

Medicinal Plants of Arunachal Pradesh: Traditional Uses, Conservation Strategies, And Economic Viability

Dr. Wangda Gyatso Gyana*

Sr. Assistant Professor, Department of Commerce, Dera Natung Government College, Itanagar, Arunachal Pradesh, India

*Corresponding author: Dr. Wangda Gyatso Gyana

| Received: 27.08.2024 | Accepted: 11.11.2024 | Published: 28.11.2024 |

Abstract: The Eastern Himalayan biodiversity hotspot is the home of one of the richest medicinal plant biodiversity in India, in Arunachal Pradesh. The use of traditional medicine from plants plays an important role in Indigenous peoples' health, cultural continuity and means of livelihood throughout the state. However, the fast socio-economic changes, the degradation of the ecosystems, and unregulated extraction pose threat to medicinal plant resources and traditional knowledge systems. The article gives a comprehensive review on: (i) traditional ethnomedicinal uses, (ii) conservation issues and, strategies and (iii) economic potential of medicinal plants as means of livelihood. Through the ethnobotanical studies, conservation literature, and political-economic analysis, this paper contends that medicinal plants are not only biological resources, but also socio-ecological capital, which is vital to inclusive development in Arunachal Pradesh if it is to be managed sustainably.

Keywords: Biodiversity Hotspot, Health, Cultural Continuity, Livelihood, Ecosystems, ethnobotany.

INTRODUCTION

Located in the eastern part of the Himalayas in India, the state of Arunachal Pradesh is a biodiversity hotspot and the world's most richly diverse floral and cultural region. More than 5,000 angiosperms species are found in the state with more than 500 species used as traditional medicinal plants by the many indigenous tribal communities of the state (Haridasan *et al.*, 2003; Murtem, 2000; as cited in Tiwari *et al.*, 2011). The indigenous ethnobotanical knowledge systems which have been handed down through the generations are still predominant in various remote rural settings where the medical system is inadequate or non-existent (Tiwari *et al.*, 2011; Bushi *et al.*, 2024). Leaves, roots and barks of numerous forest plants are used among the Monpa community to treat various ailments including dermatological problems and gastrointestinal illnesses, which is a clear demonstration of their local knowledge about the efficacy of forest plants (Namsa *et al.*, 2011). Likewise, detailed surveys in various Eastern Himalayan areas have recorded the traditional use of at least 74 medicinal plant species for treatment of malaria, jaundice, respiratory ailments and urological diseases in the tribes like Nocte, Nyishi and Adi (Tiwari *et al.*, 2010).

Traditional medicine systems in mountainous and forest dependent societies have always been based

on medicinal plants. Physiographic isolation, lack of transport facilities and inadequate biomedical infrastructure are still a problem in Arunachal Pradesh, where traditional medicine cannot be dispensed with (Kala, 2005; Ghosh *et al.*, 2010). The Eastern Himalayan region with its high endemism and species richness has an ideal ecological condition for medicinal flora (Haridasan *et al.*, 2003).

The state of Arunachal Pradesh has more than 26 major tribes and over 100 sub-tribes with their own ethnomedicinal practices based on ecological niche, cultural worldview and adaptive knowledge systems (Murtem & Chaudhry, 2016). These traditions are not static relics, but dynamic systems that are reacting to patterns of disease, environmental shifts and socio-economic pressures.

Conservation of these precious plant resources is both an ecological and socio-economic necessity. However, many wild medicinal species have been overharvested, fragmented and are not being managed sustainably, and researchers/policymakers are calling for sustainable management options (Haridasan *et al.*, 2003). Conservation also seeks to stimulate community involvement in sustainable collection practices, cultivation and policy support which combine traditional

Quick Response Code



Journal homepage:
<https://saspublishers.com/>

Copyright © 2024 The Author(s): This is an open-access article distributed under the terms of the Creative Commons Attribution 4.0 International License (CC BY-NC 4.0) which permits unrestricted use, distribution, and reproduction in any medium for non-commercial use provided the original author and source are credited.

Citation: Wangda Gyatso Gyana (2024). Medicinal Plants of Arunachal Pradesh: Traditional Uses, Conservation Strategies, And Economic Viability. *Cross Current Int Peer Reviewed J Human Soc Sci*, 10(9), 204-210.

knowledge with biodiversity preservation frameworks (Hussain & Hore, 2008).

From an economic point of view, ethnomedicinal plants of Arunachal Pradesh are very promising. It becomes evident that local communities earn their living by collecting, processing and selling plant materials in rural bazaars, which helps to increase their family income and helps the rural economy (Murtem & Chaudhry, 2016). Documentation of ethnomedicinal uses also pave the way for future phytochemical research and possible pharmaceutical applications, providing opportunities for value addition, cultivar development, and possible incorporation into formal herbal medicine industries (Bushy *et al.*, 2024).

In this context, an integrated approach to traditional uses, conservation and economic importance further emphasizes the necessity of utilizing and conserving medicinal plants in Arunachal Pradesh with both cultural continuity and sustainable development in mind.

It is found, Mandal (2011, 2017) notes that natural resources in Arunachal Pradesh are not only ecological resources, but they are also the backbone of livelihoods. As a result, medicinal plants play a key role, especially in terms of health security, biodiversity protection and rural economy.

LITERATURE REVIEW

Bushy *et al.* (2021) conducted a comprehensive review of ethnomedicinal knowledge from fourteen tribal communities from which 358 species of medicinal plants from 100 families were reported, treating a wide range of ailments (e.g., cardiovascular, dermatological, gastrointestinal, respiratory), and calculated the informant consensus factors (ICf) and informant consensus values (ICv) to identify priority taxa for further pharmacological investigations.

Based on the field survey, the Eastern Himalayan communities of Nocte, Nyishi and Adi used 74 species of plants and the ICF of traditional healers for malaria, jaundice, urological problems were high, indicating ethnopharmacological relevance (Tiwari *et al.*, 2011).

In ethnobotanical studies described and documented 50 medicinal plant species among Monpa ethnic group, which correlated plant growth form with specific plant parts and medicinal uses with 22 common diseases of humans and animals, indicating predominance of herbaceous taxa in the folk medicine practices. In ethnobotanical studies Namsa *et al.* (2011) described and documented 50 medicinal plant species among the Monpa ethnic group which correlated plant growth form with specific plant parts and medicinal uses with 22 common diseases of humans and animals, and

indicated predominance of herbaceous taxa in the folk medicine practices.

This was extended to a cross-cultural study by Siram *et al.* (2023), who compared the medicinal knowledge of four tribal groups (Monpa, Miji, Aka, Bugun), noting a total of 59 species and highlighting the consensus values that represent areas of shared interest in the use of medicinal plants and suggest areas of shared interest for sustainable management or cultivation.

There are other area-specific ethnobotanical surveys done by Murtem & Chaudhry (2016) in Upper Subansiri district and studies on Nyishi home gardens which add value to the regional compilation and shows the important roles of plants in food, medicine and culture.

Conservation research like Hussain & Hore (2008) focused on collecting medicinal plants in the field, identifying threats of over-collection and habitat destruction and recommending specific conservation actions and baseline data as essential for developing conservation strategies based on ecological values.

As a whole, these works have laid a solid foundation for the advancement of interdisciplinary studies in ethnobotany, conservation biology, and pharmacology of tribal ethnomedicinal resources in Arunachal Pradesh, India.

RESEARCH GAP

Although there are vast ethnobotanical studies on medicinal plants in the state, there are a number of critical gaps:

Conservation Strategy Integration: Though species with high use value, which may require conservation, have been identified by Hussain & Hore (2008) and Bushy *et al.* (2021), no study has included a systematic ecological assessment with a community-based conservation model and evaluated the population trends of key medicinal species.

Economic Viability and Value Chain Analysis: There is a lack of rigorous economic analysis or value chain study. These will cover limited information on market dynamics, income contributions, commercialization potentials and profitability of cultivation versus wild-harvesting, especially for high demand taxa.

Pharmacological Validation and Bioactivity Studies: Traditional use information is widely reported but there are few cases of phytochemical profiling, clinical efficacy or safety studies for the majority of species recorded. The lack of this remains despite repeated requests for bioactive investigations of high use plants.

Policy and Institutional Frameworks: Policy and institutional support frameworks are mainly documented

with regard to practices and seldom with regard to the impact of policy or institutional support systems (such as inclusion in AYUSH policy, benefit sharing, community IPRs etc.).

These gaps identify various interdisciplinary studies needed between ethnobotany and conservation science, economics and pharmacology to boost sustainable use, conservation of biodiversity and livelihood generation in Arunachal Pradesh.

OBJECTIVES

On the basis of the above research gap, the following objectives are considered:

1. To explore the medicinal plant diversity and its traditional uses.
2. To search the livelihood contribution and economic viability of medicinal plant.
3. To assess the ethno-medicinal knowledge system, conservation and challenges of medicinal plant.

RESEARCH METHODOLOGY

1. Nature of the Study: This study is descriptive and analytical. It is intended to review the traditional uses, conservation and economic feasibility of medicinal plants of Arunachal Pradesh with a view of examining the same.

2. Sources of Data: All the data used in the present study has been collected from published books, peer-reviewed journals, research articles, government reports, conference proceedings and authenticated online databases which are relevant to medicinal plants and ethnobotanical studies of Arunachal Pradesh.

3. Data Collection: Literature related to the plant species was gathered from different scientific sources such as published articles, books, ethnobotanical survey, conservation research, and socio-economic research among different tribal groups of Arunachal Pradesh.

4. Method of Analysis: The collected data was reviewed, categorized and analyzed according to a qualitative and thematic approach. The data was grouped under major themes including: traditional uses, conservation issues, livelihood contributions, and economic prospects.

RESULTS AND DISCUSSION

Medicinal Plant Diversity and Traditional Uses: A wide variety of medicinal plants and their uses are found in the region. The region has a wide range of medicinal plants and their uses. In Arunachal Pradesh, ethnobotanical studies and field surveys have consistently shown that the region has a long history of medicinal plant use, which is deeply embedded in the traditional health care practices and cultural beliefs of the indigenous people. Thirty-five hundred eighty medicinal plant species from 100 families were reported from ethnobotanical literature for use by fourteen indigenous tribal communities to cure 107 types of diseases, including cardiovascular diseases, gastrointestinal

diseases, dermatological diseases, and respiratory diseases (Bushy *et al.*, 2021). Patterns in plant use are important and are known from regional and community surveys. For example:

1. Among the tribes, Nocte, Nyishi and Adi in the Eastern Himalayan zones, 74 species belonging to 41 families of medicinal plants were recorded, in which traditional uses were represented by 25 various disease categories.
2. In the Monpa ethnic group, for the treatment of human disorders, 50 species of 29 families of plants were recorded and the majority of medicinal taxa were herbs, while 22 species were used to treat the veterinary disease.
3. A cross-cultural ethnomedicinal study of Monpa, Miji, Aka and Bugun communities revealed 59 species, elucidating plants like *Curcuma amada* and *Curcuma longa* with high use value and cross-community consensus in applications like inflammation and digestive disorders.

Plant Parts Used and Prepared: In most of the studies some patterns of the use of medicinal flora have been observed. A preliminary survey of medicinal plants by the Monpa and the tribal people showed that herbs occupy a major position in the medicinal pharmacopeia followed by shrubs and trees, which means that herbs are easier to access than shrubs and trees for medicinal use (Namsa *et al.*, 2011; Bushy *et al.*, 2021). Similarly, common parts of plants employed for the making of remedies include leaves, rhizomes, roots and fruits, among which leaves are often mentioned as the parts with the highest concentration of active metabolites, which are easily harvested (Namsa *et al.*, 2011).

Most of the studies still focus on qualitative documentation, although traditional practices provide a wealth of ethnobotanical information, with very few studies focusing on quantitative bioactivity validation. This highlights the importance of phytochemical profiling and efficacy studies to connect traditional knowledge with modern pharmacology.

LIVELIHOOD CONTRIBUTIONS AND ECONOMIC VIABILITY OF MEDICINAL PLANT

Ethnobotanical studies have, therefore, been used indirectly to bring into focus the economic importance of medicinal plants especially for the economic status of the rural population. The documentation of the uses of the plants, market surveys and commerce in folk medicine indicate that in addition to its nutritional values, the medicinal plants can be used to improve the livelihoods of the people by selling in local markets and in the services of traditional healers, particularly in remote areas where biomedical facilities are not available.

Murtem and Chaudhry's field investigations in Upper Subansiri show that medicinal plants are entangled in folk markets and cultural practices and are

not being utilized in their sustainable harvest systems or in herb growing, which indicates potential for value addition in these areas.

Formal economic analysis quantifying value chains, contributions to income and trade potential for species, however, is limited. This emphasizes the importance of market-oriented research for determining the profitability of the medicinal plant-based businesses, feasibility of cultivation and incorporation of the businesses within government programs such as AYUSH programme to enhance the earnings of the rural people.

ECONOMIC VIABILITY OF MEDICINAL PLANTS

Medicinal Plants and Rural Livelihoods: Household income is a considerable part of the income from medicinal plants collection in forest dependent communities. Mandal (2017) argues that resource-based livelihoods in Arunachal Pradesh serve as coping mechanisms when there is no industrial jobs. Medicinal plants, thus, serve as “livelihood buffers”, especially during times of lean seasons in agriculture.

Market chains and value addition: The trading of medicinal plants is mainly extractive in nature and is informal with little value addition at the community level. Collectors get a small percentage of the market value. Local processing, grading, drying, and packaging can significantly boost income and limit the strain on wild populations.

Political Economy and Policy Perspective: Mandal's political-economic study on Arunachal Pradesh emphasizes the need to correlate the ecological conservation with the livelihood security for sustainable development. When applied to medicinal plants, three priorities can be identified:

1. Institutional support for community enterprises
2. Equitable benefit-sharing mechanisms
3. Integration of traditional knowledge into formal development planning.

Failure to make such structural changes could lead to the reinforcement of inequality and depletion of resources in the process of commercialization.

ETHNO-MEDICINAL KNOWLEDGE SYSTEM, CONSERVATION AND CHALLENGES

Although there are good reports of traditional uses, there is less information regarding conservation outcomes. There is also a problem of over collection, degradation of habitat and shifting cultivation, evidenced by the historical and ecological assessments of Hussain and Hore (2008) that resulted in 64 accessions from 46 species being collected in western districts of the state.

Community-level conservation responses are coming to the fore. For instance, recent studies document

ethnomedicinal plants kept in Nyishi home gardens, which strengthens the argument that lands under the control of tribal people are a source of genetic resources for medicinal plants.

Even with these observations, there are still no population-scale assessments of these plants' dynamics or regeneration rates, and this lack of knowledge creates a significant gap in the understanding of the long-term sustainability of populations of these wild medicinal plants.

ETHNOMEDICINAL KNOWLEDGE SYSTEMS

Diversity of Traditional Medical Practices: Traditional medicine practices vary from people to people. Ethnobotanical surveys throughout Arunachal Pradesh reveal amazing medicinal use of plants. Only 158 species of medicinal plants were documented among the Apatani tribe alone which includes gastrointestinal, dermatological, respiratory and musculoskeletal ailments (Kala, 2005). Likewise, Ghosh *et al.* (2010) reported that 74 medicinal plant species were used by the Adi, Nyishi and Nocte tribes; with high informant consensus rating for the use of medicinal plants against malaria, jaundice and fever.

The Monpa people link their medicinal plant use to their Buddhist cosmology, using both medicinal plants and ritual healing (Namsa *et al.*, 2011). Plants used to treat injuries associated with shifting cultivation, and forest work are central in the medicine of the Lohit and the Khampti communities (Das & Tag, 2009).

Plant Parts, Preparation, and Administration: This involves learning about the parts of plants and how they are prepared for use and administered. The leaves are the most common part of the plant used by most of the tribes, because they are easy to collect and regenerate, followed by roots, rhizomes, bark, fruits and seeds (Kala, 2005). They are made in various ways such as decoctions, infusions, poultices, powders and raw consumption. The methods of administration are varied, oral, topical, inhalation, fumigation, and evidence of understanding of sophisticated pharmacology based on empirical observation.

The transfer of knowledge and the loss of culture: Ethnomedicinal knowledge is passed down orally, usually by the elders and trained healers. Several studies have pointed out that formal education, religious conversion and participation in market economies have been associated with a reduction in intergenerational transfer of wealth (Ghosh *et al.*, 2010; Murtem & Chaudhry, 2016). This is the loss of cultural heritage as well as the loss of local medical knowledge for local disease ecologies.

Indigenous Knowledge and its Conservation: The management of medicinal plants in Arunachal Pradesh should be based on a biocultural approach on the basis of

the recognition of the indigenous knowledge as intellectual property. With scientific validation and ethical commercialization, medicinal plants can become engines of sustainable rural development, if they are available in the community.

SYNTHESIS AND IMPLICATIONS

The results as a whole show that:

1. The State of Arunachal Pradesh is rich in medicinal plants and traditional knowledge systems of the tribes of the state are well documented.
2. Herbs and the parts of plants are the most commonly used in medicine; and different preparation techniques are used depending on the nature of the ailment.
3. Conservation issues are recognised, and there is sparse systematic information on the status of key species or their regeneration potential.
4. Economic potential is recognized but there is still a need for in-depth research of value chains and livelihoods to guide sustainable development strategies.

The results indicate that the combined efforts of ethnobotany, conservation science, and economic study, along with phytochemical validation, are essential to promote the ecological sustainability and socioeconomic viability of medicinal plant resources in the Terai region of Arunachal Pradesh.

CONSERVATION AND ECOLOGICAL CHALLENGES

Threats to Medicinal Plant Diversity: Although medicinal plants are important, they are under threat. Pope *et al.* (2003) and Hussain and Hore (2008) report that several species of high value have shown a decrease in their populations due to over harvesting for commercial trade, forest degradation, infrastructure development and intensification of shifting cultivation. Slow regeneration and high market demand are responsible for the vulnerability of the species like *Paris polyphylla*, *Taxus baccata* and *Illicium griffithii*.

The pressures of climate change add to these, changing the distribution of plants by elevation, the timing of events (phenology), and the suitability of habitat, particularly of plants found in alpine and sub-alpine areas that are used for medicinal purposes.

CONSERVATION STRATEGIES

In-situ Conservation: Community-managed forests, sacred groves and customary land-use have been effective conservation mechanisms historically. It is very important to reinforce these indigenous institutions for the in-situ conservation of medicinal plant diversity.

Ex-situ Conservation: In the interest of avoiding extinction, botanical gardens, medicinal plant nurseries, seed banks and tissue culture laboratories offer protection and facilitate the domestication of threatened species (Hussain & Hore, 2008).

MAIN CHALLENGES FOR CONSERVATION

The main challenges for conservation of medicinal plants are presented as follows.

Although Arunachal Pradesh is endowed with a rich diversity and traditional use of medicinal plants, the region has a number of challenges that are closely related to sustainable use, conservation and economic development of the medicinal plants.

1. Loss of Traditional Knowledge and Change of Cultural: Traditional Knowledge and Cultural Change are being lost and are changing. One of the big problems is the loss of indigenous knowledge as a result of modernization, changing culture and unavailability of the documentation. Research works reveal that the traditional medicinal knowledge is largely with the elders and the younger generations are less interested and involved in it, which might lead to its eventual loss (Namsa *et al.*, 2011; Kala, 2005).

2. Degradation of Habitat due to Unsustainable Harvesting: The pressure on wild medicinal plant resources has been increased due to overexploitation, and habitat loss caused by deforestation and land conversion has reduced populations in several wild medicinal plants in certain locations. The initial assessments revealed that the intensive exploitation of selected species had led to the noticeable depletion of biological wealth and thus compromising availability for future use (Haridasan, *et al.*, 2003).

3. Knowledge Transfer Gaps and Documentation Deficiencies: Oral transmission is the most important mode of traditional plant use and thus only a few written records exist. This creates threats for intergenerational transfer and scientific exploration of ethnomedicinal knowledge (Namsa *et al.*, 2011; Kala, 2005).

4. Limited Economic Integration and Market Structures: Organized value chains and commercial structures are underdeveloped while communities rely on medicinal plants for their livelihoods and household income. Very little processing, standardization or quality assurance of medicinal plant products is done formally, limiting income opportunities and wider market participation (Haridasan *et al.*, 2003).

5. Erosion and collapse of conservation values: Conservation activities have generally been opportunistic or community-based (such as home gardens) and with little regional planning on a strategic level or systematic assessment of the status of species. While cultivation in home gardens helps to support conservation at the local level, landscape scale assessments of conservation priority taxa are still limited (Techi & Nimasow, 2024).

6. Poor policy support and integration: While there is growing awareness of traditional knowledge systems

within state and national policies (e.g. linking with community health programmes), policies that focus on medicinal plant conservation, benefit-sharing and intellectual property rights are not well institutionalized. This mismatch hinders conservation and commercialization, especially at the community level with tribal communities.

These challenges together highlight the complexity of maintaining medicinal plant systems that are ecologically diverse yet subject to ecological stresses and socio-cultural shifts.

FINDINGS

Medicinal plants have great economic potential to contribute to the robustness of the rural economy, through value addition, cultivation and market integration. But the potential is still largely untapped and hampered by short and weak value chains, lack of markets and policy support, and the lack of comprehensive economic feasibility studies. In the absence of organised mechanisms for commercialisation and benefit-sharing, local communities cannot maximise their economic benefits from their traditional knowledge and biological resources.

Simultaneously, the results indicate that medicinal plant resources in the state are under growing pressure from their unsustainable exploitation, degradation of their habitats, and the progressive loss of traditional knowledge associated with them as a result of socio-economic changes. Community-based approaches like home-garden cultivation and customary forest management are the important factors for local conservation, but these practices are not adequate in the absence of systematic ecological monitoring and coordinated and landscape-scale conservation planning. Ensuring sustainable availability of these resources is challenging because long-term population assessments and regeneration studies are not available for high use species.

SUGGESTIONS

The following are recommended strategies on how to overcome these challenges and to ensure sustainable practice, conservation and economic viability:

1. Improve documentation and knowledge preservation: The importance of having a traditional medicine documentation system, such as written documentation, community databases and archival databases on the Internet, should be emphasized. This will reduce the loss of knowledge and aid in scientific study as suggested by the ethnobotanical survey of many tribes.

2. Encourage sustainable harvesting and cultivation by the community: High-use medicinal species can be promoted in home gardens and agroforestry to lower wild populations pressure, while promoting food and

medicine security as has been done among the Nyishi (Techi & Nimasow, 2024). Education about sustainable harvesting and regeneration methods will contribute to in-situ conservation.

3. Set up Value Chains/Market Linkages: Structured value chains involving local producers – with quality requirements, certification systems and market access – can improve the economic viability of medicinal plant resources. Cooperative and non-governmental organizations as well as private sector involvement can be engaged to assist in processing, packaging and distribution.

4. Include Policy Support and Benefit-Sharing Mechanisms: Policy development on issues of community benefit sharing, access and benefit agreements, and IPR protection will bring empowerment to tribal knowledge holders and drive conservation.

5. Promote Interdisciplinary Research and Phytochemical validation: Collaborative work between ethnobotanists, pharmacologists and conservation biologists can confirm traditional knowledge and provide identification of bioactive compounds that may be of pharmaceutical use. Research and conservation prioritization can be directed by prioritizing species by their high use-value indices.

6. Engagement within Education and Youth: Education programmes that bring traditional knowledge into formal education can engage young people and can help to maintain cultural heritage. Generational gaps in knowledge can be bridged through workshops, community schools, participatory field training and can help sustain interest in traditional healing practices.

7. Landscape-Scale Conservation Planning: Priority medicinal species should be subjected to conservation strategies on a regional level that incorporate protected areas, community forests and seed banks. The use of scientific monitoring and community observations can monitor population changes and guide adaptive management.

Through these strategies, stakeholders can make sure medicinal plants continue to contribute to the livelihoods of people in Arunachal Pradesh, while maintaining ecological sustainability and contributing to the preservation of bio-cultural heritage.

LIMITATIONS OF THE STUDY

1. This study is purely secondary data and has no primary field survey.
2. The study doesn't give quantitative assessment of medicinal plant resources in district level.
3. The comprehensive economic information about market value, trade volume, and income generation due to medicinal plants is lacking.
4. There may have been some variation in ethnomedicinal use of different tribes, which may not be adequately captured.
5. There is no phytochemical, pharmacological or clinical validation of medicinal plant uses in the study.

6. There is little long term monitoring data available on medicinal plant conservation.

CONCLUSION

The importance of the present study is that Arunachal Pradesh is one of the richest reservoirs of medicinal plants of India, which has been maintained and developed by its tribal communities over the years with the rich indigenous knowledge system. The large volume of documentation of traditional use, clearly shows that medicinal plants are still vital in primary health care, traditional medicine and subsistence living, especially in remote and ecologically sensitive regions where there is still a lack of modern health services. The variety in species employed, diseases treated, and ethnomedicinal information conveyed among communities further emphasizes the scientific and cultural significance of this bio-cultural heritage.

In conclusion, the sustainable future of medicinal plants in Arunachal Pradesh requires an holistic strategy that incorporates documentation of traditional knowledge, scientific research and validation of their medicinal properties, community-based conservation efforts, and sustainable economic models that involve all stakeholders. Increasing institutional support, involving the youth, equitable benefit sharing, and connecting conservation with livelihood improvement are vital in the protection of this medicinal plant heritage. This comprehensive approach can help to sustain the contribution of medicinal plants to healthcare security, biodiversity protection, and sustainable development in Arunachal Pradesh.

REFERENCES

1. Bushi, D., Bam, K., Mahato, R., Nimasow, G., Nimasow, O. D., & Tag, H. (2021). Ethnomedicinal plants used by the indigenous tribal communities of Arunachal Pradesh, India: A review. *Ethnobotany Research and Applications*, 22, 1–40. <https://ethnobotanyjournal.org/index.php/era/article/view/3005>
2. Das, M., & Tag, H. (2009). An ethnobotanical study of traditional anti-inflammatory plants used by the Lohit community of Arunachal Pradesh, India. *Journal of Ethnopharmacology*, 125(2), 234–245.
3. Ghosh, S., Meyer-Rochow, V. B., & Chakravorty, J. (2010). An ethnobotanical survey of medicinal plants in the Eastern Himalayan zone of Arunachal Pradesh, India. *Journal of Ethnopharmacology*, 134(1), 18–25.
4. Haridasan, K., Sarmah, A., Bhuyan, L. R., & Bisht, N. S. (2003). Medicinal plants sector in Arunachal Pradesh—An overview. *Indian Forester*, 129(1), 37–47. <https://doi.org/10.36808/if/2003/v129i1/2234>
5. Hussain, S., & Hore, D. K. (2008). Collection and conservation of major medicinal plants of Arunachal Pradesh. *Indian Forester*, 134(12). <https://doi.org/10.36808/if/2008/v134i12/877>
6. Kala, C. P. (2005). Ethnomedicinal botany of the Apatani in the Eastern Himalayan region of India. *Journal of Ethnobiology and Ethnomedicine*, 1, 11. <https://doi.org/10.1186/1746-4269-1-11>
7. Mandal, R. K. (2009). *Socio-economic transformation of Arunachal Pradesh*. Omsons Publications.
8. Mandal, R. K. (2011). Development challenges in Arunachal Pradesh: A political economy perspective. *Journal of North East India Studies*, 1(2), 45–62.
9. Mandal, R. K. (2014). *Developmental process in North-East India*. Concept Publishing Company.
10. Mandal, R. K. (2017). Natural resources, livelihoods, and sustainability in frontier regions of Northeast India. *Indian Journal of Regional Science*, 49(1), 1–15.
11. Murtem, G., & Chaudhry, P. (2016). An ethnobotanical study of medicinal plants used by tribes in Upper Subansiri District of Arunachal Pradesh, India. *American Journal of Ethnomedicine*. https://www.researchgate.net/publication/303882643_An_Ethnobotanical_Study_of_Medicinal_Plants_Used_by_the_Tribes_in_Upper_Subansiri_District_of_Arunachal_Pradesh_India
12. Namsa, N. D., Mandal, M., Tangjang, S., & Mandal, S. C. (2011). Ethnobotany of the Monpa ethnic group at Arunachal Pradesh, India. *Journal of Ethnobiology and Ethnomedicine*, 7, 31. <https://doi.org/10.1186/1746-4269-7-31>
13. Siram, J., Hegde, N., Singh, R., & Sahoo, U. K. (2023). Cross-cultural studies of important ethnomedicinal plants among four ethnic groups of Arunachal Pradesh, Northeast India. *Ethnobotany Research and Applications*, 25, 1–23. <https://ethnobotanyjournal.org/index.php/era/article/view/4309>
14. Tech, N., & Nimasow, G. (2024). Ethnomedicinal plants on home gardens of the Nyishi tribe of Papum Pare District of Arunachal Pradesh, India. *International Journal of Ecology and Environmental Sciences*, 50(2). <https://doi.org/10.55863/ijeec.2024.0224>