

Western Himalayan Cold Deserts: Biodiversity, Eco-Restoration, Ecological Concerns and Securities

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Abstract: This paper provides an insight into the intimate relationships between plant diversity, land degradation and ecological concerns in the cold deserts, which is a unique eco-system of Western Himalayas. Undoubtedly, addressing desertification, including land, soil, water and plant degradation, can certainly facilitate or ease the ecological concerns, but may not completely solve it in presence of the other issues, related causes and the effects. In view of the fact that very little or for that matter no site specific research work has been done in these fragile but ecologically significant areas, an attempt has been made to offer some suggestions, in the wider context, so as to evolve and develop ecologically and socio-economically sensitive and acceptable strategies for holistic development of the area under reference.

Key words: Cold deserts, ecosystem, biodiversity, hot spot, land-use, degradation.

Biodiversity usually refers to the variety within a living organism and the broad usage of this term embraces many different parameters. In the heart of ecological research and the related conservational aspects, biodiversity gains significance since all types of organisms that exist in nature are important, both from scientific and social point of view. What is required now is to collect, collate, relate and document the existing natural wealth for the ultimate benefit of living organism in particular and to the society at large.

India, one amongst the top 12 major mega diversity countries of the world, possess a rich flora of about 17,000 flowering species with a high degree of endemism. The Great Himalayas, covering approximately 10% of India's total land surface, are one of the largest and youngest mountain chains in the world and provide an important habitat to the flora and fauna including 9000 species of angiosperms and hence, considered as the hot spot of biodiversity. In this spectrum, there are about 3470 species considered exclusively endemic to the Himalayas. Fragmentation of ecological factors with the passage of time has, however, led to the habitat loss, mainly due to ever increasing biotic pressure in the cold deserts, which, of course, are of great concern from conservationists' point of view. Compared to other parts of the world, such dry lands are considered to suffer disproportionately from land degradation and desertification (UNCCD,

1994) and have lagged behind in terms of the benefits that have been made from technological advances elsewhere in the world linked to food production and the related aspects.

It may specifically be mentioned here that the diverse climate and varied environmental conditions prevailing in the region require equally different strategies for eco-rehabilitation of such areas. The issue gains further significance in view of the fact that bio-capacity constraints, other biological thresholds, bio-physical assets including other ecosystem regulating functions (Stringer *et al.*, 2011) also hold good for the cold deserts of Mighty Himalayas and, therefore, requires constant, consistent and site specific research inputs and development of the strategies for the holistic and sustainable development of these harsh and fragile areas.

This article, therefore, seeks to provide a review of the relationships for all such aspects for sustainable use of the resources in the cold desert areas. It looks at the role of different environmental and bio-physical factors and then highlights the economic and social factors that contribute to the extent and expense of desertification. It further identifies the issues for sustainable management that can provide a useful tool for addressing these issues at the local level.

Cold Deserts in India

Cold deserts refer to an area where the climate has characteristics and great extremes of hot and cold combined with excessive dryness.

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Temperature in these tracts normally ranges from -45°C during winters to 40°C in summers. Water deficiency and dry conditions prevail primarily because of the absence of monsoon rains. Precipitation is mainly in the form of snow during winters and if at all there is any rainfall, it is normally below 60 mm. The terrain consists of plains, plateaus, hills and valleys. The soils are generally grey and light, characterized by low fertility status coupled with poor water retention capacity and scanty plant cover. In absence of any substantial leaching of minerals from the soil, the bases are continuously added to the soil complex, thereby rendering the pH values on alkaline side (7.4 to 9.4). However, due to huge variations in the geology of the region, the nature and composition of the soil varies. Summers (June to September), the major growth period for the plants growing, is quite short and because of this plants require more time to establish themselves in such harsh areas. Because of various extremities, entire region of the cold deserts remains undeveloped.

The cold deserts in India lie in between $31^{\circ}44'$ to $36^{\circ}0'$ N latitude and $75^{\circ}15'$ to $80^{\circ}15'$ E longitude with a total geographical area of approximately 74,809 sq. km. State and district wise distribution of cold deserts in India is given in Table 1.

Land Use

Land use statistics reveal that only 32% of the total land of inhabited villages is under cultivation, which amounts to only 0.2% of the total geographical area of the region. Per-capita cultivation of the land is very low (0.14 ha). The cultivation is confined only to the flatter portions of the valley land and with possibilities of irrigation. Very little is known about the indigenous land-use techniques and agricultural technologies practiced in the area

including in Lahaul Valley, Himachal Pradesh lying in the North-western Himalayas and where the area is inaccessible by road for seven months in a year due to heavy snowfall. Here, agricultural operations are normally carried out only in one cropping season (rabi season) and until recent decades, agricultural practices were traditional, with high crop diversity. However, shift towards the cash crops such as potatoes, peas and hops in the recent past have gained favor and as a result of it, diversity of staple food crops as well as "wild" cash crops has decreased considerably. One cannot ignore the improvement in socio-economic status of many farmers brought about by planting cash crops, but the large number of marginal farmers have suffered the most from the cutbacks since they can hardly afford expensive inputs like high-yield variety seeds, inorganic fertilizers, or pesticides. On account of shortage of suitable low-lying agricultural land in the area, people are now cultivating on >45 degree slopes, which has caused and is causing heavy landslides thereby, leading to severe ecosystem degradation. Since, whole of the area is cold and arid and falls within a rain shadow zone, it is crucial to upgrade existing earthen water irrigation channels. This calls for the revival of traditional systems in a scientifically informed collaboration of administrators, planners, and local people, under a participatory, integrated management approach designed for long-term sustainability (Singh *et al.*, 1997).

Land use and land cover changes that occurred during 1991 to 2001 in the Jahlama watershed of Lahaul Valley, a cold desert region of the North-western Himalaya, were evaluated recently by Oinam *et al.* (2005), and the results revealed that out of the six major land-use forms within the watershed, land areas under agriculture, kitchen gardens

Table 1. State-wise distribution of cold deserts in India

States	Cold desert region	Latitude (North)	Longitude (East)	Approximate area
Jammu & Kashmir	Leh & Kargil district of Ladakh	$32^{\circ}15'$ to $36^{\circ}0'$	$75^{\circ}15'$ to $80^{\circ}15'$	68,321 sq. km (with 27,555 sq. km under the occupation of China and Pakistan)
Himachal Pradesh	Lahaul & Spiti districts, a small pocket of Bharmour in Chamba district	$31^{\circ}44'$ to $32^{\circ}59'$	$76^{\circ}46'$ to $78^{\circ}44'$	6,488 sq. km
Uttarakhand*	Small pocket in the Janvi valley of Uttarkashi district	-	-	-
Sikkim*	Baren northern tip	-	-	-

*Information about the approximate area of cold deserts in these states is not available.

and settlement lands were found to be on the increase, whereas, areas under grasslands, barren lands and under plantations of the *Salix* spp. declined. The areas of grassland decreased from 31.41% in 1991 to 29.81% in 2001. Such a dramatic land-use and land cover changes taking place within the 33 sq. km watershed area in a single decade clearly indicates the prevailing danger of land degradation and environmental deterioration in the region.

Generally, single crop is harvested in a year in such ecosystems, but at the lower altitude like that of Kinnaur, a part of which falls in the cold desert, two crops are also possible. The main staple crops of Leh & Ladakh are barley, wheat, millet and gram along with a variety of horticultural and vegetables crops, whereas, in Lahaul & Spiti major crops sown are wheat, buck-wheat, barley, millets along with cash crops like pea, potatoes, kuth (*Sassurea lappa*) and hops (*Humulus lupulus*). Rawat (2004) has observed that land encroachments in Lahaul Valley are on the rise due to the large scale diversion of forest land for cultivation of the cash crops thereby causing a large scale ecological degradation in this fragile zone and, accordingly, gives a clarion call thereby developing control measures for proper management of these areas of significance.

Animal Husbandry

Animal husbandry, because of the large size of livestock population, is the second most important sector in the region and forms another important source of livelihood thereby, adding towards sustenance of life in these areas in addition to the existing agricultural and horticultural practices. The livestock population mainly consists of donkeys, yaks, churu, sheep, goats and Pashmina goats. Population of the livestock is about 2-3 times more than the human population. Sheep and goats account for about 85% of the total livestock population in the region. This factor magnifies the fodder problem of the region, which otherwise supports very scanty vegetation-major areas mainly consisting of semi-desertic scrub alpine steppe of *Artemesia*.

In a study undertaken by Mishra (1997), around Kibber Wildlife Sanctuary in the Indian trans-Himalayas, it was seen that livestock depredation by the snow leopard (*Uncia uncia*) and the wolf (*Canis lupus*) has

resulted in human-wildlife conflict that hinders the conservation of these globally threatened species throughout their range of distribution. He further analyzed the alleged economic losses due to livestock degradation by these carnivores and the retaliatory responses of an agro-pastoral community around this wildlife sanctuary. The three villages studied (80 households) attributed a total of 189 livestock deaths (18% of the livestock holding) over a period of 18 months to the wild predators and it amounted to a loss per household which was equivalent to half of the average annual per capita income. Recent intensification of the conflict seems related to 37.7% increase in livestock holding in the last decade. A self-financed compensation scheme and modification of existing livestock were suggested as area-specific short-term measures so as to reduce the conflicts. Therefore, an urgent need to address the problems of increasing livestock holdings in the long run had been emphasized.

General Vegetation

Based on Gaussen's criterion, vegetation classification for these areas is as under:

- Eremic (Desertic) of Leh region
- Hemi-eremic (Sub-Desertic) climate of Kargil region

The desertic climate is also prevalent in Lahaul (part) and Spiti region of Himachal Pradesh. However, in the Pooh sub-division of Kinnaur, Lahaul (part) and Kargil, there are some pockets where the general desertic conditions find a change due to occasional escape of monsoon winds bringing mild showers. The region appears to carry only about a dozen endemic plant genera, mostly small and specialized. According to Champion and Seth's classification, the natural vegetation may be assigned to following broad forest types:

- 15/C3 – Alpine pastures
- 16/C1 – Dry alpine scrub
- 16/E1 – Dwarf juniper scrub

Amongst the woody shrubs and trees (indigenous and introduced), which are of special significance to the local populace for meeting their requirements of fodder, fuel and small timber, mainly include *Saliix elegans* Wall., *S. alba* Linn., *S. fragillis* Linn.,

S. selerophylla Anderss., *Populus alba* Linn., *P. euphratica* Oliv., *P. nigra* Linn., *P. candicans* Lodd ex Loud., *P. ciliata* Wall., *P. angustifolia* Fanes., *Juniperus polycarpus* C. Koch., *J. communis* Linn., *J. macropoda* Boiss., *J. recurva*, *Astragalus* spp., *Artemisia* spp., *Myricaria bracteata* Royle., *Hippophae rhamnoides* Linn., *Tamarix gallica* Linn., *Elaeagnus angustifolia* Linn., *Caragana pygmaea* DC. *Atriplex crassifolia* C.A. Mey., *Ephedra* spp., *Rosa moschata*, *Medicago sativa* and *Haloxylon thomsonii* Bunge. The dominant families include Ranunculaceae, Caryophyllaceae, Geraniaceae, Fabaceae, Rosaceae, Saxifragaceae, Apiaceae, Boraginaceae, Scrophulariaceae, Gentianaceae and Asteraceae.

In a study Joshi *et al.* (2006) concluded that owing to harsh climatic conditions and a short growing season, Trans-Himalayan mountains support low vegetation cover (<20%), and are known to harbor a unique assemblage of flora and fauna, which have not been systematically inventoried and documented. The spatial and non-spatial information on landscape units, vegetation characteristics and plant species diversity of Nubra Valley in Ladakh, India, was worked out accordingly. Based on digital - visual (on screen) interpretation of remote sensing data coupled with knowledge-based classification 19 cover classes (11 vegetation types and 8 non-vegetation categories) were delineated. The vascular plants (angiosperms and gymnosperms) were systematically collected using stratified random sampling of different landscape/vegetation to characterize plant communities and assess the distribution patterns of species. The study further revealed that nearly 78-80% of plant species in Nubra are restricted to the valley bottoms. In all, 414 species of vascular plants belonging to 56 families and 202 genera were recorded from the study area. Of these, 102 species were reported to be used in traditional system of medicine by Amchis, over 80 species are largely associated with cultivated fields and human habitation. As many as 49 species were cultivated which include several varieties of crop plants especially those of barley and buckwheat. Aspects of bio-prospecting and conservation of valuable species have also been discussed.

Negi and Upreti (2000) recorded a total of 21 species of lichens from a sample of 7500 point intercepts on 75 line transects of 1 m length each on rock and soil substrates along an

elevation gradient, ranging from 3300 m to 5200 m amsl in the Rumbak catchment of Hemis National Park in Ladakh, India. Rocks were richer than the soil in terms of species richness, contributing to more than 80% of the total species encountered in the study area. Notably, one of the fifty six trees of *Salix* and *Myricaria* spp. surveyed, supported lichens presumably due to high bark peeling rates associated with the high wind speeds in the river banks where these tree species predominantly occur. While many of the species were rare, *Xanthoria elegans* emerged as the most abundant species on rocks throughout the sampling gradient. A non-linear relationship between altitude and species diversity (richness and turnover) on rocks was also demonstrated with maximum number of species being confined to the middle elevations. While rocks seem to provide a relatively stable and very fertile substrate for the rich growth of lichens, soil harbors poor diversity probably due to its unstable top layer augmented with disturbance by the grazing animals. Long-term monitoring of lichens in relation to the grazing and movement patterns of both domestic as well as wild herbivores would help in evolving strategies for conservation of lichens in these areas of interest.

Characteristics of the Vegetation

Annual and perennial herbs followed by a few dwarf bushes dominate the flora of cold deserts. The plant species are mostly xerophytes followed by mesophytes. The vegetation starts growing with the onset of summer on mountain slopes, alpine meadows and pasturelands, resulting in a spectacular view of different varieties of flowers during June-September and for rest of the year plant species remain dormant. Most of the prominent plants of the region are woody perennials growing in widely scattered tufts. The vegetation is characteristic of the area showing typical adaptations for an arid zone. The flora has adapted itself to survive the harsh climatic conditions of the region, leading to certain changes in underground and aerial parts. To ward off the high velocity winds, almost all the plant species remain stunted, wither forming mats or spreading along the ground. Aerial parts of these plants show definite adaptations to the xeric conditions such as thick pointed leaves, wooly tomentum on leaves and floral parts, reduced stem, spines etc., which reduce

transpiration losses and thereby, helps in conserving the moisture. The underground parts similarly have developed a deep and spreading root system to access and absorb moisture. The extensive root system also helps the plant to remain firm during high velocity winds, characteristics to the region. In addition, the root system acts as a storehouse of energy required by the plants during winter, providing a necessary food reserves for the plants to emerge immediately after the melting of snow. Another very striking feature of the plants of this region is its profuse flowering; probably a mechanism to ensure the continuation of their progenies (Kapoor *et al.*, 2002). A check list on the floristic wealth of Trans-Himalayan Cold Deserts (Chaurasia and Gurmet, 2003) has been prepared where social and ecological angles have been combined with an eye to conserve the local and important floral elements with special reference to the medicinal and aromatic plants.

Earlier Efforts for Promoting Greenery: Some Issues

In Laddakh region, establishment of introduced exotics plantations started only in 1956-57 by the state forest department by taking up plantations of willows, poplars, sea-buckthorn and *Myricaria*. In the recent efforts towards establishment of plantations, attempts are being made to propagate *Robinia pseudoacacia* Linn., *Juglans regia* Linn., *Aesculus indica* Colebr and it has been found that these species can successfully be grown in Kargil, Nubra and Leh, provided irrigation is available abundantly.

Based on the interim report of National Commission on Agriculture on Desert Development presented in 1974, Kargil and Leh district of Jammu & Kashmir and Spiti block of Himachal Pradesh were identified for starting Desert Development Program (DDP) amongst other areas of hot desert. Thereafter, the Commission made detailed recommendations regarding the development of desert areas in the country in 1976. A working group was set up in 1977 by the Planning Commission with the view to critically review the various programs in operation, in the desert areas and also to evolve suitable strategies for arresting the spread of desert. This group recommended the launching of anti-desertification program

with schemes relating to afforestation including grassland development, harvesting of water resources and their optimum utilization, rural electrification and development of agriculture, horticulture and animal husbandry. This scheme of desert development with 100% central assistance was launched in 1977-78. It is in the sense that under DPAP, the objective is to harness local resources to their optimum utilization, while under DDP, these resources have to be developed gradually as the local resources are utterly inadequate.

The program, which began as cent per cent centrally sponsored scheme, was funded from 1979-80 to 1984-85 on 50:50 sharing basis by the Government of India and the State Governments concerned. However, from 1985-86 onwards, the scheme is being entirely financed by Government of India by making allocations in the core sectors of land shaping, soil and moisture conservation, water harvesting, afforestation and pasture development including other activities like agriculture, horticulture, animal husbandry, but with no separate provision for research and development in this core project. Considerable investment had been made on afforestation activities since the inception of this program in Spiti and Pooh.

However, efforts made under DDP suffered or were unable to generate the desired impact in checking desertification and increasing the productivity of the areas mainly because of the lack of efficient technological support besides some other constraints. Moreover, up-till now we are not so sure about our priorities for the cold deserts - a hard fact which has to be seen in totality. The existing agroforestry practices, which usually play an important role in the development and improvement of an area, can always be recommended as the potential option for developing and improving the land-use settings, of course, with active participation of the rural folk. Accordingly, different agroforestry systems have been suggested for improving the productivity of land in cold desert region (Singh *et al.*, 1998).

Likewise, *Hippophae rhamnoides* can also be recommended as the other option for carrying out the plantations since, the species has been found to be the most useful in the rural settings of the cold deserts. The species is generally

found in the cold and hilly areas of Ladakh in Jammu & Kashmir, Lahaul-Spiti in Himachal Pradesh and parts of Arunachal Pradesh and Sikkim. Fruits of seabuckthorn are a rich source of vitamins and its leaves are also a rich source of protein and antioxidants. Its fruits are now utilized for making juices and other food products. Its oil has anti-radioactive and UV-protective effect. Thus seabuckthorn is a multipurpose plant of Ladakh (Dwivedi *et al.*, 2002). Its natural population varies in color, shape, size of fruits, leaves thorns, etc., and thus, provoked the studies on genetic variability in the natural seabuckthorn population indicates the presence of subspecies in the region, which needs to be confirmed by taxonomists (Singh *et al.*, 2006).

Why the Need for Native Species?

Every species has got some basic ecological requirements and definite ecological amplitude. Hence, before going in for the large-scale plantations in an area, it becomes imperative our part to identify a species suitable to the site, which then requires scientific background and some basic knowledge on these lines. Apart from taking up afforestation practices in the normal sites, cold deserts especially need great care both in identification of the species and to the planting technology as well involved for getting better growth responses keeping in view the peculiar physical and climatic settings those have combined to support a unique floral assemblage. Apart from it, availability of the land and the feasibility in the existing area in such harsh sites also matter to a great extent. It is quite well known fact that the plant species also have a remarkable adaptability to the extreme climatic condition and biotic pressures. Identification also gives an idea about structure of a vegetation, climatic condition, soil structure, etc. Keeping in view all these points as discussed, need to identify a native species for recommending the same for taking up afforestation cannot be over looked. It can certainly provide an opportunity to make the best use of ecologically available area for eco-restoration of these fragile sites and at the same time abstain the planners to impose the ban on the exotic species those directly affecting the micro-ecology of the area.

In a study carried out by Singh and Dogra (1996) to assess the distribution, utilization,

characterize, regeneration, biomass and nutritional values of seabuckthorn (*Hippophae rhamnoides* L.) in Lahaul Valley located in high hill dry temperate Himalaya, it was found that this species grows vigorously where the valley is broader particularly in Bhaga valley and is mainly utilized as fuelwood by the farmers. The plant has a high regenerative potential even in dry infertile soils. Its horizontal roots extends upto 245 cm to 680 cm which produced 9-27 root seedlings per root. Yield of fruits per plant varied from 590 g to 956 g. Seed oil content varied from 8.2 to 11.7%, whereas protein content ranged from 25.8 to 35.9%.

No specific technology for the indigenous forestry species those can help for carrying out afforestation/eco-resoration works in this fragile zone are available. Kapoor *et al.* (2011) then came out with the nursery and plantation technologies for such species those are also socially, ecologically and economically relevant to these areas.

Interventions Required

Human pressures on natural ecosystems are intensifying, some being incompatible with survival of certain species of plants. If these naturally occurring plant resources are not conserved timely then there is every reason for their extinction. In the cold deserts this genetic erosion coupled with soil erosion may retard prospects of future economic development and welfare of the people. The aim to assess the status of Junipers sp. in this harsh cold arid belt may provide a key for its conservation (Kapoor *et al.*, 2002).

The cold arid regions of Himachal Pradesh and Jammu & Kashmir are largely inhibited by Buddhists who subsist primarily on the agriculture and pastoralism. Most of the valley bottoms with irrigation facilities have been occupied by the locals and the gentle slopes are used for pastoralism. This centuries old system has sustained these populations. Except for modest attempt to grow *Medicago sativa*, as also indicated above very little has been done to develop pasture lands. The traditional crop varieties e.g., *Hordeum vulgare* var. (barley), *Triticum* sp. (wheat), *Fagopyrum tataricum* (buckwheat), *Brassica nigra* car. (rapseed), *Pisum* sp. (pea), etc., a few wild edible food plants e.g., mushrooms, wild lilies, rhubarbs,

wild cumins and medicinal herbs have been conserved through their culture.

Though the locals might have lived in harmony with nature in the past, however, increasing human population pressure from changing land use and lifestyle, pose questions regarding the response of the natural system (Singh *et al.*, 1997). Continuous removal of woody species such as *Artemisia*, *Potentilla*, *Acamtholimon*, *Salix* sp., *Rosa* sp., etc., for fuel-wood and their overgrazing by migratory livestock have resulted in desertification and loss of biodiversity. Excessive use and removal of medicinal plants is also adding to the vow both social on ecological fronts in these areas of significance and thus, essentially require conservation strategies (Kapoor *et al.*, 2005). Grazing areas and pastures are also no exception, this would be disaster and that too especially in areas where "Bakarwals" in Upper Suru Valley and "Gaddis" in Lahaul and Spiti bring large number of their livestock for grazing. Losses due such activities are seldom noticeable, but their long-term implications are bound to be serious.

Commenting further, that the efforts made so far had not been able to generate the desired impact in checking desertification and increasing the productivity of these areas, it becomes evident that the efficient and site specific technologies are essentially required to be standardized. Keeping this in view, immediate objective should directly aim at:

- Survey of the specific areas for selection of the indigenous species
- Introduction of exotics, of course with due care
- Standardization of nursery and field planting techniques of both indigenous and exotics plant species
- Studies on the socio-economic and ecological aspects to standardize package of practices for overall development of the area

All these objectives can always be met with to a considerable extent by identifying the objective wise site specific research needs.

Conclusions

Through this paper it has been argued that land degradation, as emphasized at places, is certainly an exogenous issue that

can amplify and aggravate the processes that may ultimately lead to related complications in these fragile areas. Addressing the issue may not solve it completely, but can definitely facilitate and ease the situation, if taken care of appropriately. Although as comprehensive and as permitted, there are nevertheless other causes also that are beyond the scope of this paper to include. However, the present small effort has certainly suggested that it needs to:

- identify and tag the site specific issues to adequately address the different facets of the problem;
- adopt a multi-disciplinary approach combining theoretical and applied knowledge in all the relevant domains as the key strategy for understanding the complex human-environment systems;
- be institutionalized, financially coherent and socially acceptable within the national framework; and
- be meaningful, consistent and coherent across all the sectors and related actors.

Hence it is desirable to think, plan and work for long term sustainability of this unique ecosystem that too in a unique way for conservation of the unique resources on one hand and for the cause of humanity on the other.

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