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Floristic Composition, Ethnobotanical Significance, and Ecological Gradients in Semi-Arid and Mediterranean Landscapes: A Comparative Synthesis from North Gujarat and Al-Jabal Al-Akhdar

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Abstract

Floristic diversity forms the ecological foundation of terrestrial ecosystems, particularly in transitional and climatically sensitive regions such as semi-arid western India and the Mediterranean mountain systems of North Africa. These landscapes, although geographically distant, share remarkable ecological parallels in terms of rainfall variability, soil heterogeneity, human pressure, and adaptive plant strategies. The present research integrates floristic, ethnobotanical, and ecological evidence from North Gujarat in India and the Al-Jabal Al-Akhdar region of Libya to develop a unified understanding of plant diversity patterns, ecosystem functionality, and human–vegetation relationships. Drawing strictly from established botanical surveys, floristic inventories, and ecological analyses, this study synthesizes data from forested tracts, agro-ecological zones, mountain wadis, university plantations, and protected landscapes.

The Gujarat studies demonstrate that floristic diversity is not merely a function of climatic variables but is deeply embedded in cultural land-use practices, economic dependence on tree species, and ethnobotanical knowledge systems. Forest fragments in Satlasana and Patan districts reveal a complex stratification of trees, shrubs, herbs, and climbers whose distribution reflects both natural gradients and anthropogenic pressures (Patel and Bihola, 2015; Rathod and Patel, 2011). These floristic structures are closely linked with medicinal, nutritional, and economic uses of plant species as elaborated by Seth (2003) and Prajapati and Purohit (2003), where vegetation is not a passive background but an active socio-economic asset.

Similarly, the Al-Jabal Al-Akhdar region of Libya presents a Mediterranean montane ecosystem characterized by high endemism, altitudinal zonation, and pronounced microhabitat differentiation. Floristic and ecological investigations in wadis, coastal slopes, and uplands indicate that plant diversity responds strongly to elevation, soil texture, and moisture retention capacity (Al-Hamedi, 1999; Alaib et al., 2017; Abd El-Ghani and Al Borki, 2024). Human disturbances such as charcoal production, grazing, and land conversion significantly alter species composition and ecological stability (Elshatshat and Mansour, 2014). Despite these pressures, these ecosystems retain high biological value due to their adaptive plant strategies, particularly life-form spectra and functional traits described under Raunkiaer's system and Whittaker's community ecology framework (Raunkiaer, 1934; Whitaker, 1975).

By combining floristic diversity data, ethnobotanical insights, and ecological gradient analysis, this research demonstrates that both Gujarat and Al-Jabal Al-Akhdar exhibit structurally resilient but functionally vulnerable vegetation systems. Their sustainability depends on the conservation of species richness, maintenance of habitat heterogeneity, and protection of indigenous ecological knowledge. This article therefore contributes a comparative ecological synthesis that strengthens the theoretical and applied understanding of biodiversity management in climatically stressed regions.

Keywords: Floristic diversity, ethnobotany, Mediterranean ecosystems, semi-arid forests, plant ecology, species richness, vegetation gradients

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1. Introduction

Plant diversity is one of the most fundamental components of ecological systems, shaping not only the structure and function of habitats but also the livelihoods, cultures, and economic stability of human societies. Across the world, regions characterized by semi-arid climates and Mediterranean environmental conditions are among the most ecologically sensitive, as they experience strong seasonal variability, irregular precipitation, and intense anthropogenic pressure. Within such landscapes, floristic diversity serves as both a biological archive of evolutionary adaptation and a living resource for local populations.

In North Gujarat, India, the forested and agro-ecological zones of districts such as Mehsana and Patan represent an interface between arid and semi-humid ecosystems. These regions host a mixture of dry deciduous forests, scrublands, cultivated lands, and village commons, all of which contribute to a complex mosaic of plant communities. Detailed floristic studies in the Satlasana forest area have shown that even relatively small forest patches can harbor substantial botanical richness, with species representing multiple growth forms, ecological strategies, and economic values (Patel and Bihola, 2015). Similarly, Patan district contains a wide array of economically important tree species that play critical roles in agriculture, medicine, fuelwood supply, and cultural practices (Rathod and Patel, 2011).

In parallel, the Al-Jabal Al-Akhdar region of northeastern Libya constitutes one of the most biologically diverse mountain systems in North Africa. Known for its Mediterranean climate, limestone plateaus, deep wadis, and coastal escarpments, this region supports a rich flora that has been documented extensively through floristic surveys and ecological studies (Ali and Jafri, 1976; El-Gadi, 1988). The vegetation of this region reflects a strong altitudinal gradient, where lower slopes are dominated by xerophytic shrubs and grasses, while higher elevations support woodland and mesic plant communities (Hegazy et al., 2011; Abd El-Ghani and Al Borki, 2024).

Despite their geographic separation, North Gujarat and Al-Jabal Al-Akhdar share important ecological similarities. Both regions are exposed to water stress, soil heterogeneity, and human exploitation of plant resources. In both cases, vegetation is not only a product of natural processes but also of centuries of human interaction, ranging from grazing and farming to medicinal plant harvesting and urban expansion. The ecological consequences of such interactions have been increasingly documented, particularly in relation to species loss, habitat fragmentation, and changes in community composition (Elshatshat and Mansour, 2014).

A major gap in existing literature, however, lies in the lack of integrative frameworks that link floristic composition with ethnobotanical use and ecological gradients across different regions. While studies from Gujarat focus strongly on economic and medicinal plant values (Seth, 2003; Prajapati and Purohit, 2003), and Libyan studies emphasize ecological and floristic inventories (Al-Hamedi, 1999; Alaib et al., 2017), few attempts have been made to bring these perspectives together. Understanding plant diversity only in taxonomic terms risks ignoring the social and functional dimensions of vegetation, while purely ethnobotanical approaches may overlook the ecological processes that sustain plant populations.

Therefore, this research aims to synthesize floristic, ethnobotanical, and ecological evidence from both North Gujarat and Al-Jabal Al-Akhdar to develop a holistic understanding of how plant diversity is structured, utilized, and threatened in semi-arid and Mediterranean landscapes. By drawing on multiple botanical traditions and ecological theories, this study seeks to reveal the deep interconnections between species richness, habitat gradients, and human dependency on plant resources.

2. Methodology

The methodological framework of this research is based entirely on a comprehensive synthesis and interpretative analysis of published floristic, ecological, and ethnobotanical studies conducted in North Gujarat, India, and the Al-Jabal Al-Akhdar region of Libya. Rather than generating new field data, this study adopts a comparative ecological review approach, integrating botanical inventories, vegetation analyses, and theoretical frameworks provided by the referenced literature.

In the case of North Gujarat, floristic and biodiversity data were drawn primarily from the Satlasana forest survey and the Patan district tree biodiversity assessment. The Satlasana study by Patel and Bihola (2015) provides detailed accounts of plant species distribution, abundance, and growth forms within a defined forested area. These data include information on tree, shrub, herb, and climber species, enabling a structural and functional interpretation of forest vegetation. Similarly, Rathod and Patel (2011) offer a focused inventory of economically important tree species in Patan district, which serves as a basis for evaluating how human economic priorities influence species selection, conservation, and propagation.

To contextualize these floristic records within a broader ecological and ethnobotanical framework, the theoretical and applied works of Seth (2003) and Prajapati and Purohit (2003) were used. Seth's work on the economic importance of trees provides a functional classification of species according to their uses in timber, food, medicine, and industry, while Prajapati and Purohit's handbook on medicinal plants offers insight into traditional and modern uses of plant resources in India.

For the Libyan Mediterranean region, the methodological foundation rests on classical and contemporary floristic surveys and ecological analyses. Al-Hamedi's (1999) master's thesis and the later field investigation by Alaib et al. (2017) provide detailed vegetation and floristic data for Wadi Al-Agar, including species composition, habitat types, and ecological conditions. These studies were complemented by the authoritative Flora of Libya series by Ali and Jafri (1976) and El-Gadi (1988), which collectively establish the taxonomic baseline for the region's plant diversity.

Ecological interpretation of vegetation patterns across Al-Jabal Al-Akhdar was further informed by gradient and habitat analyses conducted by Hegazy et al. (2011), Abd El-Ghani and Al Borki (2024), and Dakeel et al. (2024). These studies utilize species richness, importance value indices, and environmental variables such as elevation and soil properties to explain spatial variation in plant communities. The theoretical frameworks of Whittaker (1975) and Raunkiaer (1934) were employed to interpret these patterns in terms of community structure and life-form strategies.

Finally, to incorporate the human dimension of vegetation change, the findings of Elshatshat and Mansour (2014) regarding land abuse, grazing, and charcoal burning were integrated into the analysis. This allowed the study to assess not only natural ecological gradients but also anthropogenic drivers of floristic change.

Through this integrative methodology, the study systematically compares two geographically distinct yet ecologically analogous regions, enabling a nuanced interpretation of how plant diversity emerges, persists, and declines under combined environmental and human influences.

3. Results

The synthesis of floristic and ecological data from North Gujarat and Al-Jabal Al-Akhdar reveals strikingly parallel patterns in vegetation structure, species richness, and functional diversity, despite their differing biogeographical histories.

In the Satlasana forest area of Mehsana district, the floristic inventory documented by Patel and Bihola (2015) indicates a highly heterogeneous plant community. Trees form the dominant structural layer, providing canopy cover and microclimatic regulation, while shrubs and herbs occupy the understory and ground layers. Climbers and lianas contribute to vertical complexity, allowing the forest to maximize light capture and spatial utilization. This multi-layered vegetation structure is typical of dry deciduous and semi-arid forests, where water limitation necessitates efficient resource use.

The Patan district survey by Rathod and Patel (2011) highlights the prominence of economically important tree species such as those used for timber, fruit, fodder, and medicine. These species are not randomly distributed but are often concentrated in areas of human settlement, agricultural boundaries, and community lands. This

pattern suggests that human management has a significant influence on floristic composition, favoring species that provide direct benefits while potentially reducing the abundance of less economically valuable taxa.

Ethnobotanical data from Prajapati and Purohit (2003) further demonstrate that a large proportion of the region's flora has recognized medicinal value. Many plant species are used in traditional treatments for digestive disorders, skin diseases, respiratory ailments, and general health maintenance. This widespread medicinal use implies that local communities maintain detailed knowledge of plant properties, which in turn affects how vegetation is harvested, conserved, or cultivated.

In Al-Jabal Al-Akhdar, floristic richness is similarly high, but its spatial distribution is strongly governed by environmental gradients. Studies from Wadi Al-Agar show that species composition changes markedly from valley bottoms to surrounding slopes and plateaus (Al-Hamedi, 1999; Alaib et al., 2017). Moisture-loving herbs and shrubs dominate the wadi floors, where water accumulates and soils are deeper, while drought-tolerant shrubs and perennial grasses prevail on rocky slopes.

Altitudinal gradients further structure vegetation patterns across the region. Hegazy et al. (2011) reported that species richness increases with elevation up to a certain point, reflecting improved moisture availability and reduced temperature stress, before declining at higher altitudes where conditions become harsher. Abd El-Ghani and Al Borki (2024) confirmed that soil texture, organic matter content, and nutrient availability are key determinants of plant distribution, with fertile soils supporting more diverse communities.

The Importance Value Index analysis conducted by Dakeel et al. (2024) in the Cyrene Campus area demonstrates that a small number of dominant species often account for a large proportion of vegetation cover and biomass, while numerous subordinate species contribute to overall diversity. This pattern is consistent with Whittaker's (1975) model of plant communities, where dominance and diversity coexist in dynamic balance.

Human activities have a measurable impact on these floristic patterns. Elshatshat and Mansour (2014) documented that overgrazing and charcoal production reduce plant cover, simplify community structure, and favor disturbance-tolerant species at the expense of more sensitive taxa. Similar processes are observed in North Gujarat, where land conversion and intensive resource use alter species composition and reduce habitat heterogeneity.

Together, these results indicate that both regions support rich and functionally complex vegetation systems, but their long-term stability is threatened by environmental stress and human exploitation.

4. Discussion

The comparative analysis of floristic diversity in North Gujarat and Al-Jabal Al-Akhdar underscores the universality of certain ecological principles while also revealing region-specific expressions of plant–environment and plant–human interactions. One of the most significant insights emerging from this synthesis is that species richness alone does not fully capture the ecological or socio-economic value of vegetation. Instead, it is the combination of taxonomic diversity, functional traits, and cultural utility that defines the true significance of plant communities.

In North Gujarat, the strong representation of economically and medicinally important species suggests that human selection has historically shaped vegetation patterns (Rathod and Patel, 2011; Prajapati and Purohit, 2003). While this has ensured the survival of many useful species, it also creates a bias toward certain taxa, potentially reducing overall ecological resilience. From an ecological perspective, diverse communities with a wide range of functional traits are better able to withstand disturbances such as drought, pests, and climate variability (Whitaker, 1975). Therefore, the selective promotion of a limited number of useful species may increase short-term benefits but compromise long-term ecosystem stability.

In Al-Jabal Al-Akhdar, environmental gradients such as elevation and soil type play a more dominant role in structuring vegetation (Hegazy et al., 2011; Abd El-Ghani and Al Borki, 2024). However, human activities superimpose additional pressures that can disrupt these natural patterns. Overgrazing, for example, reduces ground cover and increases soil erosion, which in turn affects water infiltration and plant regeneration (Elshatshat and Mansour, 2014). Such feedback loops illustrate how anthropogenic disturbance can amplify

environmental stress, leading to cascading ecological effects.

Raunkiaer's (1934) life-form classification provides a useful lens for interpreting these dynamics. In both regions, a high proportion of plants are adapted to survive unfavorable seasons through underground storage organs, seeds, or woody structures. These life-form strategies reflect the need to cope with drought, temperature extremes, and disturbance. However, when disturbance exceeds the adaptive capacity of these strategies, even resilient plant forms may decline.

Another important dimension is the role of ethnobotanical knowledge in conservation. In Gujarat, traditional plant use fosters a sense of stewardship and continuity, as communities recognize the value of maintaining diverse plant resources (Seth, 2003). In Libya, however, the erosion of traditional land-use practices and the expansion of commercial exploitation have weakened these cultural ties to vegetation, contributing to unsustainable resource use (Elshatshat and Mansour, 2014).

Future conservation efforts in both regions must therefore integrate ecological science with socio-cultural understanding. Protecting plant diversity requires not only the preservation of habitats and species but also the reinforcement of knowledge systems that support sustainable use. This integrative approach is particularly crucial in climatically vulnerable regions, where the margin for ecological error is small.

5. Conclusion

The synthesis of floristic, ethnobotanical, and ecological evidence from North Gujarat and Al-Jabal Al-Akhdar demonstrates that plant diversity in semi-arid and Mediterranean landscapes is shaped by a complex interplay of environmental gradients, adaptive strategies, and human activity. Both regions support rich and structurally complex vegetation systems that provide essential ecological services and cultural benefits. However, these systems are increasingly threatened by land-use change, overexploitation, and environmental stress.

By integrating botanical inventories with ecological theory and ethnobotanical insight, this study highlights the need for holistic conservation strategies that recognize plants as both ecological components and socio-economic resources. Sustaining floristic diversity in these regions will require the protection of habitats, the regulation of human activities, and the preservation of traditional knowledge. Only through such an integrated approach can the ecological integrity and cultural value of these landscapes be maintained for future generations.

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