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Conservation Status, Threat Analysis, and Population Trends of Snow Leopards in Pakistan

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ABSTRACT

Snow leopard is a crucial indicator species of mountain ecosystems. However, in Pakistan, its survival is beneath increasing danger. These threats get up from each environmental changes and human activities. This review-based technical report gathers and analyzes existing studies to better recognize the conservation popularity and population traits of the species. The study reviews special scientific methods used to estimate population size, which include sign surveys, predator–prey biomass analysis, genetic strategies, digital trapping, seize–recapture techniques, and biotelemetry equipment like GPS monitoring and radio collaring. The report examines the modern-day distribution of the snow leopard. It specializes in spatial evaluation methods and its presence in snow-protected areas. The study also gives a detailed study of the most important threats to the species. These consist of habitat loss, declining prey populations, retaliatory killings, and the outcomes of weather trade. This also evaluates conservation projects from ecological, socio-monetary, and coverage views, with a focus on network-based programs, collaborative procedures, and the position of each governmental and non-governmental group. Although some conservation has been effective, the population of snow leopards in Pakistan is still threatened. Their numbers vary broadly throughout distinct areas. The survival of the species in the long term depends on further research, sound regulations and active encouragement of neighborhood.

Keywords: Snow Leopard Conservation, Population Dynamics, Habitat Connectivity, Climate Resilience, Community-Based Conservation

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INTRODUCTION

Panthera uncia or the snow leopard is a felid that belongs to the family Felidae and the subfamily Pantherinae. It also cannot roar like lions or tigers; unlike other large cats, it does not have the thick fibroelastic tissue in its vocal cords that allows it to roar (Usman & Khan, 2025). It has this unique feature, which has led it to be put in a different genus in the past, Uncia. It is a rare and inaccessible giant carnivore and is found in the mountainous areas in 12 countries in Asia (Rashid et al., 2021). The geographical range of *P. uncia* confines to the regions of the Altay, Tien Shan, Pamir, Kun Lun, Hindu Kush, Karakoram and highland of the Central Asian countries (Yasmeen & Aslam, 2023).

It is known as umbrella species, with iconic value and given high conservation priority globally by virtue of the protection of snow leopards directly benefiting overall biodiversity of the high-altitude Asian ecosystems (Rashid et al., 2021). In Pakistan, *P. uncia* inhabits comparatively dry and high-altitude regions, including the districts of Swat, Dir, Kohistan, as well as the Gilgit-Baltistan (GB), KPK region of the Northern Areas and the Neelam Valley. This specie is naturally adapted to mountainous environments and is typically found at elevations ranging from 3,000 to 4,500 meters (Yasmeen & Aslam, 2023).

Within alpine and subalpine habitats, snow leopards typically occupy ridges, gullies, cliffs, and rocky outcrops. However, *Panthera uncia* has also been documented in relatively flat or gently rolling terrain in regions such as Mongolia and Tibet, provided sufficient vegetative or geological cover is available for concealment (Usman & Khan, 2025). They mainly hunt wild sheep and goats, but they also attack livestock belonging to pastoral communities that live within their remote though increasingly accessible habitats (Weckworth, 2021). The snow leopard, being an apex predator, supports biodiversity and is essential for the ongoing provision of ecosystem services in high-altitude areas (Sultan et al., 2022).

As a keystone species, the snow leopard serves as an important indicator of climate change in the Trans-Himalayan region. Snow leopards may cope with the immediate consequences of climate change, but secondary threats such as disease outbreaks, illegal hunting, habitat degradation, and conflicts with humans are growing significantly. Warming conditions have intensified glacier melt, raised the altitude of tree growth, and improved pasture quality for grazing animals. Higher temperatures will prompt individuals to cultivate and keep livestock in high altitudes and these areas will be in the natural habitat of big cats. This growth heightens the chances of human-snow leopard conflicts (e Hani et al., 2024).

The IUCN (2010) classified *Panthera uncia* as a critically endangered species in Pakistan, and is gradually becoming extinct in many areas of its Asian range (Usman & Khan, 2025). It has been endangered by the IUCN since 1972, and is critically endangered in the mammalian Red List of Pakistan. In Pakistan, hunting of fur and retaliatory killings as a result of livestock predation are the major causes of population decline (Riordan et al., 2016).

The range of the species has shrunk considerably. In historical times, the species had a large distribution area of around 10.47 million square kilometers but today it has been reduced to about 3.20 million square kilometers. In the high altitude snow leopard populations, which are very few in the northern high altitude valleys of the Chitral

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region, there are evidence of localized declines revealing how vulnerable the species is in those remote regions (Usman & Khan, 2025).

Mountain habitats are essential to both humans and wildlife. Numerous important species can be found in the *P. uncia* environment. There are about 78 various types of therapeutic plants, Fruits, grains, vegetables, and fodder are among the most significant goods grown in the area, and about 80% of the population works in agriculture. They are vital to Gilgit Baltistan's economy (Fatima et al., 2019). The number of snow leopards in the world is estimated to be over 2,500, a number that makes Panthera uncia a species that is endangered. Pakistan harbors the third-largest population of this species worldwide, with its highest densities occurring in the Gilgit-Baltistan region. Two of the most prominent protected areas in Gilgit-Baltistan are the Central Karakoram National Park and Khunjerab National Park, both of which encompass suitable habitats for snow leopards (Usman & Khan, 2025).

In Pakistan, the snow leopard population is estimated to range between 200 and 420 individuals, yet their survival is increasingly threatened due to six principal risk factors (Kazmi et al., 2022). Poaching, Competition for main prey, illegal killing of main prey, trophy hunting, environmental factors and lack of research (Nabi et al., 2018).

More than 90% of these cases take place in five countries China, India, Mongolia, Tajikistan, and Pakistan. In Khunjerab National Park (KNP) and the nearby conservancy areas, 13 snow leopards have been killed over the past seven years (S. Ahmad et al., 2022). Competition for primary prey occurs as increasing populations of feral dogs compete with snow leopards for their main natural food sources (Khattak et al., 2021). Human snow leopard conflict arises because snow leopards often prey on livestock, sometimes killing many animals at once (S. Ahmad et al., 2022). Due to Environmental challenges and limited research, climate change, habitat loss, fragmentation, isolation and large infrastructure projects, such as the China-Pakistan Economic Corridor, further intensify the pressure on their fragile ecosystems (Nabi et al., 2018).

In the high-altitude regions of Asia, snow leopards are under intense pressure from various political, social, economic, and ecological factors, which have fragmented and destabilized their natural environments. These challenges are driven by multiple factors such as political boundaries with fencing, climate change, transboundary infrastructure development, encroachment of agriculture and settlements into carnivore habitats, human-snow leopard conflicts, and the illicit trade in snow leopard skins and bones (Bagchi et al., 2020). Mitigating the risks in transboundary snow leopard landscapes is hindered by alterations in land use and land cover (Penjor et al., 2021). Conservation measures work effectively only if they consider ecological and social mechanisms that enhance socio-ecological systems (Laterra et al., 2016)

Inadequate environmental management, combined with rising human activities like settlements, infrastructure development across borders, grazing, agriculture, and tourism, is heightening the vulnerability of snow leopards (Bitabarova, 2018). The looming ecological collapse is disrupting the equilibrium of both the socio-economic and ecological systems within the snow leopard's habitat (Lauerburg et al., 2020). If left unchecked, the illegal wildlife trade could be funneled through the China-Pakistan Economic Corridor (CPEC) under the Belt and Road Initiative (Gaston et al.),

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potentially reaching major trafficking hubs in other Southeast Asian countries. Consequently, closely regulating the illegal commerce of wild animals and their products is vital (Farrington & Li, 2024).

MATERIAL AND METHODS

The research was conducted in the form of a review-based technical report, which involved gathering and analyzing previously published scientific documents and research and review articles on the subject of the provided species. This approach's target is to provide an extensive overview of the species' Conservation Status, population size, habitat distribution, threats and conservation strategies in Pakistan by summarizing and synthesizing the knowledge that has been gathered from earlier studies.

The primary sources of information were Google Scholar, Research Gate, and Web of Science of peer-reviewed academic papers. To provide up to date and testable information, articles and books of reputable conservation agencies such as the International Union of Conservation of Nature (IUCN), the World Wildlife Fund (WWF) and Snow Leopard Foundation (SLF) were not left out.

To locate the relevant studies, the search approach was structured. In order to take into account current scientific knowledge, a variety of keywords and key combinations were used during the search process. The study whose information were not clear or was weak were not referred to. In order to ensure that the review incorporates the most up-to-date knowledge, a preference was made toward research publications that were published in peer-reviewed journals over the past 10 years. In case true demographic and conservation statistics were provided, reports and publications of the national and international organizations also were included.

Some of the areas that data on relevant research was carefully gathered and compiled include distribution, habitat, population size, population trends, risks and conservation strategies. Subsequently, the information was analyzed in order to identify similarities, patterns and inconsistencies among the studies. To determine how the population has changed over the years, to determine the effectiveness of conservation programs, and to understand the key issues endangering snow leopards in Pakistan comparative analysis was done. The analysis's findings offer a thorough overview of the species' current state of conservation and serve as the foundation for the report's discussion and suggestions.

RESULTS AND DISCUSSION

Methods of Estimating Snow Leopard Abundance

Understanding the distribution of snow leopards within a region and their relative abundance in various habitats is essential for optimizing their management. Because of its reclusive nature, measuring its abundance is challenging. The abundance of snow leopards is determined through capture-recapture, observation of evidence of their existence, predator: prey biomass ratio, photographic-capture rate and genetic analysis. Until 1980 no image of a snow leopard in the wild existed. Live-capture (the direct capture of an animal) that is almost impossible to use as it has an extremely low encounter rate (approximately 3/1,000 trap nights) has been replaced with the advent of camera traps (Li et al., 2010).

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Sign Surveys (SLIMS)

The Snow Leopard Information Management System (SLIMS) was created lately to track snow leopards' and their prey's movements. Standardized sign surveys are the foundation of the system and are frequently utilized. Sign surveys yield relative snow leopard abundance indices that can be used to compare regions with comparable topographies. Over time, this approach helps spot changes in numbers within one location - provided tools such as DNA tests or motion-sensor cameras back it up. Snow leopards are often watched using SLIMS, mainly since it costs less and doesn't disturb them much. Absolute estimates of density are superfluous luxuries because most ecological problems can be solved with just density indices; in most circumstances, SLIMS may be adequate (Ale et al., 2014).

Jackson and Hunters way of figuring out how many Snow Leopards are there is by looking at the signs they leave behind like their footprints or scrapes. A simple, rapid, and user-friendly strategy that has proven helpful in conservation planning in nations with limited resources is 20 signs per kilometer, which denotes 10 individuals per 100 km2. The cameras need to be spread out, put at least one camera every 25 km². This is because female snow leopard usually roams around that area (Ale et al., 2014).

Hiking through the area is required to identify all locations where snow leopards have sufficient habitat and terrain, as well as where their prey are found, in order to establish where transects for sign surveys should be placed. Following the identity of transects places with a high probability of snow leopard incidence they're tested for snow leopard signs. Additionally, it's miles viable to record signs among transect strains to provide beneficial records for evaluation with that received alongside signal transects (Sharma et al., 2014). The signs include scent marks (also called spray), scratches, droppings, paw prints, and stones or boulders that snow leopards use for their scent or cheek rubs. Scrapes and scent marking cost more than looking for dung and pugmarks. But they might provide us with additional biological and ecological data (Ale et al., 2014). It is important to do sign surveys in countries during summer and spring to get a better idea of how well sign surveys work during other seasons. Conducting surveys during the spring season alone could suffice if surveys conducted during the spring show that it is more probable to find signals. A uniform methodology should be applied when estimating predator counts using SLIMS (Ghoshal et al., 2019).

Table 1 Signs indicating the abundance of snow leopards in different seasons (Valentová, 2017).

Season	Transect	Length Km	Feces	Pugmarks	Scrape	Spray	Hair	Total	Total sign/km
Autumn	9	7.2	19	10	33	4		66	9.2
Spring	15	11.0	15	6	90		1	112	10.2
Summer	27	19.4	22	3	16			41	2.1
Total		37.6	56	19	139	4	1	219	5.8

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Predator: Prey Biomass Ratio

Predator-prey models of population dynamics predict negative feedback between the biomass of prey and predators. This is the basis for another way to figure out how many snow leopards there are: the predator: prey biomass ratio. If you know how much prey there is, you can use this method to guess how many snow leopards there are, which is what SLIMS does. To count the number of snow leopard prey, each station needs to be in a good spot where the animals won't be bothered and where the size, age, and sex of each individual can be found (Valentová, 2017). You can use binoculars and spotting scopes to look at things. Mean prey mass improves due to the wide variety of populations observed to calculate normal prey biomass. Ungulates biomass equivalent to the hundred km square can then be converted to leopard biomass using an average mass of 50 kg for snow leopards using a simple conversion wing of 10,000 kg of prey to 90 kg of prey. Nevertheless, the struggle for survival against other predatory animals, like wolves, might alter the predator: prey ratio (Sathyakumar et al., 2011).

The greatest number of snow leopards that can be sustained by the available prey (its carrying capacity, K) is another, more advanced way. This is computed as: (Aryal et al., 2012)

$K = A / (ESSR \times AHRS)$

With,

$ESSR = PBY / (PD \times SUF \times BD \times EHD)$.

Where; **A** stands for area; **AHRS** for average home range size (about 22.6 km2/individual); **ESSR** for ecologically sustainable stocking rate; **PBY** for prey biomass/snow leopard/year (~548 kg/year, 1.5 kg/day); **PD** for total prey biomass/km2.

The safe use factor or SUF is the total biomass production of the ecological site that can be used by animals, and the rest of the biomass production can be used to sustain the ecology (Aryal et al., 2014). BD stands for birth: death, like in the case of blue sheep in Nepal. Assuming that 50 per cent of the blue sheep of the Dhorpatan Hunting Reserve die before attaining the age of two, it is supposed to be 2:1. EHD stands for environmental and human disturbance elements, such as livestock grazing and poaching, in the grassland habitat that supports the population of predators (Ale et al., 2014).

Genetic Analysis

A promising technique for determining snow leopard abundance is genetic analysis of fecal DNA. Also, an improved scat collection format may allow a more detailed study of the territoriality or marking behavior. The only technique that can reveal genetic links, including the disperser's source, is genetic analysis. Another benefit is that because the estimations are based on the use of specialist equipment and prior training, they are not susceptible to observer bias. Genotyping of feces can produce more known individuals and provide minimum population estimates as compared to visual discrimination using photos (Valentová, 2017).

However, the cost of these methods (about USD 50–225 for one sample) and the complications of moving feces between nations are significant drawbacks. Using domestic labs to process the genetic data is one way to cut expenses. To utilize

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genetic analysis to monitor snow leopards, samples have to be first collected. To develop a more precise sampling technique, hair samples from cheek rubbing or scent pads might be utilized. It is crucial to reduce the number of samples that do not belong to snow leopards by choosing them based on their size, location, and form (Valentová, 2017). Prevented contamination by the use of plastic spoons and latex gloves to collect fecal samples, which were then collected in different 5-ml tubes containing 4 ml of 90% ethanol. Overall, it is reasonable to obtain samples of scrapes to enhance the confidence of snow leopard sign to avoid mistakes made during scat collection (Aryal et al., 2014).

After collecting the samples, the DNA is extracted at a lab and the polymerase chain reaction (PCR) is set to amplify a small quantity of DNA in the samples. Stool kits, such as the Qiagen stool kit, and techniques that include negative controls to check for contamination can be used for DNA extraction. Following PCR, a sample of about 160 base pairs from the mitochondrial DNA regulatory region's cytochrome B gene is sequenced. Specific primers and previously described techniques are utilized to determine which species deposited each fecal sample. Having as many primers (polymorphic microsatellite loci) as possible is appropriate so that to identify individual snow leopards. Ten polymorphic microsatellite loci are used (Jackson et al., 2010) .

Camera Trap

There are many applications for camera trapping, from birds to animals. It is used to calculate daily activity patterns, abundance, and presence/absence of population characteristics. Camera traps are emerging as a modern non-invasive method for population detection of species whose individuals can be identified through tagging, as well as tracking creatures living in hiding such as snow leopards. When species are rare and sample sizes are limited, it is more reliable than other approaches. Describe in detail how to use camera traps to estimate the densities of snow leopards (*Panthera uncia)*. Digicam networks are really good for doing these studies on their own. They can keep doing them for a long time (Alexander et al., 2016a).

There are some problems, with the cameras too. They are challenging to utilize in places that are hard to reach because of steep terrain, dense foliage, or long distances. The cameras do not work properly when the weather is bad like when it's raining a lot or very cold. Any picture of a snow leopard or a group of pictures of a snow leopard taken by a camera trap is called a "photo event" of a snow leopard even if we cannot tell which snow leopard it is (Valentová, 2017). According to Wilson and Anderson (1985) photographic rate is a measure of how common a species. It is calculated by taking the number of photos of that species and dividing it by the number of trap-days, 100 trap nights at a particular site. It is useful to resort to images of humans taken with more than one camera over the same hour to arrive at more accurate conclusions. The cameras and the days that the cameras are working together figure out the trap-nights of the cameras.

For example, McCarthy (2008) surveyed between 1,078 and 1,180 trap-nights in each region. In order to minimize the impact of sunlight, cameras are typically orientated towards the north or south. Placing cameras tends to focus on key spots where snow leopards might travel, often near rocky outcrops they mark repeatedly, sometimes at

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valley bases, occasionally along sharp elevated edges that stand out clearly across the terrain. Later on, cameras get placed in a ring formation spaced two kilometers apart with each unit positioned just under half a meter off the surface; they capture images with a minute-and-a-half delay separating them. A key feature includes integration of infrared detection capability (Valentová, 2017).

Capture-Recapture Method

Because snow leopards live far apart and roam widely, estimating their numbers can be tough, yet camera trapping helps by spotting unique individuals over large areas. This approach works well when animals are sparse but carry distinct markings visible through photos taken at intervals across terrain. However, this approach may be susceptible to logistical limitations when the densities are extremely low (Zakharenka et al., 2016, Zarif, et al., 2024).

Some ideas suggest ways to create a space zone of likely capture spots, aiming to include every location. One method uses average longest distances between recaptures. This approach relies on data from repeated captures within small mammal groups. This idea is frequently criticized in the literature because it is believed to become less reliable as home range size increases and trap rate decreases (Ale et al., 2014). Another alternative is to use the maximum distance between recaptures of the buffer. The literature does not support the former concept well and is often challenged since it is believed that dependability declines with both increase in home range size and decrease in trap rate (Suryawanshi et al., 2019).

Using the average minimum reported home-range size or average home-range size of the species is a third notion or approach. Estimating the extent of the home range is difficult since it depends on the amount of food biomass that is available (Aryal et al., 2014). A typical domestic type is roughly 22.6 km² per individual. The lack of data for certain regions where snow leopards are common is another problem. A good example is the Tien Shan Mountains. The size of carnivore home ranges and prey biomass are often negatively associated. Therefore, we should take into account the ungulate densities and apply a linear regression so as to fit the data (Valentová, 2017). Calculate effective study area by the techniques. The radius of normal minimum home range common home range, half of the mean maximum distance traveled by repeated animals, indicates the maximum distance traveled by repeated animals, and the radius of variation of home projected by ungulate density (Valentova, 2017).

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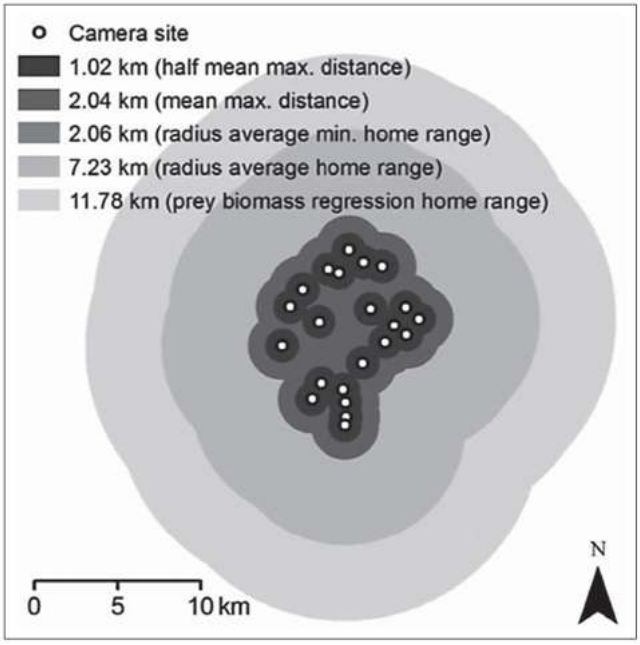
The density estimates can be significantly changed by selecting one of these techniques The density rating is based on the dimension of the total space saved by using the camera and the powerful space of the buffer coil (Valentová, 2017).

Figure-1: Good buffers for studying snow leopard Around Camera-Decoy Website (Valentová, 2017).



Biotelemetry (Global Positioning System Collaring and Radio Collaring)

A technique for gathering precise information on animals that are difficult to view is biotelemetry. Biotelemetry can be used to understand the migration patterns and factors that affect the distribution of animals, the range of their homes, the patterns of habitat consumption, social structure and selection of habitats (Lumetsberger et al., 2017). This understanding is crucial to the administration and preservation of protected areas and the behavioral ecology. Snow leopards are tracked with the help of radio and satellite transmitters (Global Positioning System, GPS). The basis of both techniques is the receipt of information or signals by the transmitter attached to a collar at the neck of the animal (Valentová et al., 2022). Both of these techniques are seen as invasive since the animal must be trapped in order to fit the collar, which calls for specialized knowledge and may occasionally be dangerous for the animal. Jackson (1996) states that good places to capture snow leopards are those where their movement is constrained by vegetation. This is less than 0.5 m large through vegetation, rocks and various body systems, and where clean snow leopard scrapes and a large range of associated signs are made. Typically, the immobile animals are fitted with a radio collar, weighed, measured, and have an identifying number tattooed inside one ear (Valentová, 2016).

Due to the personnel and equipment required, telemetry is roughly an order of magnitude more expensive than camera trapping. A significant amount of the snow leopard's territory is located around national borders and other politically sensitive

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locations, where its use is frequently prohibited. Radio tracking is based on radar devices sending out radio frequency pulses and timing how long it takes for those pulses to be reflected back (Valentová, 2016).

This time shows how far away the radar unit is from the objects it is reflecting. Highly directional antennas can make broadcasts and signal reflections back very focused, which makes it possible to guess the direction of such reflected objects. The downside of this method is that in rocky, mountainous areas, radio waves can bounce, deflect, and lose strength, which can affect how far they can travel and how well they can be received (Valentová et al., 2022).

Because GPS is more accurate than radio telemetry, it is utilized more frequently these days. By comparing the animal's GPS coordinates with a habitat map made from satellite images or aerial photos and ground-truthing, the researcher can find out what habitat features or conditions are important for feeding, resting, or reproducing (Mahmood et al., 2021).

Scientists can more accurately estimate the number and density of snow leopard populations by using information on average home range sizes and prey concentrations. The Snow Leopard Trust team put collars on a female snow leopard and her sub-adult offspring. This makes it possible to keep track of where the mother and cub go and when and how the young cat becomes independent (Valentová et al., 2022).

Comparison of the Methods Used for estimating the Population Density of Snow Leopards

It is essential to gather data on all the regions where snow leopards can be found in order to compare their populations thoroughly. This data is not available. The research that has been done in different snow leopard regions does not employ consistent methodology. The explanations could be objective, such as environmental variations that make data collection challenging or variations in snow leopard densities that prevent the application of the same methodology (Thinley & Dagay, 2014; Taha, 2017). The camera capture-recapture technique can be used at high densities (48 individuals/100 km2), lower standard errors, and a long-term period of investigation of an area. It may be impossible to gather enough information for viable capture-recapture modeling in a short amount of time (about seven weeks) in regions with extremely low populations and no prior understanding of snow leopard behavior (Network, 2014).

This brings us to the conclusion that the camera capture-recapture method cannot be depended on in the case when the ranges of houses differ in size and capture rate is very low. Another useful technique for gathering comprehensive data on people's spatial dynamics is biotelemetry (Suryawanshi et al., 2019). These days, GPS collars are more common than radio collars, which are less dependable. However, the extremely high cost and logistical difficulties of GPS tracking are major issues. According to this perspective, only nations with high per capita incomes or those with outside assistance from international organizations may employ this strategy (Alexander et al., 2015).

Scientists can more accurately estimate the number and density of snow leopard populations by using information on average home range sizes and prey

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concentrations. The Snow Leopard Trust team put collars on a female snow leopard and her sub-adult offspring. This makes it possible to keep track of where the mother and cub go and when and how the young cat becomes independent (Valentová et al., 2022).

Sign surveys or photo rates can be used when a precise assessment of the density is not required. Due to their resemblance to genetic data, these two approaches offer a reliable indicator of snow leopard abundance. On the other hand, the estimates made on the basis of capture-recapture and predator-prey biomass ratios are similar to other abundance estimates. As previously noted, non-invasive genetic tests would be more suitable for obtaining precise estimates of densities (Karnaukhov et al., 2020). Unlike other methods, such as incorrect scat identification, their results are not susceptible to observer bias. In my opinion, correlating the findings of sign surveys with those of other techniques is the most effective way to estimate snow leopard abundance (Oberosler et al., 2022).

Current distribution and quantification

This data of the current distribution range of the snow leopard is that of the IUCN Red list. The List of Threatened Species (2015) was used to analyze the present distribution of the species. The distribution range was mapped and quantified using QGIS (Quantum Geographic Information Systems) which showed that the species now occupies an area of approximately 3.20 million km2 (Mahmood et al., 2019).

Range Quantification

Previous studies and conservation journals provided the history and present distribution of the Snow Leopard. In a study, the cumulative extent of past and present distribution ranges was approximated by adding individual spatial polygons with QGIS. Next, the distribution changes and expansion or contraction of ranges were determined by comparing the historic and current ranges. To assess the degree of habitat loss the percentage change between the historic and current range of the species was calculated (Mahmood et al., 2019).

Proteced Areas and Snow Leopard Distribution Range

The presence of snow leopards in the protected areas was acquired through the information provided by the World Database on Protected Areas and other published literature. Past research mapped the distribution patterns of snow leopards in the past and present in the preserved areas. These data were to analyze the shifts in the distribution of the species, to discover the protected areas where snow leopards disappeared or remain to this day (Pan et al., 2024).

Ecological and human-related factors that were presented in the literature were also considered care to learn the causes of persistence or local extinction of various places (UNEP-WCMCand, 2018).

The Snow Leopard (Panthera uncia) distribution in the Pakistani protected areas was estimated based on the information available in the already published studies and GIS databases. Past research mapped the distribution patterns of snow leopards in the past and present in the preserved areas. Protected Planet's World Database on Protected Areas provided the information (Mahmood et al., 2019).

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Table 2 Information about some of the larger Protected Areas (PA's) of Pakistan (Mahmood et al., 2019).

Protected areas	category	Country	Area km2	Past range	Current range
Khunjerab National Park	National Park	Pakistan	2269.13	yes	yes
Sheikh Buddin National Park	National Park	Pakistan	195.4	yes	No
Astore wildlife Sanctuary	Sanctuary	Pakistan	414.72	yes	yes
Ghamot Game Reserve	Game Reserve	Pakistan	272.83	yes	yes
Argham Basti Wildlife Sanctuary	Sanctuary	Pakistan	298.66	yes	yes
Argham Wildlife Sanctuary	Sanctuary	Pakistan	298.66	yes	yes

According to available literature and spatial data, historical distribution of snow leopards in Pakistan contains a few protection regions. Some of these Khunjerab National Park includes Sheikh Buddin National park, Khunjerab National Park, and Astore Wildlife Sanctuary because Khunjerab National Park is one of the most significant snow leopard habitats in north Pakistan because of its high altitude hilly terrain and the variety of natural prey species (Kalinkat et al., 2017).Comparisons between the distribution information published in the literature of the past and the present show that snow leopards still exist in certain area of protection, but have either declined or disappeared in others (Tumursukh et al., 2016).

There is a myriad of ecological and human factors that can be attributed to this disparity such as habitat degradation, a reduction in prey species, climate change and an increase in human activity. Ecological and human-related factors that were presented in the literature were also considered care to learn the causes of persistence or local extinction of various places (UNEP-WCMCand, 2018).Consequently, secure zones are needed in the conservation of appropriate habitats and the long-term conservation of Pakistani snow leopard populations (Ghoshal et al., 2019).

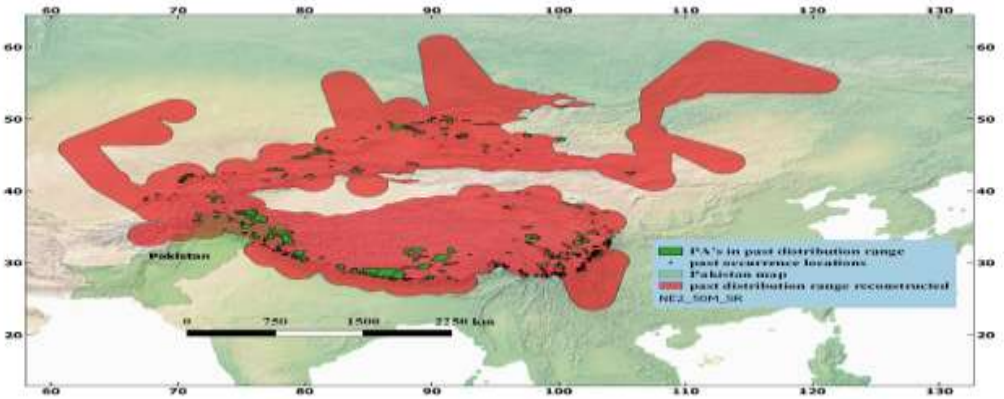

Figure 2 Snow leopard GIS-based map in comparison with Protected Areas (PA's) in Pakistan (Mahmood et al., 2019).

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Threats to snow leopard

There are estimated to be 200 and 420 snow leopards in Pakistan, however there are six major factors that put their life at risk (Kazmi et al., 2022).

Poaching

Thirteen snow leopards have been killed in Khunjerab National Park (KNP) and the conservancies that surround it within the last seven years. Nonetheless, a professional evaluation indicates that the condition is even more terrible than the mentioned annual numbers would imply (Maheshwari & Niraj, 2018).

Competition for primary prey

As the number of feral canines rises, snow leopards are facing more competition for the markhor (*Capra falconeri*), which is their main natural prey. In the 77.4 km2 Chitral Gol National Park (CGNP), over the past 15 years, feral dogs have killed 392 markhor; however, information on markhor mortality and ibex is not available in other areas (Khattak et al., 2021).

Illegal killing of primary prey

Ibex and markhor are frequently killed illegally for their meat in Pakistan's snow leopard habitats. More than 100 ibex were recently slaughtered for government officials and notable people (Mir, 2020). Due to uncontrolled hunting, Markhor's population has dropped from 2,868 in 2019 to less than 800 today (Ahmad & Nabi, 2022).

Illegal Trade

Snow leopards' survival is also seriously threatened by the illegal trafficking in these animals. Snow leopards are killed for commercial objectives in addition to killing cattle. Snow leopard pelts are highly sought after in Chinese medicine, followed by their claws, flesh, male organs, and bones as alternatives to tiger bones (Theile, 2003, Taha, 2019). Some of the former socialist states are still pushing for sustainable development today. Although poaching is less common now, it still occurs in many of the former Soviet nations (McCarthy et al., 2010).

Human-snow leopard conflict

Domestic livestock are a major source of prey for snow leopards (S. Ahmad et al., 2022). Every year, pastoralists kill a significant number of snow leopards in an attempt to maintain their way of life (Usman & Khan, 2025). Considering the effects of human activity, the natural environment is a crucial component of the biological system. When human wants and actions negatively affect wildlife, conflicts between humans and wildlife arise (Lumetsberger et al., 2017).

Snow leopards must gaze for space and resources whilst they are forced to live close to human populations. In conservation biology, the conflict between people and wildlife is becoming more and more troublesome. Conflict between humans and wildlife affects human needs and is a significant management challenge (Naha et al., 2020).

It is known that direct persecution by humans can have a detrimental effect on

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carnivore populations. The loss of habitat and the decrease in the availability of prey. In some situations, carnivores may benefit from interspecific interactions, and a small number of carnivorous animals show adaptation and even success in ecosystems altered by human activity (Sharma et al., 2015).

If social resilience is high, disputes are well handled, and conservation tactics are successfully implemented, carnivore populations can endure in the presence of sizable human populations. The snow leopard suffers many challenges in its natural habitat and faces extinction (Li et al., 2020).

Large predators have a substantial impact on the health of biological systems, and carnivore dominance has been linked to major habitat changes. The degradation of rangelands and the decline of hoofed animal populations have been caused by an exponential increase in both human and domesticated animal populations. This has led to higher carnivore mortality rates and increased predation on currently under investigation, especially domestic livestock (Shi et al., 2025).

The degradation of rangelands and the decline of hoofed animal populations have been caused by an exponential increase in both human and domesticated animal populations. This has led to higher carnivore mortality rates and increased predation on currently under investigation, especially domestic livestock (Thapa, 2022).

The endangered Snow Leopard is found in remote and challenging elevations of Southern and Central Asia, where it has a large population of domesticated animals, kept by the farming community below. Domesticated animals have been wiped out by *P.uncia* over hundreds of years. According to research, 12% of the livestock property is within the snow leopard's habitat, which has caused problems for animals raised for food (Sami et al., 2025).

In *Panthera uncia*, increased animal and feral prey numbers result in increased hunting activity. However, both inside rural areas and in nearby areas, the geographical and temporal dynamics of predation differ (Suryawanshi et al., 2014). According to studies on food habits, the percentage of animal deaths varies from 15% to 70%, depending on sociobiological factors that impact the kinds of domesticated animals that are killed (Schofield, 2019).

Climate Change

Biodiversity is seriously threatened by climate change. Climate change generally destabilizes systems and how they are managed, such as the equilibrium between local resource usage and wildlife biodiversity. As a result of substantial alterations in the plant communities, there will be an increase in the likelihood of snow leopards migrating to low altitude levels as their prey, including blue sheep in the Trans-Himalayas, seek grazing areas at low altitude levels, where they may encounter livestock and kill them. The reason is that grasses, along with several types of shrubs, do not grow abundantly enough at higher altitudes anymore (Aryal et al., 2014).

Predictions based on bioclimatic models indicate that a shift in the treeline and subsequent shrinkage in the alpine zone, primarily at the southern edge of the range and in river valleys, may result in the loss of roughly 30% of snow leopard habitat in the Himalayas (Aryal et al., 2014).

Rotational grazing where corrals are kept at different altitudes is used in most parts of the snow leopard habitat. Thus, herding methods and cattle killing are related. The

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people's livelihoods have been adversely affected by the blue sheep raiding crops and by snow leopards killing their livestock (Forrest et al., 2012).

Table 3: Overall effect of climate change on four parameters. Source: Interview with local people (n = 221) (Aryal et al., 2014).

Rangeland%	**Livelihood%**	**Blue sheep%**	**Snow Leopard%**
Reduction in water sources (18)	Reduction in food and drier farmland (9)	Reduction in numbers (38)	Reduction in numbers and fewer sightings (41)
Reduction in grass (33)	Reduction in livestock (4)	Crop raiding (16)	Increase in attacks on livestock (24)
Drier (12)	Health problems with new diseases (3)	Movement downward towards farmland (14)	Approaching villages (13)
Reduction in snowfall (27)	Reduction in drinking water and fewer irrigation channels (36)	Sightings near villages (4)	Change in use of habitat and increase in their tendency (22)
Move towards desertification (10)	Changes in the timing and agricultural crops (27) Increase in wind speed Economic crise	Reduction in grazing land (20) Change in habitats use (8)	

Lack of Awareness and Policy

Conservation efforts are further hampered by the widespread ignorance of the need to protect wildlife, particularly predators, at both the local and national levels. In certain cases, such as when genetic tests are employed, samples must be transported between nations in order to determine snow leopard numbers. Such surveys are complicated by the inability to move samples between nations, particularly in regions close to politically sensitive international borders (Fast, 2019).

Transboundary cooperation is not achieved in almost all areas that have snow leopards, such as the Himalayan area, Commonwealth of Independent States, and Western China, based on IUCN's findings. For instance, only one laboratory dealing with wildlife issues is found in Kathmandu, Nepal. This is inadequate (Valentová, 2017).

The China-Pakistan Economic Corridor (CPEC), habitat loss, fragmentation, isolation, and climate change all pose significant environmental problems (Nabi et al., 2018). The inaccessibility and geopolitical sensitivity of the research location, together with the wildlife department's lack of financing and cooperation with research, further impede the conservation of snow leopards (Usman & Khan, 2025).

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Conservation of snow leopard

Establishing protected areas, putting conservation laws and regulations into effect and enforcing them, offering financial incentives, and assisting community-based conservation (CBC) initiatives are all common components of biodiversity conservation efforts. "Community members or a community-based organization are involved in efforts to protect or conserve the lands and environment they live on or nearby through the highest levels of participation" in CBCs. CBC interventions are becoming more widespread, particularly in the global South (Galvin et al., 2018).

Resources for CBC are sometimes scarce, partly due to their modest scale but also because their efficacy is rarely assessed convincingly with assessments that are either focused on modeling predictors of success or have restricted breadth and scale (Fariss et al., 2023). Conflicts between humans and wildlife provide a significant obstacle to conservation (IUCN, 2023).

Large animals, such as wolves in the northern hemisphere, are frequently at the center of these fights (Salvatori et al., 2020). The effects of carnivores on cattle, livelihoods, well-being, and even human life are complicated issues (Van Eeden et al., 2018). The inhabitants of the snow leopard's habitat are distinguished by a marginalized, agro pastoral lifestyle, a rich culture, and a high degree of ethnic diversity (Li et al., 2020).

Their average parity income is USD 250-400 annually, yet almost 40% of them earn less than the national poverty line (Jackson et al., 2010). Snow leopards and wolves frequently prey on livestock, and domestic and wild ungulates compete with one another for pasture (Li et al., 2020). People that rely on livestock exploit the vast alpine habitat of snow leopards (*Panthera uncia*) (Alexander et al., 2016b).

After killing cattle, snow leopards may be retaliated against (Suryawanshi et al., 2017). Community members take an active role in designing, implementing, and monitoring interventions in collaboration with the Snow Leopard Trust and other collaborating organizations. It involved 232 communities that safeguarded over 88,000 km2 of snow leopard habitat in 2017 (Redpath et al., 2017).

Collaborative conservation of Snow leopard

Many have examined long-term monitoring data from China, Kyrgyzstan, India, Mongolia, and Pakistan to determine the effectiveness of community-based snow leopard conservation initiatives. These studies highlight four main approaches that were developed in collaboration with local communities and tailored to meet their unique needs. To prevent animals from attacking livestock, it is crucial to construct or reinforce predator-proof corrals (Samelius et al., 2021).

Implementing vaccination and immunization programs is an essential measure to reduce mortality in livestock caused by infectious diseases, thereby decreasing economic losses for local communities. In addition, community-based livestock insurance schemes have been introduced to provide financial compensation to herders when animals are lost due to predation or disease, helping to improve their economic resilience. Moreover, conservation-oriented livelihood initiatives have been encouraged, particularly those centered on handicraft production, which enable communities to generate income while simultaneously supporting environmentally sustainable practices and reducing pressure on wildlife (Zakharenka et al., 2016).

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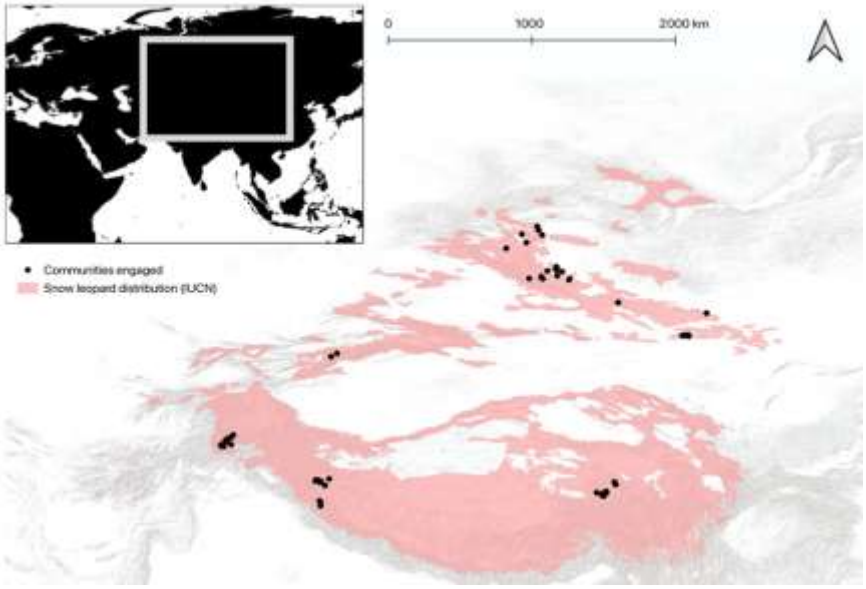

Figure 3 Map showing the location of community-based conservation interventions in five countries, India, Mongolia, Hindu Kush-Pamir in Pakistan, Kyrgyzstan, and China (Mishra et al., 2017).

Earlier research indicates that such interventions, typically implemented over extended periods prior to assessment, have yielded notable ecological as well as socio-economic advantages. Studies focusing on corral-based strategies have examined in detail various factors, including the construction and design of livestock enclosures, improved animal husbandry and management practices, and observed patterns or changes in livestock losses due to predation over time (Agvaantseren et al., 2016).

Broader evaluations of conservation initiatives also consider a range of demographic and socio-economic variables, including factors such as age, educational background, household income, and levels of livestock ownership. Studies focusing on corral-based strategies have examined in detail various factors, including the construction and design of livestock enclosures, improved animal husbandry etc. These characteristics are analyzed to understand how they influence community participation, attitudes, and overall engagement in conservation-related activities, as well as the effectiveness and sustainability of such programs (Suryawanshi et al., 2019).

Table 4 Year in which intervention programs started in each intervention country (Young et al., 2024).

Country	Predator-resistant coral	Handicraft Program	Livestock Vaccination	Livestock Insurance
China				2015
India	2011	2013		2002
Kyrgyzstan		2003		
Mongolia	2015	2000		2009
Pakistan	2014	2003	2003	2003

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A substantial amount of research utilizes the Theory of Planned Behavior to analyze human attitudes toward wildlife conservation. Based on this framework, individuals with positive attitudes, positive social pressures, and a strong sense of control over their behavior would be more inclined to behave in ways that are conservation-supportive, including refusing to kill snow leopards in retaliation. To conclude, the literature reviewed indicates that ecological measures should be accompanied by socio psychological strategies to make the conservation of snow leopards effective in the long term (Davis & Goldman, 2019).

The research was conducted in a comparative method that was used to measure the difference between the household responses of the groups that were subjected to conservation interventions and groups that did not receive any intervention (manage groups). Control communities had been selectively and cautiously chosen in connection with healthy intervention websites, both in demographic and socioeconomic features within the snow leopard range of distribution, thus boosting the accuracy of comparisons (Miller et al., 2015).

Table 5 Earnings for households from local communities per year (in USD) (Young et al., 2024)

Country	Year 1	Year 2	Year 3
Pakistan	39	13	15
Mongolia	145	110	112
Kyrgyzstan	74	171	97
India	15	35	21

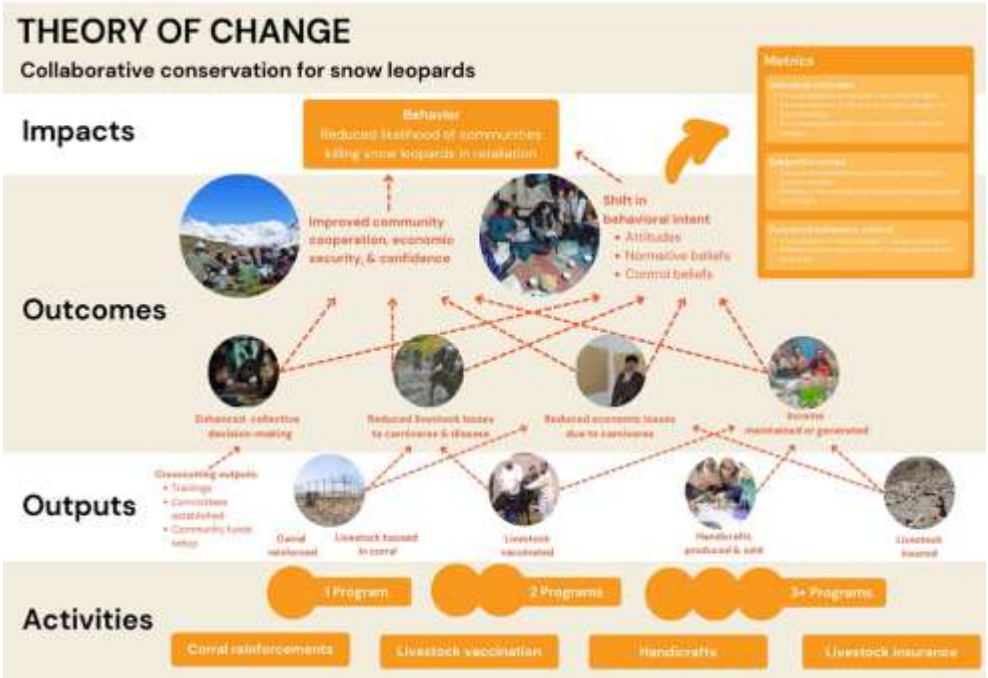

Figure 4 Theory of change for collaborative conservation of snow leopards in high Asia (Young et al., 2024).

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Both surveys employed a modified systematic sampling technique to obtain a representative coverage. This method allowed the incorporation of homes across spatial regions and thus it was able to capture the geographic variation as well as reduce the possible bias that may arise due to the location of a household (Eklund et al., 2017). However, it is acknowledged that certain socioeconomic disparities could have persisted between the intervention and control communities, as conditions on the site and previous experiences with conservation programs can differ significantly across sites. The study pattern had 57 groups that represented five countries with a wide geographical coverage (Alexander et al., 2022).

Each network was split into three groups of households based on their degree of engagement in conservation interventions: those who were not engaged in these interventions, those who were engaged in one intervention, and those who collaborated on multiple interventions. A balanced sampling structure was implemented by determining the number of families to be included in each category almost equal to each other so that meaningful comparisons could be made (Galvin et al., 2018).

The gender stability of respondents has also been attempted to maintain, as it is important to acknowledge the importance of the inclusive views in conservation studies. Besides this, key informants such as village leaders had a crucial role in the identification of households and the provision of contextual statistics about the extent to which the households were likely to participate in interventions. Their enter changed into especially precious in regions lacking up to date maps or clear agreement facts, including semi-nomadic groups, in which making sure spatial illustration posed additional demanding situations (López-Bao et al., 2017).

Table 6 Summary of communities and households (HH) surveyed per country (Young et al., 2024).

Country	**No. of communities surveyed**	**No. of HH interviewed**	**No. of intervention at HH interviewed**		
			0	**1**	**2**
China	6	89	41	29	19
India	15	248	91	116	41
Kyrgyzstan	3	35	15	20	0
Mongolia	11	98	49	41	8
Pakistan	22	353	184	126	43
Total	57	823	380	332	111

Livestock insurance programs were implemented in 66 localities with over 1,400 households in Mongolia, Pakistan, India, and China. The social and economic impacts of community-managed livestock insurance systems have been the subject of numerous studies. Numerous studies indicate that households participating in these schemes typically insure both small livestock (like sheep and goats) and larger animals (like horses, camels, yaks, and donkeys), often covering a sizable fraction of their overall livestock assets. Many respondents reported feeling more financially secure, indicating that they had greater faith in their capacity to manage and bounce

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back from financial setbacks. . Their enter changed into especially precious in regions lacking up to date maps or clear agreement facts, including semi-nomadic groups, in which making sure spatial illustration posed additional demanding situations. The social and economic impacts of community-managed livestock insurance systems have been the subject of numerous studies. Furthermore, these programs have been linked to stronger social ties, as many people who took part said they saw more cooperation and shared responsibility in their communities (Van Eeden et al., 2018).



Figure 4 Visual documentation of collaborative conservation programs implemented across five countries: India, Mongolia, Pakistan, Kyrgyzstan, and China. The funding for this conservation programs came from multiple sources listed above. The non-

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governmental organizations provided the funding for materials, while community members donated their time and collected locally available materials (Young et al., 2024).

Conservation Status and strategies

Because the locals in these areas have relied heavily on livestock for millennia, snow leopard assaults on animals have led to several confrontations. In order to prevent this issue, corals made of bricks known as "predator proofing" were built, which assisted in preventing snow leopard attacks on cattle. Programs such as livestock insurance, community-based ecotourism and livestock vaccination were started in order to enhance the standard of living of the local people. Between 2011 and 2013, a conservation initiative was initiated by the Snow Leopard Trust named Save Our Species Project (SOS) in five valleys of Gilgit with fourteen villages involved. This project has led to an increase in the amount of meat sold in the local market (Johansson et al., 2015).

Through the distribution of brochures, pamphlets, seminars, and training courses, environmental education initiatives were established to raise local community knowledge of the importance and conservation of species. Different nature clubs were established to engage the local population in conservation activities and to educate at the school level. Engaging the local population in these initiatives led to a rise in favorable attitudes regarding conservation (Sami et al., 2025).

In order to reduce hunting and illicit trade, anti-poaching initiatives were started, such as the creation of several natural reserves and protected areas, such as Khunjerab National Park in northern Pakistan and Chitral Gol National Park in the KPK region (Din et al., 2024).

Despite these, some additional efforts included tracking programs, research programs for habitat studies, climate wise landscape management programs for examining the effects of climate change on population, and species population counts (Forrest et al., 2012).

In the past, efforts have been made to restore the *P. uncia* population by designating a sizable area as a natural protected area; however, these initiatives cannot succeed without the support of the local populace. Compared to setbacks obtained by the *P. uncia*, money-related strategies pay a very little amount (three percent). The Baltistan Wildlife Conservation and Development Organization (BWCDO) launched Project Snow Leopard (PSL), a protection program that includes local ranchers and Gilgit Baltistan's ecotourism endeavors, in order to make up for the herders' suffering and soften their attitude toward the snow leopard (Sami et al., 2025).

The residents' board of trustees and the project authorities jointly oversee the Project Snow Leopard. The municipal board of trustees and PSL officials determine the amount of compensation to be provided to the worried owners as a result of the *P. uncia* predation incidence on farmed animals. It could help keep snow leopards safe in the area. There have been accounts of snow leopards residing in the 12 gorges of Chitral through the WWF-P, which is another program that seeks to protect P. uncia, in addition to the Snow Leopard Trust and Snow Leopard Information Management System (Johansson et al., 2016).

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There have been many threats to this species and its environment and this has necessitated the use of landscape level preservation strategies that are based on sound information about the needs for species endurance. The Global Snow Leopard Ecosystem Protection Program (GSLEP) is a worldwide plan to conserve snow leopards and their enormous ecosystem, which cuts across twelve countries and supports a billion population (Din et al., 2024).

The proximity of aggregate solids for possible application in producing realistic species movement dependent on accurate data and scientific techniques such as MaxEnt is considered by current technological developments including camera trapping and molecular methods (Zakharenka et al., 2016).

Research is indicating that 40% of the 170 protected areas for Panthera uncia cover less area than the range of a single mature male, while only 13% are large enough to give a 90% probability of containing at least 15 mature females. Furthermore, it has been estimated that 33% of the identified or potential Panthera uncia habitat is located fewer than 100 kilometers from the world's borders of the 12 countries. To reduce risks to snow leopards and the biological system, the Global Snow Leopard and Ecosystem Protection Program (GSLEP) advocates advancing the transboundary preservation plan (Network, 2014).

Legislation

Nature reserve designation by governments and efforts by non-governmental organizations have formed the basis for legislation concerning snow leopards. But their skills are restricted (Li et al., 2014). Little is known about how protected areas are now managed or how they support snow leopard populations (Green & Zhimbiev, 1995). Currently, just 0.3–27% of snow leopard habitat in 11 out of 12 nations is protected by natural reserves. 57% of the habitat of the snow leopard is under protection only in Bhutan (Hunter et al., 1997, H. Ullah, 2021).

In all levels – from the local to the regional and even national level, it is crucial that laws and conservation policies should be passed to ensure that hunting, killing, possessing, selling, and trading of snow leopards or any other part and derivative from its body shall cease in order to protect it from harm (Theile, 2003).

It would be beneficial if governments could receive support and guidance on how to punish lawbreakers and think about putting in place "whistle-blower" programs to offer incentives for reporting unlawful activity. Theile also suggests creating "antipoaching" teams that would keep an eye on major marketplaces and trade hubs to gather information about unlawful killings (Maheshwari & Niraj, 2018).

Little is known about how protected areas are now managed or how they support snow leopard populations (Green & Zhimbiev, 1995). Currently, just 0.3–27% of snow leopard habitat in 11 out of 12 nations is protected by natural reserves. 57% of the habitat of the snow leopard is under protection only in Bhutan (Hunter et al., 1997).

In the long run, however, further study and analysis of the relationships among populations within and outside the protected area are required to improve our knowledge of the determinants affecting the effectiveness of protected areas in maintaining variety (Gaston et al., 2008). Each state's government must promote conservation for it to be successful. There are now national action plans in four

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countries: Pakistan, Nepal, and Mongolia and Russia (Li et al., 2014).

Role of women in conservation of snow leopard in Pakistan

Women make up 47.5% of the population in Pakistan. In Pakistan, only 16% of women can read and write. In Pakistan, women have a very good position in both religion and culture. Women are the critical discern in nearly all of the sports in each the urban and rural setting. All subjects of domestic and community hobby revolve around them; no question they're the center of daily habitual, from sunrise to dusk (Inayat, 2002).

Linkages of Rural Women to Natural Resources

Women in rural areas have a lot of exposure to the natural world and its resources. To fulfill their various essential needs, they mainly rely on natural resources. Their primary source of income is the natural world and its riches. They gather feed and fuel wood, and they let their animals graze on mountain pastures (Jackson & Lama, 2016).



Figure 6 Women collecting Fuel wood (A photo from Chitral Gol National Park) (Alexander et al., 2022).

Financial Support

Understanding local herders' financial circumstances is crucial for effective conservation, as is figuring out how to prevent conflicts between livestock rearing and wildlife protection in low-income nations (Ikeda, 2004). Involving herders in ecotourism and Pakistan is one way to improve the compensating mechanism (Shafqat Hussain, 2000). Organized trophy hunting of ungulates or cottage industry, for instance, crafts produced in the village, can be considered as additional economic incentives proposed by the Snow Leopard Survival Strategy (Valentová, 2017).

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Trophy hunting

The late Major (retired) Amanullah Khan of Pakistan proposed trophy hunting as a preservation strategy in the 1970s after noticing declining big ungulate numbers. In Pakistan, trophy hunting first became popular in the late 1970s. Trophy hunting programs can benefit local and global communities in a variety of ways, both financially and naturally, when they are organized and carried out in a scientific and appropriate manner. Due to its notable financial and environmental outcomes, this technique has become a hotly debated topic worldwide (Naidoo et al., 2016).

There are several examples of how trophy hunting can provide income for the community advantages for preservation in some countries and financial assistance for the portrayal of natural life in some regions. The villagers do not benefit much from trophy hunting (PARTASASMITA, 2016). The trophy hunting program's revenue-generating activities aren't properly distributed to the organization that helps to preserve trophy hunting animals (Nordbø et al., 2018).

The lack of wildlife population monitoring is a common problem with trophy hunting (Khan et al., 2016). Although ¾ of the Khunjerab National Park territory is protected by the Shimshal's population, the park is not adequately managed and is essentially neglected. There is no road access in Shimshal's KNP, and only the gutsiest trekker can visit. In 1993, trophy hunting was introduced to the Community Controlled Hunting Area, which is located in the KNP's protected sector (Khattak et al., 2020).

The objective was to ensure that there were more prey animals like the Panthera uncia, ibex, and blue sheep so that the community could have continuous revenue from them. According to a previous study, the trophy hunting program has not helped to improve dubious judgment that is at odds with wildlife. The community's opinions of Panthera uncia were relatively less unfavorable to the wolves, maybe as a result of awareness campaigns or conservation initiatives. For the majority of the locals, Snow Leopard is an enemy. The introduction of trophy hunting programs has increased the conflict between people and Panthera uncia, so it's time to examine how trophy hunting is used in Pakistan (Kachel et al., 2017).

The trophy hunting models are currently use in Tajikstan's Wakhan, Khyber Pakhtunkhwa and the Torghar region of Balochistan, and Gilgit-Baltistan due to their positive social, economic, and ecological effects and their shortcomings in resolving the gaps and difficulties related to ethics, law, science, policy, and administration. This, if left unchecked, may put wildlife under selection pressure for or against particular traits, which could have an impact on evolution (Adhikari et al., 2021).

Similar to trophy hunting initiatives, improper management and execution of mass tourism can have detrimental effects on the environment by causing ecosystems to become unstable and pollution levels to rise (Rashid et al., 2020). For the majority of the locals, Snow Leopard is an enemy. The introduction of trophy hunting programs has increased the conflict between people and Panthera uncia, so it's time to examine how trophy hunting is used in Pakistan. Mass tourism is regarded as an unsustainable activity because of the related detrimental effects on the environment, such as pollution and the deterioration of natural habitats (Wang et al., 2019).

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Anthropogenic impacts on snow leopards in district Neelum, Pakistan

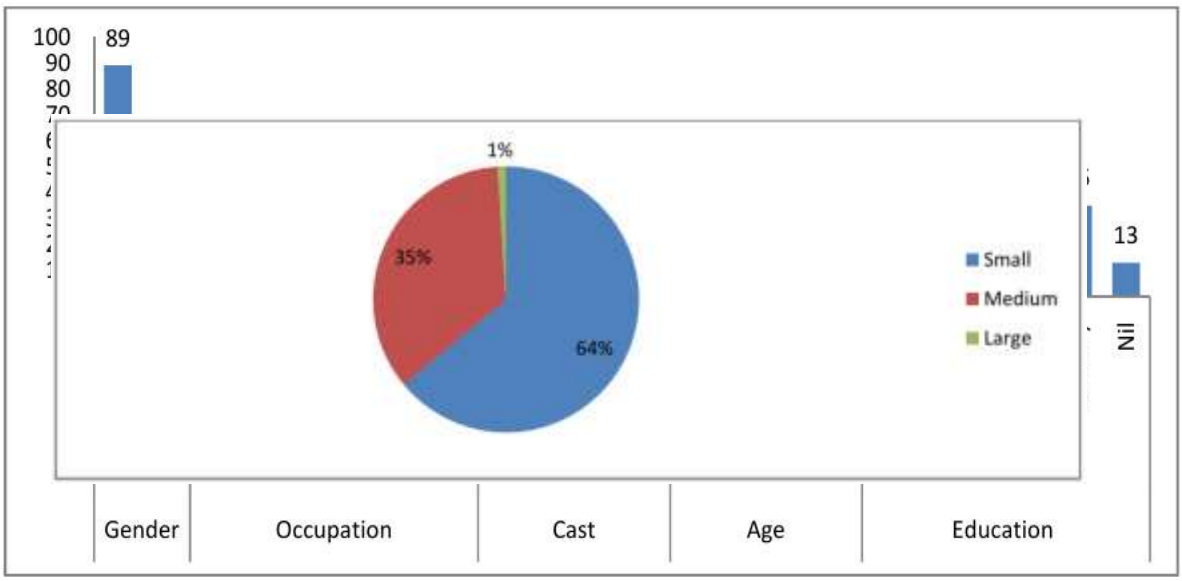
As per previous researches, Neelum District is referred to as the northernmost area of Azad Jammu and Kashmir, Pakistan which occupies a significant share of the Neelum Valley. The district houses approximately 191,000 individuals. The Neelum River starts its journey in the Gurez Valley and merges into the Jhelum River in Muzaffarabad. The valley is covered in forests, with heights that lie between 4,000 and 7,500 feet, whereas the mountain tops around the valley can reach 17,000 feet (Fatima et al., 2019).

The previous study was done within the same area, but for only one year, from March 2017 to February 2018. The study was done through structured questionnaires involving 100 participants in the area. This study considered the important factors within the ecology and environment, such as migration, dispersion, habitat, reproduction, and climate change effects (J. Ahmad et al., 2022).

Previous studies conducted in District Neelum record that facts had been collected from each male and girl respondents, with males comprising the bulk of individuals. The sample comprised different occupational profiles such as shepherds, laborers, farmers, teachers, traders, and drivers. The participants came from different ethnicities, levels of education, and varied age groups, such as between the ages of 25 to over 60 years.

Figure 7 The respondents' profile (Fatima et al., 2019).

Previous study conducted, as per majority of respondents (64%), population of snow



leopard in the study area was small. It is due to the low temperature tolerance (82%) of the snow leopard. In this way, migration of snow leopard was observed by the majority of the respondents was (60%), also stated that snow leopards had large geographic range (67%), low reproductive rate (46%), and high dispersal ability (82%) (Fatima et al., 2019).

Figure 8 Local people perception about the Population size of snow leopard (Fatima et al., 2019)

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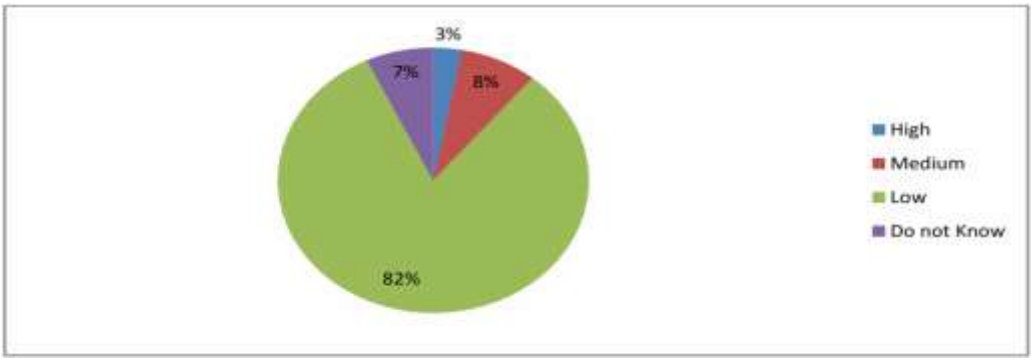

Figure 9 Local people perception about the temperature tolerance of snow leopard (Fatima et al., 2019).

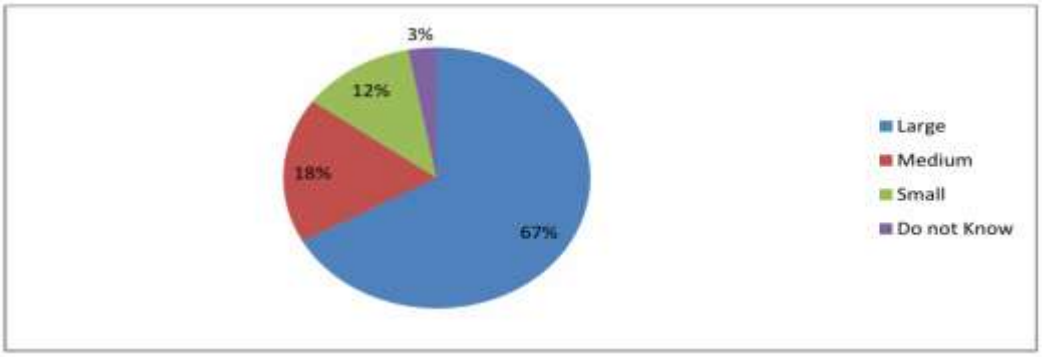

Figure 10 Local people perception about the dispersal ability of snow leopard (Fatima et al., 2019).

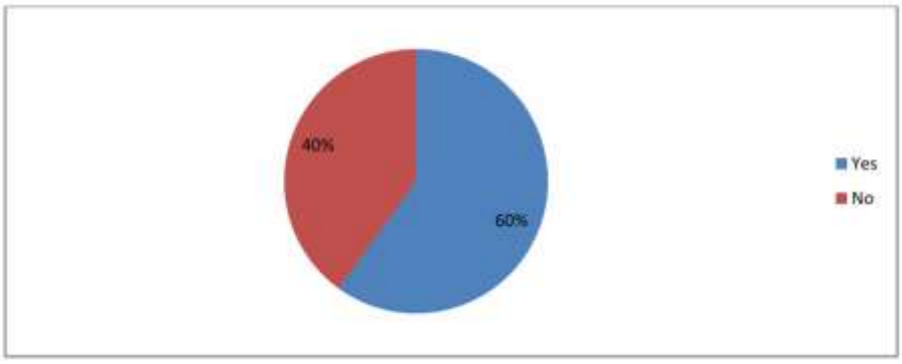

Figure 11 Local people perception of the geographic range of snow leopard (Fatima et al., 2019).

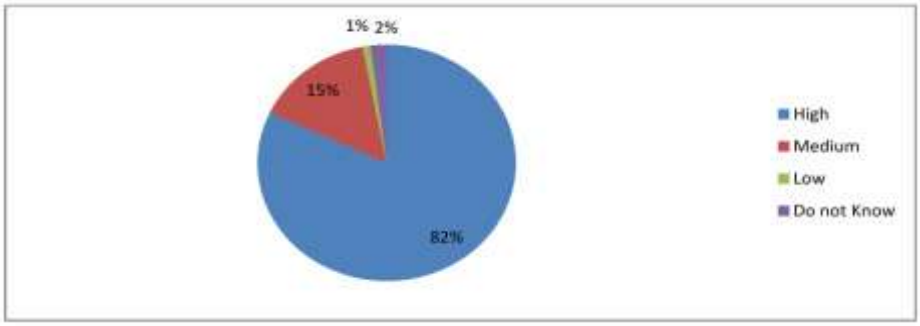

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Figure 12 Local people perception about the migration of snow leopard (Fatima et al., 2019).

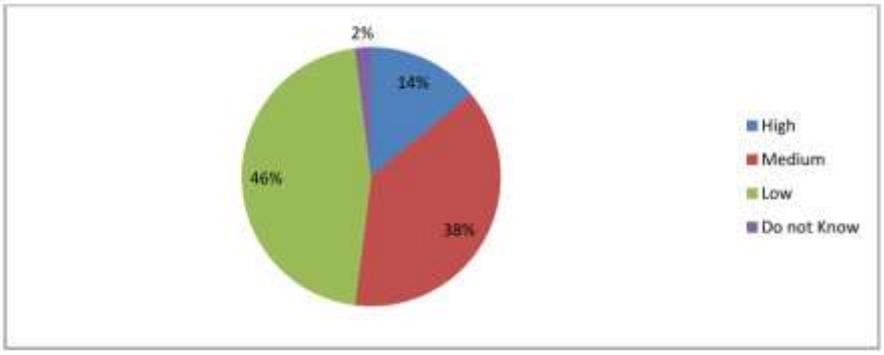

Figure 13 Local people perception about reproductive rate of snow leopard (Fatima et al., 2019).

CONCLUSION

The snow leopard is nonetheless in risk of going extinct, although it continues to play a significant role in Pakistan's high-altitude ecosystems. This review demonstrates how difficult it is to obtain an accurate census of its numbers despite the fact that improved scientific techniques have helped us learn more about its ecology, distribution, and population since it is difficult to locate and lives in difficult terrain. Snow leopard populations in Pakistan are not evenly distributed throughout the Himalaya, Karakoram, and Hindu Kush mountains, according to several researches. Although protected areas are crucial hiding places, they are insufficient to ensure long-term conservation, particularly in situations where habitat connectivity is poor and human pressures are increasing. The situation with the snow leopards is still very bad because of some problems. These problems are people killing them their homes being destroyed, not having food and fighting with humans. We should not give up. There are some things happening to help the snow leopards. For example, people in the community are working together to protect them there are laws to keep them safe. We are using new ways to watch them like cameras and special tests to see what they are related to. If people in the community work together the government does its job and scientists keep finding ways to help then the snow leopards in Pakistan might have a chance to survive. We need to keep helping the snow leopards.

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