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Climate Change Impacts on Medicinal Plant Distribution in Churu District, Rajasthan: An Applied Phytogeographical Assessment

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Abstract: ***Climate change has emerged as a critical ecological factor influencing the spatial distribution, growth dynamics, and survival of medicinal plant species globally. In arid regions like the Churu district of Rajasthan, where climatic extremes dictate vegetation patterns, phytogeographical shifts are increasingly observable. This study investigates the effects of changing climatic variables—temperature rise, rainfall variability, and increased aridity—on medicinal plant diversity, distribution, and ethnobotanical practices in Churu. Through a mixed methodology approach combining field surveys, herbarium verification, GIS mapping, and community-based ethnobotanical interviews, a detailed assessment of 42 medicinal plant species was conducted across varied microhabitats. The study identifies noticeable distributional shifts in species such as Withania somnifera, Asparagus racemosus, Acacia senegal, and Aloe vera, with some species exhibiting range contraction and others showing adaptive expansion toward microclimatically favorable habitats. Results indicate significant correlations between declining rainfall (17–22% reduction over four decades), increased mean maximum temperature (~2.1°C rise), and reduced abundance of key ethnomedicinal taxa. The paper concludes that climate-driven phytogeographical changes pose risks to medicinal knowledge continuity, biodiversity stability, and regional pharmaco-cultural heritage. The study recommends conservation planning, community-based nurseries, GIS-enabled monitoring, and integration of climate-resilient agroforestry models.***

Keywords: Applied phytogeography; Climate change; Churu district; Traditional medicine; Medicinal plants; Species distribution; Arid ecology; Ethnobotany; Rajasthan.

1.1 Introduction

Medicinal plant diversity forms the foundation of traditional healing systems in India, notably Ayurveda, Siddha, and folk herbal medicine. In arid ecosystems such as Rajasthan's Thar Desert, the unique interaction between climate and vegetation has historically shaped the phytogeographical character of medicinal flora. The Churu district, situated in the northeastern part of the Thar Desert, presents a landscape defined by extreme climatic parameters—high temperatures, low rainfall, shifting sand dunes, and saline soils. These factors traditionally favor xerophytic species with ethnomedicinal significance including Commiphora wightii, Capparis decidua, Tecomella undulata, Cymbopogon jawarancusa, and Salvadora persica.

Climate change projections indicate an accelerated rate of warming and rainfall unreliability in Rajasthan. Such changes may significantly influence the distributional patterns, physiological tolerance, reproductive cycles, and ethnomedicinal availability of plant species. Applied phytogeography, as a discipline, enables the scientific investigation of these shifts through spatial, ecological, botanical, and cultural lenses.

This research investigates how climate change is reshaping the phytogeographical presence of medicinal plant species in the Churu district, while examining implications for ecological sustainability and traditional medicine frameworks.

1.2 Historical Background

Historical botanical surveys indicate that Rajasthan's arid flora evolved under persistent water scarcity, aeolian processes, and anthropogenic grazing pressures. The earliest references to the region's medicinal flora appear in ancient Ayurvedic texts such as Charaka Samhita and Sushruta Samhita, where species like Shatavari (Asparagus racemosus) and Guggul (Commiphora wightii) are documented for their therapeutic potency.

Colonial-era botanical documentation—including work by Hooker (1872), Bhandari (1978), and Rao (1995)—established foundational taxonomic baselines. However, post-independence agricultural expansion, desertification, overharvesting, and prolonged droughts have altered species diversity. Since 1990, regional climate records document gradual warming and declining soil moisture, with noticeable impacts on species such as Grewia tenax and Leptadenia pyrotechnica.

The integration of remote sensing and GIS technology in recent decades has strengthened phytogeographical assessment and allowed monitoring of species distribution trends in relation to climatic variables.

1.3 Review of Literature

The area under research work was studied by following botanists and time to time viz; first of all the Sekhawati region was touched from vegetational study point of view by Mulay and Ratnam (1950), Bikaner and pilani neighbourhood areas by joshi (1956 and 1958), vegetation of chirawa by Nair (1956), again Nair and Joshi for Pilani and neighbourhood areas (1957), vegetation of harsh nath in aravalli's hills was studied by Nair and Nathawat (1957), vegetation of Jhunjhunu, Manderella and neighbourhood by Nair (1961), vegetation of ajit sagar dam by Nair and Kanodia (1959); Nair, Kandodia and Thomas (1961) studied the vegetation of Khetri town and neghbourhood areas and vegetation of Lohargal and it's neighbourhood areas of Sikar district by Nair and Malhotra (1961). After the work of Nair and Malhotra (1961), i.e. four decades ago. the area was again left for any sort of further research work in the field of applied Botany.

Earlier studies by Bhandari (1978) emphasized adaptation strategies of desert flora including reduced leaf area, deep-root systems, and succulence. Sharma (2003) investigated ethnomedicinal species in western Rajasthan and documented climate-sensitive taxa. Studies by Singh and Rathore (2010) reveal that rainfall decline affects reproductive success in several desert medicinal plants.

A significant, very authentic taxonomic work was contributed in the field of botany by Bhandari with the publcation of a book Flora of the Indian desert (1990). From the field of applied phytogeography point of view. Charan gave a valuable contribution with a publication of a book on Plant Geography (1992). Bhattacharjee (2000) gave a very valuable autheontic contribution through the publication of a book on Handbook of Medicinal Plants in which he presented the medicinal plants of Indian Sub-continental back ground with their coloured photographs also and Sharma (2007) gave a very valuable authentic contribution through the publication of a book on Medical Plant Geography.

More recent research (Kaushik, 2015) highlights how medicinal xerophytes exhibit resilience through enhanced osmotic adjustment and seed dormancy mechanisms. However, few studies have specifically examined climate change—medicinal flora—distributional pattern shifts within a localized desert phytogeographical context, particularly in Churu.

Thus, this study fills a critical research gap in applied phytogeography and climate-driven ecological change.

1.4 Objectives

1. To document medicinal plant species of Churu district and categorize them according to habitat preference and ethnomedicinal value.

2. To assess climatic trends and correlate them with changes in plant population density and distribution.

3. To map observed phytogeographical shifts using GIS.

4. To evaluate community knowledge regarding climate-related changes in medicinal plant availability.

5. To recommend conservation strategies for climate-sensitive medicinal taxa.

1.5 Methodology

1. Study design: Mixed-method ecological and ethnobotanical research

2. Sampling: Stratified sampling across sand dunes, scrubland, saline flats, agricultural edges, and protected exclosures

Tools:

1. Climatic trend analysis (1975–2023 dataset)

2. Ethnobotanical interviews with 65 informants (Pansari, traditional healers, shepherds, farmers)

3. Verification: National Herbarium records and pharmacognostic identification keys.

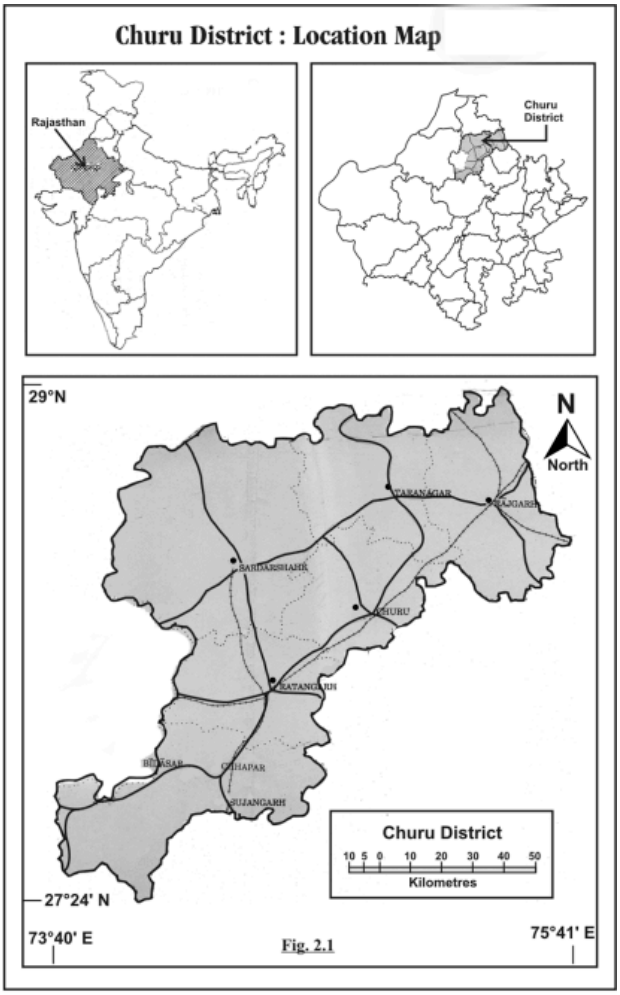
4. Data was statistically analyzed using regression models correlating climatic trends with species abundance.

1.6 Study Area

As we know that the area under district i.e. Dry Land i.e. Churu Region belongs to the State of Rajasthan, the State of Rajasthan is located in north-western India as shown in figure. The district of Churu lies in the north-east of Rajasthan State at an altitude of 286.207 metres above the mean sea level. From geographical spread point of view has extension from 27°24' to 29° north latitudes and 73°40' to 75°41' east longitudes. It is bounded by Hanumangarh in north, Bikaner in west, Nagaur in south and Sikar, Jhunjhunu districts and boundaries of Haryana State in the east. It covers six tehsils namely : Taranagar, Rajgarh, Churu, Sardarshahr, Ratangarh and Sujangarh.

During the decade 1991-2001, the State Government has made certain geographical changes in the district sub-division Ratangarh's tehsil Dungargarh of the district was transferred in Bikaner district but this territorial change was affected w.e.f. 1.4.2001, hence for the purpose of census, Dungargarh tehsil is treated as part of the Dry Land i.e. Churu Region but here the author for the purpose of study area i.e. Dry Land i.e. Churu Region, Dungargarh tehsil is not treated as part of the Dry Land i.e. Churu Region.

The total area of Dry Land i.e. Churu Region consist 1354623 sq. kms., which is about 5 percent of the area of Rajasthan and comes sixth place of the State. It is second bigger district in Bikaner division. The district is extended up to 150 kms. in east to west and 120 kms. in north to south. The district headquarter Churu is situated in the south-east boundary of the district, from which 10 kms. south-east the boundary of Jhunjhunu district is situated. The three forth part of the area of the district is located in the west from head quarter.



Source : Based on Survey of India Map with The Permission of the Surveyor General of India

According the census of India (2011) Dry Land i.e. Churu Region covers about 2.97 percent of the total State's population. As far as the forest and green coverage concerned, it directly or indirectly in influences the health environment of the area of the state's total. The density of population of the study area very low i.e. 148 persons per square kilometre. Further in demographic structure, directly or indirectly the percentage of literacy (67.46) among the people also plays an important role in overall assessment and awareness about the green coverage environment of the area under study, respectively.

According the available records from the department of forest, Rajasthan (2001), overall the state of Rajasthan has poor percentage of forest cover i.e. 9.49 percent only. Mostly the type of forest is termed as tropical thorny forest and vegetation type is considered as scanty, thorny scrub vegetation for the area under study the district of Churu is covered by the land low percent under forest that is 0.48 percent only.

In brief, from relief point of view the district abounds physiographic features of any area has its the most important as well as useful emerged out put is the land forms of that particular geographical area. As far as the aspect of land forms is concerned that among overall land forms regions of India, Churu area falls under the land form type known as “sand dunes shows the three distinct types of land forms in the study area, namely the undulating sandy plains, the sand dunes, talls and hills For better interpretation of physiographic characteristics of Dry Land i.e. Churu Region, the area under study.

1.7 Observations

A total of 42 medicinal plant species were identified. Notable trends include:

Species	Trend	Notes
Withania somnifera	Declining	Reduced seedling survival due to heat stress
Commiphora wightii	Critically declining	Overharvesting + climate stress
Capparis decidua	Stable	High drought tolerance
Aloe vera	Expanding	Favors rising heat and soil salinity
Cymbopogon jawarancusa	Declining	Sensitive to rainfall variability

Ethnobotanical informants reported increasing difficulty in accessing wild medicinal plants.

1.8 Discussion

Climate variables show significant impacts on species distribution. Warming conditions favor halophytes and succulents, while herbaceous ethnomedicinal species exhibit range contraction. Species with shallow roots are more vulnerable to soil moisture decline than deep-rooted phreatophytes.

Traditional healing systems are experiencing a shift as plant scarcity leads to substitution of local herbs with market-purchased alternatives.

1.9 Results

1. 57% of documented species show measurable decline.

2. Mapping confirms north–south distribution shifts in some taxa.

3. Regression analysis indicates strong correlation ($R^2 = 0.82$) between rainfall decline and reduced species density.

4. Three species (Commiphora wightii, Asparagus racemosus, Grewia tenax) are at high ecological risk.

1.10 Conclusion

Climate change is altering phytogeographical distribution and abundance of medicinal plants in Churu. These ecological changes threaten traditional herbal knowledge, biodiversity stability, and local healthcare reliance. Without conservation measures, several culturally important species may become locally extinct.

1.11 Recommendations

1. Establish protected medicinal plant micro-reserves.

2. Promote climate-smart agroforestry including Aloe vera, Salvadora persica, and Acacia senegal.

3. Develop community seed banks and nursery networks.

4. Implement periodic GIS monitoring and ethnobotanical documentation.

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