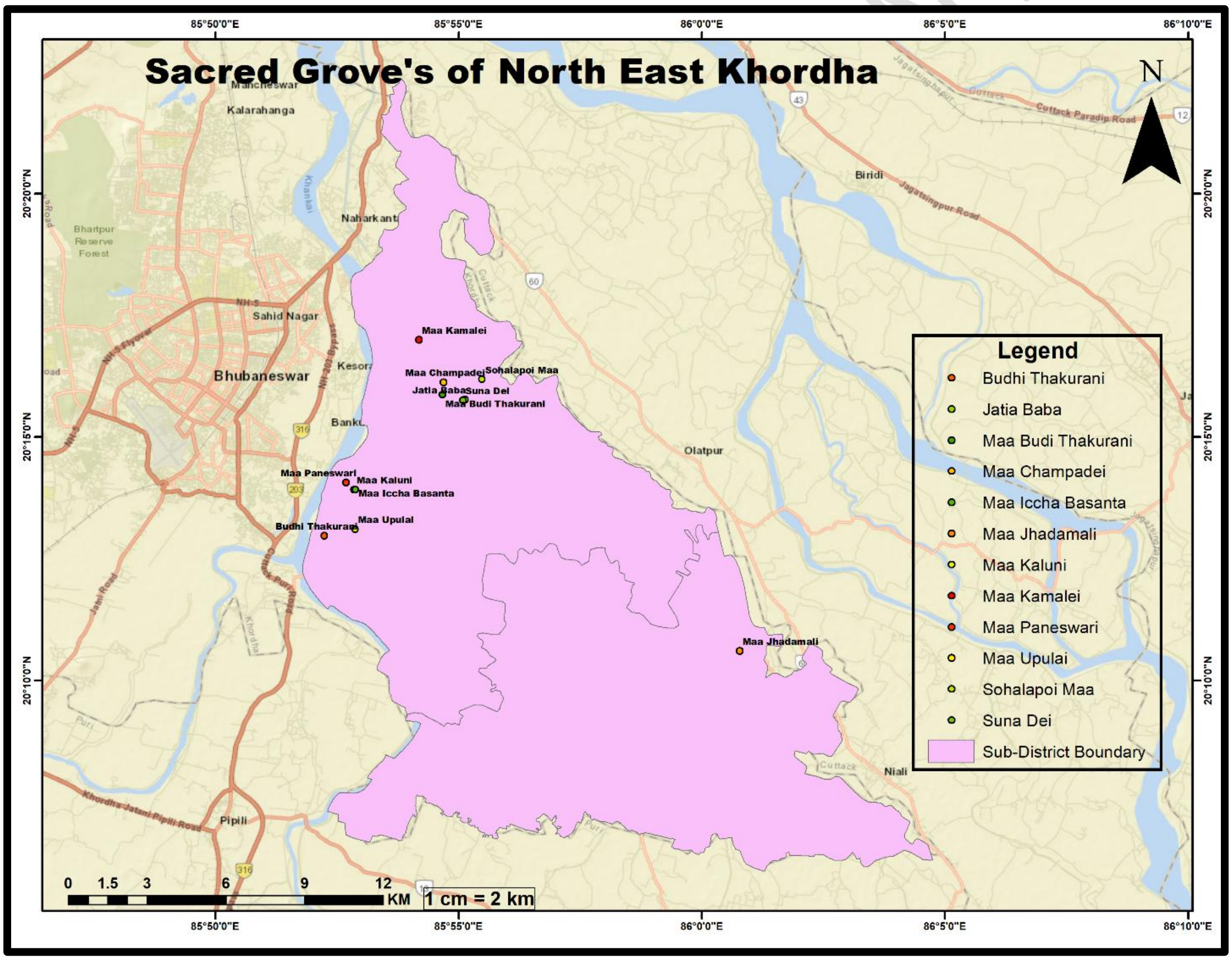
The nearest-neighbor analysis indicates that many groves are separated by distances exceeding optimal dispersal limits for forest-dependent species.

Connectivity and Corridor Potential

Connectivity analysis shows weak structural connectivity among sacred groves. However, several potential corridors emerge along:

- Seasonal stream networks
- Low-intensity agricultural zones
- Remnant vegetation strips

These corridors could serve as stepping-stone habitats if managed appropriately.



Discussion

The results demonstrate that sacred groves in Khordha District function as isolated ecological patches within a fragmented landscape. While cultural protection has ensured their survival, external land-use pressures have compromised ecological connectivity. The GIS-based approach reveals that connectivity restoration is feasible through strategic corridor identification rather than large-scale afforestation.

Integrating sacred groves into broader landscape planning can enhance biodiversity conservation while respecting local cultural values. Community-based management, supported by spatial planning tools, offers a sustainable pathway for conservation.

There was presence of a sacred grove in each village, usually in the middle or end of the village. It was believed to be the abode of certain deity, worshiped by the village priest. People had adopted strict rules of not cutting any trees, no grazing of herbivores, and no killing of animals inside the groves, believing such place and specifically the trees to be the abode of God and ancestral spirits. Different rituals and religious functions were performed inside the site for the wellbeing of the villagers, their animals, crops, and protection against diseases. Some ornamental plants as well as plants required in rituals and worship were found to be naturally-occurring in these premises.

Indigenous communities in India have cultural and religious beliefs and have worshiped trees since time immemorial. This religious belief serves as an instrument for protection of rare plant species. Every sacred grove has own legends, lore, and myths that link between the present and past society in terms of biodiversity, culture, religious and ethnic belief. It represents an excellent example of traditional conservation practice that continues to provide respite to the dwindling bio-resources in different parts of the world, predominantly in tropical Asia, Africa, South America and Australia. They have also been reported from different parts of India and found mainly in tribal localities. Prohibition of killing animals and cutting down trees, except when wood is needed for the religious purposes like construction and repair of temple buildings, and temple rituals in the sacred groves of Khordha district substantiate the findings of earlier studies. All the sites visited in Khordha district of Odisha show various level of depletion due to anthropogenic and other allied activities. As reported by elderly villagers, most of these plant species were predominantly growing in the past, which have now vanished from the surrounding locality due to such interference. The area and vegetation of sacred groves are rapidly shrinking due to biotic pressure.

Plant species recorded from selected sacred groves of Khordha district, Odisha

Sl No.	Local Name	Botanical Name	Family
1	Kaincha	*Abrus precatorius* L.	Fabaceae
2	Bana	*Rita Acacia sinuata (Lour.)* Merr.	Mimosaceae
3	Bela	*Aegle marmelos* L.	Rutaceae
4	Kadamba	*Anthocephalus cadamba* Roxb.	Rubiaceae
5	Jeuta	*Artocarpus lacucha* Roxb.	Moraceae
6	Karamanga	*Averrhoa carambola* L.	Geraniaceae
7	Nima	*Azadirachta indica* A.	Juss Meliaceae
8	Kendu	*Diospyros melanoxylon* Roxb.	Ebenaceae
9	Kaitha	*Feronia limonia* L.	Rutaceae
10	Dimiri	*Ficus racemosa* L.	Moraceae
11	Aswastha	*Ficus religiosa* L.	Moraceae
12	Amba	*Mangifera indica* L.	Anacardiaceae
13	Tulsi	*Ocimum sanctum* L.	Lamiaceae
14	Ashoka	*Saraca asoca* Roxb.	Caesalpiniaceae
15	Ambada	*Spondias pinnata* Kurz.	Anacardiaceae

Conclusion

This study highlights the usefulness of GIS and landscape ecology tools in analyzing the connectivity and fragmentation of sacred groves. In Khordha District, sacred groves are ecologically significant but increasingly isolated. Identifying and protecting ecological corridors can improve landscape connectivity and strengthen ecosystem resilience. Policymakers and planners should recognize sacred groves not as isolated cultural sites but as integral components of regional ecological networks. Our study demonstrates the importance of sacred groves in protecting and conserving various life forms. As the sacred groves surveyed have been observed to become the victims of exploitation at different levels, suitable remedial measures like awareness programme and formation as well as implementation of some legal guidelines are warranted for protection of such mini biosphere reserves in Khordha district of Odisha. Moreover, there should be further in depth study in wider scale covering larger areas of the state to pinpoint the status of sacred groves and the threatened, endangered or near extinct species, if any, which once dominated the concerned region.

Recommendations

- Incorporate sacred groves into district-level land-use planning
- Protect riparian and fallow lands as ecological corridors
- Encourage community participation in corridor management
- Use GIS-based monitoring for long-term conservation planning

References

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