Impacts of Global Warming on the Snow Leopard

Xiaotong Feng[1,*,†][a], Jiaxuan Li[2,*,†][b], Hanwei Liu[3,*,†][c] and Jiahui Zhang[4,*,†][d]
[1]*The University of California, Davis, 95616 Davis CA California, U.S.A.*
[2]*Shanghai Shangde Experimental School, 200001 Shanghai, China*
[3]*Shanghai New Channel School, 200001 Shanghai, China*
[4]*Jiangxi University of Technology High School, 330000 Jiangxi, China*

[*]*Corresponding author*
[†]*These authors contributed equally*

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Abstract: The distribution of the snow leopard is around 12 countries where the elevation is between 3, 000-4, 500 meters with arid and semi-arid shrubland, grasslands, or steppes. As a top predator, the snow leopard plays an important role in controlling the prey population and promoting biodiversity. However, global warming caused by human activities is destroying the living environment of the snow leopard. In order to protect snow leopards effectively, this study investigates the impacts of global warming on the living situation of the snow leopard from four aspects. Primarily, glacial melting is discussed, where the retreating speed of many glaciers in snow leopard's habitat and their prey is reduced. Subsequently, treeline shift effects are analysed, where climate change results in treeline shift, and the forest ascending into alpine shrub and grassland which are snow leopard's preferred habitats. In addition, extreme weather events are also evaluated, where global warming brings the high frequency of extreme weather, decreasing the survival rate of the main prey of the snow leopard. Eventually, the impacts of wetlands are demonstrated, where destruction of wetlands due to global warming threatens the livestock the main prey and increases the competition between humans and snow leopards. These results show the urgency of protecting the snow leopard.

1 INTRODUCTION

Global warming is the long-term increase of temperature over the world since the pre-industrial period caused by human activities such as the overuse of fossil fuels. Over the last century, Global warming has led to ocean acidification, treeline shift, sea-level rise, and other environmental problems (Aryal, 2016). According to the observations, creatures are very sensitive to climate. When climate change, species will go extinct or colonize new habitats where the climate becomes newly suitable (CNCCC, 2007). For terrestrial biota, global warming will change soil chemistry, e.g., leaching and erosion rate. In addition, global warming results in species shifting at different rate, i.e., communities often dissociate into their component species. Additionally, unusual assemblages of plants and animals would form since species responded differently to climate change (CNCCC, 2007).

As a typical species living in marginal habitats, the snow leopards are deeply shrunk by climate change. The snow leopard is distributed in 12 countries from the southern Himalayas, across the Qinghai-Tibet Plateau, and the mountain in central Asia. Most of the habitats of the snow leopard are arid and semi-arid shrubland, grasslands, or steppes. They live in places with the elevation between 3,000 and 4,500 meters, even up to 5,500 meters in the Himalayas region (Conservation of Migratory species of Wild Animals, 2020). Even though the range of snow leopards is around 12 countries, it is still under low density ranging between 4, 500-6000

[a] https://orcid.org/0000-0001-8509-8112
[b] https://orcid.org/0000-0002-7903-2050
[c] https://orcid.org/0000-0002-3036-381X
[d] https://orcid.org/0000-0002-3707-9299

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individuals (Dubey, 2003). The snow leopard has an important role in controlling the prey populations and promoting biodiversity in ecological function. Besides, it is essential for the protection area to gather financial support (Dyurgerov, 2005). However, due to the reduction of habitat and food, the number of snow leopards continued to decrease significantly. The main habitat of the snow leopard is the Himalayan region, which is one of the most climate-sensitive areas in the world. For example, the temperature in the Himalayan region increased three times than the general area from 1975-2005 (Farrington, Li, 2016). Owing to increasing temperature, tree line shifts up, glacial melts and extreme weather events appear which threatens the living conditions of the snow leopard. According to anticipation models, 10-30% of snow leopard habitat in the Himalayas region will lose until 2050 (Dyurgerov, 2005). Besides, according to the dearth of even anecdotal report in 2006, the conflict between the snow leopard and human was common and a growing problem due to living habitats loss (Farrington, Tsering, 2019). Therefore, the International Union for Conservation of Nature (IUCN) set the snow leopard as "Vulnerable" (Dubey, 2003).

There were only a few passages that focus on the impact of global warming on the snow leopard. In order to bring the public's attention to the current difficulty and threats faced by the snow leopard, this study will analyze the living situation of the snow leopard from four perspectives: 1) tree line shift, 2) glacial melting, 3) reduction in prey and increasing conflict with human and 4) extreme weather.

2 IMPACTS ON SNOW LEOPARDS

Global warming has resulted in a wide range of changes in the globe, some of which have important implications for distribution and survival of snow leopards. This study specifically investigates four changes: glacial melting, tree line shift, wetlands decreasing, and more frequent extreme weather events; and the corresponding impacts on snow leopards.

2.1 Glacial Melting

With the rising temperature under climate change, many glaciers in the snow leopard's range have been retreated. The IPCC AR5 report states that over the last 10 years, the Asian mountains have been one of the earth's five regions that have lost their glacial ice most (Fernandez-Gimenez, 2012), due in part to constant and continuous warming process in these regions. Over last 100 years, the warming extent in Himalayas has been a great deal greater than global average of 0.74℃ (Forrest, 2012). Furthermore, the Tibetan Plateau, a primary region in the snow leopard's range, is one of the most sensitive areas responding to climate change as the warming trend is more pronounced with an increase in elevation (Grace, 2002). Its increase in temperature was approximately 0.16℃ from 1955 to1996, exceeding the average increase in the northern hemisphere (Harman, 2002).

As a result, the retreating speed of many glaciers in snow leopard's habitat are higher than other regions (IPCC, 2007). As shown in Fig.1, the line representing Himalaya falls most steeply among other lines, which indicates that the retreat of Himalaya glaciers is relatively rapid in comparison to other mountain regions. Moreover, on the Tibetan Plateau, the glacial area has reduced by 4.5% over the last two decades (IPCC, 2013). Hence, time-released water needed by snow leopards and their prey is reduced, affecting the population of snow leopards.

Moreover, in the eastern and central Himalayas, glacial melt associated with climate change has led to the formation of glacial lakes in open areas behind exposed end moraines. Plenty of these high-elevation lakes are dangerous, and may result in glacial lake outburst flood (GLOF) hazards, bringing catastrophic consequences downstream (Harman, 2002). This may potentially kill numerous livestock and even blue sheep (Kazmi, 2021). The consequent decline of prey may indirectly affect the snow leopards.

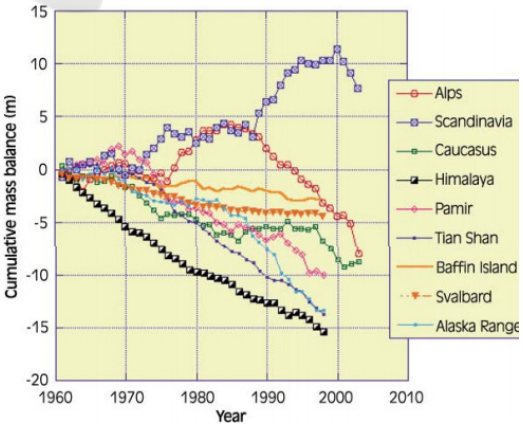

Figure 1: Rapid retreat of greater Himalayan glaciers compared with the global average (IPCC, 2007).

2.2 Tree Line Shift

The tree line is the edge of the habitat at which trees are capable of growing. Tree line shift is usually a result of human activities, e.g., grazing and woodcutting. Nevertheless, previous studies have proved that the transition of tree line has a strong correlation with rising temperature (Körner, 2004); (Liu, Chen, 2000), indicating that upward tree line movement may also be a response of climate change. In addition, Himalayan region is one of the most pristine environments on earth. Therefore, it is least affected by anthropogenic activities (Lovari, 2013), which means that tree line shift is more likely to be a response of warming.

Climate change results in tree line shift, directly affecting snow leopard's habitats. The upward shift of tree lines means the forest ascending into alpine shrub and grassland, which are snow leopard's preferred habitats. Fig. 2 shows that snow leopard habitat is vulnerable to the climate-induced tree line shift. It indicates that snow leopards may lose a considerable number of habitats, and their distribution may be affected greatly. It is observed that in Himachal Pradesh in the Western Himalaya, tree line is presently increasing in elevation at a rate of 14–19 m/decade (Lovari, 2013). Owing to such rapid upslope shift of tree lines and resultant shrinkage of alpine zone, the snow leopard habitat in higher Himalayas may be reduced by around 30%. Snow leopard habitat may also shift northward, since the habitat loss mainly occur along the southern edge of the Himalayas, forcing snow leopards to migrate to the north (Mahmood, 2019).

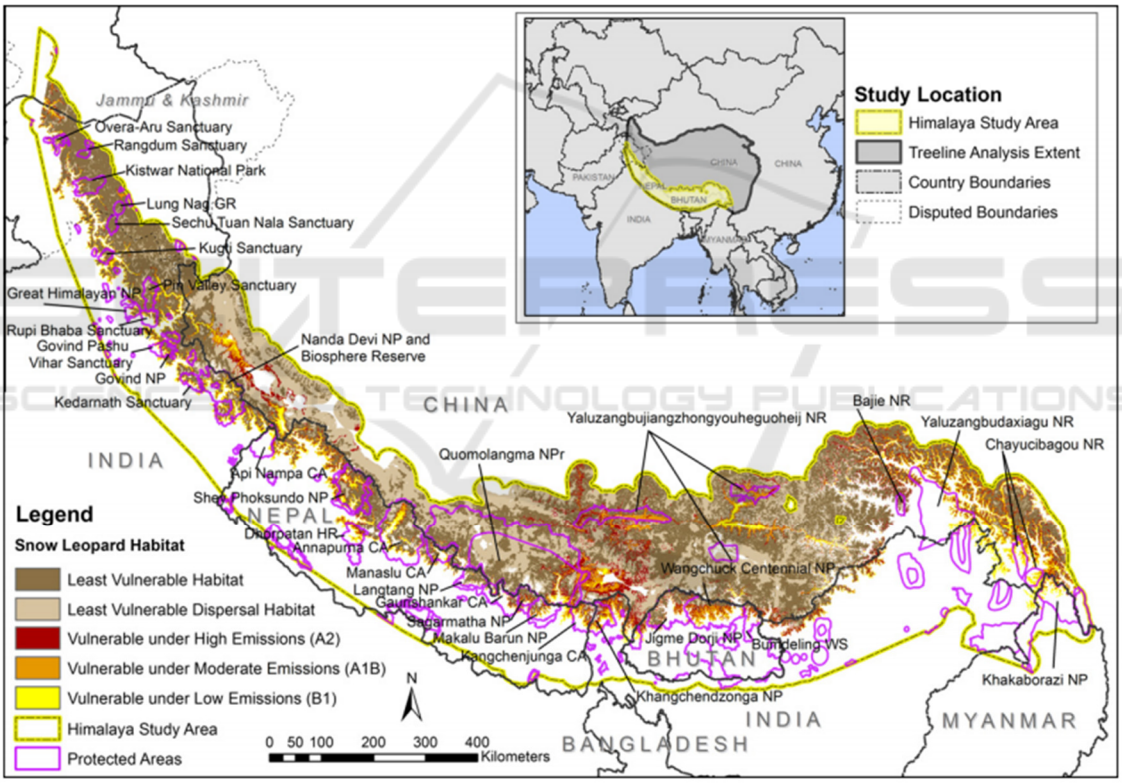

Figure 2: Vulnerability of snow leopard habitat in the Himalaya to treeline shift (Mahmood, 2019).

The upward movement of tree line will also lead to the upslope shifting of various species that living depend on or below the forest line. On this basis, it can translate to the interspecific competition which is a competition between organisms between two different species. Common leopard, which is one of the biggest threats for snow leopard, are chosen to be a widely acceptable object for numerous researches. It is one of the top predators in the world, which has a preference for inhabiting in woodland while snow leopard tends to live and hunt in cold and rocky area which is almost above the tree line. As common leopard can live up to 5200m whereas along the Himalayan range down to 3000m is for snow leopard, there has been an overlap in about 2200m between the two species along the Himalayan range. This

overlap will worsen the situation of snow leopard in aspects of loss of territories, interspecific killing and competition in prey (Peters, 1990).

Since the habitats are occupied by common leopard, which is larger, heavier and more adaptable to environment change than those of snow leopard, the habitats and population size of snow leopard will be threatened badly. Besides, due to the diet overlap, the niche breadth and spectrum of prey species of the snow leopard are smaller than those of the common leopard. All of those competitive factors will lead snow leopard's population to shrink or even to extinct (Farrington, Li, 2016); (Peters, 1990).

2.3 Extreme Weather Events

It is reported that extreme weather events happened in higher frequency and intensity because of climate change. In Mongolia, severe winter snow disasters, known as "dzud" are increasing in frequency (Shen, 2020). During dzud, deep snows often made livestock unable to forage on grass, result in starvation and high mortality rates of livestock. There were six dzud events occurred in Mongolia during 1991 - 2010, a number higher than the sum of events happened over last 50 years, while the 2009-2010 dzud killed 20% of Mongolia's livestock (Shen, 2020). In addition, the frequency of spring droughts and unseasonal spring and summer snowfalls is higher. These events either delay or reduce the growth of grass at the time when nutritious grass shoots are most needed by livestock that has recently given birth (Kazmi, 2021). Hence, less livestock is available, leading to lower prey availability, which can have severe impact to snow leopards. Since snow leopard is a key stone species which has function of controlling organisms' population in high altitude area, the fluctuations of prey number will bring significant influences indirectly due to the potential impact on food chain.

Among all the affected prey species, blue sheep can be one of the most common and representative prey for snow leopard all over the world. Study shows distributions and number of blue sheep have decreased in past several years and will possibly continue declining in the future which can translate to the decrease of number of snow leopard. Climate change leads to a low degree of overlap between blue sheep and snow leopard. In addition, the reduction of the main prey may lead snow leopard to broaden its diet breadth with common leopard as well as other carnivores such as Tibetan wolf, and the competitions are adverse for snow leopards. Furthermore, the decrease of wild prey can force snow leopard to search for other kind of food sources such as livestock of human, this can lead to a retaliation between human and snow leopards. Therefore, the population size of snow leopard will reduce (Farrington, Li, 2016); (Wang, 2006).

2.4 Wetlands

Wetland is a major ecosystem in the snow leopard's range, but it is also vulnerable to the climate change due to slow adaptation to changing environments, especially for alpine wetlands where warming is more pronounced. On account of permafrost degradation caused by climate change, the area of alpine wetlands on the Tibetan Plateau has declined by 37% over recent decades (Xu, 2007). Moreover, the level of saline lakes increased at a rapid rate, inundating much pastureland. As a result, many herding communities reduced in size and had to move upslope, leading to more competition between livestock and blue sheep. As less food is available for livestock, its number declined. This also contributed to more severe snow leopard-human conflict (Kazmi, 2021).

3 CONCLUSION

In summary, this paper aims to investigate the effects of climate change on the distribution of snow leopards. The basic background about snow leopards is that they mainly live in the region of the Himalayas which is nearer to China. In this paper, the hypothesis is the population of snow leopards will decrease due to the global warming caused by climate change. Based on our analysis, the shrink and upload of tree line shifting will cause a decrease in the size of their habitats which may trigger the decrease in population. Glacial melting will cause a decrease in water resources and flooding, which is the reason that may intrigue the decreasing of snow leopards' population. These effects can directly contribute to the shrinking areas of snow leopards' population, limiting their distribution. Additionally, the decrease in wetland and raising the saline lake enable the edible water resources to disappear, i.e., the population of preys (Himalayan tahr, blue sheep, Siberian ibex) and snow leopards will be decreased, which has the same function as such extreme weather such as snow disasters and big storms. These events will result in the interspecific competition and reduction in prey. The effects of interspecific competition are expressed by the distribution upload shifting, for the snow leopards will avoid the conflict to protect themselves or confront the conflict to gain food. The reduction of prey, naturally caused by some

geographic impacts mentioned before, will be influenced by human activities. The food chains' balance is broken. All of these reasons are led by climate change and will result in decreasing of snow leopards' population and affecting the distribution of snow leopards. This result responses to the hypothesis and research question.

Species are already being impacted by anthropogenic climate change, and its rapid onset is limiting the ability of many species to adapt to their environments. Climate change is currently affecting 19% of species listed as threatened on the IUCN Red List of Threatened Species, increasing the likelihood of their extinction including the snow leopards. Therefore, reducing the impact of climate change and protect the species is an important work for the human.

Establishing the protected area is a method that can contribute to the protection directly. Scientists have already built some protected areas to protect the population of snow leopards. One of the main advantages of having nature reserves is that they protect biodiversity and endangered species such as snow leopards. Because enough biodiversity is needed to maintain the natural balance of the ecosystem. The species can get rid of the human impact mainly. Nevertheless, the drawback is that for some endangered species, Protected areas do nothing to help snow leopards get rid of climate change naturally. Thus, any of the causes that were talked about before are potentially harmful to the snow leopards. A human can try more ways that can reduce the impacts of climate change on geographic and biological impacts. These results offer a guideline for the importance and urgency of snow leopards' protection

REFERENCES

Aryal, A., Shrestha, U. B., Ji, W., Ale, S. B., Shrestha, S., Ingty, T., Raubenheimer, D. (2016), Ecology and Evolution, 6, 4065–4075.

CNCCC(2007), China National Report on Climate Change (in Chinese).

Conservation of Migratory species of Wild Animals, (2020)

Dubey, B., Yadav, R.R., Singh, J., Chaturvedi, R. (2003), Curr. Sci., 85, 1135–1136.

Dyurgerov, M.D.; Meier, M.F. (2005), Glaciers and Changing Earth System: A 2004 Snapshot, 117.

Farrington, J. D., and Li (2016), J. Snow Leopards, Academic Press, 85-95

Farrington, J. D., and Tsering, D. (2019), Biological Conservation, 237, 504–513.

Fernandez-Gimenez, M.E., Batkhishig, B., Batbuyan, B. (2012), Glob. Environ. Change., 22, 836–851.

Forrest, J. L., Wikramanayake, E., Shrestha, R., Areendran, G., Gyeltshen, K., Maheshwari, A., Mazumdar, S., Naidoo, R., Thapa, G. J., andamp; Thapa, K. (2012), Biological Conservation, 150, 129–135.

Grace, J., Berninger, F., and Nagy, L. (2002), Annals of Botany, 90, 537–544.

Harman, S. (2002), Weather., 57, 392–393.

IPCC (2007), Climate Change 2007: The Physical Sciences Basis.

IPCC (2013), Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change.

Kazmi, F. A., Shafique, F., Hassan, M. U., Khalid, S., Ali, N., Akbar, N., Batool, K., Khalid, M., Khawaja, S. (2021), Brazilian Journal of Biology = Revista Brasleira de Biologia, 82, e240219.

Körner, C., and Paulsen, J. (2004), Journal of Biogeography, 31, 713–732.

Liu, X.D., Chen, B.D., Int. J. (2000) Climatol., 20, 1729-1742.

Lovari, S., Ventimiglia, M., and Minder, I. (2013), Ethology Ecology and Evolution, 25, 305–318.

Mahmood, T., Younas, A., Akrim, F., Andleeb, S., Hamid, A., and Nadeem, M. S. (2019), PLoS ONE, 14, 1–11.

Peters, R. L. (1990), Forest Ecology and Management, 35, 13–33 .

Shen, Q. (2020), IOP Conference Series: Earth and Environmental Science, 552.

Wang, G., Li, Y., Wu, Q., and Wang, Y. (2006), Earth Sciences, 49, 1156–1169.

Xu, J.C., Shrestha, A., Vaidya, R., Eriksson, M., Hewitt, K. (2007), ICIMOD Technical Paper.