



Diversity and Utilization of Forestry Resources for Enhancing Household Food Security in the Leh Himalaya, India

F.A. Shah Khan ^a, M.A. Islam ^{a*}, A.A. Gatoo ^a, G.M. Bhat ^b,
A.A. Parrey ^c, M.R. Bakshi ^b, Ummer Atta ^a
and Chandramolly ^d

^a Division of Forest Resource Management, Faculty of Forestry, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Benhama, Ganderbal, Jammu and Kashmir, India.

^b Division of Silviculture and Agroforestry, Faculty of Forestry, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Benhama, Ganderbal, Jammu and Kashmir, India.

^c Division of Wildlife Sciences, Faculty of Forestry, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Benhama, Ganderbal, Jammu and Kashmir, India.

^d Block Technology Manager, Agricultural Technology Management Agency (ATMA), Chhataramandu, Ramgarh-829122, Jharkhand, India.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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*Corresponding author: Email: ajaztata@gmail.com;

ABSTRACT

Food resources extracted from forestry landscapes enhance the quality of diets, improve health care, and ensure income diversification for local communities in developing countries. This paper explores the diversity, seasonality, distribution, mode of use, frequency of use, and reliance of forestry food resources on livelihoods in the Leh Himalaya. Data were collected from 185 sample families that were selected from five blocks and nine villages using a multi-stage random sampling procedure. Descriptive statistics were applied to the data analysis. Results revealed that 37 forestry food resources were harvested from 27 herbs, 3 shrubs, and 3 trees belonging to 28 genera and 19 families, and consumed as vegetables (15), fruits (5), dye or flavour (4), pot herb (4), salad (3), beverage (2), sauce (2), condiment (1), oil seeds (1), flatbread (1), sour (1), and *tantur* (1). Over 63.18% of sample households extracted and utilised all the forestry food resources extremely often for cash earnings and sustenance during the peak period. Forestry food resources constitute a key source of food, nutrition, health care, subsistence, cash income, and safety nets. This study gives insights to promote the conservation of forestry foods, develop management strategies that could be harmonised with rural development, poverty alleviation, food security, and livelihood sustainability for rural communities in Leh Himalaya, and accordingly design useful policy implications.

Keywords: Forestry resources; wild edibles; food security; livelihoods; Leh; Himalaya; India.

1. INTRODUCTION

The indigenous communities in the Leh area of Ladakh consume forestry resources to enhance the quality of their diets and sell or trade them to diversify household income [1]. The rural landscapes provide a rich and diverse wealth of nutritious forestry food resources, including vegetables, fruits, dyes or flavours, pot herbs, salads, beverages, sauces, condiments, oil seeds, sour, etc., that contribute to local diets [2]. The forestry food resources collected from forestry interventions in Leh are widely consumed by rural households to supplement and enrich their diets with vitamins, minerals, fats, starch, and other ingredients. Uses of forestry food resources as a diet supplement or as a coping mechanism in times of food shortages provide an important safety net for rural people. Forestry food resources are also an indispensable source of health care systems for poor people in rural areas. The consumption of these forestry foods reduces the risk of several ailments like diabetes, heart disease, cancer, neurodegenerative disorders, etc. [3]. Additionally, the collection of forestry food resources is a potential source of income for vulnerable people in rural areas. Although the share of forestry food income in total household income was low, poorer households experiencing shocks derived higher income shares from these food resources [4]. The urban markets carry forestry foods regularly, making it possible that those without easy access to forestry resources may be able to include them in their diets.

Forestry foods are often sold unprocessed, although it has long been tradition to process them—especially fruits—to make value-added goods like beverages, jams, and other confections. Although forestry foods are collected primarily by women, they are consumed by both men and women across all age groups.

In order to provide affordable food for human consumption and livelihood subsistence, it is crucial to explore, document, preserve, and promote forestry food resources [5]. The benefits of these forestry food resources encourage us to use wise management strategies to protect these resources so that they can continue to be a sustainable source of food for future generations [6]. Developing forestry policies and management plans requires a thorough understanding of the food resources gathered from forestry plantations and the households who harvest them [7]. More information is specifically required on the extent to which forestry foods contribute to local diets and nutrition, as well as the identification of the households and communities that benefit most from these contributions. Knowledge of forestry food resources can help alleviate food insecurity and serve as an affordable alternative in developing plans for the rural poor's food security [8]. In recent times, the increasing dependence of rural populations on food resources derived from forestry has led to a surge in scientific curiosity among scholars, policymakers, and development professionals operating in developing nations.

Despite this, empirical study on the traditional wisdom and people's reliance on forestry resources for food and nutrition security is scarce, with a few notable exceptions. In light of these facts, the purpose of this study was to compile vital data regarding the diversity, seasonality, distribution, mode of use, frequency of use, and reliance of forestry food resources on livelihoods.

2. MATERIALS AND METHODS

2.1 Description of Study Area

Leh district (Fig. 1) is one of the coldest and highest inhabited regions in the world, with 112 inhabited villages and one uninhabited village at an altitude ranging from 2900 to 5900 metres [9]. With an area of 45110 sq. km, it is likely the largest district in the nation. The district is located at an elevation of between 2300 and 500 metres above sea level, approximately between 32- and 36-degrees north latitude and 75- and 80-degrees east longitude. The district is bordered to the west by Pakistan-occupied Kashmir, to the east and north by China, and to the south by the

Laquan Spite of Himachal Pradesh. The district is located 474 km from Manali (HP) and 434 miles from Srinagar. Geographically, the district is entirely mountainous, featuring three parallel Himalayan mountains. The district is divided into nine (9) blocks: Leh, Chuchot, Panamic, Saspol, Khru, Nyoma, Durbok, and Nubra. The Leh district is cut off from the rest of the nation for half of the year due to excessive early precipitation (snow) caused by its high altitude and geographic location. Since the Zojila and Rotang passes are closed due to severe winter snowfall, the area continues to be inaccessible from both Srinagar and Himachal Pradesh. The human population of Leh district is 117232 [10]. The density of population is 3 people per sq. km. One of the areas on Earth with the lowest population density is the Leh district. The population is divided into 76.70% rural areas and roughly 23.30% semi-urban areas. The working population is mostly employed in domestic industry, employment in agriculture, and other occupations. The district's principal development organization was established in September 1995 and is known as the Ladakh Autonomous Hill Development Council.

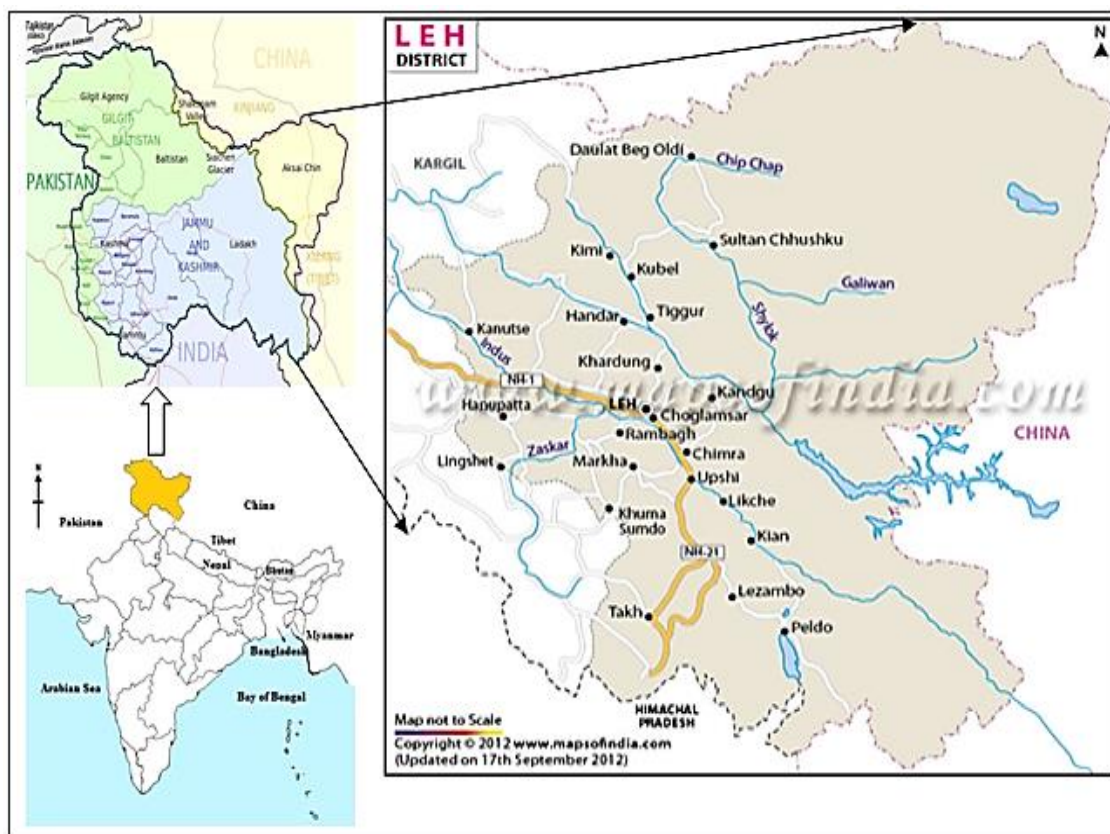


Fig. 1. Location map of the study area
Source: www.mapsofindia.com

2.2 Sampling Technique and Sample

The present study was conducted in the Leh district of Ladakh Union Territory. A multi-stage random sampling technique [11] was used to select the villages and the respondents. The first stage was the random sampling of five (5) blocks, namely, Leh, Nyoma Chochot, Panamic, and Khaltsi of Leh district. The second stage involved random sampling of ten (10) villages, viz., Saboo from Leh Block, Chumathang and Mud from Nyoma Block, Stakna and Nang from Chochot Block, Lakjung and Panamic from Panamic Block, and Dha, Lamayuru, and Nurla from Khaltsi Block. In the third stage, a total of 185 households were selected from the sample villages with a 15 percent sampling intensity employing a simple random sampling technique for the field study. The respondents interviewed were either household heads or eldest members. The summary of the sample selection process is given in the flow chart, as detailed below in Fig. 2.

2.3 Data Collection

The current study used both qualitative and quantitative methodologies to accomplish its research goals. Primary field surveys as well as secondary sources were used to gather data. Structured interviews with specific respondents and non-participant observations were utilized as primary sources [12]. Secondary sources

included documentation from several governmental and non-governmental organizations, literature from journals, records from the forest department, records from the village, the internet, earlier studies, annual reports, and other relevant materials. The primary data were collected at the household level, whereas the secondary data were collected at the block, village, and household/individual level.

2.3.1 Structured interview

The primary data were collected through the personal interviews of the respondents through a well-structured, pre-tested interview schedule at the household level. The interview schedule for the household survey was prepared on the basis of the literature referred to, a reconnaissance survey of the study area, discussion with local people, and consultation with the experts. The interview schedule so prepared was employed to collect information on forestry food resources, including species name, family, vernacular name, common name, plant habit, parts used, mode of use, frequency of use, seasonality, and livelihood importance. The data, thus generated through these approaches, was used in exploring the reliance on forestry resources for food and nutrition security among the rural communities to put forth strategies to keep pace with current development and future challenges in the locality.

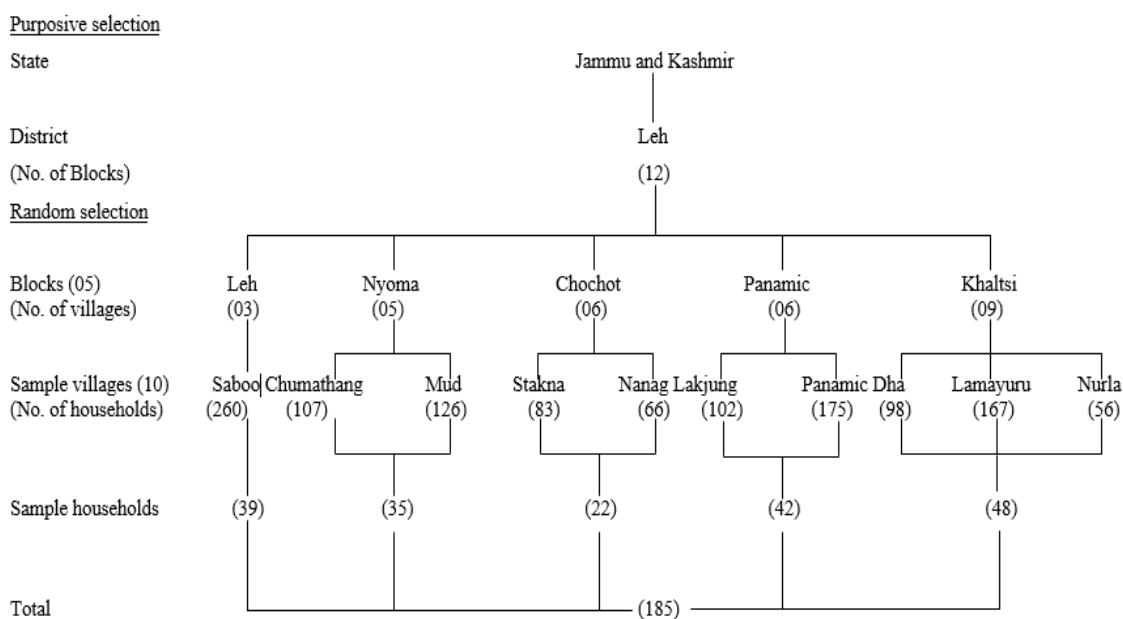


Fig. 2. Sampling procedure

2.3.2 Non-participant observation

The basis for the qualitative analysis was firsthand observation and conversation with the respondents. The use of this technique made it possible to interact with the respondents directly, observe their behaviour in a realistic setting, and research the situation-based characteristics of behaviour.

2.4 Data Analysis

To summarize the forestry resources that were extracted for food security, data pertaining to the species name, family, parts used, frequency of use, seasonality, livelihood importance and mode of use were recorded. We used simple descriptive statistics like frequency (f), percentage (%), average (x), standard error, and range to analyze the data [13]. The numerical data and text information were presented either as tables or graphs.

3. RESULTS

The food plants constituted 33 (19.76%) species of the total useful forestry plant flora belonging to

28 genera and 19 families, mostly extracted and consumed for food and livelihood security (Table 1). Among food plants, vegetables comprised 15 (37.50%), fruit 5 (12.50%), dye or flavor 4 (10.0%), pot herb 4 (10%), salad 3 (7.50%), beverage 2 (5.0%), *chutney* (sauce) 2 (5.0%), condiment 1 (2.50%), oil seeds 1 (2.50%), *paratha* (flatbread) 1 (2.50%), sour 1 (2.50%), and *tantur* (local dish) 1 (2.50%) (Table 2). All the forestry food resources were extracted and consumed by over 63.18% of sample households very frequently for subsistence and cash income during the peak period (Table 2). The plant parts consumed as food were leaves (11), whole plants (10), shoots (8), fruits (4), flowers (3), and oilseed (1) (Fig. 3). Among food plants, the maximum (27) species were herbs, while shrubs and trees comprised 3 species each (Fig. 4). The family Asteraceae (6) had the highest representation, followed by Polygonaceae (4), Chenopodiaceae (3), Lamiaceae (3), Rosaceae (2), Brassicaceae (2), Amaranthaceae (1), Amaryllidaceae (1), Boraginaceae (1), Braericeae (1), Capparidaceae (1), Crassulaceae (1), Elaeagnaceae (1), Ephedraceae (1), Gentianaceae (1), Liliaceae (1), Orobanchaceae (1), Salicaceae (1) and Urticaceae (1) (Fig. 5).

Table 1.a. Extraction of Forestry resources for food security in the sample households (N=185)

Species	Family	Local name	Part used	Mode of use
<i>Allium humile</i> Schrenk.	Amaryllidaceae	Skotche	Whole plants	Plants fresh as well as dried are used as condiment.
<i>Amaranthus spinosus</i> Willd.	Amaranthaceae	Chulai	Tender shoots/leaves	Used as vegetable. Young leaves dried and stored for winter.
<i>Anaohalis triplinervis</i> (sims) Clark var.	Asteraceae	Yaktso	Buds	Young buds are edible, generally eaten by children as salads.
<i>Anaphalistriplinervis</i> Clarke var.	Asteraceae	Yaktso	Young buds	Edible as vegetable, usually the buds are eaten as salad.
<i>Arnabia guttata</i> Bunge.	Boraginaceae	Demok	Roots	Roots yields edible fat-soluble red dye which is used by locals for coloring dishes.
<i>Capparis spinosa</i> Linn.	Capparidaceae	Kabra	Leaves	Flowers- edible. Young leaves are eaten as vegetable.
<i>Capsella ellcptica</i> C.A.M.	Braericeae	Shangshoo	Whole plant	The tender leaves are generally plucked during early summer and cooked as vegetable.
<i>Chenopodium glaucum</i> Linn.	Chenopodiaceae	Kupaid	Leaves	Leaves are eaten as a potherb.
<i>Chenopodium album</i> Linn.	Chenopodiaceae	Neung	Whole plants	The whole herbs are properly boiled and used as vegetable. Also used for making paratha

Species	Family	Local name	Part used	Mode of use
				(flatbread) etc. either fresh or dehydrated for prolong winter use by locals.
<i>Chenopodium foliosum</i> Asch.	Chenopodiaceae	Sangsti	Young leaves/ tender shoots	The young leaves and tender shoots are used as potherb by the locals.
<i>Christolea crassifolia</i> Camb.	Brassicaceae	Sanak	Shoots	The tender shoots are consumed as vegetable by the local.
<i>Elshotzia densa</i> Benth.	Lamiaceae	Philongtso	Leaves	The tender leaves are eaten as raw or after making <i>chutney</i> (sauce) or flavors in local dishes.
<i>Ephedra gerardiana</i> Wall.ex.stapf.	Ephedraceae	Chappat	Fruits	Fruits-edible
<i>Eremurus himalaicus</i> Baker.	Liliaceae	Nyamgtso	Young flowers	Young flower buds are edible.
<i>Erigeron multiradiatus</i> Benth.	Asteraceae	Durang-phang	Whole plants	Leaves and the tender shoots are eaten as potherb.

Table 1.b. Extraction of Forestry resources for food security in the sample households (N=185)

Species	Family	Local name	Part used	Mode of use
<i>Erigeron multiradiatus</i> Benth.	Asteraceae	Phang	Leaves	Leaves are cooked as a vegetable.
<i>Fagopyrum tataricum</i> Linn.) Gaertn.	Polygonaceae	Dayat	Whole plants	Dried leaves are eaten as vegetable.
<i>Fagopyrum tataricum</i> Linn.	Polygonaceae	Dayat	Leaves	The leaves are consumed as vegetable after drying.
<i>Gentiana humilis</i> Steven ex Bunge.	Gentianaceae	Nylo	Whole plants	Young flowers/ buds are edible.
<i>Hippophae rhomnoides</i> Linn.	Elaeagnaceae	Tesmarma	Fruits, seeds/ leaves	Fruits are edible. Popular Leh berry juice is extracted from fruit pulps.
<i>Lactuca scariola</i> Linn.	Asteraceae	Khala	Whole plant	Young plants are eaten as vegetable.
<i>Lepidium latifolium</i> Royle.	Brassicaceae	Gyerdut	Young Leaves	Young leaves are used as salad.
<i>Malus x domestica</i> Borkh	Rosaceae	Kushoo	Fruit	Fruit-edible.
<i>Nepeta longibracteata</i> Benth	Lamiaceae	Prianku	Whole plants	Aromatic oil of strong fragrance is extracted from the species and used by the local <i>amchi</i> (medicinal practitioners).
<i>Nepeta 113loccose</i> Benth.	Lamiaceae	Shamalo	Leaves/ shoots	The dried leaves and shoots are aromatic and used to add flavor in local dishes.
<i>Orobanchae hansii</i> A.Kern	Orobanchaceae	Broom-Rape	Shoots	The tender shoots are used in making soup.
<i>Polygonum</i>	Polygonaceae	Chhiankar	Leaves	The tender leaves are cooked

Species	Family	Local name	Part used	Mode of use
<i>aviculare</i> Linn.				as pot herb.
<i>Prunus armeniaca</i> L.	Rosaceae	Chule	Fruits	Fruits/ oil seeds- edible.
<i>Reheum tibeticum</i> Maxim.exH k.f.	Polygonaceae	Lachu	leaves	Small leaf stalk contains vitamin C and is eaten raw.
<i>Rhodiola heterodrta</i> Boiss	Crassulaceae	Shrolo	Leaves	The tender parts are to make a local delicious dish <i>Tantur</i> .
<i>Salix daphnoides</i> Vill.	Salicaceae	Shoa	Leaves	The tree leaves are used to make local tea.
<i>Taraxacum officinale</i> Wiggers.	Asteraceae	Han	Whole plants	Very nutritious wild edible plant used as vegetable in far flung areas.
<i>Urticahyperborea</i> Jacq. Ex, Wedd.	Urticaceae	Zazot	Whole plants	Young leaves are dried and cooked as vegetable during winter.
<i>Elaeaganus angustifolia</i> L.	Elagenaeeceae	Sersing	Fruit	Fruit- edible.

Table 2. Consumption status, frequency of use, livelihood significance and seasonality of forestry food resources in the sample households (N=185)

Forestry food resource	Households consuming food type (%)	No. of species consumed (%)	Frequency of use	Livelihood significance	Seasonality (Peak/ lean)
Vegetables	185 (100.00)	15 (37.50%)	Very frequently	Subsistence, cash income	Peak, lean
Fruits	185 (100.00)	5 (12.50%)	Very frequently	Subsistence, cash income	Peak
Dye or flavour	122 (65.94)	4 (10.0%)	Frequently	Subsistence	Peak, lean
Pot herb	135 (72.97)	4 (10%)	Frequently	Subsistence, cash income	Peak
Salad	141 (76.21)	3 (7.50%)	Frequently	Subsistence, cash income	Peak
Beverage	163 (88.11)	2 (5.0%)	Frequently	Subsistence	Peak, lean
<i>Chutney</i> (sauce)	152 (82.16)	2 (5.0%)	Frequently	Subsistence	Peak
Condiment	145 (78.37)	1 (2.50%)	Frequently	Subsistence, cash income	Peak, lean
Oil seeds	126 (68.11)	1 (2.50%)	Occasionally	Subsistence, cash income	Peak, lean
<i>Paratha</i> (flatbread)	118 (63.18)	1 (2.50%)	Occasionally	Subsistence	Peak, lean
Sour	137 (74.05)	1 (2.50%)	Occasionally	Subsistence	Peak, lean
<i>Tantur</i> (local dish)	129 (69.73)	1 (2.50%).	Occasionally	Subsistence	Peak, lean

4. DISCUSSION

The diversity of edible forestry resources consumed reflected the rich biodiversity of the rural landscape. Edible forestry resources form the main component of the food basket of the local people in the district. Food security is an

acute concern for most families in the district; hence, all families in the villages collect and consume a great variety of forestry food resources on a regular basis. Forestry food resources (Fig. 6) contribute in two ways to food security, i.e., direct consumption of forestry food resources next to grains and selling the

resources to buy grains in times of shortage [14]. Although the diet of the poor local people is seriously deficient in carbohydrates, protein, fats, sugar, vitamins, minerals, etc., forestry food resources are important sources for meeting their daily diet requirements. Although the largest proportion of forestry food resources are consumed at home, low income and meagre returns from farm products have compelled many families to trade some parts of the edible forestry products in the local daily markets. The market value of edible forestry products is not regulated, and vendors generally get trivial earnings not remunerative to their labour used. The sale of forestry food resources contributes considerable cash income to the household annual income, which is mostly used to buy grains; the products are therefore the most important safety net or key coping strategy to combat food

shortages. Forest foods have gained global attention due to their contribution to household livelihoods, food security, poverty reduction, and biodiversity conservation [15,7]. Forestry food resources fulfil the health and nutritional needs of about 80% of the population of developing countries [16]. Overall, edible forestry resources are an indispensable source of diet, food, nutrition, health care, and livelihood in different parts of the world [17]. The diversity of edible forestry food resources offers variety in diets and contributes to household food security [18]. Some edible forestry food products are even reported to be more nutritious than conventionally eaten crops [19]. Besides food and nutrition, the utilization of edible forestry food products as coping strategies during scarcity is prevalent, particularly in developing countries where food insecurity is acute [20].

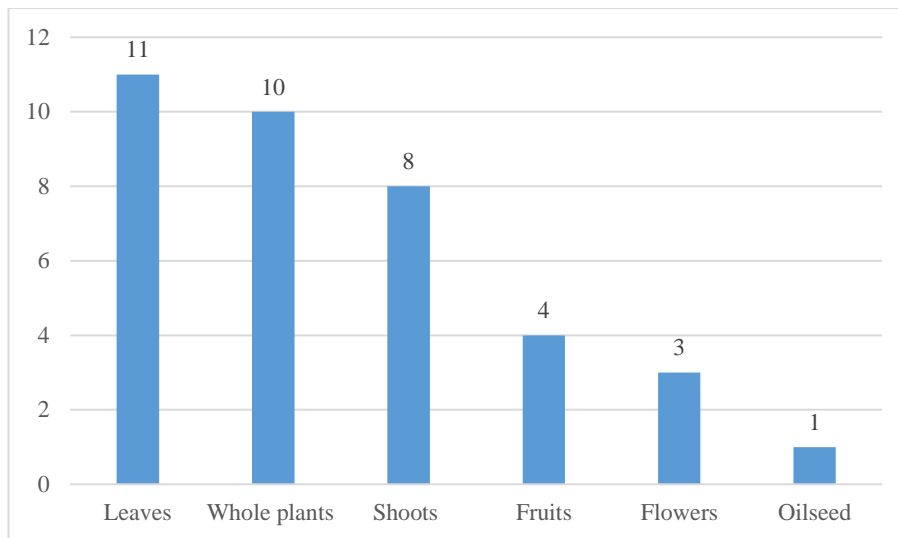


Fig. 3. Plant parts used as forestry food resources

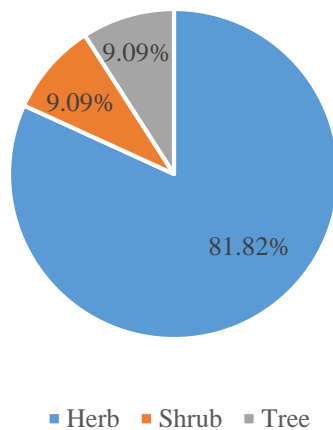


Fig. 4. Life forms of forestry food resources

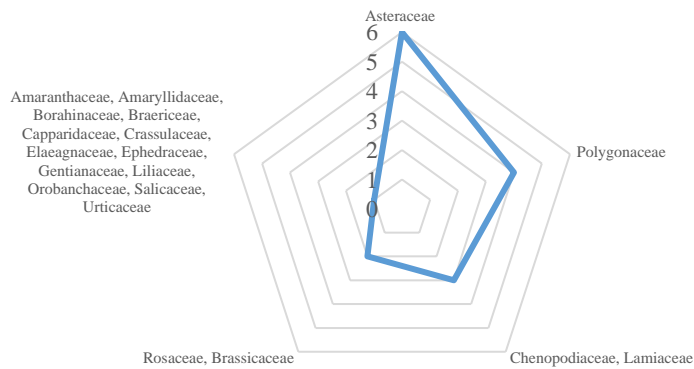


Fig. 5. Family-wise distribution of forestry food resources



6. a. Collection of Sea buckthorn fruits



6. b. Beverage processing from Sea buckthorn fruits



6. c. Local woman selling dried wild vegetables



6. d. *Capsella ellcptica* (Shangshoo) consumed as vegetable

Fig. 6. Forestry food resources of rural communities in Leh

5. CONCLUSION

The extraction of forestry resources is a vital source of food, financial income, sustenance, and a safety net for the rural residents of Leh Himalaya. To satisfy rural residents' dietary demands, the vast portion of foods produced by forestry landscapes are consumed for subsistence, with very little being sold for profit. Besides this, forestry food resources are also consumed by the local people as herbal medicine for health care. The supply of forestry foods is expected to decrease in the near future due to current unsustainable extraction, increased market demand on forestry food resources, loss of forestry landscapes from conversion to agriculture, and rapid population growth. Therefore, maintaining a pace with present growth and addressing future difficulties requires the sustainable management of forestry resources and conservation through forestry access regulation. The monetary revenue generated is substantial to support household livelihoods, even though the economic value of forestry foods is not comparable to the labours expended in the endeavor. Therefore, future interventions that can offset conservation efforts and encourage livelihood diversification for the poorest people include value-adding of economically and culturally significant forestry food resources and entrepreneurship in micro-enterprises of forestry food products. The present findings on forestry food resources and rural food security linkage suggest that forestry food resources should be given due focus in policy implications to harmonize food security, livelihood improvement, and poverty alleviation, besides forestry conservation in the Leh Himalaya.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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