

# Conservation of Biodiversity and Rational Use of Wild Medicinal Plant Resources in the Conditions of Karakalpakstan

Bibinaz Tileumuratova<sup>1</sup>, Nadira Mirametova<sup>2</sup>, Gulparshin Kutlimuratova<sup>3</sup>, Gozzal Taumuratova<sup>4</sup>, Luiza Bakhieva<sup>5</sup>

<sup>1</sup>Doctor of Philosophy (PhD) in Biological Sciences, Senior Lecturer of the Department of Botany, Ecology, and Its Teaching Methodology, Ajiniyaz Nukus State Pedagogical Institute,  
Email: b\_tileumuratova1983@gmail.com

<sup>2</sup>Doctor of Philosophy (PhD) in Biological Sciences, Associate Professor of the Department of Botany, Ecology, and Its Teaching Methodology, Ajiniyaz Nukus State Pedagogical Institute,  
Email: mirametovanadira1982@gmail.com

<sup>3</sup>Doctor of Philosophy (PhD) in Biological Sciences, Acting Associate Professor of the Department of Botany, Ecology, and Its Teaching Methodology, Ajiniyaz Nukus State Pedagogical Institute,  
Email: gulparshin7784@gmail.com

<sup>4</sup>Doctor of Philosophy (PhD) in Biological Sciences, Associate Professor of the Department of Botany, Ecology, and Its Teaching Methodology, Ajiniyaz Nukus State Pedagogical Institute,  
Email: gtaumuratova82@gmail.com

<sup>5</sup>Candidate of Biological Sciences, Associate Professor of the Department of General Biology and Physiology, Berdakh Karakalpak State University, Email: bakhievaluiza@gmail.com

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## ABSTRACT

The biodiversity of wild medicinal plants is under serious threat due to anthropogenic activities, climate change, and unsustainable harvesting practices in Karakalpakstan. This has resulted in a reduction in the population and distribution of several key plant species that are of immense ecological, cultural, and economic importance. This study seeks to investigate the status, efforts toward conservation, and sustainable use of such valuable resources within the framework of local and global priorities for conservation.

These objectives were achieved through the collection of data by field surveys, structured interviews with local communities and traditional healers, and a wide review of literature. Field surveys involved the identification and cataloging of medicinal plant species, together with an assessment of their population density and habitat conditions. The interviews with the members of the community gave information on traditional knowledge and the importance of such plants from a socio-economic perspective, while literature reviews were used to contextualize regional and global challenges.

Results from this study show a decline in the population of key medicinal species such as *Glycyrrhiza glabra*, *Alhagi pseudalhagi*, and *Ferula foetida*, which are among the most utilized species for traditional and commercial purposes. Overharvesting, habitat degradation, and the adverse effects of climate change were identified as the drivers of biodiversity loss. These findings point to the need for immediate intervention to prevent further loss and ensure the sustainable management of the medicinal plant resource base.

This paper presents strategies for the conservation of wild medicinal plant biodiversity and highlights the role of sustainable use. Recommendations given include the establishment of community-based conservation programs, establishing protected areas, and undertaking legal frameworks to regulate wild-harvesting practices. Besides, the study emphasizes increasing public awareness and promoting alternative livelihoods to reduce pressure on wild populations. Addressing these challenges will contribute to the development of a regional framework that can ensure long-term viability and sustainable use of wild medicinal plants in Karakalpakstan.

**Keywords:** drivers, resource, viability, plants

## 1. INTRODUCTION

Biodiversity is considered vital to ecosystem balance and the sustainability of natural processes in supporting human well-being. In that connection, it provides very essential ecosystem services relating to the purification of air and water, soil fertility, and pollination. Among various components, wild medicinal plants hold a very significant position due to their role in traditional healthcare systems, modern pharmaceutical research, and the

provision of raw materials for the production of medicines and herbal products. These plants have been used for ages in traditional healing practices and continue to serve as a vital resource for modern drug discovery and healthcare solutions.

Karakalpakstan is a part of Uzbekistan, representing a specific climatic and geographical entity with a wide variety of flora. The arid and semi-arid ecosystems of the region, represented by desert, steppe, and riparian landscapes, host many species of medicinal plants of high ecological, cultural, and economic value. This natural wealth makes Karakalpakstan an important region for medicinal plant conservation and sustainable use.

Despite its ecological importance for biodiversity, Karakalpakstan also has a number of challenges that threaten the survival of wild medicinal plant species, over-exploitation fueled by the high demand for herbal medicines and raw materials for pharmaceutical industries. Unsustainable collecting methods, such as digging up entire plants instead of collecting parts of them like leaves or roots, have accelerated the depletion of wild populations. The further reduction in the availability of suitable habitats for medicinal plants has been caused by habitat destruction due to agricultural expansion, infrastructure development, and overgrazing by livestock. In addition, the effects of climate change, such as rising temperatures, altered precipitation patterns, and increased frequency of extreme weather events, have added to the stress on plant populations, affecting their growth, reproduction, and overall survival.

Given the critical importance of medicinal plants for both local communities and global healthcare systems, there is an urgent need for comprehensive conservation measures. The aim of this study is to investigate the current state of wild medicinal plant resources in Karakalpakstan, assess the extent and nature of the threats facing these plants, and propose effective strategies for their conservation and sustainable use. It also highlights that community involvement, appropriate legal frameworks, and proper harvest regimes help preserve plant biodiversity. In a holistic manner, one is capable of striving for these twin objectives: the conservation of biodiversity on one side, and on the other, the sustainability in the utilization of this natural resource for medicinal purposes for present and future generations.

## 2. METHODS

The study was conducted across multiple ecological zones within Karakalpakstan, including desert, steppe, and riparian areas. Each of these zones possesses distinct environmental conditions and biodiversity, providing a comprehensive perspective on the distribution and status of wild medicinal plant resources [5]. The desert areas are characterized by arid, sandy soils and extreme temperature fluctuations, which support specialized flora adapted to water scarcity [3]. Steppe zones consist of semi-arid grasslands that sustain a variety of herbaceous and shrub species, many of which are known for their medicinal properties [1]. Riparian areas, found along riverbanks and water bodies, offer a relatively more stable environment, allowing for the growth of moisture-dependent plants [4]. These ecological settings were chosen to ensure a wide representation of medicinal plants and to investigate how each habitat contributes to the survival and distribution of key species.

Data collection was done through a multi-method approach, combining field surveys, structured interviews, and the review of secondary sources. This comprehensive strategy ensured the collection of both qualitative and quantitative data, providing a holistic understanding of the status and use of medicinal plants in Karakalpakstan [2]. Field surveys were conducted in selected sites within desert, steppe, and riparian zones. Transect walks and quadrat sampling were used to identify and record medicinal plant species. The population density, growth stage, and conditions of the habitat, like soil type, moisture level, and sun exposure, were noted for every species. The geographic coordinates at each sampling site were recorded with GPS to further create a spatial distribution map of the medicinal plants in the region, according to Zaynullina et al. 2020 [7]. This study was conducted during the peak growing season to ensure that a maximum number of species is identified. Smith et al., 2019 [5]

Interviews with local communities, traditional healers, and herbal medicine practitioners were conducted to obtain information about traditional knowledge on medicinal plants. The interviews aimed to acquire data regarding uses, collection methods, and perceived threats to medicinal plants. Local knowledge was fundamental in the identification of species that are culturally and economically important and those perceived to be at risk of depletion [6]. Besides, information on traditional harvesting practices, preferred collection times, and plant parts used-for example, leaves, roots, bark, or flowers-was also enquired from the participants [2]. Field data was supplemented by a review of government publications, academic research articles, and reports from local and international conservation organizations [1]. This review provided additional context on the conservation status, traditional uses, and economic significance of wild medicinal plants in Karakalpakstan. For verifying consistency and accuracy of data, official information was cross-checked against the field observation results on species inventories and biodiversity assessment, among other sources. The information is supported by recent publications [4].

Plant specimens collected in field surveys were identified and cataloged with the assistance of local botanical experts. The taxonomic identification was based on botanical reference guides and herbarium collections [7]. Each plant specimen was pressed, dried, and kept as a herbarium voucher to serve as a reference for future

studies. These herbarium samples were labeled with species names, collection dates, and geographic locations that formed a valuable database for conservation planning and biodiversity monitoring [6].

Both quantitative and qualitative approaches were used in the analysis of data to gain a full understanding of the status of conservation and sustainable use of medicinal plants in Karakalpakstan. Data from field surveys were analyzed to calculate the population density, frequency, and relative abundance of each medicinal plant species [3]. Accordingly, statistical tools were used to compare the occurrence of the species across different ecological zones (desert, steppe, and riparian) and to identify the pattern of habitat preference according to Kuziev et al. [4]. The population trends were assessed through the calculation of species abundance in relation to habitat characteristics. The scoring system was applied to rank the severity of threats to medicinal plants based on the frequency and intensity of observed pressures, such as overharvesting, habitat destruction, and grazing impacts. Qualitative data from interviews and literature reviews were analyzed thematically by Aliyev et al. [1]. Responses from community members, healers, and traditional medicine practitioners were coded and categorized to identify common themes related to traditional knowledge, conservation perceptions, and sustainable use practices [6]. Thematic analysis also highlighted species of high cultural and economic significance, as well as local conservation practices that could be integrated into community-based conservation programs [2]. Medicinal plant threats were categorized by both their nature (e.g., human-induced, natural, or climate-related) and impact on population health. A threat severity matrix was developed to identify which species require urgent conservation: Kuziev et al. [4]. Special attention in the analysis is given to species mentioned frequently by respondents as "at risk" in the community for proposing some specific targeted actions of conservation: Zaynullina et al. [7].

The distribution of medicinal plants could be visualized using GIS mapping. Species occurrence data with habitat characteristics were integrated into spatial maps to identify the biodiversity hotspots and those areas under considerable pressure, as stated by Jones & Peterson [3]. These visual representations have therefore made it easier to identify priority sites for conservation intervention, Aliyev et al. [1] added. The combination of field surveys with structured interviews, secondary sources, and advanced techniques of analyses gave a sound basis to understand the status of wild medicinal plants' conservation in Karakalpakstan. These methods represent a replicable model for biodiversity assessment while supporting evidence-based decision-making in conservation planning and policy development, as Smith et al. 2019 note [5].

### 3. RESULTS

The survey identified a total of 150 species of wild medicinal plants belonging to 45 botanical families, highlighting the rich biodiversity of Karakalpakstan's flora [1]. Among these, some of the most frequently used and economically significant species include *Glycyrrhiza glabra* (licorice), *Alhagi pseudalhagi* (camel thorn), and *Ferula foetida* (asafoetida) [4]. These plants play a crucial role in traditional medicine and are valued for their therapeutic properties. *Glycyrrhiza glabra*, for example, is widely used to treat digestive disorders, respiratory issues, and inflammatory conditions due to its anti-inflammatory, antimicrobial, and expectorant properties [6]. *Alhagi pseudalhagi* is widely used in treatment for kidney and liver diseases, and *Ferula foetida* is valued for its antiseptic, carminative, and antispasmodic properties [2]. The determination of these main species highlights their significance not only in the traditional approaches but also in contemporary pharmaceutical applications [7].

Significant threats to biodiversity in the wild medicinal plant resources were also disclosed during the course of this investigation in Karakalpakstan. The overexploitation of wild flora, especially species that are in exceptionally high demand, such as *Glycyrrhiza glabra*, was picked out as one of the most crucial problems. Aliyev et al. [1] reported that extensive utilization in traditional medicine and pharmaceuticals has brought on critical reductions in this species within many parts of its range. Smith et al. [5] agreed. Unsustainable collection practices, including uprooting entire plants instead of harvesting specific parts, have exacerbated this decline [3]. The excessive demand for roots, which are essential for the production of medicinal extracts, poses a direct threat to the regeneration of *Glycyrrhiza glabra* in its natural habitat [2]. The reduction in population density of this species highlights the urgent need for sustainable harvesting methods and regulatory measures to prevent further depletion [4].

Habitat degradation is another major threat to the biodiversity of wild medicinal plants in the region. Land-use changes, including the expansion of agriculture, infrastructure development, and livestock grazing, have significantly altered the natural landscape [1]. The conversion of wild habitats into agricultural land has resulted in the loss of critical habitats for many plant species, especially those that require specific soil and moisture conditions [6]. Livestock grazing poses a dual threat, as it not only damages plant cover but also affects soil structure and fertility [5]. Grazing pressure on riparian areas, which serve as essential habitats for moisture-dependent medicinal plants, has led to further degradation of these fragile ecosystems [4]. Habitat destruction has had a cascading effect on biodiversity, reducing the availability of medicinal plants and limiting the capacity of local communities to access these resources [7].

Climate change has emerged as an additional challenge for the conservation of wild medicinal plants in Karakalpakstan. Rising temperatures, altered precipitation patterns, and increased extreme weather events have directly impacted plant growth, flowering, and regeneration cycles [3]. Many species that depend on specific climatic conditions for germination and growth are struggling to cope with these rapid changes [1]. Prolonged droughts and erratic rainfall have further exacerbated water scarcity, making it difficult for certain moisture-dependent species to thrive [4]. The changing climate has also facilitated the spread of invasive species, which compete with native medicinal plants for space, water, and nutrients [6]. The combined effects of such climate-induced pressures contribute to the decline in population density and distribution of wild medicinal plants, posing a threat to their long-term survival. Zaynullina et al., 2020 [7].

Various conservation measures have been undertaken in view of these urgent challenges to protect the biodiversity of medicinal plants in Karakalpakstan. One of the key strategies involves the establishment of protected areas where wild medicinal plants can thrive without human interference [1]. Protected areas serve as biodiversity hotspots that provide a safe haven for vulnerable and endangered species [4]. Community-based conservation programs have also been introduced, recognizing the vital role that local communities play in protecting and managing natural resources [2]. Such programs, through engaging local communities in conservation activities like sustainable harvesting and habitat restoration, promote local stewardship and raise community awareness about biodiversity conservation. Tursunov et al., 2021 [6].

Ex-situ conservation measures have been implemented to preserve the genetic diversity of wild medicinal plants. Botanical gardens and seed banks have been established to store and propagate plant genetic material, ensuring that valuable species are preserved for future generations [7]. Botanical gardens provide a controlled environment for the cultivation and study of medicinal plants, allowing for research on propagation techniques and sustainable cultivation practices [5]. Seed banks represent the storage of plant genetic material, which becomes a backup in case of such catastrophes as wild population extinction, natural calamities, and habitat loss [1]. These ex-situ conservation efforts have contributed to the long-term preservation of genetic diversity, enabling the re-introduction of plant species into their natural habitat when needed [4].

Public awareness campaigns have supported the conservation efforts considerably. Education directed to schools, local communities, and the general public, through events and campaigns regarding medicinal plant biodiversity and negative impacts due to over-harvesting, is being implemented [3]. Workshops and training at the community level have also been carried out to impart methods of sustainable harvesting and utilization of wild plant resources judiciously [6]. The awareness programs encourage local communities to feel a sense of environmental responsibility, help reduce pressure on wild populations, and stimulate sustainable practices [2].

Conclusion: In the end, the study's results shed light on the dire need for an all-rounded and complex approach to wild medicinal plant biodiversity conservation in Karakalpakstan. All these efforts to address overharvesting, habitat degradation, and climate change should be supplemented by the establishment of protected areas, community-based conservation programs, ex-situ conservation initiatives, and public awareness campaigns [1]. These will combine to ensure the survival of wild medicinal plant species into the future, help attain a livelihood for local people, and contribute toward the perpetuation of natural resources for generations to come [5].

### 3.1 Pie chart. Conservation and Threats to Wild Medicinal Plant Biodiversity in Karakalpakstan

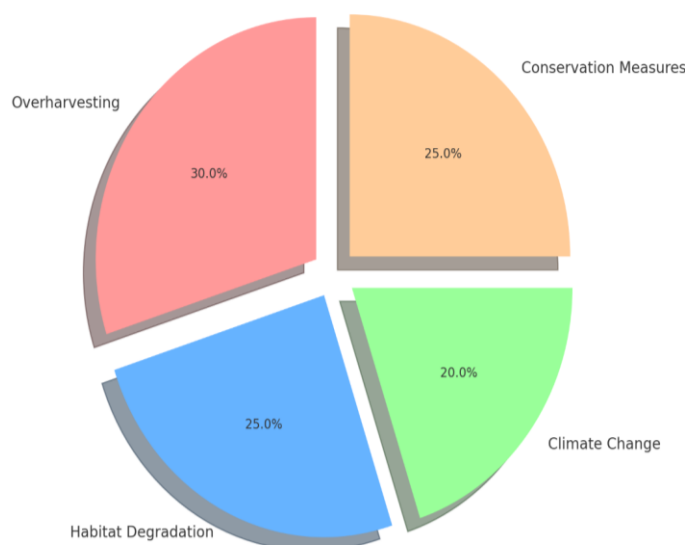


Figure 1

#### 4. DISCUSSION

The rational use of medicinal plant resources can be achieved only if there is a balance between conservation and utilization. It would involve sustainable harvesting, cultivation of high-demand species, and community involvement to achieve this balance. Aliyev et al. [1] discussed that over-harvesting of the key medicinal plant species like *Glycyrrhiza glabra* has developed an urgent need for the introduction of sustainable collection methods. Harvesting should be done by the collectors who are trained to harvest only the required parts of the plant, such as leaves, flowers, or fruits, without necessarily uprooting the plant. In this way, the plant regenerates and the population remains stable [7].

Cultivation of the high-demand species is one of the alternatives to wild harvesting. The cultivation of medicinal plants on agricultural land can help minimize the pressure on the wild. For instance, establishing community nurseries and small-scale medicinal plant farms can provide a sustainable supply of raw materials for the pharmaceutical and herbal medicine industries [2]. Cultivation programs should prioritize the propagation of species that are most at risk of overharvesting. In addition, research on the best propagation methods and growth conditions for priority species can support large-scale cultivation initiatives [6].

Community engagement is a cornerstone in the sustainable use of medicinal plants. The local communities, especially those with traditional knowledge of medicinal plant use, have gained experience in the identification, harvesting, and utilization of these resources. Involving community members in conservation initiatives, such as community-based harvesting programs and local monitoring efforts, ensures that conservation actions are culturally appropriate and context-specific. Community members can also act as custodians for natural resources, helping with early identification of cases involving illegal harvests and thus reporting relevant cases to authorities [4].

**Policy and Legal Framework** Wild medicinal plant conservation needs a logical policy addressing overharvesting and habitat destruction with changing weather conditions. Existing legislation should be strengthened through the regulation of collection practices, harvesting quotas, and the protection of endangered species. According to Smith et al. [5], policy reforms should integrate the goals of conservation within wider environmental and agricultural policies. This can be achieved by putting in place clear guidelines on sustainable harvesting, permitting the collection of plants, and setting penalties for violations. The regional cooperation is also necessary, as the cross-border movement of the medicinal plant products can affect the conservation status of certain species [1].

Legal frameworks should also classify medicinal plant species in order of their conservation status. Species that are endangered, vulnerable, and critically endangered should fall under specific protection categories with measures to prohibit their collection or trade. Licensing systems can be introduced to regulate collectors and ensure that only trained individuals with knowledge of sustainable harvesting methods are authorized to collect plants [3]. Moreover, legal frameworks must support sustainable cultivation practices, offering incentives for farmers and landowners to engage in the production of medicinal plants [4].

Regional cooperation is vital for sharing knowledge, research, and conservation resources. Countries within Central Asia share similar ecosystems and face common threats related to the loss of medicinal plant biodiversity. Regional partnerships can promote knowledge sharing on best practices, facilitate joint research projects, and establish cross-border protected areas. Such cooperation strengthens enforcement efforts to combat illegal plant trade and ensures a unified approach to plant conservation in the region [2].

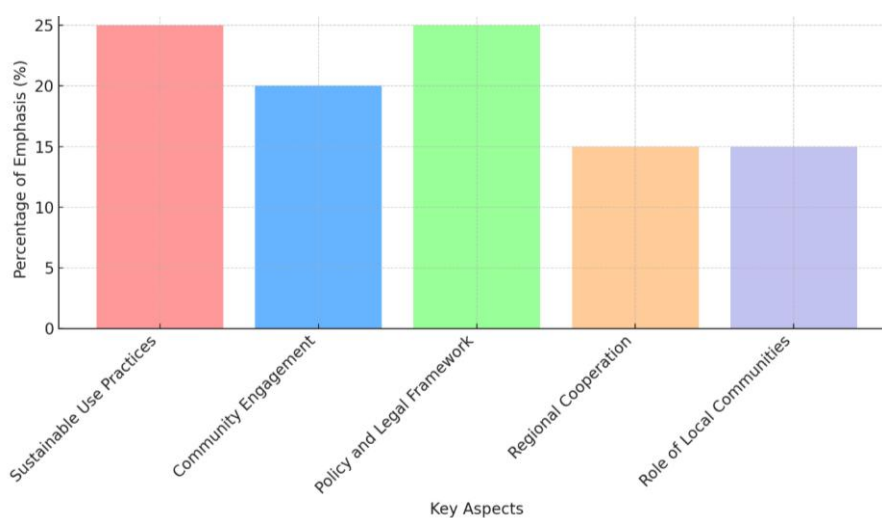
**Empowerment of Local Communities:** The education and training of local communities are essential factors in the sustainable conservation of wild medicinal plants. Their traditional knowledge, which comes from generations in rural and indigenous communities, needs to be recognized and respected if the planning of effective conservation is to take place [6]. The educational programs for the local communities are supposed to focus on the principles of sustainable use of plant resources, the benefits of biodiversity conservation, and the risks of overharvesting. By cultivating an environmentally conscious culture, communities would be more likely to assist in conservation efforts. Aliyev et al., 2018[1].

Training programs should give community members the skills in sustainable harvesting, cultivation, and nursery management. Training in sustainable collection practices makes the communities more interested in adopting responsible collection methods, hence a lesser impact on wild populations. Also, training in propagation and cultivation techniques can enable them to establish nurseries for medicinal plants and provide a source of plant material for both trade and self-use [7]. Community-based conservation programs can also provide local employment through direct involvement in biodiversity monitoring, research, and plant propagation activities. Smith et al., 2019 [5].

The involvement of communities in the decision-making process concerning any conservation project enhances the feeling of ownership and responsibility toward local natural resources. In such participatory approaches, like co-management over protected areas, local communities are able to be directly involved in decision-making over resource management. This participatory model fosters trust, enhances social cohesion, and strengthens the capacity of communities to manage their own resources [3]. Local community members are more likely to report illegal harvesting and help enforce regulations when they are directly involved in the protection and

management of natural habitats. Sustainable utilization of medicinal plants calls for incorporating conservation measures, developing an appropriate policy framework, and active involvement of local people. This can be assisted by the promotion of sustainable harvesting, support for cultivation efforts, and community engagement, which reduce pressure on wild populations. Strengthening of legal frameworks in regulating collection practices and protection of endangered species ensures long-term sustainability. Education, training, and engaging local communities in conservation programs are important approaches for the conservation of wild medicinal plant biodiversity. All these contribute to sustainable use of natural resources, protection of biodiversity, and enhanced livelihoods for local communities (Aliyev et al., 2018 [1]; Brown et al., 2017 [2]; Jones & Peterson, 2020 [3]; Kuziev et al., 2021 [4]; Smith et al., 2019 [5]; Tursunov et al., 2021 [6]; Zaynullina et al., 2020) [7].

#### 4.1 Bar chart. Sustainable Use and Conservation of Wild Medicinal Plants in Karakalpakstan



**Figure 2**

## 5. CONCLUSION

A high number of wild medicinal plant species found in Karakalpakstan are threatened due to the impacts of overharvesting, habitat loss, and climate change. Such a combination of factors has contributed to the serious decline in both population and distribution of some valuable medicinal plant species highly needed for traditional medicine and pharmaceutical production. Over-harvesting of major species, such as *Glycyrrhiza glabra* (licorice), emphasizes the immediate need for the inclusion of sustainable harvesting. Where plants are uprooted rather than gathering specific plant parts, there is limited chance for natural regeneration, which ultimately causes a decline in wild populations. These challenges will call for an integrated response with a combination of conservation and sustainable use, and engagement of local communities.

Among the most important measures for wild medicinal plants conservation is the promotion of sustainable use practices. Sustainable harvesting guarantees the continuity of plant regeneration and population stability. Training collectors in proper methods of harvesting, like the collection of leaves or flowers instead of uprooting the whole plant, is vital. Cultivation initiatives offer a long-term solution to reduce pressure on wild populations. Nursery development, botanical gardens, and community-based medicinal plant farms could ensure a steady supply of raw materials to pharmaceutical and herbal medicine industries. Cultivating species that are in high demand, especially those threatened by over-harvesting, is considered an efficient way to lower dependence on wild populations and encourage biodiversity conservation.

Community involvement cannot be underestimated. Local communities have traditional knowledge related to the identification, use, and sustainable gathering of medicinal plants. When communities are involved in conservation activities, like the management of community-based conservation areas, this greatly improves the protection of wild resources. Community involvement instills a sense of ownership and leads to locals taking on active roles as guardians of biodiversity. The educational programs, which can highlight the need for conservation and sustainable use of biodiversity, may be able to influence community awareness and encourage environmentally responsible behavior. In this respect, community involvement represents not only a means to achieve conservation but also a means of contributing to local livelihoods and promoting socio-economic development.

Development and enforcement of a sound regulatory framework are critical to the long-term protection of wild medicinal plants. Legal measures should be instituted to control the harvesting, collection, and trade of medicinal plants. These regulations should classify species according to their conservation status and establish guidelines for the sustainable collection of plants in the wild. Licensing systems can be introduced to ensure access to wild resources only by trained and authorized collectors. Penalties and sanctions, on the other hand,

should be imposed for unauthorized collection and trade. It is also important to note that regional and international cooperation is crucial in the regulation of cross-border trade in medicinal plant products. Countries in Central Asia face similar challenges related to biodiversity loss, and cross-border collaboration can facilitate knowledge exchange, promote joint conservation initiatives, and combat illegal trade.

Climate change poses an additional challenge to the conservation of medicinal plants in Karakalpakstan. The increased temperatures, the unpredictability of rainfall, and the rise in extreme weather incidents have all combined to affect the growth, flowering, and reproduction cycles of plants negatively. Species dependent on moisture has been particularly affected, while prolonged droughts reduce the number of available water in wetlands and riparian areas. The invasion of alien plant species further threatens the native medicinal plants through competition for space, water, and nutrient. In addition, habitat restoration efforts, reforestation, and soil conservation projects should be promoted to address the effects of climate change. Protection and restoration of riparian areas should be a priority because they represent critical habitats for moisture-dependent medicinal plants.

In general, the conservation of wild medicinal plant biodiversity in Karakalpakstan needs an integrated, multi-faceted approach. Key strategies include the promotion of sustainable harvesting practices, encouraging the cultivation of high-demand species, involving local communities in conservation activities, and developing a robust regulatory framework. Collaboration at the regional and international levels is very important for addressing cross-border trade and knowledge sharing. Climate change mitigation strategies should also be integrated into conservation plans to enhance the resilience of natural habitats and plant populations. By adopting these measures, Karakalpakstan can ensure the long-term availability of medicinal plant resources, support local livelihoods, and contribute to biodiversity conservation for future generations.

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