BASELINE RESEARCH STUDY

BUILDING ECOLOGICAL AND SUSTAINABLE TRANSPORT/LINEAR INFRASTRUCTURE FOR SNOW LEOPARDS IN THE HINDU KUSH KARAKORAM HIMALAYA LANDSCAPE IN PAKISTAN (BEAST)

Assessing the Impacts of Transport Infrastructure on Snow Leopards and its Prey Species with Proposed Recommendations for Consultation

This report could not have been possible without the support and endorsement of the Gilgit Baltistan Parks and Wildlife Department, Government of Gilgit Baltistan
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<th>Full Form</th>
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<tr>
<td>AJK</td>
<td>Azad Jammu Kashmir</td>
</tr>
<tr>
<td>ArcGIS</td>
<td>Aeronautical Reconnaissance Coverage Geographic Information System</td>
</tr>
<tr>
<td>CCHA</td>
<td>Community-Controlled Hunting Areas</td>
</tr>
<tr>
<td>CKNP</td>
<td>Central Karakoram National Park</td>
</tr>
<tr>
<td>EIA</td>
<td>Environmental Impact Assessment</td>
</tr>
<tr>
<td>EPA</td>
<td>Environmental Protection Agency</td>
</tr>
<tr>
<td>GB</td>
<td>Gilgit-Baltistan</td>
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<tr>
<td>GEE</td>
<td>Google Earth Engine</td>
</tr>
<tr>
<td>GLOF</td>
<td>Glacial Lake Outburst Flood</td>
</tr>
<tr>
<td>HKH</td>
<td>Hindukush-Karakoram-Himalaya</td>
</tr>
<tr>
<td>IUCN</td>
<td>International Union for the Conservation of Nature</td>
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<tr>
<td>KKH</td>
<td>Karakoram Highway</td>
</tr>
<tr>
<td>LULC</td>
<td>Land Use Land Change</td>
</tr>
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<td>KNP</td>
<td>Khunjerab National Park</td>
</tr>
<tr>
<td>KP</td>
<td>Khyber Pakhtunkhwa</td>
</tr>
<tr>
<td>NP</td>
<td>National Park</td>
</tr>
<tr>
<td>P&amp;DD</td>
<td>Planning and Development Department</td>
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<tr>
<td>RF</td>
<td>Random Forest Classifier</td>
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<td>WVC</td>
<td>Wildlife-vehicle Collisions</td>
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EXECUTIVE SUMMARY

Famed for its magnificent mountain ranges, grand glaciers, and striking landscapes world over, Gilgit-Baltistan (GB) lies at the intersection between Central, South, and East Asia and the meeting point of three great mountain ranges – Hindu Kush, Karakoram, and the Himalayas (HKH). The region has undergone substantial transport/linear infrastructure development in the past several decades, easing access and connectivity, in turn ensuing a notable boost in tourism. An unchecked growth in infrastructure and hospitality industry combined with worsening climate leading to higher temperatures has exposed GB’s beautiful vistas and its inhabitants to a multitude of threats. Wildlife in the region, particularly the snow leopard (Panthera uncia), is gravely vulnerable to physical and ecological changes.

In light of recent developments in the HKH belt, the World Wide Fund for Nature – Pakistan (WWF - Pakistan) launched the “Sustainable Infrastructure Initiative” in 2019, which aims to build across-the-board capacities, raise awareness, as well as advocate for sustainable and green infrastructure planning and development in the region. One of the two major projects under this initiative is Building Ecological and Sustainable Transport/Linear Infrastructure for Snow Leopards in the Hindu Kush Karakoram Himalaya Landscape in Pakistan (BEAST). The aim of the BEAST project is to develop a case for designing wildlife friendly transport infrastructure and transition to nature positive infrastructure. This report serves as a baseline and presents the findings of a research study conducted under the BEAST project and proposes recommendations for consultation with the relevant stakeholders.

The study employed a mixed-method approach to map land usage/coverage changes in snow leopard habitats, ascertain the frequency of wildlife-vehicle collisions (WVC), and examine the impact of expanding linear infrastructure development on human-wildlife interactions in select project sites. The study area encompassed known snow leopard habitats along the Karakoram Highway (KKH) and Gilgit-Shandur road, and project sites included protected sites—national parks and community-controlled hunting areas (CCHA)—as well as other locations.

Findings from the community perception survey suggest that there has been considerable infrastructure development in the study area, primarily major roads, while GIS mapping indicates evident change in land usage/coverage and habitat degradation—pronounced decline in snow and water coverage. Moreover, there is limited evidence of WVCs involving snow leopards, but community survey data indicates it is an emerging issue for its prey species, such as the Himalayan Ibex, and domestic livestock, primarily due to the sharp rise in the volume of traffic. Lastly, weak, and inconsistent enforcement of prevailing laws on hunting and poaching, land encroachments, retaliatory killings, and lack of signage are major gaps in the existing infrastructure that encourage human-wildlife interaction and conflict.
Certain measures, if integrated in the existing linear infrastructure could considerably mitigate the risk of human-wildlife interaction: construction of wildlife corridors, road fencing in identified hotspots, wildlife passage or structures for safe crossings, prominent road signage to alert or caution motorists, seasonal road closures, and devoted law enforcement personnel to patrol habitats. In addition, wildlife hotspots where snow leopards and their prey species are known to frequent, should be formally declared as construction free zones to prevent development of hospitality infrastructure in areas of high ecological importance.

While the aforementioned measures are critical for protecting wildlife from threats associated with sprawling infrastructure and unregulated human activity, a paradigm shift in the current approach to socio-economic development through infrastructure is essential to bolster long-term climate resilience and conservation of GB’s natural habitats and biodiversity.

Figure 1: A Himalayan Red Fox Spotted at KNP on the KKH
A historically significant geostrategic location, Gilgit-Baltistan (GB) has undergone rapid linear infrastructure development since the completion of the Karakoram Highway in the 1970s.\(^1\) Also known as “Bam-e-Dunya” (Roof of the World)\(^2\) and “axis of Asia”\(^2\), GB’s unique geographic position—an intersection between Central, South, and East Asia and the meeting point of three great mountain ranges, Hindukush, Karakoram, and the Himalayas—makes it immensely attractive to regional economic powers and tourists alike. While the region is known for its mighty mountains and glaciers world over, it is also a gateway to Central Asia and the Indian Ocean, with the potential of becoming an important trade hub.

With its growing prominence as a budding trade center and an established tourist destination, large-scale transport-infrastructure development and burgeoning hospitality projects have exposed GB’s local biodiversity and pristine landscapes to intrusion and destruction. The region is also home to diverse wildlife, including the vulnerable snow leopard (Panthera uncia)\(^3\), and surge in linear infrastructure development effectively fragmented their habitats, disrupting movement and dispersal, and heightening the risk of human-wildlife

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interactions. For the purposes of this report, “Linear Infrastructure” is defined as any infrastructure that cuts through a landscape, and includes, but is not limited to, transport infrastructure, such as roads and railways.

Infrastructure-related projects and their environmental consequences have recently drawn considerable attention from across the globe. The discourse also arose out of the complex association between anthropogenic activities and environmental degradation mounting on the vulnerability of Asia’s vast ecosystems. These concerns are exacerbated by extensive development projects carried out as part of Pakistan’s infrastructure development. Despite facilitating interconnectivity through trade and tourism, these infrastructure developments frequently and unknowingly overlook environmental

In 2020, a WWF report based on a systematic review of snow leopard research spanning 100 years up to 2020, stated that more than more than 70% of snow leopard habitat remains understudied, leaving conservation planning handicapped by large information gaps.4

The need for a study on road ecology

Table 1: Snow Leopard Habitat Area Covered by Research by Country, 1904-2020 (WWF, 2020)

<table>
<thead>
<tr>
<th>Range country</th>
<th>Estimated snow leopard habitat (sq km)</th>
<th>% of global snow leopard range</th>
<th>Number of studies</th>
<th>% of total studies</th>
<th>Total area covered by research (sq km)</th>
<th>% of total country range area covered</th>
</tr>
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<tr>
<td>China</td>
<td>1,100,000</td>
<td>61.94</td>
<td>40</td>
<td>22</td>
<td>270,625</td>
<td>25</td>
</tr>
<tr>
<td>India</td>
<td>75,000</td>
<td>4.22</td>
<td>46</td>
<td>25</td>
<td>30,152</td>
<td>40</td>
</tr>
<tr>
<td>Nepal</td>
<td>30,000</td>
<td>1.69</td>
<td>42</td>
<td>23</td>
<td>22,205</td>
<td>74</td>
</tr>
<tr>
<td>Pakistan</td>
<td>80,000</td>
<td>4.5</td>
<td>11</td>
<td>6</td>
<td>8,431</td>
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</tbody>
</table>

The same report points to glaring gaps in the human elements of snow leopard conservation in research till 2020. Rangeland-related issues were highlighted as one of the least studied aspects of snow leopard conservation, despite their importance. There was an evident focus on ecological research which had the highest frequency of papers, followed by human-wildlife conflict and social dimensions of research. Other themes such as direct threats to snow leopards and wild ungulates, conservation plans and policies, threats and rangeland issues, climate change and conservation technology received less attention.

The report further elucidated that while ecological aspects dominated the snow leopard research, a breakdown of ecological research revealed a predominant focus on survey and monitoring with abundance and distribution of snow leopards and wild ungulates being the primary focus of most studies. Movement Ecology was the least prioritized whereas emerging threats such as infrastructure development were unaccounted for.\[5\]

\[5\] Ibid.
This underscores the need to conduct the necessary assessments, studies, and on field research to begin developing the requisite baselines to provide data backed recommendations to ensure that linear infrastructure is planned, designed, and construction in a manner which protects the conserves these habitats and the wildlife that resides within it.

In view of the significant infrastructure growth in the region, WWF-Pakistan launched the “Sustainable Infrastructure Initiative” in 2019, which aims to build across-the-board capacities, raise awareness, as well as advocate for sustainable and green infrastructure planning and development in the Hindukush-Karakoram-Himalaya (HKH) region.

One of the two major projects under this initiative is Building Ecological and Sustainable Transport/Linear Infrastructure for Snow Leopard in the Hindu Kush Karakoram Himalaya Landscape in Pakistan (BEAST). With the support of “With Snow Leopards” Small Grant (SLSG), which is initiated by Tencent Foundation and Shan Shui Conservation Center, and supported by Huatai Foundation, Amity Foundation, and Peking University Center for Nature and Society. The overarching objective of the BEAST project is to develop a case for designing wildlife friendly transport infrastructure and adapting existing infrastructure through the integration of mitigating measures like wildlife crossings and corridors.

To develop a compelling case for nature positive infrastructure that conserves local biodiversity and ecosystems, WWF-Pakistan carried out a first of its kind research study under the umbrella of a broader road ecology theme to gather evidence on infrastructure related threats to snow leopards and their habitats in GB. The study collected data on wildlife-vehicle collisions (WVC) through a community perception survey, examined the impact of infrastructure sprawl on human-wildlife interaction, and employed GIS mapping to analyze changes in land usage/coverage in known snow leopard habitats over the past 20 years. The study area comprised of two major roads – the KKH and planned and under construction Gilgit-Shandur Road – as they both bisect snow leopard home ranges in GB.

The subsequent sections present the findings of the research study and offers evidence-based recommendations to aid in the protection and conservation of snow leopard habitats and a transition towards the development of nature- and climate-positive infrastructure in the region.

**BACKGROUND**

Native to the high mountain ranges of Central and South Asia, the snow leopard is a rare and elusive species of big cats.\(^8\) It is distinctly difficult to estimate the exact population of

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Linear infrastructure, by definition, can create barriers to wildlife movements. It is also the backbone of national and regional economies and can cross multiple jurisdictions (local, regional, and even international borders), both of which present multiple issues when attempting to minimize or mitigate the threat from these development projects. Most roads in snow leopard habitat are categorized to be low-traffic mountain tracks, however, some larger roads with significant traffic (mostly trade related) bisect snow leopard range, such as the Karakoram Highway in northern Pakistan.

Previous behavioral research indicated that snow leopards occasionally cross valleys and lowland areas for dispersal, movement, or other reasons, and thus cross major roads (or even railways) to complete their movements. Another globally accepted, indirect effect of linear infrastructure is the continued encroachment into snow leopard habitat by the construction of roads and fences. Conservationists argue that in both cases, consideration should be given to providing snow leopards and their ungulate prey species with safe passage.
with options for crossing that minimize the roadway’s interference with movements. Options include the construction of overpasses, underpasses, and in areas known to be movement routes for wildlife: warning signs and speed limit reductions.\(^\text{12}\)

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**SNOW LEOPARDS IN PAKISTAN**

Also known as “ghost of the mountains,” an approximate 200-420 individuals inhabit the northern mountain ranges of Pakistan in GB, Khyber Pakhtunkhwa (KP), and Azad Jammu Kashmir (AJK).\(^\text{13}\) The entire snow leopard range in Pakistan is around 80,000 km\(^2\) spanning four major mountain ranges: Hindu Kush, Pamirs, Karakoram, and Himalayas. A significant proportion of snow leopard population (>60 percent) resides in the GB region, mainly concentrated in two adjoining national parks: Kunjerab National Park (KNP) and Central Karakoram National Park (CKNP).\(^\text{14}\)

In 1972, the International Union for the Conservation of Nature (IUCN) listed snow leopards as “endangered” on the IUCN Red List of Threatened Species. However, in 2017, the threat level was downgraded to “vulnerable” in, but snow leopards are still listed as “critically endangered” in Pakistan.\(^\text{15}\)

The snow leopard favors hunting wild herbivores and its prey base includes the Astor markhor (Capra falconeri falconeri), Marco Polo sheep (Ovis ammon polii), Himalayan ibex (Capra sibirica), blue sheep (Pseudois nayaur), and the musk deer (Moschus moschiferus). Additionally, as they are opportunistic predators, they are known to target domestic livestock as well. Research on snow leopard diet shows that globally about 25 percent of their food consumption is based on domestic livestock.\(^\text{16}\) This number is twice as high for Pakistan.\(^\text{17}\) In fact, some argue that there would be an adverse impact on snow leopards’ sustenance if domestic livestock were completely removed from their habitats. Figure 4 exhibits the diverse wildlife and their respective habitats across GB as of 2018. As seen in the map, while most of the snow leopard habitats are part of protected areas, some also reside outside, which includes in the districts of Ghizer, Kharmang, Ghanche.

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\(^{12}\) Ibid.


\(^{15}\) Din, J.U., et al. (2022). Drivers of snow leopard poaching and trade in Pakistan and implications for management. scheme-for-farm-livestock.


Snow leopards in Pakistan face a similar combination of conventional and emergent threats as elsewhere in Asia—poaching and hunting; habitat loss and degradation caused by overgrazing and climate change; habitat fragmentation due to human settlements and poorly planned activities like infrastructure development; competition for prey; and human-wildlife conflict. Moreover, studies suggest that expanding roads and railway networks cause habitat fragmentation, hampering movement, particularly in the lowlands where snow leopards search for prey or mates.

Snow leopard habitats are also at risk from the impacts of climate change, which includes higher temperatures and receding snow lines. The World Bank’s South Asia Climate Action Plan 2021-2025 contends that climate change is the biggest development challenge for Pakistan and frequent landslides, glacial lake outburst flood (GLOF), floods (2022) in GB sustains this assertion.

Nonetheless, there has been a significant rise in sightings of snow leopards in GB, mostly in protected areas like KNP, Passu Valley, and Khyber. While increased sightings do not signify a rise in actual population of snow leopards, it is worth noting that concerted conservation efforts by communities have played a critical role in familiarizing wildlife to freely move in protected sights.

In addition, based on discussions with communities and relevant government departments, the Trophy Hunting Program in particular has contributed to a dramatic increase in the population of the Himalayan

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21 Season commences in November and ends in April.
ibex, one of the snow leopard’s prey species. Concurrently, the program also entails economic benefits for participating communities. In the 2022-23 season, the Government of GB auctioned its highest value markhor-hunting license, worth USD 165,000.\(^\text{22}\)

As the apex predator, the snow leopard is indicative of the overall health of its habitat; thus, its protection and conservation are not only important for its prey species but for the overall ecological health of the area.

WILDLIFE CONSERVATION POLICIES AND PROJECTS

In examining the relationship between infrastructure development and human-wildlife interaction, it is important to consider existing laws and regulations that empower the state to regulate or limit such connections. Similarly, adherence to international policies and projects reinforce the government’s commitment to protect wildlife and natural ecological systems from anthropogenic activities and stimulating sustainable development.

i. National Policies

Wildlife and environmental conservation in Pakistan are primarily under the jurisdiction of provincial and regional authorities, resulting in separate legislation for wildlife protection in each province or region. When Pakistan was founded in 1947, it inherited the Indian Forest Act of 1927 which was originally designed to address the country’s forest conservation requirements. The initial legislation specifically addressing wildlife conservation in Pakistan was the Wildlife Protection Ordinance of 1959. Interestingly, the snow leopard was not included in this ordinance and was neither categorized as a protected nor an unprotected species. The absence of the snow leopard from earlier legislation could be attributed to the fact that its primary habitat was situated within the independent states of Swat, Dir, Chitral, Azad Jammu and Kashmir, and Gilgit Baltistan, resulting in limited available information about the species’s presence. It wasn’t until the 1970s, when most provincial regulations were introduced, that the snow leopard was officially recognized as a protected species. The first mention of snow leopards in legislation came with the Pakistan Wildlife Ordinance of 1971. Despite this recognition and the snow leopard’s Endangered status on the IUCN Red List, there was no specific emphasis on its protection. Instead, a more generalized approach was applied to all wildlife species under the wildlife laws of the 1970s and 1980s.\(^\text{23}\)

In addition to the wildlife specific acts, several policies cover biodiversity safeguarding and the protection of wildlife as part of Pakistan’s biodiversity legislative framework, including but not limited to the National Conservation Strategy (1992), Biodiversity Action Plan (2000), National Environment Policy (2005), National Sustainable Development Strategy (2012) and the National Climate Change Policy (2012).\(^\text{24}\)


\(^{24}\) Previously Ministry of Climate Change.
**ii. Regional Policies in Gilgit Baltistan**

Pertinent to GB, the Northern Areas Wildlife Preservation Act was passed in 1975, which consists of 46 sections and regulates hunting activities and human settlements in protected areas. Under its Third Schedule, the Act explicitly lists snow leopard, brown bear, musk deer, blue sheep, Marco Polo sheep as protected animals, prohibiting their capture, hunting, or killing, not only in wildlife reserves or national parks, but outside protected areas as well.

Moreover, the Act prohibits human activities like habitation, farming, livestock grazing in wildlife parks or sanctuaries and prescribes penalties in case of violations. Moreover, the provisions of the GB Environmental Protection Act 2015 uphold the protection, conservation, and rehabilitation of the environment and instructs the Environmental Protection Council and Environmental Protection Agency (EPA) to ensure enforcement of guidelines, rules and regulations listed in the Act.

Recently, the Ministry of Climate Change and Environmental Coordination (MoCC) finalized a draft of the country’s first National Wildlife Policy 2018, which provides a framework to promote conservation of wildlife habitats through sustainable management best practices. As of 13th September 2023, it is yet to be approved by the federal cabinet.

In addition, the GB Forest Act 2019 is applicable to all “forests, watershed areas, rangelands, wastelands, wetlands, river and stream beds, and glaciers and their biodiversity and allied resources found in forests and such lands or areas, whether government owned, community or privately owned” and imposes a duty to ensure the protection, rehabilitation, establishment, sustainable use, conservation, and management of forests. Similarly, the Act under sections 168-172 also ensures the safeguarding, protection, conservation and management of endangered species, their migratory routes and corridors.

**iii. Some Key Government Projects**

In 2020, the Government of Pakistan launched the “Protected Areas Initiative” that aimed to increase the country’s protected areas—national parks, wildlife reserves, wetlands—from 13.9 percent in 2020 to 15 percent by 2023. Part of this initiative is to ensure these are not paper parks but “fully functional with community buy-in.” Through this initiative, the government aimed to register at least seven of its national parks under IUCN’s Green List of Protected Areas, considered the gold standard for conservation. This initiative will also address Aichi Biodiversity Target-11 on expanding protected areas coverage at landscape and seascape levels.

Among other public and private initiatives, in collaboration with the (MoCC) and the United Nations Development Programme, the Snow Leopard Foundation implemented a four-year project called the “Pakistan Snow Leopard and Ecosystem Protection Program (PSLEP),” funded by the Global Environment Facility (GEF). The project employed a participatory approach to conservation and sustainable management of forest and critical habitats.

1) The Government of Gilgit-Baltistan and the Ministry of Climate Change and Environmental Coordination are jointly implementing a five year PSDP Project titled “Ten Billion Tree Tsunami Program: Up Scaling of the Green Pakistan Program (Revised) Revival of Wildlife Resources” Gilgit-Baltistan component (2019-2021)

2) Participatory Management of CKNP Gilgit Baltistan, Phase II – PKR 202.40 million

3) Strengthening of PAS Management in Gilgit-Baltistan – PKR 98.00 million

4) Integrated Carnivores Management Program (ICCP) in Gilgit-Baltistan – PKR 30,000 million

5) Ladach Urial Translocation and Rehabilitation in Gilgit-Baltistan PKR.40,000 million

6) Participatory Management of Himalayan and Nanga Parbat National Parks (with the involvement of local communities) - PKR 98.727 million
Pakistan is a signatory to several international conventions on wildlife conservation including:

1) Convention on International Trade of Endangered Species (CITES) – Pakistan became a member in 1976
2) Convention on Conservation of Migratory Species
3) Convention on Biodiversity (CBD)
4) Global Biodiversity Framework 2022
5) Ramsar Convention on Wetlands
6) Sustainable Development Goals, Agenda 20230
7) World Heritage, Desertification and Climate Change conventions
8) Cartagena Protocol on Biosafety

Up till 2019, the Government of Pakistan has reported progress against the national and global biodiversity targets, in line with commitments stated in the Strategic Plan for Biodiversity 2011-2020 and the Aichi Biodiversity Targets 2011-2020. In addition, the MoCC has prepared a National Biodiversity Strategy and Action Plan (NBSAP) 2017-2030, which emphasizes safeguarding ecosystems, species, and genetic diversity to prevent further biodiversity loss and promote sustainable use of resources.

While strict enforcement of existing laws would go a long way toward conservation efforts and restricting human-wildlife contact, these laws or Acts offer an entry point to better plan and regulate infrastructure development as well.
LINEAR INFRASTRUCTURE DEVELOPMENT IN HINDUKUSH KARAKORAM-HIMALAYAS, GILGIT BALTISTAN

This section recounts the evolution of transport-infrastructure development in GB and its apparent consequences for known snow leopard or wildlife habitats. The discussion provides the rationale for the need of targeted measures or interventions to adapt existing transport infrastructure to make it nature and wildlife friendly.

By virtue of its difficult terrain and rugged landscape, the region of GB remained isolated for hundreds of years. After the creation of Pakistan, a combination of security and trade concerns accentuated the importance of connecting Gilgit with the rest of the country, ultimately leading to the construction of the KKH between 1958 to 1978. It is said, “the road took twenty years and the life of one worker every mile, to carve through towering mountains, glaciers and isolated valleys to build [the] 500 miles long Karakoram Highway.”

Starting from Khunjerab Pass in the north on Pak-China border, the road extends till Hasan Abdal in Punjab. The 1,300 km long highway effectively unlocked the region and its valleys to the rest of the country and the world, easing accessibility through a paved road. While the KKH connects South-West and North-East, the other major road in GB is Gilgit-Chitral and Gilgit-Skardu Road which extends from North-West to the South-East. Both these roads cross Gilgit city.

The KKH has had tremendous implications for socio-economic development in the region after the 1980s. Since then, GB has experienced gradual and consistent growth in physical and hospitality infrastructure, resulting in a tourism boom in the last decade.

In the past 10 years alone, the following linear infrastructure projects have been planned or completed in the region:

1) Gilgit-Shandur Road: A two-lane 216 km long highway. It is part of the National Highway network, titled N-140 and alternative to KKH, pertinent for connectivity and tourism

2) Chitral-Chakdara Road (near completion)

3) Gilgit-Shounter and Astore-Shounter roads (planned)

4) Shandur-Chitral Road: 153 km (planned)

5) Railway track between Kashgar, China and Havelian, Pakistan (planned)

Habitat fragmentation is a grave risk to the survival of snow leopards, and wildlife in general, as it limits their movement, leading to inbreeding and loss of genetic diversity. Loss in genetic diversity and connectivity in turn weakens the health of a population and its ability to adapt to environmental changes, making it vulnerable to disease and death.

Substantial research echoes that environmental decay and biodiversity loss are major threats associated with infrastructure projects. For example, while there are a multitude of positive externalities for tourism and local economic development of building the Gilgit-Shandur Road, EPA’s Environmental Impact Assessment (EIA) acknowledged short-term, negative, and in some cases irreversible damage to topography, surface and ground water quality, air quality, flora, fauna, land acquisition during the “construction and operation phase” of building the road. Moreover with the influx of a large number of tourists and accompanying pollution and traffic congestion environmental degradation has become a major issue in GB.

Through various global commitments, also mentioned in the previous section, snow leopard range countries agree on the need for resilient, low carbon, and ecologically sensitive
infrastructure that will also protect natural systems for future generations. Although the snow leopard population is seeing a steady increase in government notified protected areas and CCHAs in the Hunza district due to positive interventions such as livestock insurance schemes, improved corrals, and livestock vaccination programs by the GB Forest, Parks and Wildlife Department; and through effective conservation efforts by organizations such as WWF-Pakistan and the Snow Leopard Foundation, it is vital that the Government of Pakistan and the Government of GB not only integrate the principles of environmentally sustainable development into policies and frameworks but also ensure compliance to reduce the adverse impacts of linear infrastructure on biodiversity.

Research on road ecology corroborates that linear infrastructure, particularly roads, have dire consequences for ecosystem components, species, and functions as well as far-reaching ecological effects on landscapes. In addition, studies also highlight the lack of Pakistan specific empirical data, limiting the development and adoption of context-specific conservation measures in the country.

Although infrastructure development is one of the few growing ventures in Pakistan, the concept of integrating wildlife crossings or corridors to minimize disruption of migratory routes is nearly non-existent. While the importance of wildlife corridors—safe transit zones to facilitate movement and connection between divided land or habitats (overpasses, underpasses, green bridges, culverts)—is well-established in global conservation efforts, research, and discourse on this dimension of conservation in Pakistan remains limited. Thus, the BEAST project research study seeks to fill this lacuna through carrying out a road ecology study in the HKH landscape for the purposes of developing a baseline with the aim that successive research will build upon the same.

SCOPE OF STUDY

The objective of this research study is to build a case for wildlife friendly transport infrastructure in the HKH region. For this purpose, the study sought out to gather evidence on human-wildlife interactions, with a focus on road kills, and habitat degradation related to infrastructure development in the study area to identify hotspots that require mitigating measures.

The scope of study for this research included the following aspects:

- Analyze physical changes in snow leopard habitats in the past 20 years to assess habitat fragmentation and degradation;
- Collect data on wildlife-vehicle collisions or road kills;
- Identify major gaps in the existing physical infrastructure that encourage human-wildlife interactions and amplifies wildlife vulnerability to human activity;
- Propose measures or interventions to prevent human-wildlife connection and conserve local biodiversity.

Following are the three main research questions:

1. Is there evidence for snow leopard habitat fragmentation and degradation in the HKH landscape?
2. Are wildlife-vehicle collisions (WVC) an evident threat to snow leopards and its prey species in the study area?
3. What are the major gaps in existing physical infrastructure that give rise to human-leopard interaction and conflict?
The research employed a multi-pronged and mixed-method approach to examining the impact of linear infrastructure on wildlife habitats and human-wildlife interactions in the study area.

The term “road ecology” was first used in German as “Straßenökologie” in 1981 and was later translated into English by Forman et al. (2003) for their book “Road Ecology: Science and Solutions” who defined it as:

“...the interaction of organisms and the environment linked to roads and vehicles.”

The overall aim of road ecology research is to quantify the ecological effects of roads, with the ultimate aim of avoiding, minimizing, and compensating for their negative impacts on individuals, populations, communities, and ecosystems. These effects include the loss and fragmentation of habitat, increased rates of wildlife/vehicular collisions, alterations to light, moisture, and wind regimes due to the creation of edges, pollution from traffic, and facilitating the spread and dispersal of weeds and feral animals.

In this study, WWF-Pakistan concentrated on two key aspects within the broader context of road ecology: firstly, evaluating the potential wildlife mortality rates resulting from vehicle collisions and wildlife-vehicle interactions, and secondly, examining the gradual fragmentation of habitats caused by infrastructure development, affecting both snow leopards and their prey species overtime. Given the absence of prior research addressing these specific facets, this study marks the initial step in a systematic research approach. It can further broaden the scope and contribute significantly to establishing essential conservation benchmarks for snow leopards in the future.

Given the physical difficulties and complexity involved in conducting field level research on an elusive species like the snow leopard, it was crucial to carry out a systematic analysis of secondary data on snow leopard habitats and infrastructure development in GB. In order to fully understand the various threats to snow leopards and their prey base and changes in their habitats, a host of documents, case studies, reports, and blogs were reviewed. In addition, relevant regional, national, and international policies, plans, and frameworks were also reviewed in detail; but as discovered during fieldwork, enforcement of these policies is evidently weak and deficient. The analysis of secondary data informed primary data collection, both quantitative and qualitative.

To kickstart the project, an initiation workshop was conducted in January 2023 at the WWF–Pakistan Lahore head office. The workshop brought together key experts from WWF-Pakistan including wildlife experts, GIS experts, regional experts, and conservation experts. The workshop sought to inform on the design (what we seek to achieve through the project, how our research ties in with a broader conservation objective), methodology (to achieve the best results what mixed methodology is most effective), tools (for data collection) and expanded on the research objectives of the project.

The workshop successfully designed the structure and methodology for the project which was executed through the finalized framework.
**STUDY AREA**

With KKH being the major road in the HKH landscape, the study area constituted sites along the KKH and Gilgit-Shandur Road, as these roads cut through known habitats of snow leopard and its prey species and caters to the scope of the research. The selection criteria also ensured that both protected and non-protected sites are included in the study area, while being fairly easy to access. These included:

i. Khunjerab National Park  
ii. Handrap Shandur National Park  
iii. Ghulkin – CCHA  
iv. Khyber – CCHA  
v. Sikanderabad – CCHA  
vi. Phandar Valley  
vii. Shishkat-Attabad  
viii. Terru Village

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**TRAINING ON THE RESEARCH TOOL**

In order to utilize the best approach to collecting the data, a virtual one-day training workshop for the field team was conducted in April 2023. The training workshop was organized and delivered by WWF-Pakistan with field and research experts who informed the field teams on the structure of the questionnaire, research ethics and considerations, sampling, coding the data and standardizing and collating the information in the form of data.
Quantitative research entailed administering a perception survey on WVCs and local infrastructure development to 200 respondents residing in two types of sites along the KKH: protected areas and non-protected. Protected areas included two national parks: KNP and the Handrap Shandur National Park, and three CCHAs: Khyber, Ghulkin, and Sikanderabad; non-protected areas included Phandar Valley, Shishkat-Attabad and Terru Village.

"A team of five enumerators collected data over eight days, from May 09 to May 26, 2023."

For this study, a non-protected area is any area that does not come under the definition of a protected area by the Convention on Biological Diversity, i.e., non-protected is not "recognized, dedicated, and managed through legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values."
An extensive ground truthing exercise was also conducted during the aforementioned period which generated strong evidence of snow leopard activity in the study area. Notable findings include the passage of its target species; the Himalayan Ibex crosses the KKH in herds, and the discovery of a snow leopard crossing site in KNP, validated through scent-spray, scat, and pug marks along the KKH. There is also substantial evidence of the Himalayan wolf (Canis himalayensis) and Himalayan red fox (Vulpes vulpes) in Terru and Handarap along the Ghizer Shandur Road.
Table 2: Ground Truthing Survey Data Sample Conducted Between May 9th to May 26th, 2023

<table>
<thead>
<tr>
<th>Time</th>
<th>Village/ CCHA</th>
<th>Location</th>
<th>Wildlife Specie</th>
<th>GPS Coordinates</th>
<th>Distance</th>
<th>Number of Animals</th>
<th>Number of Road Kills/ Collisions</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>11:10 AM</td>
<td>SIKANDERABAD</td>
<td>HARASPO DAS</td>
<td>HIMALAYAN IBEX</td>
<td>36 14 722 74 20 780 05655 FT</td>
<td>10 KM</td>
<td>13</td>
<td>-</td>
<td>SNOW LEOPARD HILL SIGHTED POINT</td>
</tr>
<tr>
<td>12:30 PM</td>
<td>SHISKAT/ ATTABAD</td>
<td>SHISKAT</td>
<td>SNOW LEOPARD</td>
<td>36 21 285 74 52 35 08491 FT</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1:26 PM</td>
<td>GHULKIN/ HUSSAINI</td>
<td>GHULKIN</td>
<td>HIMALAYAN IBEX</td>
<td>36 25 614 74 52 218 08682 FT</td>
<td>50 METER</td>
<td>35</td>
<td>-</td>
<td>HIMALAYAN IBEX ROAD CROSSING POINT</td>
</tr>
<tr>
<td>1:30 PM</td>
<td>GHULKIN/ HUSSAINI</td>
<td>GHULKIN</td>
<td>HIMALAYAN IBEX</td>
<td>36 25 902 74 52 320 08425 FT</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>HIMALAYAN IBEX ROAD CROSSING POINT</td>
</tr>
<tr>
<td>1:31 PM</td>
<td>GHULKIN/ HUSSAINI</td>
<td>HUSSAINI</td>
<td>HIMALAYAN IBEX</td>
<td>36 25 902 74 52 320 08426 FT</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>HIMALAYAN IBEX ROAD KILL POINT</td>
</tr>
<tr>
<td>1:45 PM</td>
<td>GHULKIN/ HUSSAINI</td>
<td>HUSSAINI</td>
<td>HIMALAYAN RED FOX</td>
<td>36 26 97 74 52 405 08491 FT</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>HIMALAYAN RED FOX ROAD CROSSING POINT</td>
</tr>
<tr>
<td>12:30 PM</td>
<td>KHYBER</td>
<td>KHYBER</td>
<td>SNOW LEOPARD</td>
<td>36 32 29 74 48 834 08556 FT</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>SNOW LEOPARD SIGHTED POINT</td>
</tr>
<tr>
<td>1:00 PM</td>
<td>KHYBER</td>
<td>KHYBER</td>
<td>HIMALAYAN IBEX</td>
<td>36 32 903 74 48 366 08546 FT</td>
<td>-</td>
<td>45</td>
<td>-</td>
<td>HIMALAYAN IBEX</td>
</tr>
</tbody>
</table>

QUALITATIVE RESEARCH

Qualitative primary research was undertaken through in-depth interviews with key stakeholders and communities. Detailed meetings were held with representatives from the following organizations:

Planning & Development Department, Government of GB; GB Environmental Protection Agency; National Highway Authority; Parks and Wildlife Department, GB; and China Study Center, Karakoram International University, GB; and game watchers in KNP. Group discussions were conducted with community members from three CCHAs – Sikanderabad, Ghulkin, and Khunjerab Village Organization (KVO).
A two-member team carried out FGDs and in-depth interviews from June 22 to June 24, 2023.

The GIS Lab of WWF-Pakistan meticulously prepared detailed maps of project sites to analyze the changes in land coverage and usage, discussed in greater detail in the subsequent section.
The foremost integration of the GIS component in this project was by selection of snow leopard habitat zones (08) mainly including National Parks (02), Community Controlled Hunting Areas (03) and Non-Protected Areas (03) along the Gilgit-Shandur Section of KKH. This process of site selection involved consultation meetings with the project team and major stakeholders. The boundaries of the Project Sites were delineated using Google Earth base maps as well as ground information and knowledge of local communities and wildlife experts.

### SITE SELECTION FOR GIS MAPING

The data collected from the field was preprocessed in the GIS environment and was used for different mapping activities. The data mainly includes GPS coordinates of snow leopard presence, road ecology and vehicle intensity and collision data. The basic objective of data development was to develop a standardized GIS-based database for assessment and analysis. The spatial data related to the study area was digitized from Google Earth and other published sources.

### BASELINE SURVEY

### DATA DEVELOPMENT AND PROCESSING

The Land use/Landcover (LULC) change analysis of all 08 of the project sites was performed on Landsat (4-5) and Landsat 8 (OLI) satellite images having 30m spatial resolution. The band characteristics of the satellite images used in the LULC development are as follows (Table 3 and 4).
Table 3: Landsat 4-5™ Characteristics

<table>
<thead>
<tr>
<th>Bands</th>
<th>Wavelength (micrometers)</th>
<th>Resolution (meters)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Band 1 - Blue</td>
<td>0.45-0.52</td>
<td>30–</td>
</tr>
<tr>
<td>Band 2 - Green</td>
<td>0.52-0.60</td>
<td>30–</td>
</tr>
<tr>
<td>Band 3 - Red</td>
<td>0.63-0.69</td>
<td>30–</td>
</tr>
<tr>
<td>Band 4 - Near Infrared (NIR)</td>
<td>0.76-0.90</td>
<td>30–</td>
</tr>
<tr>
<td>Band 5 - Shortwave Infrared (SWIR) 1</td>
<td>1.55-1.75</td>
<td>30–</td>
</tr>
<tr>
<td>Band 6 - Thermal</td>
<td>10.40-12.50</td>
<td>120 (30)–</td>
</tr>
<tr>
<td>Band 7 - Shortwave Infrared (SWIR) 2</td>
<td>2.08-2.35</td>
<td>30</td>
</tr>
</tbody>
</table>

Table 4: Landsat 8 Characteristics

<table>
<thead>
<tr>
<th>Bands</th>
<th>Wavelength (micrometers)</th>
<th>Resolution (meters)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Band 1 - Coastal aerosol</td>
<td>0.43-0.45</td>
<td>30–</td>
</tr>
<tr>
<td>Band 2 - Blue</td>
<td>0.45-0.51</td>
<td>30–</td>
</tr>
<tr>
<td>Band 3 - Green</td>
<td>0.53-0.59</td>
<td>30–</td>
</tr>
<tr>
<td>Band 4 - Red</td>
<td>0.64-0.67</td>
<td>30–</td>
</tr>
<tr>
<td>Band 5 - Near Infrared (NIR)</td>
<td>0.85-0.88</td>
<td>30–</td>
</tr>
<tr>
<td>Band 6 - Shortwave Infrared (SWIR) 1</td>
<td>1.57-1.65</td>
<td>30–</td>
</tr>
<tr>
<td>Band 7 - Shortwave Infrared (SWIR) 2</td>
<td>2.11-2.29</td>
<td>30–</td>
</tr>
<tr>
<td>Band 8 - Panchromatic</td>
<td>0.50-0.68</td>
<td>15–</td>
</tr>
<tr>
<td>Band 11 - Thermal Infrared (TIRS) 2</td>
<td>11.50-12.51</td>
<td>100</td>
</tr>
</tbody>
</table>
The cloud free images of Landsat 4-5 TM satellite were used for the year 2002 and thereby keeping an interval of 20 years, Landsat 8 images were acquired for year 2022. The month for all images was kept same to avoid any sort of discrepancy. These satellite images were processed using Google Earth Engine (GEE), the advanced online cloud computing platform. The major LULC classes include barren land, built-up, snow/ice, soil, vegetation, and water. For each LULC class, about 30 training samples were marked to enhance the image classification accuracy. The supervised image classification technique utilizing the Random Forest (RF) classifier was adopted to conduct LULC change analysis. After extraction of LULC classes for each site, their areas were calculated using ArcGIS software and compared statistically.

The GPS data acquired from the baseline assessment surveys was translated into GIS format. This data was processed in the GIS environment to showcase the maps of:

- LULC Change Analysis
- Vehicles Density
- Wildlife Road Crossings
- Animals Killed in Vehicle Collision
- Snow Leopard Presence

Over a two-decade period, the Landsat 8 data shows desired results in documenting changes within communities. But the 30-meter spatial resolution was limited in terms of analyzing roadways in particular. Settlements, which included different built-up areas such as roads, houses, and farms, were sufficiently visible, but the resolution was too low to clearly see roadways. As a result, the analysis focused mostly on changes inside settlements and the assessment of dynamics related to roads.

**STUDY LIMITATIONS**

While this study is the first of its kind, it is important to recognize the limitations that affect the generalizability of its findings. For one, the snow leopard home range and HKH landscape is extremely vast, varied, and difficult to traverse, due to which data collection had to be restricted to easily accessible communities. Likewise, traffic data for the project sites is quite sparse, if not somewhat non-existent, and why this study also became a scoping exercise in determining what areas have the highest traffic density and which areas did not. Moreover, whatever data there was on traffic insights and trajectories is available through independent research, but again, very limited, and not as comprehensive and exhaustive that would allow us to have a holistic picture of the situation in the region.

Due to the project duration the study does not capture data and trends for winter. Furthermore, due to financial and time constraints, the sample size of the community perception survey was relatively small. Finally, there was limited literature or secondary data to inform and support the findings of this study.
The first research question pertains to examining whether linear infrastructure development in GB has disturbed or disrupted snow leopard habitats. The construction of infrastructure projects are associated with land clearing activities such as deforestation. For instance, infrastructure development in GB is expected to witness large-scale deforestation as part of clearing and grubbing efforts, which would have a direct impact on carbon sequestration and soil conservation, leading to adverse impacts on the larger ecosystem’s biodiversity. In addition, deforestation through removal of vegetative cover from steep slopes is likely to make the area more prone to soil erosion, flooding, silting, and desertification along with natural hazards such as landslides.32

A research study conducted in 2018 sought to assess the forest cover along 10km of the Karakoram Highway (N-35), originating from Hasanabdal till the Sazin and Chilas regions, for a period of 25 years with years 1990, 2000, 2010, and 2016 as the primary focus.33 The researchers gathered and interpreted visual data using satellite imagery to generate forest cover maps for LULC classes including the categories of urban sprawl, vegetation, open land, forests, water, and snow in the research analysis. The results of the study illustrated a significant decrease of 26 per cent in forest cover areas and a subsequent increase of 12 per cent in urban areas across the stated time period. The overall trend suggests an increase in deforestation, a dramatic fall in forest cover, and a rapid rise in urbanization overtime. Similarly, WWF-Pakistan’s own preliminary research suggested that the construction of roads in GB may result in soil erosion and landscape modification.

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33 Ibid
On the one hand, land degradation due to deforestation caused by linear infrastructure development will increase soil erosion while on the other, it will amplify the chances of rock falling or debris flow. Soil, which is a sequestering agent for greenhouse gases (GHGs), is responsible for absorbing GHGs. Erosion of soil will, therefore, be detrimental to ecological preservation efforts and the land’s ability to absorb GHGs, which will have negative effects on the climate. Additionally, the building process, involving blasting and drilling for construction purposes along with the repair of roads, may weaken the geology of the area and lead to increased incidences of rock fall and landslides, which will degrade GB’s environment and pose significant dangers to both local communities and wildlife populations.

Changes in human settlements, infrastructure development, and climate change are globally recognized to be the main drivers of alterations in land formation. As this is the first time a mapping exercise is conducted from a road ecology perspective in Pakistan, it is crucial to recognize the challenge of pinpointing specific factors behind changes in the LULC change at this point. Albeit it is difficult to state that the changes in LULC are a direct consequence of road construction, it can be identified as one of the factors (among many) that could have contributed to the same.

While these maps can serve as a baseline for subsequent round of spatial analysis for comparison, they are still useful in noting the changes in land components or elements that have a direct bearing for wildlife, such as water, vegetation, and snow.

Figures 24-31 illustrate the changes in LULC in project sites over the last 20 years. Based on the maps, a general analysis concluded that there has been habitat degradation in at least one element – snow/ice, soil, vegetation, water – across project sites. In the case of protected areas, within the two national parks, there has been a notable loss in snow/ice, vegetation, and water reserves. Interestingly, although built area has increased in CCHAs, so has coverage of snow/ice (Khyber, Ghulkin), vegetation (Ghulkin, Sikanderabad). Still, water coverage has decreased in all three CCHAs. As for non-protected project sites, there is an evident decline in snow/ice coverage in two sites, particularly Phandar Valley. Whereas snow coverage has increased in Terru Village, there has been a notable decline in vegetation and soil degradation.

The LULC of KNP shows that there is a significant change in the built-up area that has increased from 3.5 to 5 ha. This increase is associated with the rehabilitation of KKH over the years and construction of sheds for the road workers. A certain decrease in vegetation, water and soil has also been observed over the past 20 years.
In Khyber (CCHA), the built-up area accelerated from 8 to 13 ha as a result of the growing population. As per the LULC change analysis, the barren area and snow/ice cover also increased in their extents. Whereas rapid decline in the extent of water and vegetation cover was also observed over the years.

A massive increase was observed in the built-up area of Ghulkin (CCHA) that increased from 23 to 90 ha, while the vegetation and snow/ice cover also increased significantly. The water bodies drastically declined from 29 to 12 ha over the years.
The Shishkat-Attabad (non-protected) site shows a prominent change in LULC over the years with the built-up areas surging from 8 to 34 ha. This LULC change is associated with the shifts in settlements as a result of the natural disaster that occurred 2010; due to glacial lake outburst, a new natural lake emerged and as a result the water bodies increased from 125 to 300 ha. Other classes show no significant change.

The built-up areas in Sikanderabad (CCHA) slightly increased from 6.5 to 7 ha, while the vegetation cover and barren area increased from 5,351 and 484 to 5,532 and 541 ha, respectively. A significant decline in water bodies and bare soil was observed. The snow/ice cover declined from 95.5 to 55.4 ha over the years.
In Phandar Valley (non-protected area), the built-up area slightly increased to 2 ha and the vegetation cover increased from 205 to 230 ha. The water bodies also increased over the years from 98 to 124 ha. The decline in snow/ice cover was observed from 613 to 366 ha followed by decrease in barren land from 15,400 to 15,000 ha.

Insignificant LULC changes were observed in the Handrap-Shandur National Park. There has been no change in the built-up area while the barren area increased from 41,760 to 42,800 ha. A rapid decline has been observed in the snow/ice cover from 2,200 to 1,680 ha which can be a result of climate change over the years. The vegetation cover also declined slightly from 642 to 612 ha and water bodies declined from 540 to 425 ha.
In Terru Village (non-protected area), significant LULC changes were observed, as decline in vegetation cover and bare soil that declined from 1,979 and 530 to 1,658 and 432 ha, respectively. A rapid increase was observed in snow/ice cover that increased from 536 to 869 ha.

The GIS mapping analysis is in line with the literature that identifies land degradation due to human activities and worsening climate as a major threat to wildlife in GB. Comparatively shorter winters and harsher summers have accelerated water scarcity and waning of the snow line in GB, which is not only alarming for the survival of wildlife like snow leopards, but humans as well.

Data from the community perception survey also corroborates the growth in linear infrastructure across project sites within the past five years (Table 5). Whereas, roads are primarily being repaired in Hunza, a significant proportion of respondents in district Nagar mentioned construction of new roads in their area.
Furthermore, more than 50 percent of survey respondents believed that infrastructure development has negatively impacted wildlife in their area (Table 6).

### Table 5: Survey Data - Increase in Road Infrastructure

<table>
<thead>
<tr>
<th>Response</th>
<th>District</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Ghizer</td>
<td>Hunza</td>
</tr>
<tr>
<td>Yes, more roads are being constructed actively</td>
<td>11%</td>
<td>12%</td>
</tr>
<tr>
<td>Yes, more roads are being constructed to some extent</td>
<td>25%</td>
<td>8%</td>
</tr>
<tr>
<td>Yes, only existing roads are being repaired</td>
<td>12%</td>
<td>37%</td>
</tr>
<tr>
<td>No</td>
<td>52%</td>
<td>43%</td>
</tr>
<tr>
<td>Total</td>
<td>75</td>
<td>100</td>
</tr>
</tbody>
</table>

### Table 6: Survey Data - Infrastructure's Impact on Wildlife

<table>
<thead>
<tr>
<th>Impact</th>
<th>Residing within or Near Protected Area</th>
<th>Not Residing within or Near Protected Area</th>
<th>Don’t Know</th>
<th>Total</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Negatively Impacted</td>
<td>94</td>
<td>14</td>
<td>0</td>
<td>108</td>
<td>54%</td>
</tr>
<tr>
<td>No Impact</td>
<td>64</td>
<td>9</td>
<td>0</td>
<td>73</td>
<td>36.5%</td>
</tr>
<tr>
<td>Unsure</td>
<td>16</td>
<td>2</td>
<td>1</td>
<td>19</td>
<td>9.5%</td>
</tr>
<tr>
<td>Total</td>
<td>174</td>
<td>25</td>
<td>1</td>
<td>200</td>
<td>100%</td>
</tr>
</tbody>
</table>

Relatedly, 92 percent of the surveyed population agreed that development of roads has affected the traffic density in their area as well and 93 percent acknowledged that construction of roads prompts further infrastructure development (Annex1-Table 7). These findings point to the emerging issue of mounting litter, air pollution, and traffic congestion in the region, repeatedly highlighted in discussions with key stakeholders and communities. A Fellow and researcher at Karakoram International University, GB, stressed that the drastic surge in the influx of tourists to GB is exerting pressure on local natural resources, which has adverse and long-term consequences for ecological sustainability.

The collected GPS data was also translated into GS format and maps were developed to show the snow leopard presence, survey sites and ground trudging data. The selected Road Ecology parameters include density of vehicles passing, wildlife road crossing frequency and animals killed in road vehicle collision, all of which were classified into various categories based on their repetition frequencies and depicted with proportional colored symbols. Each color represents the intensity and distribution of the collected data.

Figure 32 depicts traffic density based on the survey data. The maximum high traffic densities were found in KNP, Shishkat-Attabad, Khyber, and near Terru village. Only some points of Sikanderabad and Attabad consist of low traffic density while all project sites consist of high to medium traffic density records. No data of vehicle density was recorded in Handrap-Shandur.
Based on field research, snow leopard sightings have risen in recent years, suggesting that snow leopard habitats once previously inaccessible have now been opened up vis a vis the construction of transport infrastructure development in the project sites.

In our discussions with local communities, it was relayed that it is quite common for snow leopards to be seen roaming on the KKH road near Khunjerab Pass. Likewise, the incidence of wildlife on main roads is not unusual anymore either – as seen in (Figure 33), a photograph of a herd of Himalayan Ibex crossing the KKH, taken during primary data collection. A community member from KVO also affirmed snow leopard sightings are a regular occurrence in Sost Village, especially October onwards. Other species sighted near the road include the Golden marmot (Marmota caudata) and the Himalayan ibex (Capra sibirica).

Figure 32: Map of Traffic Density in Study Area Based on Survey Data

Figure 33: A Herd of Himalayan Ibex Crossing the KKH at KNP
(Figure 34), wildlife has been observed frequently and regularly crossing the KKH in three sites including KNP, Sikanderabad and Khyber.

Frequent sightings on roads and near water bodies point to a gradual convergence of space shared between snow leopards and humans. Owing to both land degradation and fragmentation, snow leopards in certain project sites, like KNP and Attabad, are compelled to dwell in lowlands for water and food, and many times wander into human settlements and main roads, which raises the risk of human-wildlife conflict. This evidence suggests that the human footprint has affected noticeable deterioration and fragmentation of snow leopard habitats in the past 20 years in select project sites.

There was also one additional observation made by the survey team. In the KKH study area, snow leopards are known and observed to be sighted closer to the road. This was confirmed by both community surveys, and by a video by a local documentary filmmaker a few years earlier which showed a snow leopard running and climbing the mountain.

No record of wildlife crossing a road was observed in Handrap-Shandur NP.
that was right next to the road. Similarly, a video caught by a local Wildlife Ranger showed a snow leopard walking on the road until it noticed the car behind it causing it to sprint to the other side.

However, in the Gilgit Shandur study area, the survey team were informed that snow leopards were known to stay at higher altitudes and would be rarely seen near the site of the under-construction road. Instead, the Himalayan brown bear (Ursus arctos isabellinus) is known to frequent the area more often and could potentially be impacted once the road is constructed.

WILDLIFE-VEHICLE COLLISIONS

The second research question deals with the frequency or incidence of wildlife-vehicle collisions (WVCs) in project sites.

According to data from the community perception survey, WVCs are an emerging issue in GB.

Although a considerable proportion of respondents, 96 percent, confirmed the presence of snow leopards in their area, none could recall a road accident involving a snow leopard in the past five years. Similarly, 63 percent of respondents stated that WVCs are not a significant problem in their area (Annex I – Table 8).

By plotting the GPS survey data, the snow leopard presence data (Figure 38) was found to be scattered along the KKH. The snow leopard can be commonly found in 07 of the project sites whereas, in some parts of Sikanderabad and Terru village, it was found rarely. No presence signs were recorded from Handrap-Shandur NP.
Figure 39 shows that the maximum number of animals that were killed in result of vehicle collision were recorded in Khyber.

Sikanderabad and KNP also hold significant records of animal causalities by vehicle collision, while in the other project sites this number was relatively low.
Still, there is evidence of WVCs involving other animals in the study area, particularly in districts of Hunza and Nagar, which are also popular tourist destinations. About 25.5 percent of respondents stated witnessing animal road kills “often” to “very frequently” (refer to Annex I -Table 9). Regarding possible explanations for WVCs, respondents identified “grazing” and “seasonal migration” as the major reasons behind animals crossing main roads, followed by search for “water” and “prey/hunting” (refer to Figure 40).

The survey results are consistent with secondary data that provides limited evidence on snow leopard road kills in the region compared to other wildlife. However, this could be explained by the fact that snow leopards typically remain on higher altitudes during peak tourist season – summer months. Snow leopard follows altitudinal migration, high altitudes in summers and on low altitudes in winters, so the frequency of being spotted near water bodies increases in winters at low altitudes and near human settlements. Plus, snow leopards are most active during early morning or late evening hours, when the flow of traffic is typically thin. While road accidents involving snow leopards have been far and few, WVCs is a substantial threat to other wildlife in the region, especially its prey base like the Himalayan Ibex. As per local reports, a tourist car collided with an Ibex on main KKH road, as recent as March 2023 – the animal died on the spot.

Additionally, with plans to utilize KKH as a major trade route all year long, the risk of WVCs involving snow leopards will escalate exponentially. It should be noted that taller and heavier vehicles, used in transporting goods, have bigger blind spots and longer braking distance. They also exert greater force when crashing with a smaller object, in this case wildlife, who would instantly expire upon impact.

"Considering snow leopards are most active during darker hours and frequently cross main roads like the KKH, nightly traffic could be disastrous for them."
The final research question explores the major gaps in existing physical infrastructure that give rise to human-leopard interaction and conflict.

Considering the substantial overlap of snow leopard habitats and human settlements and the marked rise in sightings, chances of human-wildlife interaction and conflict are quite high in GB. Illegal hunting/poaching and retaliation killings are two major manifestations of human-wildlife interaction and conflict in the region.

At present, there is an implicit understanding of sharing spaces with wildlife with limited restrictions on land occupation. In this regard, land encroachment is a grave concern, even in protected areas. While not a major threat in declared national parks, according to the Conservator Parks and Wildlife, GB, the government had to intervene in Naltar Valley (wildlife sanctuary) to control incidences of land encroachment.
Secondly, the study found limited evidence of physical signs that inform and caution locals, tourists, or outsiders of federal and regional laws that prohibit hunting and poaching of endangered wildlife. Moreover, no signs indicating that an area is a commonly used crossing for certain wildlife were seen in any of the project sites. Even within KNP, there are limited road signs to indicate proximity to endangered wildlife and warn against hunting/poaching. Figure 42 exhibits a road sign displayed at the entry gate of KNP that forbids hunting of snow leopards, one of few in the whole park.

Given that sharing the land with wildlife is the dominant doctrine in GB, local communities, particularly in protected areas, have done incredible work in controlling retaliatory killings. Similarly, in an effort to restrict reactive killings, the Forest, Parks, Wildlife and Environment Department, GB established a Central Endowment Fund of Pakistani Rupees 200 million under Livestock Compensation Scheme to compensate farmers for snow leopard attacks. Additionally, the Forest, Parks and Wildlife Department has launched an ADP Project titled “Integrated Carnivores Management Program”; amounting to PKR 30,000 million. Although strong conservation efforts coupled with government initiatives like compensation payments, microinsurance, and predator-proof corrals have been effective in curbing revenge kills to a great extent, they have not been able to halt them entirely. As recently as 2018, farmers in Misgar, Hunza, imprisoned a snow leopard for killing dozens of their domestic animals which was later released in KNP after successful negotiation by the GB Parks and Wildlife department.34

On the other hand, top-down conservation has also engendered animosity in certain communities and farmers, particularly in non-protected areas. In discussions with the locals in project sites, the research team discovered simmering resentment among farmers regarding the promotion of wildlife and livestock interaction. For one, there are numerous cases where farmers did not receive compensation for loss of livestock as they were unable to produce proof of a snow leopard attack. In other cases, domestic livestock, despite being vaccinated, have been infected by diseases due to unavoidable contact with wildlife in shared grazing spaces. While most communities in non-protected areas adhere to laws on safeguarding wildlife, the surge in interaction puts wildlife at risk to certain disgruntled characters that may be looking to even the score.

Field research indicates that poaching and illegal hunting continues to be a concern in project sites. This is backed up by secondary investigative sources, that state that skins, hides, and bones of endangered wildlife, including snow leopard, red fox, and brown bear, are openly traded in local markets and clandestine websites.35 The case of a local who hunted a snow leopard in Hopper Valley, Nagar in 2020 is frequently cited. The offender was jailed for six months and fined PKR 0.5 million.

Both secondary research and stakeholder consultations also corroborate that poaching of snow leopard and its prey species, the Himalayan Ibex is a persistent issue.36 Overall, in the approach of land sharing over land sparing,37 snow leopards and wildlife in general are at constant threat from ill-intentioned humans, who in pursuit of self-interest are prone to harm and damage wildlife and their habitats.

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Extensive literature acknowledges that linear infrastructure development in the GB has generated economic opportunities for local communities. Similarly, community perception survey respondents also substantiated that local communities are extremely pleased with ongoing infrastructure development and the tourism boom in the region. While locals recognize nuisances like growing litter and pollution, they deemed them minor irritants compared to the monetary benefits associated with tourism and the hospitality sector.

Nonetheless, conservationists and researchers concede that the current approach to development in GB is neither beneficial nor sustainable for the local ecosystem. Presently, GB is slowly transitioning out of the “latency period” (delayed onset of consequences), as devastating effects of human activities and climate change have started to occur—receding snowline, frequent natural disasters, GLOF, water scarcity, rising temperatures, and so on.

As the Director, EPA GB noted, “conventional development programming promotes wayward or unplanned projects,” which is detrimental to the utilization of finite natural resources. Still, authorities or those in charge are upholding the business-as-usual approach to development in a distinctly unconventional and special region. It is critical to act now to strike a balance between boosting economic well-being without damaging biodiversity and the environment in GB.

With this in mind and taking into account the main findings of this study, targeted interventions can be adopted to safeguard and conserve snow leopard habitats for their sustenance and survival. Certain mitigation practices and measures related to road infrastructure could significantly minimize human-wildlife interaction and habitat destruction.
It is worth stressing that the following list of proposed road management measures are most effective when implemented as one integrated and comprehensive strategy.  

This report thereby, in light of its current findings, recommends the following:

i. Current laws regulating protected areas and wildlife conservation strictly prohibit human settlements and linear infrastructure development in protected areas, and it is equally important to prohibit encroachment in known wildlife habitats. This can be done through declaring the hotspots identified in Figure 38 as “construction free zones”. This could be a first step in ensuring that encroachment and the construction of unsustainable hospitality infrastructure in snow leopard habitats is prevented.

ii. Fencing of habitats (potential areas identified in Figure 34), could potentially minimize wildlife access to high-traffic roads, but the exact location and design must be chosen carefully to avoid the barrier effect that further disrupts wildlife movement or dispersal. Additionally, the construction of different water points accessible to species to avoid crossing roads can significantly reduce WVCs.

iii. Integration of wildlife passage structures or crossings – overpasses, culverts – within existing infrastructure to facilitate safe movement and migration of wildlife and minimize the risk of WVCs. The potential areas identified in identified in Figure 34 can serve as a baseline for further assessment and research.

iv. Install and post prominent road signage along the KKH and in known wildlife habitats, ideally with flashing lights, which instruct motorists to reduce speed and alert them about proximity to wildlife.

v. Evening/dusk-to-dawn and seasonal road closures to prevent WVCs, particularly during known migratory periods.

vi. Deployment of devoted law enforcement and traffic personnel to monitor and patrol the identified areas to enforce prevailing laws and routinely patrol habitats and surrounding areas to thwart hunting and poaching of snow leopards, as well as illegal encroachments.

The proposed list is by no means exhaustive and the identified hotspots through this baseline study are not absolute; nevertheless, adoption and integration of these measures will go a long way to preserve natural systems and wildlife habitats in GB.
The impact of anthropogenic activities on climate, environment, and biodiversity is substantially analyzed and documented, yet unregulated human-led exploitation and modification of natural landscapes continues undeterred. As species in an ecosystem interact and are interdependent, the human footprint strongly influences their continuance and existence. There is a compelling case for socio-economic growth through linear infrastructure development in GB, but it should not be at the cost of causing permanent damage to wildlife habitats and unquantifiable loss of biodiversity.

One must recognize that conservation of natural habitats and systems is not only an ecological imperative, but also a moral and economic one. The region of GB attracts thousands of tourists every year for its natural beauty, wildlife, and cultural heritage that have thrived for hundreds of years without exposure to outsiders. Thus, a paradigm shift toward nature and climate-positive infrastructure development is essential for the long-term resilience of snow leopard habitats.

This study also serves to be an important baseline to aid in the identification areas where wildlife crossings should be constructed. As a follow up to this, it is recommended that camera traps are deployed in the areas identified as having the highest sightings of snow leopards to monitor movement and finalize sites for construction of wildlife corridors. In addition, to further bolster the findings of this study, and to improve the data set, a winter road ecology should also be conducted.

Going forward, it would be essential to build upon this research by conducting further detailed studies on wildlife migration routes for a deeper analysis of the impact of infrastructure development on wildlife habitats and their movements. Additionally, with the support of the Planning and Development Department (P&DD), WWF-Pakistan proposes to present the findings and recommendations of this report at the Joint Coordination Committee, a forum which scrutinizes and approves infrastructure projects under China Pakistan Economic Corridor (CPEC). To mainstream biodiversity priorities and integrate proposed interventions for wildlife friendly infrastructure, WWF-Pakistan urges P&DD to utilize its allocated funds for Climate Change (one percent of annual budget) to finance wildlife crossings and corridors in key wildlife hotspots identified in this report.


### Table 7: Survey Data – Impact on Traffic Density

<table>
<thead>
<tr>
<th>Response</th>
<th>Frequency</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>184</td>
<td>92%</td>
</tr>
<tr>
<td>No</td>
<td>16</td>
<td>8%</td>
</tr>
<tr>
<td>Total</td>
<td>200</td>
<td>100</td>
</tr>
</tbody>
</table>

### Table 8: Survey Data – Presence of Snow Leopards

<table>
<thead>
<tr>
<th>Response</th>
<th>Frequency</th>
<th>Total</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Ghizer</td>
<td>Hunza</td>
<td>Nagar</td>
</tr>
<tr>
<td>Yes</td>
<td>58</td>
<td>100</td>
<td>21</td>
</tr>
<tr>
<td>No</td>
<td>7</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Yes, but they are very rare</td>
<td>10</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>Total</td>
<td>75</td>
<td>100</td>
<td>25</td>
</tr>
</tbody>
</table>

### Table 9: Survey Data – Main Reasons for WVCs

<table>
<thead>
<tr>
<th>Reasons</th>
<th>Frequency</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Population is distributed on both sides of the road</td>
<td>5</td>
<td>2.54%</td>
</tr>
<tr>
<td>(habitat fragmentation)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Location of drinking water points</td>
<td>28</td>
<td>14.21%</td>
</tr>
<tr>
<td>Breeding/mating areas</td>
<td>1</td>
<td>0.51%</td>
</tr>
<tr>
<td>Prey-species</td>
<td>17</td>
<td>8.63%</td>
</tr>
<tr>
<td>Grazing area</td>
<td>94</td>
<td>47.72%</td>
</tr>
<tr>
<td>Seasonal migration pathway</td>
<td>52</td>
<td>26.4%</td>
</tr>
<tr>
<td>Any Other Reason</td>
<td>3</td>
<td>0.03%</td>
</tr>
<tr>
<td>Total</td>
<td>200</td>
<td>100</td>
</tr>
</tbody>
</table>
Table 10: Survey Data - Frequency of Road Kills

<table>
<thead>
<tr>
<th>Response</th>
<th>Frequency</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very frequently</td>
<td>5</td>
<td>3%</td>
</tr>
<tr>
<td>Frequently</td>
<td>4</td>
<td>2%</td>
</tr>
<tr>
<td>Often</td>
<td>42</td>
<td>21%</td>
</tr>
<tr>
<td>Rarely</td>
<td>79</td>
<td>40%</td>
</tr>
<tr>
<td>Never</td>
<td>70</td>
<td>35%</td>
</tr>
<tr>
<td>Total</td>
<td>200</td>
<td>100%</td>
</tr>
</tbody>
</table>

Table 11: Survey Data - Incidence of WVCs in the Area

<table>
<thead>
<tr>
<th>Response</th>
<th>Frequency</th>
<th>Total</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Ghizer</td>
<td>Hunza</td>
<td>Nagar</td>
</tr>
<tr>
<td>Yes</td>
<td>1</td>
<td>28</td>
<td>17</td>
</tr>
<tr>
<td>No</td>
<td>59</td>
<td>63</td>
<td>4</td>
</tr>
<tr>
<td>Unsure</td>
<td>15</td>
<td>9</td>
<td>4</td>
</tr>
<tr>
<td>Total</td>
<td>75</td>
<td>100</td>
<td>25</td>
</tr>
</tbody>
</table>