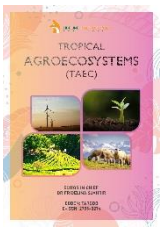
ZIBELINE INTERNATIONAL™ PUBLISHING

ISSN: 2735-0274 (Online)
CODEN: TARGDB

Tropical Agroecosystems (TAEC)

DOI: http://doi.org/10.26480/taec.01.2024.41.46



RESEARCH ARTICLE

YARSAGUMBA (*OPHIOCORDYCEPS SINENSIS*): UNVEILING THE HIMALAYAN FUNGUS – AN EXTENSIVE EXPLORATION OF CLIMATE RESPONSES, PHYTOCHEMICAL PROFILING, ECONOMIC DYNAMICS, CHALLENGES, AND FUTURE PATHWAYS

Samarth Bista[a,b], Anjela Adhikari[a,b], Priyanka Kumari Chaudhary Kalwar [a,b], Abhishek Raut[a,b]

[a]College of Natural Resource Management, Pakhribas, Dhankuta
[b]Agriculture and Forestry University
[*]Corresponding Author: Samarth Bista bistasamarth@gmail.com

ARTICLE DETAILS

Article History:

Received 23 September 2024
Revised 18 October 2024
Accepted 04 November 2024
Available online 08 November 2024

ABSTRACT

In the breathtaking Himalayan landscapes, amidst towering peaks and lush valleys, lies a natural wonder captivating the realms of traditional medicine, ecology, and economics: Yarsagumba, the Himalayan fungus (*Ophiocordyceps sinensis*). This fungus, often referred to as the "Himalayan Gold," thrives in high-altitude environments between 3,500m to 5,500m above sea level. Its unique life cycle involves a symbiotic relationship with the larvae of ghost moths, resulting in the formation of a rare caterpillar-fungus fusion. Yarsagumba holds significant cultural and economic importance, particularly in traditional medicine and local economies.

Yarsagumba's unique habitat and cultural importance set the stage for a detailed examination of its various aspects, encompassing climate sensitivity, phytochemical composition, economic contributions, challenges faced, and potential future trajectories. This review aims to shed light on its multifaceted aspects. This paper provides a comprehensive exploration of Yarsagumba, a unique Himalayan fungus that has garnered significant attention for its medicinal properties and economic importance. The study encompasses a detailed analysis, investigating the intricate interplay between Yarsagumba and its environment, elucidating the fungus's responses to climate variations and ecological factors. The phytochemical profiling of Yarsagumba reveals a diverse array of bioactive compounds, including polysaccharides, nucleosides, fatty acids, sterols, and proteins, which contribute to its medicinal properties. Furthermore, the paper discusses the medicinal properties of Yarsagumba, emphasizing its role in traditional medicine and its potential therapeutic benefits. Yarsagumba's unique properties make it a promising candidate for various health applications.

In addition to its ecological and medicinal importance, Yarsagumba plays a pivotal role in the economic dynamics of mountain communities, where it serves as a crucial source of income for local harvesters and traders. However, the commercial exploitation of Yarsagumba presents various socio-economic challenges, including resource depletion, conflicts over harvesting rights, and market fluctuations. The paper also takes a stroll through the socioeconomic landscape, unraveling how Yarsagumba serves as a lifeline for local communities and influences regional economies.

Addressing these challenges requires a multidisciplinary approach that integrates ecological conservation, socio-economic development, and sustainable management practices. This abstract highlight the need for collaborative efforts among policymakers, researchers, local communities, and conservation organizations to devise effective strategies for the conservation and equitable utilization of Yarsagumba resources.

Looking ahead, the abstract discusses potential future pathways for Yarsagumba research and management, emphasizing the importance of scientific innovation, community empowerment, and policy support. By fostering a holistic understanding of Yarsagumba and its intricate relationships with climate, ecology, economy, and society, this abstract aims to inform evidence-based decision-making and facilitate sustainable development in the Himalayan region and beyond.

1. INTRODUCTION

Yarsagumba is a unique and valuable fungus found in the Himalayan region, particularly in Nepal and Tibet. The caterpillar fungus *Ophiocordyceps sinensis* (syn.† *Cordyceps sinensis*), which was originally used in traditional Tibetan and Chinese medicine (TCM), is called either "yartsa gunbu" or "DongChongXiaCao *(Dōng Chóng Xià Cǎo)*" ("winter worm-summer grass"), respectively (Lo et al., 2013).

'Tsa' means grass, 'kuhun' means winter, 'yar' means summer, and 'bu' means insect in Tibetan, alluding to the peculiar life cycle of Yarsagumba, which is a combination of plant and insect. In Nepal, it is called as Keera ghaas (insect herb). When parasitic mushroom spores infect and mummify

Quick Response Code	Access this article online	
	Website: www.taec.com.my	DOI: 10.26480/taec.01.2024.41.46

Cite The Article: Samarth Bista, Anjela Adhikari, Priyanka Kumari Chaudhary Kalwar, Abhishek Raut (2024). Yarsagumba (Ophiocordyceps Sinensis): Unveiling the Himalayan Fungus – An Extensive Exploration of Climate Responses, Phytochemical Profiling, Economic Dynamics, Challenges, and Future Pathways. *Tropical Agroecosystems, 5(1): 41-46.*

a ghost moth larva dwelling in the earth, a rare caterpillar-fungus fusion known as Yarsagumba takes place. A slender fungus emerges from the deceased caterpillar host's head, reaching a height of two to six centimeters above the soil. This distinctive growth serves as a small, finger-shaped marker for harvesters seeking the world's most valuable biological resource commonly called biological gold. This enigmatic organism, born from the intricate dance between a parasitic fungus and its caterpillar host, has sparked widespread interest due to its unique ecological niche, potent phytochemical composition, and socioeconomic significance. Yarsagumba flourishes in the scenic heights of the Himalayas, thriving at altitudes ranging from 3000 to 5000 meters in Nepal, China (Tibet), India, and Bhutan (Harvey, 2014).

Yarsagumba, a parasitic fungus endemic to the Himalayan region, plays a pivotal role in traditional medicine and local economies. In Nepal, as the Yarsagumba harvesting season unfolds, one can observe groups of people ascending the snowy peaks of the Himalayas. Laden with blankets, tents, and cooking supplies, these groups comprise individuals departing from their villages. Entire communities undergo a temporary exodus, with schools closing their doors, and only the elderly and unwell remaining behind due to the challenging and arduous ascent to altitudes reaching thousands of meters above sea level. The entire population mobilizes to participate in the profitable pursuit of Yarsagumba during this annual harvesting period. Understanding the intricate relationship between Yarsagumba and its climatic environment serves as a crucial foundation for comprehending its ecological dynamics and forecasting potential impacts in the face of climate change.

Table 1: Name Given to Yarsagumba in Different Languages (Mishra and Upadhyay, 2011)

Different Languages	Name
English	Cordyceps mushroom, Caterpillar fungus
Nepali	Yarsagumba, Jeebanbuti, Sanjivani, Kiraghas
Hindi	Keeraghas, Keedaiadi, Keedaaghas
Sanskrit	Sanjivani
Tibetian	Yarchagunbu
Japanese	Totsukasu, Tochukasu
Chinese	Hiatsao tong tchon dong chong xi cao

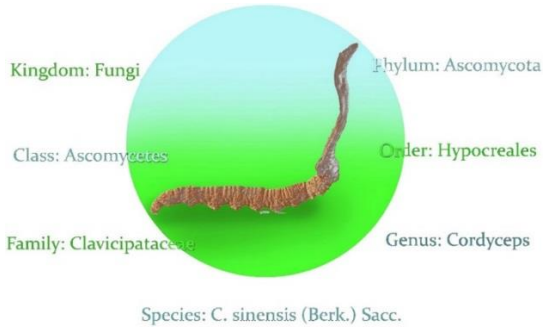


Figure 1: Characteristics of Yarsagumba

2. LIFECYCLE

Yarsagumba (*Cordyceps sinensis* or *Ophiocordyceps sinensis*) is a fungus that parasitizes ghost moth larvae and produces a fruiting body prized as herbal medicine (Sen et al., 2023).

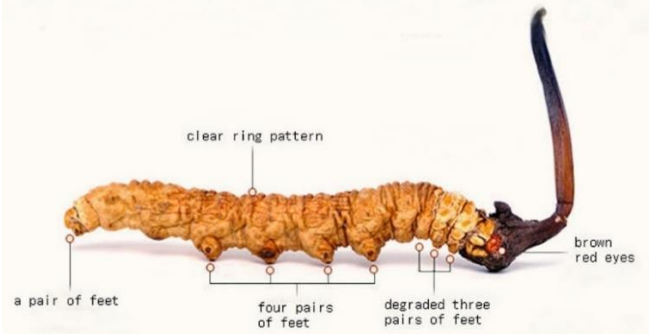


Figure 2: Bodies of Yarsagumba. (Jag Bahadur Budha, 2021)

During the summer and early autumn, mature fruiting bodies of Yarsagumba release millions of ascospores in the air which infect the larva and germinate inside its body. Thus, the life cycle of Yarsagumba needs one year to complete (Chakraborty, Sudipta et al., n.d.). Live caterpillars are used to germinate the fungus. Infected insects lift their heads upward from earth tunnels toward the surface. Fungal stromae grow from the caterpillars' mouths and extend above ground when they die. This allows the ascospores to disperse (Koirala et al., 2017).

Fungal cells spread through the larva's body, which then buries itself vertically in the soil. During winter, the fungus consumes the larva's organs, leaving only the exoskeleton. The fungal cells transform into dormant endosclerotium, surviving harsh conditions. In spring, the endosclerotium germinates, extruding through the larva's head, reaching the soil (Sen et al., 2023).

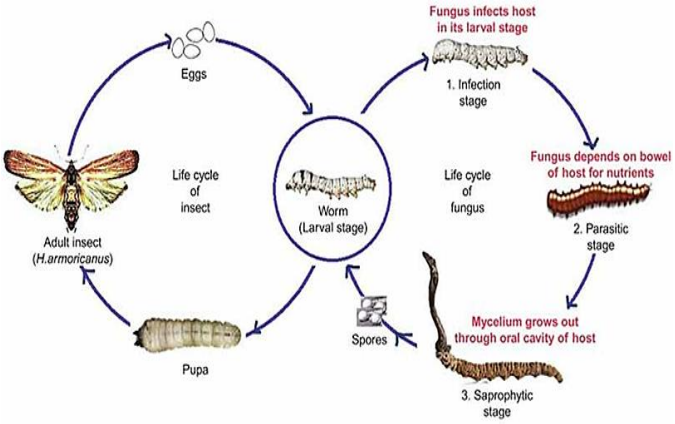


Figure 3: Lifecycle of Yarsagumba (Chakraborty, Sudipta et al., n.d.)

3. CLIMATE CHANGE AND YARSAGUMBA

According to the UN, Climate change refers to long-term shifts in temperatures and weather patterns. These shifts may be natural, but since the 1800s, human activities have been the main driver of climate change, primarily due to the burning of fossil fuels (like coal, oil and gas), which produces heat-trapping gases. According to the data from the International Centre for Integrated Mountain Development (ICIMOD) and RPC 4.5 climate model, Dolpa district of Nepal had an average annual temperature of -2.7°C in 1990. By the year 2000, it had increased to -2.45°C and as of 2023, it stands at around -2.1°C. Based on this trend, it is projected that by around 2043, approximately 20 years from now, the temperature in Dolpa could decrease further to around -0.9°C. This increasing temperature indicates a warmer winter which affect the growth and longevity of Yarsagumba. A warmer winter doesn't favor the optimal growth of Yarsagumba fungus. The fungus that incubates in the permafrost layer of the soil relies on a certain temperature range. As temperature rise due to climate change, the permafrost layer starts melting, affecting the fungus incubation process. The term permafrost refers to a place where the temperature remains at or below -0°C on the ground. Furthermore, precipitation has also a significant impact on the collection and cultivation of Yarsagumba. The destruction caused by changing temperature, environmental factors and climatic conditions directly influence the growth and availability of Yarsagumba. The process of "fungal fruiting" is the most crucial aspect in the formation of Yarsagumba and it is also susceptible to the negative impacts of climate change. This is because Yarsagumba requires a specific level of moisture for its growth, which is not provided adequately by insufficient precipitation.

Climate change and overharvesting from nature have put Yarsagumba at risk of extinction. And it is sad to note that the Government of Nepal does not have worked out any provisions for conservation of this valuable HCHM biodiversity. Villagers who once collected 150 to 200 pieces of the fungus in a month are now hardly finding 10-30 pieces. Various reports have indicated that climate change may be one of the major reasons for this decline. The regions where the fungus normally grows have experienced lower levels of snow fall and rain fall as well as higher temperatures for the past few years (Rajbhandari, Binayak, 2019). A 2018 research titled 'The demise of caterpillar fungus in the Himalayan region due to climate change and overharvesting', an analysis of multiple evidence-based approaches using data spanning nearly two decades and four countries, revealed that caterpillar fungus production is declining through much of the Himalayan range (Kafle, 2021).

3.1 Phytochemical profiling

The renowned entomogenous fungus, which thrives in the harsh conditions of the alpine nival zone across the Trans-Himalayas and Tibetan Plateau, has formed a symbiotic relationship with the larvae of the *Thitarodes* (Hepialus) insect.

This unique ecological niche has facilitated the accumulation of a distinct array of metabolites within the fungus, encompassing proteins, nitrogenous compounds, polysaccharides, sterols, nucleosides, fatty acids and their derivatives, vitamins, and various inorganic substances. In the realm of traditional Chinese medicine, this fungus stands as a revered cornerstone, featuring prominently as a key constituent in numerous therapeutic formulations aimed at addressing a broad spectrum of human health maladies (S. Shrestha et al., 2013).

Pharmacologically active components of *Cordyceps* remain unknown, at least two chemical constituents; cordycepin (deoxyadenosine) and cordycepic acid (mannitol) have been identified and suggested as being the active compounds in improving lung function and increasing energy levels and sex drive. Its main application is for treating exhaustions, respiration and pulmonary diseases (i.e., tuberculosis, asthma), renal, liver and cardiovascular diseases, back pain and sexual problems (i.e., lack of sex drive, premature ejaculation) (Zhu et al., 1998).

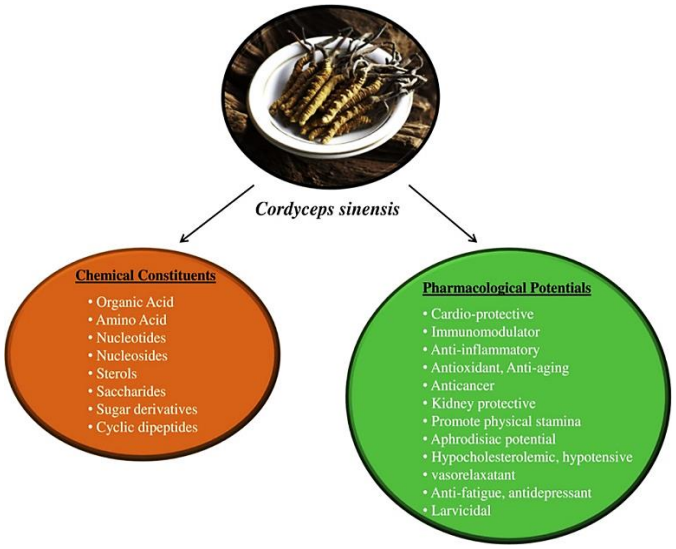


Figure 4: Active components of Cordyceps (Sen et al., 2023)

Yarsagumba, also known as *Cordyceps sinensis*, contains a diverse array of active phytochemicals, including organic acids, phenolic acids, amino acids, various nitrogenous compounds, nucleosides, nucleotides, fatty acids, sterols, and polysaccharides. These compounds exhibit various pharmacological actions, contributing to the medicinal properties attributed to yarsagumba. Nucleosides, particularly cordycepin (3′-deoxyadenosine), are considered major active constituents of yarsagumba with significant roles in cancer therapy and antiviral treatments.

Cordycepin and other nucleosides found in Yarsagumba have been studied for their neuroprotective effects, demonstrating potential benefits in managing focal cerebral ischemic or reperfusion injury and myocardial infarction. Cordycepin has also been reported to possess immunity-regulating, analgesic, broad-spectrum antibacterial, antiviral, and insecticidal activities, further highlighting its therapeutic potential.

Adenosine, another important nucleoside present in yarsagumba, exhibits various activities such as energy transfer, signal transduction in cells, cytoprotection, anti-inflammatory properties, and anticonvulsant effects. Adenosine monophosphate (AMP), a precursor of adenosine in Yarsagumba, plays a role in cellular processes and is converted into inosine, which also exhibits pharmacological activities.

Yarsagumba contains nucleotides such as adenosine-5′-monophosphate, uridine-5′-monophosphate, and guanosine-5′-monophosphate, which contribute to immune response enhancement, fatty acid metabolism, iron absorption promotion, and gastrointestinal injury repair.

Moreover, Yarsagumba is rich in biologically active polysaccharides, both intracellular and extracellular, which have been studied for their antioxidant, anti-tumor, immunoprotective, anti-influenza virus, hypocholesterolemic, and hypoglycemic properties. Specific polysaccharides, such as CPS-1 and CPS-2, exhibit antioxidant activity and inhibition of cell proliferation, indicating their potential therapeutic benefits in managing conditions like blood glucose levels, renal failure, and platelet-derived growth factor-induced cell proliferation.

Furthermore, Yarsagumba contains sterols and glycosidic derivatives, including ergosterol and H1-A, which have been studied for their roles in vitamin D synthesis and autoimmune disease management, respectively.

The fungi also produce various protease enzymes, including a novel acid deoxyribonuclease and serine protease with fibrinolytic activity, as well as polypeptides such as cordymin and cordycedipeptide-A, which exhibit cytotoxic activity against cancer cell lines.

Overall, the diverse array of bioactive compounds present in Yarsagumba underscores its potential therapeutic value and highlights the importance of further research to elucidate its mechanisms of action and clinical applications (Sen et al., 2023).

Chemical constituents-

Table 2: Chemical constituents and their corresponding pharmacological actions of *C. sinensis* (Liu et al., 2015)

Chemical Constituents of *C. sinensis*	**Pharmacological effects**
Cordycepin	Anti-inflammatory effect Analgesic effect Stimulates steroidogenesis Enhances immunity Antitumor activity Antibacterial, antivirus and insecticidal activities
Adenosine	Anticonvulsant activity Inhibits cancer cell growth Anti-inflammatory effect
EPSF	Immunomodulatory effect Antitumor effect Antioxidant effect
APS	Antioxidant effect Immunomodulatory effects
CPS-1	Antioxidant effect
CPS-2	Inhibits cell proliferation
Mannoglucan	Cytotoxicity activity
CME-1	Antioxidant effect
Cordyglucans	Antitumor effect
CS-F10	Hypoglycemic activity
Cordysinocan	Induces cell proliferation
Ergosterol	Cytotoxicity Antimicrobial activity
H1-A	Immunoregulator
CSDNase	Hydrolyzes DNA Nucleolytic properties
CSP	Fibrinolytic activity
Cordymin	Antidiabetic
Tryptophan	Sedative hypnotic effect
Cordycepic acid	Treating liver fibrosis diuretic Improving the plasma osmotic pressure Anti-free radical
Monosaccharide saponins	Antitumor activity

4. Medicinal Properties

Yarsagumba is widely used as a part of traditional medicine in China and it is very popular in several Southeast Asian countries (Chakraborty, Sudipta et al., n.d.).

It is important to mention that the genus Cordyceps contains many bioactive compounds with different biological activities, and one of the best described is cordycepin (Tuli et al., 2014).

Its health benefits have been re-cognized from more than 1,500 years ago. The Yarsagumba is largely used for brain and body nourishment furthermore to improve the immune system (Gupta and Manvitha, 2017). It is used as a reno-protective, anti-inflammatory, anti-metastatic, and neuroprotective agent (Das et al., 2021).

Yarsagumba has been traditionally used for various health conditions, including immune modulation, energy enhancement, and sexual vitality.

Recent research explores its potential in treating pulmonary hypertension due to its anti-inflammatory, vasodilatory, and antioxidant effects (Luitel et al., 2020).

Yarsagumba is utilised as an antitumor agent to cure tumours since tumour disorders are widely recognised as a major cause of death for humans (Zhou et al., 2009).

The high value low volume Yarsagumba (*Ophiocordyceps sinensis*) is one of the important Medicinal fungi harvested by local communities in mountainous part of Nepal as a treatment for a variety of ailment, as a reputed curative for many diseases, anti-ageing, hypoglycemic, aphrodisiac and also treatment against cancer (Meena et al., 2010).

4.1 Cordyceps Medicinal Properties

First off, Yarsagumba's therapeutic benefits were first identified in China around 2000 years ago. Particularly the *Cordyceps sinensis* species, is an exceptional dietary supplement and medicinal fungus that is a significant source of material in Traditional Chinese Medicine (Seth et al., 2014).

It has been shown that Yarsagumba can be used to treat conditions such as hyposexuality, night sweats, hyperglycemia, hyperlipidemia, arrhythmias, and other heart, respiratory, renal and liver diseases (Gupta & Manvitha, 2017).

To be more specific;

Cordyceps is very much effective against the liver patients, including those with viral hepatitis A, chronic hepatitis B, chronic hepatitis C, hepatitis fibrosis, etc (Liu & Shen, 2003).

Ergothioneine has been found to protect the kidneys by lowering oxidative stress and inflammation (Pao et al., 2012).

Clinical trials on cancer patients have been conducted in many Asian countries, showing talented results in reducing tumor size (Elkhateeb and Daba, 2020).

Cordycepin has shown antiviral activities against different viruses such as plant viruses and human viruses (influenza virus,epstein-Barr virus, murine leukemia virus) (Ryu et al., 2014).

Cordyceps sinensis has potent antioxidant and anti-aging properties (Yamaguchi et al., 2000).

Cordycepin and adenosine can improve aerobic capacity and reduce tiredness by increasing oxygen intake and utilization by the cells (Geng et al., 2017; Song et al., 2015)

Yarsagumba is well known as Himalayan Viagra. Human clinical trials have similarity demonstrated the effectiveness of *C. Sinensis* in combating decreased sex drive and virility (Chen et al., 2016).

Yarsagumba has been shown to modify neurotransmitter levels such as dopamine and serotonin, which are involved in mood and energy regulation (Geng et al., 2017).

5. Present Scenario

In these high alpine regions, where Yarshagumba is collected, the governance systems have had a difficult time in recent decades adjusting to these changes and putting in place and enforcing management mechanisms for the sustainable collection of the species (Cannon et al., 2009; Winkler, 2009). Governance systems that include both official government agencies and unofficial community management structures now impact the collection.

According to the research, the governance structures for resources in isolated mountain regions, with a particular emphasis on yarshagumba gathering (Wallrapp et al., 2019). The legal and social contexts of the two locations in which these systems are compared in the Kailash Landscape are the Api Nampa Conservation Area (ANCA) in Nepal and the Kumaon area of Uttarakhand State in India. In Nepal, in contrast, Yarsagumba collection and sale in all community forests and conservation areas is legal, but conflicts regarding access between villagers and distant collectors are common. The demand and prices for medicinal and aromatic plants have increased over the last decades. Like Yarsagumba, most of them are collected in the wild by local populations in isolated locations rather than being grown (Uprety et al., 2016).

The case study demonstrates the ability of people and governments to adjust to shifts in the value of their resources (Wallrapp et al., 2019). We find that in isolated alpine places, where resource values are rising quickly, neither people nor governments can guarantee good governance. In order to ensure that innovative approaches reach the policy level (vertical integration) and can spread across administrative boundaries (horizontal interaction), a link must be made during learning processes between the amendment of actions (single-loop learning), in our case initiated by communities, and the revision of the formal policies and the frame (double-loop learning). To achieve appropriate adaptation and innovative, context-specific learning processes, a complex and complementary resource governance framework made up of governmental institutions and communal management systems is needed.

6. Market Trends

The significant revenue generated by Yarsagumba in Nepal reflects its economic importance as a non-timber forest product. The income from Yarsagumba serves as a vital source, contributing to local food security, acting as a safety net, and creating employment opportunities in the region. Yarsagumba stands out as the most lucrative non-timber forest product in Nepal, constituting 41% of the total revenue from such products in 2011. Its collection, occurring from late spring to early summer, draws significant attention due to exploding market demand and substantial price hikes. The collection season, typically from the second week of May to the end of July, involves around 35,000 people in the highland pastures of Darchula, raising concerns about sustainability. (Thapa et al., 2014)

Harvesters are being recruited at a quick rate since the market's growing demand and sharp price hikes. There is a general concern regarding the sustainability of the current harvest rates. Every year, in the summer months of June and July, about 35,000 people come together in the highland pastures of Darchula to harvest and earn fungal money (Cannon et al., 2009; Shrestha et al., 2012; U. B. Shrestha and Bawa, 2013; Liu et al., 2015). Among the best places to gather Yarsagumba is Dolpa, an isolated county in western Nepal with high, steep slopes and a dry climate. Merely the Dolpa district provides over half of the yearly supply of Yarsagumba. Here, in quest of the gold rush, not just adults but also schoolchildren take unofficial holidays (Rajbhandari, Binayak, 2019). It is not entirely unexpected that there is competition for choosing Yarsagumba. Its potential contribution to the yearly household income from Yarsagumba collecting surpasses that of other conventional streams of income, such as agriculture and cattle. Performing this for a little over a year, they can provide for a family for an entire year. This implies that harvesters are willing to risk their lives because they perceive the opportunity costs of engaging in Yarsagumba collecting as being low (Winkler, 2009). There is an absence of recent data and very little study on Yarsagumba's impact on harvester households.

In Nepal's mountainous areas, the harvesting of Yarsagumba adds to the advancement of new cultural trends. The majority of Yarsagumba collectors are traditionally farmers, but as a result, farming has taken a backseat to other activities (Negi, 2007). Almost all socioeconomic activity stops during the harvest season: social life is badly impacted, government offices in these hilly districts become less functioning, and schools are shuttered (Shrestha and Bawa, 2013).

Numerous villagers from distant regions travel to tall mountains in May and June of each year to gather Yarsagumba. Many Nepalese households may not have the monthly income to match the estimated Rs. 2,500 that a villager can make picking Yarsagumba in a single day. Up until 2001, it was forbidden to collect Yarsagumba in Nepal. However, due to the plant's widespread appeal and the efforts of several groups, the government of that country removed the prohibition, albeit with a Rs. 20,000 royalties attached. The price of one kilogram of Yarsagumba, which was around Rs. 315 in 1992, rose to Rs. 105,000 in 2002. Due to the increased interest in this enigmatic "medicine" that is half mushroom, half caterpillar (HCHM), the price has been skyrocketing internationally (Rajbhandari, Binayak, 2019).

7. Legal and Regulatory Framework

7.1 Shared resources and ecologically sound administration

a. Common Pool Resources: It is challenging to keep common pool resources like grazing areas and forests out of service as they are subtract able.

- When incentives for sustainable consumption are absent, the issue of collective action in resource management is made worse.
- Access and usage should be restricted by regulations in order to manage these resources responsibly.

b. Dynamic Social-Ecological Systems:

- Constant adaptation and reaction are necessary to keep up with changes in social-ecological systems.
- Changes in social-ecological systems demand constant adaptation and responses.
- Sudden changes can be triggered by external factors or internal factors.
- Changes can trigger power struggles and conflicts.

c. Government rules, private property rights, and local management are some of the governance systems that are seen to be most appropriate for resource sustainability.

- Governmental actors face challenges in enforcing regulations due to limited resources or resentments.
- Local communities can manage common pool resources effectively, but face challenges when sudden changes occur.

7.2 Adaptive Capacity and Governance Systems

- In order for players to deal with unforeseen changes, governance systems promote creativity, learning, adaptability, and collaboration.
- The ability of a resource governance system to modify procedures and adjust structural components in reaction to societal or environmental changes is known as adaptive capability.
- Learning involves actors experimenting with creativity up until they run into limitations and new frontiers through an exploratory, step-by-step search process.
- (Pahl-Wostl, 2009) created an analytical framework to examine several social learning phases in systems of resource governance.
- Single-loop learning, which is gradual learning, and triple-loop learning, which is structural change, is examples of multi-level and multi-loop learning processes. Single- and double-loop learning both include adaptive change processes.
- Institutions and players, the interaction between state and non-state actors, and governance systems are important components for these learning processes.

The following table 3 states a clearer picture of the regulatory framework.

Table 3: regulatory framework (Pant et al., 2017)

Policies and regulations	Major focus	Line agencies under Ministry of Forest and Soil Conservation
Herbs and Non-Timber Forest Products (NTFP) Development Policy 2004 (HNCC 2004)	• Calls for private sector participation in NTFPs development • Emphasizes local processing • Stresses conservation and preservation of high value herbs and NTFPs and as well as regulations on the amount to be harvested each season	Department of Plant Resources
Government of Nepal Gazette 2016 (GON 2016)	• Allows users to collect Yarsagumba by paying NRP 25,000/kg	Ministry of Forest and Soil Conservation
Conservation Area Management Rules 1996 (GON 1996)	• Calls for the management of conservation areas through a community-based approach • Provides communities the right to manage the area through the development of village management plans	Department of National Parks and Wildlife Conservation
Community Forestry Directive 1995 and Community Forestry Development Programme Guidelines 2008 (DOF 1995; DOF 2008)	• Government retains ownership of forest • CFUG holds the right to use and make management decisions • CFUG develops 5-year operational plan and annual plan, which need approval of government authority • Government approves any sale outside	Department of Forests

8. Conclusion

Yarsagumba stands at the intersection of tradition, science, and economic value. As we explore its multifaceted dimensions, we must balance conservation efforts with harnessing its therapeutic potential. Future research should delve deeper into its mechanisms of action and clinical applications. With this in mind, the paper paints a picture of the future, suggesting collaborative pathways for research, conservation, and sustainable management. It envisions a harmonious blend of scientific understanding, traditional wisdom, and community cooperation. Ultimately, this review serves as a guide, advocating for the delicate balance needed to preserve Yarsagumba's charm, ensuring both ecological resilience and the prosperity of the communities it touches.

Moving forward, it's clear that sustainable management practices are essential for ensuring the longevity of Yarsagumba resources. By engaging both scientific knowledge and local wisdom, we can chart a course that respects the ecological integrity of Yarsagumba habitats while supporting the livelihoods of those who depend on it.

Ultimately, the journey towards responsible Yarsagumba utilization calls for collaboration and innovation across various sectors. Through collective effort and thoughtful stewardship, we can harness the potential of Yarsagumba to benefit both the environment and the communities it sustains.

In conclusion, this research underscores the urgent need for holistic management strategies to ensure the sustainable utilization of Yarsagumba resources. By integrating scientific insights with community engagement and policy interventions, we can navigate the complex terrain of Yarsagumba harvesting, fostering socioecological resilience and equitable development in the Himalayan region

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