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CLIMATE CHANGE IS GLOBALLY IMPACTING THE ENDANGERMENT OF MEDICINAL PLANTS

Saikat Kumar Basu* and Showkeen Ahmad Gulzar

Department of Botany
Sunrise University, Alwar, Rajasthan, India

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ABSTRACT

Climate change is significantly contributing to the global endangerment of medicinal plants, which are vital for traditional and modern medicine. Rising temperatures, altered precipitation patterns, and extreme weather events are causing habitat degradation and forcing plants to migrate to higher altitudes or latitudes, often beyond their ecological limits. Changing climate conditions disrupt ecosystems, leading to the decline of plant diversity. This particularly affects rare or endemic medicinal species with limited distribution. Climate Change alters flowering and fruiting times, which can affect plant reproduction and reduce yields of bioactive compounds essential for medicinal use. Warmer climates can boost the spread of pests and plant diseases, further threatening the survival of medicinal plant populations. Climate-induced scarcity can lead to overharvesting of remaining plant populations by communities relying on them for health and livelihood, compounding their risk of extinction. Several indigenous and local communities that depend on these plants for traditional medicine face health and economic challenges due to reduced availability. Climate Change exacerbates existing threats to medicinal plants, underlining the need for conservation strategies, sustainable harvesting practices, and climate-resilient cultivation methods.

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INTRODUCTION

Climate Change refers to significant, long-term alterations in global or regional climate patterns, primarily driven by human activities (Applequist et al., 2020; Verma, 2021). While natural factors have historically influenced Earth's climate, the rapid changes observed since the Industrial Revolution are largely due to anthropogenic causes (Guha, 1990; Voggesser et al., 2013). Climate Change encompasses long-term shifts in temperatures and weather patterns. These shifts can be natural, such as through variations in the solar cycle (Cahyaningsih et al., 2021). However, since the 1800s, anthropogenic activities (Sen and Lalhrietpui, 2006) have been the main driver of Climate Change, primarily due to burning fossil fuels like coal, oil, and gas (Cavaliere, 2009).

Causes of Climate Change

The primary anthropogenic (Sen and Lalhrietpui, 2006) causes cumulatively responsible for global Climate Change (Applequist et al., 2020) include indiscriminate combustion of coal, oil, and gas for electricity, heat, and transportation releasing significant amounts of carbon dioxide (CO_2) and other greenhouse gases into the atmosphere (Guha, 1990;

*Corresponding author: *saikat.basu@alumni.uleth.ca*

Applequist et al., 2020). Trees absorb CO_2; thus, large-scale deforestation reduces the planet's capacity to sequester carbon (Springate-Baginski et al., 2006), exacerbating greenhouse gas concentrations in the atmosphere stimulating long term changes in weather patterns (Cahyaningsih et al., 2021). Furthermore, manufacturing and other industrial activities emit various greenhouse gases, including methane (CH_4) and nitrous oxide (N_2O) (Guha, 1990; Springate-Baginski et al., 2006). Last but not the least; livestock farming produces methane, while certain fertilizers release nitrous oxide, both potent greenhouse gases (Cavaliere, 2009; Applequist et al., 2020).

Impact of Climate Change

The major long term impacts of Climate Change are both widespread (Springate-Baginski et al., 2006) and multifaceted (Cahyaningsih et al., 2021). Due to Climate Change has increased the Earth's average surface temperature significantly, with recent data indicating a 12-month average increase of 1.58°C above pre-industrial levels (Guha, 1990; Sen and Lalhrietpui, 2006). Increased frequency and severity of events like hurricanes, droughts, and heavy rainfall are being witnessed around the world (Cahyaningsih et al., 2021). Glacial retreat and polar ice melts have further contributed to sea-level rise (Springate-Baginski et al., 2006; Applequist et al., 2020), threatening island and coastal communities as well as low lying areas of the planet (Kulkarni et al., 2001; Sen and Lalhrietpui, 2006).

Increased air pollution and heat waves can lead to respiratory issues and heat-related illnesses (Guha, 1990; Sen and Lalhrietpui, 2006). Wildfire smoke, intensified by climate change, has been linked to thousands of deaths in the U.S. over a 15-year period. Altered habitats and changing climates can lead to species extinction (Springate-Baginski et al., 2006) and reduced biodiversity (Cahyaningsih et al., 2021). A study published in Nature Climate Change reveals that the wealthiest 10% of the global population have been responsible for approximately two-thirds of Global Warming since 1990 (Guha, 1990). This highlights the disproportionate impact (Springate-Baginski et al., 2006) of affluent lifestyles on Climate Change (Harish et al., 2012).

Impact of Climate Change on Medicinal Plants

Climate Change has significantly contributed to the endangerment of medicinal plants (Cahyaningsih et al., 2021) through several interconnected factors like changes in temperature (Bose, 2010), precipitation patterns, and extreme weather events disrupting ecosystem (Bose et al., 2012) where medicinal plants thrive (Hebbar et al., 2004). Many of these plants grow in specific environments, and shifting climate conditions are making these areas unsuitable for their survival (Chattyopadhyay, 2010). As temperatures rise, some plants may shift their range to higher altitudes or latitudes (Cavaliere, 2009; Springate-Baginski et al., 2006).

However, not all plants can adapt quickly enough to new conditions, and suitable habitats may be limited or already occupied by other species (Cahyaningsih et al., 2021) leading to reduced populations (Harish et al., 2012). Climate Change, coupled with deforestation and agricultural expansion (Bhowmick, 1981), reduces biodiversity in many ecosystems (Bose 2010; Bose et al., 2012). Medicinal plants (Fig. 1) often depend on complex interactions with other species (such as pollinators or symbiotic plants), and the loss of biodiversity can destabilize these relationships (Kulkarni et al., 2001; Cahyaningsih et al., 2021).

Climate Change can alter the distribution and intensity of pests and diseases, making medicinal plants more susceptible to infestations or infections (Chattyopadhyay, 2010; Cahyaningsih et al., 2021). This further threatens their survival in the wild (Kulkarni et al., 2001). It exacerbates the pressures of overharvesting (Hebbar et al., 2004; Cahyaningsih et al., 2021). Many indigenous (aboriginal) communities rely on medicinal plants for traditional medicine (Springate-Baginski et al., 2006), and as plant populations decline, they are harvested at unsustainable rates, pushing them closer to extinction.

Indigenous and local communities possess vital knowledge about the medicinal properties of plants (Voggesser et al., 2013; Cahyaningsih et al., 2021). As Climate Change forces communities to migrate or change their traditional practices, there is a risk that this knowledge may be lost along with the plants themselves (Cavaliere, 2009; Cahyaningsih et al., 2021). These combined factors not only threaten the survival of medicinal plants (Springate-Baginski et al., 2006); but, also jeopardize the potential for discovering new medicines, which could be crucial in treating diseases or developing therapies in the future

Fig 1: The rich diversity of medicinal plants survive with respect to the close network of their corresponding ecosystem components; and any disruption of these ecological parameters could lead to the their endangerment. Photo credit: Saikat Kumar Basu

Endangerment of Medicinal Plants Impact Food Safety and Security

The endangerment of medicinal plants (Hebbar et al., 2004; Sen and Lalhrietpui, 2006; Cahyaningsih et al., 2021) can impact food safety and security in several ways:

Biodiversity and Ecosystem Services: Medicinal plants are an integral part of biodiversity (Bhowmick, 1981). The loss of these plants can disrupt ecosystems, reducing pollination, soil health, and water purification (Chattyopadhyay, 2010; Cahyaningsih et al., 2021). This, in turn, can harm agricultural productivity (Springate-Baginski et al., 2006), leading to reduced food availability and security (Cavaliere, 2009; Cahyaningsih et al., 2021).

Traditional Agricultural Practices: In many communities, medicinal plants are used alongside food crops in agroforestry systems (Bhowmick, 1981; Sen and Lalhrietpui, 2006), or traditional farming methods (Harish et al., 2012; Cahyaningsih et al., 2021). These systems often promote sustainable agriculture by improving soil health, pest control, and resilience to environmental changes (Harish et al., 2012). The loss of medicinal plants can weaken these practices, negatively affecting food production (Kulkarni et al., 2001).

Nutrition and Health: Medicinal plants play a crucial role in human health (Bose, 2010), particularly in rural and indigenous communities (Sen and Lalhrietpui, 2006) that rely on traditional medicine (Harish et al., 2012). When medicinal plants become endangered, people may face more health challenges (Rawat et al., 1997), which can reduce labour capacity in agriculture and food production (Chattyopadhyay, 2010), leading to food insecurity (Voggesser et al., 2013).

Economic Impact: In regions where medicinal plants are harvested (Bhowmick, 1981) for sale or trade (Rawat et al., 1997), their endangerment could reduce household incomes (Bose et al., 2012), limiting families' ability to purchase food (Harish et al., 2012; Cahyaningsih et al., 2021). This economic pressure can exacerbate food insecurity (Hebbar et al., 2004).

Thus, the endangerment of medicinal plants not only threatens health systems (Gupta et al., 2019); but, can also weaken the broader food system (Bose et al., 2012) and security framework (Chattyopadhyay, 2010); especially in vulnerable communities (Harish et al., 2012; Cahyaningsih et al., 2021).

Importance of Medicinal Plants from the Perspectives of Ecology and Economy

Medicinal plants hold significant importance from both ecological (Cahyaningsih et al., 2021) and economic perspectives (Bose et al., 2012; Harish et al., 2012). Here's an overview of their roles in these areas:

1. Ecological Importance

Biodiversity Preservation: Medicinal plants (Fig. 2) are integral components of ecosystems (Cahyaningsih et al., 2021), contributing to overall biodiversity (Hebbar et al., 2004). Their conservation (Springate-Baginski et al., 2006) is critical for maintaining ecosystem balance and resilience (Gupta et al., 2019), as they often serve as habitats or food sources for various species (Cavaliere, 2009).

Ecosystem Services: Many medicinal plants contribute to essential ecosystem functions such as pollination (Gupta et al., 2019), soil enrichment (Bose et al., 20120, water regulation (Bose, 2010), and carbon sequestration (Harish et al., 2012). For example, trees like Cinchona not only provide medicinal compounds (quinine); but, also support wildlife (Rawat et al., 1997) and regulate local climates (Hebbar et al., 2004; Sharma et al., 2020).

Sustainable Resource Usage: The cultivation and sustainable harvesting of medicinal plants (Bose et al., 2012) help preserve natural habitats (Kulkarni et al., 2001). When managed properly (Springate-Baginski et al., 2006), they can be renewable resources (Cahyaningsih et al., 2021), minimizing deforestation and land degradation (Gupta et al., 2019; Sharma et al., 2020).

Cultural and Traditional Knowledge: Ecologically, medicinal plants also play a significant role in preserving traditional ecological knowledge (Gupta et al., 2019), as indigenous and local communities (Bose et al., 2012; Sharma et al., 2020) often have profound knowledge of plant-based medicines (Voggesser et al., 2013). This knowledge fosters a deep connection with nature and encourages sustainable practices (Sharma et al., 2020; Fatima et al., 2021).

2. Economic Importance

Pharmaceutical Industry: Medicinal plants are the foundation of the pharmaceutical industry (Chattyopadhyay, 2010; Cahyaningsih et al., 2021). Many modern medicines are derived from plants or their compounds (*e.g.*, aspirin from willow bark, morphine from poppies) (Springate-Baginski et al., 2006). This provides a significant economic value (Sharma et al., 2020), with billions of dollars invested in plant-based drug research and development (Harish et al., 2012).

Herbal Medicine Market: The global market for herbal medicines and natural health products is growing (Hebbar et al., 2004; Prakash and Verma, 2021). Medicinal plants are used in various forms (teas, tinctures, oils, etc.)(Bose, 2010; Fatima et al., 2021), and their increasing popularity supports local economies (Bose et al., 2012; Tripathi 2016), particularly in rural and developing regions (Kulkarni et al., 2001; Chattyopadhyay, 2010; Sharma et al., 2020; Cahyaningsih et al., 2021).

Agricultural Livelihoods: Cultivating medicinal plants provides income for farmers and smallholders (Bhowmick, 1981; Tripathi, 2019), particularly in regions where agricultural options may be limited (Gupta et al., 2019). This can promote economic stability and diversification (Cavaliere, 2009; Cahyaningsih et al., 2021).

Tourism: Ecotourism and medicinal plant gardens attract visitors interested in natural health (Bhajaj, 19998), biodiversity (Bose, 2010), and conservation (Chattyopadhyay, 2010; Fatima et al., 2021). This can create revenue streams for local communities and support environmental conservation efforts (Harish et al., 2012; Sreedevi et al., 2013).

Medicinal plants are crucial for sustaining ecological integrity (Sreedevi et al., 2013); while also offering significant economic opportunities (Voggesser et al., 2013). Their preservation and sustainable use are essential for both environmental health (Sharma et al., 2020) and economic development (Hebbar et al.,

Fig 2: The rich biodiversity of medicinal plants constitute an important natural resource that successfully sustain the pharmacological and pharmacognostic needs of both traditional and modern medicine for manufacturing essential drugs. Photo credit: Saikat Kumar Basu

Economic Importance of Medicinal Plants from the Perspectives of Pharmaceutical, Nutraceutical and Functional Food Industries

Medicinal plants play a crucial role in the economy (Gupta et al., 2019; Shrma et al., 2020; Cahyaningsih et al., 2021), particularly within the pharmaceutical, nutraceutical, and functional food industries (Harish et al., 2012; Sreedevi et al., 2013). Here are some key points highlighting their importance from these perspectives:

1. Pharmaceutical Industry

Source of Active Ingredients: Many modern pharmaceuticals are derived from plant compounds (Fatima et al., 2021). For instance, over 25% of prescription drugs in the U.S. are derived from plants (Kulkarni et al., 2001; Sreedevi et al., 2013; Sharma et al., 2020).

Cost-Effectiveness: Medicinal plants often provide a cheaper alternative to synthetic drugs (Bhajaj, 19998), reducing overall healthcare costs (Cavaliere, 2009; Fatima et al., 2021).

Market Growth: The increasing trend toward natural and holistic remedies has led to a significant rise in the demand for herbal medicines (Chattyopadhyay, 2010; Cahyaningsih et al., 2021), driving economic growth in this sector (Gupta et al., 2019).

2. Nutraceutical Industry

Health Benefits: Nutraceuticals, which are food products with health benefits, often incorporate extracts from medicinal plants (Chattyopadhyay, 2010; Fatima et al., 2021). These products help in disease prevention and health promotion, supporting the growing health-conscious consumer market (Gupta et al., 2019; Sharma et al., 2020; Cahyaningsih et al., 2021).

Research and Development: Investment in research to validate the health benefits of these plants boosts economic activities (Bhajaj, 19998), including

innovation and job creation in biotech and pharmaceutical companies (Kulkarni et al., 2001; Fatima et al., 2021).

Global Trade: The international demand for plant-based supplements contributes significantly (Cahyaningsih et al., 2021) to the economy through exports and imports (Hebbar et al., 2004; Sharma et al., 2020).

3. Functional Food Industry

Consumer Demand: There is a growing consumer preference for functional foods that provide health benefits beyond basic nutrition (Dushing and Patil, 2010; Fatima et al., 2021). Medicinal plants are often key ingredients in these products (Harish et al., 2012; Sharma et al., 2020).

Sustainability: Many functional foods derived from medicinal plants promote sustainable agricultural practices (Cavaliere, 2009; Cahyaningsih et al., 2021), which can benefit local economies and promote biodiversity (Fatima et al., 2021).

Cultural and Traditional Knowledge: The use of traditional knowledge (Tripathi 2016) related to medicinal plants (Hebbar et al., 2004) can create economic opportunities in local communities, especially in developing regions (Gupta et al., 2019; Fatima et al., 2021), through sustainable harvesting and production (Voggesser et al., 2013).

The integration of medicinal plants into these industries not only supports economic growth (Bhajaj, 1998; Tripathi 2019); but, also promotes health and wellness (Dushing and Patil, 2010), making them a vital component of modern economies (Kulkarni et al., 2001; Cahyaningsih et al., 2021). The ongoing trend toward natural and sustainable products further enhances their economic importance (Cavaliere, 2009; Fatima et al., 2021).

Short Supply of Medicinal Plants Related to Food Safety and Security

The short supply of medicinal plants can significantly impact food safety and security in several ways (Fig. 3). Many medicinal plants are also used in traditional diets and have nutritional value (Gupta et al., 2019; Fatima et al., 2021). A decrease in their availability can lead to a reduction in dietary diversity and nutritional quality, impacting food security (Dushing and Patil, 2010). Medicinal plants often play a role in integrated pest management (Gupta et al., 2019; Fatima et al., 2021). Their scarcity can lead to an increased reliance on synthetic pesticides (Sharma et al., 2020; Cahyaningsih et al., 2021), which can affect food safety and increase health risks for consumers (Hebbar et al., 2004; Sreedevi et al., 2013).

A shortage of medicinal plants may lead to an increase in the use of synthetic drugs, which can have side effects and contribute to health issues (Fatima et al., 2021). This can strain healthcare systems and impact food security by affecting the overall health of the population, reducing productivity (Cavaliere, 2009; Gupta et al., 2019; Fatima et al., 2021). In many cultures, medicinal plants are integral to traditional food practices (Cahyaningsih et al., 2021). A decline in their availability can disrupt these practices (Sharma et al., 2020), affecting community health and food traditions, which are vital for food security (Dushing and Patil, 2010; Voggesser et al., 2013; Fatima et al., 2021).

Many communities depend on the cultivation and sale of medicinal plants for their livelihoods (Harish et al., 2012; Gupta et al., 2019). Shortages can lead to economic instability, affecting food access and security for those reliant on income from these plants (Hebbar et al., 2004; Dushing and Patil, 2010). A short supply of medicinal plants often correlates with broader biodiversity loss (Cahyaningsih et al., 2021), which can disrupt ecosystems (Bhajaj, 19998). Healthy ecosystems are crucial for food production and maintaining food systems (Gupta et al., 2019; Cahyaningsih et al., 2021). The relationship between the supply of medicinal plants and food safety and security is interconnected (Dushing and Patil, 2010; Fatima et al., 2021); affecting nutrition, health, economic stability, and cultural practices (Voggesser et al., 2013; Gupta et al., 2019; Cahyaningsih et al., 2021).

Fig 3: The rapid decline of several essential as well as rare, endemic and endangered medicinal plants can significantly impact food safety and security. Photo credit: Saikat Kumar Basu.

Climate Change Directly Related to Global Endangerment of Medicinal Plants

Climate Change significantly impacts the endangerment of medicinal plants worldwide through several interconnected mechanisms (Bhajaj, 19998). Changes in temperature and precipitation patterns have lead to the degradation and loss of habitats (Sharma et al., 2020) where medicinal plants thrive (Cavaliere, 2009; Dushing and Patil, 2010). For instance, shifts in climate zones may make previously suitable habitats inhospitable for certain species (Harish et al., 2012; Fatima et al., 2021). Many medicinal plants have been forced to migrate to cooler areas or higher altitudes as temperatures rise (Fatima et al., 2021). This can disrupt existing ecosystems (Springate-Baginski et al., 2006) and the relationships between plants and the pollinators or animals that depend on them (Cahyaningsih et al., 2021); Ahmadi-Lahijani and Moori, 2022).

Climate Change leads to more frequent and severe weather events (*e.g.*, droughts, floods, hurricanes), which damage and/or destroy habitats (Harish et al., 2012); directly impacting the survival of medicinal plants (Cavaliere, 2009; Cahyaningsih et al., 2021). Changes in climate can affect soil quality and composition, reducing the ability of medicinal plants to thrive (Dushing and Patil, 2010; Fatima et al., 2021). For example, increased rainfall leads to soil erosion, while drought reduces soil moisture (Hebbar et al., 2004; Sharma et al., 2020). These factors combined can facilitate the spread of invasive species (Dushing and Patil, 2010; Cahyaningsih et al., 2021); which may outcompete native medicinal plants for resources (Gupta et al., 2019). This competition can lead to declines (Sharma et al., 2020) in various vulnerable native populations (Kulkarni et al., 2001; Fatima et al., 2021).

Changes in temperature and precipitation also disrupt the growing seasons of medicinal plants, affecting their life cycles and reducing their populations (Cavaliere, 2009; Dushing and Patil, 2010; Fatima et al., 2021). As habitats shrink and become fragmented due

to Climate Change, the genetic diversity of medicinal plants can decrease (Bhajaj, 1998; Sharma et al., 2020; Cahyaningsih et al., 2021), making them more vulnerable to diseases and environmental changes (Gupta et al., 2019; Fatima et al., 2021). Many communities rely on medicinal plants for traditional medicine (Springate-Baginski et al., 2006) and income (Voggesser et al., 2013; Sharma et al., 2020).

Furthermore, Climate Change threatens these resources, impacting local economies and cultural practices tied to the use of these plants (Dushing and Patil, 2010; Harish et al., 2012; Fatima et al., 2021). The interplay between Climate Change and the endangerment of medicinal plants (Bhajaj, 1998) poses significant risks to biodiversity (Voggesser et al., 2013), ecosystem health, and human well-being (Gupta et al., 2019; Fatima et al., 2021; Cahyaningsih et al., 2021). Conservation efforts must consider these climate-related challenges to protect and sustain these valuable resources (Harish et al., 2012; Sharma et al., 2020; Fatima et al., 2021).

Current Scenario of Global Medicinal Plant Industry

The medicinal plant industry is a significant and growing sector worldwide (Sharma et al., 2020), characterized by its diverse practices and products (Dushing and Patil, 2010). The global herbal medicine market is projected to reach USD 400 billion by 2026, driven by increasing consumer interest in natural and holistic health solutions. There is a rising demand for herbal supplements, essential oils, and plant-based pharmaceuticals (Ahmadi-Lahijani and Moori, 2022).

Three market regions are extremely important (Sreedevi et al., 2013). The Asia-Pacific market dominates the international market arena (Sharma et al., 2020), particularly in countries like China and India, known for their traditional medicine systems (Traditional Chinese Medicine and Ayurveda) (Dushing and Patil, 2010). The North American market has growing interest in herbal remedies and dietary supplements, with significant investments in research and development (Sreedevi et al., 2013; Voggesser et al., 2013). Lastly, the European market has very strong regulatory frameworks supporting the industry, with increasing acceptance of herbal products (Gupta et al., 2019; Sharma et al., 2020).

Medicinal plants are sourced from both wild harvesting and cultivation (Bhajaj, 1998; Tripathi 2016). Sustainable practices are becoming increasingly important to preserve biodiversity and ecosystems (Hebbar et al., 2004; Sharma et al., 2020). Some countries have developed specific regions for cultivating medicinal plants, often supported by government policies (Bhajaj, 19998). Among the most important key trends of the market indicates sustainability (Harish et al., 2012). There is a push for sustainable harvesting and cultivation practices (Springate-Baginski et al., 2006) to protect endangered species and habitats (Dushing and Patil, 2010). Another trend is increased investment in Research and Development leading to new drug discoveries and formulations based on traditional knowledge (Sharma et al., 2020). But variability in regulations across countries affects market access and quality control, making standardization essential (Gupta et al., 2019).

Among the most important challenges of the medicinal plant industry include overharvesting and biodiversity losses (Dushing and Patil, 2010; Sreedevi et al., 2013). Unsustainable practices are threatening wild populations of medicinal plants at an alarming rate (Gupta et al., 2019; Sharma et al., 2020). Since successful agronomic production of medicinal plants are restricted to only a handful species (Bhajaj, 19998); hence, majority of medicinal plants are excited from our forests (Springate-Baginski et al., 2006), remote rural areas, wilderness zones and sensitive ecosystems (Hebbar et al., 2004; Sharma et al., 2020).

The rate of exploitation by untrained collectors has resulted in rapid endangerment of many important medicinal plant species (Springate-Baginski et al., 2006), many being dangerously pushed towards extinction (Voggesser et al., 2013). Adulteration has surfaced as a major spoiler; since authentic medicinal plants is becoming increasingly difficult to collect from their natural ecosystems (Guha, 1990; Sreedevi et al., 2013; Tripathi, 2019; Sharma et al., 2020). Under these circumstances ensuring the purity and efficacy of herbal products is a major concern (Harish et al., 2012). The multi-national pharmaceutical, nutraceutical and functional food industries and companies (Sharma et al., 2020) are dominating the global market (Bhajaj, 1998; Springate-Baginski et al., 2006), impacting the availability and pricing of plant-based medicines (phytomedicines) (Kulkarni et al., 2001; Harish et al., 2012; Gupta et al., 2019).

Conclusion

Climate Change is significantly impacting medicinal plants across the globe, affecting their distribution, growth, potency, and availability. Warming temperatures and shifting rainfall patterns are altering

the habitats where medicinal plants thrive. Several plants are migrating to higher altitudes due to rising temperatures. Some medicinal species are being displaced by invasive or heat-tolerant species, threatening traditional medicine. Stress from higher temperatures, drought, or erratic rainfall can lower plant productivity and alter the concentration of bioactive compounds. Droughts reduce the survival and growth of many medicinal plants, especially in arid and semi-arid regions. Some medicinal plants are under threat due to increasing drought conditions. Species like *Rauvolfia serpentina* (Sarpagandha) and *Withania somnifera* (Ashwagandha) are suffering from water shortages. Changes in temperature and precipitation affect the timing of flowering, fruiting, and harvesting seasons, disrupting traditional collection and use. Deforestation, habitat fragmentation, and climate change combined are causing loss of native medicinal species. Overharvesting and desertification threaten endemic medicinal plants. Climate Change and land use change threaten endemic medicinal plant diversity.

As medicinal plants become scarce or shift locations, indigenous communities face loss of access and knowledge continuity. Reduced access to culturally important plants can erode traditional medicine systems. Hence, *in-situ* and *ex-situ* conservation (botanical gardens, seed banks), promoting sustainable cultivation under controlled conditions, and predicting suitable future habitats for threatened species are important steps for conserving endangered medicinal plants. The medicinal plant industry is evolving with trends towards sustainability, research, and consumer demand for natural products. As the sector grows, addressing challenges related to regulation, quality control, and biodiversity will be crucial for its future.

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