Ecological footprint and sustainability aspects of commercially harvested non-timber forest products (medicinal and aromatic plants) in Hindu Kush Himalayan region of Swat Pakistan

Hazrat Bilal (✉ hazrat.mses599@iu.edu.pk)
Beijing Normal university

Hassan Sher
University of Swat

Xiaowen Li
Beijing normal university

Rabia Quraishi
University of Swat

Research

Keywords: NTFPs, MAPs, Acorus calamus, Podophyllum hexandrum, Trillium govanianum, Morchella esculenta

DOI: https://doi.org/10.21203/rs.3.rs-62303/v1

License: This work is licensed under a Creative Commons Attribution 4.0 International License.
Read Full License
Abstract

Background

Environmental and ecological stability has been compromised globally as a result of increasing demand and commercial abuse of natural resources. Un-sustainable harvesting of non-timber forest products (NTFPs) has substantially challenged the survival of many wild plants, especially medicinal and aromatic plants (MAPs), resulting in the extinction of many important species either at local or global levels. To study the ecological aspects and consequences of commercial harvest of medicinal and aromatic plants in Hindu Kush Himalayan region District Swat, a study was designed to carry out extensive market surveys, and observe commercial harvesters in wild to find the symptoms of over or destructive harvesting. We examined three perspectives: herbal market, collectors and post-harvest survival of these species.

Results

Among 70 targeted species, about 69% were found to be harvested exclusively from wild, while only 7% were found to be collected from cultivated source. Hence our three-way investigation helped to differentiate among species with no sustainability issues, and species with conservation urgencies, i.e. Species like *Acorus calamus, Podophyllum hexandrum, Trillium govanianum, Morchella esculenta, Paeonia emodi* were found struggling for survival. This research demonstrates that amplified commercialization of these medicinal plants play a vital role in the decline of the resource and species loss. The economic value was also found to have a considerable impact on the survival of plant species (i.e. in case of *Trillium govanianum* and *Morchella esculenta*), which are collected from the wild in bulks to make more economic benefits hence compromising post-harvest survival of these species.

Conclusion

With the increasing market demand and commercialization of these herbal species, District Swat should be considered a priority zone for medicinal plant conservation and promotion of sustainable extraction practices. Also engage local people of the area to conserve aspects of these ecological resources which are critically important for their livelihoods, which may also lead to a long-term public support for conservation of globally exhausted ecological resources and threatened biodiversity.

1. Introduction

The use of medicinal plants is ancient and vital to health care of millions of individuals, the primary health care of almost 80% population of the world is based on traditional herbal medicines, and medicinal plants have a significant role for the rest of 20% as well, Medicinal and aromatic plants also play a vibrant role in modern economies in the form of rural livelihood and traditional healthcare (Darper et al. 2016; Sher et al. 2016; Tareen et al. 2016). The global herbal remedies are estimated to be approximately US$ 23 billion
annually, which play a substantial role in the economies of herbs producers (Schippmann et al. 2002). Almost two-thirds of the reported 50,000 medicinal and aromatic plant species come from the wild (Edwards 2004). Previously collection of medicinal plants was mostly done by traditional healers. But due to the increased demand, collection of these medicinal plants has become the field of inexperienced and apathetic commercial collectors (Williams et al. 2000). Over the last decade, a significant commercial and scientific trend of herbal based products has been observed due to its economic potential and widespread cultural suitability (Sher et al. 2014, 2015a). One of the most devastating problems occurring throughout the world is the extinction of species, and the situation is worsening in the developing countries (Rahbek & Colwell, 2011; Tedesco et al. 2014; Tahir et al. 2016). The common interest concerning biologists and conservationists over the past decade is conservation and preservation of the endangered species. Many people are attached to the trade of medicinal herbs which have been commonly used by the locals to cure various ailments since pre-historical times, and that is the reason why medicinal plants are overexploited and are becoming extinct (Qureshi et al. 2009). However, the un-sustainable collection threatens not only the survival of these medicinal herbs but also the livings of people dependent on them. So these species should be given conservation priorities to protect them from extinction as a result of overexploitation (Hamilton, 2006).

1.1 Study Area

Swat valley is among the significant valleys of Hindu Kush mountains system and an administrated district of KPK province of Pakistan, situated between 341340o-351550o north latitude and 711100o-721500o east longitude having an altitude of about 733 m in the south to 6261 m in the north (Rahman and Khan, 2011; Qasim et al. 2011; Bilal et al. 2016). With the highest peak of Falaksair (6261 m) (Ali et al. 2012; Shah et al. 2016). The uneven topography of Swat valley, and its range of Altitudes and exposures significantly modify the climate within the area. Therefore seven climatic and vegetation zones can be found in the area, i.e. alpine forest, dry temperate forest, subalpine forest, Subtropical chirr pine forest, dry subtropical broad-leaved forest, moist temperate forest, and tropical dry deciduous forest each with its unique climate (Champion et al. 1965).

2. Methods

Fieldwork and market surveys were carried out in 2018-20, In April–July 2018, we carried out systematic quantitative surveys on several herbal markets in District Swat and species, price, uses and volumes of Medicinal and aromatic plants sold were recorded from about 220 collectors, traders, and practitioners. We enquired about the quantity of Medicinal and aromatic plants they collect, buy, sell, and discard per week. They were also asked for the abundance and popularity of these species in the area. The data collected helped us calculate the bulk and economic value of plant material available in the market. Afterwards, we estimated total yearly sales of these species (van Andel et al. 2008). Particular picking techniques, the part collected, the observed collection sites and the vegetation type where it was extracted are some of the vital information which was recorded for each species. During field surveys, we also tried to record indigenous management systems prevailing in the area and searched for potential signs of destructive collection, i.e.
killing of individual plants due to destructive and unsustainable harvest. We watched collectors during medicinal plant collection in forest fields and house yards, and identified wild-harvested, cultivated wild plants and domesticated exotics. We also tried to find out the factors behind high economic value and demand in the market. We also compared the prices, current conservation status, post-harvest survival, market supply and availability to identify species with conservation priorities. The data collected was authenticated by the help of different experts, practitioners, Sellers, Users and the available literature.

2.1 Identifying Species with conservation priorities

For classification of species on the bases of conservation priorities, a protocol modified by Albuquerque et al. (2011b), was followed. This takes into account data on the availability of medicinal plants species in the wild in addition to the data on the local uses of each specie. Current study considered this a starting point for the analysis of conservation priorities from a temporal perspective (Souza et al. 2017).

3. Results

3.1 Potential collection sites and Markets in the Area

Given the lack of inventory data and economic analysis at the local level, there exist a minimal data for international trade, domestic production, trade and consumption of Medicinal and aromatic plants in Pakistan as a whole and District Swat in particular. In this study, we tried to collect the grass-root level data and authenticate it from different experts, practitioners, traders, users and available literature.

The study found that District Swat has been contributing a fair amount of medicinal plants to the national and international markets. Mingora is the largest Medicinal and aromatic plants market of the area. As the centre for trade of medicinal plants, it offers inimitable prospects to obtain facts and figures from both collectors and traders about the volumes, diversity and sources of medicinal plants supply. It also give information regarding urban users and their medicinal plant preferences. The study area has a vibrant potential of Medicinal and aromatic plants. After analyzing all the data it is evident that most of the medicinal plants about 63% are being collected from Kalam, Malamjaba, sakhra, Lalku, Elum, Kala kaly and Spin sar areas, the total amount of these leading medicinal and aromatic plants produced is about 210 tons. The survey also shows that about 71% of families living in these areas are solely dependent upon the collection of these medicinal and aromatic plants, while some are found to be part-time collectors. According to the survey conducted average per day collection of these medicinal and aromatic plants from wild sources ranges from 0.5 to 5 kg per day per family.
Table 1
Leading medicinal plants, their local names, source and part used reported by local collectors and traders n = 220.

| Family       | Specie                  | Local Name   | Part Used    | Source |
|--------------|-------------------------|--------------|--------------|--------|
| Acoraceae    | Acorus calamus          | Skha waja    | Rhizome      | W      |
| Alliaceae    | Allium sativum          | Ooga         | Bulbs/ leaves | C/D    |
| Alliaceae    | Allium cepa             | Pyaz         | Bulbs/ leaves | C/D    |
| Anacardiaceae| Pistacia integerrima    | Shanai/ Kakra singi | Leaves      | W      |
| Araliaceae   | Artemisia vulgaris      | Tarkha       | Leaves/ shoot | W      |
| Asteraceae   | Saussurea lappa         | Kut          | Root         | C/W    |
| Berberidaceae| Berberis lyceum        | Spen Kwarey  | Whole plant  | W      |
| Berberidaceae| Podophyllum hexandrum   | Kakora       | Dried rhizome | W      |
| Cucurbitaceae| Cucumis sativus         | Kado         | Seed         | C/D    |
| Geraniaceae  | Geranium wallichianum   | Ratan joth/ Sra zela | Root      | W      |
| Lamiaceae    | Ajuga bracteosa         | Booti        | Dried Herb   | W      |
| Melanthiaceae| Trillium govanianum     | Mather jarhi | Root         | W      |
| Morchellaceae| Morchella esculenta     | Gughī        | Dried whole body | W      |
| Paeoniaceae  | Paeonia emodi           | Mamekh       | Dried herb   | W      |
| Papaveraceae | Corydalis stewartii     | Mamera       | Rhizome      | W      |
| Poaceae      | Trachyspermum ammi      | Sperkai      | Dried fruit  | W      |
| Ranunculaceae| Aconitum violaceum      | Zahar Mora   | Rhizome      | W      |
| Rosaceae     | Rubus fruticosus        | Karwara      | Fruit        | W      |
| Rutaceae     | Zanthoxylum armatum     | Dambara      | Dried fruit  | W/C    |
| Saxifragaceae| Bergenia ciliata        | Qamar Panra  | Leaves; Rhizome | W      |
| Solanaceae   | Atropa acuminate        | Bargak       | Root         | W      |
| Valerianaceae| Valeriana jatamansi     | Mushk-e-Bala | Rhizome      | W/C    |
| Violaceae    | Viola biflora           | Banafsha     | Flower/Whole plant | W/C |

W=Wild, C=Cultivated, D=Domesticated,

3.2 Collector’s knowledge about sustainable collection, handling and processing of medicinal and aromatic plants
After collection, these medicinal plants go through many processes, i.e. drying, smashing, boiling and grinding to get ready to be applied for different ailments by the local community or become a part of many complex Compounds and products to be marketed locally, nationally and internationally. These activities are found to have impacts on the survival and sustainability of these medicinal plants (Fig. 6). Although many projects have been executed since 2009 in the area by some local, national and international non-government organizations i.e. National rural support program NRSP, Human development organization doaba HDOD, The United Nations Development Program UNDP and LASUNA etc. to promote and train the collectors for proper and sustainable collection and handling, most of the collectors and handlers 74% still are having no technical knowledge for sustainable harvest, handling and processing of medicinal and aromatic plants as shown in (Fig. 2).

Which is why only about 45% of the collected plant material was found good enough to be sold in international (18%) and national markets (27%), 24% of the collected plants were good enough to be used locally while 31% get wasted. After a detailed investigation of the wasted material, we found 56% of the material get wasted due to improper handling during collection, processing, storage and transportation. While the remaining 44% was due to non-selective collection, i.e. either the wrong part of the potential plants collected or whole plant collected instead of potential part. Hence lack of knowledge about how to collect, what to collect and how to handle, process and store material after collection not only make the collectors unable to get excellent material and maximum financial benefits but leads to unsustainable harvest and pose threats to post-harvest survival of this ecological resource (Fig. 6).

3.3 Role of medicinal and aromatic plants in poverty alleviation and local economy and health care system.

People in the rural areas of district swat were found dependent on these ecological resources for their livelihood. Poverty in the area seems to contribute to biodiversity loss, but it is only one of the multiple factors we found. Whether they conserve or overexploit, this resource is dependent upon specific conditions and circumstances and particularly on the influence of external governing influences. The respondents representing all stakeholders were interviewed regarding the benefits and impacts of collection and trade of medicinal and aromatic plants. After analyzing, the data revealed a vital role of medicinal and aromatic plants to the health care system and economy of the area. Many economic, medicinal, and religious uses and benefits of these plants were reported by the respondents. The survey also shows that about 71% of families living in these areas are solely dependent upon the collection of these medicinal and aromatic plants, while some are found to be part-time collectors. While some of the collections were solely for personal medicinal use which would indirectly help minimizing health care costs for these families Fig. 3.

Most of the collectors were collecting Medicinal and aromatic plants to earn their livelihoods. The range of earnings from medicinal and aromatic plants collection reported was about PKR 300–2500 per day/family.
Many local practitioners were also found getting financial benefits from the business of medicinal and aromatic plants but among all the stakeholders wholesale traders 57% were found to be the top beneficiaries because they make considerable profits from the trade activities by selling these medicinal and aromatic plants in different national and international markets. Overall reported medicinal and aromatic plants were found to contribute about 2.3 million USD to the local economy based on local market survey. And hence play a vital role in poverty alleviation. The study also found that if the collectors are adequately trained for sustainable and selective harvesting, the economic benefits of Medicinal and aromatic plants will increase by about 30% in the area.
### Table 2
Economic value and total turnover of the reported medicinal plants.

| Species                     | Quantity (Kg) | Turnover (Million PKR) |
|-----------------------------|---------------|------------------------|
| Acorus calamus              | 24000         | 7.680                  |
| Allium sativum              | 45000         | 12.60                  |
| Allium cepa                 | 73000         | 4.380                  |
| Pistacia integerrima        | 3000          | 3.900                  |
| Artemisia vulgaris          | 2500          | 0.250                  |
| Saussurea lappa             | 4200          | 0.840                  |
| Berberis lyceum             | 2200          | 0.660                  |
| Podophyllum hexandrum       | 2000          | 1.000                  |
| Corydalis stewartii         | 4000          | 1.560                  |
| Geranium wallichianum       | 2200          | 0.880                  |
| Ajuga bracteosa             | 2000          | 0.160                  |
| Trillium govanianum         | 3000          | 126.0                  |
| Morchella esculenta         | 5000          | 70.00                  |
| Paeonia emodi               | 8000          | 0.800                  |
| Corydalis stewartii         | 4000          | 1.600                  |
| Trachyspermum ammi          | 1500          | 0.450                  |
| Aconitum violaceum          | 800           | 14.40                  |
| Rubus fruticosus            | 3900          | 1.560                  |
| Zanthoxylum armatum         | 3000          | 1.200                  |
| Bergenia ciliate            | 5000          | 1.750                  |
| Atropa acuminata            | 4000          | 0.800                  |
| Valeriana jatamansi         | 3000          | 1.500                  |
| Viola biflora               | 4000          | 12.00                  |

#### 3.4 Ecological impacts of the trade in medicinal and aromatic plants: Threat factors

The commercial exploitation of medicinal and aromatic plants raises serious concerns about the environmental consequences of the practice on wild medicinal plants species and the ecosystems from...
which they are obtained. However, the use of wild plant resources are not detrimental in itself, but the commercialization of these Medicinal and aromatic plants are considerable in the area. We found a direct relationship between the economic importance (Price) of a medicinal plant and its survival challenge Fig. 8.

The impacts of commercialization of these species was evident in the case of *Trillium govanianum*, which was nearly vanished from the wild at once when a local NGO made the people aware of the economic importance of the specie. Same is the case *Morchella esculenta* in the area. Besides, increasing pressure on plants populations in the wild can be witnessed as a result of over and unsustainable exploitation of medicinal and aromatic plants from wild resources, lack of knowledge about the potential part of the plant to be collected, destructive collection, improper handling and processing, craze of money-making and habitat loss as a result of deforestation and agricultural encroachments.

### 3.5 Commercial exploitation and species with conservation priorities

On the basis of regular field visits, observations, interviews from collectors, availability in the market, part used and available literature it was concluded that many of the above mentioned plants species are under immense pressure. Species like *Acorus calamus, Podophyllum hexandrum, Trillium govanianum, Morchella esculenta, Paeonia emodi, Aconitum violaceum, Bergenia ciliata, Valeriana jatamansi, Viola biflora* were found at the verge of locally endangered. These species are also reported by Hamayun et al. 2003, Hamayun et al., 2006, Ullah & Rashid 2014.
Along with other factors, i.e. destructive harvesting, miss handling and habitat loss, the overharvesting as a result of the commercialization of these species was found to challenge the survival of these important species.

We found a direct relationship between the economic importance (Price) of a medicinal plant and its survival. The impacts of commercialization of these species was evident in the case of *Trillium govanianum* which was nearly vanished from the wild at once when a local NGO made the people aware of about the economic importance of the specie. Same is the case *Morchella esculenta* in the area these days. If solid steps for training and educating the collectors for sustainable collection of Medicinal and aromatic plants are not taken in time, the area may lose its treasure of this precious natural resource.

### 4. Discussion
On the bases of above results it is evident that the livelihood of most of the people living in the investigated sites depend upon the collection and sale of NTFPs especially medicinal and aromatic plants (MAPs). Also reported by Sher et al. (2005, 2010b) and Lange (1998) that about 5000 poor families in the area are involved in the collection and marketing of medicinal and aromatic plants. The geo-climatic condition of the study area offers an ideal environment for many high value medicinal and aromatic plants. Hence contributing to economic development of the local people, in particular, and the country in general. But recently it is observed that the natural regeneration ability of these important plants is badly affected by over exploitation for commercial use, deforestation, urbanization, over grazing and by their unauthorized harvesting in the area.

The study on the trade pattern revealed that various MAPs are traded in large amounts both in local, national and international markets. However, unfortunately, due to commercialization and unsustainable harvest, both the population and diversity of these medicinal and aromatic plants is declining at alarming rate. The natural resources are not managed scientifically, and therefore, these resources are rapidly declining in the study area. Analysis of market, harvesters, and plants indicate that except few species, i.e., cultivated or domesticated, all the other wild plants species i.e. *Acorus calamus*, *Morchella esculenta*, *Podophyllum hexandrum*, *Bergenia ciliate*, *Trillium govanianum*, *Paeonia emodi*, *Viola biflora*, *Aconitum violaceum* and *Valeriana jatamansi*, were found at the verge of locally endangered as a result of the commercialization and over harvest to the limits, since there is no cultivation for these species, many of them are struggling for survival in the area. It was witnessed that until the decline of wild resources, the local people seem to have no intentions to cultivate these plants species. For some of them cultivated plants are qualitatively substandard to wild-gathered plants.

Moreover, most of the collectors in the area are seasonal Collectors who collect and sell plants in their free time, also called occasional collectors and do not care about post-harvest survival and sustainability of the wild natural resource but their income. They come and sweep the area in days while the local people who are solely dependent upon these wild resources are more concerned about the sustainability of these resources for their survival. Other factors like conflicting land use, cattle ranging, large-scale logging, agriculture, tourism, and deforestation are also responsible for these resources to become scarce. Moreover sustainable harvesting of these plants depends on knowledge of the proper methods of harvesting, time of harvesting and parts used, we have found 74% of the collectors in this area do not have appropriate knowledge for sustainable harvesting of these valuable resources in the wild while Some times daily wage laborers working for PKR. 200–300 per day are hired by the local agents to collect and handle these plants. As a result, the considerable amount of plant material is lost during collection, drying, cleaning, grading, processing and packing at each level of value addition process.

The present study also evaluated price trends and patterns of these marketed plants from collectors to the international markets and their impacts on the survival of the species having high market values. Most of the plant species having high market and medicinal value are vulnerable as there exist no management structure for to the exploitation of these resources. Hence, the rate of harvest is much more and beyond their regeneration ability. Destructive harvesting techniques, Over-extraction and habitat loss are some of
the severe threats to MAPs in the area. It was also revealed that harvesters now need to put more energies and walk longer distances for collection of the same materials of plants as compared to past twenty years. The price MAPs was found lowest at the collector's level and increasing much folds from collectors to the national and international markets. Among many, one of the causes for the lower price at collector's level was lack of awareness, as the plant material is mostly handled by untrained people. And results in loss of valuable plant materials due to lack of sustainable scientific methods and knowledge for collection of medicinal and aromatic plants. It was also observed that MAPs are collected without any proper check, hence results in loss of biodiversity and depletion of wild natural resources.

5. Conclusion

The current study demonstrates that the amplified commercialization, along with other numerous factors is playing a vital role in the decline of Medicinal and aromatic plants resources and species loss in Hindu Kush Himalayan region of Swat Pakistan. More than half of commercial species are found to be harvested exclusively from the wild and hence results in a considerable decline of resources in the wild. And hence species like *Acorus calamus*, *Podophyllum hexandrum*, *Trillium govanianum*, *Morchella esculenta*, *Paeonia emodi*, *Aconitum violaceum*, *Bergenia ciliata*, *Valeriana jatamansi*, *Viola biflora* are struggling for survival. The study also found that the market value of these resources has a considerable impact on the survival of plant species (i.e. in case of *Trillium govanianum*). So keeping the increasing market demand and role of commercialization of these herbal species to the welfare and economy of the local people, District Swat should be considered priority zone to promote sustainable medicinal plant conservation, cultivation and extraction. Therefore there is a need to discover and promote ways to harvest medicinal plants sustainably from the wild. Trainings for local collectors to promote sustainable harvest, educating and motivating local farmers to grow these medicinal plants in their fields, and to properly process, and handle the harvested plants in order to prevent wastage of these resources and make maximum economic returns.

Abbreviations

NTFPs: non-timber forest products; MAPs: medicinal and aromatic plants; KPK: Khyber Pakhtunkhwa; NRSP: National rural support program; HDOD: Human development organization doaba; UNDP P: The United Nations Development Program; PKR: Pakistani rupees; USD: United states dollars; NGO: Non-government organizations ;

Declarations

Authors’ contributions

All authors equally contributed to all aspects of this work.

Availability of data and materials
The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

**Ethics approval and consent to participate**

The subject has no ethic risk.

**Competing interests**

The authors declare that they have no competing interests.

**Acknowledgments**

We thank the University of Swat plant science and biodiversity research group for provision of all available resources to carry out this study.

**References**

Ali H, Ahmad H, Marwat KB, Yousaf M, Gul B, Khan I. 2012. Trade potential and conservation issues of medicinal plants in district swat, Pakistan. Pak J Bot 44(6):1905–1912.

Bilal H, Quraishi R, Khan FA, Ghufran MA. 2016. Plastic Waste Management! A Step towards Climate Change Adaptation and Sustainable Development in District Swat, Kpk, Pakistan. International Journal of Science and Research. 5(10):961-966.

Boggan J, Funk V, Kelloff C, Hoff M, Cremers G, Feuillet C. 1997. Checklist of the Plants of the Guianas (Guyana, Surinam, French Guiana), 2nd ed. University of Guyana, Georgetown.

Champion SH, Seth SK, Khattak GM. 1965. Forest types of Pakistan. Forest types of Pakistan. PFI Peshawer.

CITES. 2007. Convention on International Trade in Endangered Species of Wild Fauna and Flora, Appendices I, II and III. Available via http://www.cites.org.

Draper Munt D, Muñoz-Rodríguez P, Marques I, Moreno Saiz, JC. 2016. Effects of climate change on threatened Spanish medicinal and aromatic species: predicting future trends and defining conservation guidelines. Israel Journal of Plant Sciences 63(4): 309-319.

Edwards R. 2004. No remedy in sight for herbal ransack. New Sci. 181:10–11.

Hamilton AC, Hamilton PB. 2006. Plant Conservation: an ecosystem approach (Earthscan London UK).

Hamayun M, Khan SA, Sohn EY, Lee IJ. 2006. Folk medicinal knowledge and conservation status of some economically valued medicinal plants of District Swat, Pakistan. Lyonia, 11(2): 101-113.
Hamayun M, Khan MA, Begum S. 2003. Marketing of medicinal plants of Utor- Gabral valleys, Swat, Pakistan. Ethnobotanical Leaflets 2003(1): 13.67

IUCN. 2007. International Union for Conservation of Nature and Natural Resources Red List of threatened species. Available via http://www.iucnredlist.org/.

Qasim M, Hubacek K, Termansen M, Khan A. 2011. Spatial and temporal dynamics of land use pattern in District Swat, Hindu Kush Himalayan region of Pakistan. Appl.Geogr 31:820– 828.

Qureshi R, Waheed A, Arshad M, Umbreen T. 2009. Medico-ethnobotanical inventory of tehsil Chakwal, Pakistan. Pak J Bot 41 (2):529-538.

Rahbek C, Colwell RK. 2011. Biodiversity: Species loss revisited. Nature, 473(7347):288 289.

Rahman AU, Khan AN. 2011. Analysis of flood causes and associated socio-economic damages in the Hindu Kush region. Nat. Hazards 59:1239-1260.

Schippmann U, Leaman DJ, Cunningham, AB. 2002. Impact of Cultivation and Gathering of Medicinal Plants on Biodiversity: Global Trends and Issues. FAO, Rome.

Shah SA, Shah, NA, Ullah S, Alam MM, Badshah H, Ullah S, Mumtaz AS. 2016. Documenting the indigenous knowledge on medicinal flora from communities residing near Swat River (Suvastu) and in high mountainous areas in Swat-Pakistan. J Ethnopharmacol 182:67-79.

Sher H, Bussmann RW, Hart R, de Boer HJ. 2016. Traditional use of medicinal plants among Kalasha, Ismaeli and Sunni groups in Chitral District, Khyber Pakhtunkhwa province, Pakistan. J Ethno Pharmacol 188:57-69.

Sher H, Aldosari A, Ali A, de Boer HJ. 2015a. Indigenous knowledge of folk medicines among tribal minorities in Khyber Pakhtunkhwa, northwestern Pakistan. J. Ethnopharmacol 166: 157–167.

Sher H, Aldosari A, Ali A, de Boer HJ. 2014. Economic benefits of high-value medicinal plants to Pakistani communities: an analysis of current practice and potential. J. Ethnobiol. Ethnomed. 10.

http://dx.doi.org/10.1186/1746-4269-10-71.

Souza AS, Albuquerque UP, Nascimento ALB, Santoro FR, Torres-Avilez WM, Lucena RFP et al. 2017. Temporal evaluation of the Conservation Priority Index for medicinal plants. Acta Botanica Brasilica 31(2):169–179.

Tahir N, Bibi Y, Iqbal M, Hussain M, Laraib S, Safdar I, Bibi G. 2016. Overview of Dioscorea deltoidea Wall.ex Griseb. Wall. Ex Griseb: An Endangered Medicinal Plant from Himalaya Region. J Biodivers Environ Sci 9:13-24.

Tedesco P, Bigorne R, Bogan AE, Giam X,Jézéquel C, Hugueny B. 2014. Estimating how many undescribed species have gone extinct. Conservation Biology 28(5):1360- 1370.
Tareen, NM, Saeed-ur-Rehman MA, Shinwari ZK, Bibi T. 2016. Ethnomedicinal utilization of wild edible vegetables in district harnai of Balochistan province-Pakistan. Pak J Bot 48:1159-1171.

Ullah A, Rashid A. 2014. Conservation status of threatened medicinal plants of Mankial Valley Hindukush Range, Pakistan. International journal of biodiversity and conservation, 6(1): 59-70.

Van Andel TR, Behari-Ramdas JA, Havinga RM, Groenendijk S. 2008. The medicinal plant trade in Suriname. Ethnobotany Research and Applications 5:351–373.

Williams VL, Balkwill K, Witkowski ETF. 2000. Unravelling the commercial market for medicinal plants and plant parts on the Witwatersrand, South Africa. Economic Botany 54(3): 310–327.

**Figures**

![Figure 1](image_url)
Figure 1

District Swat location in Hindu Kush Himalayan region. Note: The designations employed and the presentation of the material on this map do not imply the expression of any opinion whatsoever on the part of Research Square concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. This map has been provided by the authors.
Figure 1

District Swat location in Hindu Kush Himalayan region. Note: The designations employed and the presentation of the material on this map do not imply the expression of any opinion whatsoever on the part of Research Square concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. This map has been provided by the authors.
Figure 2

Efficiency and knowledge of medicinal plants collectors in District Swat
Figure 2

Efficiency and knowledge of medicinal plants collectors in District Swat
Figure 2

Efficiency and knowledge of medicinal plants collectors in District Swat

|          | Trained | Untrained |
|----------|---------|-----------|
| Respondents | 24      | 74        |

Medicinal and aromatic plants collectors in District Swat
Figure 3

Application of local medicinal plants locally that helps to minimize health care cost
Figure 3

Application of local medicinal plants locally that helps to minimize health care cost
Figure 3

Application of local medicinal plants locally that helps to minimize health care cost
Figure 4

Market value fluctuation over the last twenty years in District Swat.
Figure 4

Market value fluctuation over the last twenty years in District Swat.
Figure 4

Market value fluctuation over the last twenty years in District Swat.
Challenges to Medicinal and aromatic plants found and reported in District Swat

Figure 5

Challenges to Medicinal and aromatic plants found and reported in District Swat
Figure 5

Challenges to Medicinal and aromatic plants found and reported in District Swat
Commercial exploitation of medicinal and aromatic plants resulting in ecological consequences

Figure 6

Commercial exploitation of medicinal and aromatic plants resulting in ecological consequences
Figure 6

Commercial exploitation of medicinal and aromatic plants resulting in ecological consequences

| Plant Part use | Rhizome 3% |
|----------------|------------|
| Bulbs          | 3%         |
| Flower         | 8%         |
| Bark           | 4%         |
| Fruit          | 14%        |
| Whole plant    | 9%         |
| Stem           | 5%         |
| Seed           | 7%         |
| Leaves         | 30%        |
| Gum & Latex    | 2%         |
| Tubers         | 1%         |
| Roots          | 13%        |
| Fronds         | 1%         |

Part used and Post harvest survival

Seed, Fruit, Bark, Gum, Latex
Leaves, Flowers, Stem
Root, Rhizome, Tubers, Bulbs, Whole plant
Figure 7

Source of commercially harvested medicinal and aromatic plants in District Swat n=220.
Source of commercially harvested medicinal and aromatic plants in District Swat n=220.

Figure 8

Resource exhaustion with increasing commercial value and unsustainable harvest of wild MAPs
Resource exhaustion with increasing commercial value and unsustainable harvest of wild MAPs

**Figure 8**

Resource exhaustion with increasing commercial value and unsustainable harvest of wild MAPs

**Supplementary Files**

This is a list of supplementary files associated with this preprint. Click to download.

- Graphicalabstract.png
- Graphicalabstract.png
- Graphicalabstract.png