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Medicinal Plants and Human Wellbeing: A Phylogenetic and Ethnobotanical Approach in the Hilly Zones of Karak, KP

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ABSTRACT

This study presents the first phylogenetic and ethnobotanical assessment of plant communities across four hilly regions in District Karak, Khyber Pakhtunkhwa, Pakistan. The research aimed to analyze the phylogenetic structure of local flora and document traditional knowledge regarding the medicinal and utilitarian uses of plant species in the area.Field surveys were conducted from March 2018 to April 2019 across four communities: Tappi Kanda, Andai, Metta Khel, and Algadi Karak. Floristic data were collected and analyzed for species richness and phylogenetic diversity. Ethnobotanical information was gathered through interviews with local inhabitants, herbalists, and traditional healers. Species were identified and classified according to standard botanical protocols. A total of 45 plant species from 23 families were documented. Phylogenetic analysis revealed high species richness and diversity but a non-significant pattern of phylogenetic clustering across communities, suggesting a random distribution influenced by stochastic processes such as dispersal and recruitment limitations. Dominant families included Poaceae, Lamiaceae, and Chenopodiaceae, many of which propagate vegetatively. Traditional knowledge among the local population was extensive, with plants like *Convolvulus arvensis*, *Aloe vera*, *Acacia modesta*, and *Withania coagulans* used widely for medicinal purposes. However, modernization and lifestyle changes threaten the transmission of this knowledge. Additionally, overgrazing, logging, and uncontrolled harvesting were identified as major threats to local biodiversity. The findings indicate that environmental and stochastic factors shape the phylogenetic structure of plant communities in the study area. The region is rich in medicinal flora, and local communities depend heavily on plant resources for healthcare and livelihood needs. Urgent conservation strategies are needed to protect threatened species and preserve traditional knowledge. Integrating ethnobotanical heritage with sustainable resource management can support both biodiversity conservation and community development.

Introduction

Plant diversity is a fundamental component of ecosystems, underpinning their structure, function, and resilience. It encompasses three main dimensions: taxonomic diversity, phylogenetic diversity, and functional diversity. Taxonomic diversity primarily reflects species richness and relative abundance, while functional diversity captures the variation in traits that influence species performance and ecosystem functioning. Phylogenetic diversity, however, provides a more evolutionary perspective, incorporating information about the historical relationships among species to predict ecological similarity and divergence (Cheng et al., 2018). Phylogenetic diversity is particularly valuable as it integrates evolutionary history into biodiversity assessments. It quantifies the sum of the branch lengths of a phylogenetic tree that spans all species within a given community, thereby offering insights into the extent of evolutionary divergence among co-occurring taxa. This approach facilitates the identification of ecological and evolutionary processes governing community assembly, including niche differentiation, environmental filtering, and competitive exclusion (Cheng et al., 2018).

Recent advances in community ecology have emphasized the integration of phylogenetic data to understand ecological patterns and processes. Phylogenetic tools have emerged as essential for assessing the conservation significance of species and communities, enabling researchers to infer the mechanisms shaping species co-occurrence and spatial distribution patterns (Khan et al., 2011). Through phylogenetic analyses, ecologists can discern whether observed community structures are driven more by environmental factors and biotic interactions or by historical and evolutionary constraints (Cadotte et al., 2008). Phylogeny-based approaches aim to elucidate the processes of community assembly by examining the evolutionary relationships among co-occurring species. Specifically, these methods investigate patterns such as phylogenetic clustering or overdispersion, which can indicate the relative influence of environmental filtering or competitive interactions. In this context, the co-occurrence of closely related species is particularly informative, as it may reflect shared ecological tolerances or adaptive strategies (Zulqarnain et al., 2017).

The current study applies phylogenetic metrics to evaluate the community structure of plant assemblages in the hilly areas of District Karak, Khyber Pakhtunkhwa, Pakistan. These regions are characterized by diverse plant species, many of which possess ethnobotanical and medicinal value, forming a crucial part of the local health care system. Traditional medicinal knowledge, often passed down through generations, plays a pivotal role in rural communities, where access to formal medical facilities is limited. Globally, approximately 80% of the population relies on traditional plant-based remedies for primary healthcare, underlining the importance of preserving both the biological and cultural components of ethnomedicinal systems (Siddique et al., 2016; Khan et al., 2011).

District Karak's unique topography and climatic conditions support a rich diversity of medicinal flora. Local communities in this region exhibit extensive traditional knowledge of plant use, encompassing both wild and cultivated species. Such practices not only support livelihoods and health but also contribute to the in situ conservation of plant diversity (Alam et al., 2011). Medicinal plants, in particular, produce an array of secondary metabolites with proven therapeutic properties, and their role in traditional medicine systems is globally recognized (Malik et al., 2001). India alone harbors approximately 15% of the world’s medicinal plant species, with around 90% distributed across varied climatic zones (Patel, 2014). This reflects the broader biogeographical importance of South Asia in sustaining medicinal plant biodiversity. Despite rapid modernization, traditional medicine remains widely used, particularly in rural and mountainous areas, where indigenous knowledge systems continue to thrive (Patel, 2014; Siddique et al., 2016).

The current study focuses on assessing the phylogenetic diversity and traditional uses of medicinal plants in selected hilly areas of District Karak. Located approximately 123 km south of Peshawar along the Indus Highway, District Karak lies between 33°7′12″N latitude and 71°5′41″E longitude, covering an area of 3,372 km² with an estimated population of 536,000 (Fawad et al., 2017). Administratively, the district is divided into three tehsils: Karak, Banda Daud Shah, and Takht-e-Nasrati. The local language is Pashto, primarily the softer Kandahari dialect. Notably, Karak has one of the highest rural literacy rates in Pakistan (93.52%), highlighting the community’s potential for participating in and benefiting from ethnobotanical research (Siddique et al., 2016). Climatically, the region experiences arid to semi-arid conditions, with summer temperatures often exceeding 40°C and frequent sandstorms. Mean air temperature peaks at 39.5°C in June, with an average wind speed of 5.5 km/h. Relative humidity reaches up to 77.21% in September, while the annual precipitation averages around 121.6 mm. The soil temperature in July is approximately 26.77°C, indicating generally dry conditions conducive to xerophytic and drought-tolerant plant species. As a result, the local vegetation is dominated by spiny, scrubby, and dwarf species well-adapted to harsh environmental conditions (Fawad et al., 2017). The district also hosts diverse wildlife and is known for seasonal hunting of species such as quails, cranes, and pheasants. In addition to its ecological

richness, Karak is endowed with significant natural resources, including salt mines, oil, gas, and uranium, particularly in Makori, Noshpa Banda, and Gurguri regions (Fawad et al., 2017).

The primary aim of the present study is to explore the phylogenetic diversity and traditional medicinal uses of plant species in the hilly areas of District Karak, Khyber Pakhtunkhwa, Pakistan. This research seeks to document indigenous knowledge related to the use of medicinal plants, which has been passed down through generations and remains integral to the healthcare practices of local communities. Furthermore, the study aims to analyze the phylogenetic structure of plant communities to better understand the evolutionary relationships among species and the ecological processes shaping their distribution.

In addition, the research endeavors to assess the medicinal and economic value of the recorded plant species, with the goal of highlighting their potential for local healthcare and sustainable livelihood development. A crucial objective is to raise awareness within the local community about the significance of medicinal plant biodiversity, thereby promoting the conservation and responsible use of these valuable natural resources. Through this multifaceted approach, the study contributes to both scientific understanding and the preservation of traditional ethnobotanical knowledge.

Materials and Methods

Study Planning and Data Collection

Prior to the initiation of fieldwork, a detailed research plan was formulated to guide the systematic collection of ethnobotanical and phylogenetic data. General background information regarding the medicinal plant species in the target region was gathered through preliminary literature reviews and consultations with local experts. Field surveys were conducted over a 13-month period, from March 2018 to April 2019, across selected hilly regions of District Karak, Khyber Pakhtunkhwa, Pakistan. The specific sites included Tappi Kanda, Andai Karak, Metta Khel, and Algadai Karak, which are known for their distinct topographical and ecological features (Figure-1)

Figure-1. Map showing the research areas in District Karak, Khyber Pakhtunkhwa, Pakistan.

Exploration of Local Flora

To aid in field navigation and accurate site demarcation, a topographic map of District Karak was obtained from the relevant governmental office. A standardized data collection proforma was designed to record detailed information about each encountered plant specimen, including botanical name, family, growth habit, local name, parts used, and both traditional and medicinal applications. This format ensured uniformity in data gathering across all field locations.

Collection of Medicinal Flora and Ethnobotanical Data

During exploratory visits, medicinal plant specimens were systematically collected using standard botanical collection techniques as described by Ahmad and Ali. Photographs of each species were taken in situ to document habitat and morphological characteristics. Concurrently, ethnobotanical information was obtained through direct interviews with local inhabitants, particularly traditional healers, elders, farmers, and herbalists (Hakims). Informants were questioned regarding plant identification, traditional uses, preparation methods, and perceived efficacy in treating various ailments.

Multiple

informants were interviewed per locality to ensure data reliability and minimize individual bias. Data obtained from these
interviews were cross-verified through repeated queries and subsequently compared with existing ethnobotanical literature for validation.

Questionnaire Surveys
Structured and semi-structured questionnaires were designed following ethnobotanical standards and distributed among residents of different villages within the study region. These questionnaires were aimed at capturing indigenous knowledge related to the medicinal uses of local flora. In addition to formal interviews, extensive participant observations were conducted to understand plant use practices in daily life. The data collected through these tools were later organized and analyzed following the methodologies outlined by Zulqarnain et al. (2017) and Hazrat et al. (2001).

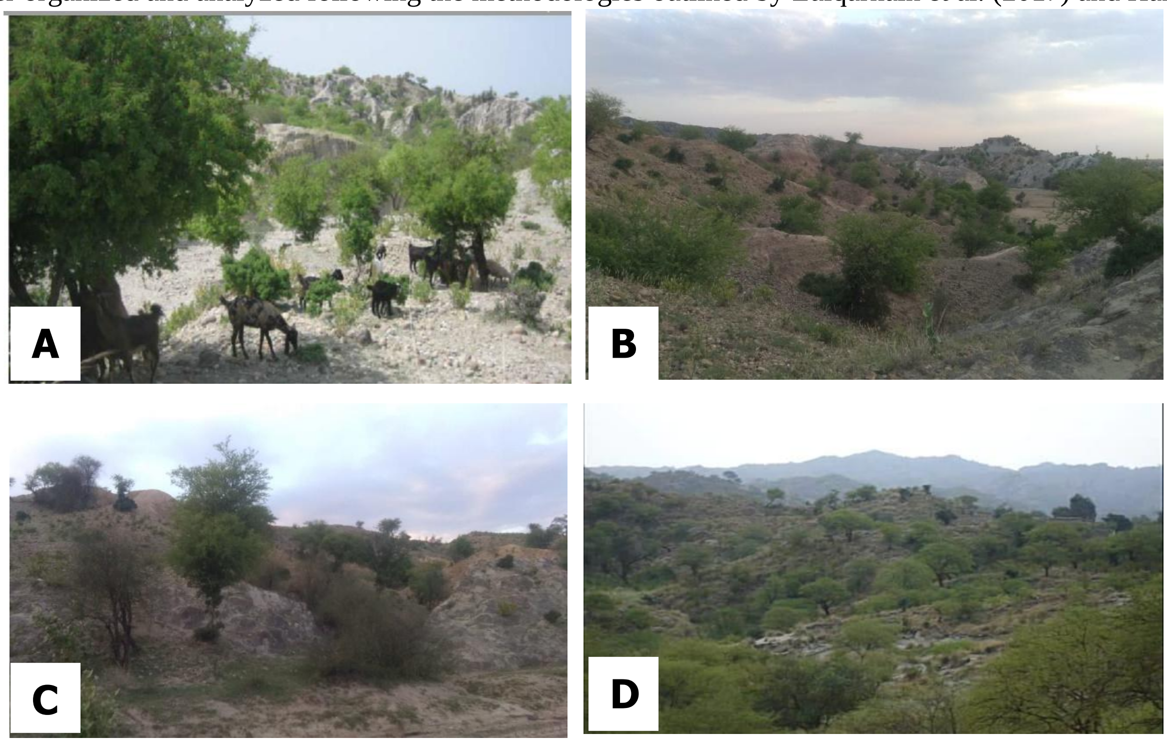

Figure-2. A) View of Tappi Kanda (Community A); B) View of Andai Karak (Community B); C) View of Algadi Karak (Community C); D) View of Metta Khel (Community D).

Specimen Collection and Taxonomic Identification
Plant specimens collected during the field surveys were pressed, dried, and transported to the Herbarium of the relevant university for further examination. Identification of all specimens was performed using standard taxonomic keys provided in the *Flora of Pakistan*. Specimen identification was verified with the assistance of expert taxonomists to ensure accuracy and to confirm any ambiguous taxa.

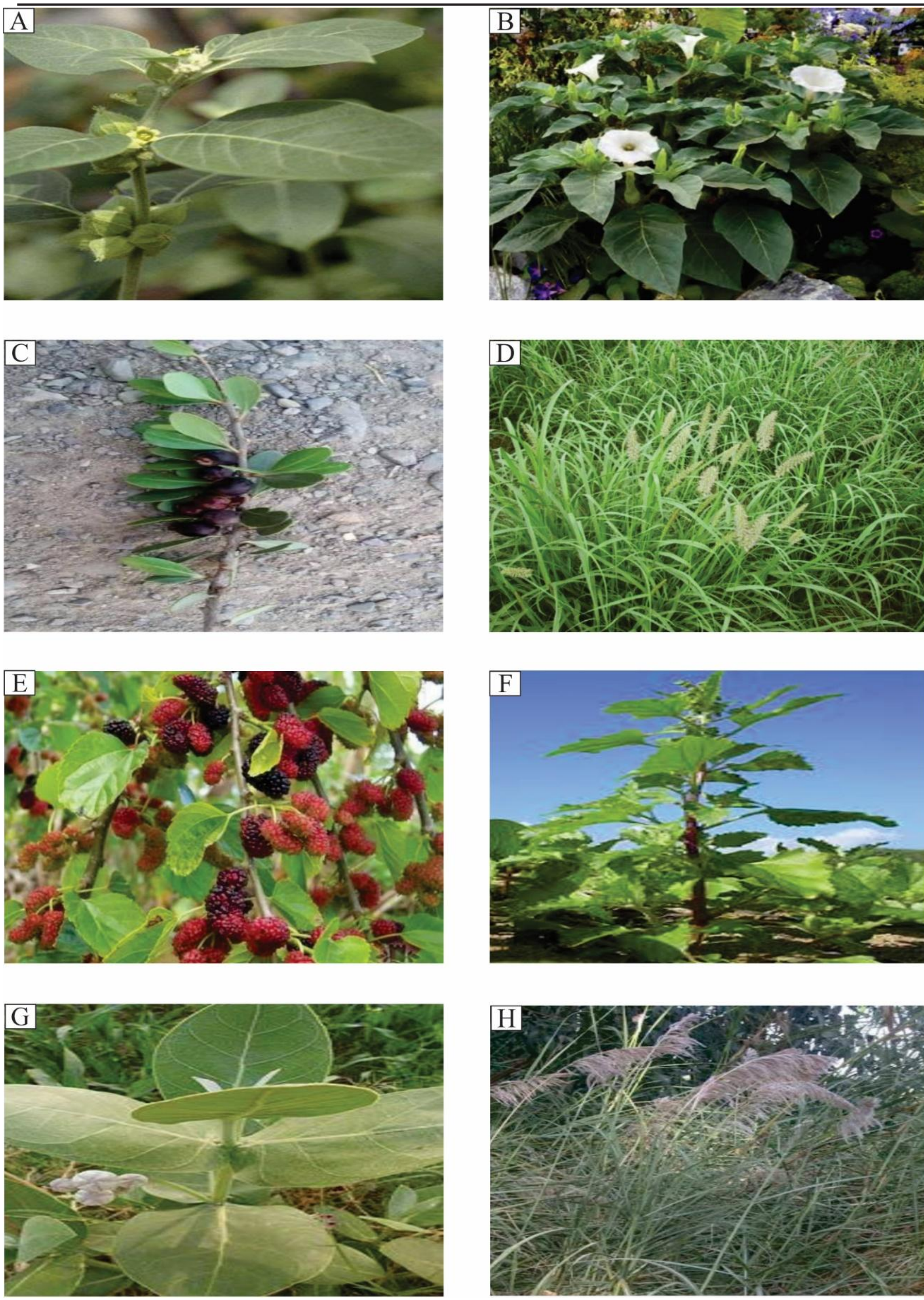

Figure-3. (View-I) Survey of medicinal plants from Karak's hilly areas.

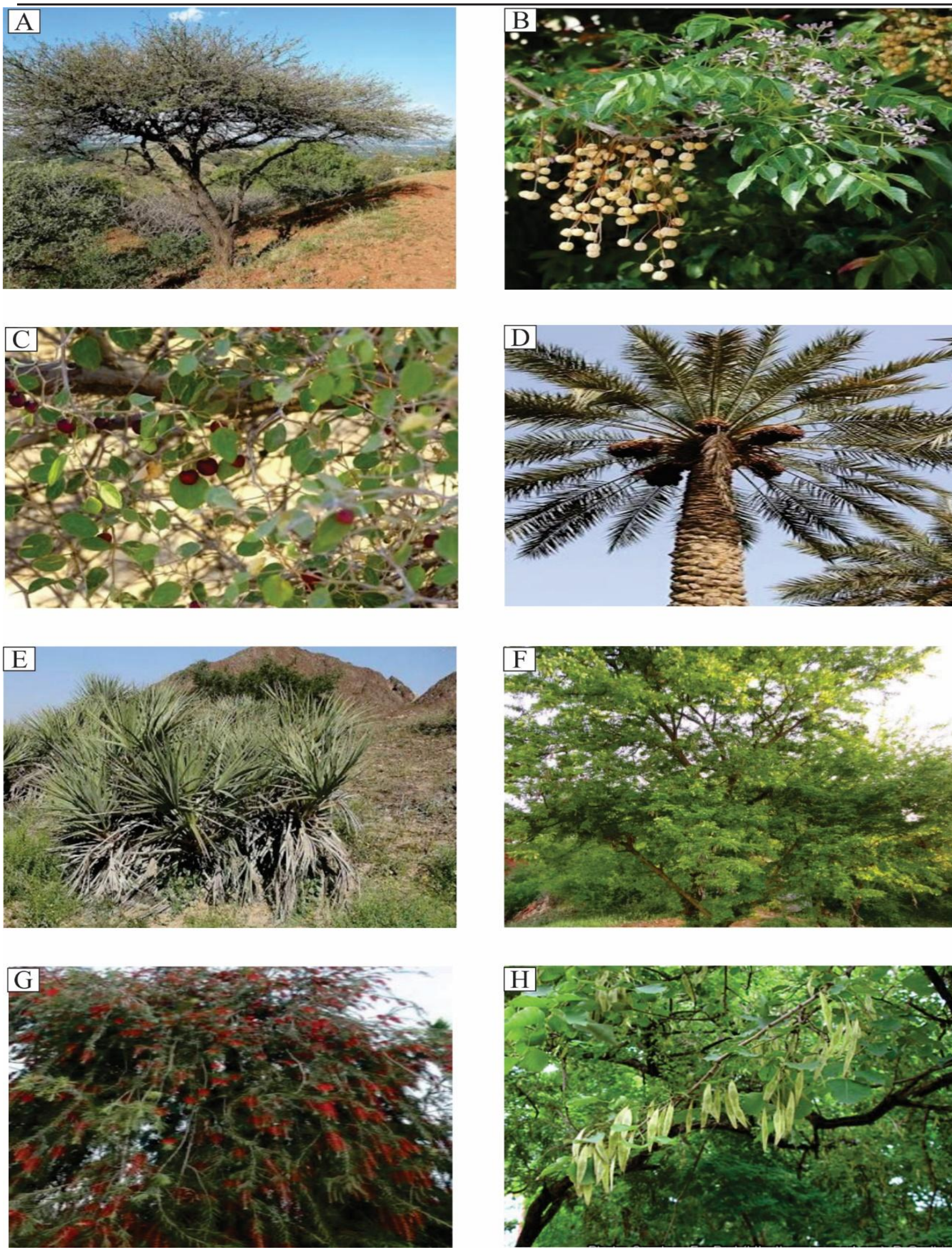

Figure-3. (View-II) Survey of medicinal plants from Karak's hilly areas.

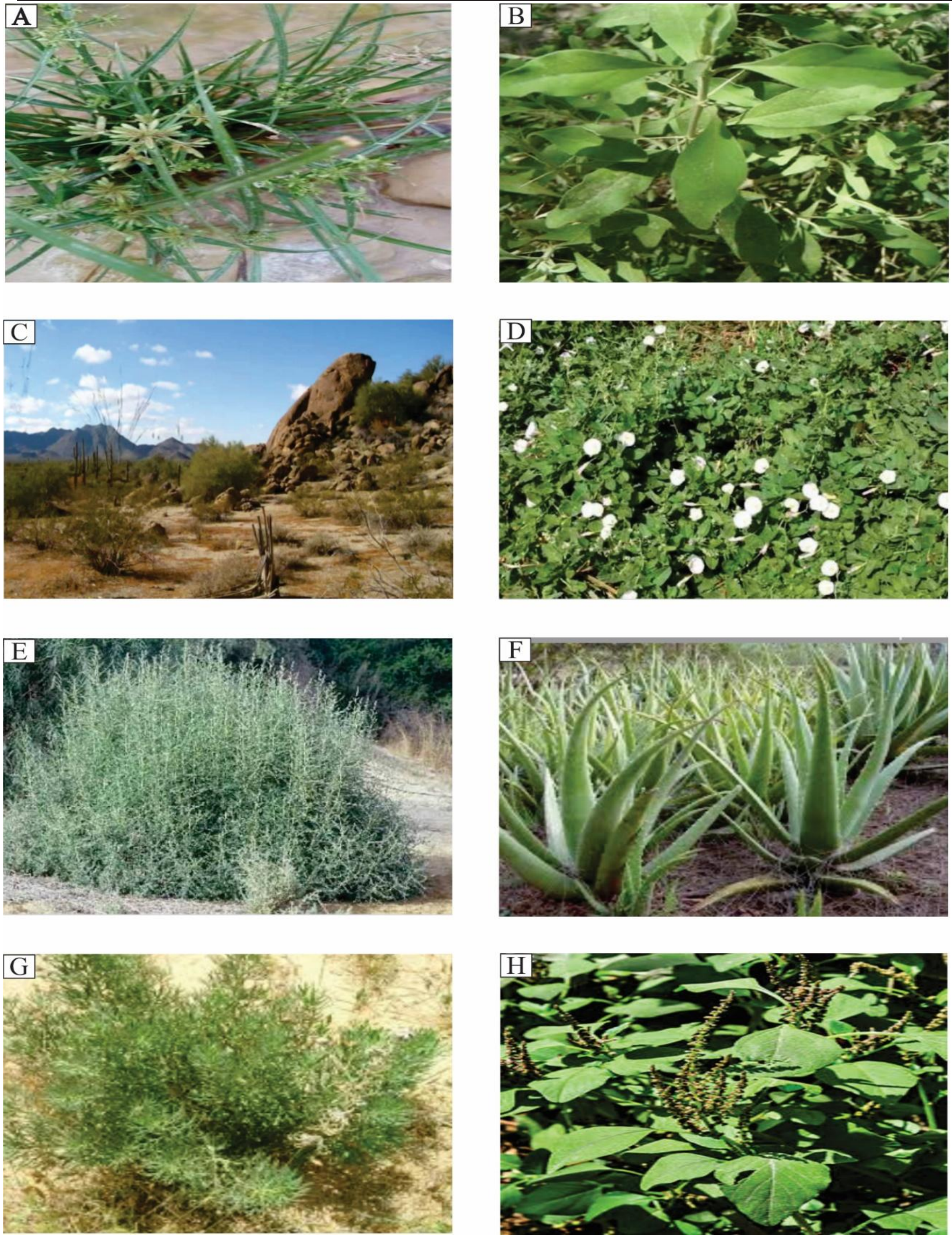

Figure-3. (View-III) Survey of medicinal plants from Karak's hilly areas.

Data Organization and Categorization

The collected ethnobotanical and phylogenetic data were compiled and managed using Microsoft Excel 2007. Plant species were categorized based on their life forms into herbs, shrubs, and trees, and their life cycles were classified as annual, biennial, or perennial. The plant parts used for medicinal purposes were also systematically recorded and grouped into categories: leaves, roots, stems, whole plant, seeds, fruits, and flowers. This classification facilitated further statistical and comparative analysis. Phylogenetic diversity was assessed in accordance with the methodology adopted by Zulqarnain et al. (2017).

Quantitative Ethnobotanical Analysis

A simple frequency-based approach was applied to quantify the traditional uses of each plant species. The use report (UR**)** method was used, wherein the number of informants mentioning each species for a particular medicinal purpose was counted. The total number of use reports was calculated for all recorded plant species to assess their relative cultural significance.

Phylogenetic Diversity Analysis

To assess the evolutionary relationships among the recorded species, phylogenetic trees were constructed using available molecular data and phylogenetic tools. The phylogenetic diversity (PD) of each site was quantified by calculating the total branch length of the phylogenetic tree encompassing all species within the local community. In addition, the standardized effect size (SES) of the diversity measures was computed to allow for comparisons across different sites and communities. This statistical normalization enabled the detection of phylogenetic clustering or overdispersion, providing insights into the processes governing community assembly.

Results

The study revealed that the medicinal plants growing naturally across various seasons in the hilly regions of District Karak serve multiple purposes and hold significant ethnobotanical value for local communities. Due to limited access to formal healthcare and trained medical personnel, indigenous populations rely extensively on these plant species for medicinal and other essential needs. Traditional knowledge pertaining to the benefits and applications of these plants was documented through interviews with local inhabitants and healers.

A total of 45 plant species belonging to 24 botanical families were identified and documented from the surveyed areas. These included 15 tree species, 16 shrubs, and 14 herbs, which are utilized extensively in traditional medicinal practices. The species were distributed across four ecologically distinct communities within the study region.

Phylogenetic trees were constructed for each community using phylogenetic software, following the methodology of Zulqarnain et al. (2017). The phylogenetic diversity (PD), defined as the cumulative branch length of the phylogenetic tree encompassing all species within a local community, was computed for each site.

- Community 1 comprised 31 species, with dominant representation from the Arecaceae, Poaceae, and Solanaceae families, contributing a total of 12 species.
- Community 2 included 30 species, with Chenopodiaceae, Poaceae, and Solanaceae emerging as dominant families, collectively accounting for 14 species.
- Community 3 consisted of 33 species, with dominance from Asclepiadaceae, Mimosaceae, and Poaceae, contributing a total of 14 species.
- Community 4 had the highest species richness with 34 species, primarily from Arecaceae, Solanaceae, Mimosaceae, and Poaceae, encompassing 23 species in total.

Across all communities, the Poaceae family was found to be the most dominant, comprising 6 species, followed by Asteraceae and Papilionaceae with 5 species each. Families such as Solanaceae, Amaranthaceae, and Brassicaceae were represented by 3–5 species, while others like Cactaceae, Lamiaceae, Mimosaceae, Malvaceae, Boraginaceae, and Verbenaceae contributed modestly to the overall floral composition.

In terms of phylogenetic spread, the presence of diverse families such as Alliaceae, Apiaceae, Asclepiadaceae, Cyperaceae, Moraceae, Myrtaceae, and Tamaricaceae added depth to the evolutionary landscape of the flora. Notably, many species demonstrated multipurpose utility, being employed not only for medicinal treatments but also for cultural, nutritional, and ecological functions within the community.

The documentation of traditional knowledge reflects a deep-rooted ethnobotanical heritage in the region, emphasizing the significance of these plant species in local health practices and biodiversity conservation (Table 1). The observed variation in species richness and phylogenetic composition across communities further highlights the ecological heterogeneity of the area and underscores the value of integrating phylogenetic metrics in biodiversity assessment.

Table 1 presents a comprehensive ethnobotanical profile of 45 medicinal plant species documented from the hilly regions of District Karak. These species, belonging to 24 plant families, are traditionally utilized by local communities for a wide range of therapeutic and practical purposes. Each plant is catalogued by its botanical and local name, family, growth habit (herb, shrub, or tree), plant parts used, and specific traditional or medicinal applications.

The table highlights the widespread use of leaves, roots, seeds, and whole plants in folk remedies addressing ailments such as gastrointestinal disorders, skin diseases, asthma, joint pain, and infections. Several species are also noted for their non-medicinal roles, including use as fodder, fuel, hedge material, and in traditional crafts and construction. Notably, many species like *Calotropis procera*, *Withania coagulans*, and *Saccharum bengalense* serve multiple purposes, demonstrating their cultural and economic value.

This documentation underscores the rich traditional knowledge held by the inhabitants of Karak and the significance of conserving both plant biodiversity and indigenous practices.

Table 1. Ethnobotanical Uses of Medicinal and Multipurpose Plant Species in the Hilly Regions of District Karak

Plant Family	Botanical Name	Local Name	Habit	Part Used	Traditional and Medicinal Uses
Asclepiadaceae	*Calotropis procera*	Spalmaka	Shrub	Whole plant	Expectorant, anthelmintic; young flowers used for tumors. Whole plant used as fodder and fuel.
Amaranthaceae	*Amaranthus viridis*	Ranzaka	Herb	Leaves	Used for gastrointestinal disorders; also used as fodder.
Apocynaceae	*Rhazya stricta*	Gandarai	Shrub	Root, Leaves	Leaf extract used as anticancer; root used for toothache. Leaves protect stored grain, used as fuel, hedge, and bee forage.
Arecaceae	*Nannorrhops ritchieana*	Mazaray	Herb	Leaves	Decoction for stomach problems; used for roofing thatches.
Arecaceae	*Phoenix dactylifera*	Khajora	Tree	Whole plant	Fruit is laxative; leaves used for mats, ropes, and baskets.
Asclepiadaceae	*Aloe vera*	Zargia	Herb	Leaves	Leaf extract used for arthritis, backache, hepatitis, and dermatitis.
Asclepiadaceae	*Asphodelus tenuifolius*	Pyazakay	Herb	Leaves, Seeds	Leaves are diuretic; seeds used topically for ulcers and inflammation. Also supports bee foraging.
Asteraceae	*Parthenium hysterophorus*	Banga	Herb	Leaves, Branches	Used as fodder and fuel.
Boraginaceae	*Heliotropium bacciferum*	Markondi	Herb	Seeds	Ground seeds applied for backache relief.
Chenopodiaceae	*Chenopodium murale*	Sorma / Spen Soba	Herb / Shrub	Leaves	Used as laxative, purgative, for food and as bee forage.
Chenopodiaceae	*Kochia indica*	Qurashka	Herb	Whole plant	Dried plant used as fuel.
Convolvulaceae	*Convolvulus arvensis*	Parwata	Herb / Shrub	Whole plant	Used for menstrual regulation, asthma, and skin diseases; also fodder and bee forage.
Cactaceae	*Opuntia ficus-*	Ganderi	Shrub	Whole plant	Used for hedging and sheltering; flowers

	indica				used by children.
Cyperaceae	*Cyperus rotundus*	Dela	Shrub	Leaves	Leaves are laxative, purgative, and used as fodder.
Lamiaceae	*Otostegia limbata*	Her Sasa	Herb	Whole plant	Stimulant, carminative; also used for fuel, hedging, and sheltering.
Lamiaceae	*Ocimum basilicum*	Boburai	Shrub	Flowers, Seeds, Roots	Diuretic, carminative, mucilaginous; used for respiratory, gastrointestinal, and pediatric ailments. Also ornamental and bee forage.
Meliaceae	*Melia azedarach*	Bakanra	Tree	Leaves, Seeds	Leaves are antiseptic; seeds used for blood pressure. Also fuel, ornamental, furniture, and shelter.
Mimosaceae	*Acacia modesta*	Palosa	Tree	Whole plant	Bark is analgesic; leaves used as coolant; used for tools, fuel, hedging, shelter, and as bee forage.
Mimosaceae	*Acacia nilotica*	Kikar	Tree	Whole plant	Bark used for stomach ailments; seeds are demulcent. Plant used for furniture, fuel, tools, and fodder.
Mimosaceae	*Prosopis juliflora*	Kikray	Tree	Branches	Used for hedging, sheltering, fuel, and fodder.
Moraceae	*Morus alba*	Spin Shatut	Tree	Fruits, Wood	Laxative; wood used for fuel, tools, and furniture. Also bee forage, hedging, and bird shelter.
Moraceae	*Morus nigra*	Toor Shatut	Tree	Leaves, Fruit, Wood	Fruit consumed; wood for fuel and tools. Bee forage; excessive use may cause constipation.
Myrtaceae	*Callistemon lanceolatus*	Bottle Brush	Tree	Whole plant	Grown for ornamental purposes.
Myrtaceae	*Eucalyptus lanceolatus*	Lochay	Tree	Branches, Fruit	Fruit is digestive; branches used for thatching, hedging, and sheltering.
Papilionaceae	*Albizia lebbeck*	Sreen	Tree	Branches	Used for fuel and shelter; also in furniture making.
Papilionaceae	*Dalbergia sissoo*	Shawa	Tree	Whole plant	Used for fuel, furniture, agricultural tools, and shelter.
Poaceae	*Cynodon dactylon*	Osha	Herb	Whole plant	Laxative; used in asthma, as fodder, and for ornamental purposes.
Poaceae	*Saccharum arundinaceum*	Muskanray	Shrub	Leaves	Used for roofing, fuel, and fodder.
Poaceae	*Cenchrus biflorus*	Kurashka	Herb	Seeds	Used for cancer treatment and as fodder.

Poaceae	*Saccharum spontaneum*	Cheyaka	Shrub	Leaves	Used as a cooling agent and supports bee foraging.
Poaceae	*Saccharum bengalense*	Kana	Shrub	Leaves, Roots	Diuretic; used for urinary disorders, roof making, soil erosion control, and bee foraging.
Papilionaceae	*Alhagi maurorum*	Ganderi	Shrub	Whole plant	Used for fuel and fodder.
Rhamnaceae	*Ziziphus nummularia*	Karkanha	Tree	Fruits	Edible; used for fencing, fuel, fodder, and bee forage.
Solanaceae	*Datura metel*	Barbaka	Shrub	Leaves, Seeds, Roots	Used for skin conditions, insanity, diarrhea, and tumor pain. Toxic in high doses.
Solanaceae	*Withania coagulans*	Shopianga	Shrub	Fruits	Used for stomach pain relief.
Sapotaceae	*Monotheca buxifolia*	Gurgura	Tree	Fruits	Laxative and digestive; also used for fuel, tools, shelter, and bee forage.
Tamaricaceae	*Tamarix decidua*	Sor Ghazz	Tree	Leaves, Bark	Antiseptic; used for wound healing and postpartum care. Also fuel and bee forage.
Tamaricaceae	*Tamarix aphylla*	Sheen Ghazz	Tree	Leaves, Bark	Treats tetanus; bark for skin diseases; used for fodder (especially for camels), fuel, timber.
Verbenaceae	*Vitex negundo*	Nirgandi	Shrub	Flowers, Seeds, Roots	Used for fever, vomiting, joint pain, ulcers, and sexual vitality. Also for erosion control and shelter.
Zygophyllaceae	*Fagonia cretica*	Spelaghzai	Herb	Whole plant	Used for diabetes, blood purification, inflammation, and scabies.
Zygophyllaceae	*Peganum harmala*	Sponda	Herb	Fruit, Roots	Used for heart pain and lice control; attracts honey bees.

Ethnobotanical Significance and Economic Potential of Medicinal Plant Species in District Karak
Table 2 presents the ethnobotanical and commercial significance of 48 plant species documented in the Karak District, Khyber Pakhtunkhwa, Pakistan. The listed species span across 25 plant families, with Fabaceae, Poaceae, Chenopodiaceae, and Solanaceae being among the most represented.
Each species was evaluated for its traditional/medicinal uses and marketing potential based on field surveys and local knowledge. The traditional uses include a wide range of applications such as treatment for gastrointestinal disorders, respiratory conditions, skin diseases, and wound healing. Market value is associated with species utilized in fuelwood, fodder, construction materials, ornamental use, and local trade of medicinal products.
Of the total species listed:

- 95% (46 species) are used traditionally for medicinal or ethnobotanical purposes.
- 52% (25 species) possess identifiable marketing or commercial value within the local economy.

- Some plants, such as *Phoenix dactylifera*, *Aloe vera*, *Saccharum bengalense*, and *Tamarix aphylla*, are valued for both medicinal and economic purposes, indicating their multifunctional role in rural livelihoods.

This table highlights the importance of native flora not only in traditional healing systems but also in supporting socio-economic sustainability through local commerce and ecosystem services. Further ethnopharmacological validation and value chain assessments are recommended to support conservation and commercial utilization efforts.

Table 2. Ethnobotanical Significance and Commercial Potential of Documented Plant Species in District Karak

Plant Family	Botanical Name	Traditional / Medicinal Uses	Commercial / Market Value
Asclepiadaceae	*Calotropis procera*	✓	—
Amaranthaceae	*Amaranthus viridis*	✓	✓
Apocynaceae	*Rhazya stricta*	✓	—
Arecaceae	*Nannorrhops ritchieana*	✓	✓
Arecaceae	*Phoenix dactylifera*	✓	✓
Asphodelaceae	*Aloe vera*	✓	✓
Asphodelaceae	*Asphodelus tenuifolius*	✓	✓
Asclepiadaceae	*Calotropis procera* (dup.)	✓	—
Asteraceae	*Parthenium hysterophorus*	✓	✓
Boraginaceae	*Heliotropium bacciferum*	✓	—
Chenopodiaceae	*Chenopodium murale*	—	✓
Chenopodiaceae	*Kochia indica*	✓	—
Convolvulaceae	*Convolvulus arvensis*	✓	—
Cactaceae	*Opuntia ficus-indica*	✓	—
Chenopodiaceae	*Chenopodium album*	✓	—
Chenopodiaceae	*Chenopodium murale* (dup.)	✓	—
Convolvulaceae	*Convolvulus arvensis* (dup.)	✓	✓
Cyperaceae	*Cyperus rotundus*	✓	✓
Lamiaceae	*Otostegia limbata*	✓	—
Lamiaceae	*Ocimum basilicum*	✓	—
Meliaceae	*Melia azedarach*	✓	✓
Mimosaceae	*Acacia modesta*	✓	—
Mimosaceae	*Acacia nilotica*	✓	—

Fabaceae	*Prosopis juliflora*	✓	—
Moraceae	*Morus alba*	✓	✓
Moraceae	*Morus nigra*	✓	✓
Myrtaceae	*Callistemon lanceolatus*	✓	✓
Myrtaceae	*Eucalyptus lanceolata*	✓	✓
Fabaceae	*Albizia lebbeck*	✓	—
Fabaceae	*Dalbergia sissoo*	✓	✓
Poaceae	*Cynodon dactylon*	✓	✓
Poaceae	*Saccharum arundinaceum*	✓	—
Poaceae	*Cenchrus biflorus*	✓	—
Poaceae	*Saccharum spontaneum*	✓	✓
Poaceae	*Saccharum bengalense*	✓	✓
Fabaceae	*Alhagi maurorum*	✓	—
Rhamnaceae	*Ziziphus nummularia*	✓	—
Solanaceae	*Datura metel*	✓	✓
Solanaceae	*Withania coagulans*	✓	✓
Sapotaceae	*Monotheca buxifolia*	✓	✓
Tamaricaceae	*Tamarix decidua*	✓	✓
Tamaricaceae	*Tamarix aphylla*	✓	✓
Verbenaceae	*Vitex negundo*	✓	—
Zygophyllaceae	*Fagonia cretica*	✓	✓
Zygophyllaceae	*Peganum harmala*	✓	✓

Notes:

- ✓ = Present / Observed / Used
- — = Not reported / Not observed

Comparative Distribution of Medicinal Plant Species Across Four Ethnobotanical Communities in District Karak

Table 3 illustrates the presence and distribution of various ethnobotanically important plant species across four distinct communities within District Karak: Tappi Kanda (Community 1), Andai (Community 2), Metta Khel (Community 3), and Algadi Karak (Community 4). The data capture species richness and potential phylogenetic diversity by documenting the occurrence (denoted by "1") of 46 plant taxa from 24 botanical families in each community.

The table reveals that several species such as *Calotropis procera*, *Amaranthus viridis*, *Rhazya stricta*, *Phoenix* *dactylifera*, *Heliotropium bacciferum*, and *Dalbergia sissoo* are commonly shared across all four communities, reflecting a core set of culturally and medicinally significant plants. In contrast, some species like *Asphodelus tenuifolius*, *Parthenium hysterophorus*, and *Otostegia limbata* are locally restricted, indicating community-specific ethnobotanical knowledge or microhabitat preference.

This distribution pattern provides insight into the biocultural dynamics of plant use and contributes to the understanding of species richness and phylogenetic diversity within a regional ethnobotanical context.

Table 3. Presence of Plant Species Across Four Ecological Communities in District Karak

Plant Family	Botanical Name	Tappi Kanda	Andai	Metta Khel	Algadi Karak
Asclepiadaceae	*Calotropis procera*	✓	✓	✓	✓
Amaranthaceae	*Amaranthus viridis*	✓	✓	✓	✓
Apocynaceae	*Rhazya stricta*	✓	✓	✓	✓
Arecaceae	*Nannorrhops ritchieana*	—	✓	✓	—
Arecaceae	*Phoenix dactylifera*	✓	✓	✓	✓
Asphodelaceae	*Aloe vera*	✓	—	✓	✓
Asphodelaceae	*Asphodelus tenuifolius*	—	✓	—	—
Asteraceae	*Parthenium hysterophorus*	—	✓	—	—
Boraginaceae	*Heliotropium bacciferum*	✓	✓	✓	✓
Chenopodiaceae	*Chenopodium murale*	✓	—	✓	✓
Chenopodiaceae	*Chenopodium album*	—	✓	—	✓
Chenopodiaceae	*Kochia indica*	✓	—	✓	✓
Convolvulaceae	*Convolvulus arvensis*	✓	—	✓	—
Convolvulaceae	*Convolvulus arvensis*	—	✓	—	✓
Cactaceae	*Opuntia ficus-indica*	✓	✓	✓	✓
Cyperaceae	*Cyperus rotundus*	✓	—	✓	—
Lamiaceae	*Otostegia limbata*	—	—	—	✓
Lamiaceae	*Ocimum basilicum*	✓	✓	—	✓
Meliaceae	*Melia azedarach*	✓	—	✓	✓
Mimosaceae	*Acacia modesta*	✓	✓	✓	✓
Mimosaceae	*Acacia nilotica*	✓	✓	✓	✓
Mimosaceae	*Prosopis juliflora*	—	—	—	✓
Moraceae	*Morus alba*	✓	—	✓	✓

Moraceae	*Morus nigra*	✓	✓	—	—
Myrtaceae	*Callistemon lanceolatus*	✓	✓	—	✓
Myrtaceae	*Eucalyptus lanceolatus*	✓	✓	—	✓
Papilionaceae	*Albizia lebbeck*	—	✓	✓	✓
Papilionaceae	*Dalbergia sissoo*	✓	✓	✓	✓
Poaceae	*Cynodon dactylon*	✓	✓	✓	✓
Poaceae	*Saccharum arundinaceum*	✓	—	✓	✓
Poaceae	*Cenchrus biflorus*	—	✓	✓	✓
Poaceae	*Saccharum spontaneum*	✓	—	✓	✓
Poaceae	*Saccharum bengalense*	—	✓	✓	✓
Papilionaceae	*Alhagi maurorum*	✓	—	✓	✓
Rhamnaceae	*Ziziphus nummularia*	—	—	—	—
Solanaceae	*Datura metel*	✓	✓	✓	✓
Solanaceae	*Withania coagulans*	✓	—	✓	✓
Sapotaceae	*Monotheca buxifolia*	—	✓	✓	—
Tamaricaceae	*Tamarix decidua*	✓	—	✓	—
Tamaricaceae	*Tamarix aphylla*	✓	✓	✓	✓
Verbenaceae	*Vitex negundo*	✓	—	✓	—
Zygophyllaceae	*Fagonia cretica*	✓	✓	—	✓
Zygophyllaceae	*Peganum harmala*	✓	✓	✓	✓

Notes:
✓ = Present / Observed / Used.
— = Not reported / Not observed

Phylogenetics

The phylogenetic structure of plant communities in the study area was analyzed using metrics such as Phylogenetic Diversity (PD), Mean Pairwise Distance (MPD), and Net Relatedness Index (NRI). Across the four sampling communities—Tappi Kanda (Community A), Andai Karak (Community B), Algadi Karak (Community C), and Metta Khel (Community D)—the following observations were made:

- High Phylogenetic Diversity (PD) was observed in all communities, indicating a wide taxonomic breadth and evolutionary distinctiveness among the species.
- Mean Pairwise Distance (MPD) values showed no significant clustering or overdispersion ($p > 0.05$), suggesting a random phylogenetic distribution.

- Net Relatedness Index (NRI) values remained close to zero for all sites, further supporting the absence of strong environmental filtering or competitive exclusion.

Despite the environmental heterogeneity among the communities, the overall phylogenetic patterns did not reflect significant niche-based assembly. This randomness implies that stochastic processes, such as dispersal and recruitment limitations, likely play a dominant role in shaping community composition.

The major plant families contributing to phylogenetic diversity included Poaceae, Lamiaceae, Fabaceae, Chenopodiaceae, and Asteraceae. Many of these families include species that reproduce vegetatively or rely on short-distance dispersal mechanisms, leading to reduced phylogenetic structuring.

No evidence of phylogenetic clustering was found in relation to habitat type, elevation, or community use intensity. This further indicates that phylogenetic community assembly is not strongly governed by local environmental filters, but rather by neutral or random processes (Figure-4).

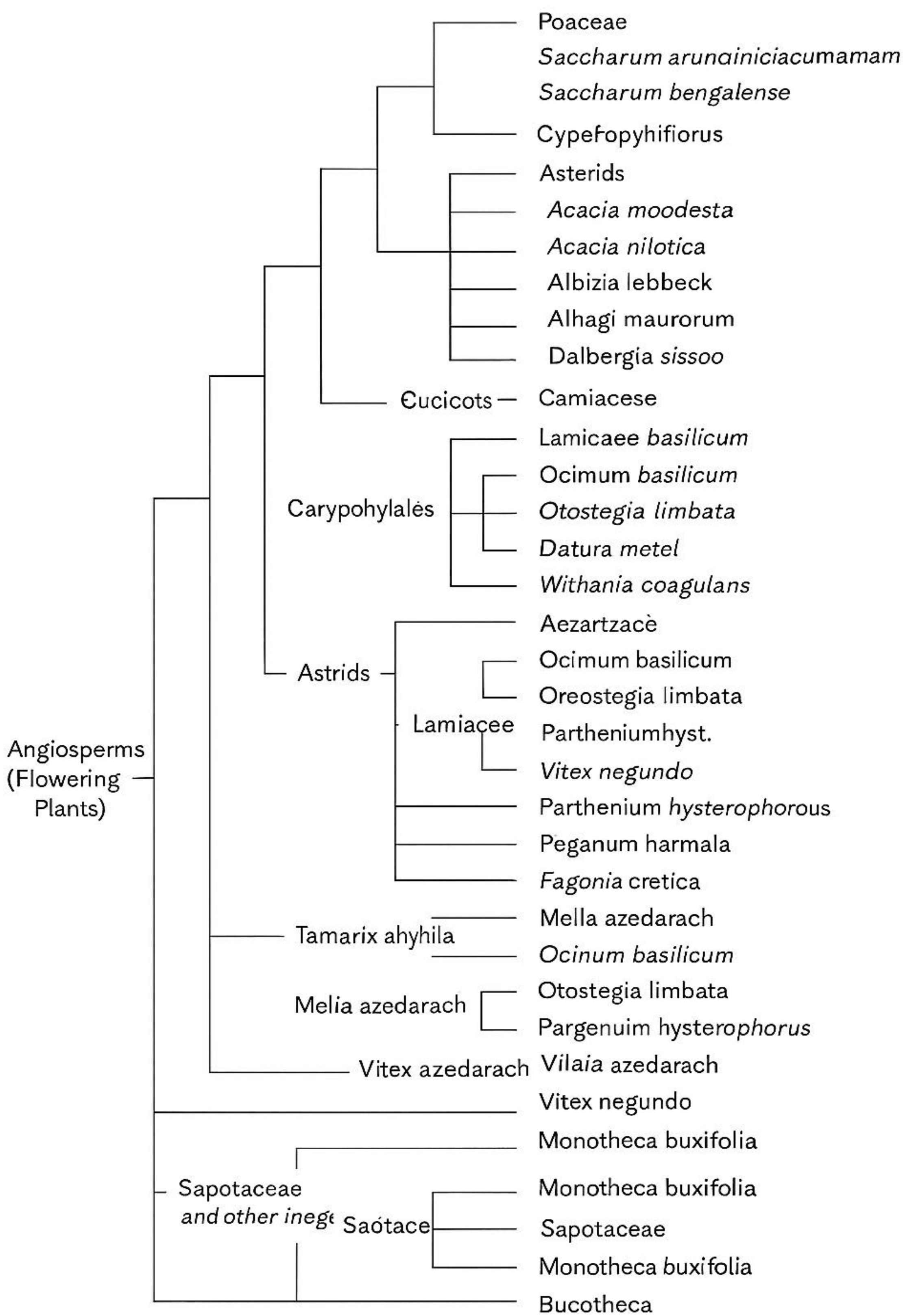

Figure-4. Phylogenetic Tree for Documented Plants Species

Discussion

Our results revealed high phylogenetic diversity across the four communities (Table 2), though no significant phylogenetic clustering or convergence was observed. This non-significant pattern may stem from stochastic factors such as dispersal and recruitment limitations, leading to a random distribution of plant species. Thus, we propose that weak competitive exclusion, combined with stochastic processes, explains the observed diversity. Dispersal limitations reduce seed movement away from parent plants, while recruitment limitations hinder establishment at all suitable sites (Zulqarnain et al., 2017). Many species in the study—especially from *Poaceae*, *Lamiaceae*, and *Chenopodiaceae*—reproduce vegetatively, which further restricts dispersal. Species from *Fabaceae* often disperse via dung of domesticated animals, which graze near parental trees, promoting local germination and reducing competition.

Such conditions slow down competitive exclusion and the arrival of new species (Cadotte et al., 2008). The plants observed from March 2018 to April 2019 were widely used by locals for medicinal and daily purposes. Due to limited healthcare access, these 45 species represent critical resources for traditional medicine. Ethnobotany plays a vital role in documenting indigenous plant knowledge (Khan et al., 2014). As a collaboration between scientists and local communities, it supports sustainable rural development. Documenting this knowledge (Murad et al., 2013) helps conserve biodiversity and supports training for sustainable harvesting. Traditional healers utilize nearly all plant parts. However, these claims require phytochemical and pharmaceutical validation (Shinwari et al., 2011). Key species like *Convolvulus arvensis* treat menstrual disorders and asthma, while *Acacia modesta* and *Ziziphus jujuba* are used for cooling and healing. *Aloe vera*, *Withania coagulans*, and *Eucalyptus lanceolatus* are applied for skin issues, digestion, and various ailments. Plants like *Datura metel*, *Vitex negundo*, and *Alhagi maurorum* are used for pain, infections, and even livestock fodder. However, this knowledge is mostly retained by elders, with younger generations favoring allopathic medicine. As noted by Khan et al. (2014), the loss of older knowledge holders puts this cultural heritage at risk. Its preservation requires urgent educational initiatives targeting youth, as recommended by Shinwari et al. (2011).

Conclusion

Based on the findings of this study, it can be concluded that the floristic composition of the studied area in District Karak exhibits a random phylogenetic distribution of plant species, primarily influenced by environmental heterogeneity and stochastic ecological factors such as dispersal and recruitment limitations. This study represents the first phylogenetic assessment of this region, revealing that competitive exclusion is not a dominant force shaping the community structure, and instead, random processes prevail. The random occurrence of species suggests that these communities are not phylogenetically clustered, indicating a lack of strong environmental filtering or niche-based assembly mechanisms.

The area harbors a rich diversity of medicinal plants and provides favorable ecological conditions for their growth and natural propagation. Moreover, the ethnobotanical survey revealed that local inhabitants possess substantial traditional knowledge regarding the use of native plant species for treating common ailments and for subsistence needs such as fodder, fuelwood, and shelter. However, modernization and changing socioeconomic dynamics are leading to a gradual decline in the transmission of this indigenous knowledge, which is currently confined largely to the older population. If not documented and preserved, this cultural and medicinal heritage may be lost to future generations. The dependency of the local population on plant resources, as shown in Table 1, underscores the importance of these species not only for medicinal purposes but also for their role in daily survival strategies. Nevertheless, unsustainable harvesting practices, including overgrazing, excessive fodder collection, and logging, pose significant threats to the native vegetation. This is particularly evident in the declining populations of multipurpose species such as *Acacia modesta* and *Dalbergia sissoo*, which are increasingly vulnerable to habitat degradation.

Recommendations

In light of these findings, it is recommended that future research should focus on the conservation status and regeneration potential of key medicinal and multipurpose species in the region. There is also a critical need for community-based conservation programs that involve and educate local people about sustainable harvesting techniques. Furthermore, initiatives aimed at documenting and preserving traditional plant knowledge—especially among younger generations—should be prioritized. Integrating traditional ethnobotanical knowledge with modern conservation strategies will be vital

in ensuring both the ecological and cultural sustainability of the region's rich plant biodiversity.

References

1. Adnan, M., Tariq, A., Mussarat, S., Begum, S., Islam, A. N., & Rehman Ullah. (2015). Ethnogynaecological assessment of medicinal plants in Pashtun's tribal society. *BioMed Research International*, 2015.
2. Alam, N., Shinwari, Z. K., Ilyas, M., & Zahid Ullah. (2011). Indigenous knowledge of medicinal plants of Chagharzai Valley, District Buner, Pakistan. *Pakistan Journal of Botany*, 43(2), 773–780.
3. Cadotte, M. W., Cardinale, B. J., & Oakley, T. H. (2008). Evolutionary history and the effect of biodiversity on plant productivity. *Proceedings of the National Academy of Sciences*, 105, 17012–17017.
4. Cheng, X.-L., Yuan, L.-X., Nizamani, M. M., Zhu, Z.-X., Friedman, C. R., & Wang, H.-F. (2018). Taxonomic and phylogenetic diversity of vascular plants at Ma'anling volcano urban park in tropical Haikou, China: Responses to soil properties. *PLoS ONE*, 13(6), e0198517.
5. Donoghue, M. J. (2005). Phylomatic: Tree assembly for applied phylogenetics. *Molecular Ecology*, 5, 181–183.
6. Khan, M., Shinwari, Z. K., Shah, M., & Shahana, M. (2014). An ethnobotanical survey of medicinal and other useful plants of Khattak tribe in Tehsil Karak, Khyber Pakhtunkhwa, Pakistan. *Medicinal Plant Research*, 4(8), 61–67.
7. Khan, N., Ahmed, M., Ahmed, A., Shaukat, S. S., & Wahab, M. (2011). Important medicinal plants of Chitral Gol National Park (CGNP), Pakistan. *Pakistan Journal of Botany*, 43(2), 797–809.
8. Malik, H. M. A. (2001). Treatment through herbs. In R. Anwar, N. Haq, & S. Masood (Eds.), *Medicinal Plants of Pakistan* (pp. 21–23).
9. Murad, W., Azizullah, A., Adnan, M., Tariq, A., Ullah, K., Waheed, S., & Ahmad, A. (2013). Ethnobotanical assessment of plant resources of Banda Daud Shah, District Karak, Pakistan. *Journal of Ethnobiology and Ethnomedicine*, 9, 77.
10. Saad Ullah, Rehman Ullah, K., Sultan, M., Ihsan Ullah, & Manzoor Ullah. (2013). Biodiversity of prominent indigenous medicinal plants of Village Khujaki, District Karak, KP, Pakistan. *Journal of Medicinal Plants Studies*, 1(4), 87–92.
11. Shinwari, S., & Qureshi, R. (2011). Ethnobotanical study of Kohat Pass, Pakistan. *Pakistan Journal of Botany*, 43, 135–139.
12. Siddique, A., Akhtar, N., Khan, M. S., Anwar, M., Jan, S., & Khan, W. M. (2016). Diversity, distribution, and indigenous uses of the medicinal plants of District Karak, KP, Pakistan. *Pakistan Journal of Weed Science Research*, 22(2), 317–327.
13. Zaman, S., Hazrat, A., & Shariatullah. (2013). Ethnobotanical survey of medicinal plants from Tehsil Dargai, District Malakand, Pakistan. *FUUAST Journal of Biology*, 3(1), 109–113.
14. Zulqarnain, Z., Islam, Z. U., Zain Ullah, Rehman Ullah, Zaman, L., Faizan Ullah, Iqbal, T., & Farhad Ullah. (2017). Phylogenetic diversity and composition of plant communities in the semi-arid area of District Karak, KP, Pakistan. *Asian Journal of Plant Science and Research*, 7(5), 46–53.