

TECHNICAL GUIDELINES FOR HABITAT AND PREY RESTORATION IN SNOW LEOPARD LANDSCAPES

MANUAL



TECHNICAL GUIDELINES FOR HABITAT AND PREY RESTORATION IN SNOW LEOPARD LANDSCAPES



Acknowledgments:

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Aishwarya Maheshwari and G. S. Rawat

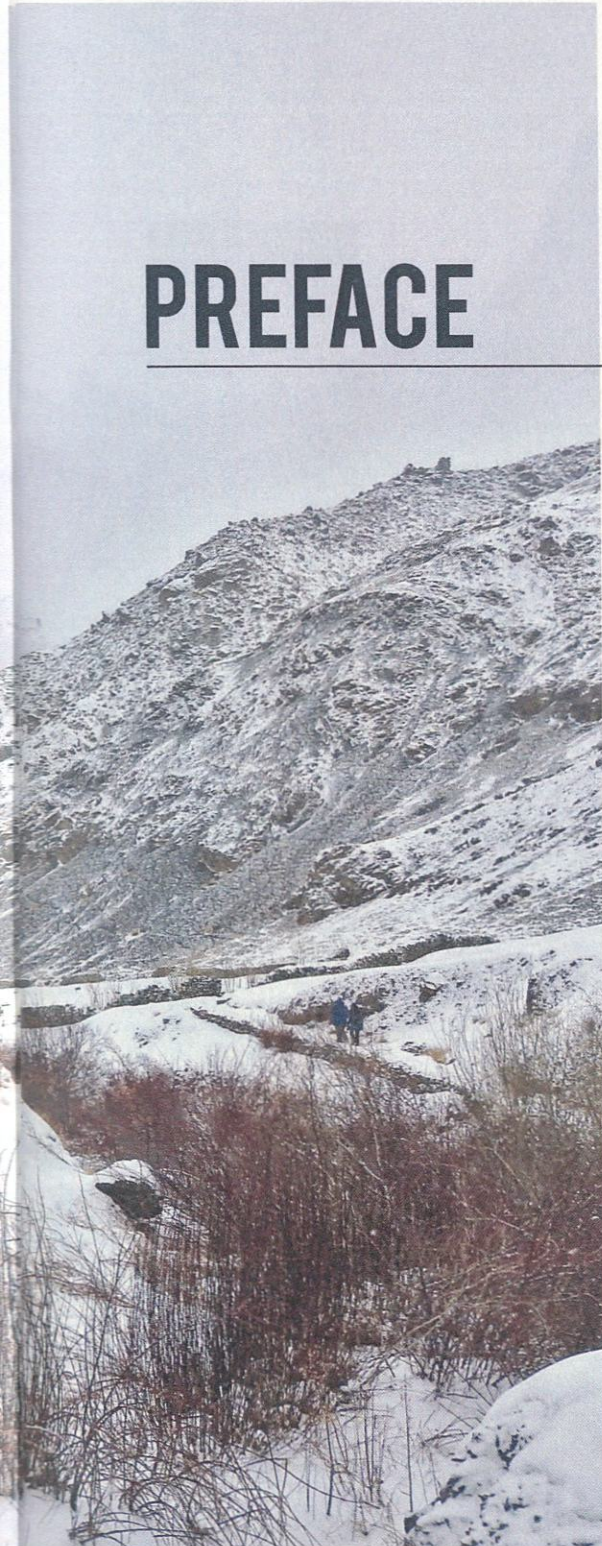


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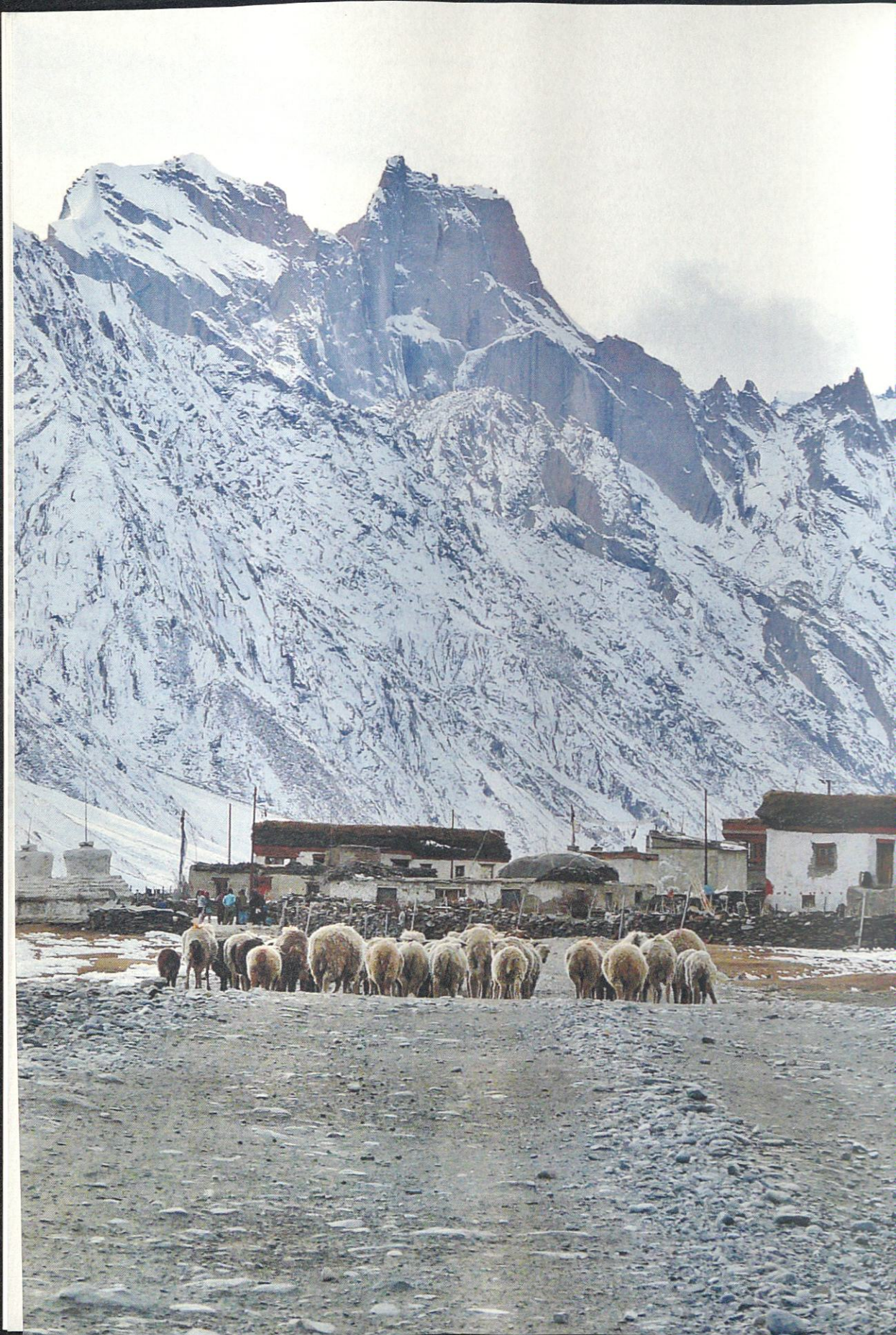
PREFACE



Advances in field data collection methods, recording and analytical tools for habitat assessment and monitoring are evolving at a rapid pace. Wildlife studies in the cold and remote high altitude mountain areas are resource intensive and are possible only when adequate resources and necessary training in field methods are available. The global snow leopard range is confined to cold and remote high altitude mountains of Asia where trained manpower and adequate resources are necessary to monitor the wildlife populations and their habitats.

Literature are available on design, methods and analysis for wildlife habitat assessment, monitoring and restoration. Approaches, methods and techniques compiled and described in this manual are adapted from the published literature and are those that are being used by researchers and managers across the snow leopard range states. In this manual, the emphasis is given on “where to look and how to look” philosophy to ensure accurate and appropriate data collection from the field.

The recent book, *Snow leopards*, edited by Dr. Tom McCarthy and Dr. David Mallon Elsevier, New York, and *Snow Leopard Conservancy* (2016) are two of the main sources of this manual.



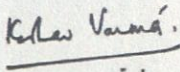
FOREWORD

The high altitude mountain ranges of central and southern Asia encompass a wide array of habitats which are not only home to several endangered and threatened species, having global conservation significance, but also provide resources for the day-to-day needs of local communities living in and around these habitats. Needless to mention, millions of people living in plains, are either directly or indirectly dependent on the ecosystem services which these mountain landscapes provide.

The past and present generations have been blessed with the availability of such valuable natural resources, which in general, have not been fully appreciated and conserved. The central and southern Asian highlands also known as the 'roof of the world', are degrading due to ever increasing anthropogenic pressures and emerging threats due to climate change. Due to habitat degradation, the survival of several wildlife species is also at risk. An in-depth appraisal of factors causing degradation is required for evolving a strategy to revive the mountain ecosystem.

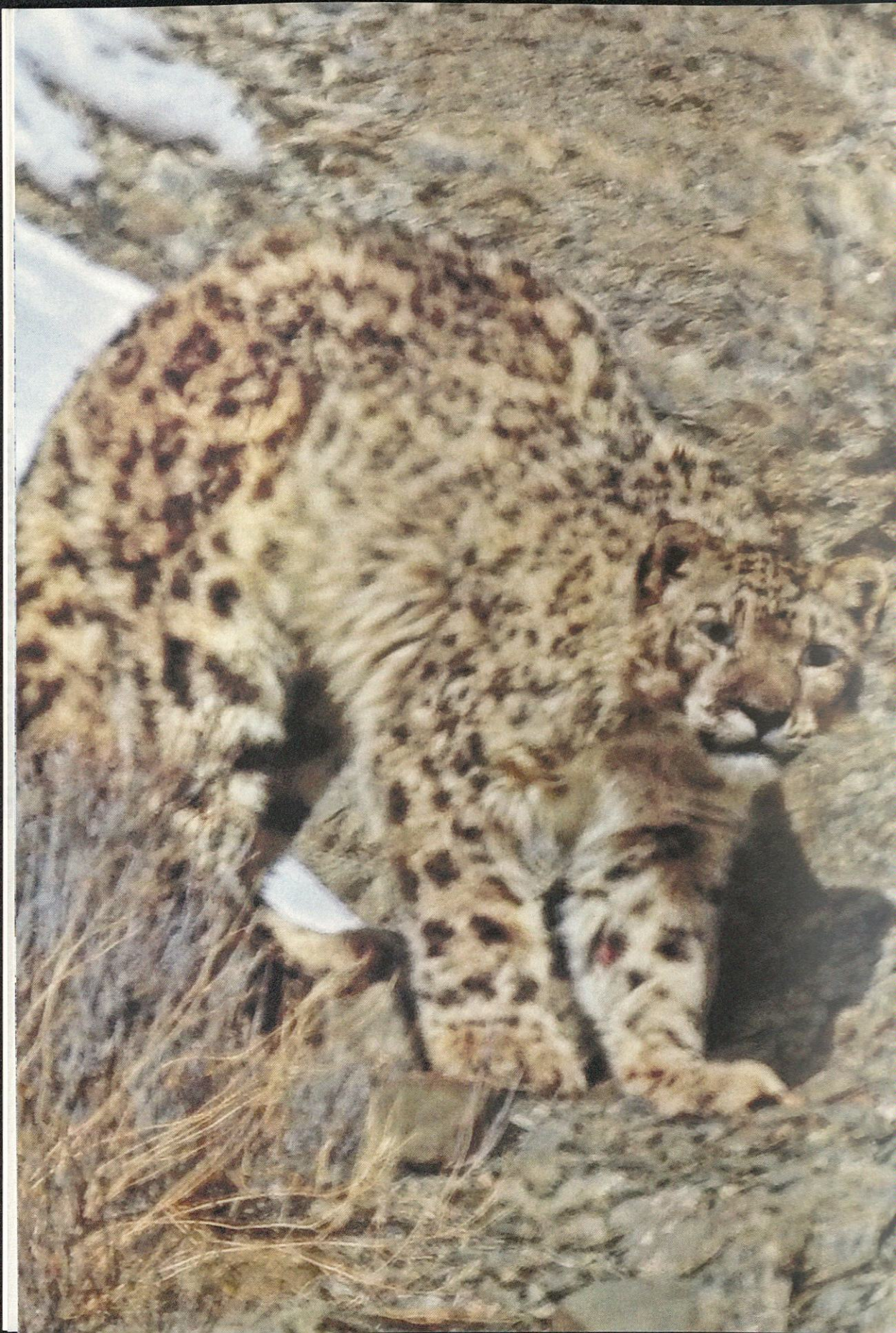
There are very few case studies on habitat restoration relating to snow leopard landscapes. The instant manual puts in place a comprehensive set of guidelines in this context.

The Global Tiger Initiative Council, and its implementing arms, Global Snow Leopard & Ecosystem Protection Program and the Global Tiger Forum are happy to partner with the Wildlife Institute of India in this endeavour. I compliment the field managers of snow leopard landscapes and scientists of Wildlife Institute of India for giving shape to this manual. I am confident that this would be serve as a valuable field guide for practitioners engaged in snow leopard conservation.



Keshav Varma
CEO & Executive Director
Global Tiger Initiative Council

26th June, 2017
New Delhi



FOREWORD

The mountain systems on planet Earth have always been a source of awe, inspiration and spiritual solace. The central and southern Asian mountains provide an amazing array of essential ecosystem services to mountain inhabitants as well as to the people in the plain lands. These services inter-alia include the storage and release of fresh water, watershed protection, forest products and land for food production, habitats for flora and fauna of local and global significance, the regulation of natural hazards and climate, natural areas for leisure and recreational activities. Also, these mountains ranges are crucial to the maintenance of natural and agricultural biodiversity and provide a profound sense of place, a source of inspiration and a rich cultural heritage.

The snow leopard has been identified as a focal species for landscape conservation planning in the central and south Asian mountain ecosystem. However, recent developmental activities such as resource extraction, building road network and hydroelectricity power facilities across most of the snow leopard's range are increasingly fragmenting the historic range of the species. Across the snow leopard range, threats are similar but their severity and magnitude vary from country to country. The Wildlife Institute of India has been actively engaged in implementing numerous collaborative programs and in continuation of these efforts, this manual provides technical guidelines for habitat restoration in the snow leopard landscapes.

I compliment the authors, contributors, reviewers and associated organizations for their tenacity and diligence in preparing this manual.



V.B. Mathur

Director
Wildlife Institute of India

26th June, 2017
Dehradun

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BACKGROUND

The Snow leopard is a charismatic large carnivore, distributed over high mountain ranges across Central and South Asia including most of the Greater and Trans-Himalaya. The species has drawn tremendous conservation appeal internationally in recent times as evident from Bishkek Declaration-2013 and Global Snow leopard and Environment Protection Programme (GSLEP; Snow Leopard Working Secretariat, 2013). It qualifies both as a flagship and an umbrella species representing the high mountain ecosystem across 12 range countries and that its continued presence would mean healthy and secure mountain ecosystem in the given area.

The snow leopard inhabits high altitude mountainous terrain characterized by sparse vegetation including alpine dry scrub, desert steppe, and meadows having reasonably good populations of mountain ungulates. These areas are also characterized by low primary productivity, generally unsuitable for agriculture and human habitation except along river valleys. The most dominant form of land use in such habitats has been livestock grazing and hence often described as high altitude rangelands. Other anthropogenic activities in the snow leopard ranges include collection of brushwood for fuel, construction of road and other infrastructure for promotion of tourism,

camping around sources of water, mining and quarrying. Major causes of habitat degradation in these rangelands include sedentarization of pastoral communities, excessive collection of fuelwood and resultant decline in population of natural prey base. However, sparsely vegetated, apparently 'barren' mountain slopes should not be categorized as 'degraded' and attempts at increasing the 'green cover' in conventional sense may not be the practical approach to habitat restoration in these areas.

It is seen that a considerable proportion of world's human population draws water for irrigation, hydro-power, and various other purposes arising from the snow leopard habitat (Snow Leopard Working Secretariat, 2013). Major threats to snow leopard and its habitat, some of the best pro-conservation land use practices within snow leopard landscapes, methods for assessing habitat quality, restoration of habitats for maintaining quality and connectivity so as to ensure long term survival of the prey populations and snow leopard and long term monitoring are presented in this manual. Though degradation is a widespread phenomenon, we visualize selection of only critical wildlife areas on priority basis and establishment of a suitable mix of protection, sustainable livestock herding and social fencing measures to reduce biomass extraction and depletion of

Ecological restoration is the process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed - Society for Ecological Restoration



fodder resources for the wild prey populations. It has to be kept in mind that unlike tropical and subtropical habitats, high altitude rangelands require much longer time to show the visible outcomes of restoration activities. It is important that conservation agencies would be able to convince the local communities that restoration and sustainable management of high altitude landscapes

would be crucial for long term flow of ecosystem services and human well-being and the management authorities will develop appropriate incentive based mechanisms for the local herders who will participate in the restoration of degraded rangelands. Restoration, habitat management and monitoring will therefore have to be made participatory.



MAJOR THREATS TO SNOW LEOPARD AND ITS HABITATS

Across the snow leopard range, threats are similar but their severity and magnitude vary from country to country. Sometimes they are interlinked, which makes it a challenge to mitigate. For example, traditional hunting practices of wild ungulates (for meat) eventually leads to loss of natural prey and increased incidences of livestock depredation by snow leopard and other predators. Annexure – 1 gives a relative score of threats to snow leopard and its habitat across various range countries.

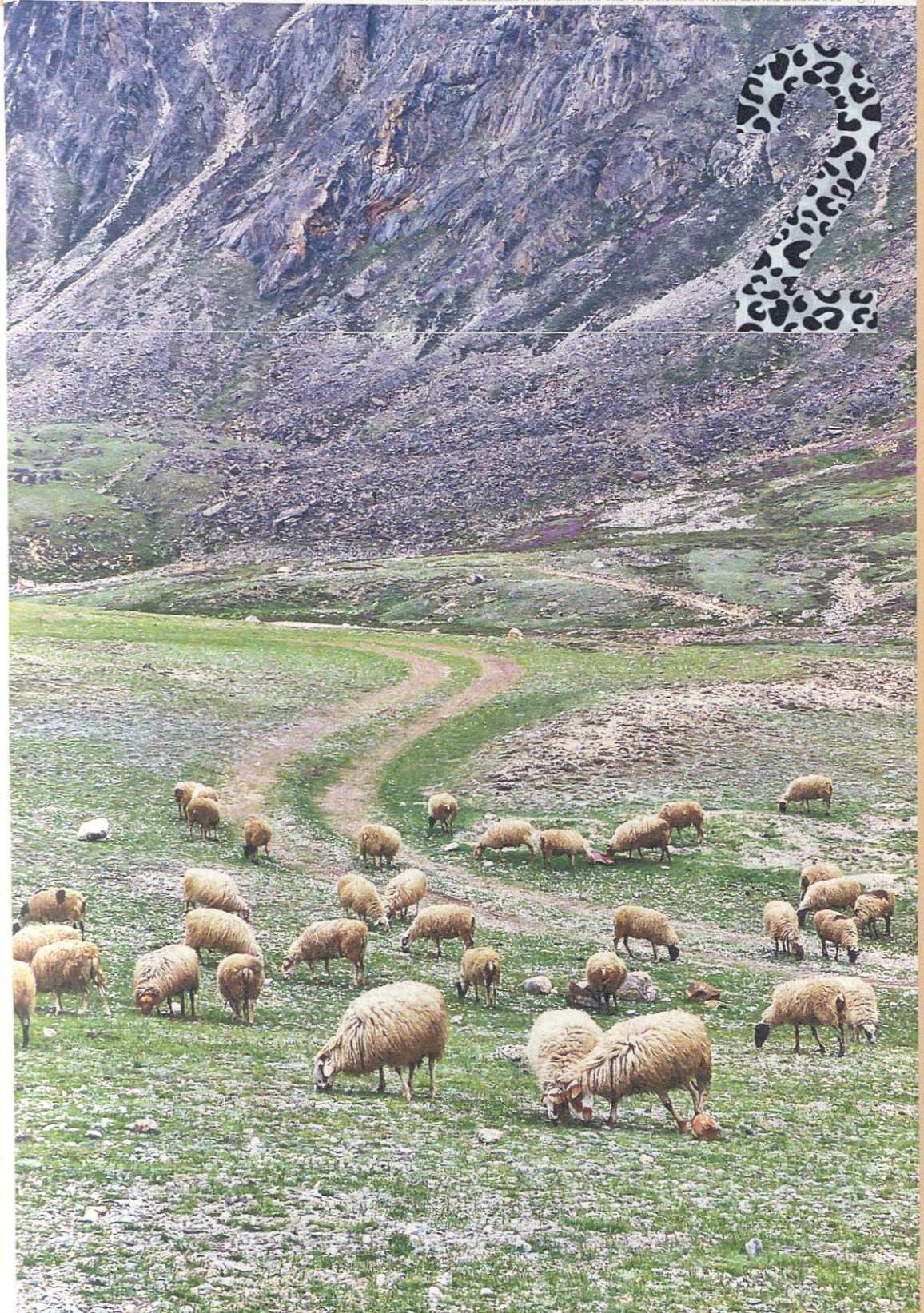
Detailed information on each of the threats is given below.

Increasing livestock and overgrazing: loss of natural prey base and retaliatory killing of snow leopards and associated species

Though human density in the snow leopard's habitat is relatively low but the communities residing in these habitats are primarily agro-pastoral and depend on the natural resources. With growing human population and rising demand for cashmere, milk and its products, livestock herds have greatly increased in size. This is resulting in

overgrazing which leads to degradation of pastureland, wildlife habitats and serious soil erosion and the decrease in their regenerative capacity, along with a reduction in vegetation production and biomass, and depletion of soil fertility (Steinfeld and Wassenaar, 2007). On the Qinghai-Tibetan Plateau, excessive livestock grazing is reported to have caused vegetation degradation and created barren soils over some 70,319 km² (Shang and Long, 2007).

Increasing livestock population also leads to killing of wild ungulates (ibex, blue sheep and markhor) to reduce competition between domestic and wild ungulates that impact loss of natural prey base for snow leopards. It altogether results into livestock depredation by snow leopards which eventually lead to protective or retaliatory killing of snow leopards. About 3 to 18% of local livestock holdings are reportedly lost to snow leopards annually (Oli et al., 1994; Mishra, 1997; Jackson and Wangchuk, 2001; Namgail et al., 2007; Maheshwari et al., 2010a and b). These damages could amount to upto 56% of the local average per capita income (Mishra, 1997; Ikeda, 2004). Large losses sometimes create such level of hatred towards the snow leopard that local communities lose complete tolerance of the cat and view total extermination of this cat as the only solution to the conflict (Oli et al., 1994; Suryawanshi et al., 2013).



Habitat fragmentation and degradation

Habitat fragmentation and degradation have emerged as one of the most significant threats to the snow leopard and its habitat in the previous decade. The recent developmental activities such as resource extraction (especially precious mineral and fossil fuels) in the snow leopard central Asian range countries, building road network and hydroelectricity power facilities across most of the snow leopard's range are increasingly fragmenting the historic range of the species (Snow leopard Working Secretariat, 2013). Even urbanization is rapidly increasing in the remote locations of the snow leopard's range. Altogether these human encroachments may restrict snow leopard's historic movements.

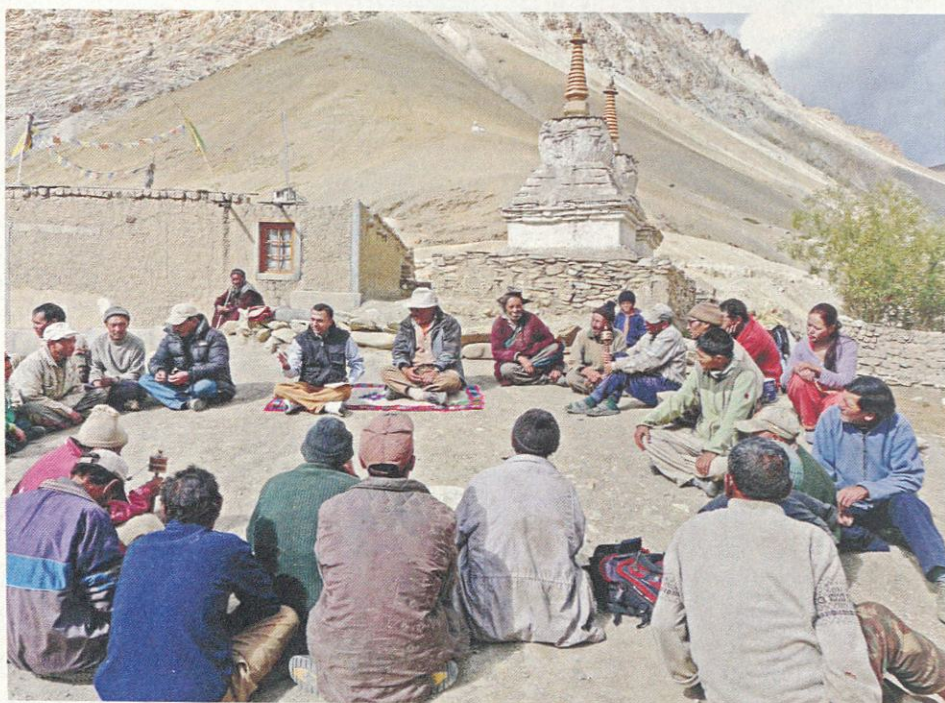
Lack of Awareness

Snow leopard is less studied and lesser known Pantherinae amongst lion, tiger, jaguar, leopard. Across most of the snow leopard's

range indigenous communities are not even aware about their ecological importance. In general, all levels of society within and outside the snow leopard range countries, from local people to leaders of governments and from the private sector to the general public have poor knowledge about snow leopards which restricts general attention and understanding about this elusive cat.

Weak Trans-Boundary Cooperation

Snow leopards cover large distances and data from camera trapping and radio collaring have provided substantial evidence of snow leopard crossing International borders. Therefore, without trans-boundary cooperation amongst snow leopard range countries, conservation goals cannot be achieved. Also, for a landscape conservation approach and providing protection to the snow leopard and associated species, strong trans-boundary policy and political will is





crucial. For example, snow leopard covers both India and Pakistan and the Siachen and Kargil is in the species' core area (Jackson, 2002). Therefore, promotion of the snow leopard as a 'flagship species' could become an important symbol representing fragile trans-boundary mountain ecosystem across central and southern Asia.

Trade and Poor Law enforcement

Pelt appears to be the main snow leopard product in demand, whereas other body parts found in trade, include bones, nails, meat, and sexual organs of male cats. There is also evidence of demand for live animals for private zoos and circuses. Snow leopard bones are known to be valued for traditional Asian medicine similar to those of tiger bones. Evidence of trade in snow leopard bones has been reported from China and Nepal. Nevertheless, it is not clear if bones

are sometimes the primary incentive for killing snow leopard or a by-product of the skin trade. Demand for snow leopard products is at the national and international level and consumers are reported to have included the powerful and privileged in the central Asian range countries, Mongolia, Pakistan and Russia, while the Middle East and Europe were cited as destinations for skins outside the snow leopard's range (Maheshwari and Meibom, 2016).

MAJOR CAUSES OF HABITAT DEGRADATION IN THE HIGH ALTITUDE RANGELANDS



Sedentarization of pastoralists

Sedentarization is the process by which once highly mobile pastoral communities tend to settle down and concentrate around wintering ranges or close to strategic locations such as trade routes or close to perennial source of water. As a result, the herders no longer follow the traditional practices of rotational livestock grazing. Sedentarization often leads to cash economy. In a study of nomadic cultures, Khazanov (1994) described a global trend in which nomadism is being replaced by market-oriented ranching and sedentarization. In such cases, the result is a prolonged occupation of livestock within a given area and the subsequent

impoverishment and desertification of the landscape. Keohane (2008) reports a similar transition among Bedouin tribes who were traditionally highly mobile i.e., every 3 to 5 days and now have become highly sedentary. Often, sedentarization leads to the overgrazing of pastures, loss of biodiversity, and ultimately desertification (Savory, 1999).

Depletion of marsh meadows

The high altitude marsh meadows are generally located in the relatively flat alluvial plains along valley bottoms of Himalayan rivers and in the vicinity of lakes and ponds which represent the wetland habitats. The high altitude wetlands play key roles in regulating the hydrology and other ecological functions. These wetlands function as simple



reservoirs or aquifers, storing water during wet periods and releasing it throughout drier periods and important sites for biodiversity conservation. For example, Zoige marsh in Tibetan Plateau of China represents one of the important biodiversity hotspots in China as it harbours many endemic and endangered species, including black-necked crane (*Grus nigricollis*). The marsh meadows serve as wintering ranges of domestic livestock due to abundance of vegetation. Thus they are crucial for pastoral livelihoods. For instance, the Longbaotan Wetland, Qinghai Province in China lies within the Longbao National Nature Reserve in Yushu Tibetan Autonomous Region. Longbaotan and its surrounding pastures are important grazing sites for the livestock belonging to Tibetan herders in the area.

About two decades ago, the nomadic herders were practising rotational grazing during various seasons in this area. However, now herders have settled down at one place and are no longer nomadic. Recently, approximately 200 households settled down around the Longbaotan Wetland, using its meadows as their main grazing land. Such sedentarization of pastoralists are degrading the high altitude marsh meadows.

Excessive removal of fuel wood and conversion of scrub-steppe into desert steppe

High altitude scrub-steppe in central and south Asia is dominated by shrubs and

bushes such as *Caragana versicolor*, *Hippophae rhamnoides*, *Loniceraspp.*, *Myricaria spp.*, *Artemisia spp.*, and *Kraschennikovia ceratoides*, to name a few. Of these, *Caragana versicoloris* is confined to west and north-west Himalaya, China, Nepal, Afghanistan and Pakistan and harvested as one of the most important fodder and fuel across the Trans-Himalayan region. Similarly, *Ceratoides papposa* is one of main source of energy for the local communities in the eastern Pamir. But over-harvesting of such shrubs has led to a severe decrease in the plant cover and loss of old plants. In addition, uprooting of plants in large number has led to a severe soil erosion and decrease in grazing land i.e. converting into desert steppe.

Diversion of water for agricultural production

Much of the area under snow leopard range is dry and rugged, unsuitable for the production of food crops. The agro-pastoral communities prefer gentle slopes and valley bottoms of rivers and rivulets below 4000 m above mean sea level for cultivation. In some regions of central Asia local communities have taken up plantation of fruit trees such as walnuts, almonds, cherries, plums, and apples (Snow leopard Working Secretariat, 2013). In general, villages get water for irrigating their fields from nearby springs. Glacial water in cold deserts of the Indian Himalayan Region (IHR) which forms the prime source of sustaining life in the region is brought to the field by making water channels built along the hill gradient for maintaining proper gravity for irrigation. Across the snow leopard habitats, 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 60mm. Thus, reduced availability of water and for agriculture leads to less water available and degradation of the rangelands.

Loss of soil and vegetation cover

In general, across the snow leopard habitats, soils are generally grey and light, characterized by low fertility status coupled with poor water retention capacity and scanty plant cover. Erosion processes in alpine regions differ from lowland soil erosion in many aspects. Here the soil is less developed and much exposed due to frequent freeze-thaw cycle, avalanche, trampling and flash floods. In addition, grazed areas exhibit increased soil compaction that leads to a decrease in water infiltration and an increase in run-off, especially during storm events (Lawrence, 1995). Physical damage to the vegetation and the erodible organic alpine humus soils leads to increases in the amount of bare ground. As little as 5% bare ground in alpine areas can cause substantial increases in surface run-off and soil loss (Costin et al., 1960), particularly where frost heave and wind ablation are active. The risk of land degradation increases as bare ground increases and vegetation cover declines (Costinet et al., 1960), and for effective soil conservation the cover of vegetation should be maximal (Costin et al., 1960). This is not possible in grazed areas.

Selective removal of high value medicinal plants

The high altitude rangelands harbour a large number of medicinal and aromatic plants used by the local communities for their traditional health care. However, in the wake of increasing demand in the market for the raw drugs, several species are being extracted at commercial scale from the alpine areas. Excessive harvest of high value medicinal plants especially underground parts can lead to loss of vegetation cover, soil erosion and habitat degradation. Some of the species found in high alpine rangelands and currently in high demand from herbal industries include *Aconitum heterophyllum*, *Ephedra*

gerardiana, *Nardostachys jatamansi*, *Podophyllum hexandrum*, *Picrorhiza kurroa*, *Dactylorhiza hatagirea*, *Saussurea costus*, and a few mushrooms including morel (*Morchela esculenta*) and Caterpillar fungus (*Ophiocordyceps sinensis*).

Prolonged camping around water courses and tree-line

Tourism is one of the major sources of livelihood for a large proportion of South and Central Asian society. However, unplanned and unregulated tourism in the high altitude areas has taken its own toll in mountainous region. Major issues are poor infrastructure, lack of professionalism in tourism management, off-road driving, camping in ecologically sensitive habitats such as wetlands and lake borders leading to degradation of the snow leopard habitats.

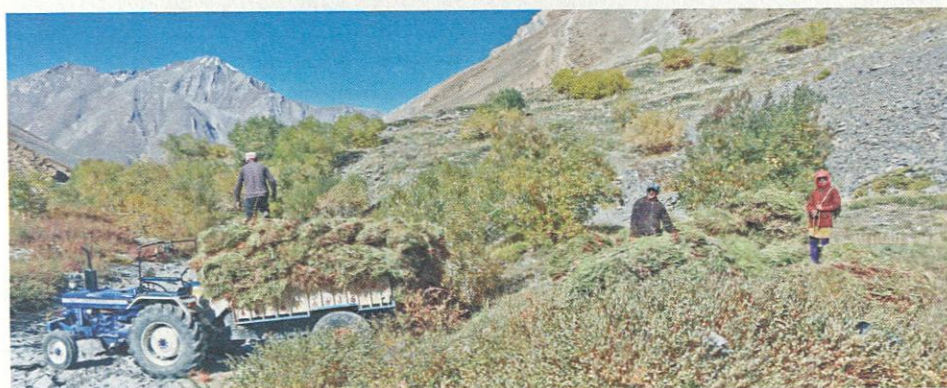
Mining

Mining is one of the major threats to the snow leopard and its habitat in the Central Asia; Mongolia and other Central Asian countries (Farrington, 2005). For instance, Mongolia is rich in mineral deposits, particularly copper, gold, coal, molybdenum, fluorspar, uranium, tin, and tungsten. Mining already accounts for a large part of foreign direct investment and government revenues in Mongolia. Mining has the potential to bring enormous benefits to the country, increasing

its potential for development and improving the livelihoods of citizens, through better infrastructure, social services, educational opportunities and employment. If properly managed, environmental protection benefits can be achieved by minimizing negative consequences on natural ecosystems, landscapes and traditions of Mongolia (Farrington, 2005). However, mining, if not planned properly, can lead to serious environmental damage, pollution and disturbances to rangelands and wildlife habitat, especially in fragile desert ecosystems. Open pit mines, blasting, large vehicular movements, excessive use of water leads to further degradation of desert ecosystem (Source: Anon., 2012).

Developmental Projects

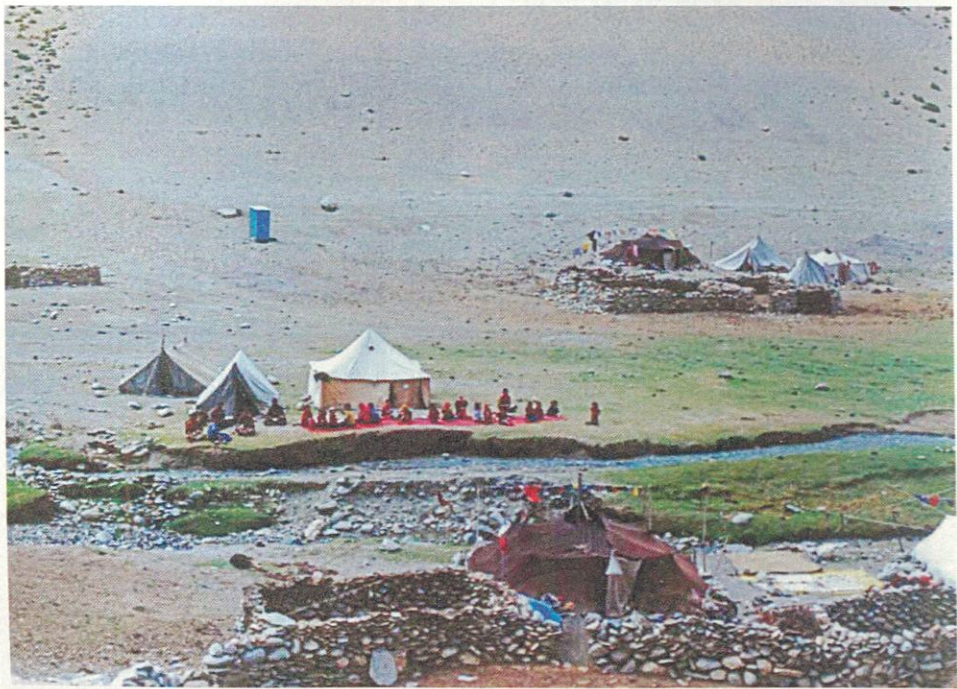
Emerging threats to snow leopard habitats are the developmental projects that are being planned for the future in most of the range countries. For instance, road building, infrastructure development, hydropower projects, land diversion for town planning and other activities. Much of these areas do not have regional / strategic environmental assessment plans for development and hence it is difficult to work towards managing these large landscapes in a planned manner. It is important to take into consideration such available developmental plans or prepare them prior to initiating developmental activities in a piece-meal approach.



Over-exploitation of natural resources from snow leopard habitat



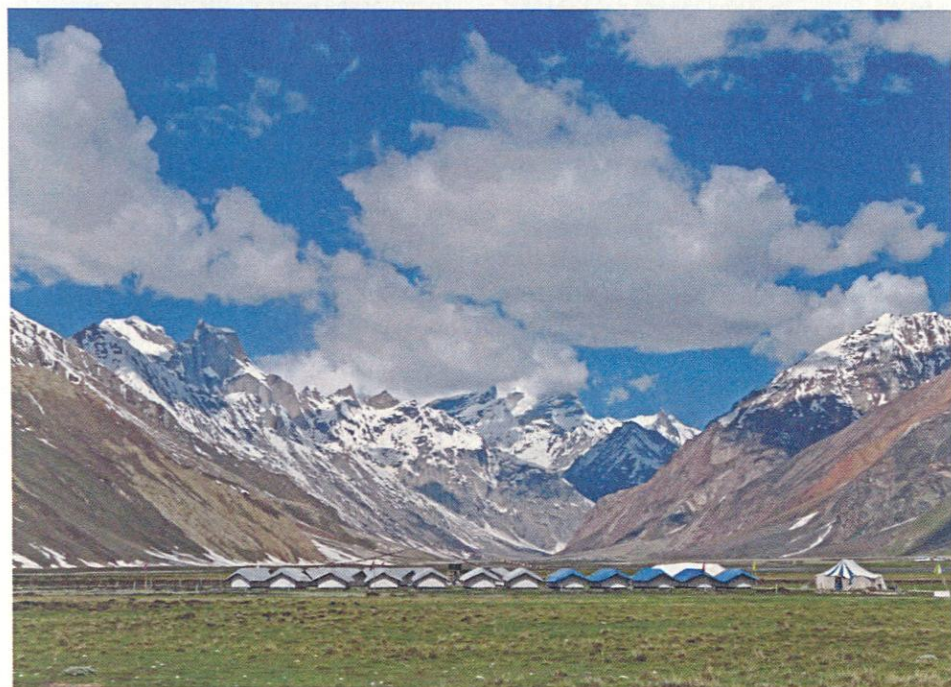
Accumulation of juniper and other scrub vegetation for fuelwood



Camping at critical winter habitats of ungulates



Habitat degradation due to sedentarization



Camping near the ecologically sensitive wetland and marshy habitat

HABITAT RESTORATION

Background

Overstocking of rangelands by domestic livestock, excessive removal of brushwood for fuel wood, mining and encroachment of moist meadows for establishment of camps by tourists and other agencies, diversion of water from stream courses lead to severe soil erosion and degradation of wildlife habitat in the high altitude rangelands. Depending upon the altitude and topography the cover of natural vegetation in the rangelands vary considerably and often, sparsely vegetated rangelands may not represent degraded rangelands. Therefore, wildlife/ natural resource managers in the snow leopard ranges will have to have evaluate the conditions of the rangelands and develop complete understanding of causative factors leading to degradation and weigh possible clear strategy for restoration. It has to be kept in mind that unlike the process of degradation, restoration and recovery of ecosystems may take much longer time.

How to ascertain that high altitude rangelands are degraded? This question often confronts the wildlife managers as well as livestock husbandry officials in the snow leopard ranges. The concerned officials and agencies will have to use a number of parameters and various combinations of these parameters to ascertain the relative stages of habitat degradation. Some of the indicators of habitat degradation in these areas include: (i) High

proportion of thorny and unpalatable species in the rangelands; (ii) Signs of sheet and gully erosion, signs of digging of medicinal plants and brushwood; (iii) Loss of vegetation cover and soil erosion in alpine sedge meadows; (iv) Lack of forage availability for wild and domestic ungulates during peak winters resulting in mortality in ungulates; (v) Competitive exclusion of wild ungulates due to prolonged livestock grazing in an area and evidences of local extinction of wild herbivores; and (vi) Reduced pastoral production in terms of yield in milk and deteriorated health condition of livestock, etc. Some of these signs are easier to detect in the moist alpine meadows as compared to cold deserts.

Heavily eroded and degraded alpine sites need to be protected on temporary basis in order to allow recovery. Some of the native herbs which are fast growing and opportunistic, such as *Persicaria polystachya* (Polygonaceae), should not be viewed as 'weeds' and uprooted. Kala et al. (1998) have highlighted the role of such herbs and opined that they play an important role in the stabilization of alpine environment such as soil formation, stabilization of slopes, role in the forest succession near treeline and soil enrichment. In Greater Himalaya, many rare and endangered plant species populations have shown recovery after cessation of

"When forests degrade they convert into secondary scrub, when scrub vegetation degrades it becomes sparsely vegetated herbaceous or grassy formation. But if alpine herbaceous formations degrade they become sparsely vegetated dust bowls and man seldom notices the degraded alpine habitats..." - Anonymous



livestock grazing. In the trans-Himalaya, especially in eastern Ladakh the moist sedge meadows (*Kobresia pygmaea* turfs) are highly threatened due to excessive grazing, and at times due to diversion of water and camping. Such meadows are crucial for sustenance of wild as well as domestic ungulates especially during winter. Therefore, utmost care would be needed to conserve such patches of vegetation.

Eco-restoration i.e., bringing the degraded ecosystem back to its original or near original stage involves careful manipulation of nature in terms of its structure and composition. It attempts to re-create species composition and ecosystem process close to the state that existed before disturbance and re-establishes the structure, productivity and species diversity of the original community (Figure 1). In other words, it recovers the ecological processes and functions of the original community (Singh et al., 2014). Hobbs and Cramer (2008) have compiled information on major restoration projects being successfully implemented in different regions of the world. In different projects, ecological restoration has improved the biological diversity on degraded landscapes, increased the populations and distribution of threatened species, enhanced the availability of environmental services to humans. However, such interventions have not been made in the natural range of snow leopard.

Strategies for Habitat Restoration

The following strategies, depending upon the degree of degradation, are suggested for habitat restoration in the snow leopard range:

Passive Restoration or Natural Recovery

Many sites in the semi-arid and moist alpine areas which have seen loss of vegetation cover, especially in and around water courses and wetlands, temporary closure for a few years in consultation with the local communities including the migratory pastoral communities. When only vegetation has been destroyed and soil is intact, natural recovery along the pathway of ecological succession is easy. In case of wetlands, the passive restoration involves the removal of the factors that cause wetland degradation. For instance, if livestock grazing is degrading the wetland, then remove the livestock and it will allow natural regeneration of wetland plant communities, natural re-colonization of wildlife and re-establishment of wetland hydrology.

Active Restoration

Sites for active restoration in the snow leopard range are rather limited. Only small areas can be taken up using environmental engineering to restore actively as this involves

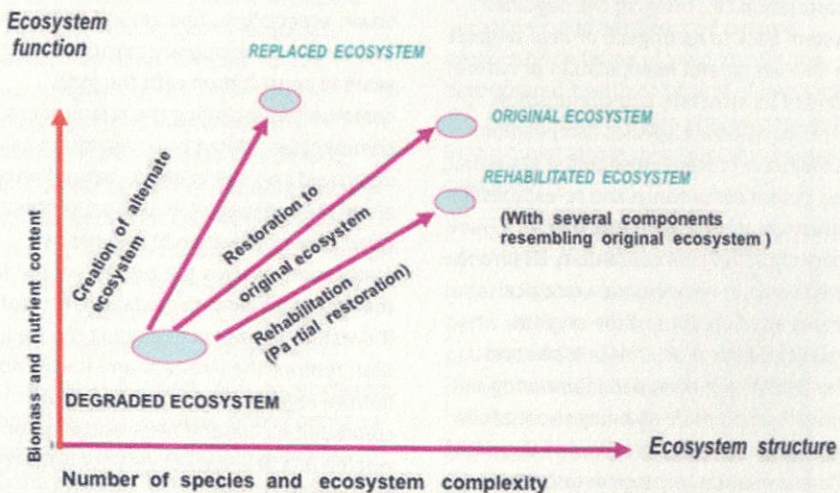
tremendous knowledge, money and time. The major challenges in active restoration of larger landscapes include: i) inadequate knowledge about the original ecosystem; ii) difficulty in putting a halt to factors causing the damage, iii) original community may be a result of processes which are no longer operative, iv) difficulty in duplicating the sequence of species introductions and disappearances. Full restoration, therefore, is almost impossible to achieve in a majority of cases (Cairns, 1991).

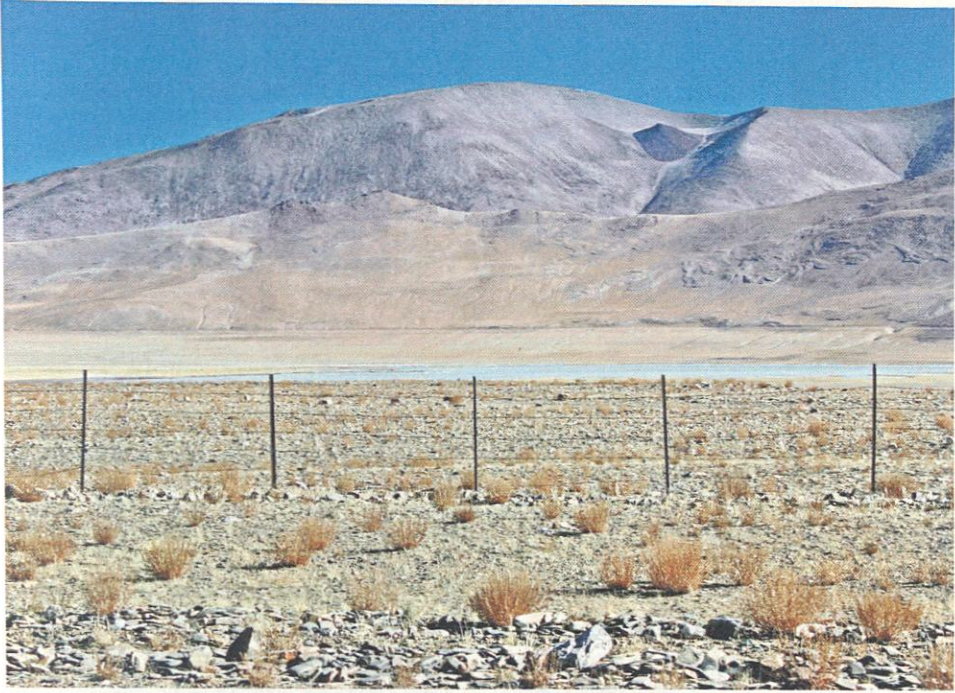
Rehabilitation

Degraded ecosystem is restored to a form and productivity conforming to a pre-decided use plan defining ecosystem components of value. This involves repair of the degraded ecosystem and restores selected ecological

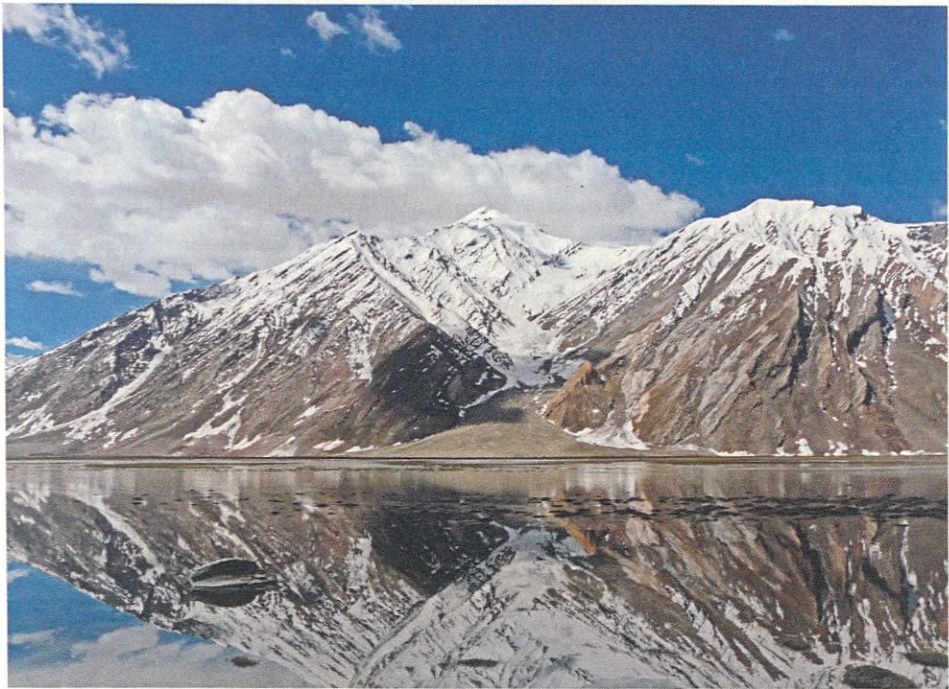
attributes of the site, making the system functional and stable (Singh and Jha, 1992). Rehabilitation has several advantages: i) it converts unproductive land to self-perpetuating ecosystem, ii) it prevents further damage to adjoining ecosystems (e.g. downstream aquatic ecosystem), iii) it reverses the negative trend of land degradation and iv) it removes pressure on undisturbed lands (Brown and Lugo, 1994).

Figure 1. Relationship between restoration, rehabilitation and creation of an alternate ecosystem (adopted from Singh et al., 2014).





Grazing enclosure at Tso Kar (high altitude wetland in Ladakh) attempts restoration



High altitude lakes, apart from their ecological significance, play crucial role in biodiversity, wildlife habitat and socio-economic aspects in the snow leopard habitats

GOOD PRACTICES

I. Reducing grazing pressures and improving degraded habitats in India

Community Driven Restoration Programme – Nanda Devi Biosphere Reserve, India

Local communities in the parts of Nanda Devi Biosphere Reserve especially, Niti Village Panchayat have set aside one of the hill slopes for conservation of wild medicinal plants and other resources. Such an arrangement done using mutually agreed terms under full participation of local communities has proven to be very effective in conserving flora as well as fauna. It is seen that the population of blue sheep, Himalayan musk deer and monal have come back on the slope protected by the villagers. In the Indian Trans-Himalaya such practices can be seen in upper Byans Valley (Kutti village) and in some pockets of Lahaul, and Spiti in Himachal Pradesh.

Grazing Free Reserve - Spiti Valley, Himachal Pradesh, India

One of the examples of participatory conservation approach in the IHR is setting-up a grazing free reserve in the Spiti Valley in the Western Himalaya. In such a reserve, wildlife could thrive without competing with the domestic livestock and anthropogenic pressures and such areas are earmarked grazing free. According to Mishra (2016),

grazing free reserves are created by herding communities in snow leopard habitat. Part of the grazing area belonging to the village council is protected from livestock and other forms of resources use to enable the recovery of snow leopards and their prey. Three reserves exist in northern India (two in the Spiti Valley and one in Ladakh), and now a fourth one has been created in the community of Lossar (further up the Spiti Valley).

II. Reducing Mining Impacts in Mongolia and Kyrgyzstan

1. Case Study from Mongolia (Source: Hotham et al., 2016)

The United Nations Development Programme (UNDP), in partnership with the Mongolian Ministry of Environment and Green Development, Ministry of Mines and Energy, and Ministry of Industry and Agriculture, with funding from the Global Environment Facility (GEF), is collaborating with the private sector to develop the Land Degradation Mitigation and Offsets in Western Mongolia project. Started in 2015, the project aims to reduce the negative impacts of mining on rangelands in snow leopard habitat of the western mountain and steppe region by incorporating the mitigation hierarchy and offset into landscape level planning and management. The project proposes to work with selected mining companies, in close cooperation with local government and communities, to pilot



best practice approaches. The aim is to conserve biodiversity and enhance ecosystem services while maintaining ecological function, including pastureland and water quality and quantity. The project will also capture lessons, to be fed into other initiatives seeking to address large-scale development impacts in sensitive landscapes. Key criteria provide a decision support framework for selecting sites where the approaches will be implemented. These include the ecology, cultural and historical heritage, socioeconomics, and institutional context. The project sites are highly biodiverse, being remote and in excellent ecological condition. In addition, Sutaikhairkhan, a nationally significant sacred mountain on the border of the Hovd and Gobi Altai Aimags, lies within this snow leopard landscape; the project will contribute to the protection of this important area. The project will also promote collaboration between the different land users to their mutual benefit while protecting vital resources through sustainable development initiatives. Existing activities and sustainable pastoralism projects will contribute to the suite of potential activities.

2. Case Study from Kyrgyzstan (Source: Hotham et al., 2016)

The presence of the Kumtor Mine has provided benefits to snow leopard

conservation in the Central Tien Shan region of Kyrgyzstan. In the late 1990s, multilateral lenders (EBRD and IFC) engaged an NGO to review the biodiversity aspects of Kumtor's Environmental Impact Assessment. The review made recommendations on mitigation measures for the mine, ranging from no-hunting policies to wildlife monitoring, which Kumtor adopted and continues to report results against in their annual environmental reports. The lenders also encouraged the Kyrgyz government to establish the Sarychat-Ertash Reserve (SER) adjacent the mine site. Once established, the lenders and Kumtor mobilized funds and resources to support NGO-led initiatives that have built the capacity of the reserve, developed a reserve management plan and supported biodiversity focused research and community development efforts. A strict no-hunting policy is still being applied on the mine site that acts as a barrier to poachers. The number of argali on the reserve has increased from 750 to 2500, making it the largest population in Kyrgyzstan. The population of ibex has stabilized at 750 to 850 head. Research also confirms that the number of snow leopards present in and around the SER has increased significantly to 18 individuals (Prizma, 2014).

ECOLOGICAL ENGINEERING

Engineering is sometimes described as the study and practice of solving problems with technological designs. Environmental engineering develops the technology for connecting society to the environment. But the technology is only half of the interface with environment. The other half of the interface is provided by the ecosystems as they self-organize to adapt to the special conditions. Ecological engineering takes advantage of the ecosystems as they combine natural resources and outputs from the economy to generate useful work. Ecological engineering is the study and practice of fitting environmental technology with ecosystems for maximum performance. Eco-restoration is an important component of ecological engineering. For instance, In the Qilian Mountain (an important ecological functioning zone nourishing the oasis in northwest China), was severely degraded due to the unsustainable use of the forest and experienced deterioration of its ecological environment. To alleviate desertification and alleviate soil erosion, government has adopted ecological engineering such as “Grain for Green” program (GFG), “Natural Forest Protection Project”, and “The Three-North Shelter Forest Program” since 2005 in this region and improved water yield and soil water content by an increment of 32%, and 46% (Tian et al., 2016).

Carbon Benefits from Eco-restoration

Steppe soils store large amounts of carbon, yet the sequestration potential is debated and depends on land use. Very few estimates are available on the rates of C sequestration in the high altitude forests and alpine meadows. It is estimated that the Himalayan forests sequester about 6-7 tonnes of C ha⁻¹ yr⁻¹ (Rana et al. 1989). However, rate of sequestration and storage varies considerably depending upon the slope, aspect and altitude. For example, fir (*Abies pindrow*) and brown oak (*Quercus semecarpifolia*) forests in the Greater Himalaya can sequester upto 9 and 10 tonnes of C ha⁻¹ yr⁻¹ respectively (Adhikari et al., 1995; Rai, 2013). Rate of C

sequestration decreases with increasing altitude and aridity. Yan and Lu (2015) found that after 6-8 years of grazing exclusion and restoration in Tibetan Plateau (quite similar to Changthang WS in Ladakh, India) alpine meadows, alpine desert steppe, grasslands and scrub steppe accumulated up to 403, 156, 320 and 277 kg C ha⁻¹ yr⁻¹ respectively. In Kedarnath WS, Uttarakhand, India (similar to parts of Govind WS), Rai (2013) estimated that grazed meadows in and around treeline sequestered 564 – 992 kg C ha⁻¹ yr⁻¹ while ungrazed meadows had the sequestration potential upto 1460 kg C ha⁻¹ yr⁻¹. Xiong et al. (2014) found that after six years of protection from livestock grazing, alpine sedge meadows in Northern Tibet, there was 25-69% increase in aboveground biomass.



Sedge meadows form an important habitat in the Trans-Himalaya, crucial for nesting and breeding of migratory birds and wild ungulates. A brief review of studies on C sequestration potential in various ecosystems in the Himalayan region is given in Table 1.



Table 1. Carbon sequestration potential in various ecosystems in the Himalaya

| Location/study description TP = Tibetan Plateau; WH= Western Himalaya; KWS = Kedarnath WLS | biomass of the herbs/forests (kg ha-1) | C sequestration/ accumulation kg C ha-1yr-1 | References |
|---|--|---|---|
| Subalpine conifer forest, TP (Soil C) | | 385 | Yu-Qiang et al., 2009 |
| alpine meadow, TP (Soil C) | | 271 | |
| Alpine meadow, TP | 708-806 | 354-403 | 6-8 Years of Grazing Exclusion Yan & Lu, 2015 |
| Alpine desert steppe, TP | 171-312 | 85.5-156 | |
| Alpine grassland, TP | 485-639 | 242.5-319.5 | |
| Alpine steppe, TP | 339-554 | 169.5-277 | |
| Grazed | 150-750 | 75-375 | |
| Grazing exclusion experiments, China Increase in ecosystem carbon storage | 57 | 28.5 | Lu et al. 2015 |
| The average annual SOC accumulation rates 2500-4900m, Himachal Pradesh | - | 19-473 | Longbottom et al., 2014 |
| Afforestation of <i>Hippophae rhamnoides</i> , TP | - | 1382 | Shi et al., 2015 |
| Afforestation of Populous, Larix, TP | - | 1133 | |
| Alpine grassland, KWS | 3820-4090 | 1910-2045 | Ram et al., 1989 |
| Alpine meadow, TP | 320-2560 | 160-1280 | |
| Alpine steppe, China | 980-1880 | 490-940 | Ma et al., 2010 |
| Alpine meadow, China | 1580-3681 | 790-1840 | |
| SokhKharak, KWS, less grazed | 1686 | 843 | Rawat 2007 |
| Rudranath, ungrazed | 1759 | 879 | |
| Pin valley Grazed | 815 | 408 | |

| Location/study description TP = Tibetan Plateau; WH= Western Himalaya; KWS = Kedarnath WLS | biomass of the herbs/forests (kg ha ⁻¹) | C sequestration/ accumulation kg C ha ⁻¹ yr ⁻¹ | References |
|---|---|--|------------------------|
| Pin valley ungrazed | 1396 | 698 | |
| Treeline ungrazed, KWS | 2920 | 1460 | Rai 2013 |
| Treeline grazed, KWS | 1128-1984 | 564-992 | |
| 6 Himalayan forests | - | 6800-7400 | Rana et al., 1989 |
| Oak forests (rianj and tilonj oak) | - | 9680 | Singh & Singh, 1992 |
| Mixed banj oak chir pine forest | - | 6830 | |
| <i>Betula utilis</i> , WH | 15288 | 7644 | Rai, 2013 |
| <i>Abies spectabilis</i> , WH | 17341 | 8670 | |
| <i>Quercus semecarpifolia</i> , WH | 18657 | 9328 | |
| Mixed Sub-alpine Forest, WH | 21138 | 10569 | |
| <i>Betula utilis</i> forest, WH | 15200 | 7600 | Garkoti & Singh, 1995 |
| <i>Abies-Picea</i> , China | 8500 | 4250 | Ni, et al., 2001 |
| <i>Abies pindrow</i> , WH | 18900 | 9400 | Adhikari et al., 1995 |
| <i>Q. semecarpifolia</i> , WH | 24600 | 12300 | |
| <i>Q. semecarpifolia</i> , Nepal | 15800 | 7400 | Subedi & Shakya, 1988. |

The eco-restoration visualizes in highly degraded sub-alpine forests and reduction in number of scrub cattle and heavy grazing by livestock in biodiversity hotspots. Following these interventions, it can be assumed that there would be a steady accumulation of biomass at a sigmoidal rate.

APPROACH TO HABITAT RESTORATION

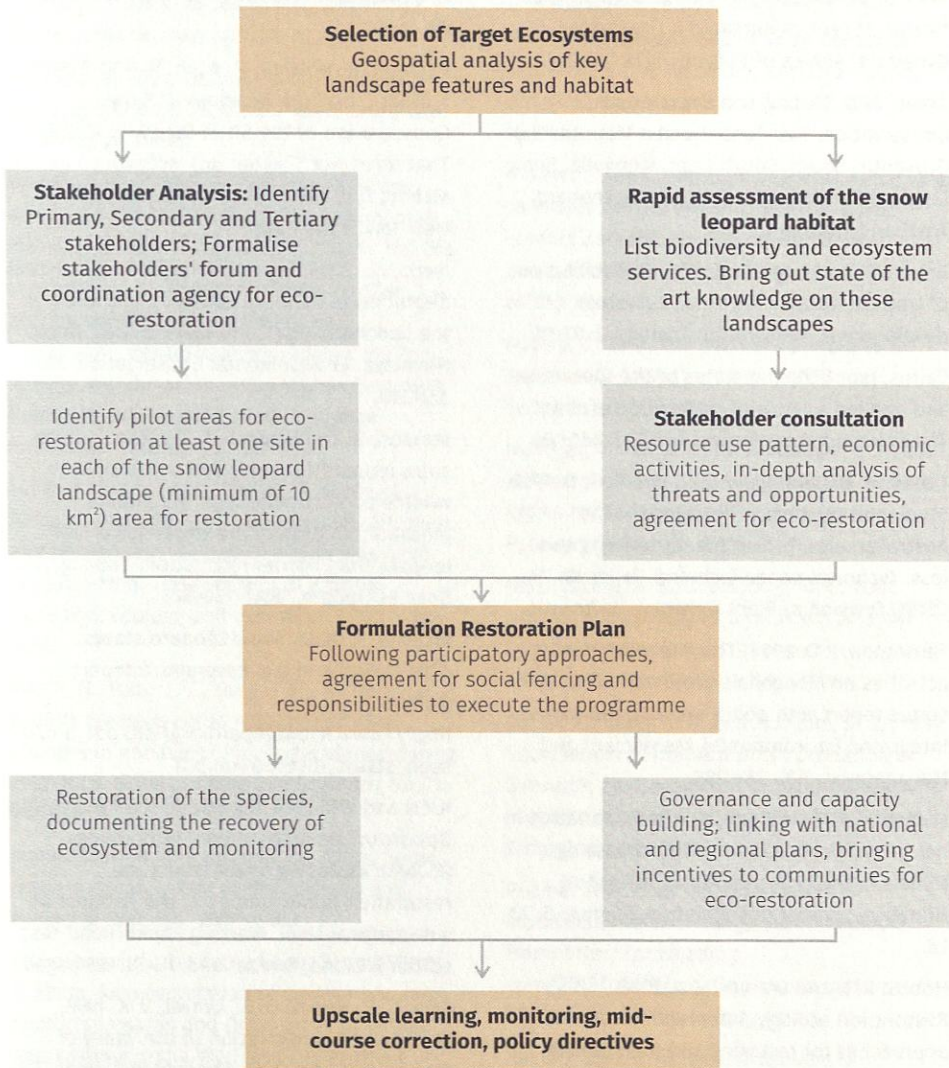
This approach could be formulated following a standard approach popularly known as Restoration Opportunity Assessment Methodology (ROAM) (Figure 2). It is a concise and replicable method for identifying landscape restoration opportunities on a local and global context developed by IUCN and WRI (2014). It makes use of series of tested steps for an effective habitat restoration planning. Major steps include stakeholder consultation and developing partnerships for eco-restoration; define knowledge gaps, data requirements and necessary capacity building needs; actual data collection and analysis at local and landscape levels; spatial analysis of restoration potential and mapping areas for snow leopard landscapes; cost and benefit analysis of the snow leopard habitat eco-restoration options and implementation of the restoration plans. The following work elements have been visualized for formulation of snow leopard habitat eco-restoration:

- a) Identification of restoration opportunity in the project landscape
- b) Identification of key stakeholders and beneficiaries of restoration project
- c) Stakeholder consultation and capacity building needs
- d) Geospatial and historic trend analysis
- e) Devise site specific restoration strategies
- f) Implementation strategy and financial viability of the programme





Figure 2. Framework for Eco-restoration of snow leopard habitat



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ANNEXURE

Annexure 1.

Threats to Snow Leopards, wild prey and their ecosystems

(Key score: Low threat=1-5, Medium threat=6-10; High threat=11-15)

Source: Snow leopard Working Secretariat, 2013

| Threats | Afghanistan | Bhutan | China | India | Mongolia | Nepal | Pakistan | Russia | Kyrgyzstan | Kazakhstan | Tajikistan | Uzbekistan | Mean value |
|--|-------------|--------|-------|-------|----------|-------|----------|--------|------------|------------|------------|------------|------------|
| Category 1: Habitat and prey related | | | | | | | | | | | | | |
| Habitat degradation | 11 | 5 | 6 | 10 | 7 | 9 | 11 | 3 | 9 | 6 | 6 | 11 | 8.2 |
| Habitat fragmentation | 10 | 2 | 8 | 6 | 8 | 10 | 10 | 0 | 6 | 9 | 0 | 7 | 6.3 |
| Prey reduction due to illegal hunting | 13 | 5 | 0 | 6 | 11 | 11 | 15 | 11 | 15 | 11 | 14 | 14 | 11.0 |
| Prey reduction due to competition with livestock | 11 | 8 | 6 | 8 | 14 | 9 | 13 | 7 | 14 | 7 | 12 | 14 | 10.7 |
| Prey reduction due to legal hunting | 0 | 0 | 2 | 0 | 5 | 3 | 3 | 6 | 10 | 9 | 0 | 0 | 3.1 |
| Prey reduction due to disease | 4 | 5 | 4 | 8 | 6 | 6 | 12 | 0 | 4 | 3 | 7 | 7 | 5.5 |
| Fencing that disrupts movement/ natural migration | 3 | 0 | 11 | 8 | 3 | 3 | 3 | 0 | 3 | 3 | 6 | 0 | 3.6 |
| Category 2: Direct killing or removal of snow leopards | | | | | | | | | | | | | |
| Retribution for livestock depredation | 13 | 6 | 10 | 8 | 11 | 12 | 14 | 8 | 6 | 12 | 8 | 8 | 9.7 |
| Poaching for trade in hides and bones | 9 | 6 | 6 | 6 | 6 | 9 | 12 | 10 | 15 | 11 | 11 | 9 | 9.1 |
| Zoo and museum collection of live animals | 0 | 0 | 0 | 0 | 0 | 6? | 0 | 0 | 2 | 3 | 3 | 5 | 1.1 |
| Traditional hunting of snow leopards | 0 | 3 | 3 | 0 | 4 | 3 | 0 | 0 | 0 | 6 | 1 | 9 | 2.4 |
| Secondary poisoning and trapping of snow leopards | 3 | 7 | 6 | 6 | 7 | 9 | 6 | 14 | 9 | 10 | 4 | 0 | 6.7 |
| Diseases of snow leopards | 1 | 5 | 1 | 8 | 5 | 5 | 11 | 0 | 3 | 3 | 2 | 2 | 3.9 |
| Potential threats from Legal hunting of snow leopards | 0 | 0 | 0 | 0 | 6 | 1 | 5 | 0 | 5 | 0 | 0 | 0 | 1.4 |
| Category 3: Policy and awareness issues affecting conservation of snow leopards, prey and habitat | | | | | | | | | | | | | |
| Lack of appropriate policy | 13 | 8 | 10 | 10 | 6 | 3 | 9 | 15 | 14 | 3 | 8 | 12 | 9.2 |
| Lack of effective enforcement | 14 | 5 | 8 | 12 | 13 | 7 | 13 | 15 | 15 | 12 | 12 | 12 | 11.5 |
| Lack of trans-boundary cooperation | 9 | 11 | 12 | 8 | 9 | 8 | 9 | 6 | 9 | 7 | 9 | 12 | 9.1 |



| Threats | Afghanistan | Bhutan | China | India | Mongolia | Nepal | Pakistan | Russia | Kyrgyzstan | Kazakhstan | Tajikistan | Uzbekistan | Mean value |
|--|-------------|--------|-------|-------|----------|-------|----------|--------|------------|------------|------------|------------|------------|
| Lack of institutional capacity | 14 | 10 | 6 | 12 | 12 | 9 | 13 | 12 | 12 | 3 | 10 | 12 | 10.4 |
| Lack of awareness among local peoples | 8 | 9 | 6 | 12 | 14 | 10 | 13 | 12 | 13 | 10 | 8 | 12 | 10.5 |
| Lack of awareness among policy makers | 14 | 10 | 4 | 12 | 12 | 3 | 11 | 9 | 13 | 3 | 12 | 12 | 9.6 |
| Category 4: Other issues | 9 | 0 | 0 | 9 | 0 | 6 | 9 | 0 | 4 | 0 | 1 | 0 | 3.2 |
| War and related military activities | | | | | | | | | | | | | |
| Human population growth (rapid) / poverty (indirect threat) | 10 | 5 | 7 | 7 | 6 | 3 | 10 | 0 | 12 | 3 | 10 | 11 | 7.0 |
| Feral dogs attacking snow leopard and prey | 1 | 10 | 5 | 11 | 3 | 4 | 7 | 0 | 0 | 1 | 2 | 7 | 4.2 |
| Poaching and wildlife trade by migrant workers | 3 | 2 | 5 | 10 | 3 | 8 | 11 | 0 | 8 | 9 | 1 | 0 | 6.0 |
| Poaching by military personnel | 13 | 6 | 0 | 7 | 3 | 0 | 9 | 6 | 15 | 8 | 11 | 9 | 7.2 |
| Emerging threats | | | | | | | | | | | | | |
| Climate change | 10 | 12 | 10 | 10 | 12 | 12 | 11 | 9 | 4 | 3 | 10 | 15 | 9.8 |
| Growing livestock population and intensifying human-wildlife conflict | 11 | 13 | 12 | 10 | 13 | 9 | 15 | 9 | 13 | 10 | 15 | 15 | 12.1 |
| Large scale development projects | 1 | 0 | 8 | 10 | 10 | 11 | 10 | 7 | 5 | 6 | 10 | 0 | 6.5 |
| -Direct and indirect impacts due to mineral exploration / mining (local) | 1 | 0 | 9 | 7 | 10 | 5 | 9 | 11 | 12 | 3 | 12 | 0 | 6.5 |
| -Impacts due to hydroelectric projects | 0 | 6 | 7 | 5 | 5 | 12 | 9 | 0 | 3 | 3 | 6 | 0 | 4.7 |
| -Impacts due to roads or railroads | 0 | 0 | 8 | 11 | 11 | 9 | 9 | 0 | 6 | 9 | 3 | 0 | 5.5 |
| -Disturbance due to Cordyceps collection | 0 | 12 | 10 | 7 | 0 | 12 | 0 | 0 | 0 | 0 | 0 | 0 | 0.4 |

