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IUCN RED LISTED CATERPILLAR FUNGUS EFFECTED BY OVERHARVESTING ON GORI GANGA WATERSHED

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Abstract

The world's costliest fungus caterpillar (ophiocordyceps sinensis) is also known as Himalayan Viagra, which sells in international markets. Caterpillar has entered the International Union for Conservation of Nature's (IUCN) red list of threatened species, the world's most comprehensive information source on the global conservation status of animal, plant and fungi species. Caterpillar fungus is an endemic herb of the higher Himalayan regions. The fungus is also known as Keeda Jadi in Uttarakhand because of its caterpillar-like appearance. In the last two decades, the caterpillar fungus has become the main source of livelihoods for thousands of people where it occurs. It has become the very important source of cash income in the Gori Ganga watershed. This new occupation of the local inhabitant arisen out of extraction of caterpillar fungus in the higher Himalayan areas is now struggling for its survival due to overharvesting and various anthropogenic activities. The adverse impacts by activities are increase human pressure in the cater pillar growing areas and use of plastic materials is in the region by the local inhabitant. Felling and burning of trees and shrubs in the region are creating vast impact on the study area environment. All these activities have accelerated the process of warming the region. The fundamental objective of this paper is to study in detail about how caterpillar fungus entered IUCN red list, caterpillar fungus as a source of livelihood for villagers, and overharvesting impacts in caterpillar fungus and environment of study area by employing a higher Himalayan watershed viz., Gori Ganga as an experimental laboratory.

***Key Words*: IUCN red listed, Caterpillar Fungus, Effected, Gori Ganga Watershed**

1.0 INDTRODUCTION

Cordyceps sinensis is a high altitude Himalayan fungus-caterpillar association found in alpine meadows of Gori Ganga watershed, Kumaon Himalaya. The caterpillar fungus grows on above the ground with the advent of snow melt during the following spring and early summer (Pegler et al. 1994). It is collected for medicinal use and the traded product is thus a fungus–caterpillar (Wang and Yao 2011). Caterpillar fungus has been in use in the traditional Chinese medicine for over 2000 years (Li et al. 2011). The common name of species varies from place to place and caterpillar is popularly known as Yartsa Gunbu in Tibet, Tockukaso in Japan, Yarsagumba in Nepal, Keerajadi in India and the Chinese caterpillar fungus in English (Belwal et al. 2019). Caterpillar fungus dpecies is growing to high altitude habitats and grasslands/Bugyal and alpine meadows as well as on open dwarf scrublands near around the potential timberline and along gentle mountain slopes of the high Himalayan region (Baral et al. 2015). Caterpillar fungus grows between altitudinal ranges of 3000-5000 m average mean sea level but upper altitude limit however may reach the snowline areas above 5000 m (Jang et al. 2016). Table 1 is presented caterpillar fungus growing area and altitude in the four most countries of the world.

Table 1: presenting caterpillar fungus growing area and altitude in the four most countries of the world.

Country	Reported regions	Altitudinal group (m)	References
Bhutan	Namna, Bumthang valley and Bumdeling wildlife sanctuary	4200-5200	Balfour-Browne (1955), Kobayasi (1980), Cannon et al. (2009)
China	Xinjiang, Yunan, Jilin, Shanxi, Shaanxi, Hubei, Zhejiang, Jiangxi, Guizhou, Taiwan, Guangdong, Guangxi, Sichuan, Hainan Province, Lhasa and Shannan in Tibet	2260-5000	Winkler (2009), Li et al. (2011)
Nepal	Dolpa, Darchula, Jumla, Bajura, Kalikot, Mugu, Humla, Rukum, Bajhang, Manang, Mustang, Gorkha, Lamjung, Dhading, Rasuwa, Dolakha, Sindhupalchowk, Solukhumbu, Sankhuwasabha, and Taplejung districts	3540-5050	Shrestha and Sung (2005), Adhikari (2008), Devkota (2008, 2010)
India	Uttarakhand (Darma valley, Choudans valley, Ralamdhura, Panchachuli base, moist alpine areas of Dharchula and Munsyari blocks especially, Pindari catchment in Bageshwar district, Niti valley, Nanda Devi biosphere reserve, Sutol, Kanol in chamoli district, Sikkim (north and east Sikkim i.e. Luchung, Khangchendzanga national park and wildlife sanctuary, etc. and Arunanchal Pradesh	3200-4800	Negi (2009), Negi et al. (2006, 2014), Kuniyal and Sundriyal (2013), Sharma (2004), Pradhan (2016)

After 1990's collection of high-value, low-volume caterpillar fungus has become a very important livelihood activities and source of income in the mountainous parts of China (Winkler 2008, 2009), Bhutan (Wangchuk et al., 2010), Nepal (Shrestha and Bawa 2014a) and India (Kuniyal and Sundriyal 2013; Negi et al. 2014). Some studies have analyzed the economically importance of caterpillar for rural/villager population in Bhutan (Cannon et al. 2009), China (Yeh and Lama 2013), India (Kuniyal and Sundriyal 2013; Caplins and Halvorson 2017), and Nepal (Shrestha and Bawa 2013). Shrestha and Bawa (2013) suggest the largest producer of cater pillar fungus is China (95-96 %), Nepal (1.2-1.8 %), India (1.5–2.0 %) and Bhutan (0.6–0.8 %) of total global production.

In the Gori Ganga watershed increased prices and market demands have obviously led to significant increase in the number of collectors for cater pillar fungus. This situation has posed severe pressure on cater pillar fungus life, natural populations and alpine ecosystems. Negi et al. (2014) presented a study, which is based on the valley of Gori Ganga in Pithoragarh district of Uttarakhand (India) alone, the number of cater pillar fungus gatherers at alpine habitats has increased fourfold since the year 2000.

2.0 OBJECTIVE

The fundamental objectives of the present investigation to study the IUCN red listed caterpillar fungus harvesting impacts on Gori Gagna watershed, which incorporates the following aspect:

a) How caterpillar fungus entered in IUCN red list?
b) Study of caterpillar fungus as a source of livelihood for villagers of the study area.
c) Study of overharvesting impacts in caterpillar fungus and environment of study area.

3.0 STUDY AREA

The study area, viz., the Gori Ganga watershed at Kumaun Himalaya (Figure 1) extends between $29^0$45'0''N to $30^0$35'47''N latitudes and $79^0$59'33''E to $80^0$29'25''E longitude, and encompasses an area of about 2191.95 km^2. The Milam glacier is the second largest glacier of the Kumaun Himalaya. The glacier is 16.7 km long and it is receives ice from the Trishul peak and seven tributary glaciers in the Gori Ganga watershed. The Gori Ganga River originates from the Milam glacier, a major tributary of the Kali River which meets with Kali at Jauljibi in the district Pithoragarh. The altitude of the Gori Ganga watershed varies between 626m and 6639m (Figure 2). The Gori Ganga watershed has 168 villages (Figure 3) and total population is about 40616 (2011). Gori Ganga watershed spreads in three blocks, i.e., Munsyari, Dharchula and Didihat, in three Tehsils, i.e., Munsyari, Dharchula and Didihat, and in one sub-Tehsil known as Bangapani. Munsyari town one of its key advantages is the superb backdrop that is provided by the high Himalayan Pancha-Chooli range in full view; it is an awe inspiring place surrounded by undisturbed nature and high mountains. Land uses spread across region comprise settlements, terraced farms, Van-Panchayat, reserve forests and the Askote Musk deer sanctuary. Gori Ganga region has 52 Van-Panchayat. There are many tribes in the watershed. One of the most important tribe in this region is called Bhotiyas, Barpatiya and Anuwal Samuday. Tribal peoples move seasonally to their summer villages in the interior of the Johar valley located between 3000m to 3500m. The last village of the watershed is Milam which is 65 km far from the motor road.

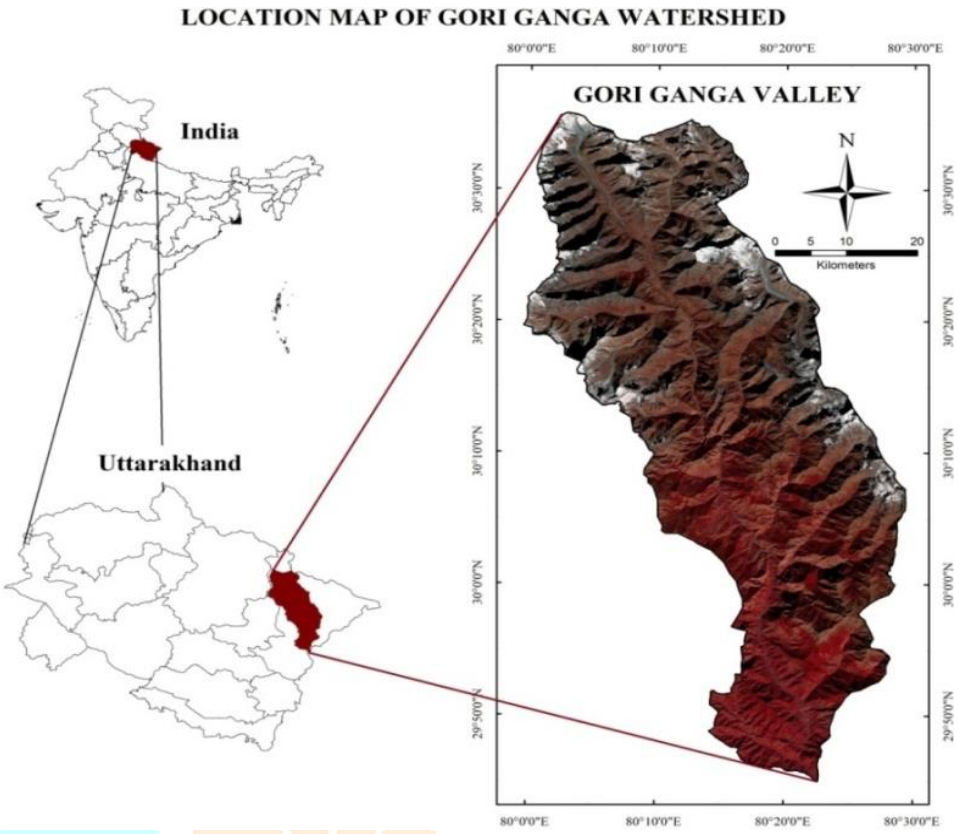

Figure 1: Location map of the study area, viz., Gori Ganga watershed.

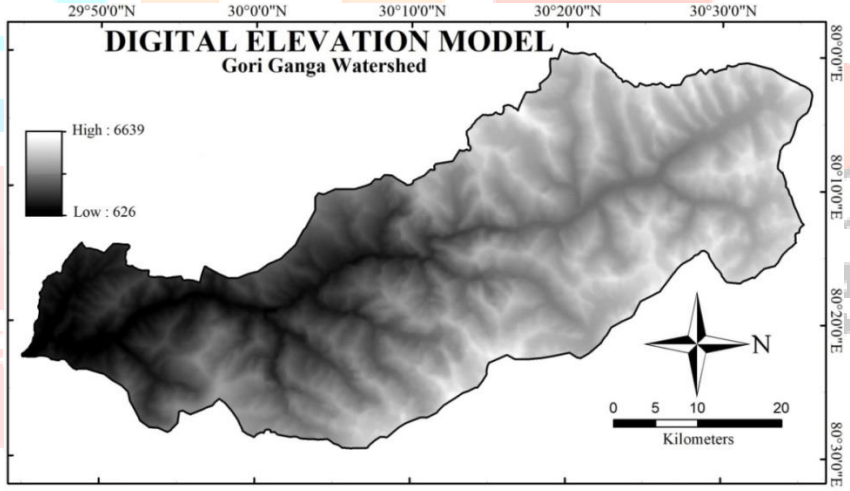

Figure 2: DEM map of the study area, viz, Gori Ganga watershed *(based on cartosat-1 satellite Data).*

4.0 METHODOLOGY AND DATA BASE

For delineation of the study area and demarcation of caterpillar fungus areas Geographic Information System (GIS) techniques were uses. The open source GIS software QGIS 2.18 was used for GIS analyses. The Gori Ganga watershed was delineated using Digital Elevation Model (DEM) based on Cartosat-1 data. The location of village, grassland (Bugyal) collected by field visit and GPS. Village's location map of Gori Ganga watershed (Figure 3), village depending on Bugyals/grassland (alpine meadows) and caterpillar fungus growing region (Figure 4) and drainage map (Figure 5) were prepare using Cartosat-1 data and through QGIS. Primary data were collected from field visit with observation method and secondary data are collected from news papers, research article, research papers and research journals and population data (census 2011) collected from Vikas Bhawan, Pithoragarh.

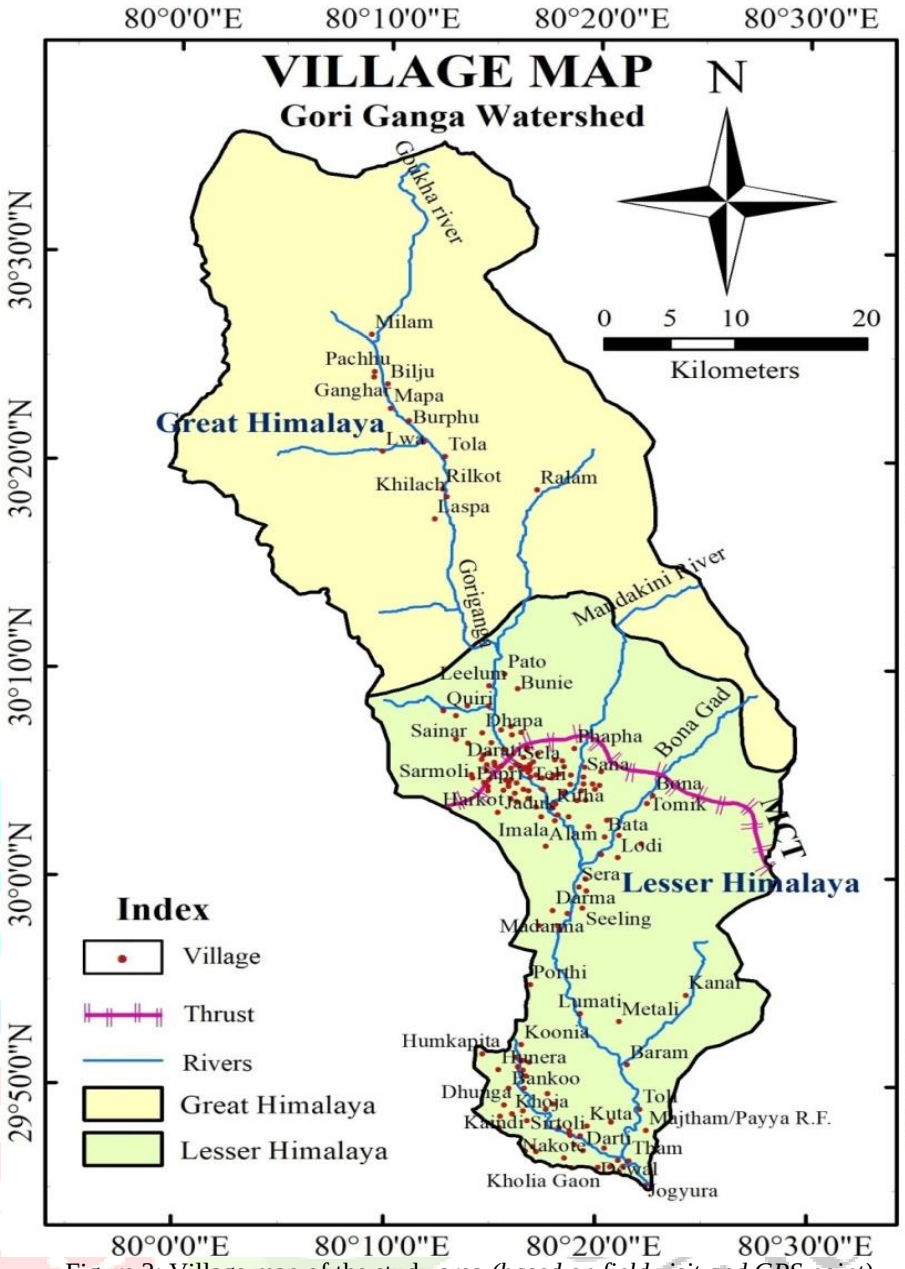

Figure 3: Village map of the study area *(based on field visit and GPS point)*

5.0 RESULT AND DISCUSSION

Figure 3 depicts village map of the study area and figure and Table 2 certain growing area of caterpillar fungus in different altitudinal zones of the Gori Ganga watershed. Table 3 certain villages depend on nearby Bugyals/grassland for collecting cater pillar fungus and Table 4 certain main rivers and tributaries in the Gori Ganga watershed. Figure 4 depicts village depended on Bugyals/grassland and caterpillar Fungus growing area and Figure 5 depicts drainage map of the study area. Plate 1 depicts abandoned shelters of caterpillar fungus collectors at the end of the harvesting season.

5.1 Caterpillar Fungus

Ophiocordyceps sinensis is scientific name of caterpillar fungus is a fungal parasite of larvae (caterpillars). It is endemic to the high Himalayan region between 3000 to 5500 meters above sea level. It grows through their bodies and emerges through the larvae's heads to the surface. Caterpillar fungus is highly valued in traditional Tibetan and Chinese medicine as a tonic, where it has been used for centuries to treat much kind of diseases including kidneys, lungs and liver related problems. Recently the caterpillar fungus species has been widely traded and used as a powerful tonic and often called the Himalayan Viagra. The home of cater pillar fungus in the Indian Himalayan region has been documented in the region from the alpine meadows and also protected areas such as Askote wildlife sanctuary and Nanda Devi biosphere reserve.

5.2 Gori Ganga Related to Caterpillar Fungus

Basically, people who lived in Gori Ganga watershed in the Kumaon Himalaya traded wool, millet and salt between Tibet (North) and the Sivalik and Bhabar (south) region of the Uttarakhand. After 1962 India-China conflicts trade stopped and peoples of this area had to start collecting medicinal herbs and in the 1990's, the community discovered caterpillar fungus in the study area. The cater pillar fungus is found among the high-altitude alpine meadows of the study area where mostly herbs founded. The harvesting season for caterpillar fungus in the study area lasts from the beginning of May till the end of July. When searching fungus peoples lie on the ground, trying to spot the tiny caterpillar fungus.

5.3 How caterpillar fungus entered in IUCN red list?

Citing by IUCN is the reason for placing the world most costly fungus also known as Himalayan Viagra in the red list of threatened species category. IUCN added the world's most expensive fungus, caterpillar fungus (ophiocordyceps sinensis), has entered the IUCN Red List as Vulnerable on 9 July 2020 (https://www.iucn.org). IUCN said "its spread has declined by at least 30 % over the past 15 years as a result of overharvesting".

Jane Smart, the global director of the IUCN's biodiversity conservation group, said: "saving the fast-growing number of threatened species from requires transformational change, supported by action to implement national and international agreements. The world is needs to act fast with an ambitious post-2020 biodiversity framework (www.theguardian.com). Speaking to TOI, **Vivek Saxena**, India representative of IUCN, said, "The purpose of putting the fungus in the red list under the 'vulnerable category' is to ensure that proper government policies are implemented in order to conserve it so that it remains in the wild."

5.4 Importance of Caterpillar Fungus Saving

New research from Stanford University has also shown climate change is responsible for this decline, in a region where average winter temperatures have increased by 4 degrees Celsius since 1979 in some places. On the Gori Ganga watershed in Kumaun Himalaya, caterpillar fungus is also going to disappearing and its distribution area creeping further up the mountains because of anthropogenic activities have accelerated the process of warming and de-glaciations.

5.4.1 Source of Livelihood and Villages Depends

In the last two decades, the cater pillar fungus has become the main source of livelihoods for thousands of people in the Gori Ganga watershed. There are 19 grassland and other alpine region where cater pillar fungus are growing mostly and nearby villagers are totally depends on cater pillar fungus.

Today, at least one person in every household around the Gori Ganga watershed has left in pursuit of caterpillar fungus, now traded across cities in Asian countries. In the study area 85 villages are depends on cater pillar fungus and involve in business of cater pillar fungus directly or indirectly. Figure 4 and table 3 is presenting depended villages on Bugyal/grassland and cater pillar fungus growing area. Table 2 is presenting caterpillar fungus growing area.

Table 2: Growing area of caterpillar fungus in different altitudinal zones of the Gori Ganga watershed *(based on Cartosat-1 satellite image)*

Height in meters	Area in km^2	Growing area in km^2
3000-3500	196.42	196.42
3500-4000	262.57	262.57
4000-4500	321.95	321.95
4500-5000	352.74	352.74
Total study area	2191.52	1133.68
In percentage	100.00%	51.73%

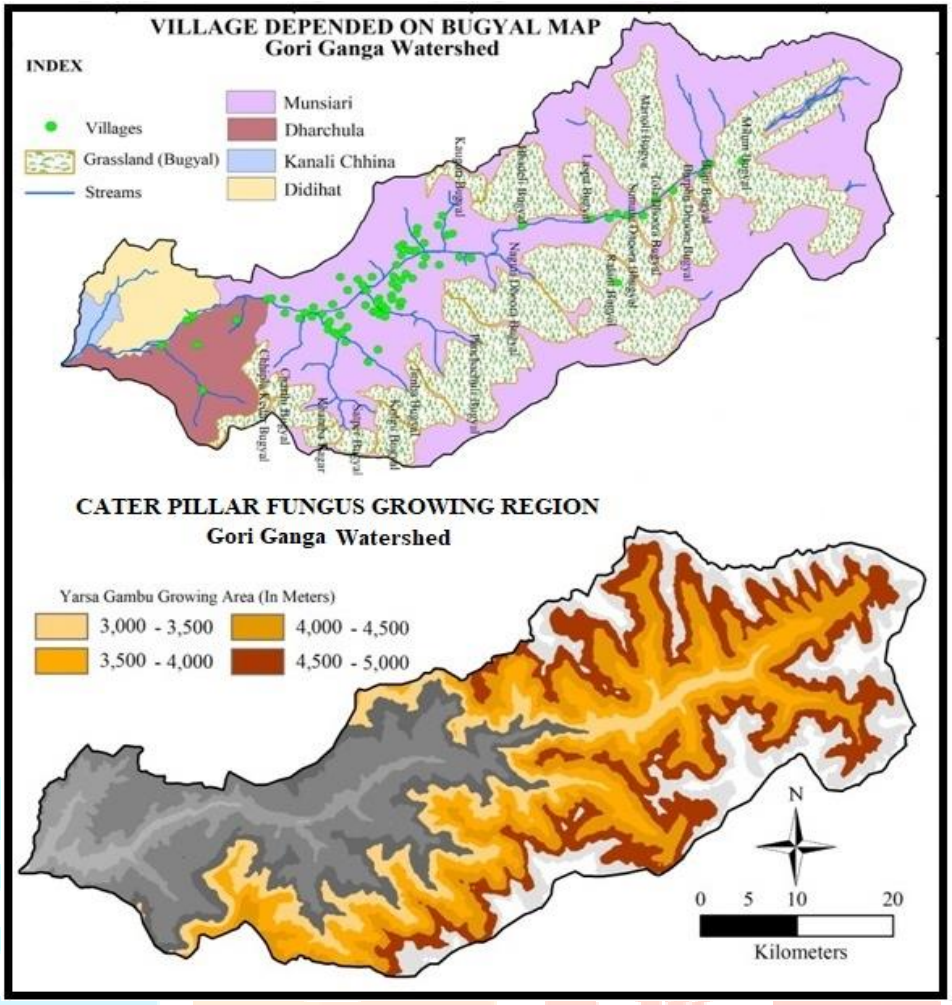

Figure 4: Village depended on Bugyal/grassland and caterpillar fungus growing area *(based on field visit and Cartosat-1 satellite image).*

Table 3: Villages depend on nearby Bugyals/grassland for collecting caterpillar fungus *(based on field visit and GPS points).*

S.N.	Bugyal/grassland	Depended villages
1	Chhipla Kedar	Baram, Kanar, Metali, Chami, Lumti, Jara Jibli, Bangapani, Mavani, Darma, Seeling, Khartoli
2	Thalba	Sirtola, Ghangli, Sera
3	Charthi	Lodi, Ghangli, Tanga, Bata, Mulyan Pani, Bali Bagar, Bhikuriya, Seraghat, Alam
4	Khamba Bagar	Golfa, Tanga, Bata
5	Satper	Golfa, Bona, Nirtoli
6	Kolgu	Golfa
7	Jimba	Bona, Tomik, Nirtoli
8	Panchachuli	Walthi, Madkote, Dunamani, Josha, Gandhinagar, Imla, Golma, Chona, Narki, Dobari, Waiga, Sana, Chulkote, Wadni, Okhli, Syalthing, Ringu, Dolma, Timphu, Dharikhet, Gaila,
9	Nagini Dhoora	Basantkote, Bhatkura, Uchhaiti, Dhuratoli, Deelam, Kulthum,
10	Ralam	Buinee, Paton, Lang
11	Milam	Madkote, Dadabisa, Darati, Dhapa, Synnar, Suring, Ranth, Milam, Panchhu, large number Tourists,
12	Sumatu Dhoora	Sumatu, Milam, Tola
13	Tola Dhoora	Tola, Ghanghar, Bilju, Sumatu, Burphu, Martoli
14	Burphu Dhoora	Burphu, Bilju, Laspa, Tola
15	Bilju	Bilju, Laspa, Sumatu,
16	Laspa	Laspa, Rilkote, Old Rilkote, Tola
17	Martoli	Martoli,
18	Bhadeli	Quiry, Jimia, Sain, Polu, Lari Pyankti
19	Kauguri	Quiry, Jimia, Sain, Polu, Lari Pyankti, Synnar

5.5 Overharvesting Impacts in the Gori Ganga Watershed

Demand for the caterpillar fungus has risen sharply since the 1990s. The majority of collectors believe that harvesting caterpillar fungus has become more difficult in the recent past years because of competition and a decline in the abundance of the cater pillar. In the Gori Ganga watershed, overgrazing and growing human pressure on the alpine pastures has had a negative impact on cater pillar fungus health and alpine meadows.

5.5.1 Impact on Environment and caterpillar fungus

The environmental and ecological impacts on Gori Ganga watershed of overharvesting caterpillar fungus in alpine region, grassland, include loss of pastures as a result of trampling, soil compaction, mass wasting, landslides, forest fire, deforestation and dumping of solid wastes in the pastures.

Most of the researcher studies have presented that the caterpillar fungus history, status, populations and its per-capita harvest is declining (Negi et al. 2014; Shrestha et al. 2014; Shrestha et al. 2017). Recently Shrestha et al. (2017) reported a mean annual decline of 25 pieces in the per capita harvest of caterpillar fungus in Nepal during 2010-2014. The major impact for decline in availability and per capita harvest of cater pillar fungus include: (i) unregulated harvesting of the resource (Shrestha et al. 2014; Pouliot et al. 2018), (ii) premature harvesting (Negi et al. 2014; Shrestha et al. 2017), (iii) decrease in moth and larval populations due to global warming and changing climatic conditions (Shrestha & Bawa 2013), and (v) increased grazing intensity and impact of climate change (Shrestha & Bawa 2013).

6.0 ORIGIN OF PROBLEMS

- The world's most expensive fungus, caterpillar Fungus has entered the IUCN red list as vulnerable because of demand for the fungus has risen sharply since the 1990s and overharvested in many Himalayan region by peoples.
- During the study and field visit in the Gori Ganga watershed alpine region (Bugyals) we documented how thousands of villagers go to collect the fungus each year, taking their tents (Plate 1), food and domestic animals. These activities are bound to destroy remote pastures and threaten the endangered Himalayan Viagra and other herbs (alpine plants).
- Ultimately, over-harvesting in the study area is most certainly responsible for a sharp decline in caterpillar fungus population.

Plate 1: Abandoned shelters of caterpillar fungus collectors at the end of the harvesting season

- Since many major and minor tributaries of Gori Ganga River (Table 4 and Figure 5) originate in the high altitude meadows, the habitat of caterpillar fungus is also a vital source of water for people living in the downstream (valley region).
- Pollution and destruction of habitat here will have profound effects on the quality and availability of water in the Gori Ganga River.

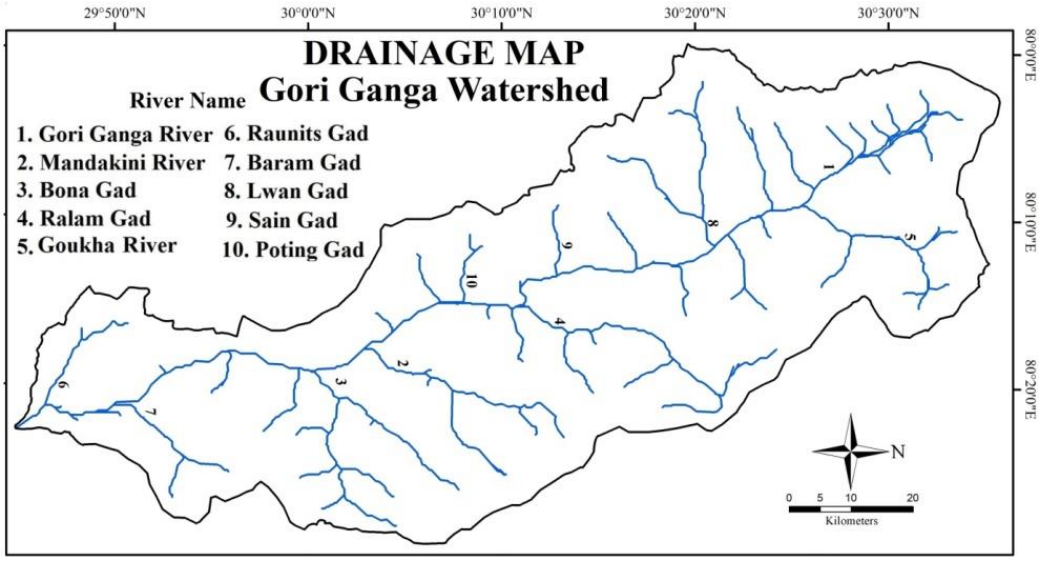

Figure 5: Drainage map of the study area *(based on Cartosat-1 satellite data)*

Table 4: Main Rivers and tributaries in the Gori Ganga watershed (*based on DEM and field visit*).

S.N.	River name	Length (km)	Origin place /Type	Meeting place
1	Gori Ganga	97.97	Milam/Glacial	Jauljibi
2	Mandakini River	27.95	Panchachuli/Glacial	Madkote
3	Bona Gad	22.69	Jimba/Glacial	Seraghat
4	Ralam Gad	22.99	Ralam/Glacial	Near Paton Village
5	Goukha river	20.39	Gaukha/Glacial	Milam Village
6	Rauntis Gad	16.97	Ghanghura/ Non-Glacial	Garjiya
7	Baram gad	15.28	Chhipla Kedar/ Non-Glacial	Baram
8	Lawan Gad	12.24	Shalang/Glacial	Lawan Village
9	Sain Gad	9.9	Khaliya/ Non-Glacial	Jimighat
10	Poting Gad	16.67	Poting/Glacial	Bogdiyar
Total Length		263.05		

7.0 CONCLUSION

The economic boom is easily seen in villages where the villagers are collecting cater pillar fungus and the inclusion in the red list is going to impact all depended villagers of Gori Ganga watershed in Kumaon Himalaya who were dependent on collecting the fungus as their primary source of livelihood. Present study advocates that, the villagers are not much aware for its conservation priorities and importance for traditional medicine. The current cater pillar fungus harvesting pressure on alpine region of the study area is unprecedented. There should be a proper understanding between collectors, forest departments and other agencies for the proper harvesting and conservation of this species, while it is not extracted sustainable in planed way in the study areas. Awareness and scientific knowledge is very necessary for the future prospects regarding to conserve Yarsa-Gambu.

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