International Journal of Botany Studies
www.botanyjournals.com
ISSN: 2455-541X
Received: 11-04-2026, Accepted: 12-05-2026, Published: 27-05-2026
Volume 11, Issue 2, 2026, Page No. 297-302

Loss of plant biodiversity in forest area of Jaipur, Rajasthan

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Abstract
The current survey-based study identified a total of 20 medicinal plants in Jhalana forestry area facing the danger of extinction owing to several natural and anthropogenic factors. The study identified a total of 20 species belonging to a total of 16 families, including, highest number of plants belonging to Mimosaceae (3), Bignoniaceae (2) and Apocynaceae (2) followed by Bursaraceae, Compositae (Asteraceae), Euphorbiaceae, Papilionaceae (Leguminosae), Rhamnaceae, Solanaceae, Convolvulaceae, Amaranthaceae, Meliaceae, Papaveraceae, Acanthaceae and Combretaceae (1 plant each family). The identified species of medicinal plants belonged to a total of 19 unique genera and four different habitats, including, trees (10), shrubs (4), herbs (3) and climbers (2). The identified plants have been found to possess several medicinal attributes and used to treat a number of chronic illnesses associated with various systems of the body, including, Circulatory System, Respiratory System, Digestive System, Nervous System, Musculoskeletal System, Endocrine System, Integumentary System, Reproductive System, Immune System and Urinary system. The medicinal attributes of the identified plants are because of presence of key bioactive secondary metabolites, that hold great pharmacological value. Various factors were found to be responsible for endangerment of medicinal plants in Jhalana forest area, including, overharvesting of the plant species, habitat destruction due to deforestation, habitat destruction, Illegal logging for its valuable heartwood, overgrazing, illegal trade, agricultural expansion, pollution as well as and climate change.

Keywords: Jhalana forestry area; endangered; medicinal plants; loss of plant bidioversity

Introduction

Change is the law of nature and everything that has appeared on this planet must extinct as a part of evolutionary cycle. However, rapid urbanization, industrialization and abrupt increase in anthropogenic activities over the last few decades have greatly accelerated the process of extinction at an alarmingly unnatural rate. Plants are destroyed by a number of anthropogenic activities like overgrazing, shifting cultivation, fire, consistent and perpetual exploitation of entire plants for commercial purpose, destruction of natural habitats and niches, deforestation surge, expansion of agriculture, increasing pollution etc. Talking about Rajasthan, many areas in the arid region of Rajasthan have been subjected to immense ecological changes by a number of anthropogenic activities such as industrialization, urbanization, mining, introduction of Indira Gandhi Canal expansion of agriculture land, decrease in the area of grazing land, introductive of exotic invasive weeds and trees and other developmental processes occurring in the state (Yusuf *et al.,* 2023; Rathoure *et al.,* 2020; Sharma *et al.,* 2021) [7, 8]

The global race for urbanization and industrialization has led to depletion of forest cover and increased usage of forest area for various commercial activities such as mining, construction and setting up of different industries. This rat race may have somehow led us towards the achievable goal of development but has failed the environment and associated species in their goal towards their "right to sustainability and sustenance". Habitat loss has contributed to extinction of a number of plant species, both globally as well in the Rajasthan area, especially Jaipur (Rajasekharan *et al.,* 2020; Bhargava *et al.,* 2020; Pandit., 2021) [9, 10, 11]

Considering this anarchical situation, the current study is focused on the biodiversity of medicinal plants of Jhalana Forest area. Apart from enlisting the major medicinal plants in this area, the study also sheds light on major causes of loss of plant biodiversity in Jhalana forest area while also highlighting the phytochemical composition and medicinal attributes of the identified plant species.

Materials and Methods

Jhalana forest area lies in the heart of Jaipur city of Rajasthan in the north-western part of the country. Jhalana forest area lies between latitudes 26.54'02N to 26.50'09N and longitudes 75.49'25E to 75.52'01E while covering a total area of about 20 SqKms. Jhalana forest area is demarcated by Aravali ranges running from top to bottom in the forest area. The climate in Jhalana Forest Area is characterized by presence of semi-arid conditions, with summer months (March to June) with temperature exceeding 40°C, Winters (November to February) with temperatures ranging from around 5°C (41°F) to 25°C (77°F), monsoon season (July to September) with rainfall between 500-600 nm and low humidity.

Frequent surveys were conducted to observe diversity, their loss and factors causing that loss.

Results and Discussion

The current study identified a total of 20 species of medicinal plants in the Jhalana forestry area, all of which are endangered owing to multiple factors, including overharvesting of the plant species, habitat destruction due to deforestation, habitat destruction, Illegal logging for its valuable heartwood, overgrazing, illegal trade, agricultural expansion, pollution as well as and climate change. The identified plant species include, *Abrus precatorius, Acacia catechu, Acacia nilotica, Achyranthes aspera, Withania somnifera, Adhatoda vasica, Anogeissus latifolia, Argemone mexicana, Azadirachta indica, Boswellia serrata, Rauwolfia serpentina, Euphorbia neriifolia, Ziziphus jujuba, Nerium*

oleander, Prosopis cineraria, Cuscuta reflexa, Tecomella undulata, Xanthium strumarium, Tinospora cordifolia and *Sapindus emarginatus.* The identified plants were found to belong to a total of 16 families, including, highest number of plants belonging to Mimosaceae (3), Bignoniaceae (2) and Apocynaceae (2) followed by Bursaraceae, Compositae (Asteraceae), Euphorbiaceae, Papilionaceae (Leguminosae), Rhamnaceae, Solanaceae, Convolvulaceae, Amaranthaceae, Meliaceae, Papaveraceae, Acanthaceae and Combretaceae (1 plant each family). The identified plants belonged to a total four different habitats, including, trees (10), shrubs (4), herbs (3) and climbers (2). The identified plants belonged to a total of 19 unique genera.

The current study identified various endangered plants in Jhalana forestry area with important medicinal implications. Some of these plants have been enlisted below, along with reasons for their endangerment.

1. Abrus precatorius Linn.

- **Ethnomedicinal attributes:** Seed powder is given to cattle to treat constipation
- **Reasons for Loss of Biodiversity:** Several factors such as Habitat destruction owing to urban expansion as well as agricultural practices have led to decline in plant biodiversity. Overharvesting of the plant species for commercial usage have also contributed to decline in plant numbers.
- **Family Name:** Papilionaceae
- **Habit:** Climber
- **Phytochemicals:** Abrine, Proteins, Saponins, Tannins

2. *Acacia catechu Willd.*

- **Ethnomedicinal attributes:** Wood-edible; bark-astringent, bactericide, skin infections; leaves and young shoot as fodder
- **Reasons for Loss of Biodiversity:** Several factors such as overharvesting of the plant species for its resin along with habitat destruction due to deforestation coupled with competition with agricultural land have led to decline in plant biodiversity.
- **Family Name:** Mimosaceae
- **Habit:** Tree
- **Phytochemicals:** Catechin, Tannins, Acacins, Quercetin

3. *Acacia nilotica Linn.*

- **Ethnomedicinal attributes:** Bark and leaf paste for healing wounds and cuts, fuelwood
- **Reasons for Loss of Biodiversity:** Several factors such as overexploitation of the plant for its gum, land degradation, as well as habitat loss due to agricultural expansion have contributed to decline in plant biodiversity.
- **Family Name:** Mimosaceae
- **Habit:** Tree
- **Phytochemicals:** Tannins, Flavonoids, Gum Arabic

4. *Achyranthes aspera Linn.*

- **Ethnomedicinal attributes:** Whole plant – antiparasitic, anticancer, antiinflammatory, anti-depressant.
- **Reasons for Loss of Biodiversity:** Several factors such as overexploitation of the plant for its gum, land degradation, as well as habitat loss due to agricultural expansion have contributed to decline in plant biodiversity.
- **Family Name:** Amaranthacae
- **Habit:** Herb
- **Phytochemicals:** Saponins, Alkaloids, Flavonoids, Phenolic compounds

5. *Withania somnifera* (Ashwagandha)

- **Ethnomedicinal attributes:** The plant is used in traditional medicine for adaptogenic properties as it helps in reduction of stress and enhancing stamina.
- **Reasons for Loss of Biodiversity:** Several factors such as overharvesting of the plant species, habitat destruction, as well as competition with crops have contributed to decline in plant biodiversity.
- **Family Name:** Solanaceae
- **Habit:** Shrub
- **Phytochemicals:** Withanolides, Alkaloids, Saponins

6. *Adhatoda vasica Nees*

- **Ethnomedicinal attributes:** Leaves, Flower - Bronchitis and asthma.
- **Reasons for Loss of Biodiversity:** Several factors such as Illegal logging for its valuable heartwood, deforestation, and habitat destruction have contributed to decline in plant biodiversity.
- **Family Name:** Acanthaceae
- **Habit:** Shrub
- **Phytochemicals:** Vasicine, Vasicinone, Flavonoids

7. *Anogeissus latifolia Wall*

- **Ethnomedicinal attributes:** Bark - antifungal, antibacterial, anti-inflammatory; wood as timber and fuel; leaves and young shoot as fodder.
- **Reasons for Loss of Biodiversity:** Several factors such as Overharvesting of the plant species, habitat destruction, and overgrazing have contributed to decline in plant biodiversity.
- **Family Name:** Combretaceae
- **Habit:** Tree
- **Phytochemicals:** Tannins, Flavonoids, Saponins

8. *Argemone mexicana Linn.*

- **Ethnomedicinal attributes:** Whole plant - antimicrobial, antidiabetic, antioxidant
- **Reasons for Loss of Biodiversity:** Several factors such as Habitat loss due to deforestation and overharvesting of seeds for biodiesel production have contributed to decline in plant biodiversity.
- **Family Name:** Papaveraceae
- **Habit:** Herb
- **Phytochemicals:** Alkaloids, Saponins, Flavonoids

9. *Azardirachta indica L.*

- **Ethnomedicinal attributes:** Fruits – Edible; leaf, flower, bark, stem – antioxidant, antifungal, antidiabetic, antibacterial, blood purification
- **Reasons for Loss of Biodiversity:** Several factors such as Habitat destruction due to agricultural expansion and climate change have contributed to decline in plant biodiversity.
- **Family Name:** Meliaceae
- **Habit:** Tree
- **Phytochemicals:** Azadirachtin, Nimbin, Flavonoids

10. ***Boswellia serrata Roxb.***
- **Ethnomedicinal attributes:** Bark, stem, leaves, flowers – anti-arthritic, used in cold and fever, anti-inflammatory, antifungal
- **Reasons for Loss of Biodiversity:** Several factors such as Habitat destruction, overgrazing, and competition with agricultural crops have contributed to decline in plant biodiversity.
- **Family Name:** Bursaraceae
- **Habit:** Tree
- **Phytochemicals:** Boswellic acids, Essential oils

11. ***Rauwolfia serpentina*** **(Indian Snakeroot)**
- **Ethnomedicinal attributes:** Used in traditional medicine for treating hypertension and mental health disorders.
- **Reasons for Loss of Biodiversity:** Several factors such as Overharvesting of the plant species and habitat destruction due to agricultural activities and urbanization have contributed to decline in plant biodiversity.
- **Family Name:** Apocynaceae
- **Habit:** Shrub
- **Phytochemicals:** Reserpine, Ajmaline, Sarpagine

12. ***Euphorbia neriifolia*** **(Saru)**
- **Ethnomedicinal attributes:** Used in traditional medicine for its antiseptic and wound-healing properties.
- **Reasons for Loss of Biodiversity:** Several factors such as Overgrazing by livestock, habitat destruction, and illegal trade have contributed to decline in plant biodiversity.
- **Family Name:** Euphorbiaceae
- **Habit:** Shrub
- **Phytochemicals:** Euphol, Euphorbin, Saponins

13. ***Ziziphus jujuba*** **(Indian Jujube)**
- **Ethnomedicinal attributes:** Used in traditional medicine for its anti-inflammatory and anti-oxidant properties. It also aids in digestion and boosts immunity.
- **Reasons for Loss of Biodiversity:** Several factors such as Habitat degradation, deforestation, and overgrazing have contributed to decline in plant biodiversity.
- **Family Name:** Rhamnaceae
- **Habit:** Tree
- **Phytochemicals:** Saponins, Flavonoids, Triterpenoids

14. ***Nerium oleander*** **(Oleander)**
- **Ethnomedicinal attributes:** Used in traditional medicine for its anti-cancer properties, though it is highly toxic and should be used with caution.
- **Reasons for Loss of Biodiversity:** Several factors such as Overharvesting of the plant species and habitat loss due to land conversion and urban expansion have contributed to decline in plant biodiversity.
- **Family Name:** Apocynaceae
- **Habit:** Tree
- **Phytochemicals:** Oleandrin, Neriifolin, Cardenolides

15. ***Prosopis cineraria Linn.***
- **Ethnomedicinal attributes:** Leaves, seed, fruits are used as vegetable; flowers, bark, leaves – antidiabetic, anti-bacterial, used in treatment of bronchitis, asthma, dysentery.
- **Reasons for Loss of Biodiversity:** Several factors such as Deforestation and overharvesting of medicinal parts have contributed to decline in plant biodiversity.
- **Family Name:** Mimosaceae
- **Habit:** Tree
- **Phytochemicals:** Tannins, Flavonoids, Saponins

16. ***Cuscuta reflexa Roxb.***
- **Ethnomedicinal attributes:** Whole plants for treatment of urinary disorders, cough, muscle pain and as blood purifier
- **Reasons for Loss of Biodiversity:** Several factors such as Habitat loss due to agricultural expansion and urbanization have contributed to decline in plant biodiversity.
- **Family Name:** Convolulaceae
- **Habit:** Climber
- **Phytochemicals:** Flavonoids, Alkaloids

17. ***Tecomella undulata*** **G. DON**
- **Ethnomedicinal attributes:** Roots used in treatment of Leucorrhoea in females and bark to cure to cure eczema and eruptions.
- **Reasons for Loss of Biodiversity:** Several factors such as Overharvesting of the plant species, habitat destruction, and changing land use have contributed to decline in plant biodiversity.
- **Family Name:** Bignoniaceae
- **Habit:** Tree
- **Phytochemicals:** Tecomine, Tannins

18. ***Xanthium strumarium*** **Linn.**
- **Ethnomedicinal attributes:** Leaves and roots used as anodyne, antirheumatic, appetizer, diuretic
- **Reasons for Loss of Biodiversity:** Several factors such as Agricultural expansion and overharvesting have contributed to decline in plant biodiversity.
- **Family Name:** Compositae
- **Habit:** Herb
- **Phytochemicals:** Xanthium, Flavonoids

19. ***Tinospora cordifolia Thunb***
- **Ethnomedicinal attributes:** Stem used for diabetes, rhinitis and to boost immune system
- **Reasons for Loss of Biodiversity:** Several factors such as Habitat destruction and competition with agricultural crops have contributed to decline in plant biodiversity.
- **Family Name:** Bignoniaceae
- **Habit:** Tree
- **Phytochemicals:** Tinospora alkaloids, Triterpenoids

20. ***Sapindus emarginatus Vahl***
- **Ethnomedicinal attributes:** Fruits used in treatment of asthma, dysentery and during childbirt
- **Reasons for Loss of Biodiversity:** Several factors such as Habitat destruction due to agricultural practices and urbanization have contributed to decline in plant biodiversity.
- **Family Name:** Sapindaceae
- **Habit:** Tree
- **Phytochemicals:** Saponins, Flavonoids

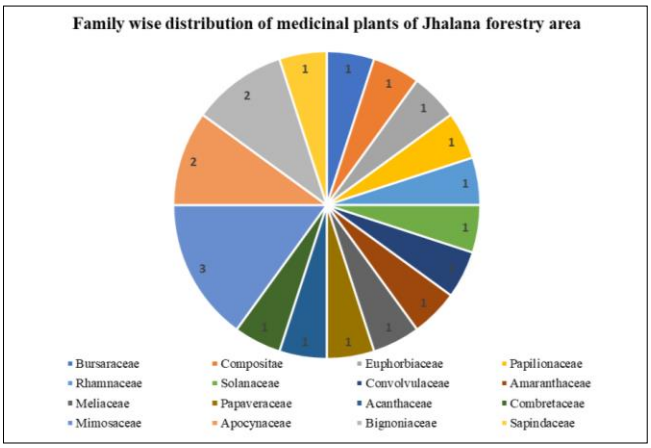

Fig 1: Family wise distribution of medicinal plants of Jhalana forestry area

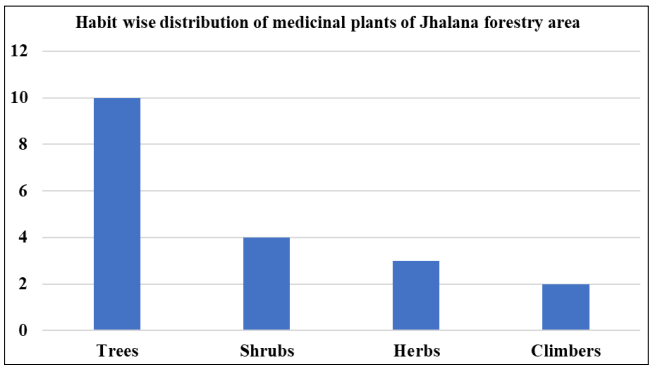

Fig 2: Habit wise distribution of medicinal plants of Jhalana forestry area

Discussion

Ever since immemorial times, we have co-existed on this earth with a myriad of other species, some of which have contributed to human existence and survival while others such as disease-causing pathogens have antagonized human existence by instigating deadly infections and inflammatory outbursts. However, invention of antimicrobial compounds was a big step towards alleviating these infections and ameliorating the prevalent disastrous condition. Nonetheless, development of antimicrobial resistance has been a cause for concern for the scientific community owing to increased mortality and increased hospitalization stay. This anarchical situation demands for supplementation of current pharmaceutical regimen with natural antimicrobials to overcome the problem of antibiotic resistance. In addition to this, another drawback of the prevalent antimicrobials is their nefarious side effects on human health. Therefore, implementing the usage of natural antimicrobials seems to be a one-stop solution to all these problems.

Our mother nature has bestowed us with invaluable resources in the form of "Plants", that not only supply the much-needed oxygen and nutrients which sustain the life on earth, but are also an "Emporium of medicinal biocompounds" which help us develop a healthy life and safeguard ourselves from different chronic ailments that inflict torment on the human race. It is a misfortune that in spite of India, being a land of Ayurveda and Unani medicine, we took so long to acknowledge this "powerhouse of nutrients and medicinal compounds". However, studies over the last few decades have acknowledged the medicinal properties of different plants and extracts derived from different plant parts and highlighted their ameliorative role in alleviation of chronic human ailments. The antimicrobial activity of the plants and their extracts can be attributed to the presence of the following secondary metabolites (Twaji *et al.,* 2022; Pang *et al.,* 2021., Elshafie *et al.,* 2023) [18, 19]

- **Quercetin:** High antiplaque property which inhibits growth of bacterial species
- **Tannins:** Iron and nutrient deprivation leading to arrest of bacterial growth; Phosphorylation, enzyme, and protein synthesis inhibition in bacterial species
- **Flavonoids:** Bacterial cell wall disruption leading to killing of bacteria; Inactivation of microbial adhesion and protein transport
- **Terpenoids:** Disruption of lipophilic compounds in bacterial membrane thus killing the bacterial species
- **Saponins:** Surface tension reduction leading to increase cell wall permeability and leakage, thus leading to bacterial killing
- **Phenolic Compounds:** Bacterial membrane disruption and biofilm and virulence inhibition.
- **Alkaloids:** Inhibition of efflux pumps thus contributing to increased bacterial susceptibility to drug candidates (Yang *et al.,* 2020; Maugeri *et al.,* 2022; Moharram *et al.,* 2021., Kamran *et al.,* 2022., Juang *et al.,* 2020) [12, 13, 14, 15, 16]

However, the last few decades have been marked by gradual loss of plant biodiversity, leading to a continuous steep decline in number of medicinal plants. Overexploitation as well as overharvesting of plant species coupled with overgrazing by wild as well as domesticated animals at a rate much faster than the rate at which species can recover and refurbish leads to decline in plant biodiversity. Other factors that have been associated with decline in plant biodiversity include increasing soil erosion and deforestation, introduction of invasive species and global climate change. Introduction of exotic invasive species retards the growth and development of native plants in a number of ways such as,

- Targeting native species with lower reproductive potential and increased susceptibility to predators
- Competition for absorption of water and nutrients from the soil
- Interaction with the resident soil microbes and dismantling plant microbial interaction of native species, thereby hampering plant development and growth
- Emergence of newly introduced diseased conditions, which affect the growth and development of native plants (Singh *et al.,* 2021; Cafaro *et al.,* 2022; Mir *et al.,* 2021; Dadhich *et al.,* 2022) [20, 21, 22, 23]

For instance, a small herb, named, *Seetzinia lantata (Willd.)* Bullock, belonging to family Zygophyllaceae and known for its efficient medicinal properties due to presence of alkaloids and saponins is at the verge of extinction due to invasion of its habitat by *Prosopis juliflora* and *Acacia tortilis*, overgrazing as well as habitat destruction by local people for mining of calcareous canker.

In a paper by Jeph *et al.,* (2014), the researchers performed an extensive survey of Beed Jhunjhunu area of Rajasthan and found that out of a total of 325 species of flowering plants including one gymnosperm, 38 were declared to be rare, endemic and threatened by IUCN. The researchers

attributed endangerment of these plant species to the following factors:

- Overgrazing
- Habitat fragmentation
- Illegal harvesting
- Over exploitation of economically important plants
- Smuggling of plant's and encroachment by nearby local community
- Pollution due to sewage and dumping of solid waste
- Alien species invasion
- Deforestation
- Unplanned developmental activities

The last decade has been marked by rapid urbanization and industrialization in Jaipur owing to a boom in the industrial sector. Jaipur houses a total of 19,592 large, medium and small-scale industries at present. Such huge number of industries discharge a lot of industrial waste, which after being subjected to both primary and secondary treatment within the industries is discharge into the water bodies. Farmers in the city use certain areas of Amanishah Nala for cultivation of food crops as well certain vegetables, therefore, the quality of water in Amanishah Nala may have a huge bearing on the quality of the cultivated crops, fruits as well as vegetables. Studies over the last few decades have shown deterioration of the water quality of Amanishah Nala as observed from increasing concentration of heavy metals such as Cu, Cd and Cr. Usage of heavy metal contaminated water for irrigation may expose the cultivated crops and plants to the disastrous effects of these obnoxious agents thus jeopardizing their overall health and well-being (Rai *et al.,* 2019; Kumawat *et al.,* 2014; Jhamaria *et al.,* 2015) [2, 4]

Textile Dye industry generates a huge amount of hazardous waste products in the form of dyes, plastics and fibres, all of which have been associated with deterioration of the environment. The effect of textile dyes on different components of the ecosystem includes, decreased growth and photosynthetic efficiency of plants, damage to the plant root system, hampering the absorption of water and nutrients from the soil as well as Induction of oxidative burst mediated damage in the plant cells. Furthermore, presence of textile dyes affects the physicochemical attributes of water such as pH, COD and BOD of water, thereby affecting the dissolved oxygen content of water and causing oxygen depletion and anaerobic growth (Bishnoi *et al.,* 2016).

Biodiversity plays a crucial role in maintaining various ecological functions that lead to perpetual sustenance of life on earth such as pollination as well as cross-fertilization of crops and other vegetation, providing protection against natural calamities and soil erosion, replenishment of fertility of soil, stabilization and maintenance of water cycle as well as sustainable stability of other existing ecosystems on earth. Considering all these parameters, it is very important to conserve biodiversity for the maintenance of ecological diversity as well as perpetual continuity of the existing food chains.

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