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ANTHROPOGENIC INFLUENCES ON THE NATURAL ECOSYSTEM OF THE NARAN VALLEY IN THE WESTERN HIMALAYAS

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Abstract

People derive many essential goods from plant resources, including food, medicines and fodder. However, the link between biodiversity and ecosystem services and their role in the support of human well-being is often poorly understood. Mountain ecosystems support a high biological diversity including rare and endangered plant species. They also provide a home to some 12% of the world's human population, who use their traditional ecological knowledge to utilise local natural resources. The Himalayas are the world's youngest and largest mountain range that supports a high plant biodiversity and hence provides many ecosystem services. Due to remote location, harsh climate, rough terrain and topography, many areas in the Himalayas have been still poorly known for their vegetation ecosystem services. The people in the Naran Valley, in the western Himalayas, depend upon local plant resources for a range of services and goods, from grazing for livestock to use of medicinal plants. During this study abundance and uses of each species were computed using computational ecology; principal components analysis (PCA) and response curves (RC) using CANOCO. The analyses showed an increasing trend of grazing, but with a decrease in fodder availability, with altitude increase in the valley. The assessment of such ecosystem services may assist in developing conservation strategies, especially for endangered mountain ecosystems.

Introduction

Study of ecosystem functions and services has become a topic of research around the globe in the 21st century. The Millennium Ecosystem Assessment and other related studies classified these services into four broad categories (Anon., 2003, Mooney *et al.,* 2004, Mooney *et al.,* 2004, Carpenter *et al.,* 2006, Jordan *et al.,* 2010, De Groot *et al.,* 2002, Boyd and Banzhaf 2007), which are provisioning, regulating, supporting and cultural services. In every ecosystem, vegetation provides the most important biotic components as the whole food web is based on it in addition to its ecological role in the regulation and maintenance of abiotic environment. Direct, provisioning services are food, grazing, fodder, fuel, timber, and medicinal products. These services ultimately contribute to agricultural, socio-economic and industrial activities (Zobel *et al.,* 2006, Boyd & Banzhaf 2007; Kremen, 2005).

In mountain regions, over-exploitation through forest cutting, livestock grazing and collection of fodder, edible and medicinal species puts the natural ecosystems at risk. Mountain vegetation all over the world responds in a very sensitive way to environmental changes. This fragility increases the chances of species extinction in future. These ecosystems are the hot spot for their unique biodiversity in terms of ecological indicators and endemism and need proper management against negative climatic and anthropogenic influences for future sustainability. In order to develop appropriate methods for their sustainable utilization, it is crucial to understand how environmental and traditional drivers influence their biodiversity. Involvement of indigenous people is necessary to assess such services, with the target of identifying plant species under risk that ultimately may cause fragility of the ecosystem. Very limited work has been done to provide quantitative descriptions of the plant use along geo-climatic and cultural gradients (Saima *et al*., 2009, Wazir *et al*., 2008, Dasti *et al*., 2007, Malik & Husain 2008). This study therefore sought to study the natural vegetation of the Naran Valley (Khan 2012, Khan *et al*., 2011c, Khan *et al*., 2011b) and also to assess the ecosystem services provided by the vegetation, with the overall aim of identifying those plant species and communities at greatest risk of overuse and loss. Pakistan's economy is mainly based on the flow of rivers from the Himalayas (Archer & Fowler, 2004). As the Himalayan mountains are a major source of irrigation water in the dry seasons for rice and wheat crops in Pakistan and other South Asian countries. The relation between natural vegetation, food security and mountains is very strong and straight forward. The plant biodiversity provide sustainable foundation for environmental and ecosystem resources including agriculture, land, water, weather and climate (Rasul, 2010). Identifying the gradient of services that occur along the valley provide the first step towards developing long-term management and conservation strategies for endangered ecosystems. Such strategies might, therefore, have optimistic outcomes for the maintenance and increase in mountain biodiversity and ecosystem services which will also have a positive impact on the lowland ecosystems which depend on the sustainability of these mountainous ecosystems.

The study area the Naran Valley, Khyber Pakhtunkhwa, Pakistan is about 270 km from the capital, Islamabad located at 34° 54.26´N to 35° 08.76´ N latitude and 73° 38.90´ E to 74° 01.30´ E longitude; elevation between 2450 to 4100 m above mean sea level. The entire area is formed by rugged mountains on either side of the River Kunhar which flows in a northeast to southwest direction down the valley to the town of Naran. Geographically the valley is located on the extreme western boundary of the Himalayan range, after which the Hindu Kush range of mountains starts to the west of the River Indus. Geologically, the valley is situated on the margin of the Indian Plate where it is still colliding against the Eurasian plate (Fig. 1). Floristically, the valley has been recognised as an important part of the Western Himalayan province (Ali & Qaiser 1986), while climatically, it has a dry temperate climate with distinct seasonal variations.

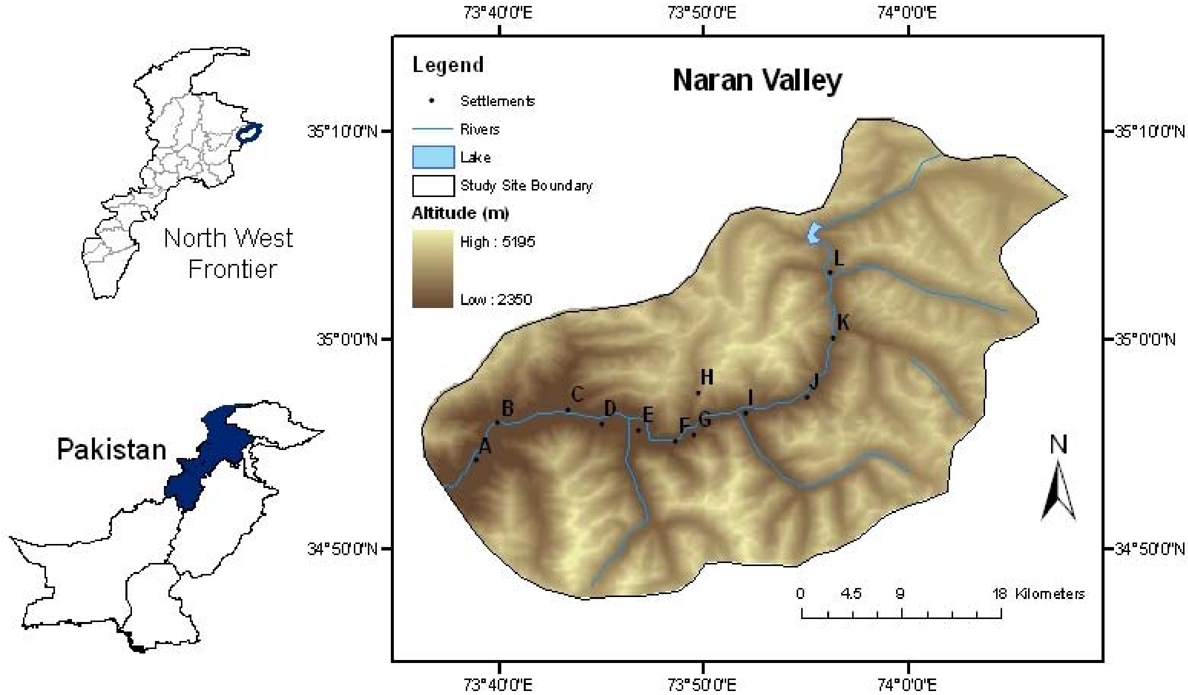

Fig. 1. Physiographic map (produced through Arch GIS) of the Naran Valley; elevation zones, location of its main settlements (A-L), the River Kunhar, originating lake (the Lake Lulusar) and the tributary streams.
(Elevation data obtained from the ASTER GDEM, a product of METI and NASA)

Methods

The data was collected in two phases i.e., Questionnaire preparation based on first field survey and interviews.

1. A questionnaire was developed to get information how the indigenous people of the valley obtain goods and services from the vegetation. The questionnaire also included a list of botanical and local names of 198 plant species occurring in the valley, recorded in the first field work (Khan *et al.,* 2011c). Questionnaire was structured in a manner to obtain information on all the possible uses of each species in quick possible time. Plant names (from vegetation classification survey; Khan 2012, Khan *et al.,* 2011c) were put in rows (first column) and services that these plants provided, e.g. food (F), fodder (Fd), grazing (Gr), timber (Ti), fuel (Fu), aesthetic (Ae), medicinal (M) and others (Ot) were recorded in columns against each species. Uses mentioned by interviewee at each settlement along the altitudinal gradient were sum up to analyze in software package CANOCO version 4.5 (ter Braak & Smilauer, 2002).

2. Twelve main localities (villages) in the project area (at approximately 5 km intervals along the valley), were visited (A-LFig. 1). Meetings were arranged with village heads or councillors and permissions were obtained for questionnaire-based interviews. A local community member, who knew the norms and traditions of the indigenous society, was engaged as a guide. Ten houses in each of the 12 settlements (a total of 120) were selected randomly for the interviews. A mixture of qualitative and quantitative data collection methods were adopted in order to obtain local knowledge about the services provided by the native vegetation (De Albuquerque, 2009, Da Cunha & De Albuquerque, 2006, Rossato *et al.,* 1999; Martin, 2004). Plant species and habitat types photographed during a field campaign in 2009 (Khan *et al.,* 2011c) were shown to the interviewees whenever felt necessary. Informant's data were analyzed to sum up the number of use categories at each locality.

Data analyses: The numbers of uses in each category at each locality were calculated for CANOCO (Chowdhury & Koike, 2010, Uprety *et al.,* 2010). Principal Components Analysis (PCA) was used to explore the cultural gradient alongside the natural (altitudinal/latitudinal) gradient (Dalle *et al.,* 2002). The response curve as a utility under the data attribute plot was used to analyze the pattern of each of the use categories along the valley. The response curves were calculated based on the Generalized Linear Model (GLM) (Toledo *et al.,* 2009). MS EXCEL was also used to categorize and count the various provisioning services (use categories).

Results

Provisioning ecosystem services and natural vegetation: One hundred and eighty three species (92.4% of those surveyed) were recognized as providing services to the inhabitants of the valley in the form of timber, fuel, food, fodder, medicines, grazing and aesthetics. Many of the species offered more than one service. The highest number of responses was recorded for grazing (31.51%), followed by medicinal and fodder uses (23.14% and 22.70%, respectively). Fuel, food and timber were mentioned by 8.22%, 7.56% and 3.38% respondents respectively (Fig. 2). The use of plants for grazing and fodder can impose a high pressure on the plant biodiversity, with implications for longer-term sustainability, while utilisation of plants as a source of medicines indicates the long and well established traditional knowledge within these mountain communities and the lack of regional health facilities.

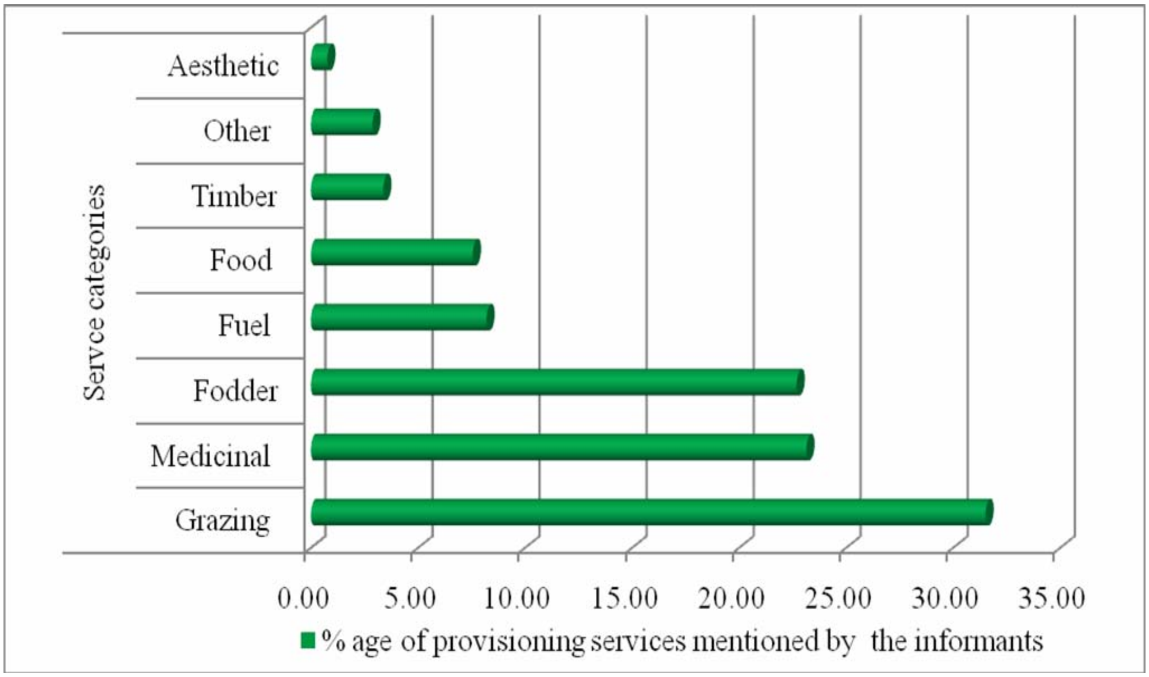

Fig. 2. Provisioning services mentioned by informants, for 183 plant species based on questionnaire data.

The first axis of PCA showed a gradient of the provisioning services with increasing elevation, i.e., from multiple uses at lower levels to simply grazing in the upper reaches of the valley. The PCA results clarified that people at relatively low altitude at the mouth of the valley use the vegetation for timber, aesthetics and fodder. In the middle stretch of the valley the trend was more towards fuel wood and medicinal plant collection, whilst grazing dominated in the upper parts of the valley, where the habitats were dominated by alpine meadows. The traditional use of medicinal plants was highest in the middle of the valley (Table 1 & Fig. 3).

Table 1. Explanation of the four axes of the PCA for various provisioning services provided by vegetation in mountain ecosystem of the Naran Valley, western Himalaya.

Axes	1	2	3	4	Total variance
Eigenvalues	0.79	0.122	0.043	0.017	1.000
Cumulative percentage variance of species data	78.1	91.2	95.5	97.1	

Total standard deviation in informants data = 5.54191

Plants provisioning services as grazing and fodder: The plant species which the local community noted that they prioritized for their live stock in the grassland were *Poa alpina, Poa annua, Bistorta affinis, Alopecurus arundinaceus, Anaphalis triplinervis, Anemone falconeri, Phleum alpinum, Anemone tetrasepala, Trifolium repens, Plantago himalaica, Plantago lanceolata, Polygonum aviculare, Leucus cephalotes,* and *Hackelia uncinata*. People cut some of the herb species and used them either fresh or dry as fodder during the off season. Species preferred for fodder were *Bistorta amplexicaulis, Eragrostis cilianensis, Pennisetum lanatum, Lathyrus pratensis, Pimpinella diversifolia, Silene vulgaris* and *Chenopodium album.* Collectively, 51.21% of the used species were reported to be important for grazing livestock either on the grasslands or in fodder form. Data attribute plots and graphs of response curves, show an increasing trend of grazing with a decrease in fodder availability along the valley. Climatic conditions favour the vigorous growth of herbaceous vegetation in the lower valley and hence people use plants as fodder, while in the upper parts the grazers utilize vegetation only during the short summer period (Figs. 3 & 4).

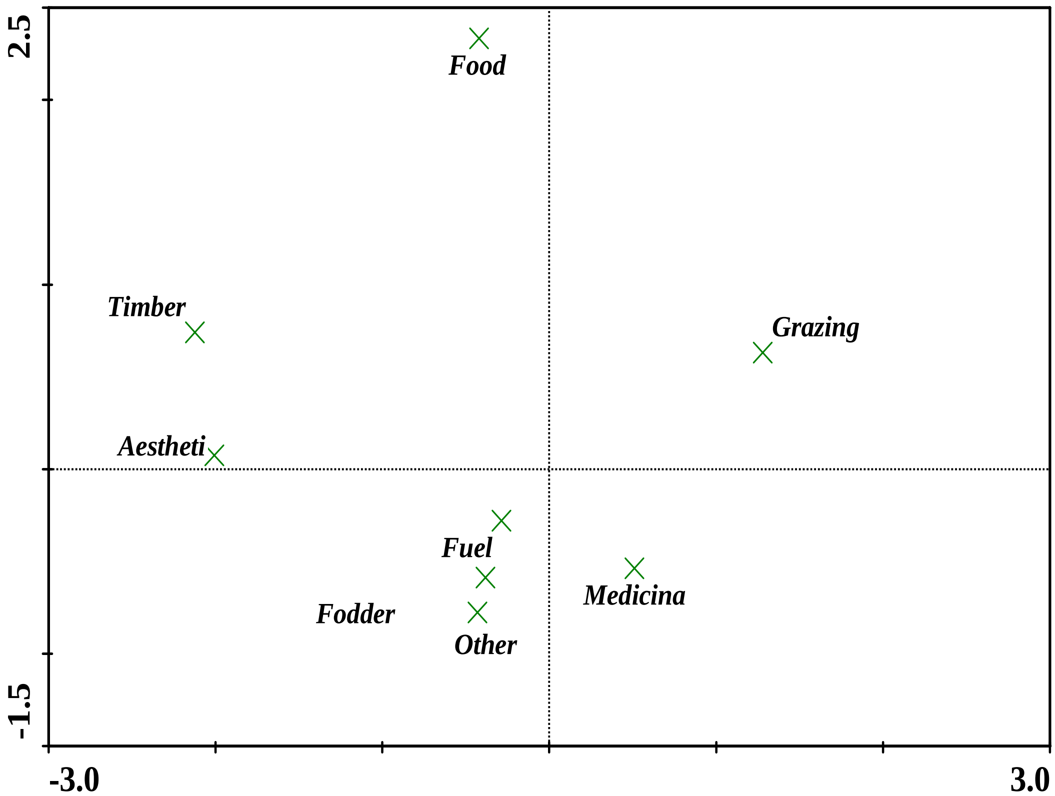

Fig. 3. PCA plot showing the distribution of various categories of provisioning services provided by vegetation along the valley as mentioned by informants.

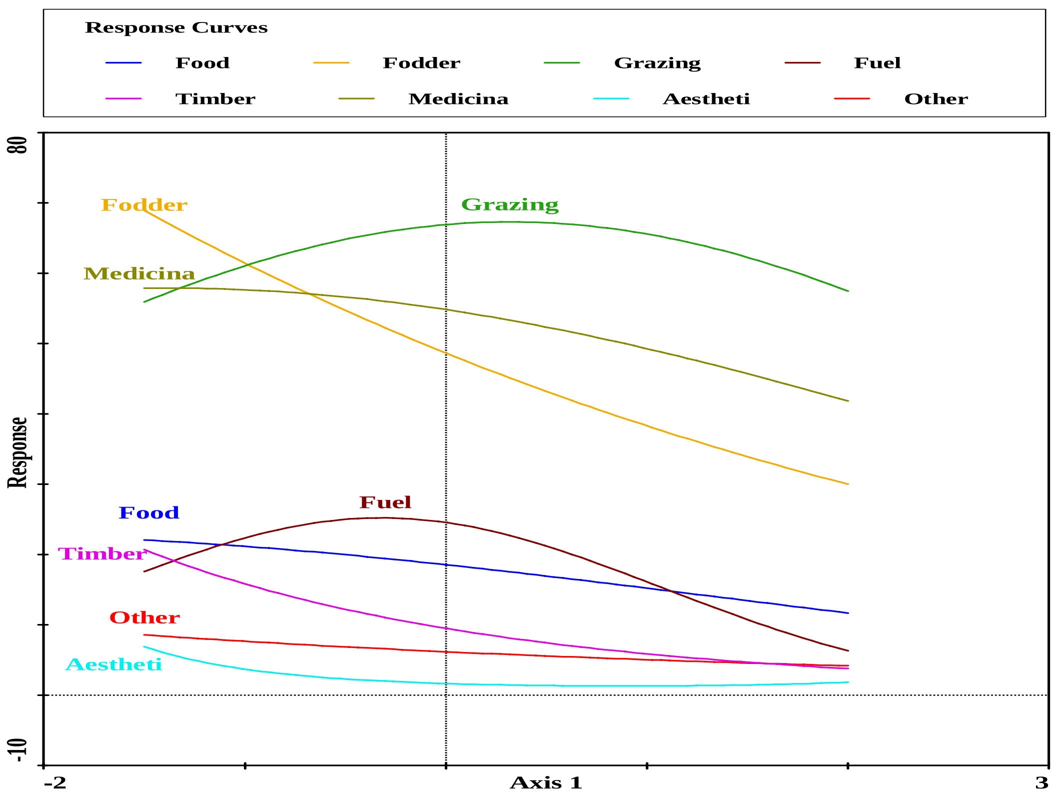

Fig. 4. Response Curves (RC) using Generalized Linear Model (GLM) show provisioning services along the valley.

Provisioning services as food: People use *Caltha alba, Dryopteris juxtapostia, Eremurus himalaicus, Salvia lanata* and *Urtica dioica* as pot herbs. Aerial parts of *Rheum australe* are used as salad. The rhizome of *Polygonatum verticillatum* is eaten mixed with dairy products as a tonic. *Fragaria nubicola, Viburnum grandiflorum* and *Crataegus oxyacantha* are used as wild fruits. Other plants used as food are *Chenopodium album, Dryopteris stewartii, Leucus cephalotes, Malva neglecta, Mentha longifolia, Viburnum grandiflorum* and *Viola canescens.* Food plants are utilized more frequently in the lower valley and there is a gradual decrease along the valley (Figs. 3 & 4).

Provisioning services as fuel: In the lower valley tree species provide fuel while in the upper valley people use woody shrubs for fuel purposes. The important species which people prioritize for fuel are *Juniperus excelsa, Juniperus communis, Juniperus squamata, Betula utilis, Indigofera heterantha, Prunus cerasoides, Aesculus indica, Acer caesium* and *Viburnum cotinifolium.* Twigs of *Abies pindrow, Cedrus deodara, Pinus wallichiana* and *Picea smithiana,* are also considered good fuel. PCA graphs show that tree and shrub species are more or less homogeneously used in the whole valley for fuel, but collection and use of fuel is at a maximum in the middle of the valley (Figs. 3 & 4).

Vegetation services as timber: Response curve graphs show the extensive use of timber wood in the lower valley. At the upper end of the valley the people are seasonal grazers who live in tents and hence have less use of timber (Figs. 3 & 4). *Cedrus deodara* and *Pinus wallichiana*, which are native trees of the Himalayas and the Hindu Kush, provide the best timber woods. Species of *Abies pindrow, Picea smithiana* and *Populus glauca* also provide good quality timber, used in ceilings, making doors and windows, utensils etc. Timber from species of *Aesculus indica, Acer caesium, Juglans regia* and *Prunus cerasoides* is considered the best for agricultural tools.

Aesthetic services of plant biodiversity: People at the mouth of the valley are involved in ecotourism and have more developed aesthetic sense; they value the vegetation for its 'artistic' importance. The graph of the response curves confirms that a cultural gradient exists from south to north in the valley (Figs. 3 & 4). Coniferous trees like *Cedrus deodara, Pinus wallichiana, Abies pindrow* and *Picea smithiana* have high aesthetic values for tourists as well as inhabitants. Other species like *Aesculus indica*, orchards and alpine meadow species are also valued for their 'artistic' nature.

Other provisioning ecosystem services of vegetation: Plant biodiversity plays an important role in providing other services. Plants are used to make hedges around the fields for protection and demarcating boundaries. Our findings show that most of the services in category of 'other services' are associated with woody species in the lower valley (Figs. 3 & 4). *Populus glauca*, *Rubus sanctus* and *Ribes alpestre* are grown around the fields for hedging purposes. Species like *Salix flabellaris*, *Dryopteris stewartii* and *Viburnum grandiflorum* and twigs of most of the tree species are used for roofing and thatching. Bark of *Betula utilis* species is used as paper especially by religious scholars to write spiritual verses to cure ailments. Species like *Rumex dentatus* is used as a dye to colour livestock with unique, distinguishing signs.

Ethnomedicinal services: People of the region use 102 species belonging to 52 families (51.5% of the total plants and 55.7% of the used ones) for medicinal purposes, with 97 therapeutic uses. The highest number of ailments cured with medicinal plants were associated with the digestive system (32.76% responses) followed by the respiratory and urinary systems, with 13.72% and 9.13% respectively. Ailments associated with the blood circulatory system, the reproductive system and the skin were given 7.37%, 7.04% and 7.03% responses, respectively. Diseases related with the general body, endocrine system, nervous system, mouth, eyes and microbes etc were considered each by less than 5% of respondents. Several species, namely *Dioscorea deltoidia* (used as a diuretic, tonic and anthelmentic), *Podophyllum hexandrum* (as a purgative and anti cancer treatment), *Berberis pseudumbellata* (used in fever, backache, jaundice, and urinary problems), *Cypripedium cordigerum* (aphrodisiac) and *Dactylorhiza hatagirea* (nerve tonic), are of global importance since they are listed by CITES as being under conservation threat. Oils extracted from *Cedrus deodara* were reportedly used in skin diseases while powder of the dried fruit nuts of *Aesculus indica* were used to treat colic and also as an anthelmentic. Among other species *Aconitum heterophyllum, Aconitum violaceum, Ephedra gerardiana, Eremurus himalaicus, Hypericum perforatum, Indigofera heterantha, Geranium wallichianum, Iris hookeriana, Nepeta laevigata, Origanum vulgare, Paeonia emodi, Rheum australe, Thymus linearis* and *Ulmus wallichiana* were also reported to be of great importance in traditional health care.

The influence of a specific service category on vegetation at a particular habitat was recognized and located using Principal component analysis (PCA) and Generalized Linear Model (GLM). These findings can be used in conservation management of endangered habitats and ecosystems.

Discussion

Provisioning ecosystem services and human well being: People living in mountainous regions rely on basic services from the natural ecosystems. The present study shows a good example of the relationships between the provisioning ecosystem services of vegetation and human well-being. Services like regulating and supporting, though important and allied to the sustainability of plant biodiversity, are given less attention by the local people as they focus on short-term benefits. Indigenous people have a long established system of health care in these regions and cure health problems with available plants resources. Similar studies confirming such indigenous knowledge have been done by Balemie & Kebebew (2006) and Khan *et al.,* (2011a, 2012). Extensive use of natural vegetation in the past has decreased the provisioning services (Giam *et al.,* 2010) and has also led to the deterioration of natural habitats and rare plant species (Díaz *et al.,* 2006, Giam *et al.,* 2010). The effects are worse as the people neither have enough provisioning services locally nor can compete in the urban societies. Due to extinction of important species, traditional knowledge is decreasing in the younger generations. Plant biodiversity can be increased, if steps for reforestation, establishing protected areas and awareness for careful collection and domestication of rare species are taken (Brown Jr. & Shogren, 1998, Niemi & McDonald, 2004, Pereira *et al.,* 2005). Long-term management might have optimistic outcomes to provisioning services. Certainly, such management will have immediate effects in terms of regulating and supporting services. Though each of the species has its importance in the system; those species which are endangered, endemic or less abundant in the region are of far greater importance. Four of the reported species in this study are of global importance as listed in CITES. One of these species was also reported in a few other studies from the Himalayas and the Hindu Kush (Ahmad *et al.,* 2009). Twenty (20) of these species are endemic to the Himalaya and hence need more attention to their sustainable use.

Safe guarding plant biodiversity: Plant biodiversity directly or indirectly provides a range of services to mankind and it is therefore, imperative that it is fully evaluated, managed and safeguarded (Anon., 1992). Assessment of vegetation diversity and biomass especially in mountain ecosystems is desirable as it provides the basic trophic level and a number of valuable services. The Naran valley supports a high plant species richness (198 species), most of which have diverse traditional uses and services. A few of the species, like *Dioscoria deltoidia, Podophyllum hexandrum, Berberis pseudumbellata, Cypripedium cordigerum* and *Dactylorhiza hatagirea* are listed internationally in the CITES (the Convention on International Trade in Endangered Species of Wild Fauna and Flora) list. Other noteworthy medicinal species of the valley like *Cedrus deodara* and *Aesculus indica* and many more are endemic to the Western Himalayas. Shortages of resources and climatic constraints have compelled the indigenous people to utilize vegetation for wood, grazing and medicinal purposes. Consequently, a number of species are under continuous anthropogenic pressure and likely to become extinct in the near future.

Several authors have addressed such issues in different regions with different approaches around the world (Balemie & Kebebew, 2006, Khan *et al.,* 2007, Shaheen *et al.,* 2011) but very few efforts have been made to tally the traditional knowledge with the abundance of plant species for better understanding and management of anthropogenic pressures (Tarrasón *et al.,* 2010, Shaheen *et al.,* 2012). Plant biodiversity can be restored and the risks of degradation may be combated, if measures like reforestation, establishment of protected areas, greater awareness by the people and *ex-situ* conservation of rare species are initiated. Our findings show that anthropogenic activities and biodiversity are in conflict with each other (Zafra-Calvo *et al.,* 2010, Evans *et al.,* 2006). People choose species only because of their own needs and hence put enormous pressure on rare species. Some of the problems associated with medicinal plants can be overcome through domestication and preservation. It is thus imperative to conserve the biodiversity and encourage its sustainable use (Zavaleta & Hulvey 2004). In this recent millennium, a number of other research studies have suggested an urgent call for the preservation of plant resources and hence the ecosystems in the developing world, particularly in the Himalayas.

Conservation of endangered ecosystems: Natural ecosystems, especially mountainous are under continuous human exploitation and require a recovery plan. Initially, an understanding of the general status and trends of biodiversity help to set a baseline which can be used to measure onward change and design conservation strategy. For this purpose, certain areas can be considered as hotspots by Conservation International based on the concentration of endemic and threatened species and the amount of habitat loss (Rey Benayas *et al.,* 2009, Hermy *et al.,* 2008; Nakashizuka, 2004). In this scenario it was felt necessary to integrate the ecological gradients exhibited by plant biodiversity with the cultural gradients of plant use in order to assess present anthropogenic trends and pressures to develop immediate and long term management plans for these endangered ecosystems. Vegetation classification is increasingly being used for conservation planning in natural ecosystems. It is imperative for managers to have a robust vegetation classification and the use of modern statistical procedures that can give rise to appropriate ecological indicators. These indicators, when employed together with traditional and economic gauges, can play a role in designing conservation strategies (Tarrasón *et al.,* 2010, Kocí *et al.,* 2003, Zou *et al.,* 2007). For this project the botanical data set published in Khan *et al.,* (2011c) was combined with data from questionnaires on vegetation use to design conservation criteria for both the individual endangered species as well as the whole ecosystem (Zou *et al.,* 2007, Pinke & Pál, 2008, Haarmeyer *et al.,* 2010, Wrage *et al.,* 2011). A narrow range of habitats for specific indicator species and the presence of endemic vegetation in the region indicate that, once deteriorated, these mountain plant communities and ecosystems would be extremely difficult to restore due to a number of climatic, edaphic and anthropogenic constraints. Our study emphasizes the importance of this fragile ecosystem for long-term environmental sustainability and ecosystem services management (Moldan *et al.,* 2011, Layke *et al.,* 2011). Our study also provides an approach which could be extended to the wider Himalayan region and compared to habitat studies in relation to anthropogenic pressure being carried out in the developed world e.g. Vačkář *et al.*, (2012). Our analyses, based on ecological as well as cultural approaches can be used to develop criteria for prioritization of protected areas, special habitats and species of conservation importance. There are very few studies that have sought to evaluate critical species as well as ecosystems in the Himalayas in a corresponding way (Ali, 2008; Samant & Dhar 1997, Qureshi *et al.*, 2007, Aumeeruddy, 2003; Kala, 2007). The major social problems responsible for the enormous anthropogenic pressures on the vegetation in the region are the prevailing poverty, lack of awareness, poor education and seasonal utilization, which combine to increase the competition for and overexploitation of the natural vegetation resources.

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References

Archer, D.R and J. Fowler, 2004. Spatial and temporal variations in the upper Indus Basin, global teleconnections and hydrological implications. *Hydrol & Earth Sys Sc*., 8(1): 47-61.

Ahmad, H., S.M. Khan, S. Ghafoor and N. Ali. 2009. Ethnobotanical study of upper siran. *J. Herbs Spices Med. Plants*, 15(1): 86-97.

Ali, S.I. 2008. Significance of Flora with special reference to Pakistan. *Pak. J. Bot*., 40(3): 967-971.

Ali, S.I. and M. Qaiser. 1986. A Phyto-Geographical analysis of the Phenerogames of Pakistan and Kashmir. *Proceedings of Royal Society Edinburgh*, 89: 89-101.

Anonymous. 2003. *Ecosystems and human well-being: a framework for assessment Millennium ecosystem assessment.*

Anonymous. 1992. CBD (Convention on Biological Diversity). *The Convention on Biological Diversity.*

Aumeeruddy, Y.A.S.J.P. 2003. Applied Ethnobotany; case studies from the Himalayan region. *People and plants working paper 12. WWF Godalming, UK.*: 3-4.

Balemie, K. and F. Kebebew. 2006. Ethnobotanical study of wild edible plants in Derashe and Kucha Districts, South Ethiopia. *J. Ethnobiology Ethnomedicine.* 2.

Boyd, J. and S. Banzhaf. 2007. What are ecosystem services? The need for standardized environmental accounting units. *Ecol. Econ*., 63(2-3): 616-626.

Brown Jr., G.M. and J.F. Shogren. 1998. Economics of the Endangered Species Act. *Journal of Economic Perspectives.* 12(3): 3-20.

Carpenter, S.R., R. DeFries, T. Dietz, H.A. Mooney, S. Polasky, W.V. Reid and R.J. Scholes. 2006. Millennium ecosystem assessment: Research needs. *Science.* 314(5797): 257-258.

Chowdhury, M.S.H. and M. Koike. 2010. Towards exploration of plant-based ethno-medicinal knowledge of rural community: Basis for biodiversity conservation in Bangladesh. *New Forests.* 40(2): 243-260.

Christensen, M. and J. Heilmann-Clausen. 2009. Forest biodiversity gradients and the human impact in Annapurna Conservation Area, Nepal. *Biodiversity Conserv*., 18(8): 2205-2221.

Da Cunha, L.V.F.C. and U.P. De Albuquerque. 2006. Quantitative ethnobotany in an Atlantic Forest fragment of Northeastern Brazil - Implications to conservation. *Environ. Monit. Assess*., 114(1-3): 1-25.

Dalle, S.P., H. López, D. Díaz, P. Legendre and C. Potvin. 2002. Spatial distribution and habitats of useful plants: An initial assessment for conservation on an indigenous territory, Panama. *Biodivers. Conserv*., 11(4): 637-667.

Dasti, A.A., S. Saima, M. Athar, Attiq-ur-Rahman and S.A. Malik. 2007. Botanical composition and multivariate analysis of vegetation on the Pothowar Plateau, Pakistan. *J. Bot. Res. Inst. Tex*., 1(1): 557-568.

De Albuquerque, U.P. 2009. Quantitative ethnobotany or quantification in ethnobotany? *Ethnobotany Research and Applications.* 7: 1-4.

De Groot, R.S., M.A. Wilson and R.M.J. Boumans. 2002. A typology for the classification, description and valuation of ecosystem functions, goods and services. *Ecol. Econ*., 41(3): 393-408.

Deane, V. 1999. Nature's Services: Societal Dependence on Natural Ecosystems. *Popul. Environ*., 20(3): 277-278.

Evans, K.L., B.J. van Rensburg, K.J. Gaston and S.L. Chown. 2006. People, species richness and human population growth. *Global Ecol. Biogeogr*., 15(6): 625-636.

Giam, X., C.J.A. Bradshaw, H.T.W. Tan and N.S. Sodhi. 2010. Future habitat loss and the conservation of plant biodiversity. *Biol. Conserv*., 143(7): 1594-1602.

Haarmeyer, D.H., U. Schmiedel, J. Dengler and B.M. Bösing. 2010. How does grazing intensity affect different vegetation types in arid Succulent Karoo, South Africa? Implications for conservation management. *Biol. Conserv*., 143(3): 588-596.

Hermy, M., S. Van Der Veken, H. Van Calster and J. Plue. 2008. Forest ecosystem assessment, changes in biodiversity and climate change in a densely populated region (Flanders, Belgium). *Plant Biosyst*., 142(3): 623-629.

Jordan, S.J., S.E. Hayes, D. Yoskowitz, L.M. Smith, J.K. Summers, M. Russell and W.H. Benson. 2010. Accounting for natural resources and environmental sustainability: Linking ecosystem services to human well-being. *Environmental Science and Technology.* 44(5): 1530-1536.

Kala, C.P. 2007. Local preferences of ethnobotanical species in the Indian Himalaya: Implications for environmental conservation. *Curr. Sci*., 93(12): 1828-1834.

Khan, S.M., A. Zeb and H. Ahmad. 2011a. *Medicinal Plants and Mountains: Long-Established Knowledge in the Indigenous People of Hindu Kush* VDM Verlag Dr. Müller, Germany. 144 p.

Khan, S.M. 2012. Plant Communities and Vegetation Ecosystem Services in the Naran Valley, Western Himalaya. PhD, University of Leicester, University of Leicester. 249 p.

Khan, S.M., D.M. Harper, S. Page and H. Ahmad. 2011b. Residual Value Analyses of the Medicinal Flora of the Western Himalayas: the Naran Valley, Pakistan. *Pak. J. Bot*., 43: SI-97-104.

Khan, S.M., D.M. Harper, S. Page and H. Ahmad. 2011c. Species and Community Diversity of Vascular Flora along environmental gradient in Naran Valley: A multivariate approach through Indicator Species Analysis. *Pak. J. Bot*., 43(5): 2337-2346.

Khan, S.M., H. Ahmad, M. Ramzan and M.M. Jan. 2007. Ethno-medicinal plant resources of Shawar Valley. *Pak. J. Biolog Scien.,* 10:1743-1746.

Kocí, M., M. Chytrý and L. Tichý. 2003. Formalized reproduction of an expert-based phytosociological classification: A case study of subalpine tall-forb vegetation. *Journal of Vegetation Science.* 14(4): 601-610.

Kremen, C. 2005. Managing ecosystem services: What do we need to know about their ecology? *Ecol. Lett*., 8(5): 468-479.

Layke, C., A. Mapendembe, C. Brown, M. Walpole and J. Winn. 2012. Indicators from the global and sub-global Millennium Ecosystem Assessments: An analysis and next steps. *Ecol. Ind.,* 17: 77-87.

Malik, R.N. and S.Z. Husain. 2008. Linking remote sensing and ecological vegetation communities: A multivariate approach. *Pak. J. Bot*., 40(1): 337-349.

Martin, G.J. 2004. *Ethnobotany; A methods manual.* WWF and IIED, Earth scans Camden London. 267 p.

Moldan, B., S. Janoušková and T. Hák. 2012. How to understand and measure environmental sustainability: Indicators and targets. *Ecol. Ind.,* 17: 4-13.

Mooney, H.A., A. Cropper and W. Reid. 2004. The millennium ecosystem assessment: What is it all about? *Trends in Ecology and Evolution*., 19(5): 221-224.

Nakashizuka, T. 2004. The role of biodiversity in Asian forests. *Journal of Forest Research*, 9(4): 293-298.

Niemi, G.J. and M.E. McDonald. 2004. Application of ecological indicators. *Annual Review of Ecology, Evolution, and Systematics*, 35: 89-111.

Pereira, E., C. Queiroz, H.M. Pereira and L. Vicente. 2005. Ecosystem services and human well-being: A participatory study in a mountain community in Portugal. *Ecology and Society*, 10(2): 1-14

Pinke, G. and R. Pál. 2008. Phytosociological and conservational study of the arable weed communities in western Hungary. *Plant Biosystems*, 142(3): 491-508.

Qureshi, R.A., M.A. Ghufran, K.N. Sultana, M. Ashraf and A.G. Khan. 2007. Ethnobotanical studies of medicinal plants of Gilgit District and surrounding areas. *Ethnobotany Res. Appl*., 5: 115-122.

Rasul, G. 2010. The role of the Himalayan mountain systems in food security and agricultural sustainability in South Asia. *Intern J Rural Manag*., 6(1): 2010:95-116

Rey Benayas, J.M., A.C. Newton, A. Diaz and J.M. Bullock. 2009. Enhancement of biodiversity and ecosystem services by ecological restoration: A meta-analysis. *Science*, 325(5944): 1121-1124.

Rossato, S.C., H.D.F. Leitão-Filho and A. Begossi. 1999. Ethnobotany of Caicaras of the Atlantic Forest coast (Brazil). *Econ. Bot*., 53(4): 387-395.

Saima, S., A.A. Dasti, F. Hussain, S.M. Wazir and S.A. Malik. 2009. Floristic compositions along an 18 - km long transect in ayubia National Park district Abbottabad, Pakistan. *Pak. J. Bot*., 41(5): 2115-2127.

Samant, S.S. and U. Dhar. 1997. Diversity, endemism and economic potential of wild edible plants of Indian Himalaya. *International Journal of Sustainable Development and World Ecology*, 4(3): 179-191.

Seppelt, R., C.F. Dormann, F.V. Eppink, S. Lautenbach and S. Schmidt. 2011. A quantitative review of ecosystem service studies: Approaches, shortcomings and the road ahead. *J. Appl. Ecol*., 48(3): 630-636.

Shaheen, H., S.M. Khan, D.M. Harper, Z. Ullah and R. Allem Qureshi. 2011. Species diversity, community structure, and distribution patterns in western Himalayan alpine pastures of Kashmir, Pakistan. *Mountain Research and Development*, 31(2): 153-159.

Shaheen, H., Z. Ullah, S.M. Khan and D.M. Harper. 2012. Species composition and community structure of western Himalayan moist temperate forests in Kashmir. *Forest Ecology and Management,* 278:138-145.

Tarrasón, D., J.T. Urrutia, F. Ravera, E. Herrera, P. Andrés and J.M. Espelta. 2010. Conservation status of tropical dry forest remnants in Nicaragua: Do ecological indicators and social perception tally? *Biodivers. Conserv*., 19(3): 813-827.

ter Braak, C.J.F. and P. Smilauer. 2002. CANOCO reference manual and user's guide to Canoco for Windows: Software for Canonical Community Ordination. Ithaca, NY, US.

Toledo, B.A., L. Galetto and S. Colantonio. 2009. Ethnobotanical knowledge in rural communities of Cordoba (Argentina): The importance of cultural and biogeographical factors. *Journal of Ethnobiology and Ethnomedicine.* 5.

Uprety, Y., R.C. Poudel, H. Asselin and E. Boon. 2010. Plant biodiversity and ethnobotany inside the projected impact area of the Upper Seti Hydropower Project, Western Nepal. *Environ. Dev. Sustainability.* : 1-30.

Vačkář, D., B. ten Brink, J. Loh, J.E.M. Baillie and B. Reyers. 2012. Review of multispecies indices for monitoring human impacts on biodiversity. *Ecol. Ind*., 17(0): 58-67.

Wazir, S.M., A.A. Dasti, S. Saima, J. Shah and F. Hussain. 2008. Multivariate analysis of vegetation of Chapursan valley: An alpine meadow in Pakistan. *Pak. J. Bot*., 40(2): 615-626.

Wrage, N., J. Strodthoff, H.M. Cuchillo, J. Isselstein and M. Kayser. 2011. Phytodiversity of temperate permanent grasslands: Ecosystem services for agriculture and livestock management for diversity conservation. *Biodivers. Conserv*., 20(14): 3317-3339.

Zafra-Calvo, N., M.Á. Rodríguez and J.M. Lobo. 2010. Discerning the impact of human-mediated factors on biodiversity using bioclimatic envelope models and partial regression techniques. *Divers. Distrib*., 16(2): 300-309.

Zavaleta, E.S. and K.B. Hulvey. 2004. Realistic species losses disproportionately reduce grassland resistance to biological invaders. *Science*, 306(5699): 1175-1177.

Zobel, M., M. Öpik, M. Moora and M. Pärtel. 2006. Biodiversity and ecosystem functioning: It is time for dispersal experiments. *Journal of Vegetation Science*, 17(4): 543-547.

Zou, D., Y. He, Q. Lin and G. Cui. 2007. Evaluation of the level of threat and protective classification of the vegetation of Makehe Forest in Sanjiangyuan Nature Reserve, west China. *Frontiers of Forestry in China*, 2(2): 179-184.

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