The Geographic Base
Vol. 7: 65-78, 2020
Doi: 10.3126/tgb.v7i0.34272
Nepal Geography Student Society, CDG, TU

Yarsagumba Collection Trend and its Impact on Livelihood of People of Bajhang District in the Context of Climate Change

Narendra Bahadur Singh[*,1], Dipak Khanal[2] and Laxmee Bhandari[3]
[1]Institute of Agriculture and Animal Science, Gauradaha Agriculture Campus, Nepal
[2]Institute of agriculture and Animal Science, Pakhlihawa Campus, Nepal
[3]Gokuleshwor Agriculture and Animal Science College, Baitadi, Nepal

***Corresponding email:** iaassingh2010@gmail.com

Received: 18th May, 2020 **Accepted:** 26th November, 2020

Abstract

Yarsagumba is anendoparasitic fungi growing on insect larvae found in high Himalayan region of Nepal which is very expensive and better income source of local peoples. The study was conducted randomly selecting 80 households of two rural municipalities namely Talkot and Saipal who are involved in yarsagumba collection to assess the impact of yarsagumba on livelihood of local people of Bajhang district. Surveyed result revealed that climate change has highly affected harvesting of yarsagumba. Its selling price is affected by market value fluctuation. Yarsagumba play the significant role in livelihood of the local peoples. From the surveyed data comparing last five year (2068 to 2072) shows that, the highest income was found to be NRs. 139,200 per household per season in the year 2068. The market price, trade and marketing channels of yarsagumba are unclear and commercial trading takes place illegally because of fear of being charged higher taxes. The temperature and humidity play an important role on abundance and formation of yarsagumba. The study showed that 43.8% respondent's perceived change in temperature and rainfall pattern over 10 years, and 73.7% respondents perceived that temperature and rainfall affected on yarsagumba collection.

Keywords: Climate change, farmer's income, livelihood, Yarsagumba.

Introduction

Yarsagumba (*Ophiocordyceps sinensis Berk)* is a special type of Ento-Patho creature known as "Summer grass - Winter insect", in which *Cordyceps* spp. of endoparasitic fungi grow on insect larvae during monsoon (Mishra and Upadhyay, 2011). It is Tibetan in origin and found in high Himalayan regions, i.e., both insect and fungi survive at high altitude (3,300-5,000 masl). Over a dozen of species of Hepialid moths (including eight species of Thitarodes, in which the *Ophiocordyceps* fungus grows) have been reported from Nepal (Thapa, 1998; Adhikari, 2008). Robinson (2000) reported its distribution and occurrence in China, India, Bhutan, Russia (Far East), Japan, Myanmar, Taiwan and it occurs in twenty alpine districts of Nepal (Neupane, 2013). Over the past few years, global average temperature has increased by 0.85^{o}C from 1880-2012 is expected to increase by a minimum of 0.3^{o}C– 1.7^{o}C (RCP 2.6) to a maximum of 2.6^{o}C–4.8^{o}C (RCP 8.5) by the end of this century (Shrestha & Bawa, 2014). About 6.02% (8,989 km^{2}) area of the Nepal Himalaya is suitable for Chinese caterpillar fungus habitat. However, all future climate change trajectories over three different time periods, the area of predicted suitable habitat of Chinese caterpillar fungus would expand, with 0.11–4.87% expansion over current suitable habitat (Shrestha & Bawa, 2014).

Yarsagumba is collected by large numbers of people every year (Ueda, 2000). The regular collectors are the inhabitants of mountain region, it is a major source of income for livelihood of many people residing in remote high Himalayan regions. The main season of harvesting starts from June-July and ends by August. The harvesting season in some district starts with their own local time of collection, norms and culture, which is very interesting to survey, study and find the significance of Yarsagumba collection and livelihood in the context of climate change, snow melting and shifting collection to higher elevation.

Yarsagumba is very expensive and is of paramount economic importance as the main income source of rural people in many high Himalayan alpine districts. It is believed to cure sexual impotency and known as 'Himalayan Viagra'. It is mainly used in medicinal tonics as a source of energy. 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). Some studies also reported from research on *Ophiocordyceps sinensis*, on possible anti-tumor functioning, anti-cancer and anti-viral activities, immuno modulating, cholesterol

reducing, anti-oxidant effect and potential to increase stamina, Libido (Zhu et al., 1998; Holliday et al., 2005; Canney, 2006; Devkota, 2006).

Methods and Materials

The study was carried out in Bajhang district (Figure 1), which extends over 3422 km^2 area of Far-Western Province of the country in the month of May-June, 2016. The elevation ranges from 915 m (Deura) to 7035 m (Saipal himal). The district contains various climatic regions as sub-tropical, lower temperate, upper temperate, sub-alpine and alpine. The study was mainly focused on the northern rural municipality of Bajhang district namely Talkot and Saipal rural municipality. The details of yarsagumba collection sites of Bajhang districts are as follows (Table 1).

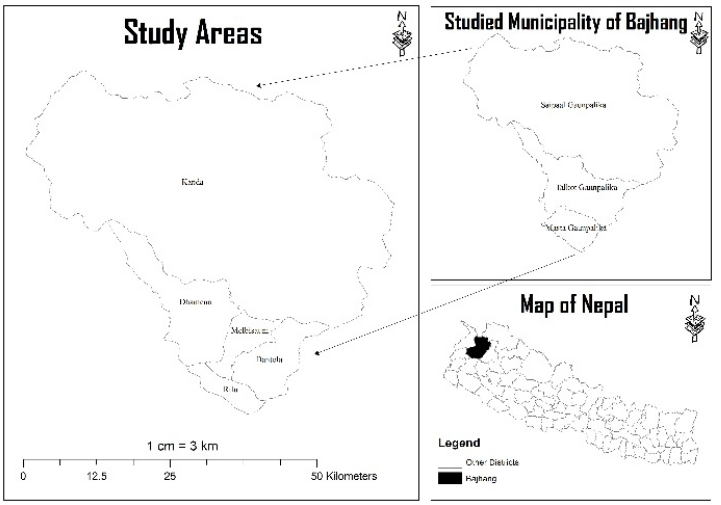

Figure 1. Study area

Table 1. Yarsagumba collection sites

S.N.	Rural municipality	Yarsagumba collection sites
1.	Saipal Rural municipality	Aula gaad, Faralkhet, Petarya, Raidhungi, Kalapaani, Kailash parbat, Thado melo.
2.	Surma Rural municipality	Surma,
3.	Talkot Rural municipality	Chirkitya, Chalyaban.

Source: Field survey, 2016.

Various sources and technique were used for collection of necessary information. Semi-structured questionnaires were prepared, pretested in periphery of study area, then questionnaires were improved and finalized. The interview schedule was administered to the 80 respondents to collect primary information from two rural municipalities. The in-depth information on the various aspects of impact of climate change was collected

through face-to-face interview. The major variables include in interview were the socio-economic characteristics, livelihood options, farmers perception and trend of yarsagumba harvesting. The secondary data were collected from different publications, research papers, and other sources. Some additional information also been gathered from District Agriculture Development Office (DADO), District Forestry Office (DFO), Central Bureau of Statistics (CBS), Ministry of Agriculture Development (MOAD), Village Development Committee (VDC), and local leaders regarding their local arrangement and norms of collecting/selling of yarsagumba. Other information was taken from local traders, porters. One focus group discussion was conducted in the study area and it was verified the result obtained from field survey. In the FGD, participants were farmers, both male and female and from all the ethnic groups residing locally. Thus, collected data were coded, entered in Micfrosoft Excel spreadsheet and analyzed by using SPSS version-20 software package. The output of analysis was presented in forms of table and figures and findings were interpreted with relevant literatures.

Results and Discussion

Farmers knowledge regarding Yarsagumba

The study showed that all respondents knew about the yarsagumba and they easily identified the time of harvesting. But they didn't know detail information about its biology. Most of the people considered yarsagumba as insect. The study revealed that majority of the respondents obtained information from friends/neighbor/self-experience (67.5%), followed by media (26.2%), government office (3.8%) and NGOs (2.5%) (Table 2). During the survey, most of the farmers expressed their response about yarsagumba as high value medicinal insect.

Table 2. Source of information regarding Yarsagumba

Source of information	Frequency	(%)
Government office	3	3.8
NGO	2	2.5
Media	21	26.2
Friends	54	67.5
Total	80	100

Source: Field survey, 2016.

Yarsagumba is a combination of caterpillar and fungus. In direct observation it looks partly like caterpillar and partly like plant. Out of total respondents, 83.8% said that it was an animal (insect) and 16.2% said combination of both plant and animal (Table 3). It was locally known as '*Kira*' which means insect. From this study, it was clear that majority of people believed that it is an insect. Yarsagumba has two components: the

lower part (underground) is dead caterpillar (insect) and the upper part is herb (fungus developed). The meaning of yarsagumba is 'summer-grass winter-worm' in their Tibetan language. Yarsagumba with both the caterpillar and fungal part in an intact single piece is an item of commerce (Mishra and Upadhyay, 2011).

Table 3. Respondents views on life form of Yarsagumba

Life form	Frequency	(%)
Insect	67	83.8
Fungus	0	0.0
Both	13	16.2
Total	80	100

Source: Field survey, 2016.

Life cycle and possibility of artificial cultivation

The households' perception on life cycle and artificial cultivation of yarsagumba were presented in Table 4. Majority of the collectors (95%) did not have any idea about the lifecycle of yarsagumba. Most people believed that it is gift of god for local people. Five %age of the respondents had little knowledge on its lifecycle pattern. According to them, it was in the form of insect initially but later on developed in plant form, and so it was combination of both insect and plant. No collectors, traders and even forest technicians working in Bajhang district had detail idea on lifecycle pattern of yarsagumba. In summer or early autumn, the mature fruiting bodies releases the millions of spores on to the ground and infest the host larvae during winter. Thus, the life cycle of yarsagumba needs one year to complete (Chakraborty et al., 2014).

Out of total respondents, 3.8% said that there was a possibility of artificial cultivation of yarsagumba but majority of respondents (96.2%) said that it could not be cultivated artificially. Therefore, both larva as well as fungus was equally important. Robinson (2000) reported that there is no cultivation practice of yarsagumba and knowledge on cultivation is also unknown in Nepal till now. The fungus grows on the caterpillar during monsoon (rainy season). As the spores of the fungus terminate and grow on a living caterpillar, the caterpillar eventually dies. The life cycle of host moth takes five to seven years to complete its life cycle and produce the natural product (IUCN, 2000). Yang et al., (2009) reported that yarsagumba can be reared in artificial condition and larvae only takes 1-1.2 years to complete. Based on the previous literature, the developmental rate of eggs seemed to 86.75% under conditions of relative humidity 50% and temperature 15^{o}C (Liu et al., 2009).

Table 4. Respondents' knowledge on life cycle and artificial cultivation of Yarsagumba

Response	Respondents view	Frequency	(%)
Idea about life cycle	Yes	4	5
	No	76	95
	Total	80	100
Idea on probability of Artificial cultivation	Yes	3	3.8
	No	77	96.2
	Total	80	100

Source: Field survey, 2016.

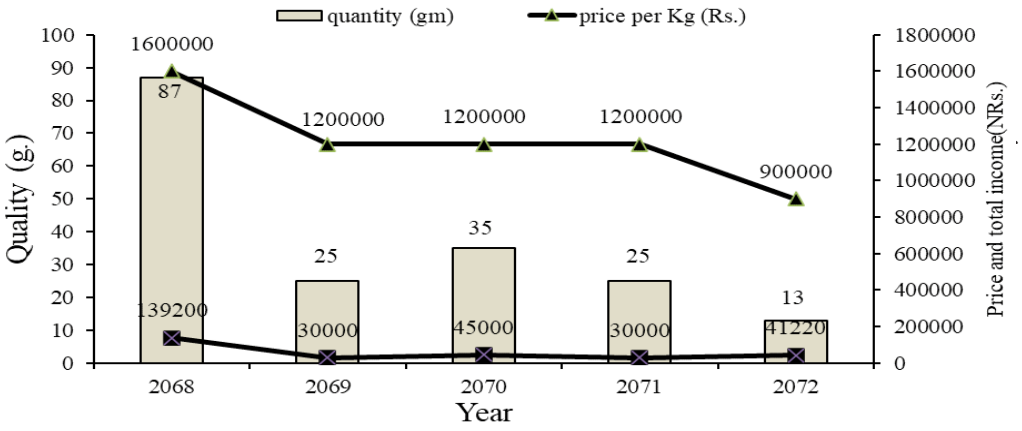

Figure 2. Economic analysis of Yarsagumba for last five years, 2016

Theper kilo gram price of yarsagumba was decreasing in manner from 2068 (2011) to 2072 (2015) at local level. The highest price was reported in 2068 (2011) i.e Rs. 1,600,000 then it was decreasedin 2069 (2012) and remained constant up to 2071 (2014) and it was again decreased with Rs. 900,000 per kilogram in 2072 (2015). From the surveyed data, the highest income was found to be Rs. 139,200 in the year 2011 due to highest production and good market price of yarsagumba. Both production and income from yarsagumba increased in the year 2013 but in the year 2015, the production decreased whereas incomes of the farmers increased.

In Nepal, trade of yarsagumba started since 1988. The price of yarsagumba in the initial year was very low. The price of Yarsagumba was NRs 700 per kg (Rs 2-3 per piece) in 1988. Since then, the price of yarsagumbahas been continuously booming which reached to NRs. 2,500,000 per kg in Kathmandu in 2015 (Chhetri, 2015). The illegal collection amount is highly significant, which is not recorded in government database. The market price, trade and channels of yarsagumba are unclear and commercial trading takes place illegally because of fear of being charged higher taxes (Banjade & Paudel,

2008). In fiscal year 2012/13, the official quantity of *O. sinensis* collected from Mustang (Annapurna Conservation Area) was less than 10 kg but more than 90 kg of *O. sinensis* had been traded from Lomanthang to Tibet (Thapa et. al., 2014). This means higher amount of yarsagumba was traded illegally.

Effect of climate change on Yarsagumba harvesting

The study showed that 43.8% respondent's perceived changes in temperature and rainfall pattern over 10 years and 73.7% respondents perceived that temperature and rainfall affected yarsagumba collection (Table 5). Chinese caterpillars' fungus (yarsagumba) distribution is assumed to be affected by winter and summer temperature and seasonality of precipitation (Shrestrha, 2014). He observed that temperature and humidity play important role in the ecology and physiology of the caterpillar fungus.

Table 5. Change in temperature and rainfall pattern and its effect on Yarsagumba collection

Knowledge		**Frequency**	**(%)**
Knowledge on change in temperature and rainfall pattern over 10 years	Yes	35	43.8
	No	45	56.2
	Total	80	100
Temperature and rainfall effect on Yarsagumba collection	Yes	59	73.7
	No	21	26.3
	Total	80	100

Source: Field survey, 2016.

Changes in different parameters of Yarsagumbain last 10 years

The perception of the respondents on yarsagumba collection, harvesting time, market value, post-harvest loss and harvesting altitude is shown in Figure 3. Majority of the respondents (55%) expressed that collection of yarsagumba was in decreasing trend followed by 26.25% respondents expressed as constant and 18.75% expressed increasing trend. In terms of harvesting time, majority of the respondents (65%) considered that there was no change in harvesting time, but 23.75%respondents considered as decreasing harvesting time in last 10 years. The majority of the respondents (46.3%) expressed that the market values was decreased followed by 20% opinioned increasing. Similarly, the majority of the respondents (50%) had perception of constant post-harvest loss followed by 40% decreasing and 10% increasing the post-harvest loss of the yarsagumba. According to farmers' perception, the harvesting altitude also changed with changing climate. Out of total respondents, 47.5% had perception of no change in altitude of harvesting area but 46.3% respondents felt increasing the harvesting area altitude.

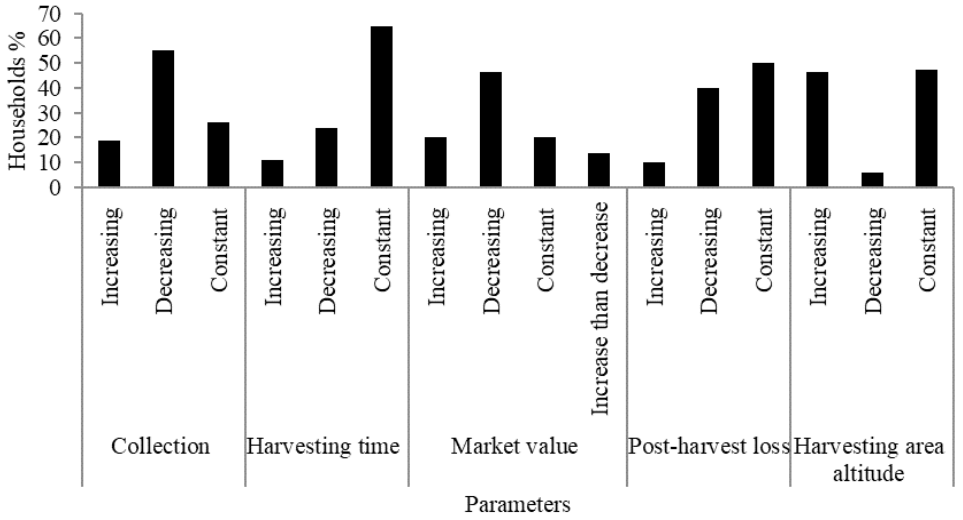

Figure 3. Trend of Yarsagumba harvesting during last 10 years

As shown in Figure 4, it is clear that the majority of respondents (42.5%) considered changes an elevation of collection area and 42.5% responded reported same elevation, i.e. no change of elevation due to climate change. Similarly, out of total respondents, about 41.3% replied decreasing the snow covering area followed by 30% responding increase in snow covering area due to climate change. Shrestha (2014) observed both increase and decrease in average elevation of the suitable habitat range of the species.

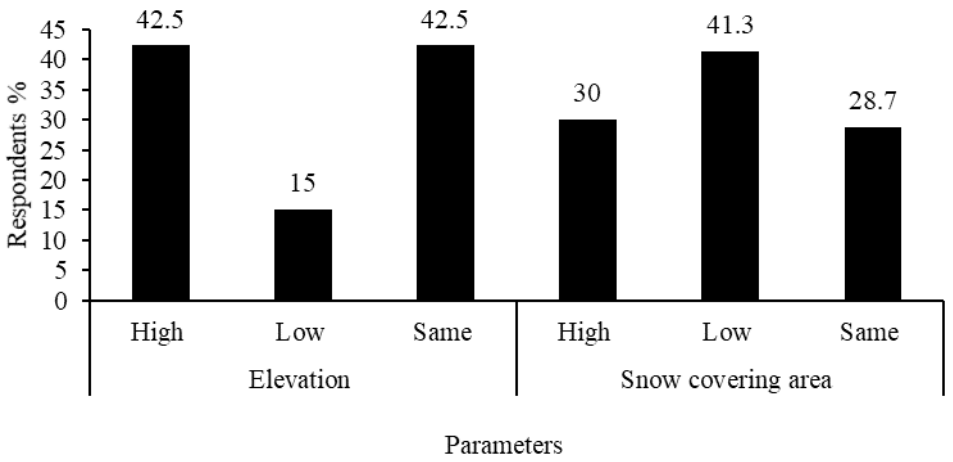

Figure 4. Change in elevation and snow covering area due to climate change

All the respondents had no idea about the temperature effect on the yarsagumba harvesting areas. It was recorded that the temperature during the sample collection in the harvesting area was -1^{o}C to 9^{o}C (average temperature 4^{o}C). The temperature of study area during collection period in 2003 was recorded 0 – 1^{0}C by ANSAB research team at Dumbling Community Forest yarsagumba Research Plot (ANSAB, 2003).

Majority of respondents (42%) considered eastern aspect as best for the highest availability of yarsagumba while 40% respondents believed that it did not play any role in the availability of the yarsagumba. According to Malla (2001) the availability of yarsagumba was higher in eastern aspect in Dolpa. According to the collectors, eastern aspect was favourable due to early sunrise and long day period, which helped in melting of snow. The fruiting body of yarsagumba developed only after melting of snow at surface level. A sunny site was preferable for yarsagumba (Zang and Kinjo, 1998).

From the collectors' experience, black colour soil proved as the best soil for yarsagumba production. Out of all respondents, 15% found best growth and development of yarsagumba in black soil and 85% respondents had no idea of soil colour in relation of growth and development of yarsagumba. The colour of soil in yarsagumba collection area of Dolpa was black (Mishra and Upadhyay, 2001).

Though collector did not have specific knowledge of the soil texture, but some collectors said sandy loam soil as good for the growth and development of yarsagumba. ANSAB (2003) reported soil texture at collection site as 50 cm depth loam black soil with low organic matter and litter and a slope of 6°. Respondents did not have any idea on soil pH and its relation with yarsagumba growth and development. According to Mishra and Upadhyay (2001), black soil with high organic matter mixed in Dolpa district. The soil pH at collection time was 7 – 7.5.

The freshly snow melted moist area was the best for the development and growth of yarsagumba as compared to dry area. All respondents considered moist area as the best for the availability of yarsagumba. As per Zang and Kinjo (1998), Yarsagumba was more abundant in the wet parts of alpine mountains while it was absent in water-lodged and marshy areas.

Farmers knowledge about use of Yarsagumba

Among the study population, majority of the respondents (73.8%) had no idea about the use of yarsagumba. They only collected yarsagumba for cash income. 26.2% of the collectors knew about the use of yarsagumba. They said that yarsagumba was used for sexual impotency and gave high energy to the human body. The major functions of yarsagumbaare 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). *Cordyceps* contains cordycepin and cordycepic acid used in improving lung function and increasing energy levels and sex drive (Zhu et al., 1998 and Holliday *et al*., 2005). Some studies also reported from research on *Ophiocordyceps sinensis*, on possible anti-tumor functioning, anti-cancer and anti-viral activities, immune-modulating, cholesterol reducing, anti-oxidant effect and potential to increase stamina (Canney, 2006 and Devkota, 2006).

Table 6. Factors affecting the total income of Yarsagumba collectors

Factors	**Cofficient**
Yarsaguma quality/size	1.33 **
Education	2.1**
Selling price	51243.22
Weather during collection	11232.1*
Expenditure during harvesting	-120.3*
Main economic sources	-4.2*
Climate change	-2120.4**
Harvesting season	1632.1
Post-harvest loss	5.2*
Problems during harvesting	-453.3
Constant	12230.9

**sig@1%;*sig@5%;sig@10%

Table 6 provides the results of multi linear regression model to determine the most critical factors that affect the total income of the yarsagumba harvesting household. Regression analysis of dependent variable annual household income was carried out on ten independent variables. Yarsagumba size/quality, HHs education, selling price, weather condition, harvesting season, post-harvest loss etc. contributed positively to the total income of the yarsagumba collectors while expenditure, main economic sources, climate change and problems during harvesting contributed positively to the total expenditure of the yarsagumba collectors.

The factors like size of yarsagumba, education status and climate change, weather condition, main economic sources, post-harvest loss was significant at 5% level. Whereas selling price, harvesting season and problems during harvesting was found non-significant. If the size of yarsagumba increases by a unit, the total income of yarsagumba collectors increases by 1.33 times and education level increases the total incomes by 2.1 times. Similarly, expenditure during harvesting, main economic sources, climate change and problems during harvesting hindered the total annual income of yarsagumba collectors. Those collectors who have favorable weather condition during

collection do have Rs. 11,232.10 more income as compared to unfavorable weather condition during yarsagumba collection (Table 6).

Table 7. Major problems faced by farmers during Yarsagumba collection

Problems	Index	Ranking
Climate change	1.977	I
Over collection	1.723	II
Increased cost of collection	1.663	III
Competition among collectors	1.521	IV
Weather fluctuation during collection	1.123	V
Unavailability of food at collection sites	1.012	VI

Source: Field survey, 2016.

Table 7 showed the major problems faced by farmers during the harvesting time. The survey findings revealed that the major problems faced were climate change, over population during collection, increase cost of collection, high risk and competition among collectors, weather fluctuation during collection and unavailability of food at collection sites. Climate change means weather condition and high population of harvesters at same time becomes one of the major problems during yarsagumba harvesting because most of the people depends on yarsagumba and all goes to high field for harvesting at a time. As a result, forest becomes destroyed, immature stages become destroyed and risk of human life is to be expired. Unfavorable environment for caterpillar growth, climate change, weather condition etc. hindered the productivity of yarsagumba. Next major problem is scarcity of food at collection sites which increases the cost of collection. The highest ranked problem was climate change with index value 1.977 followed by over collection of yarsagumba in a season with index value 1.723 and high cost of collection with index value 1.663. The least ranked problem was unavailability of food at collection sites with index value 1.012 (Table 7).

Table 8. Problem faced by farmers during selling of Yarsagumba

Problems	Index	Ranking
Market value	1.931	I
Yarsagumba availability	1.654	II
Post-harvest loss	1.534	III
National/international demand	1.443	IV
Quality of Yarsagumba	1.213	V
Monopolistic Traders	1.165	VI

Source: Field survey, 2016

Table 8 shows various problems faced by the farmers during selling or marketing of yarsagumba. The surveyed findings revealed that the problems faced by the farmers during selling of yarsagumba were market price, post-harvest loss, national and international demand, quality and monopolistic traders. Farmers of Saipal rural municipality of Bajhang district are very poor and engaged in agriculture business such as goat farming, yarsagumba harvesting etc.The problem of market value at that place was very important and a major problem with index value 1.931 followed by availability of yarsagumba with index value 1.654.

Conclusion

Bajhang district is one of the recognized or very fertile districts for production of yarsagumba. The rural people of Bajhang have more than 15 years of experience in the collection of yarsagumba. Yarsagumba was found to be most valuable cash income source of the study area. The highest income from yarsagumba was found NRs. 139,200 per household per season in the year 2068 due to highest production and good market price. Yarsagumba harvesters reveal that there are many factors which affect during yarsagumba harvesting and marketing which deteriorate the value of yarsagumba. Climate change is the major factor affecting on yarsagumba harvesting and market value affect the selling of yarsagumba. The temperature and humidity play an important role on abundance and formation of yarsagumba. Research concluded that yarsagumba play the important role in improving the livelihood of peoples of remote areas of Bajhang district. Government should focus in yarsagumba conservation and management in study area.

Acknowledgements

Authors would like to acknowledge Institute of Agriculture and Animal Science, Post Graduate Campus, Kirtipur, Kathmandu, Nepal for providing technical support to conduct this study while UNDP is highly acknowledged for financial support.

References

Adhikari, M.K. (2008). The diversity of cordycepioid fungi (Ascomycotina: Clacivicipitales) reported from Nepal. *Department of Plant Resource Bulletin* 30:1-9.

ANSAB. (2003). Non-timber forest products in Nepal. National policy workshop. *Asia Network for Sustainable Agriculture and Bioresources (ANSAB),* New Baneshwor, Kathmandu, Nepal.

Banjade, M.R., & Paudel, N.S. (2008). Economic potential of non-timber forest products in Nepal: myth or reality? *Journal of Forest and Livelihood,* 7: 36-48.

Canney, S. (2006). Ophiocordycepssinensis - animal, vegetable or both? *Journal of Chinese Medicine,* 80:43-49.

Chakraborty, S., Chowdhury, S., & Nandi, G. (2014). Review on *Yarsagumba* (*Ophiocordycepssinensis*) - an exotic medicinal mushroom. *International Journal of Pharmacognosy and Phytochemical Research* 2014; 6(2): 339-346.

Chhetri, R. (2015). *Yarsagumbapolicy, market, trade and management in Nepal.* Regional workshop on tracking options for sustainable management and trade on *Yarsagumba (Ophiocordycepssinensis)* in the Kailash Landscape Paro, Bhutan.

Devkota, S. (2006). *Yarsagumba* [(*Ophiocordycepssinensis* (Berk.) Sacc.]. Traditional utilization in Dolpa district, Western Nepal. *Our Nature,* 4:48-52.

Holliday, J., Cleaver, M., & Wasser, S.P. (2005). *Ophiocordyceps*. In: Encyclopedia of dietary supplements. Dekker Encyclopedias. Taylor and Francis Publishing, London. 1-13.

IPCC. (2013). *Climate change 2013: The physical science basis.* Contribution of working group I to the fifth assessment report of the Intergovernmental Panel on Climate Change. In: Stocker T.F., Qin D, Plattner G.K., Tignor M, Allen S.K., Boschung J, Nauels A, Xia Y, Bex V, Midgley P.M., editors. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA. 1535.

IUCN Nepal. (2000). *National register of medicinal plants.* Kathmandu: IUCN Nepal.

Liu, F., Ceng, W., & Zhang, D.L. (2009). Comparative studies on the biological character of the Hepialus introduced. *Lishizhen Med Mater Med Res,* 20:3128–9.

Mishra, R. N., & Upadhyay, Y. (2011). *Ophiocordicepssinensis*: The Chinese rasayan-current research scenario. Sagar Institute of Pharmaceutical Sciences, India.

Neupane, F.P. (2013). *Yarsagumba*: Bionomics. In: P.K. Jha, F.P. Neupane, M.L. Shrestha and I.P. Khanal (eds.) Biological Diversity and Conservation Nepalpedia Series No. 2. *Nepal Academy of Science and Technology (NAST), Kathmandu, Nepal*. 597-606.

Robinson, G.S. (2000). *A note on adult flight time of Thitarodes.* In: T. Haruta (ed.) Moths of Nepal Part 6, Tinea Vol 16 (Supplement 1). Japan Heterocerist's Society, c/o Natural History Division, Nepal Science Museum, Hyakunincho 3, Shinjuku, Tokyo, Japan. pp. 91.

Shrestha, U. B. (2014). *Impact of climate change on potential distribution of Chinese caterpillar fungus (Ophiocordycepssinensis) in Nepal Himalaya*. Department of Biology, University of Massachusetts, Boston, Massachusetts, United States of America, Ashoka Trust for Research in Ecology and Environment (ATREE), Bangalore, India.

Shrestha, U. B., & Bawa, K. S. (2014). Impact of climate change on potential distribution of Chinese caterpillar fungus (*Ophiocordyceps sinensis)* in Nepal Himalaya. *PLoS one, 9(9)*.

Thapa, B.B., Panthi, S., Rai, R.K., Shrestha, U.B., Aryal, A., Shrestha, S., & Shrestha, B. (2014). An assessment of *yarsagumba*(*Ophiocordycepssinensis*) collection in Dhorpatanhunting reserve, Nepal.

Thapa, V.K. (1998). *An inventory of Nepal's insects Vol. 2.* IUCN, Kathmandu, Nepal.

Ueda, K. (2000*). Hepialidae of Nepal. In: T. Haruta (ed.) Moths of Nepal Part 6, Tinea Vol 16* (Supplement 1). Japan Heterocerist's Society, c/o Natural History Division, Nepal Science Museum, Hyakunincho 3, Shinjuku, Tokyo, Japan. 70-93.

Yang, D., Peng, R., & Chen, J.Y. (2009). Advanced on the studies of insects of the genus *Hepialus*, the host of *Ophiocordycepssinensis* (Berk) Sacc. *The Annual Conference of Entomological Society of Yunnan Province, China* (Abstract in English and paper In Chinese).

Zang, M., & Kinjo, N. (1998). *Notes on the alpine* Ophiocordyceps of China and nearby nations. Mycotaxon. 66:215-230.

Zhu, J.S., Halpern, G.M., & Jones, K. (1998). The scientific rediscovery of an ancient Chinese herbal medicine: Ophiocordycepssinensis Part 1. *Journal of Alternative and Complementary Medicine*4:289-303.