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Conserving *Ophiocordyceps sinensis* in the Nanda Devi Biosphere Reserve, India

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Centre for Integration of Conservation and Developmental Accountability
Aranya Vihar, Kaulagarh, Dehradun,
Uttarakhand, India-248195
E-Mail: cicada.info@gmail.com

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Final Report

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Project Team

Pramod Kumar Yadav

Subhajit Saha

Ashish Kumar Mishra

Mohnish Kapoor

Manendra Kaneria

Manish Kaneria

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CICADA – Centre for Integration of Conservation and Developmental Accountability

Dehradun 248195, India.

Foreword

As the human race is moving towards a more technologically advanced society, the environmental issues associated with this progress are becoming more challenging with time. The uncontrolled rise in human populations is also putting a pressure on the natural resources which are being exploited unsustainably along with illegal trades in wild animal parts and economically important wild plants to satiate human greed. In this scenario, spreading awareness about the environmental issues amongst every section of the society, taking innovative conservation initiatives, and making policy changes to protect the environment remain a few of the rightful things to do. For environmental professionals and conservationists working towards these targets, understanding the existing and desired environmental policies in their country and the world is as much important as successfully completing a project or implementing a conservation plan to save a threatened species.

During the past few decades, the caterpillar fungus has become quite the philosopher's stone for the poor in the Hindu-Kush Himalaya. The species has been providing much to the people who would otherwise remain impoverished through a difficult socio-political predisposition in a gravely underdeveloped region. Nevertheless, overexploitation is rampant and is contrary to the sustainability and survival of this enigmatic bio-resource. Thus its conservation not only depends on good research, but it also expects much from effective policy formulations and implementations of such initiatives. Given this scenario, this project has much importance as a first step towards realising the ultimate goal of saving both caterpillar fungus as well as the livelihood of the people dependent on it.

The *Ophiocordyceps* conservation team is a dynamic and young group of researchers who have come together from various parts of India, with different expertise and interests but with a common agenda of conserving their natural wealth. Their praise worthy effort is very much contemporary and addresses a serious socio-environmental issue with their innovative ideas and activities. Their preliminary observations are substantial enough for the concerned stakeholders to put their attention to the many-fold problems associated with the species and its trade. It will be the greatest of the successes for these dedicated conservationists if the report may stir the minds of authorities and academics alike rousing them towards the conservation of the fungus, which I truly believe it will do.

N. P. Todaria

Professor and Ex- Head, Department of Forestry and Natural Resources
Ex-Dean, School of Agriculture and Allied Science
H.N.B. Garhwal University (A Central University)
Srinagar-Garhwal, Uttarakhand, India
Ex-Member, Forest Advisory Committee, MoEFCC, Government of India

Profile of the Project Team

Pramod K. Yadav (Team Leader)

Email: pramod.yadav31@gmail.com

Pramod has a masters' degree in Biodiversity and Conservation, from Guru Gobind Singh Indraprastha University, New Delhi and professional working experience in diverse fields related to conservation biology, environmental impact assessment, natural resources management and climate change. He has also done a professional certificate course on "Governance of Landscape, Forest and People" from Wageningen University, the Netherlands and his expertise is in geospatial technology; mapping and modelling landscape and habitats.

Currently, he is leading a team of young conservationists for the sustainability and conservation of caterpillar fungus in the Indian Himalayan Region. For the project, Pramod is responsible for team and financial management and coordination with project stakeholders. He was also responsible for doing field activities and research, as well as for contributing in outreach and educational programmes.

Subhajit Saha (Conservation Education and Outreach)

Email: ssaha88@gmail.com

Subhajit is an independent researcher based in the town of Dehradun, India. He has an M.Sc. degree in Conservation Biology (the University of Burdwan) and a B.Sc. degree in Zoology (the University of Calcutta). His research interest is broadly concentrated around the biological aspects of conservation, especially those of the birds and mammals, as well as community involvement in conservation through education and outreach. He has extensively travelled and did field works in the Himalayan Mountains of India. Apart from doing conservation research and outreach, he likes to trek and do nature photography. He also has a special interest in teaching conservation to college and university students, for which he worked as a lecturer for two semesters at the HNB Garhwal University, India.

Subhajit's responsibilities in the project included devising and conducting education and outreach programmes, documenting the project activities through photography and videography, and conducting stakeholder interviews.

Ashish Kumar Mishra (Species and Socio-economic Survey)

Email: ashishmishramlg@gmail.com

Ashish has done Ph.D. in Environment Biology from APS University, Rewa, and is currently working as a National Postdoctoral Fellow at the Babasaheb Bhimrao Ambedkar University Lucknow. His research focuses on riparian ecology in alpine region of the Indian Himalaya. He has also worked on forest ecology, climate change, environmental impact assessment and plant biodiversity. For the project, Ashish was responsible for conducting species habitat identification surveys and socio-economic surveys. He also contributed greatly in conducting group discussion with stakeholders and educational programmes.

Mohnish Kapoor (Conservation Policy and Wildlife Trade)

Email: mohnish1989@gmail.com

Mohnish is currently the Senior Programme Manager of the Global Tiger Forum (GTF), and is responsible for developing and implementing GTF projects, such as the Regional Capacity Building for Tiger and Snow Leopard Range Countries, implementation of Conservation Assured Tiger Standards, developing and reviewing Tiger Conservations Plans and is also the Project Director for Ranger Information Survey in India. Previously, he has worked with TRAFFIC, hosted by WWF India, Indian Wildlife Business Council and The Energy and Resources Institute (TERI). He has completed his post-graduation with a gold medal in Biodiversity and Conservation from G.G.S.I.P. University, New Delhi. Subsequently, he completed a certificate training course on Species Conservation and monitoring -"Terrestrial Mammals" at the Smithsonian-Mason School of Conservation, Virginia, USA. For the project, Mohnish was responsible for assessing trade dynamics and reviewing existing national and international policy framework for caterpillar fungus.

Manendra Kaneria (Species and Socio-economic Survey)

Email: kaneria.manendra@gmail.com

Manendra Kaneria Completed his post graduation in Forestry, wildlife & Environmental Sciences from Guru Ghasidas University Chhattisgarh, India. He worked as a Junior Research Fellow at Forest Research Institute to conduct socio-economic surveys for NTFPs and community livelihood. Thereafter, he joined Wildlife Institute of India as a Research Biologist and assigned to do camera trapping and distance sampling in different tiger landscapes. He has also contributed to prepare a working plan for forest management at Forest Research Institute. Currently, he is pursuing PhD in forest entomology at the Forest Research Institute Dehradun.

As a part of the project team, he was responsible for conducting species and socio-economic survey in the field as well as desk-based activities.

Manish Kaneria (Species and Socio-economic Survey)

Email: kaneria.manish@gmail.com

He obtained post graduation degree in Forestry, Wildlife and Environmental Sciences from Guru Ghasidas University, India. He worked as a Junior Research Fellow (JRF) at G.B. Pant Institute of Himalayan Environment and Development. During his tenure, he applied research skills to assess forest ecosystem services in the Indian Himalayan Region. He has also worked as a JRF at Forest research Institute to develop a Bamboo propagation protocol for its commercial production. He joined wildlife Institute of India and explored Vindhyachal landscape for assessment of forest vegetation and tiger habitat.

As part of the project team, he was responsible for conducting species and socioeconomic surveys. He also contributed in outreach activities by preparing different outreach materials.

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Executive Summary

The caterpillar fungus (*Ophiocordyceps sinensis)* is a flagship species of the Himalayas and is one of the world'smost expensive natural medicinal resource.This study assesses harvesters' perception on abundance, sustainability, ease of harvesting, and problem/challenges regarding collection and trade. The team has also tried to identify key stakeholders while conducting education and outreach programmes for sustainable harvesting of caterpillar fungus and to conserve the local environment of the region. However, primary information pertaining to harvesting pattern, trade and habitat of caterpillar fungus in the Nanda Devi Biosphere Reserve, and challenges and opportunities for harvesters was also investigated by conducting questionnaire surveys at the household level in the Dhauliganga Valley. The field surveys were conducted among the different stakeholders from May, 2015, to July, 2016. This study represents the first comprehensive effort to document harvesting pattern and trade of caterpillar fungus along with the quantification of its contribution to the household economy of local community of the NDBR.

The cash income of the community is heavily dependent on caterpillar fungus and its tradeis providing higher economic returns to the community. The annual harvest (number of caterpillar fungus per household) varied from 300 to 1150 (mean 599.31, SE ±10.19) in 2011; in 2015 it dramatically fell down to 2007-10 (mean 405.93, SE ±6.06). On the other hand, average daily collection per person was 11.51 (SE ±0.37) in 2011 and it dramatically decreased to 3.57 (SE ±0.09) in 2015. In contrast, average number of spending days and number of people involved has increased continuously from 2011 to 2015.

Ultimately, increasing trade induced over-harvesting seems almost certainly responsible for the threat to the species. With the gradual increase in the market value of caterpillar fungus since 2006 to 2015, the dependency of local communities is becoming more prominent on the income generated through its collection, whose livelihoods were earlier based on pastoral and agricultural activities. This is the highest source (~82 per cent of the total casch income) of income in comparison to other sources because people have lesser economic resources for livelihood in these regions. The harvesters' perception concluded that abundance (~78 per cent) and sustainability (~68 per cent) of the harvest of the species have decreased and the ease of harvesting (~78 per cent) has become difficult in the last five years in the Biosphere Reseve.

Unsustainable and rampant harvesting practices are causing threats to long term survival of this caterpillar-fungus parasitic complex along with the destruction of its habitats which support many rare, endangered and threatened Himalayan species. Present study concludes that the fungus population and per-capita harvest is decreasing continuously. It is also found that abudance and sustainability of the harvest have decreased and ease of harvesting has become difficult in last five years in the study area. The reasons may be over harvesting, ecological threats due to anthropogenic pressure and climate change, however, a more intensive scientific investigation is required to establish such facts.

The regulation of rampant exploitation and implementation of scientific sustainable harvesting should be carried out for the survival of the species and to conserve pristine alpine meadows. Government policies should be formulated and implemented subsequently to integrate conservation, livelihood and governance for this species in the region. Thus, the holistic management of the caterpillar fungus should be beneficial, not only for conservation prospective but also for economic well-being of the indigenous communities. This study also recommends that there is a need for extensive outreach and educational programmes to develop local capacity for sustainable harvesting and spread awareness about the environmental causes among the stakeholders. There is also a need to take initiatives by the *Ophiocordyceps* range countries (Bhutan, China, India and Nepal) to create a forum, involving international political, bureaucratic and scientific communities for evolving a common international holistic policy for conservation, sustainable harvesting and trade of caterpillar fungus.

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We wish to express our deepest thanks to the Conservation Leadership Programme (CLP) for providing us the first funding to kick-start the project, and the IdeaWild Foundation and Rufford Small Grant for Nature Conservation (RSG) for providing us subsequent funds for the continuation of our objectives. We would also like to thank the entire CLP management team for their tireless support and mentoring whenever needed, and Martina Anandam (CLP alumni) for her valuable suggestions, comments and support during the initial project development phase.

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The Project Team

Chapter: 1. Introduction

Timber and Non-Timber Forest Products (NTFPs) can be together termed as Natural Forest Resources, are varied,and play a significant role in the livelihood of rural people living in or around forests. The people utilisethese products for household useas well as for generatingearnings in terms of money (Fisher, 2000). In subsistence economies, natural resources maycontributea number ofnecessarycommodities and services for the livelihood of local populace, such as food, daily needs,building materials, medicines and objects of religious or cultural importance (Wong, 2000). In open economies where forest dwellers may sell or trade their commodities, forest products createsignificant employment and revenue. In India, NTFPs supplyrevenuecomparableto US$ 2.7 billion per year and provide 55 per cent of the entire employment in the forestry sector(Chauhan et al., 2008). Additionally, 50 per cent of forest revenues and 70 per cent of forest based export earnings come from NTFPs (Chauhan et al., 2008). They supply 50 per cent of the domesticearnings for about one-third of India's rural inhabitants (Mahapatra and Shackleton, 2011). In addition, forest products are at the core of research on forest management, conservation of biodiversity, and poverty alleviation (Lawrence, 2003). The unsustainable commercial gathering of these commodities could diminish both the species diversity and abundance (Quang and Anh, 2006).

The sustainability of NTFPs extraction for the enduring ecological integrity of forests depends on a number of considerations, including its significance to the local economy, likelihood of substitute sources of earnings for the people, ecological impacts of NTFPs extractions, and legal status of the forests (Mutenje et al., 2011). During the last two decades, considerableadvancement has been made in understanding the function of biological resources in the lives of underprivileged people, particularly their contribution to the household economy, and their role in alleviating poverty (Vira and Kontoleon, 2013). Commercial gathering of natural resources is robustly influenced by local and international markets as well as fluctuations in demand and supply (Weckerle et al., 2010). Therefore, the above mentioned issues combined with unsustainable wild life trade, including the gathering and trade of NTFPs;appear to be chief drivers of biodiversity loss (Broad et al., 2003). In indigenous medicinal practices, wild flora (including fungi such as caterpillar fungus) are regarded to have wider therapeutic benefits and accordingly command higher prices (Holliday and Cleaver, 2008; Olsen and Helles 2009).

Illegal forest activities consist of a broadarray of activities, among which are occupation of forest land,unlawful harvesting, transportation and trading of forest products etc. (Brown et al., 2008). There are growing concerns about unlawful activities in the forestry sector and very fewworksare in progress to comprehend the causes and consequences of nonconformity to forestry laws. Nevertheless, most studies on illegal forest activities deal with illicit timber harvesting with little efforts on other activities like the collection of NTFPs (Foundjem-Tita et al., 2014). It is hencedisappointing that NTFPs are frequentlyignored when illegal forest activities are discussed. Here we report the impact of trade on natural populations of a relatively recent natural commodity on the international stage, the caterpillar fungus complex.

Natural resources are the most accessible source of products and incomes for many economically marginalized people, and are consequently under considerable pressure to provide both production and environmental benefits (Darlong and Barik, 2005). The NTFPs span a range of wild and semi domesticated biological resources harvested by local households and communities from around homesteads, fields, grazing lands and relatively intact vegetation, such as grasslands, woodlands and forests (Belcher, 2003; Shackleton et al., 2011). In principle, people can contribute to their economic well-being by harvesting NTFPs (Shaanker et al., 2004). Patterns of forest land and natural habitat degradation determine the size and types of ecosystem services forests provide. Particularly in low-income countries, NTFPs extraction by rural people, which provides important resources and income to the rural poor, contributes to the level and pattern of forest degradation. Therefore, issues related to the conservation and management of the Himalayan landscape are very crucial, since the sustainable flows of ecosystem services from the Himalayan landscape (Singh, 2002) to the fertile lowlands of India are important for the sustainable livelihood of several hundred million people. The harvest and trade of caterpillar fungus correspondingly contribute a great source of income to the local people, acting as a major livelihood means. The project thus was aimed at assessing the economic contribution of caterpillar fungus in the local people's livelihood as well as the sustainability of this valuable bio-resource, and the various challenges associated with it.

1.1.NTFPs – Himalayan Perspective

In the Himalayan region, the NTFPs and people are inextricably linked since millions of people live in the region and harvest forest products like Satuwa (*Paris polyphylla*), Kutki (*Neopicrorhizascrophulariiflora*), Jimbu (*Allium wallichii*), Ban Lasun (*Fritillariacirrhosa*), Bajradanti (*Potentillafruticosa*), Chirayita (*Swertiachirayita*), Jatamansi (*Nardostachys grandiflora*), and recently utilised caterpillar fungus (*Ophiocordycepssinensis*). Provisioning ecosystem services include wild products that form an integral part of rural economies (Woodhouse et. al., 2014) and medicinal plants constitute a high percentage of NTFPs collected from the Himalayas (Malik et al., 2015). Most Himalayan NTFP studies have focused on the commercially important medicinal and aromatic plants; this includes a limited number of studies on marketing and household income estimates (Shrestha and Bawa, 2014 and 2013; Rijal et al. 2011; Ved and Goraya, 2008; Bista and Webb 2006). These studies confirm the existence of a standard market chain operating to move commercial NTFPs from rural up-land areas to different urban consumption centres.

Although harvesting and trade of wildlife including plants and animals has a long history in the Himalayan region, it is now threatening the survival of many species, and the sustainable use of wildlife resources in the region (Yi-ming et al., 2000). Unsustainable trade in wildlife is regarded as a major driver of biodiversity loss and ecosystem degradation.Unregulated wildlife trade propels over-exploitation of species, resulting in population declines, andoften in combination with other factors may ultimately extirpate species from their natural habitats(Shrestha and Bawa, 2013). Concern about the impacts of trade on biodiversity has largely focused on flagship faunal species. Shrub encroachment and aggregated

anthropogenic pressure into alpine meadows represents a particular grave conservation threat (Montane et al., 2007; Xu and Wilkes, 2004). Alpine regions of the world harbours many specialized as well as threatened and endemic flora and fauna. Thus the loss of alpine pasture is a major conservation concern (Brandt et al., 2013).

1.2.Conservation implications – Alpine meadows

The degradation of alpine meadows is a major conservation concern because they supporta number ofthreatened and endemic flora and fauna (Wu et al., 2007; Brandt et al., 2013). Shrub encroachment into alpine meadows represents a particularly serious conservation hazard (Montane et al., 2007). As the most extensive alpine ecosystems in the world, alpine meadows in the Greater Himalayan region are of particular concern. Historically, Himalayan meadows have been used by native agro-pastoralists whose rangeland management practices sustained both local livelihoods and biodiversity (Klein et al., 2011). Alpine meadow species can persist in the low-intensity land use systems typical of mountain regions, but even subtle environmental changes may threaten those (Thuiller et al., 2005). For example, when climate change shifts woody vegetation to higher elevations, species of alpine mountaintop meadows may not be able to migrate to other appropriate environments.Similarly, the desertion of conventional land use practiceencourages in shrub encroachment (Parmesan, 2006).

In the alpine meadows of the Indian Himalayan region, people depend on forest ecosystem services for their livelihood and sustenance. As they derive direct and indirect benefits from forest ecosystem in terms of a wide variety of high valued herbs and other NTFPs, such as caterpillar fungus. Although trade and collection of NTFPs including medicinal plants have a long history in the Himalayas, harvesting of caterpillar fungus (*Ophiocordycepssinensis*) has become extremely popular in the last decades, surpassing all other species in terms of revenue. It is traditionally harvested by the poorest of the poor living in the high mountain regions of the Himalayas during May to July (Shrestha and Bawa, 2013). The harvesting and selling of caterpillar fungus is contributing to social and economic transformations across the Tibetan Plateau and Himalayan region and it has become one of the most valuable biological resources of the world (Shrestha and Bawa, 2014b). However, well-being of mountain dwellers mainly depends upon harvesting of the NTFPs including caterpillar fungus. Changes in micro-climatic conditions, unprecedented collection intensity and profound economic dependence of rural communities certainly affect stages of the life-cycle of this fungus, which ultimately calls for sustainable resource management (Baral et al., 2015). Unregulated and rampant harvesting practices are leading for threats to long term sustainability of this caterpillar-fungus parasitic complex.

1.3.Caterpillar Fungus (*Ophiocordycepssinensis*)

The caterpillar fungus (*Ophiocordycepssinensis)* islocally known as Kira Jari (in India), Yartsagunbu (in Tibet), *YarsoGumbub*(Bhutan), *Dong Chong Xia Cao* (China) and *Yarsagumba* (in Nepal). It is endemic to the Tibetan Plateau including the adjoining high altitude areas of the Himalayas (between 3,000 to 5,500 msl). *O. sinensis*(Fig. 1) is a fungal

parasite of larvae (caterpillars) belongs to the ghost moth genus *Thitarodes (Hepialidae, Lepidoptera*).

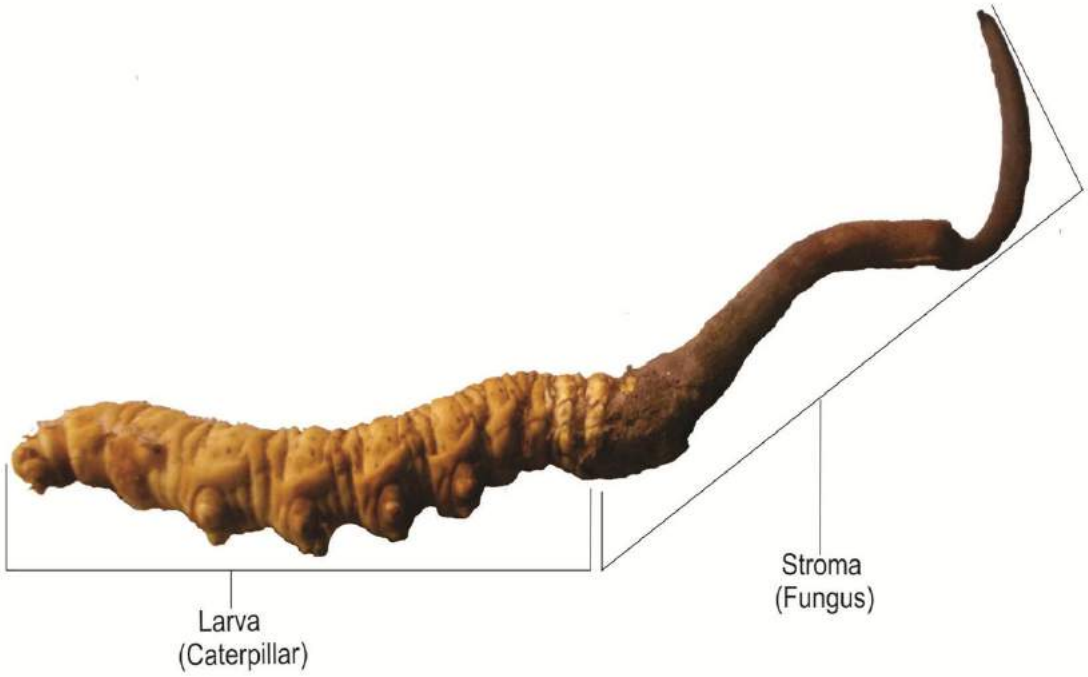

Figure: 1. Harvested Caterpillar fungus (*Ophicordycesps sinensis*)

The parasitic fungus rises upon and derives nutrients from about 60 species of lepidopteran larva in the Himalayan and Tibetan Plateau (Wang and Yao, 2011), by and large that of the Himalayan bat moth *Hepialus armonicanu*s (Gao et al., 2003; Holliday et al., 2005). The genus *Thitarodes* (previously Hepialus) is a moth species belonging to the order Lepidoptera and the family Hepialidae, globally represented by 60 genera and 587 species and often referred to as ghost moths (Nielsen et al., 2000). This fungus infects and eventually kills Lepidopteran larvae of about 60 different species (Baral et al., 2015; Wang and Yao, 2011), ordinarily that of the Himalayan bat moth *Hepialus armonicanus* (Gao et al., 2003; Holliday et al., 2005).

a. Habitat of caterpillar fungus

Caterpillar fungus flourishes in subalpine and alpine grasslands or meadows as well as open dwarf scrublands around the potential timberline and gentle mountain slope of the Tibetan Plateau and high Himalayas (Fig. 2). It is alsobeing reported from Bhutan, Tibet, China (Xizang, Gansu, Qinghai, Sichuan and Yunnan provinces), India (Arunachal Pradesh, Sikkim, Uttarakhand) and Nepal (Baral et al., 2015). The caterpillar fungus is widely distributed in patches and is been recorded at elevations of 3540–5050 m in Nepal, 4200–5200 m in Bhutan, 3200–4200 m in India and 3000–5000 m in Tibet (Shrestha and Bawa, 2013). It has also been documented in alpine meadows of some protected area like Kanchandzanga Biosphere Reserve, Sikkim, Dehan-Debang Biosphere Reserve in Arunachal Pradesh, Nanda Devi Biosphere Reserve and Askot Wildlife Sanctuary, Uttarakhand of the

Indian Himalayan Region. In the NDBR, caterpillar fungus has distributed among various alpine meadows of Gori valley, Pindar valley, Niti valley, Rishi Ganga, Mandakini valleys.

Figure: 2. Habitat for the caterpillar fungus (alpine meadow) in the NDBR

b. Harvesting techniques and collection period

The collection season starts in the beginning of May and lasts till the end of June. The collection period depends on many factors like the local weather, condition of snow in the pasture and elevation of the collection site. The harvesters recline on the ground over the high-altitude expanses, attentively scanning the terrain. It is a difficult task requiring attention and tolerance for harvesting. Indeed, the height and thickness of caterpillar fungus are so small almost like stalk of the apple that it cannot be easily seen. During spring the ground is covered with short vegetation stumps as brownish as the small caterpillar fungus. But mountain people work hard since it is considered particularly strenuous, the enterprise is highly profitable. Caterpillar is first dug out of the ground it is covered in dirt (Fig. 3A) and the best way to remove this layer is with a toothbrush. During cleaning process careful consideration must be taken not to damage or break the caterpillar fungus. After drying in shade, species is ready to trade (Fig. 3B) and people store it on dray place to save from moisture.

Due to the resource scarcity and high publicity, both the demand and the price of the caterpillar fungus is very high causing fierce competition among harvesters and traders. Over the last decade, Himalayan villagers have become astute to the commercial potential of caterpillar fungus. They harvest it, and then sell it to the local traders. These traders feed the growing demands in Asia's fast growing urban centres, as well as that of the western countries.

A B

Figure: 3. Caterpillar fungus: Uprooted from the ground (A) and cleaned and dray which is ready to sell (B)

c. Medicinal value of caterpillar fungus

The caterpillar fungus is one of the most highly priced natural resource used in traditional oriental medicine. It was discovered about 1500 years ago by Tibetan herdsmen who observed their livestock become energetic after eating certain mushroom. Consequently, the King's physicians in Ming Empire explored to develop powerful and potent medicines. Because of its highly nutritive and medicinal properties, it is considered as the single-most expensive raw material used in Oriental Medicine around the world (Holliday and Cleaver 2008). It is usually consumedby cooking with aged duck to treat patients suffering from cancer and asthenia, or cooked with hen's meat to treat hypo-sexuality and male impotence, especially emission (Jiang, 1994). Moreover, it isalso cooked with pork, sparrow and turtle to treat fatigue (Miller, 2009). In some parts of Nepal, *O. sinensis* is powdered and combined with the rhizome of *Dactylorhizahatagirea* for consumption (Devkota, 2006). A combination is made with *D. hatagirea,* honey and cow's milk for tonic and aphrodisiac (Lama et al., 2001).

Global trade of caterpillar fungus rapidly expanded after the 1993 World Athletic Championships in Stuttgart, Germany, when Chinese athletes reportedly training on dietary supplements of *O.sinensis* and turtle blood set multiple records in distance running (Winkler, 2010). The primary use of caterpillar fungus in traditional Oriental medicine is as a tonic to aid in recovery from illness or disease, to build up strength and restore energy (Pegler et al., 1994). It has been also reported as possessing a range of more specific therapeutic properties, including action against asthma and bronchial inflammation (Kuo et al., 2001), cure of renal complaints (Guo et al., 1999), stimulation of the immune system (Kuo et al. 2005), potent cytotoxic effect on various human cancer cells, including human lung carcinoma cells (Lim et al., 2009; Park et al., 2009) irregular menstruation (Zhu et al., 1998; Francia et al., 1999) and anti-inflammatory (Qian et al. 2015). Nevertheless, it is widely traded as an aphrodisiac and a powerful tonic in the name of ''Himalayan Viagra'' (Winkler, 2008 and Shrestha and Thapa et al., 2014).

Chapter: 2. Materials and Methods

2.1.Study Area: Nanda Devi Biosphere Reserve

The Nanda Devi Biosphere Reserve (NDBR) is located in Garhwal and Kumaon regions of Uttarakhand in the Western Himalaya, situated between 79^0 12'to 80^0 19' E longitude and 30^0 05' to 31^0 02'N latitude (Fig. 4). This landscape falls under Chamoli, Bageshwar and Pithoragarh districts in the Himalayan state of Uttarakhand, India. The Nanda Devi was declared as a biosphere reserve in 1988 under the Man and Biosphere (MAB) programme of the UNESCO, and subsequently in 1992, NDBR got the recognition as a World Heritage Site. The reserve encompasses 5860.69 km^2, of which 624.62 km^2 has been notified as the Nanda Devi National Park and the rest of the area (5148 km^2) forms the buffer zone that is inhabited by human settlements. The Valley of Flowers National Park (VFNP), which covers 87.50 km^2 areas, has also been included in the NDBR. It is known for meadows of endemic alpine flowers and variety of flora. The core zones (Nanda Devi National Park and Valley of Flowers) of the biosphere reserve is free of human habitation, while the buffer zone has a status of reserve forest, which serves as a centre for several ecotourism and religious activities.

The combination of high peaks and deep river gorges accessing the landscape a difficult endeavour, rivers Dhauli Ganga, Rishi Ganga, Nandakini and Pindar are main tributaries of Alaknanda River that originate from the Biosphere Reserve and one of the main tributaries of the River Ganges. The Dhauli Ganga River forms Niti valley, extend northwards to the Tibetan Plateau via the Niti pass an ancient silk route for trading goods such aswool and salt between the Tibetan Plateau and the *terai* region. Before the 1962 Indo-China war, and conflicts between the two countries, this route was used for trans-border trade but the closure of borders post the war, subsequently halted the trade.

The Biosphere Reserve is known for forests of blue pine, oak and cedrus, vast alpine meadows and tough hilly terrain with snow-laden peaks. These temperate and alpine meadows of endemism and habitats for rare, endangered and threatened Himalayan species such as Snow Leopard *(Pantherauncia),* Blue Sheep *(Pseudoisnayaur),* Aconite *(Aconitum heterophyllum),*Brahmkamal*(Saussureaovallata),* Costus*(Saussureacostus)*.It is well known for its rich biodiversity and harbours 400 species of trees, 570 species of herbs and shrubs, 86 species of mammals, 534 species of birds and 54 species of reptiles and amphibians, of these many species are rare and endangered (Maikhuri et al., 2001).

The dominant inhabitants in the NDBR belong to Bhotiya tribe who are historically shepherds, porters, traders and hunters. Woollen handlooms and beverage production are the traditional cottage industries. Tourism is another important source of income for the local populace where more than a million people visit the Hindu and Sikh shrines (Badrinath and Hemkund Sahib) and valley of flowers annually, especially during summer months (April – September), located in the buffer zone of the NDBR.

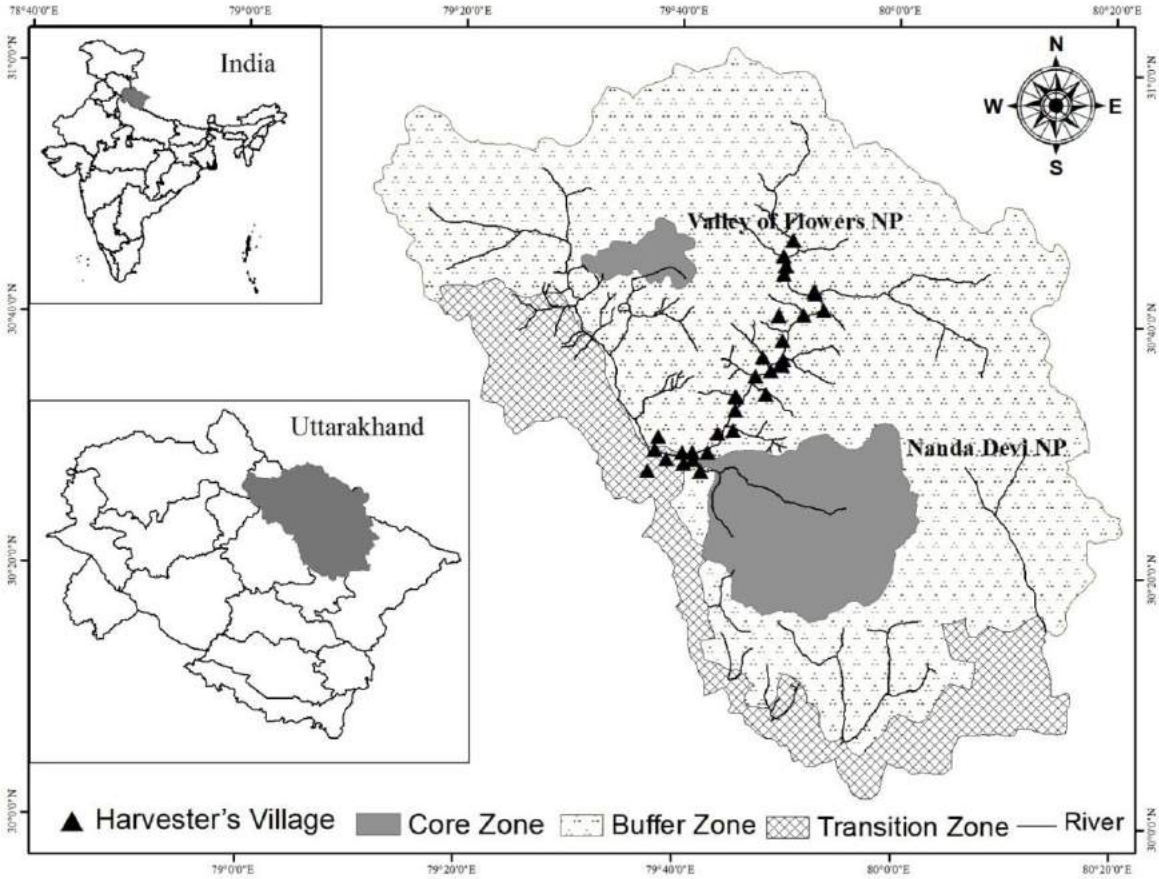

Figure: 4. Location of the study site in the Nanda Devi Biosphere Reserve

The relevant information and data for the study were collected from secondary sources available in publications and reports of various government departments and academic institutions. However, primary information pertaining to harvesting pattern, trade and habitat of caterpillar fungus in the biosphere reserve, and challenges and opportunities for harvesters was also investigated by conducting questionnaire surveys at the household level in the Dhauliganga Valley. The details of data collection and compilation are given below:

2.2.Collection of data from Secondary Sources

An extensive review of the available literatures on caterpillar fungus distribution, collection, trade, and policy was carried out by visiting different government departments, academic institutions and libraries. Published and unpublished data pertaining to caterpillar fungus and their various challenges has been collected from journals and technical reports.

2.3. Collection of Primary Data

Primary data were collected through questionnaire surveys, structured and open ended interviews, and Participatory Rural Appraisal (PRA) and Rapid Rural Appraisal (RRA) methods. Qualitative information has been collected through key informant interviews, focus group discussions, informal communications, and personal field observations (Annexure-I, Plate-1). Informal discussion and interviews lasted from 30 minutes to an hour. Purposive

sampling was done for targeting groups of the stakeholders in the Biosphere Reserve, who have been identified in the literature and through personal field visits, and by key person (like forest officials etc.) as important sources of information regarding caterpillar fungus harvesting and trade. Interviews were conducted according to local research protocols (based on initial field sampling) with the local field assistants. Field surveys to collect information on the caterpillar fungus harvesting and trade for this study were carried out in the remote alpine pastures and villages of the Dhauliganga Valley of the NDBR(Fig.7), from May, 2015 to July, 2016.

During field surveys, the aim was to interview a cross-section of the community that reflected age, gender, types of employment or livelihood and participation in traditional activities. The household is the unit of economic activities including natural resources use, and therefore interviews were conducted at this level, with the head of house hold or those involved in decision-making. One person in each household was surveyed with the aim to survey as many households as possible and avoid repetitive answers of individuals to questions within the study area. All respondents were over 18years of age and their average age was 35.45 years. The questionnaires were written in *Hindi* and translated in to local vernacular (*Garhwali*) depending on language proficiency of the respondents. Research assistants were employed from different villages of the valley that also harvest caterpillar fungus and speak Hindi and the native language.

In terms of sampling structure, households which indulge in harvesting of caterpillar fungus for at least five years and spent 10-35 days for each harvesting season were identified, and entire houses in 32 villages of the valley were numbered. Overall, 312 households (~10 per cent of total households) were randomly selected (with the representative sample being age variant, gender variant and possessing wide geographical spread) and interviewed through structured and semi-structured questionnaires and open group discussion to get information the subject. The team also documented rate of caterpillar fungus from traders and perception on trends of supply and demand.The questionnaire surveys included data formats for gathering information about harvesting procedure, trade and perception on abundance, sustainability, ease of harvesting, and faced problems during collection period. Furthermore, we conducted several informal meetings and discussions with village council leaders, school teachers and forest department officials to validate information gathered from individuals.

2.4. Data Analysis

The data gathered from the field was arranged systematically into “MS excel sheets”. Column charts table and line graphs were used to depict the following observations, derived from the structured questionnaires:

- Trend on per-capita harvest
- Trends of selling price by harvesters
- Trend of selling price by local traders
- Household cash income from different sources
- Household cash income from caterpillar fungus

- Harvesters perception
    - Abundance of the harvest
    - Sustainability of the harvest
    - Ease of harvesting
    - Challenges
- Trades perception
    - On international demand of caterpillar fungus
    - On international supply of caterpillar fungus

2.5.Conservation Awareness Programme

These initiatives were undertaken in the form of conservation education campaigns for schools and environmental awareness campaign for village communities (harvesters). In case of schools, the campaign involved poster presentation on lifecycle of caterpillar fungus and their conservation and sustainability. The events also included an environmental quiz competition, and distributed kits, containing leaflets, caps and t-shirts for promoting conservation awareness and education. For with the communities, demonstrative posters and banners were used for generating awareness on sustainable harvesting and conservation of caterpillar fungus. Apart from this, an environmental awareness discussion was conducted on garbage disposal in alpine meadows. The team has also disseminated the project findings through different national and international conferences (Annexure-I, Plate-3).

Chapter: 3. Result and Discussion

This study represents the first comprehensive effort to document harvesting pattern and trade of caterpillar fungus along with the quantification of its contribution to the household economy of local community of the NDBR. The study assessed harvesters' perception on abundance, sustainability, ease of harvesting, and problem/challenges regarding collection and trade. The team has also tried to identify the stakeholders while conducting education and outreach programme for sustainable harvesting of caterpillar fungus and to save the local environment of the region.

3.1. Harvest of caterpillar fungus

Caterpillar fungus is harvested in May to July every year by economically marginalised communities living in remote areas of the Nanda Devi Biosphere Reserve. The annual harvest (number of caterpillar fungus per household) varied from 300 to 1150 (mean 599.31, SE ±10.19) in 2011; in 2015 it dramatically fell down to 200-710 (mean 405.93, SE ±6.06). On the other hand, average daily collection per person was 11.51 (SE ±0.37) in 2011 and it dramatically decreased to 3.57 (SE ±0.09) in 2015 (Table.1). In contrast, average number of spending days and number of people involved have increased continuously from 2011 to 2015. The greater demand and higher prices of the species are likely to lead to an increased intensity of the harvesters and longer period of stay by the harvesters in the alpine meadows. On the other hand, the results show that per-capita harvest in this region has continuously decreased since 2011 to 2015.

Table: 1. Average of different parameters in caterpillar fungus harvesting by a household

Parameters	2011	2012	2013	2014	2015
	Mean (SE)	Mean (SE)	Mean (SE)	Mean (SE)	Mean (SE)
No. of Collected CF	599.31 (±10.19)	597.51 (±9.45)	517.93 (±6.60)	441.15 (±5.46)	405.93 (±6.06)
Family member involved in CF harvesting	3.2 (±0.08)	3.57 (±0.08)	3.96 (±0.07)	4.04 (±0.08)	4.48 (±0.09)
AV total number of harvest (Pieces/ person)	217.23 (±6.39)	189.72 (±4.77)	144.60 (±3.37)	124.42 (±3.08)	102.13 (±2.44)
Time spent (days/season)	20.04 (±0.29)	24.64 (±0.26)	25.88 (±0.21)	29.24 (±0.24)	28.97 (±0.21)
AV harvest (Pieces/person/day)	11.51 (±0.37)	7.93 (±0.20)	5.67 (±0.14)	4.33 (±0.11)	3.57 ±0.09)

***CF = Caterpillar Fungus; AV = Average**

3.2. Market price of caterpillar fungus

Market prices of caterpillar fungus are always unpredictable and large fluctuations are common which get influenced by many factors like market demand, timing, involvement of middle-men, and locations of trading. Within the last decade (2006 to 2015) the yearly market price of caterpillar fungus (INR Kg^{-1}) showed wide variations which are represented by line plots in Fig.5. Lowest range (200000-350000 INR) was found in the year 2006 whereas the highest range (800000-1350000 INR) was found in 20111. Each line plot represents significant difference in their market price from the year 2006 to 2015.

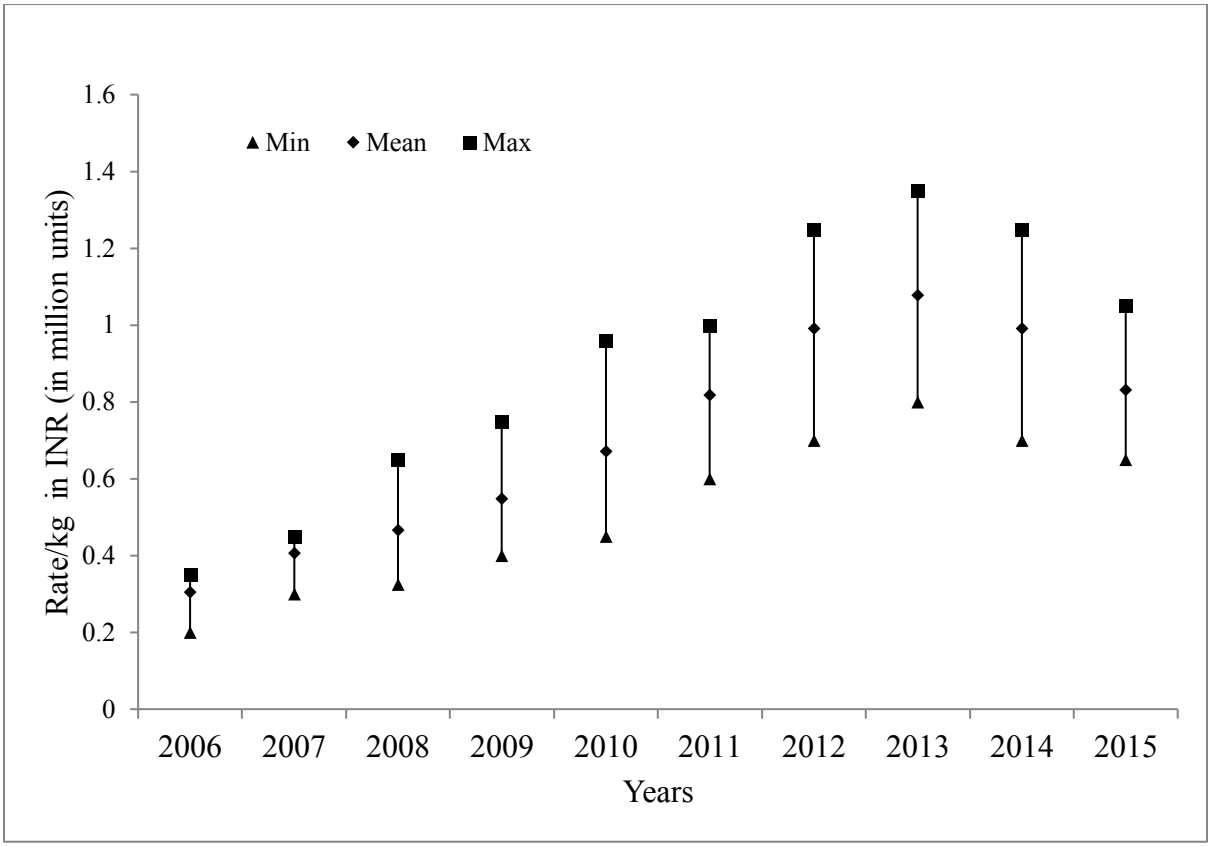

Figure: 5. Trends of selling price of caterpillar fungus by the harvesters from the NDBR

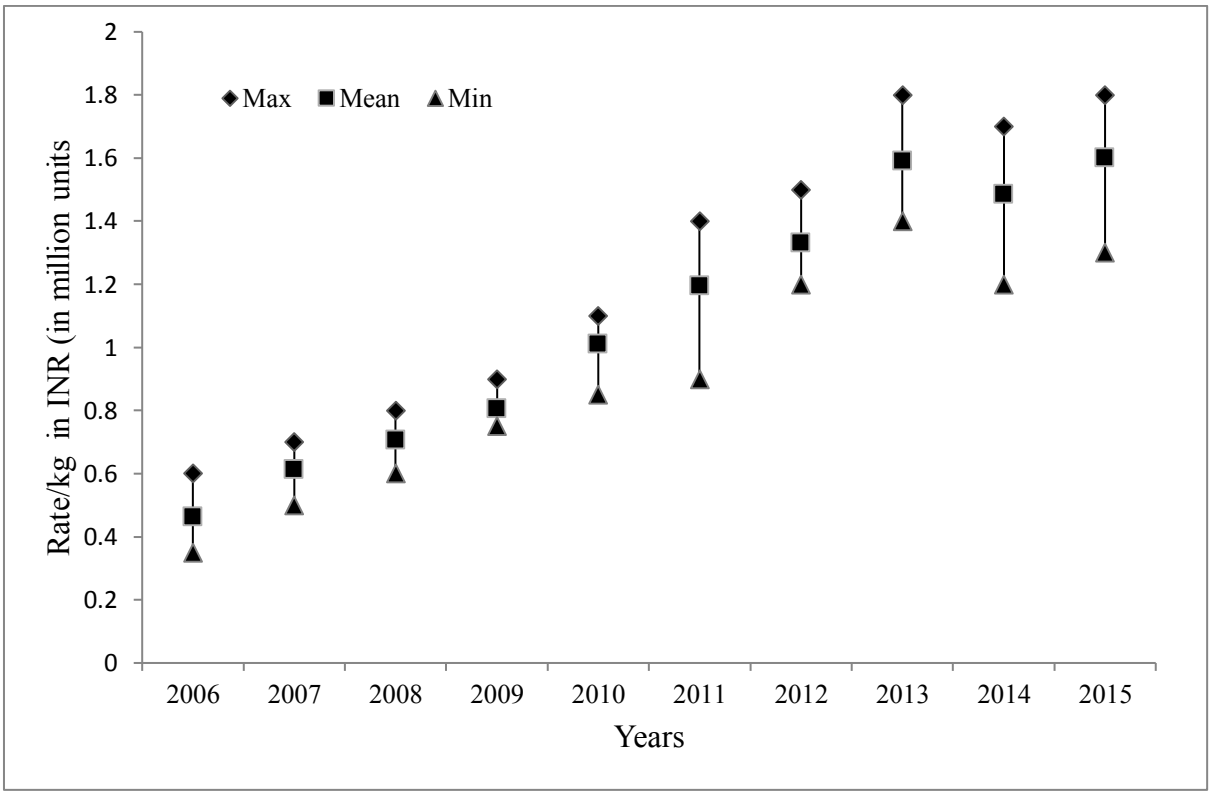

Figure: 6. Trends of selling price of caterpillar fungus by traders in India

Average market price of caterpillar fungus has increased considerably from the year 2006 to 2013 whereas it sharply decreased in last two years, i.e., 2014 and 2015. Likewise, local traders sold the caterpillar fungus to wholesalers for 350000-500000 INR-Kg^{-1} in 2006 (Fig. 6). The average rate of caterpillar fungus for local traders has increased continuously from 2006 to 2013 i.e. 462500 to 1590909 (INR-Kg^{-1}). Maximum average rate of selling by the traders was recorded in 2015, which is 1600000 INR-Kg^{-1} (Fig. 6).

3.3. Transformation in livelihood opportunities

The villagers who harvest caterpillar fungus in the NDBR belong to the economically marginal communities and are historically shepherds, porters, traders and hunters. Presently, woollen handlooms and beverage production are the basic traditional cottage industries along with agriculture and animal husbandry. Most people also work as daily wages labourers. During field surveys, the team has found that the cash flow from the caterpillar fungus is helping to improve their economic status (Fig. 7). Thus, the introduction of caterpillar fungus harvesting in this region has been empowering the economically marginalised community.

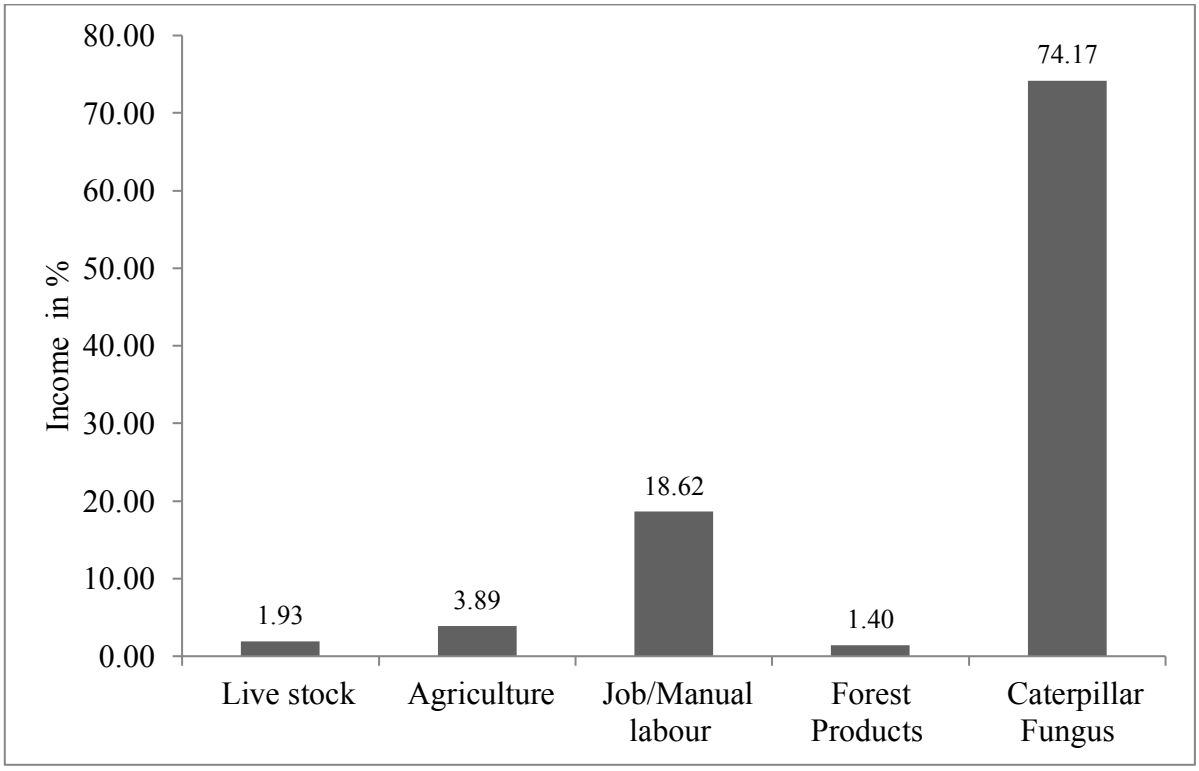

Figure: 7. Cash income of harvesters from different sources in the year 2015

High income from caterpillar fungus is attracting huge numbers of harvesters towards intensive harvesting. The results reveal that, proportional contribution of caterpillar fungus in harvesters' household cash income was around 74.17 per cent (Fig. 7). This is the highest source of income in comparison to other sources due to higher cash income generation in a very short period in comparison to other sources of income. The boom in the income from caterpillar fungus seems to be changing the economical standards of harvesters. Similar

results have been reported from Dolpha, Nepal (Shrestha and Bawa, 2014a). In the Sangdui Valley of China, caterpillar fungus contributes 72 per cent of household cash income on an average (Woodhouse et. al., 2014). The contribution is much higher in Bhutan; up to 80–100 per cent of the harvesters' income generate only from the sale of caterpillar fungus (Wangchuk, 2011; Wangchuk et. al., 2012). However, the result of this study reveals that average income has sharply declined since 2013 to 2015 (Fig. 8).

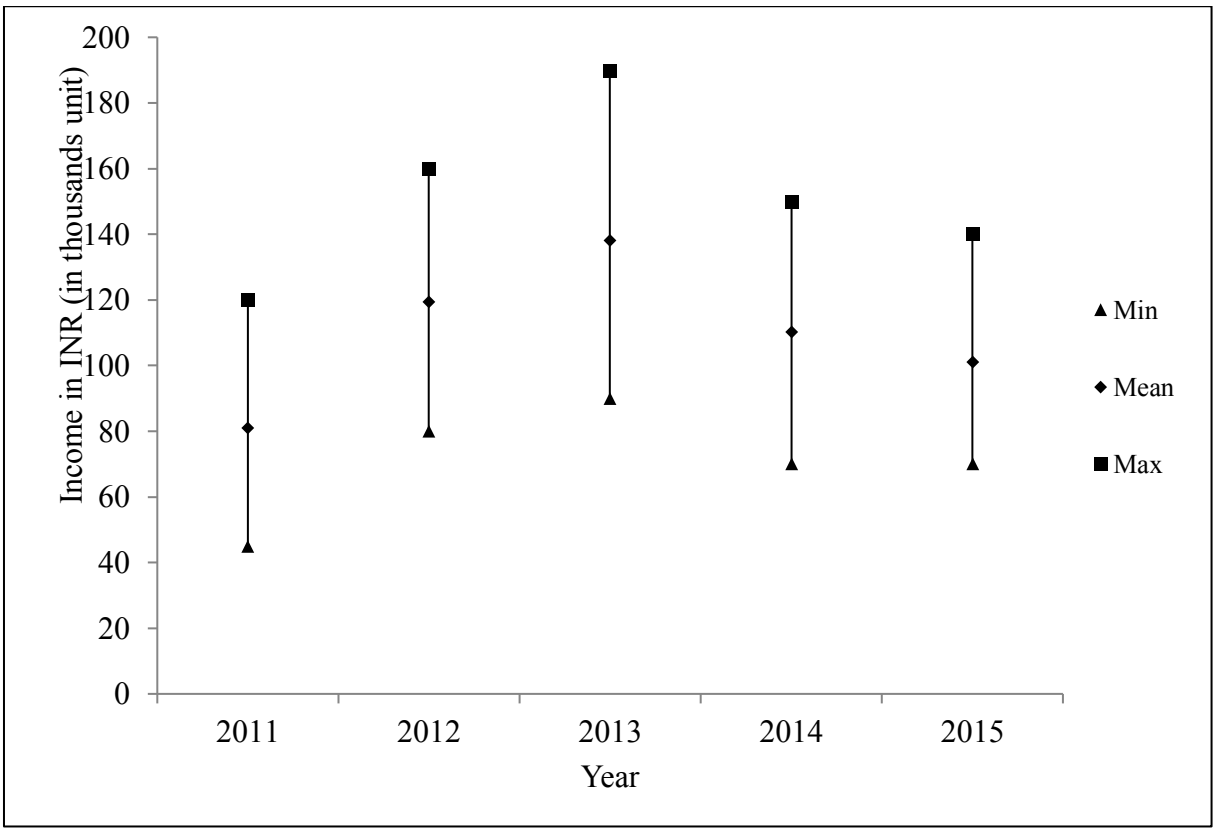

Figure: 8. Households income from caterpiller fungus

The household cash income from caterpillar fungus was plotted in the graph for years 2011 to 2015 (Fig. 8). The income trends show that there was a steady rise between years 2011 to 2013, followed by a downward trend in 2014 and 2015. The peak income was attained in the year 2013 with an average income of about INR 138000 (SD ±26715.64). The household income is proportional to the selling price for each year (Fig.8). Other factors, including availability of resource, price fluctuations due to market factors might be responsible for changes in yearly trends of income and selling price that require more intensive research to reach at any substantial conclusions.

3.4. Harvesters perception on abudance and sustanability of caterpillar fungus

As per the harvesters' perception, 82.05 per cent respondents believed that the ongoing harvesting practice is unsustainable and the 68.59 per cent respondents believed that there is a decline in the abundance of caterpillar fungus (Fig. 9 and 10) in last five years. The reasons

behind this, according to the most of harvesters, are the over exploitation and habitat destruction as the prices enhanced year by year leading to increased extraction. In contrast, during surveys, 20.51 per cent harvesters believed that harvesting of caterpillar fungus is sustainable.

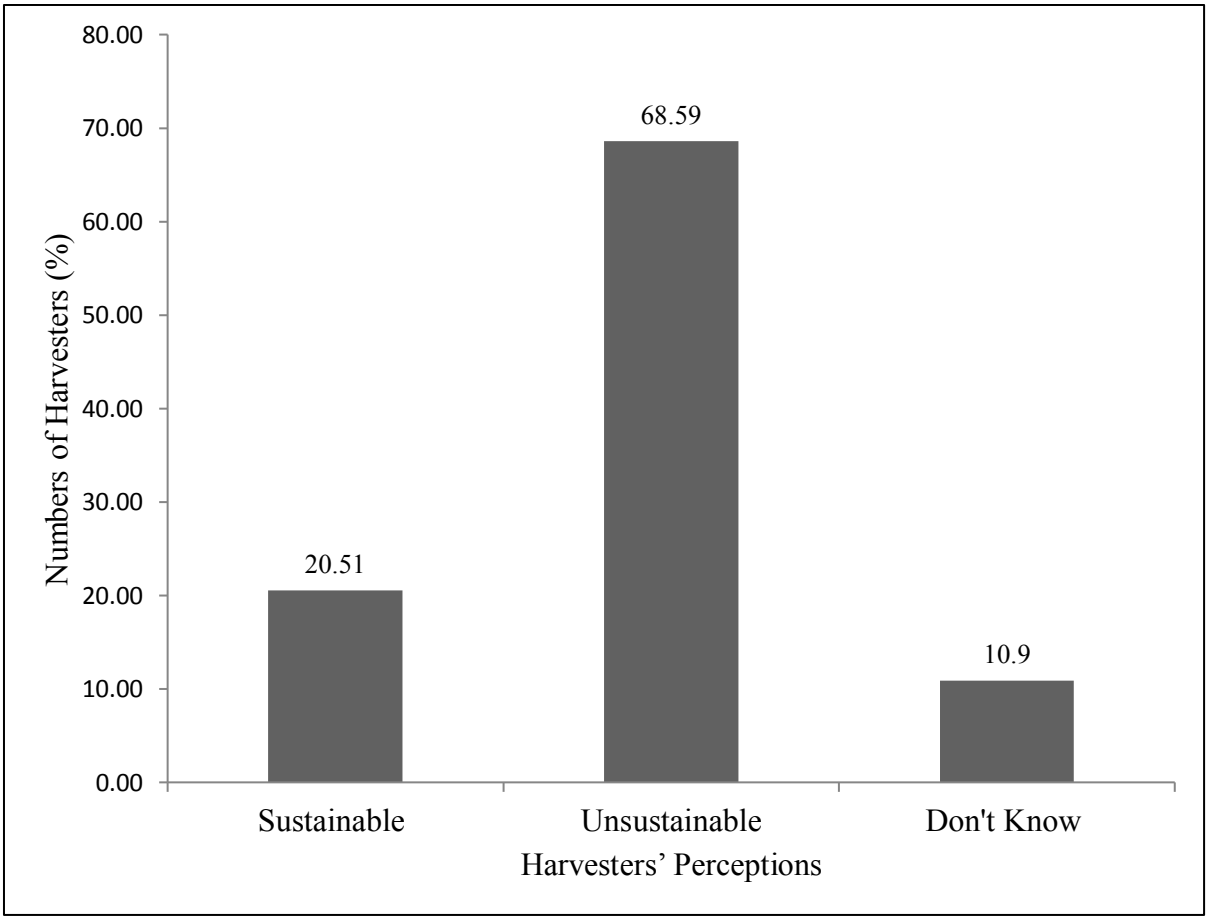

Figure: 9. Harvesters' perceptions on sustainability of the caterpillar fungus

For the cause of decline in caterpillar fungus abundance, the respondents perceived that over-harvesting, which also involves premature harvesting, is one of the major causes of such decline. Harvesters also told that less snow during winter, warming and early melting of snow in spring also effect harvesting period as well as abundance of the species in that particular year. Most of harvesters believed that the opportunities for the collection of caterpillar fungus have gone down which is resulting in drastic decline in income from the harvesting of caterpillar fungus over the last five years (Fig. 8). That might be adversely impacting the socio-economic regimes of local communities and also leading to different challenges for the communities over the harvesting opportunities (Fig. 11 and 12). The most crucial consequence of these trends is increasing pressure on this valuable natural resource. Subsequently, this natural gold has become more vulnerable to loss of its habitats throughout the landscape that would substantially affect the economic capabilities of local inhabitants. During discussion with harvesters, majority of harvesters believed that alternative years or

rotational harvesting in different pasture should be promoted instead of every-year harvesting. It would be helpful for sustainable management of caterpillar fungus.

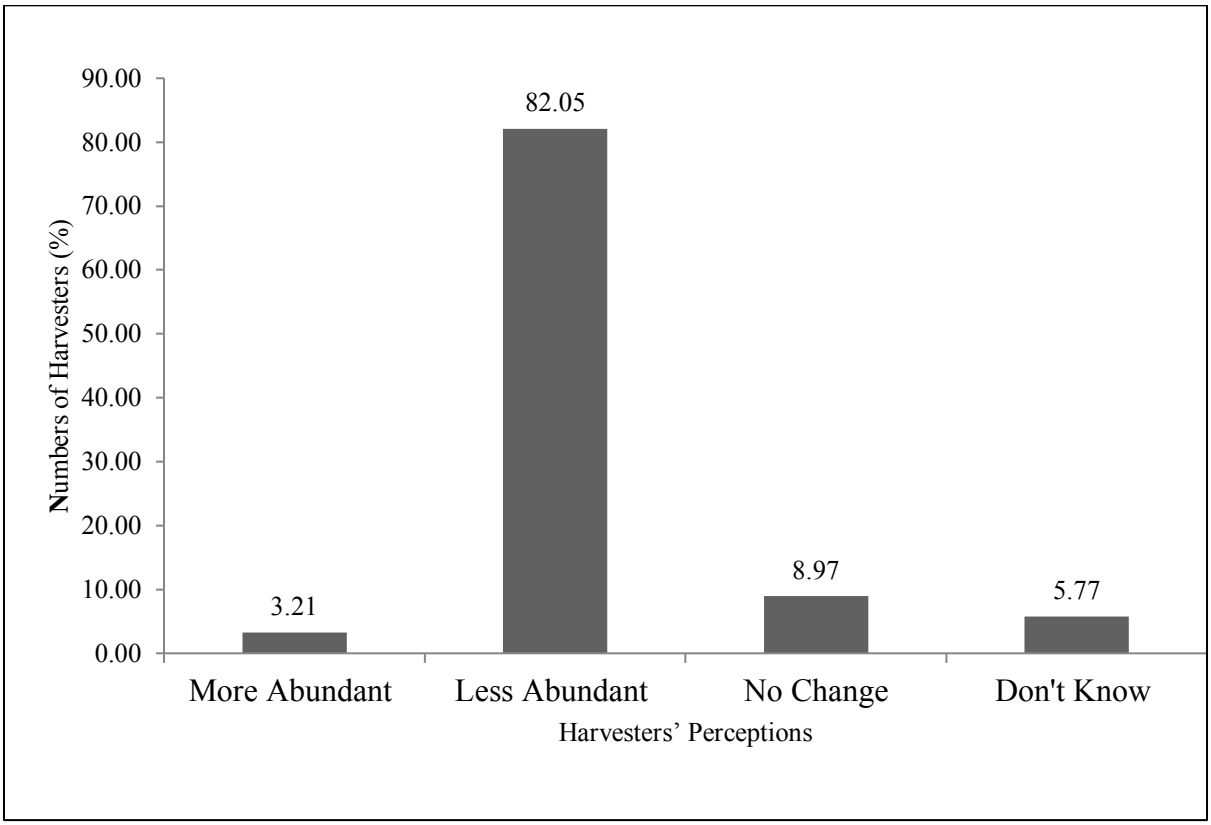

Figure: 10. Harvesters' perceptions on abundance of the caterpillar fungus

3.5. Harvesters' perception on ease of harvesting and problems /challenge

In the response of harvesting of caterpillar fungus, 78.21 per cent harvesters felt that it has become more competitive and difficult due to the lessened abundance of the caterpillar fungus in the last five years (Fig. 11). While 11.86 per cent of respondents answered that there are no changes of any kind in the way of collection of caterpillar fungus. In contrast, 6.73 per cent respondents replied that collection has become easier in last five years.

Due to legal issues, caterpillar fungus' harvesting and trade are marred with risks as many times conflicts happen between local administration/forest department and harvesters/traders. On the other hand, harvesters and traders also get into conflicts among themselves due to the breaching of trust regarding the payment of money. In the past, community disputes generally occurred over grazing rights. Nowadays, they are mostly fought over access to caterpillar fungus resources, and some of these turn violent. During interview in different villages, the stakeholders appeared worried about decreasing production (Fig. 10) of caterpillar fungus and increasing clash among the communities year by year. In India, legislation exists pertaining to the conservation of indigenous plants and other natural resources but implementation is difficult. Legislation has done little to curb the medicinal plant trade historically (Shrivastava

et al., 2010). During the surveys, 79.49 per cent harvesters believed that legal issues related to harvest and trade of caterpillar fungus are biggest challenges.

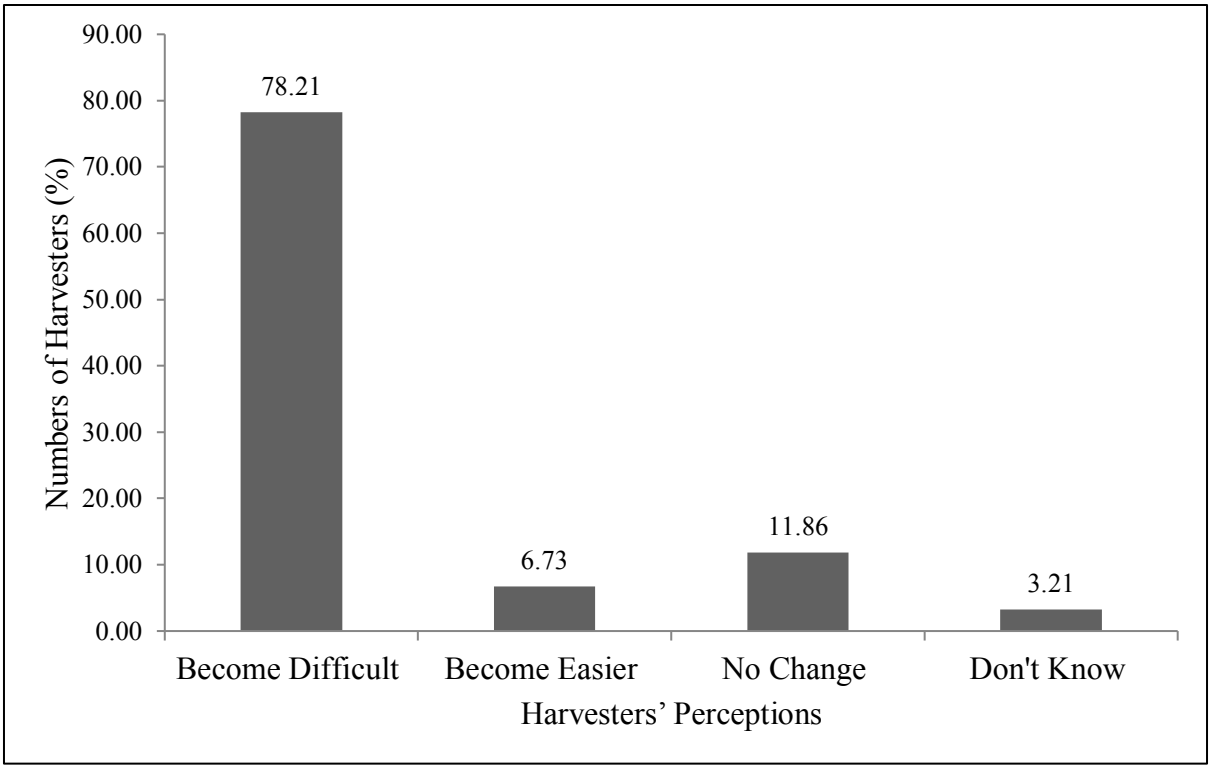

Figure: 11. Harvesters' perceptions on ease of harvesting

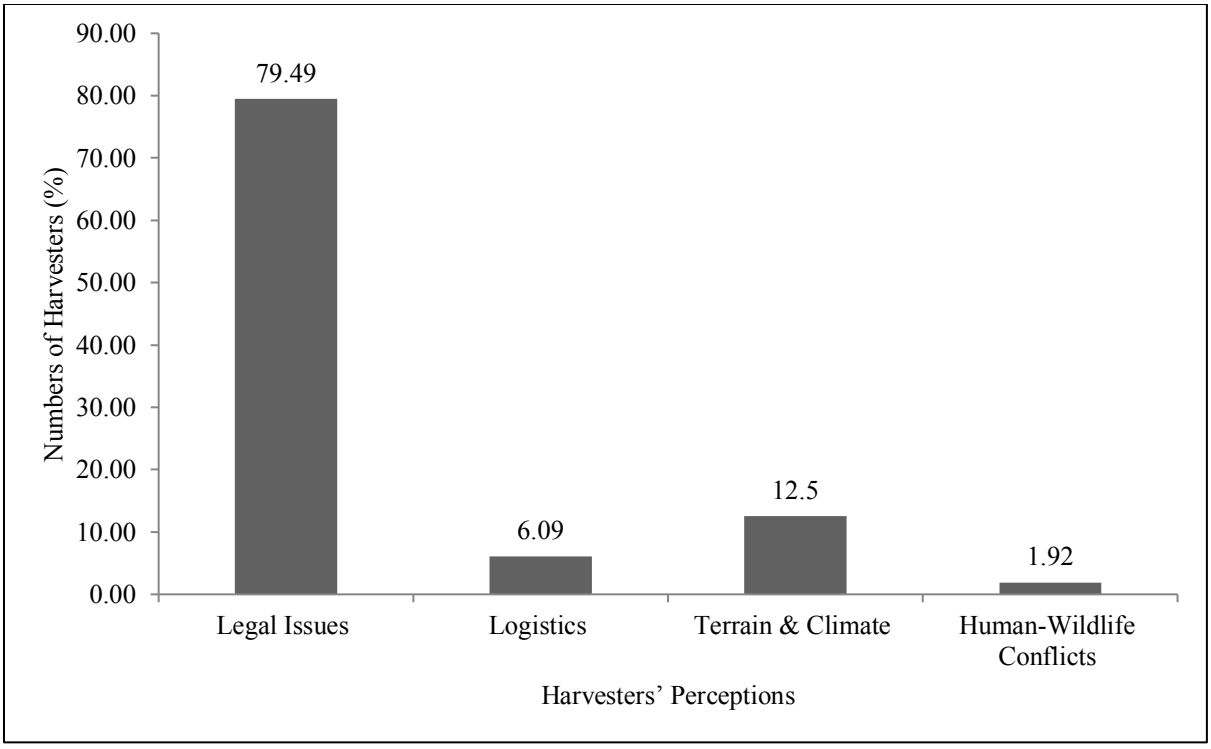

Figure: 12. Harvesters' perceptions harvesting problems /challenge

In addition, harsh climatic conditions also enhance the level of difficulty, further there is no guarantee that a collector will find any caterpillar fungus or not. Sometimes villagers fall ill with snow-blindness, painful joints and problems of breathing for their weeks of hardship in high altitude snow fields. 12.5 per cent harvesters think that terrain and climate of harvesting sites are more challenging during stay for collection of caterpillar fungus. The logistics for harvesting period and threats for wildlife in the remote alpine meadows is also an intense problem for the harvesters (Fig. 12).

3.6. Perception of traders on demand and supply

Most of the traders believed that demand for caterpillar fungus has been rising but supply is continuously declining. Results also revealed that 66.67 per cent of traders think that international demand for caterpillar fungus has increased in last five years whereas 16.67 per cent believed that it has decreased (Fig. 13). Regarding the supply, 83.33 per cent of the traders assumed that supply has declined whereas 12.50 per cent felt there has been no change in its trend (Fig.14).

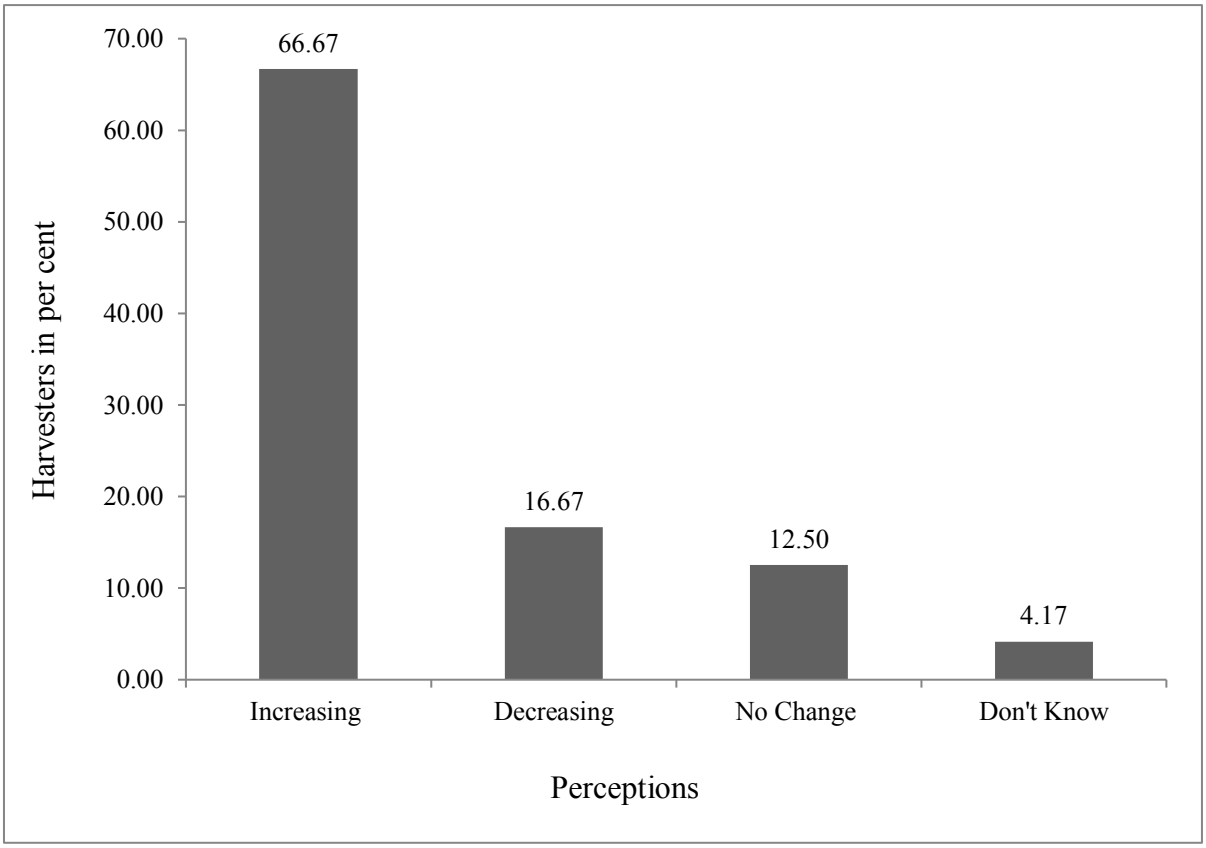

Figure: 13. Perception of traders on international demand of caterpillar fungus

The results of this study revealed that caterpillar fungus harvesting has become an integral part of livelihood of the community within a decade after its harvesting and trade has started in the landscape. Generally, market value of the NTFPs differs largely and price structure varies between markets, investment of time in collection and accessibility of markets from

harvesting sites (Shrivastava et al., 2010). In case of caterpillar fungus, prices do not seem to be determined by harvesters, rather are decided by restricted numbers of traders and international markets. Some harvesters of caterpillar fungus felt that transparency in price structure and information about international price would allow them to be able to make self-assessment and decisions on their selling trend.

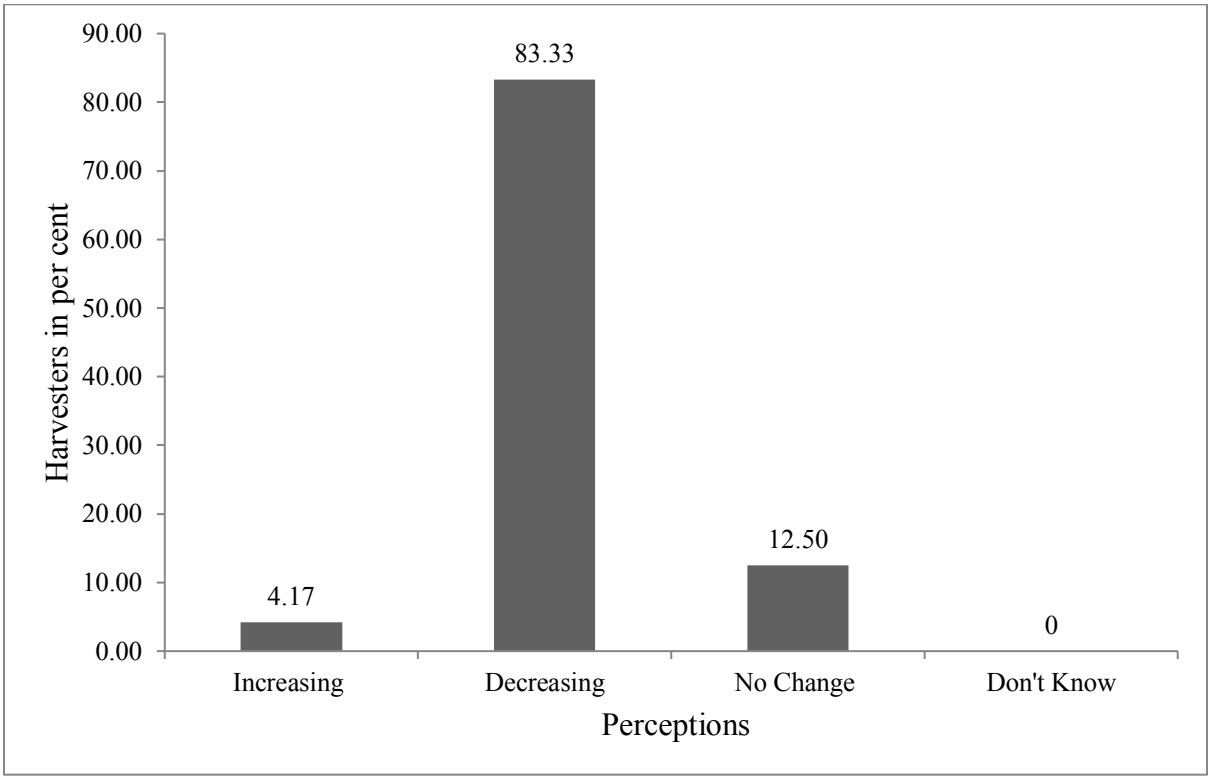

Figure: 14. Perception of traders on supply of caterpillar fungus

The results of this study also demonstrated that abundance and sustainability of the harvest have decreased whereas ease of harvesting has become difficult during the last five years in the study area. The reason might be due to incresing numbers of harvesters and collection intensity that pose a huge anthropogenic pressure on the study species as well as its habitats. In recent years, studies carried by Stone (2008) and Shrestha and Bawa (2013, 2014); Negi et al. (2015); Wangchuk et al. (2015) on caterpillar fungus' harvesting challenges across its habitats in alpine meadows (Nepal, Bhutan, China, and India) also indicate the vulnerability of habitat destruction and the risk of caterpillar fungus extinction. Some other studies *i.e.* Shrestha and Bawa (2014); Woodhouse et al. (2014), Winkler (2009) and Stone (2008) also pointed out that over-harvesting is one of the primary causes of decline in the population of the species. Studies conducted by Negi et al. (2014 and 2015) and Sharma (2004) in the Dharchula-Munsiari region conclude that since it was discovered by the villagers in that area, a massive exploitation has occurred which is resulting in a drastic decrease in populations of caterpillar fungus. During the investigation of the present study, there was a widespread concern among harvesters and traders that current trend of harvesting is unsustainable and the species had become scarce due to over-exploitation and degradation of habitats.

Chapter: 4. Stakeholders: Challenges and Opportunity

4.1. Community – Livelihood transformation

The greater Himalayan region is source of livelihood for many hill communities. Since the notification of the area (the Nanda Devi region) as a protected area in 1982, the complexities over common property resources and traditional livelihoods have increased. The Bhotiya community (Fig. 15) historically had trade relations with Tibet, apart from some small scale businesses. In lower altitude, farming was restricted to pulses and cereals. On the other hand, villages at relatively higher altitude were involved in sheep herding and woollen enterprises (ICIMOD, 2006). Post the Indo-China conflicts, the trade to Tibet ceased completely, and the primary livelihood of the area was restricted to subsistence agriculture, herding and woollen products. Gradually, the recognition of the area as a mountaineering getaway provided alternative livelihood to the villages.

Figure: 15. Bhotiya women making woollen threads to be used to make clothes

Following the notification of the area into a protected area (national park), herding and mountaineering were barred in the core zone, resulting in loss of a significant source of revenue for the communities living in the area. This led to resentment among communities in several villages, especially those near the core zone. Subsequently, the area falling under the national park was designated as the core area of the Nanda Devi Biosphere Reserve. In order to address the loss of livelihood due to closure of core zone, several activities under the Man and Biosphere Programme were launched (ICIMOD, 2006). In 1998, a massive protest against restrictions over forest resource broke out, leading to entry of several villagers into the core zone. Following this, the government agencies implemented concerted actions to address people centric issues, including issuing a declaration of community based eco-tourism and conservation of bio-cultural diversity. In 2003, a new policy to allow regulated tourism with community participation was implemented.

The impact on community has been culturally and economically transformational. There has been an immense loss of traditional knowledge that served livelihood needs, including

livestock diversity and production of woollen bags. The prosperous history of the community transformed into impoverished incomes, indicative of times after regulations were implemented. The human-wildlife interface issues have also increased, especially damage to subsistence crops by wild animals. With the loss of traditional income, people began exploring other means of livelihoods. These included small scale pastoralism in high altitudes and collection of NTFPs, primarily collection of medicinal plants, maintaining apple orchards and farming of potato. The growing search for addressing livelihood issues, led to the exploration of caterpillar fungus in the area, the economic importance of which was informed to the community, by labourers from Nepal, who worked on temporary wages with some households. The harvesting of the fungus in the alpine meadows of the region and higher economic returns led to the establishment of an informal trade regime in the region.

4.2. Opportunity and challenges for the stakeholders

The fungus is harvested by very poor mountain dwellers and sold for an extremely high price. In recent years, the price of the caterpillar fungus has continuously increased and has become the main income source for local farmers and herdsmen. Due to high market value, the income from caterpillar fungus harvesting has improved local food security, providing a much-needed economic safety net, and has generated employment opportunity for thousands of the people in this region. The lucrative income from caterpillar fungus is resulting in a visible increase, in terms of number of harvesters and intensity of harvest. Over the last decade, communities from the study area of the Biosphere Reserve were found to have become perceptive to the economic potential of caterpillar fungus. Thus, the caterpillar fungus harvest-boom is facilitating the integration of rural upper Himalayan households into greater economic cycles by providing the necessary product and cash in exchange for sharing in this commodity trade. This is causing significant distortion to local economies, and there is widespread concern that the current collection rate is unsustainable. The temptation arising out of easy money has resulted in exploitative harvesting of the species may lead to a sharp decline in its production over the years.

The villagers who harvest caterpillar fungus in the Nanda Devi Biosphere Reserve belong to marginal community, who were historically shepherds, porters, traders and hunters. Woollen handlooms and beverage production are the traditional cottage industries of the region. Investigation for socioeconomic contributions (Fig. 7) of caterpillar fungus among mountain dwellers illustrate that stream of cash income to harvesters from these gold rushes caused a far-reaching revolution in economic conditions in the last 12-15 years. Just a couple of years after initiating harvesting of caterpillar fungus, the households' income from its trading during the month of June, July and August has increased tremendously. Now people utilize this money for their children's education, family healthcare and daily needs for whole year. Furthermore, they do not have to rely completely on agriculture, which again is dependent on rainfall and affected by crop depredation by wild animals. Thus, the income derived through the collection and trade of this precious fungus has led to empowerment of marginal communities, often living in extremely remote locations, who used to secure their survival only through pastoral and agricultural activities. Furthermore, the cash influx has led to a

commoditization of local production and services. Farming or herding services are getting ignored due to the newly available cash resources from the caterpillar fungus.

Figure: 16. Poor logistics is representing challenges for the harvesters in the alpine meadows

There is also a dark side to the caterpillar fungus harvesting. In addition to braving harsh climates (Fig. 16) for finding caterpillar fungus, its rarity means that there is no guarantee that a collector will find it, even in several attempts. Some villagers return empty-handed, despite weeks of hardship in high altitude freezing temperatures, often falling sick. People often return to the village with snow-blindness, painful joints, and problems of breathing. In the past, community disputes mostly occurred over grazing rights. These days, villagers mostly fight over access to caterpillar fungus, sometimes escalating into violence. Thousands of villagers go for mass-collection of the species each year, along with their tents, food, other consumables and domestic animals. These huge aggregations in the remote pastures are bound to destroy the pristine nature of the ecosystems and the threatened species that inhabit them. Local people and ecologists alike have been complaining about the sharp decline in the abundance of the caterpillar fungus as well as the destruction of the habitats in the concerned areas within a span of a few years. Ultimately, increasing trade-induced over-harvesting seems almost certainly responsible for declining populations of the caterpillar fungus, which needs to be assessed more scientifically.

4.3. Anthropogenic pressure in the meadows

The caterpillar fungus and its associated habitats are facing many ecological and anthropogenic threats (Annexure-I, Plate-2). Goats, cows, mules and horses of the harvesters were gazing in the pristine pastures (Fig. 17).The associated habitats of caterpillar fungus (alpine meadows) of the landscape support a high degree of endemism and habitats for rare, endangered and threatened Himalayan species such as Snow Leopard (*Panthera uncia*), Blue Sheep (*Pseudois nayaur*), Aconite (*Aconitum heterophyllum*), Brahmakamal (*Saussurea obvallata*) and Costus (*Saussurea costus*). Direct degradation of habitat may be caused by caterpillar fungus harvesters through widespread digging of alpine meadow turf and consequent grassland degradation particularly if uprooted turfs are not replaced; extensive cutting of alpine shrub for fuel, dumping of large amount of trash in alpine pasture and open defecation may contaminate water sources of the landscape.

Figure: 17. Harvesters' camps and cattle in alpine pasture during harvesting season

During collection period, threats like over grazing, chopping of trees for fire-wood, increased human population in alpine pastures may have a negative impact on caterpillar fungus and the environment. Ground-dwelling birds, charismatic mega-fauna and vegetation composition might be also affected by anthropogenic activities. Degradable and non-degradable garbage in the surrounding of the base camps of harvesters can be noticed in the area. Currently, there is no management practice to mitigate or reduce generated garbage during stay of harvesters in the meadows, which may affect the pristine quality of the habitat.

Chapter: 5. Policy and Trade

Trade of caterpillar fungus has become one of the major income sources for mountain communities in Ophiocordyceps range countries (Bhutan, China, India and Nepal). It has led to over exploitation, related environmental challenges and disputes among harvesters. Although governments of different countries have made efforts from time to time for better harvesting, management of the species, policies and regulation for collection and trade.

5.1. Bhutan

The Government of Bhutan had prohibited collection and sale of caterpillar fungus before 2004. In 2004, the Bhutanese government created a new policy to regulate collection and sale of caterpillar fungus (Wangchuk et al., 2012). The policy allowed local people to obtain harvesting permits against a nominal fee. In order to prevent over-exploitation of the species, a limited harvest regime was deployed, which included prohibition on collection except during the month of June and only one member from each of the permitted households was allowed for collection (Cannon et al., 2009). To prevent overexploitation of the species, harvesting guidelines have been revised many times. Until 2007, only one person from a household was allowed to collect caterpillar fungus, which was revised in 2008 allowing all members from a household to collect. But from 2009 onwards, a new rule was enforced, allowing only three persons from each household to collect the commodity (Wangchuk and Wangdi, 2015).

The caterpillar fungus can be sold by the collectors at legally administered auction centres to Bhutanese buyers. In order to cover the costs of the auction process and support enters other environmental protection programmes; the government imposes a 4.9 per cent levy on sales (Cannon et al., 2009). The process facilitated competition and also provides transparency to the harvesters, who due to poor education have little knowledge about the actual market value of the harvest. In order to provide legal protection, caterpillar fungus was enlisted in schedule I of Forest and Conservation Act-1995 of Bhutan. Although a large proportion of the species occurs within protected areas, where the conservation and protection legislation is applicable, the numerical strength of the front line forest stuff is inadequate to prevent unregulated harvest.

5.2. China

China is the main market for caterpillar fungus. It is also by far the largest collector of the species in the region. In China, caterpillar fungus has been officially classified as a drug in the Chinese Pharmacopoeia since 1964, and listed as an endangered species under the second class of state protection since 1999 (Li et al., 2011). The harvesting of the species is de jure forbidden from protected areas. However, authorities of the nature reserves apply adaptive management strategies for harvesting of caterpillar fungus. This includes the allocation of collection areas to communities based on their traditional land use strategies and the control

of harvesters from outside, triggering self-policing of the resource by the local people (Weckerle et al., 2010).

5.3. Nepal

Nepal's Forest Act 1993 and Forest Regulations 1995 are the main legislations to protect medicinal plants including caterpillar fungus. The collection, use, and sale of caterpillar fungus were started in 1987-1988; however it was only legalized in 2001, with the provision of revenue of 20,000 Nepalese rupees per kg to the government. In 2006 the revenue amount was reduced to 10,000 Nepalese rupees per kg (Shrestha and Bawa, 2013). After the ban was lifted, the caterpillar fungus became one of the most sought after commodity in the natural medicine sector of Nepal. Under the current management regime, the caterpillar fungus is an open access common pool natural resource. The government is generating substantial revenue from the trade, which occurs mostly in unprocessed form. Thus the collection and trade is economically beneficial for both the local people and the Government of Nepal. As such there is no control over number of harvesters resulting increasing pressure on this resource. In recent time the collection of caterpillar fungus per unit per person has declined due to a large number of people getting involved in this process (ICIMOD, 2014).

5.4. India

In India, the sale of caterpillar fungus was not regulated by law, until the recent state government guidelines, which led to smuggling/illegal trade of the caterpillar fungus to Nepal and China. In order to address the problems associated with unregulated trade, the State Government of Uttarakhand, by declaring the species as an NTFP on the basis of the Indian Forest Act, 1927, has issued certain guidelines on the collection and trade of caterpillar fungus from reserve forests through village level forest councils (*Van Panchayat*), while commercial exploitation from wildlife sanctuaries and national parks is completely prohibited. The principal features of the various guidelines issued by the Forest Department time to time are as follows (as reviewed by the team members from various letters/documents obtained from the Forest Department of Uttarakhand):

- Collection should be done from May to July.
- The *Van Panchyat/ Gram Panchyat* (village council) is the authority for issuing permits for collection/harvesting of caterpillar fungus by the concern villagers.
- Each collector has to pay Rs. 1,000 per 100g of collected caterpillar fungus to the *Van Panchyat/ Gram Panchyat* for one harvesting season. The Forest Department buys the produce at Rs. 50,000 per kg.
- The traders/buying agencies are approved by the Forest Department.
- The Forest Department is authorised for issuing the transition pass to the trader/buying agency.

Legally prohibited sites (protected areas: National Parks and Sanctuaries) in reality remain open to all for harvesting of caterpillar fungus because access is not restricted strictly and government rules are not enforced (Negi et al., 2015). On top of all this, ambiguities and

complexities remain as there is no single policy of the Government pertaining to the trade and harvest of caterpillar fungus in India.

5.4.1. Trade in India

The trade chain starts from the harvesters' villages of the NDBR and is destined toward international markets, primarily China, where the demand is fuelled by the utilization of caterpillar fungus as an ingredient in traditional medicines. The trade in caterpillar fungus occurs through following channels:

a. Regulated

- The collectors sell produce through a village council/*panchayat* system.
- The village *panchayat* sells the produce to buyers authorized by the forest department at a fixed price.

b. **Unregulated** (Sharma, 2004, Negi et al. 2014 and personal interviews with the locals)

- The field harvesters collect the harvest from collection sites (NDBR). The field harvesters often work under a primary gatherer in the nearby village.
- The primary gatherer serves as an agent to the contractor, mostly situated in *Joshimath* and the border town of *Dharchula*.
- *Dharchula* serves as a porous border between India and Nepal which is also used as a transit location for other forms of trade between the two countries.

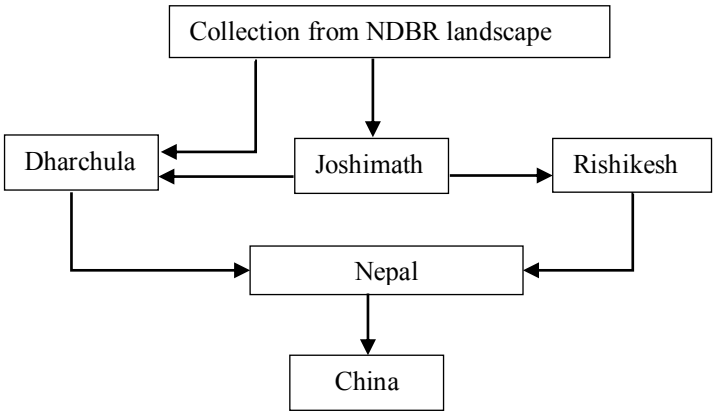

Figure: 18. Indicative trade route of caterpillar fungus from the NDBR

Due to low profitability and absence of a formalised institutional setup the villagers in the NDBR landscape are involved mostly in unregulated trade. The rising prices, owing to increase in demand, result in over-exploitation of species in their habitats. The impact of trade on natural populations needs to be scientifically assessed for Ophiocordyceps range countries (Bhutan, China, India and Nepal) and only a few studies have documented this relation (Cannon et al., 2009; Shrivastava et al., 2010; Shrestha and Bawa, 2013; Wangchuk and Wangdi, 2015).

Policy to promote sustainable harvesting and conservation of the species require sufficient knowledge on ecological status, harvesting pattern and legal status. Without this knowledge, it is highly likely that policy decisions will become difficult and impending conflicts more complex to resolve. Therefore, intensive surveys, involving a longer research period and human resource are also needed to assess species status in natural habitat, price scale escalation at various levels and the socio-economic linkages of stakeholders at each level. The economic valuation of the habitat, vis-à-vis the economic potential of the species may lead to mainstreaming of collection and trade in sound policy decisions and setting up a legal trade regime, that caters to conservation of species, without affecting the nature of the common property resource which is vital to economic viability in the region. There is also a need to take initiatives by the Ophiocordyceps range countries (Bhutan, China, India and Nepal) to create a forum with international political, bureaucratic and scientific communities for evolving a common international holistic policy for conservation, sustainable harvesting and trade of caterpillar fungus.

Chapter: 6. Education and Outreach Programme

One of the main objectives of the project was to spread environmental awareness to create common platform among stakeholders and sensitization about the issues associated with the harvest and trade of caterpillar fungus in the Himalayas and the species' conservation. This objective was followed by a number of educational and outreach programmes (Annexure-I, Plate: 3) in different villages spread throughout the study area. The team targeted different groups of people for these activities and put a special emphasis on making young people, especially school students, environmentally aware. The team discussed on various issues ranging from the harvest and trade of the caterpillar fungus of different Ophiocordyceps range countries (China, Bhutan, India and Nepal) till the public opinion on possible policy solutions for addressing various challenges in the Indian context. These discussions and other activities can be broadly categorised into the following points,

Figure: 19. Conducting outreach programme among stakeholders

a. **Popularisation of the project purpose and activities (Fig. 19, 24 and 25):** We put emphasis on telling people about our project objectives and planned activities during the project period and beyond. Examples of the topics discussed include, socio-economic assessments, anthropogenic pressure on the species and its environment, market and trade issues, medicinal importance of the species and its various usage,

environmental and pollution issues, ecological studies on the caterpillar fungus and its habitat, challenges during harvesting period, and the possible conservation and sustainable management measures for the long-term benefit of the people and the species. On the start of every discussion, we tried to convey these to the general mass on layman-terms for the popularization of the project and to generate local support to carry our work forward. The audience almost always were found to be very keen to listen to us and enquired about many points that we were making during our talks among them.

Figure: 20. Conducting meeting with stakeholders to educate about conservation of the species

b. **Sensitization of harvesting and trade pattern in Ophiocordyceps range countries (Fig. 20, 24 and 25):** During our many group-discussions and talks, we briefed the local people about the harvesting pattern, management of harvesting and trade policies of caterpillar fungus of different Ophiocordyceps range countries. People were found to be especially interested about these systems in the countries of Nepal and Bhutan, where the collection as well as trade of the species was legalised by the governments and there exist one or the other form of management for the harvesting of the caterpillar fungus. The people were keen to know in detail about the open auction systems followed in the countries of Bhutan and Nepal, and the say of harvesters in deciding the selling rate of the harvest and the harvesting systems

followed there. The people attending these discussions were sensitized about the usefulness of the sustainable harvesting and management practices, which most of the people agreed with.

Figure: 21. Conducting outreach programme with harvesters in alpine meadow of the NDBR

c. **Conservation and climate change issues associated with the caterpillar fungus (Fig. 21):** The team made it a point to discuss and sensitise people about the conservation and climate change issues that are associated with the unsustainable harvest and trade of caterpillar fungus. The discussions were also initiated to know people's views on the need for conservation of this natural commodity and their solution to address the challenges that are associated with the decrease in the production of the species as well as the climate change issues.

d. **Conflict issues and problems faced during harvest and trade (Fig. 21):** The team enquired, while doing outreach programmes, about the challenges and problems faced by the harvesters during the collection period. They were also asked about existing conflict issues among themselves and with the administration/forest department while doing harvesting or trade of the species. The audience told us about many of the challenges/problems they face, like, various health issues, the risk of accidents in tough terrains, weather issues and natural calamities like snow-storm and heavy rains, the shortage and occasional unavailability of food and fuel, the lack of proper protective clothing/shoes and tents, the boredom during the monotonous collection days due to the lack of entertainment and mobile connectivity etc. They were then sensitized about the possible solutions of these issues through mutual exchange of ideas.

Figure: 22. Conducting educational programme among school children of the NDBR

e. **Environmental awareness including habitat pollution (Fig. 21, 24 and 25):** The team also emphasised on environmental awareness among the harvesters as well as the general public. People were encouraged to be more environment-friendly and less polluting while visiting the alpine meadows or collecting caterpillar fungus. They were asked to minimize the use of plastic and bring back the non-biodegradable wastes from the meadows while returning to their village after the collection period is over. They were also asked to prepare small ditches near their camps to dispose the biodegradable wastes including food remains and human wastes, and cover the ditches with soil and stones before finally ending the season's activities in the meadows.

f. **Policy discussion (Fig. 19, 20 and 21):** The policies regarding the harvest and trade of caterpillar fungus in different countries (Bhutan, China and Nepal) and India were discussed in the outreach programmes. The audience were asked for their opinions on possible policy solutions for the caterpillar fungus in India.

g. **Popularization and educational programmes among young people/students (Fig. 22, 23 and 24):** The team conducted a number of educational programmes in schools within the harvesters' villages. The students were told about the life cycle of caterpillar fungus, the general biodiversity of the Himalayas, the biodiversity of the

Uttarakhand state, conservation, environmental protection, pollution and its control. Popular quiz contests were also held to make the young people more environmentally aware and to motivate them towards the conservation of biodiversity. During conversation section of the programmes at schools, students told us, that most of them go for caterpillar fungus harvesting during collection season (in months of May to July). They also mentioned that it is a great opportunity for them because the collection period of *Kira Jari* (caterpillar fungus) falls in the summer school break. They enjoy a lot with their friends and get more caterpillar fungus due to their better eyesight as compared to older people. They also shared challenges they faced about food, shelter, fragile mountain and fast changing weather during the collection period. During discussion period the teachers and the students asked many questions like; what is the use of caterpillar fungus? Why is it so valuable? Why caterpillar fungus is decreasing day-by-day? How could it be conserved? Why medicines from caterpillar fungus are not prepared in India? We gave answers to all these questions according to our knowledge.

Figure: 23. The project team with students during leaflet distribution in the NDBR

During different outreach programmes, the team has also discussed about collection pattern, status of species, route of trading, price in national and international market, reason for conflict among communities, challenges during stay in meadows and existing policy. During the discussion, stakeholders appeared worried about over harvesting and extinction of species in the future. Many harvesters were not happy about the policy of the state government on harvesting and trading of caterpillar fungus. During different outreach programmes with stakeholders, the team initiated group discussions on how mountain dwellers could move towards sustainability and management of caterpillar fungus in future and why conservation is so significant of this Himalayan gold (caterpillar fungus).

Figure: 24. Harvesters with banner after outreach programme

After conducting many outreach programmes during our field days in the Nanda Devi Biosphere Reserve, we have realised that education and outreach activities are crucial tools to spread environmental/conservation awareness among general mass and to gain popular support for the smooth-running of field-based projects like ours. By taking notes on these experiences, we have been motivated to put special efforts in all of our future projects for outreach activities, and by them encourage people to be more responsible for the survival of caterpillar fungus, sustainability of the trade and the protection of the beautiful and fragile alpine meadows in their areas. The outreach activities, we firmly believe, have the power to minimize conflict issues among different stakeholders and sensitise them about useful government policies for the betterment of the people and the conservation of the species. Our goals in future would thus be to conduct as much of these activities as possible and to make outreach a major part of our projects. For policy recommendations, it was also felt by the team that there should be workshops/group-discussions to debate on the possible policy ideas of the stakeholders at the ground level as well as the ideas of the team members.

Chapter: 7. Conclusion and Recommendations

Rising demand and trade for caterpillar fungus has led to increased pressure on its habitat and populations. The caterpillar fungus is a vital natural resource for generating income and acts as an economic commodity. Given the heavy dependency on the caterpillar fungus, a decline in harvest rate or price would be potentially catastrophic for the community. Likewise, conservation regulations (such as blanket ban on access to alpine meadows) would be affecting income of the mountain dwellers. The money generated from this trade has been attracting a huge number of people to the pristine meadows of the mountains who are threatening the survival of the caterpillar fungus along with the destruction of its habitats. These habitats also support many rare, endangered and threatened Himalayan species, which are falling into direct conflicts with the harvesters due to the various activities during the collection process.

Present study concludes that the fungus population and per-capita harvest is decreasing continuously. It is also found that abudance and sustainability of the harvest have decreased and ease of harvesting has become difficult in last five years in the study area. The reasons may be over harvesting, ecological threats due to anthropogenic pressure and climate change, however, a proper scientific investigation is required to establish such facts. The lure of easy money has resulted into aggregation of enormous ecological threats for the species in the landscape and leading to a sharp decline of caterpillar fungus from in its natural habitat. All these threats together are suspected to lead the local extinction of this species. Therefore, to address such issues, there is an intense thrust of long-term field studies on conservation challenges and impacts of anthropogenic pressure on the ecology of this species in its natural habitat.

The regulation of rampant exploitation and implementation of scientific sustainable harvesting should be carried out for the survival of the species and to conserve pristine alpine meadows. Government policies should be formulated and implemented subsequently to integrate conservation, livelihood and governance for this species in the region. Thus, the holistic management of the caterpillar fungus should be preferable not only for conservation prospective but also for economic well-being of the indigenous communities. This study also recommends that there is a need for extensive outreach and educational programmes to develop local capacity for sustainable harvesting and spread awareness about the environmental causes among the stakeholders. However, the communities seemed to be open to these ideas but were very less aware of them, which were causing the pollution and ecological threats as observed by the surveying team at the harvesting sites.

In India, legislation exists pertaining to the conservation of indigenous plants and other natural resources but there are a lot of gaps in the implementation. Due to legal issues, caterpillar fungus' harvesting and trade are marred with risks; many times, conflicts with local administration and forest department switch into detentions of harvesters and traders. The legal issues are not only about being challenged to harvest the natural resources but

harvesters and traders also get into conflicts among themselves due to the breaching of trust regarding the payment of the money.

On top of all this, an ambiguity and complexity remain as to the legality of caterpillar fungus on harvesting and trade in India. Illegal collection and trade across the border to China and Nepal is well known but the extent of the illegal harvest and trade has never been estimated so far. Such an investigation is also highly recommended so that the potential of this leakage could be estimated and could be channelized through legal measures. It would be very beneficial if the guidelines for extraction and trading in caterpillar fungus are worked out in consultation of ecologists and stakeholders rather than demanding blanket ban on extraction which will abstain the communities from the most potent source of their income.

During discussion with harvesters, majority of harvesters believed that a ban of harvesting for alternative years or rotational harvesting in different pasture, regulation prices, protection of habitat including solid waste management and control of cattle grazing would be helpful for sustainable management for the species. This approach may be adopted in protected areas under the supervision of forest managers and would be a great initiative for conservation and sustainability for caterpillar fungus.

Moreover, a scientific exploration is very much needed to examine the occurrence and status of the caterpillar fungus throughout its distributional ranges in the NDBR so that a strategy for its conservation and sustainable harvesting can be formulated after consulting all stakeholders. There is a lack of awareness among the local people about the sustainable use of the resources and alternative livelihood opportunity that pertains to the increasing dependency on caterpillar fungus. Sustainable harvesting and holistic management of the caterpillar fungus may play a key role in increasing investment for education, improving food security and alleviating poverty of the local communities.

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Plate 1 - Different field activities

Plate 2 - Anthropogenic pressure

Plate 3 - Education and outreach programmes

Plate 4 - Disseminating project findings through different conferences

"चलो दीदी, चलो भैय्या
सब मिलके जंगल बचालो"। (Come sister, come brother, let us save the forest together).

"चार दिन की सहेली मत बनी रहना,
उम्र भर की सहेली बनो, जंगल की रक्षा करो"। (Do not remain friends just for four days, become friends for life and save the forest).

- Chipko Movement Song (1974)

Funding

CONSERVATION LEADERSHIP PROGRAMME

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Centre for Integration of Conservation and Developmental Accountability
Aranya Vihar, Kaulagarh, Dehradun,
Uttarakhand, India-248195
E-Mail: cicada.info@gmail.com