



Invasive Plant Species as Drivers of Ethnomedicinal Plant Decline in the Rohilkhand Region of Uttar Pradesh, India: A Review of Ecological and Socioeconomic Implications

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ABSTRACT

The threat of invasive alien plant species (IAPS) to biodiversity, ecological health and sustainable use of biological resources globally is becoming increasingly obvious. In India's Rohilkhand region of Uttar Pradesh, invasive plants have been spreading rapidly, presenting a serious environmental hazard since they might damage local plant species, especially those utilized in traditional medicine. This study combines all the studies carried out on the spread, environmental, and sociological and economic repercussions of alien plant species in the area with an emphasis on their influence on the diversity of ethnomedicinal plants. Published research, regional floristic surveys and ethnobotanical studies were closely examined to uncover patterns of invasion and their implications for traditional medicinal plant resources. The assessment says several invasive species have spread to wide regions in wastelands, woods, marshes and disturbed ecosystems. The majority of these plants belong to the groups Asteraceae, Amaranthaceae, Euphorbiaceae and Convolvulaceae. These species compete with native medicinal plants for space, nutrients, water, and light, reducing the quantity of plants in the region, altering the community structure, and damaging the ecosystem. Loss of ethnomedicinal plants makes it more difficult for local people to get the plant-based remedies they have traditionally utilized and may also make indigenous knowledge systems less secure. Invasive species can also damage people's livelihoods by reducing access to essential medicinal ingredients and increasing control costs. According to the statistics, Rohilkhand suffers from biological invaders both from the environmental and economic point of view. To safeguard the biological and cultural history of the area involves increasing biodiversity monitoring, maintaining populations of plants needed for traditional medicine, recovering invaded habitats and applying traditional ecological knowledge to management plans. Invasions have strong effects on ecosystems and scientists must discover out how to evaluate those effects, track them over time, and design effective strategies for protecting and restoring them.

Keywords: Invasive alien plant species, Ethnomedicinal plants, Biodiversity conservation, Biological invasion, Traditional knowledge, Rohilkhand region, Uttar Pradesh.

INTRODUCTION

Biological invasions are becoming one of the major causes of biodiversity loss worldwide. Deliberate or inadvertent introduction of species outside their usual geographic ranges has changed ecosystem structure, biological processes and species interactions in numerous locations. Among these invasions invasive alien plant species (IAPS) are of special concern because of their capacity to establish quickly, spread aggressively and out-compete native vegetation. Their spread can often impact community composition, habitat quality, nutrient cycling and ecosystem functioning. Thus, invasive plant species are today seen as a serious environmental problem, together with habitat degradation, pollution, overexploitation of natural resources and climate change [1].

India, a country of megadiversity, has an extensive floristic legacy and a long tradition of plant-based treatment methods. The nation has thousands of medicinal plant species used in Ayurveda, Unani, Siddha, folk medicine and tribal healthcare. These ethnomedicinal plants serve a significant role in basic health care especially in rural and economically disadvantaged areas where access to contemporary medical facilities may be limited [2]. Apart from their therapeutic use, these plants are important for cultural identity, local economy and protection of biodiversity. But the rising invasion of alien species is a serious danger to the local medicinal flora and the related traditional knowledge [3].

Invasive alien plants have a number of biological features enabling successful establishment and spread. These include fast development, large seed output, strong dispersion ability, phenotypic flexibility and tolerance to a broad range of environmental circumstances. Many invasive plants are able to create dense monospecific stands that inhibit native vegetation through competition for light, water, nutrients and space. Other species also have allelopathic effects by producing biochemical substances that prevent the seed germination and development of other plants. These ecological benefits provide invasive species a competitive edge over natives in disturbed sites, croplands, marshes, grasslands, forest edges, and urban ecosystems [4].

The Rohilkhand Region of Uttar Pradesh is environmentally significant in the Upper Gangetic Plain in northern India. This area consists of the districts of Bareilly, Bijnor, Moradabad, Rampur, Sambhal, Amroha, Budaun, Pilibhit and Shahjahanpur. The plant diversity is enormous and is supported by the subtropical temperature, fertile alluvial soils, large agricultural landscapes, wetlands, riverine systems and scattered forest areas. The region is also rich in ethnobotanical traditions and local populations use several plant species for the treatment of problems such as fever, gastrointestinal disorders, skin diseases, respiratory infections, diabetes, wounds and inflammatory conditions. Traditional healers, herbal practitioners and rural households continue to use these plant resources for health treatment and livelihood assistance [5][6].

However, during the past few decades, the Rohilkhand region has seen growing invasion by alien plant species. Floristic studies have reported several invasive species from families including Asteraceae, Amaranthaceae, Euphorbiaceae, Convolvulaceae, Poaceae and Solanaceae from diverse sections of the region. Species such as *Parthenium hysterophorus*, *Ageratum conyzoides*, *Lantana camara*, *Eichhornia crassipes*, *Alternanthera philoxeroides* and *Ipomoea carnea* have grown well established in natural and disturbed environments [7][8]. The proliferation of these species has prompted concerns about their ecological consequences on native plant groups including ethnomedicinally significant taxa. Dense incursions can lower species richness, change environmental conditions, inhibit regeneration of native plants and impair the availability of medicinal substances used by local populations [9].

The repercussions of invasive plant spread go well beyond ecological damage. Many ethnomedicinal plants are collected from natural habitats and common lands. The replacement of native vegetation by invasive species can result in limited availability to traditional medicinal materials, greater collecting effort and diminishing transfer of indigenous knowledge between generations. Thus, the loss of ethnomedicinal variety is a socio-economic and cultural issue as well as a matter of conservation. Furthermore, the reduced availability of medicinal plants may have an impact on home healthcare practices and on local herbal markets that rely on these biological resources [10].

Invasive alien plant species and ethnomedicinal flora are reported in various studies in northern India. However, evidence on the direct association between biological invasions and ethnomedicinal plant variety is still fragmented. The majority of studies have concentrated either on the floristic inventory of invasive species or on the ethnobotanical documentation of therapeutic plants. Integrated evaluations that consider both ecological and socioeconomic aspects are rather rare, especially on a regional scale. Therefore, a synthesis of current information is important to assess the size of the problem and to suggest future research priorities [11][12].

This research tries to assess the effect of invasive alien plant species on ethnomedicinal plant variety in Rohilkhand area of Uttar Pradesh. It examines the distribution of key invasive species, their ecological consequences on native medicinal plant groups and larger implications for biodiversity conservation, traditional health care systems and rural livelihoods. The assessment also addresses current knowledge gaps and outlines recommendations for future research, monitoring and management techniques for the conservation of [13].

Objectives of the Study

The present review was performed with the following objectives:

1. To compile and synthesize the existing information on invasive alien plant species (IAPS) reported from Rohilkhand area of Uttar Pradesh, India.
2. To study the ecological consequences of invasive alien plant species on native plant ecosystems with specific reference to ethnomedicinal plant variety.
3. To determine the methods by which invasive species affect the distribution, abundance, regeneration and survival of ethnomedicinal plant species.
4. To assess the socioeconomic implications of dwindling ethnomedicinal plant resources on traditional health systems, local livelihoods and indigenous knowledge systems.
5. To find out the significant research gaps, conservation concerns and management issues of invasive plant species and ethnomedicinal flora of Rohilkhand region.
6. To suggest viable techniques for protection of ethnomedicinal plant resources, restoration of habitat use, sustainable exploitation and long-term management under the impact of biological invasions.

METHODOLOGY

This review is based on detailed study of available scientific literature related to invasive alien plant species and ethnomedicinal plant variety of Rohilkhand area of Uttar Pradesh, India. Relevant research publications, floristic surveys, ethnobotanical studies, books, reports and internet resources were comprehensively reviewed. Data on species richness, distribution patterns, ecological consequences and medicinal plant resources and socio-economic implications were collected, compiled and critically analyzed. Major invasive species, their impact on native ethnomedicinal flora, knowledge gaps and conservation needs were identified by a comparative study. The synthesis information was utilized to make suggestions for future study and biodiversity management [14].



Fig 1. GPS Location Invasive Plants in Rohilkhand Regions

Review of Literature

Biological invasions have become a serious global ecological issue because of their negative consequences on biodiversity, ecosystem stability and availability of natural resources. Invasive alien plant species (IAPS) are considered one of the major drivers of native species loss and habitat degradation [15][16]. According to Mooney and Hobbs (2000), invasive species can change ecosystem structures, upset ecological processes and lower biological diversity through competitive exclusion and habitat alteration. Similarly, Vitousek et al. (1997) found that biological invasions had major effects on nutrient cycle, productivity, and species composition in both wild and managed ecosystems [17].

Invasive alien plants have garnered substantial attention in India during the last two decades. Reddy (2008) reported more than 170 invasive alien plant species from different parts of the country and their ecological consequences on local vegetation. Research has indicated that species such as *Parthenium hysterophorus*, *Lantana camara*, *Ageratum conyzoides* [18][19], *Eichhornia crassipes* and *Chromolaena odorata*, are a major danger to the local flora, due to their quick growth, prolific reproduction and high competitive abilities. These plants are commonly dominant in disturbed habitats, agricultural fields, roadsides, marshes and forest edges, therefore diminishing native plant variety [20].

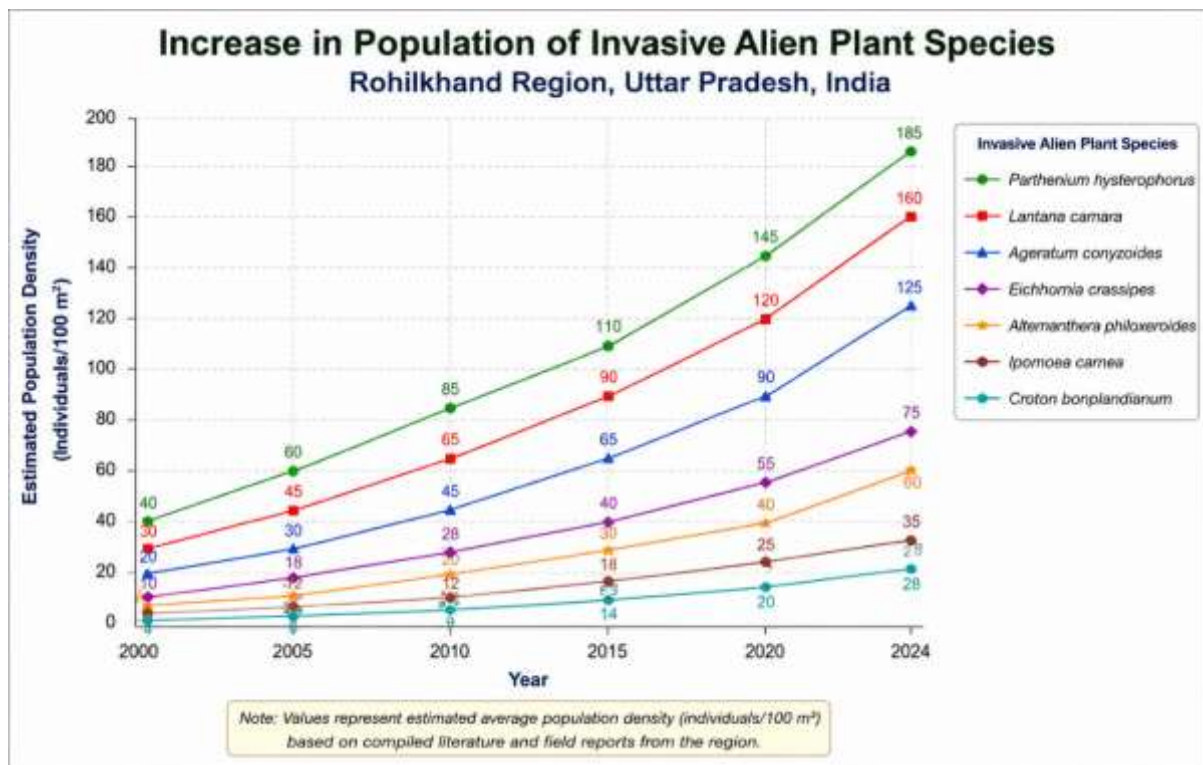
An upsurge in invasive alien species has been seen in northern India, according to research. Rastogi et al. (2015) reported 94 invasive alien species (IAS) belonging to 72 genera and 33 families in Pantnagar area of Uttarakhand. Most of the invasive species in the research were herbs that originated in tropical America. The authors stressed that massive invasion is a symptom of a poor state of natural vegetation and a severe danger to biodiversity [21].

Kumari et al. (2016) carried out a regional study and reported 79 invasive alien angiosperm species from Rohilkhand area of Uttar Pradesh. The Asteraceae was revealed to be the most dominating family, with roughly 71% of the invasive species being from tropical America [22]. The scientists noted that invasive species are increasingly invading agricultural areas, wastelands, marshes and forest borders, consequently harming native plant populations. Kumari et al., (2018) also recorded twelve invasive species out of forty-two angiosperm species appearing in ecologically challenged locations of Moradabad district [23]. Their results showed that disturbed ecosystems are suitable for establishment and spread of invasive species [24]. Ethnomedicinal plants are an important component of biodiversity and an important source of healthcare to rural populations. India has an extensive heritage of herbal medicines and huge section of population still depends on herbal medicines for primary health care. Numerous research has shown the therapeutic benefits of local plant species in the treatment of fever, skin illnesses, digestive, respiratory, diabetic and inflammatory problems. However, the ongoing increase in habitat degradation and biological incursions jeopardize the supply of these essential resources [25][26].

Recent ethnobotanical studies of the Rohilkhand region have underlined the relevance of medicinal plant variety. Singh et al. (2024) described 43 species from the family Euphorbiaceae and confirmed their widespread usage in traditional medicines for the treatment of skin illnesses, diarrhoea, dysentery, urinary problems, rheumatism, wounds and other maladies. The study highlighted the necessity to conserve the medicinal plant resources in the face of increasing environmental stressors. However, evidence on direct effects of invasive alien plants on ethnomedicinal species is still few [27][28][29]. The current research implies that invasive alien plant species are progressively displacing native vegetation and changing the ecological conditions essential for the survival of medicinal plants. Although this problem is becoming well known, there is a lack of thorough studies on the relationship between invasion ecology and ethnomedicinal plant conservation, especially in the Rohilkhand region. Therefore, a complete synthesis of current research is necessary to comprehend the ecological and socio-economic implications of invasive species, and to establish appropriate conservation and management methods [30][31].

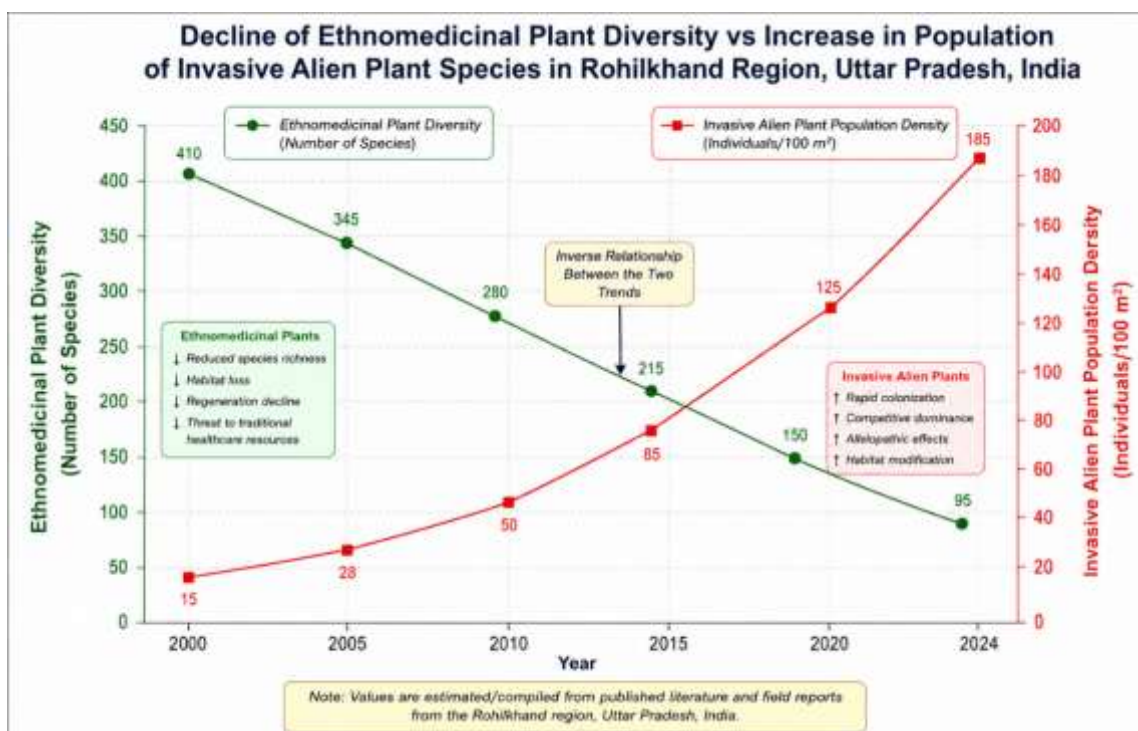
RESULTS AND DISCUSSION

The present analysis of literature shows that invasive alien plant species (IAPS) have become a major ecological problem in Rohilkhand region of Uttar Pradesh and surrounding parts of Upper Gangetic Plain. In sum, the existing floristic and ethnobotanical research show that invasive species are progressively invading natural and semi-natural environments, causing changes in vegetation structure, species composition and ecosystem functioning. These changes have crucial consequences for conservation and sustainable use of ethnomedicinal plant resources.



Diversity and Distribution of Invasive Alien Plant Species

Published research suggest a significant diversity of invasive alien plant species in the region. Floristic surveys in Rohilkhand and its neighbourhood have reported a number of invasive species belonging to Asteraceae, Amaranthaceae, Euphorbiaceae, Convolvulaceae, Poaceae, Solanaceae and Fabaceae families [32][33]. Studies by Rastogi et al. (2015) and Kumari et al. (2016) reported 94 and 79 invasive alien species respectively, demonstrating common occurrence of invasive flora in northern India. Most of these species have been discovered to be of origin from tropical America, which has been recognized as the principal supply zone for invasive plants in Indian subcontinent [34].



Impact on Ethnomedicinal Plant Diversity

The dominance of herbaceous invasive plants shows their remarkable adaptation to damaged ecosystems. *Parthenium hysterophorus*, *Ageratum conyzoides*, *Alternanthera philoxeroides*, *Ipomoea carnea*, *Croton bonplandianum*, *Tridax procumbens*, *Eichhornia crassipes* and *Lantana camara* have become common in agricultural fields, roadsides, wetlands, grazing lands, wastelands and forest margins. Their wide range is a consequence of their ability to colonize quickly, reproduce abundantly and disperse efficiently [35][36].

These species are found in increasing numbers in areas subject to anthropogenic disturbances, including land-use changes, urbanization, transportation networks, intensive agriculture and habitat fragmentation. Invasive species sometimes find it easier to establish themselves in disturbed ecosystems, which tend to have unfilled niches and less competition. Thus, many populations of native medicinal plants are becoming more vulnerable to dislocation [37].

One of the major results that emerge from the literature surveyed is the possible harmful impact of alien invasive plants on the variety of ethnomedicinal plants. Ethnomedicinal plants provide an important component of the indigenous health care traditions and rural livelihoods in Rohilkhand. Many native species are collected from woods, meadows, riverbanks, marshes and common areas that are fast being invaded by exotic plants [38][39][40].

Invasive species are direct competitors with native medicinal plants for sunshine, nutrients, soil moisture and physical space. Their vigorous development typically leads to extensive vegetation cover that inhibits seed germination and seedling establishment of indigenous species. This competitive advantage enables invasive plants to dominate environments previously held by varied native ecosystems [41].

Species like *Parthenium hysterophorus* and *Lantana camara* are notorious for forming thick stands that diminish the richness of local species. Such invasions can cause a slow decline in populations of medicinally significant species such as *Achyranthes aspera*, *Boerhavia diffusa*, *Centella asiatica*, *Phyllanthus fraternus*, *Withania somnifera*, *Eclipta prostrata* and many more native taxa used in traditional healthcare systems. The decrease in medicinal plant populations impacts not just biodiversity but also concerns the supply of raw materials for herbal medicines. The over-exploitation of many medicinal species, collected directly from natural environments, may pose problems for local people who rely on plant-based healthcare services [42].

Alteration of Habitat Conditions

The reviewed research demonstrate that invasive species greatly change ecological parameters, and consequently survival and regeneration of native medicinal plants. Several invasive plants change soil characteristics, nitrogen availability, moisture regimes and microbial populations. Such alterations might provide environmental circumstances conducive to invasive species, while being detrimental to local plants. Allelopathic effects have also been found in some invasive species. Chemical substances emitted from root, leaf or decaying litter might impede germination and growth of surrounding plant species. For instance, *Parthenium hysterophorus* synthesizes allelochemicals that negatively impact seed germination and development of neighboring plants. Such impacts have been reported in other invasive species with lower plant diversity and changed community composition. Other ecological concerns are caused by aquatic invasive plants such as *Eichhornia crassipes* which blanket water surfaces and reduce light penetration. Such circumstances have a negative impact on aquatic and semi-aquatic medicinal plants resulting in decreased variety and production of the environment [43][44].

Socioeconomic Implications

The ecological effects of invasive species are strongly related to the economic repercussions. The traditional health care system of Rohilkhand depends to a large extent on the availability of native plant resources. Decreasing populations of medicinal plants may lead to greater effort in gathering, less availability of herbal treatments and help to gradually erode traditional knowledge systems.

Medicinal herbs are still resorted to by many rural households for the treatment of common diseases owing to their cheapness and availability. The loss of these resources might lead to increased dependency on commercial healthcare services, which could further stress local economies. Also, herbal practitioners and traditional healers may find it difficult to get plant materials essential for medical treatments. Cultural effects of ethnomedicinal plant variety decline also. Traditional knowledge of ecology about identification, collecting, processing and medicinal use of plants is frequently conveyed orally from generation

to generation. Loss of medicinal plants may lead to weakening of these knowledge systems and loss of cultural legacy [45].

Conservation and Management Considerations

The literature study immediately points to the significance of integrated management strategies for the purpose of controlling invasive plant species and for the protection of diversity of ethnomedicinal plants. Good invasive species management includes early detection, ongoing monitoring, and control prior to widespread distribution. Effective management of invasive species needs several things including mechanical removal, habitat restoration, biological control, and community engagement [46].

Protected areas should target places having a number of various kinds of plants that are utilized in traditional medicine. Returning native medicinal species to damaged ecosystems may help make them more robust and tougher for intruders to get in again. It can also serve to keep track of traditional knowledge and to promote ecologically sustainable techniques of picking plants, and to protect medicinal plant resources in the long run [47].

Research Gaps and Future Perspectives

Although there is increased awareness of invasive plant concerns, numerous major research gaps remain. Most of the research in Rohilkhand is descriptive and a good deal of it is devoted to recording of floristic inventories. Quantitative examinations of the effects of invasions on populations of ethnomedicinal plants are hardly absent. Data about population dynamics, regeneration patterns, ecological services and economic losses by invasive species is also scarce [48].

Future studies should use more sophisticated ecological methodologies, including, but not limited to, biodiversity indices, geospatial analysis, species distribution modeling, remote sensing and long-term monitoring programs. In addition, molecular methods can be beneficial to investigate invasion processes and genetic variety of invading populations. Ecological research combined with ethnobotanical and socioeconomic assessments would give a more holistic knowledge of the impacts of biological invasions. To summarize, the available information clearly demonstrates the rising role of invading alien plant species as key drivers of ethnomedicinal plant loss in the Rohilkhand region. If proper conservation and management actions are not in place, their continuous expansion might result in substantial ecological, economic and cultural losses. Hence, protection of local medicinal plants variety is not only vital for conservation of biodiversity but also for sustainability of traditional healthcare systems and biological heritage of the region [49].

Table 1. Effects of Major Invasive Alien Plant Species on Ethnomedicinal Plants in Rohilkhand Region, Uttar Pradesh [50]

S. No.	Invasive Alien Plant Species	Family	Native Origin	Mode of Impact	Ethnomedicinal Plants Affected*	Ecological Consequences	Severity of Impact
1	<i>Parthenium hysterophorus</i> L.	Asteraceae	Tropical America	Competition, allelopathy, rapid colonization	<i>Achyranthes aspera</i> , <i>Boerhavia diffusa</i> , <i>Eclipta prostrata</i> , <i>Centella asiatica</i>	Reduced germination, decline in species richness	Very High
2	<i>Lantana camara</i> L.	Verbenaceae	Tropical America	Dense thicket formation, shading	<i>Withania somnifera</i> , <i>Adhatoda vasica</i> , <i>Ocimum tenuiflorum</i>	Habitat degradation and restricted regeneration	Very High
3	<i>Ageratum conyzoides</i> L.	Asteraceae	Tropical America	Aggressive competition for nutrients and moisture	<i>Phyllanthus fraternus</i> , <i>Eclipta prostrata</i> , <i>Tridax procumbens</i>	Suppression of native herbaceous flora	High
4	<i>Alternanthera philoxeroides</i>	Amaranthaceae	South America	Rapid vegetative	Wetland medicinal plants	Reduction of wetland	High

	(Mart.) Griseb.			spread		biodiversity	
5	<i>Ipomoea carnea</i> Jacq.	Convolvulaceae	Tropical America	Dense growth and habitat occupation	Riverbank medicinal species	Alteration of riparian vegetation	High
6	<i>Eichhornia crassipes</i> (Mart.) Solms	Pontederiaceae	South America	Surface water coverage	Aquatic medicinal plants	Reduced oxygen and light availability	Very High
7	<i>Croton bonplandianum</i> Baill.	Euphorbiaceae	South America	Rapid colonization of disturbed habitats	Native herbaceous medicinal plants	Reduced native plant abundance	Moderate
8	<i>Tridax procumbens</i> L.	Asteraceae	Tropical America	Competitive dominance in open habitats	Low-growing medicinal herbs	Community structure alteration	Moderate
9	<i>Xanthium strumarium</i> L.	Asteraceae	Tropical America	Resource competition	Grassland medicinal species	Decline of native species diversity	Moderate
10	<i>Cassia tora</i> L.	Caesalpiniaceae	Tropical America	Dense population establishment	Native medicinal herbs	Habitat occupation and competition	Moderate

*Examples of ethnomedicinal plants reported from Rohilkhand and adjoining regions.

Table 2. Summary of Major Effects of Invasive Alien Plants on Ethnomedicinal Flora [51]

Impact Category	Description	Consequences
Competition for Resources	Invasive plants compete for light, nutrients, water, and space	Reduced growth and survival of medicinal plants
Allelopathic Effects	Release of inhibitory chemicals into soil	Poor seed germination and regeneration
Habitat Modification	Alteration of soil properties and vegetation structure	Loss of suitable habitat
Biodiversity Reduction	Replacement of native species by invasive species	Decline in medicinal plant diversity
Wetland Degradation	Aquatic invasives cover water bodies	Reduction of aquatic medicinal species
Loss of Traditional Resources	Declining availability of medicinal plants	Threat to traditional healthcare systems
Knowledge Erosion	Reduced interaction with medicinal plants	Loss of indigenous knowledge
Economic Impact	Increased scarcity of medicinal resources	Higher collection costs and reduced income

Table 3. Comparative Impact Assessment [52]

Invasive Species	Ecological Impact Score (1-10)	Threat to Medicinal Plants
<i>Parthenium hysterophorus</i>	10	Extremely High
<i>Lantana camara</i>	9	Very High

<i>Eichhornia crassipes</i>	9	Very High
<i>Ageratum conyzoides</i>	8	High
<i>Alternanthera philoxeroides</i>	8	High
<i>Ipomoea carnea</i>	7	High
<i>Croton bonplandianum</i>	6	Moderate
<i>Xanthium strumarium</i>	6	Moderate
<i>Tridax procumbens</i>	5	Moderate
<i>Cassia tora</i>	5	Moderate

Table 4. Major Allelopathic Phytochemicals Produced by Invasive Alien Plant Species and Their Effects on Medicinal Plants [53]

S. No.	Invasive Alien Plant Species	Family	Major Allelopathic Phytochemicals	Plant Part Producing Chemicals	Mode of Action	Effects on Ethnomedicinal Plants
1	<i>Parthenium hysterophorus</i> L.	Asteraceae	Parthenin, Hysterin, Ambrosin, Chlorogenic acid, Caffeic acid	Leaves, stems, roots, pollen	Inhibits seed germination, root elongation, and nutrient uptake	Reduces establishment of <i>Withania somnifera</i> , <i>Boerhavia diffusa</i> , <i>Achyranthes aspera</i> and other medicinal herbs
2	<i>Lantana camara</i> L.	Verbenaceae	Lantadene A, Lantadene B, Phenolics, Flavonoids, Triterpenoids	Leaves, roots, litter	Suppresses germination and seedling growth	Decreases regeneration of native medicinal shrubs and herbs
3	<i>Ageratum conyzoides</i> L.	Asteraceae	Precocene I, Precocene II, Coumarins, Flavonoids, Alkaloids	Leaves and roots	Inhibits cell division and seedling development	Restricts growth of <i>Centella asiatica</i> , <i>Eclipta prostrata</i> and associated flora
4	<i>Chromolaena odorata</i> (L.) King & Robinson	Asteraceae	Phenolic acids, Scutellarein, Flavonoids, Terpenoids	Leaves and litter	Alters soil chemistry and microbial activity	Suppresses native medicinal plant regeneration
5	<i>Eichhornia crassipes</i> (Mart.) Solms	Pontederiaceae	Phenolics, Tannins, Alkaloids	Roots and decomposing biomass	Reduces aquatic light penetration and nutrient balance	Affects aquatic medicinal species and wetland biodiversity
6	<i>Alternanthera philoxeroides</i> (Mart.) Griseb.	Amaranthaceae	Phenolic acids, Ferulic acid, p-Coumaric acid	Roots and leaves	Inhibits seed germination and growth of neighboring plants	Reduces diversity of wetland medicinal herbs
7	<i>Ipomoea carnea</i> Jacq.	Convolvulaceae	Swainsonine, Calystegines, Phenolic	Leaves and roots	Toxicity and competitive suppression	Limits growth of medicinal species in riparian habitats

			compounds			
8	<i>Croton bonplandianum</i> Baill.	Euphorbiaceae	Diterpenoids, Phenolics, Tannins	Leaves and roots	Inhibits seedling establishment	Reduces abundance of native medicinal herbs
9	<i>Prosopis juliflora</i> (Sw.) DC.	Fabaceae	Juliflorine, Julifloricine, Tannins, Alkaloids	Leaves, bark, roots	Strong allelopathic inhibition of neighboring vegetation	Causes severe decline in native medicinal species diversity
10	<i>Xanthium strumarium</i> L.	Asteraceae	Sesquiterpene lactones, Phenolics	Leaves and seeds	Growth inhibition and reduced germination	Affects herbaceous medicinal plant communities

Tabel 5. Major Allelochemical Groups Released by Invasive Alien Plants [54]

Phytochemical Group	Examples	Major Biological Effects
Sesquiterpene Lactones	Parthenin, Ambrosin	Inhibit seed germination and root growth
Phenolic Acids	Ferulic acid, Caffeic acid, Chlorogenic acid	Alter nutrient uptake and suppress plant growth
Flavonoids	Quercetin derivatives, Scutellarein	Affect enzyme activity and seedling development
Alkaloids	Swainsonine, Juliflorine	Toxicity and inhibition of metabolic processes
Coumarins	Precocene I & II	Reduce germination and cellular division
Triterpenoids	Lantadenes	Inhibit establishment of neighboring species
Tannins	Hydrolysable and condensed tannins	Affect soil microbial activity and nutrient cycling

Table 6. Mechanisms Through Which Allelochemicals Affect Ethnomedicinal Plants [55]

Mechanism	Effect on Medicinal Plants
Inhibition of Seed Germination	Reduced recruitment of native medicinal species
Root Growth Suppression	Poor nutrient and water absorption
Photosynthesis Reduction	Lower biomass production
Alteration of Soil Microflora	Reduced beneficial microbial associations
Nutrient Competition	Reduced plant vigor and survival
Changes in Soil pH and Chemistry	Habitat becomes unsuitable for native medicinal flora
Reduced Seedling Establishment	Long-term decline in plant populations

Table 7. Important Ethnomedicinal Plants Potentially Affected by Allelopathic Invasive Species in Rohilkhand [56]

Medicinal Plant	Traditional Uses	Major Invasive Threats
<i>Withania somnifera</i>	Adaptogen, tonic	<i>Parthenium</i> , <i>Lantana</i>
<i>Boerhavia diffusa</i>	Kidney disorders	<i>Parthenium</i> , <i>Ageratum</i>
<i>Achyranthes aspera</i>	Wound healing	<i>Parthenium</i> , <i>Prosopis</i>
<i>Centella asiatica</i>	Memory enhancement	<i>Ageratum</i> , <i>Alternanthera</i>
<i>Eclipta prostrata</i>	Liver disorders	<i>Parthenium</i> , <i>Ageratum</i>
<i>Phyllanthus fraternus</i>	Jaundice, liver diseases	<i>Ageratum</i> , <i>Lantana</i>
<i>Bacopa monnieri</i>	Cognitive disorders	<i>Eichhornia</i> , <i>Alternanthera</i>
<i>Adhatoda vasica</i>	Respiratory ailments	<i>Lantana camara</i>

CONCLUSION

The present research indicates that invasive alien plant species have become a serious danger to the variety of ethnomedicinal plants in the Rohilkhand area of Uttar Pradesh, India. In agricultural lands, wetlands, forest margins, wastelands and other disturbed habitats, invasive species like *Parthenium hysterophorus*, *Lantana camara*, *Ageratum conyzoides*, *Eichhornia crassipes* and *Alternanthera philoxeroides* are found increasingly and these are causing significant ecological disturbances. Their rapid growth, effective spreading methods and allelopathic qualities allow them to outcompete native plants and affect ecological processes. The review indicated that invasive plants negatively influence the ethnomedicinal species by lowering seed germination, suppressing seedling establishment, altering habitat conditions and restricting the availability of vital resources including light, water, nutrients and space. Consequently, some natural species of medicinal importance are under growing pressure resulting in lower abundance and limited range. Such changes endanger not just regional biodiversity, but also traditional health care methods that are primarily dependent on plant-based medicines.

Invasive plant invasions also have substantial social repercussions in addition to ecological impacts. Loss of medicinal plant resources may constrain access to inexpensive health care, stimulate increased collecting efforts and progressively undermine indigenous knowledge systems maintained by local people and traditional healers. The decline of ethnomedicinal flora is thus a biological and cultural problem.

The findings underscore the need of developing integrated management strategies that include early identification of invasive species, habitat restoration, protection of local medicinal plants, community engagement, and long-term ecological monitoring. Equally crucial is the need to strengthen ethnobotanical documentation and promote sustainable usage techniques for the conservation of traditional knowledge and biological resources. Future study should include quantitative evaluations of the implications of invasion, allelopathic interactions, economic losses, and climate change impacts on the spread of invasive species. Protection of ethnomedicinal plant diversity is crucial for stability of ecology, conservation of biodiversity and preserving the cultural and healthcare legacy of Rohilkhand area for the future generations.

CONFLICT OF INTEREST

Authors declare for none conflict of interest.

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