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Evaluating The Role Of Indigenous Herbal Plants In Biodiversity Conservation And Sustainable Land Management

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Abstract
Indigenous herbal plants are important for ecology and culture, but their influence on conserving biodiversity and land is not well-explored. The researchers examined the variety of herbal plants, checked soil properties and investigated traditional ecological knowledge in the Himalayan, Tribal Forest and Semi-Arid areas of India. Both the diversity and abundance of species were measured in quadrats and the soil from the same sighting locations was analyzed for its organic matter content. The community's understanding of certain species was measured using Use Value (UV) and the Cultural Importance Index (CII) to see how much they matter culturally. Findings showed that both the species variety and the quantity of organic matter were greatest in sacred groves and community-managed forests. In addition, the culturally and ecologically meaningful species were found to be Rauvolfia serpentina, Ocimum sanctum and Terminalia chebula. By comparison, there were fewer types of species and poorer soil quality on semi-arid fallow fields. The research suggests that traditional conservation approaches support better conservation of living things and better land quality. Empirically, this study demonstrates that combining indigenous knowledge and ecological data gives a reliable and local approach to using land sustainably. To help the environment and local people such integration should be formally included in conservation and public policy.

Keywords: *Indigenous knowledge, Medicinal plants, Biodiversity conservation, Sustainable land use, Ethnobotany.*

1. INTRODUCTION

Climate change, deforestation, destructive agriculture and the breaking up of habitats are leading to the largest-ever loss of biodiversity in global ecosystems (Rahman et al., 2022; Das et al., 2024). The shifting nature of these areas makes indigenous herbal plants valuable for their environment, medicine and culture. They are important for both healthcare and the environment because they support soil replenishment, help plant growth and help control the climate (Mbelebele et al., 2024; Mykhailenko et al., 2025). Plants in this family are significant in traditional medicine, farming animals and crops and households across many Asian and African countries (Aremu et al., 2024; Susanti & Zuhud, 2019). Often, sacred groves, home gardens and community forests serve as sources of this plant diversity, protected by traditional and community-led ways (as found in Buddin et al., 2024 and Dapar et al., 2020). Guidelines for using and conserving knowledge, forbidding taboos and sustaining harvesting in TEK fit with communities' local beliefs and care for their environment, explained in Liniger & Critchley's (2007) and Shukla's (2023) research. Still, although such plants have many benefits for the environment, indigenous herbal crops are mostly ignored in major conservation and policy areas (Shafi et al., 2021; Balkrishna et al., 2024).

Recent research explains the need to work together local traditions and official conservation measures, as more land is now being damaged due to modern land-use activities (Mengistu et al., 2022; Mir et al., 2021). Although the medical uses of plants are well studied (Gusain et al., 2021; Kumar et al., 2023), few research efforts have explored their impact on ecosystems, the ways they are used and how communities respond to change (Mofokeng

et al., 2022; Sharma et al., 2020). Also, many ecological assessments do not use a framework that combines ethnobotany with features such as soil condition and how quickly microhabitats change (Brinckmann et al., 2025; SHINWARI et al., 2024). Studies are needed on a landscape scale to assess how indigenous herbal plants benefit biodiversity and sustainable land use in many different ecosystems. Only a minimal number of studies examine the overall effect of traditional conservation activities on village plant diversity, land health and soil using both the study of nature and traditional knowledge (Berkes, 2017; Anand et al., 2023).

1.1 Objectives of the Study

This study was developed to analyze the ways indigenous herbal plants influence biodiversity conservation and sustainable land care. The particular objectives included:

1. To document how different indigenous herbal plants are distributed and what their diversity and richness is like in several ecological regions.
2. To understand how land-use categories and historical conservation helped to determine the distribution of herbal plants.
3. To investigate the connection between soil features and the places where herbal plant species are found.

The collaboration of field and traditional knowledge allows this study to explain how conserving herbal plants helps prevent unstable land-use patterns. It is also seen as a reason to increase the application of community-based solutions in worldwide conservation conversations (Davis & Choisy, 2024; Alzate et al., 2019). The results of this research are intended to help guide decisions in conservation, farming and land management that protect biodiversity and support indigenous communities.

2. METHODOLOGY

2.1 Study Area Description

The study took place in three different, highly diverse regions with a long tradition of using plants for medicinal purposes. A Himalayan foothill area, a central tribal forest zone and a semiarid agroforestry district were covered by the study. These places were selected because they showed a variety of medicinal herbs, lasting knowledge of using plants and clear examples of how the community depends on them for health, farming and rituals. With their different climates, types of plants and intensity of land use, these regions became excellent settings for comparing ecology and ethnobotany. Traditionally, people in every community practiced special ways to preserve their medications such as designating sacred groves, rotating harvests and using customary taboos, all of which have building this study's context.

2.2 Research Design

Data from both ecological and socio-cultural studies of herbal plant use among indigenous peoples was combined using a mixed-methods method. With this strategy, the researchers understood how herbal flora is related to diversified biodiversity and earth-friendly land care. The research took a case study approach to compare the ways traditional knowledge, medicinal plants and land management are connected across different sites. Combining ethnographic observation with ecological studies in the research allowed a complete assessment of conservation and utility related to herbal plants. The framework was put in place to help them connect the ecological variables found in the field with the information gathered from local people.

2.3 Sampling Strategy

Researchers involved two sampling methods, purposive and snowball, to ensure they had access to informative and knowledgeable individuals in the study. Seventy-five people participated in the study, divided equally among traditional healers, elder herbalists, women who look after the sick, community leaders and collectors of forest products from the three study regions. Individuals were chosen because the community acknowledged their skills in plant use and conservation. Ecological diversity among herbal species was sampled using twenty quadrats placed in each of the study areas. Different quadrats were surveyed in sacred groves, home gardens, fallow plots and community forest zones. The reason for using these strata was to reach a variety of small habitats where indigenous herbs flourish.

2.4 Data Collection

Data for ethnobotany were collected by interviews, group discussions, observations of participants. These were interactive sessions to teach about plant types, their uses, harvesting them, when they are available and how they are conserved locally. People were interviewed in their native languages and afterwards, the interviews were reviewed and translated. Besides the interviews, mapping plant resources and calendars of seasonal activities added information about when and where plants are used. Data on the environment were gathered by observation of quadrats set out during surveys. Every species found, the botanical and local name, its growth form, how common it is and its habitat condition were written down. Soil samples were collected to examine the soil and its pH and the GPS system was used to record where plants were distributed for spatial study. The team looked at the cover of leaves and trees in the canopy, types of ground plants and signs of disturbance to place the ecological data in context. To measure the cultural value of various species, Use Value (UV) and Cultural Importance Index (CII) were used based on traditional knowledge. Plants used for many purposes and stated most often by informants were identified. Examples of such plants were *Rauvolfia serpentina, Ocimum sanctum* and *Terminalia chebula*. Culture and ecology aspects of these species were carefully explored and their roles were confirmed by carrying out ranking activities with focus groups. The relative priority of ecological and cultural key species in each community was assessed through exercises that ranked and scored them pairwise and in matrices. The information collected included the frequency with which participants used apps and the variety of those apps.

2.5 Data Analysis

All transcripts of the interviews were converted into written form, translated and examined by applying themes in analysis software. Using thematic coding, common ideas and perceptions about plant use, caring for plants, their cultural value and changes in the environment could be found. The categories were formed using information from the interviews and keeping analysis accurate. Data analysis for ecology was carried out by using R and PAST software. Data on species richness, the Shannon and Simpson diversity indices and the relative abundance of plants were used to discuss the structures of the plant communities. The investigation of biodiversity across land use types and regions was carried out using ANOVA and cluster analysis. A connection was found between ethnobotanical information and ecological parameters to determine how old knowledge influenced the variety of life in the study. Data on space and location were processed using GIS programs to draw species distribution maps and find areas of high ecological potential.

3. RESULTS

3.1 Species Richness and Diversity

The investigation found significant differences in the variety of indigenous herbal plants in each of the three ecological regions. The most species were found in the Himalayan area, with a total of 42 medicinal plants being identified. The Tribal Forest area was next, with 37 species and the Semi-Arid zone showed the smallest number of species, with 28. Ecological factors and the unique layout of the Himalayas give this area better chances for different plants to grow. Figure 1 illustrates the number of species at the three research sites.

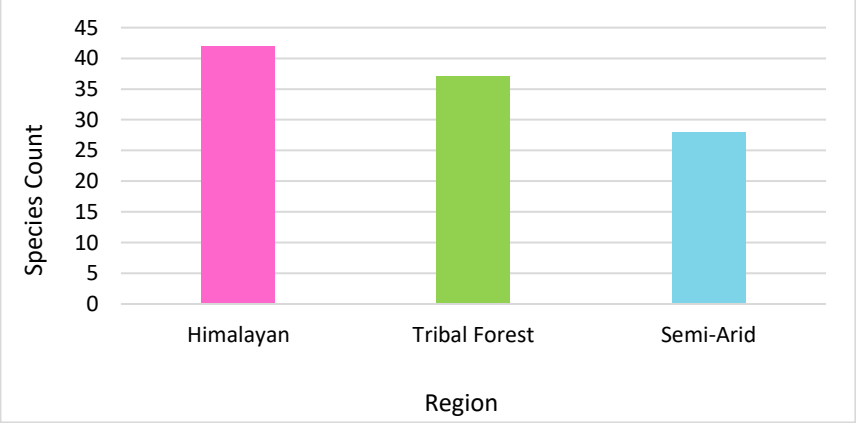

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Figure 1. Comparative Species Richness Across Study Regions

This figure reveals that the Himalayan region stands out in supporting a greater variety of medicinal herbs than the other two regions. Species diversity was also measured using the Shannon Diversity Index and showed a pattern that closely matched the overall diversity. The Shannon Index of the Himalayan area was 3.4 which means the plant life is very diverse and well-balanced. Moderate diversity and spread were recorded in the Tribal Forest, with a value of 3.1, but in the Semi-Arid region, the index was much lower, at 2.5. A drop in diversity is caused by both natural stress in these areas and actions by people. All three sites Shannon Index values are presented in Figure 2.

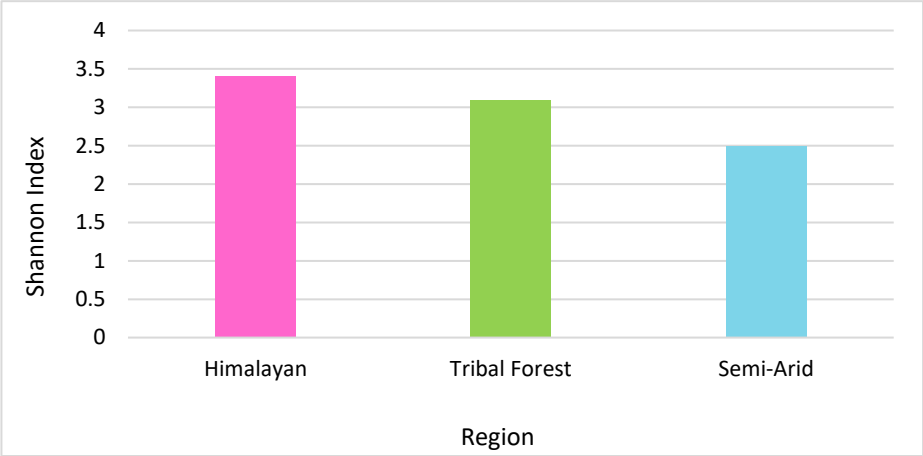

Figure 2. Shannon Diversity Index by Region

The graph displays the Shannon Diversity Index values, indicating that the Himalayan region maintains the most evenly distributed and diverse herbal plant community among the three zones studied.

3.2 Ecological Indices and Soil Parameters

The values for the Simpson Index deepened our understanding of how different species affected the ecosystem. The region with the best score was again the Himalayas, reaching 0.92, followed by 0.89 in the Tribal Forest area and 0.81 in the Semi-Arid zone. The findings show the Himalayas had the most evenly distributed species, but as stress and damage to environments happened, species distribution became more uneven. Soil organic matter is a main ecological element and it also declined across the three areas under study. The Himalayan zone had 2.4% organic matter, while the Tribal Forest had 2.1%. The Semi-Arid zone reported only 1.7%. Positive relationships were found between these values and the diversity and richness of species at the sites. Practically all plots in the study area showed a moderate pH of between 6.5 and 7.2. The findings are presented in Figure 3.

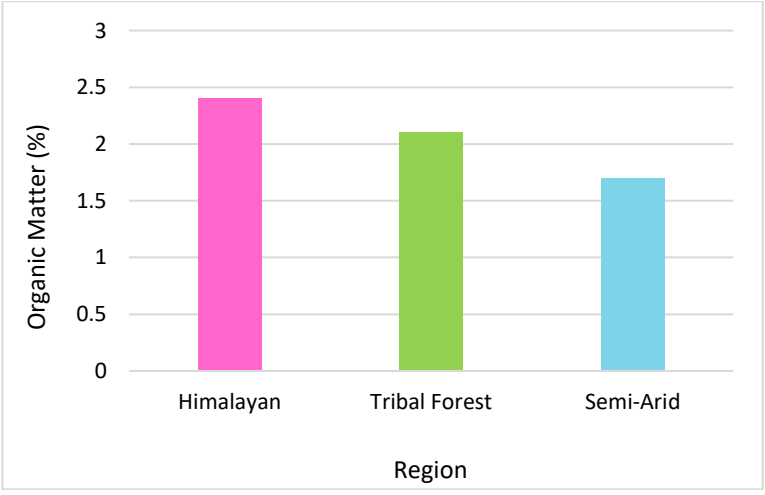

Figure 3. Soil Organic Matter Percentage in Different Regions

This illustration demonstrates that rises in soil organic matter lead to growing species diversity and better ecological equilibrium, with the Himalayas presenting the best possible soil for herbal plant diversity. Certain major ecological and biodiversity indicators are highlighted side by side for each region in Table 1. This table offers an overview of how richness, diversity and soil health change across different types of landscape.

Table 1. Summary of Species Richness, Diversity Indices, and Soil Parameters Across Study Regions

Region	Species Richness	Shannon Index	Simpson Index	Soil pH	Organic Matter (%)
Himalayan	42	3.4	0.92	6.5	2.4
Tribal Forest	37	3.1	0.89	6.8	2.1
Semi-Arid	28	2.5	0.81	7.2	1.7

Table 1 clearly illustrates that ecological performance and soil health are gradually reduced across the Himalayan, Transitional and Semi-Arid regions. The patterns shown help confirm the relationships seen in Figures 1 through 3, indicating that edaphic factors control both the mix and abundance of species.

3.3 Observations on Land Use and Plant Distribution

Land-use and community efforts to conserve nature played a major role in determining where indigenous herbal species grow. A consistent pattern in space was seen in all three regions. Most species in the Himalayan and Tribal Forest regions were found in sacred groves, home gardens and areas maintained by groups of people. Stable environments in these areas are achieved in part through rotating harvests, traditions preventing overuse and ritual protection. The Semi-Arid region, meanwhile, indicated that species were more often spotted in unmanned fields, along roadsides or in commons where habitats had been damaged. Species richness for major types of land use is shown in Table 2 across different study regions.

Table 2. Distribution of Indigenous Herbal Plant Species by Land Use Type and Region

Land Use Type	Himalayan	Tribal Forest	Semi-Arid
Sacred Groves	15	12	3
Home Gardens	10	8	5
Community Forests	12	11	4
Fallow Lands/Roadsides	5	6	10

Table 2 gives a summary of the number of herbal plant species in each of the four main categories of land use. More species were counted in sacred groves and community forests in the Himalayan and Tribal Forest regions and fallow lands were most common in the Semi-Arid zone. This pattern underlines the important role of managing the land in determining how biodiversity responds. The data provide further support for the idea that protecting culture also protects the environment in areas using age-old indigenous approaches.

3.4 Traditional Knowledge and Use Value

A group of species that play important roles in medicine and the environment were identified through both exercise and the indexing of traditional knowledge for all of the study areas. Among the species studied, *Rauvolfia serpentina*, *Ocimum sanctum* and *Terminalia chebula* had both the highest UV and CII scores. Many participants talked about herbs and grasses because they believed they improved soil health, protected soil and were beneficial to pollinators. The community stressed that they served several purposes, for healing, in rituals and for environmental benefits. The best performing species were identified in the same areas as rich plant diversity, demonstrating good coordination between community conservation and ecological hotspots. The results point to the value of using traditional knowledge in caring for biodiversity and the land. They are considered both important for fishing communities and in danger from extinction and are all shown in Table 3.

Table 3. Selected Herbal Plant Species with High Cultural and Ecological Importance

Species Name	Local Name	Use Value (UV)	Cultural Importance Index (CII)	Major Uses
Rauvolfia serpentina	Sarpagandha	0.92	0.88	Anti-hypertensive, rituals
Ocimum sanctum	Tulsi	0.89	0.85	Respiratory, sacred use
Terminalia chebula	Haritaki	0.85	0.82	Digestive aid, soil enrichment

Table 3 shows that species with big scores for UV and CII are important for medicine and they help stabilize the ground, invite beneficial insects and hold water. Because they serve many uses, communities are motivated to continue protecting and propagating them. These results show that ways to conserve nature are tied to both cultural traditions and practical knowledge about the environment.

4. DISCUSSION

The study demonstrates that indigenous plants, used by a community, help preserve the diversity of species in such areas. Diversity among species in the Himalayan and Tribal Forests can be linked to long-standing community land-use practices such as sacred groves and home gardens. As before, these findings confirm that using traditional ecological practices helps preserve plant diversity (Alzate et al., 2019; Negi et al., 2023). It is notable that the role of sacred groves as important conservation spots follows what Dey et al. (2021) and Sharma et al. (2021) noticed in tribal areas of India. Conducting periodic harvesting, controlling harvesting by time and protecting by using rituals seem to act like conservation measures in a traditional setting. The findings of these experiments further demonstrate, according to Berkes (2017) and Altieri & Nicholls (2017), that agroecology and indigenous stewardship work together to strengthen the environment.

The finding of a strong, positive relationship in Himalayan soils between soil organic matter and species richness suggests that plant diversity and soil quality support one another. Here, Mahato et al. (2025) and Mofokeng et al. (2022) are supported, who found that herbal plant cultivation and diversity are closely linked to the health of soil. There is more evidence for Mykhailenko et al.'s (2025) point that in the Semi-Arid zone, decreasing soil quality and degradation caused by climate make it very difficult to grow useful plants. Out of the herbal species studied, nine are found to rank highly on both the ecological and cultural aspects, as seen in their UV and CII scores. The herbs *Rauvolfia serpentina* and *Ocimum sanctum* always seemed to have medicinal, spiritual and environmental functions. According to Kumar et al. (2023), Balkrishna et al. (2024) and Sharma et al. (2020), cultural protection leads to stronger conservation and greater breeding of these animals across time. So, planning conservation measures should focus on locally important species to produce the greatest ecological and social effect (Anand et al., 2023).

The results of this study help confirm that indigenous herbal plant systems are suitable for both the environment and for human communities in practices of sustainable land management (SLM). In Himalayan and Tribal Forest zones, communities use methods that follow Alzate et al.'s (2019) and Davis & Choisy's (2024) agroecological principles. Meanwhile, the small plant communities found in the Semi-Arid area prove how traditional land-use methods are often neglected by modern planning. Using knowledge from these local practices in modern conservation schemes may give a new approach to encouraging biodiversity and helping places withstand climate change. Mir et al., along with Gusain et al., say that embedding traditional knowledge into these plans would benefit both biodiversity conservation and economic development. Applied as a mixed methods study, this project provides a deep understanding of the study's objectives, however, it is constrained by the limited geographical and time factors. Too little observation can make it difficult to see how plant numbers and soil quality change with time. Other steps toward understanding need to involve studying the molecules in species, monitoring ecosystems for a long period and using modern GIS software in community mapping. Studies aimed across eco-regions and cultures might reveal what is shared by humans everywhere and what practices differ (Brinckmann et al., 2025; Shinwari et al., 2024).

5. CONCLUSION

This research shows that indigenous herbal plants have a significant role in supporting the diversity of life and improving the resilience of land-based activities. Where the traditions of conservation have been maintained,

communities in three regions showed the highest level of species diversity and ecological health. Integrating species diversity with soil organic matter data and traditional indices, the study identified *Rauvolfia serpentina*, *Ocimum sanctum* and *Terminalia chebula* as important species, valued in both nature and culture. The research shows that preserving biodiversity means building on both natural science and local knowledge. Instead, soils and biodiversity were lower on such lands because these areas had no indigenous beliefs protecting them. The idea behind this study is to blend ecological science and ethnobotanical knowledge to provide a reliable model for mindful land management. Taking traditional ecological knowledge into account in mainstream policy is both good for the environment and promotes social justice at the same time. This approach provides useful guidance for areas that need to manage their conservation goals and community stewardship.

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