

Sustainable Utilization and Conservation Challenges of Medicinal Plants

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ABSTRACT

Medicinal plants are invaluable natural resources with diverse therapeutic properties, deeply intertwined with human health and well-being. However, their sustainable utilization and conservation present significant challenges in the face of increasing demand, habitat loss, and overexploitation. This paper examines the sustainable utilization and conservation challenges of medicinal plants, addressing issues such as overharvesting, habitat degradation, and indigenous knowledge protection. Through a comprehensive review of literature and case studies, the paper explores strategies for promoting sustainable harvesting practices, enhancing community involvement, and integrating traditional knowledge with modern conservation efforts. Additionally, it discusses the economic, social, and ecological implications of medicinal plant conservation, emphasizing the importance of collaboration between stakeholders and the need for holistic approaches to ensure the long-term viability of medicinal plant resources. By recognizing the challenges and opportunities inherent in the sustainable utilization and conservation of medicinal plants, this paper aims to inform policy-making, guide conservation initiatives, and promote the preservation of these invaluable natural treasures for future generations.

Key word: Medicinal plant, Conservation, Exploitation, Sustainable utilization

I INTRODUCTION

Medicinal plants (fig 1), have been a cornerstone of traditional healthcare systems across the globe for centuries, providing remedies for a myriad of ailments and contributing significantly to human well-being. In regions like India, China, and various parts of Africa and South America, medicinal plants form an integral part of cultural heritage, offering not only therapeutic solutions but also spiritual and socio-economic significance.

Despite their profound importance, medicinal plants face mounting threats due to unsustainable harvesting practices, habitat destruction, and overexploitation. As global demand for herbal medicines, dietary supplements, and natural products continues to rise, the sustainability of medicinal plant resources has become a critical concern for conservationists, policymakers, and local communities [1-2].

This paper aims to explore the challenges of using medicinal plants sustainably while preserving the environment. It considers the complex balance between human health needs

and environmental conservation. Through a combination of current research, case studies, and expert insights, this paper seeks to shed light on the multifaceted dimensions of these challenges and propose strategies for mitigating their impacts.

To provide a comprehensive overview of the current state of medicinal plant utilization and conservation, this paper draws from a variety of literature sources, including scientific publications, policy documents, and reports from conservation organizations. It integrates perspectives from ecology, ethnobotany, traditional knowledge systems, and socio-economic factors to offer a holistic understanding of the issues at hand. Through this exploration, we aim to contribute to the discourse on sustainable resource management and biodiversity conservation, advocating for the preservation of medicinal plant resources for the benefit of present and future generations. By recognizing the intricate connections between human health, cultural heritage, and ecosystem integrity, we can work towards fostering a more harmonious relationship between people and the natural world [2-4].



Fig 1- Medicinal herbs, source; <https://www.istockphoto.com/search/2/image-film?phrase=medicinal+plants>

II SUSTAINABLE UTILIZATION AND CONSERVATION CHALLENGES

Medicinal plants are valuable natural resources that provide numerous benefits to human health and well-being. However, the sustainable utilization and conservation of these plants pose significant challenges due to factors such as overexploitation, habitat loss, indigenous knowledge protection, and the need for community involvement. This section examines these challenges and explores conservation initiatives aimed at preserving medicinal plant biodiversity.

III OVEREXPLOITATION AND HABITAT LOSS

One of the primary threats to medicinal plants is overexploitation, driven by increasing demand for herbal medicines, botanical supplements, and natural products. Unsustainable harvesting practices, fuelled by commercial interests and market demand, can deplete wild populations of medicinal plants, leading to their decline or extinction.

Furthermore, habitat loss and degradation exacerbate the vulnerability of medicinal plants to overexploitation. Deforestation, urbanization, agricultural expansion, and climate change are major drivers of habitat loss, destroying natural habitats and fragmentation of ecosystems where medicinal plants grow. (Fig 2).

The loss of habitat not only reduces the available area for medicinal plant populations but also disrupts ecological processes essential for their survival, such as pollination, seed dispersal, and nutrient cycling. As a result, many medicinal plant species face heightened extinction risk due to habitat destruction and fragmentation [2,5].



Fig 2-Medicinal plant disappearing, source; The third pole

IV INDIGENOUS KNOWLEDGE PROTECTION

Indigenous communities and traditional healers have long been custodians of traditional knowledge related to medicinal plants. Their traditional knowledge systems encompass valuable information about plant identification, harvesting techniques, preparation methods, and medicinal uses, accumulated over generations through direct observation and experience. (fig 3).

However, the protection of indigenous knowledge is often undermined by biopiracy, intellectual property rights issues, and inadequate legal frameworks. The commercial exploitation of traditional knowledge without consent or

benefit-sharing with indigenous communities can lead to cultural appropriation, loss of traditional knowledge, and exploitation of natural resources.

Efforts to protect indigenous knowledge include the recognition of traditional knowledge rights, the establishment of community-based intellectual property rights regimes, and the promotion of equitable benefit-sharing agreements between indigenous communities and external stakeholders. These measures aim to safeguard traditional knowledge, empower indigenous communities, and promote sustainable management of medicinal plant resources [5-6].



Fig 3- Indigenous Knowledge Protection, source; science direct.com

V CONSERVATION INITIATIVES AND COMMUNITY INVOLVEMENT

Conservation initiatives play a crucial role in preserving medicinal plant biodiversity and promoting sustainable utilization practices. These initiatives encompass a range of strategies, including protected area management, ex-situ conservation, in-situ conservation, habitat restoration, and community-based conservation approaches.

Protected areas, such as national parks, wildlife sanctuaries, and botanical reserves, serve as important refuges for medicinal plant species, providing essential habitats for their survival and conservation. Ex-situ conservation involves the cultivation and maintenance of medicinal plants in botanical gardens, seed banks, and ex-situ gene banks, ensuring their long-term conservation and genetic diversity preservation. In-situ conservation strategies focus on the conservation of medicinal plants within their natural habitats, incorporating principles of ecosystem management, habitat restoration, and sustainable harvesting practices. Community-based conservation approaches involve the active participation of local communities in conservation efforts, empowering them to become stewards of their natural resources.

Community involvement is critical for the success of conservation initiatives, as local communities possess valuable traditional knowledge, ecological insights, and conservation practices that can inform decision-making and resource management. Engaging local communities in conservation activities fosters a sense of ownership, promotes sustainable resource use, and enhances the effectiveness and long-term viability of conservation efforts [7-8, 3-4].

VI CASE STUDIES: PROMINENT MEDICINAL PLANTS IN INDIAN DAILY ROUTINE

Medicinal plants are deeply ingrained in the daily lives of Indians, serving as integral components of traditional healthcare practices, culinary traditions, and personal care routines. Among the myriad of medicinal plants used in India, several stand out for their widespread popularity, therapeutic efficacy, and cultural significance. This section explores four prominent medicinal plants in Indian daily routine: Neem (*Azadirachta indica*), Tulsi (*Ocimum tenuiflorum*), Aloe Vera (*Aloe barbadensis*), and Turmeric (*Curcuma longa*). (Fig 4)



Fig 4-Medicines at home , Source;<https://www.freepik.com/photos/medicinal-plants>

(a) Neem (*Azadirachta indica*)

Neem, also known as "Nature's Pharmacy," holds a special place in Indian traditional medicine and daily life due to its versatile medicinal properties. The neem tree is native to the Indian subcontinent and has been used for centuries in Ayurveda, Unani, and folk medicine for its antibacterial, antifungal, antiviral, and anti-inflammatory properties.

Neem leaves, seeds, bark, and oil are commonly used in various forms for treating a wide range of health conditions, including skin disorders, digestive issues, oral hygiene, and insect repellent. Neem oil, extracted from the seeds, is particularly prized for its potent insecticidal properties and is used in organic farming, pest control, and veterinary medicine.

In Indian households, neem is often incorporated into daily routines through the use of neem-based products such as neem toothpaste, neem soap, and neem oil for hair care. Neem twigs are also used as natural toothbrushes (neem datun), believed to promote oral health, prevent cavities, and maintain dental hygiene.

Moreover, neem is an integral part of religious and cultural practices in India, symbolizing purification, protection, and auspiciousness. Neem leaves are used in rituals, ceremonies, and festivals to ward off evil spirits, purify the environment, and promote well-being.

(b) Tulsi (*Ocimum tenuiflorum*)

Tulsi, or holy basil, holds immense spiritual, medicinal, and cultural significance in India, earning it the title of "Queen of Herbs." Revered as a sacred plant in Hinduism, Tulsi is worshipped as an incarnation of the goddess Lakshmi and is believed to confer divine blessings, protection, and spiritual upliftment.

In addition to its religious significance, Tulsi is highly valued for its medicinal properties and is considered an adaptogen, helping the body adapt to stress and promote resilience. Tulsi leaves are rich in antioxidants, phytochemicals, and essential oils with anti-inflammatory, antimicrobial, and immunomodulatory effects.

Tulsi is commonly used in Ayurvedic medicine for treating respiratory ailments, fever, cough, colds, digestive disorders, and skin conditions. Tulsi tea, made from fresh or dried leaves, is a popular herbal remedy for boosting immunity, relieving stress, and promoting relaxation.

Furthermore, Tulsi is an integral part of Indian culinary traditions, used as a flavorful herb in cooking, garnishing, and food preservation. Tulsi leaves are added to teas, soups, curries, and desserts, imparting a distinctive aroma and flavor to dishes.

(c) Aloe Vera (*Aloe barbadensis*)

Aloe Vera, known as "Ghritkumari" in Hindi, is a succulent plant revered for its therapeutic properties and skincare benefits. Native to the Arabian Peninsula, Aloe Vera has been cultivated and used in traditional medicine systems worldwide for thousands of years.

In India, Aloe Vera is prized for its soothing, moisturizing, and healing properties, making it a popular ingredient in herbal cosmetics, skincare products, and medicinal preparations. Aloe gel, extracted from the inner leaf pulp, is rich in polysaccharides, vitamins, minerals, and amino acids with anti-inflammatory, antimicrobial, and wound-healing effects.

Aloe Vera gel is used topically to treat various skin conditions, including sunburn, burns, wounds, cuts, scars, acne, eczema, and psoriasis. It moisturizes and nourishes the skin, promotes tissue regeneration, reduces inflammation, and relieves itching and irritation.

Additionally, Aloe Vera juice, derived from the inner leaf sap, is consumed orally for its digestive benefits, promoting gut health, regulating bowel movements, and alleviating symptoms of indigestion, constipation, and irritable bowel syndrome (IBS). Aloe Vera juice is also believed to support detoxification, immune function, and overall well-being when consumed regularly.

(d) Turmeric (*Curcuma longa*)

Turmeric, often referred to as "Indian saffron," is a vibrant golden spice with a long history of medicinal and culinary use in India. Belonging to the ginger family, turmeric is prized for its

distinctive flavor, vibrant color, and potent medicinal properties.

Curcumin, the active compound in turmeric, is a powerful antioxidant, anti-inflammatory, antimicrobial, and anticancer agent, making turmeric one of the most extensively researched medicinal plants globally. Curcumin exerts its therapeutic effects by modulating various signaling pathways, enzyme activities, and gene expressions involved in inflammation, oxidative stress, and carcinogenesis.

In Ayurvedic medicine, turmeric is considered a "rasayana" or rejuvenating herb, promoting longevity, vitality, and overall health. Turmeric is used to treat a wide range of health conditions, including arthritis, joint pain, digestive disorders, liver diseases, skin conditions, respiratory ailments, and cardiovascular diseases.

Turmeric is a staple spice in Indian cuisine, used in curries, rice dishes, soups, stews, pickles, and beverages. Turmeric milk, also known as "golden milk" or "haldi doodh," is a popular traditional remedy for boosting immunity, promoting healing, and enhancing overall well-being [9-12,4].

VII ECONOMIC AND SOCIAL IMPACTS OF MEDICINAL PLANTS

Medicinal plants play a significant role in the economic and social fabric of societies worldwide. From providing livelihoods to rural communities to contributing to cultural preservation and identity, the utilization of medicinal plants has far-reaching impacts on various aspects of society. This section examines the economic and social implications of medicinal plants, focusing on their contribution to livelihoods, market trends and export potential, and cultural preservation and identity.

(a) Contribution to Livelihoods

One of the most notable impacts of medicinal plants is their contribution to livelihoods, particularly in rural and marginalized communities where traditional knowledge and natural resources are abundant. Medicinal plants

provide employment opportunities for millions of people engaged in various aspects of the medicinal plant value chain, including cultivation, harvesting, processing, and marketing.

In rural areas, where conventional employment opportunities may be limited, the cultivation and harvesting of medicinal plants offer a source of income and livelihood security for farmers and gatherers. Many communities rely on wild harvesting of medicinal plants from forests and natural habitats, supplementing their household income through the sale of plant material to traders and herbal companies.

Furthermore, the processing and value addition of medicinal plants create additional employment opportunities along the supply chain, including herbal product manufacturers, pharmacists, researchers, and retailers. Cottage industries, cooperatives, and self-help groups often play a crucial role in empowering women and marginalized groups by providing them with training, resources, and market linkages for value-added products.

The sustainable utilization of medicinal plants not only generates income but also enhances the resilience of rural economies, fosters entrepreneurship, and promotes socio-economic development in rural areas. By harnessing the economic potential of medicinal plants, communities can alleviate poverty, reduce dependency on external resources, and improve the quality of life for their members [13,1].

(b) Market Trends and Export Potential

The global market for medicinal plants and herbal products has witnessed significant growth in recent years, driven by increasing consumer demand for natural and holistic healthcare solutions. Market trends indicate a growing preference for plant-based medicines, dietary supplements, herbal cosmetics, and functional foods derived from medicinal plants.

India, with its rich biodiversity and traditional knowledge systems, is well-positioned to capitalize on the growing demand for medicinal plants and herbal products in domestic and

international markets. The country boasts a diverse array of medicinal plant species, many of which have been used in traditional medicine systems like Ayurveda, Siddha, and Unani for centuries.

India's herbal industry encompasses a wide range of stakeholders, including farmers, collectors, traders, manufacturers, exporters, and researchers, contributing to the country's economy and global trade. The export of medicinal plants and herbal products from India has shown steady growth, with products such as herbal extracts, essential oils, herbal teas, and Ayurvedic medicines gaining popularity in international markets.

However, the sustainable management and conservation of medicinal plants are essential to ensure the long-term viability of the herbal industry and prevent overexploitation of natural resources. Sustainable harvesting practices, cultivation initiatives, quality standards, and certification schemes play a crucial role in maintaining the integrity and competitiveness of Indian medicinal plants in global markets [14-15].

(c) Cultural Preservation and Identity

Medicinal plants are deeply intertwined with cultural traditions, beliefs, and practices, serving as repositories of indigenous knowledge, heritage, and identity. In many societies, medicinal plants are an integral part of cultural rituals, ceremonies, festivals, and everyday life, symbolizing the interconnectedness of humans with nature and the spiritual dimension of healing.

The preservation and promotion of traditional knowledge related to medicinal plants are essential for safeguarding cultural heritage, identity, and biodiversity. Indigenous communities, tribal groups, and traditional healers possess invaluable knowledge about the identification, uses, and conservation of medicinal plants, passed down through oral traditions and experiential learning.

Efforts to protect and promote traditional knowledge systems involve recognizing the rights of indigenous peoples, supporting community-based conservation initiatives, and integrating indigenous knowledge into formal education and research programs. By empowering indigenous communities to preserve and transmit their traditional knowledge, societies can foster cultural diversity, social cohesion, and environmental stewardship.

Furthermore, the revival of traditional healing practices and the integration of indigenous medicine with modern healthcare systems contribute to holistic approaches to health and well-being, bridging the gap between traditional and allopathic medicine. Cultural sensitivity, respect for diverse knowledge systems, and collaboration between different stakeholders are essential for promoting cultural preservation, social inclusion, and sustainable development [14-15,4].

VIII FUTURE PERSPECTIVES AND RECOMMENDATIONS

As we look ahead, it is crucial to consider future perspectives and recommendations for the sustainable utilization, conservation, and promotion of medicinal plants. This section discusses key strategies and recommendations to address emerging challenges and opportunities in the field of medicinal plants, focusing on promoting research and development, enhancing sustainable harvesting practices, and conducting education and awareness campaigns.

(a) Promoting Research and Development

Research and development (R&D) play a pivotal role in advancing our understanding of medicinal plants, unlocking their therapeutic potential, and addressing emerging health challenges. Investing in R&D initiatives aimed at exploring the pharmacological, phytochemical, and therapeutic properties of medicinal plants can lead to the discovery of new drugs, herbal formulations, and healthcare solutions.

Government agencies, academic institutions, research organizations, and private enterprises should collaborate to support interdisciplinary research projects, clinical trials, and pharmacological studies focused on medicinal plants. By leveraging cutting-edge technologies such as genomics, metabolomics, and bioinformatics, researchers can elucidate the molecular mechanisms of action of plant-derived compounds and accelerate drug discovery efforts.

Furthermore, fostering partnerships between traditional healers, indigenous communities, and modern healthcare practitioners can facilitate the integration of traditional knowledge with evidence-based medicine. Ethnobotanical surveys, field studies, and collaborative research initiatives can help document and validate traditional uses of medicinal plants, ensuring the preservation and promotion of indigenous knowledge systems.

In addition to drug discovery, R&D efforts should also focus on developing sustainable cultivation practices, improving post-harvest processing techniques, and enhancing quality control standards for herbal products. By promoting innovation and entrepreneurship in the herbal industry, countries can stimulate economic growth, create job opportunities, and foster a culture of scientific inquiry and innovation in the field of medicinal plants [1-2].

(b) Enhancing Sustainable Harvesting Practices

Sustainable harvesting practices are essential to ensure the long-term viability of medicinal plant populations and prevent overexploitation of natural resources. Overharvesting, habitat destruction, and illegal trade pose significant threats to medicinal plant biodiversity, jeopardizing their ecological, economic, and cultural value.

To address these challenges, governments, conservation organizations, and local communities should collaborate to develop and implement sustainable harvesting guidelines, management plans, and regulatory frameworks

for medicinal plants. These initiatives should be based on principles of ecosystem-based management, community participation, and scientific evidence, taking into account the ecological requirements and conservation status of target species.

Furthermore, promoting the cultivation of medicinal plants through agroforestry, home gardens, and community-based farming initiatives can reduce pressure on wild populations and provide alternative livelihoods for rural communities. Agroforestry systems, in particular, offer multiple benefits, including soil conservation, biodiversity conservation, carbon sequestration, and economic diversification.

Capacity-building programs, training workshops, and extension services should be provided to farmers, collectors, and stakeholders involved in the medicinal plant trade to promote sustainable harvesting practices, ethical wildcrafting techniques, and biodiversity conservation. By empowering local communities to become stewards of their natural resources, countries can promote sustainable development, poverty alleviation, and environmental conservation [3,14].

(c) Education and Awareness Campaigns

Education and awareness campaigns are instrumental in promoting the sustainable use, conservation, and cultural significance of medicinal plants among policymakers, stakeholders, and the general public. Public outreach initiatives, educational programs, and media campaigns can raise awareness about the value of medicinal plants, the importance of biodiversity conservation, and the role of traditional knowledge in healthcare.

Schools, colleges, universities, and educational institutions should integrate topics related to medicinal plants, ethnobotany, and traditional medicine into curricula and academic programs to promote interdisciplinary learning and cross-cultural understanding. Field trips, botanical gardens, and experiential learning opportunities can provide students with hands-on experiences

and practical insights into the world of medicinal plants.

Moreover, engaging local communities, indigenous groups, and traditional healers in educational activities and knowledge-sharing platforms can foster dialogue, mutual respect, and cultural exchange. Traditional medicine festivals, ethnobotanical workshops, and community-based conservation projects can serve as forums for celebrating cultural diversity, exchanging knowledge, and promoting social cohesion.

Furthermore, leveraging digital technologies, social media platforms, and multimedia channels can enhance the reach and impact of education and awareness campaigns on medicinal plants. Online resources, mobile applications, and virtual tours can provide accessible information, resources, and interactive experiences to a global audience, empowering individuals to learn, engage, and take action in support of medicinal plant conservation [14-15,3,4].

IX CONCLUSION

As we navigate the challenges and opportunities presented by the growing interest in medicinal plants, it is essential to adopt a holistic and integrated approach that encompasses research and development, sustainable harvesting practices, and education and awareness campaigns. By promoting scientific research, fostering sustainable practices, and raising public awareness, we can ensure the continued availability, conservation, and cultural relevance of medicinal plants for future generations.

Governments, civil society organizations, academia, industry stakeholders, and local communities must collaborate to implement effective strategies and initiatives that promote the sustainable use, conservation, and cultural preservation of medicinal plants. Through collective action and shared commitment, we can harness the potential of medicinal plants to improve human health, foster environmental

stewardship, and promote social equity and cultural diversity.

Sustainable utilization and conservation of medicinal plants are essential for maintaining biodiversity, preserving traditional knowledge, and ensuring the availability of plant-based medicines for future generations. Addressing challenges such as overexploitation, habitat loss, indigenous knowledge protection, and community involvement requires a multi-faceted approach involving stakeholders from diverse sectors, including government agencies, conservation organizations, indigenous communities, and the private sector.

By implementing conservation initiatives, promoting sustainable harvesting practices, protecting indigenous knowledge rights, and fostering community involvement, we can safeguard medicinal plant biodiversity, promote sustainable livelihoods, and contribute to the conservation of global biodiversity.

The case studies of Neem, Tulsi, Aloe Vera, and Turmeric exemplify the profound influence of medicinal plants on Indian daily routine, healthcare practices, culinary traditions, and cultural heritage. These plants embody the holistic approach to health and well-being prevalent in Indian society, integrating medicinal, nutritional, and spiritual aspects into daily life.

By harnessing the therapeutic potential of these medicinal plants and incorporating them into daily routines, Indians not only promote personal health and wellness but also uphold traditional knowledge systems, cultural traditions, and sustainable practices that have been passed down through generations.

Medicinal plants have profound economic and social impacts, contributing to livelihoods, market trends, cultural preservation, and identity. By harnessing the economic potential of medicinal plants, communities can alleviate poverty, promote entrepreneurship, and foster socio-economic development. Additionally, the preservation of traditional knowledge related to

medicinal plants is essential for safeguarding cultural heritage, identity, and biodiversity. Efforts to promote sustainable utilization, conservation, and cultural preservation of medicinal plants require collaboration between governments, civil society organizations, indigenous communities, and other stakeholders. By recognizing the value of medicinal plants beyond their therapeutic properties, societies can promote holistic approaches to health, well-being, and sustainable development.

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