Research Article

iMedPub Journals
www.imedpub.com

Journal of Food Science and Toxicology

2018
Vol.2 No.1:3

Wild Plant Food Resources in Agricultural Systems of Uttarakhand Hills in India and Its Potential Role in Combating Malnutrition and Enhancing Human Health

IS Bisht[1]*, PS Mehta[1], KS Negi[1], Rajni Rawat[1], Ranjana Singh[1] and SC Garkoti[2]

1 ICAR-National Bureau of Plant Genetic Resources, Regional Station, Bhowali (Nainital)-263132, Uttarakhand, India
2 School of Environmental Sciences, Jawaharlal Nehru University, New Mehrauli Road, New Delhi-110067, India

***Corresponding author:** IS Bisht

bishtis@rediffmail.com

ICAR-National Bureau of Plant Genetic Resources, Regional Station, Bhowali (Nainital)-263132, Uttarakhand, India.

Tel: +91-9873425491

Citation: Bisht IS, Mehta PS, Negi KS, Rawat R, Singh R, et al. (2017) Wild Plant Food Resources in Agricultural Systems of Uttarakhand Hills in India and Its Potential Role in Combating Malnutrition and Enhancing Human Health.
J Food Sci Toxicol Vol.2 No.1:3

Abstract

Food security today depends on a handful of widely cultivated species. On the other hand, wild food resources, world over, provide a greater dietary diversity to many native communities who depend on them. In Uttarakhand hills of India, the rural communities under different farming agro-ecologies still gather and consume many edible wild harvested plant resources. Consumption of these plants is often essential when there is food shortage during lean period. The wild plant resources are helpful in enhancing livelihoods and supporting household economies of rural farming communities. The wild plant resources are considered especially rich source of vitamins and minerals. The present case study documents a total of about 335 plant species, wild harvested as leaves, fruits, flowers, tubers, seeds, twigs, etc. under different farming agro-ecologies that form minor but important food components of the rural communities. The access to and availability of these food resources are now declining due to degradation of their natural habitats from various developmental activities, poor management of CPRs, the changing climate and recurrent droughts, nutrition transition and inflow of purchased foods, forces of globalization, loss of LEK, etc. The present case study revealed that the contribution of wild harvested foods to total food and nutritional security of native communities has been undervalued. It has now been well recognized that wild food resources are vital for nutrition and health of hill communities beside just source of food and income. The sustainable harvesting of wild economic species therefore requires a strong policy support by ensuring its continued availability to local communities. As substantial nutrition transition has been observed in traditional hill communities during recent years, traditional food revitalization projects including enhanced consumption of wild foods is considered a necessity for better health and cultural benefits. The study clearly demonstrated that we need to combine and enhance the efforts to conserving biodiversity and preserving traditional food systems and farming practices.

Keywords: Wild plant resources in agricultural systems; Native food culture; Community nutrition and health; Traditional farming practices; Local ecological knowledge

Received: October 27, 2017; **Accepted:** January 31, 2018; **Published:** February 07, 2018

© Under License of Creative Commons Attribution 3.0 License | This article is available in: http://www.imedpub.com/journal-food-science-toxicology/

Introduction

Global food security now depends on a few widely cultivated species, the three crops, wheat, maize and rice providing over 50 percent of the world's daily requirement of proteins and calories [1] and 12 species contributing about 80 percent of total dietary intake. By contrast, wild foods provide a greater dietary diversity to those who rely on them. More than 7000 species have been reported to be used at some stage in human history, in past, based on ethnobotanical surveys of wild plants [2]. In India, 600 plant species are known to have food value [3]. Many agricultural communities have been reported to rely on wild plants and animals even today.

It has been reported that the agricultural and forager communities at 36 locations in 22 countries of Asia and Africa use an average of 90-100 wild species [4]. The access and availability of wild food resources is now declining due to habitat degradation, developmental activities, agricultural expansion, and other social and ecological drivers reducing wild food use. However, with increasing pressure on enhanced agricultural productivity, the importance of wild food use has been reported to be set to grow [4].

Wild plants in particular are reported to have diverse uses [5-7]. Wild plant foods have been an integral part of human diet since ancient times and nearly 75,000 species of plants believed to be edible [8-11]. About 200 plant species have been domesticated as food crops of which only about 30% are reported to contribute 95% of the world's plant food intake [12,13]. However, despite the reliance of agricultural communities on conventional crop plants, the rural communities world over still consume wild plant foods [13-17], in its state of food insecurity in the world report, estimated that around one billion people use wild plants in their diet.

Wild vegetables play an important role in the diet of inhabitants of different parts of the world. Afolayan and Jimoh [18] reported that the nutrients available in wild vegetables of South Africa, *Chenopodium album*, *Sonchus asper*, *Solanum nigrum* and *Urtica urens* are comparable with or higher than those of commonly used vegetables such as spinach, lettuce and cabbage. In terms of anti-nutritional principles, all the vegetables had comparatively lower concentrations of phytate, alkaloids and saponins. Misra et al. [19] documented 21 wild harvested leafy vegetables from six villages of Nanda Devi Biosphere Reserve buffer zone in Uttarakhand state, India. Irrespective of social or economic status in the study villages, the farmer households had enough knowledge about availability and use of these wild leafy vegetables. The traditional knowledge, however, is eroding fast due to changing social values and non-participation of younger generation in collection and processing of such wild food resources. In an ethnobotanical investigation carried out in Kendrapara district, Odisha, India, Panda [20] reported that within the edible plant parts, leaves and fruits contributed maximum (about 75%), the remainders being edible tubers, flowers and seeds. The utilization of wild vegetables in the dietary intake of the households was emphasized.

In Uttarakhand hills, rural farming communities still gather and consume many edible wild plant resources [21]. Rural communities use these food plants to supplement their diets. Consumption of these plants is particularly vital when there is food shortage besides contributing to livelihood security and household economies of native communities. Their importance is exemplified by free and easy accessibility and nutritional richness especially vitamins and micronutrients. Therefore, they play a significant role in the livelihoods of rural communities in Uttarakhand hills.

Research on wild harvested foods in traditional agro-ecologies from forestry/agroforestry systems has so far received limited attention but it is a matter of great concern from various researchers now. Inventorying, in situ conservation and their promotion and commercialization are some important actions required for conservation and sustainable utilization of wild and neglected food plants. As most of the wild plant resources are used locally, their many values remain undocumented without being reflected in local, national or international markets. Systematic documentation of indigenous knowledge regarding the identity and use of wild harvested foods by rural communities is therefore a necessity as a growing disinterest among the younger generation in the community is often observed.

The proposed study titled "Indigenous land and food systems in Uttarakhand: A case study on traditional knowledge and use of wild foods in agricultural systems" therefore sought to:

- Inventorying wild edible food plants from traditional farming areas of Uttarakhand hills with particular emphasis on indigenous community knowledge regarding their identity and use, an integral component of subsistence hill farming. Areas of Uttarakhand hills with particular emphasis on indigenous community knowledge regarding their identity and use, an integral component of subsistence hill farming.
- Determining the food preparations, marketability and conservation of wild harvested foods.
- Determining impact of the loss of traditional knowledge and lack of use of wild food resources on community health and nutrition.
- Prioritizing wild food plants for research and marketing interventions in specific agro-ecologies of Uttarakhand hills.

Farmers' work in the food system is based on their knowledge and skills. Documenting complex farmers' knowledge for food; documenting experiential knowledge based on community culture; bio-diversity knowledge based on nature; gender division of labour, etc. with major emphasis on wild harvested food resources will also be addressed in the present case study using participatory approaches.

Description about the Study Area

Of the total geographical area of Uttarakhand state about 13.5% (766730 ha) is the net sown cropped area. About 86% geographical area of Uttarakhand is hills but the crop lands are mainly in plains, popularly known as the Terai and Bhabar region, where modern farming is practiced under assured irrigation. On the other hand, in hills, traditional mix cropping practices are

normally practiced, and farming is mainly rainfed. In Uttarakhand more than 75 percent of the population depend on agriculture for their livelihood. The three important representative agro-ecologies/farming situations in Uttarakhand hills: i) small-scale crop-livestock mixed-farming systems representing about 70% of the net sown rainfed farming area; ii) high elevation mountainous valleys adjoining Tibet mainly inhabited by nomadic pastoralists, the Bhotia or Shoka tribes and comprising about 10% of the net sown area, and iii) a few interspersed river valleys with improved agriculture under assured irrigation, comprising about 10% of the cropped area of the Uttarakhand hills.

In an exploratory survey more, household production and dietary diversity was revealed for traditional rainfed small-scale crop-livestock mixed-farming systems followed by mountainous valleys with nomadic pastoralists, and least in river valleys with improved agriculture. In hill agriculture, only farmer-led traditional innovations are predominantly practiced except in river valleys where use of improved varieties, inorganic fertilizers, pesticides, is now commonly seen. However, in the mixed crop-livestock farming system of the hills, a dynamic relationship among CPRs, native crops and livestock, still exist to a greater extent. The livestock predominantly contributes to the household cash income whereas the surplus crop produce, if any, is sold locally and contributes very little to the household agriculture economy. The nomadic pastoralists of high mountainous valleys all have some arable land beside foraging and trading of medicinal herbs. Sheep and goat are the herded livestock. Tending of livestock and foraging of medicinal herb for export purposes is common. Livestock grazing is practiced throughout the mountain valleys, although at rates significantly lower since the Indo-China conflict of 1962. Largely because the loss of trade with Tibet, the demand for livestock and agriculture products has dropped considerably.

A nutrition transition is clearly evident in farming situations particularly of river valleys with the emergence of cash crop economies and impact of globalization in recent years. Even in traditional farming areas nutrition transition in evident in a limited way. With the nutrition transition resulting from increasing socio-economic change, the problems of underweight and overweight is frequently co-existing. Besides, undernutrition, the socio-economic disparities and increased access to energy-dense foods are also creating an "obesogenic" environment in some sections, more particularly in river valley areas.

The niche target sites (20 nos.) for documenting information on wild harvested plant resources in different agroecologies are presented in (**Figure 1 and Table 1)**.

Research Methodology

Data on wild harvested plant food resources were documented from all 20 representative niche sites **(Figure 1 and Table 1)** of three main farming agro-ecologies of Uttarakhand hills during January to May 2017. Data were mainly documented for local ecological knowledge/indigenous knowledge (LEK/IK) on identity and use of wild plant food resources using semi-structured

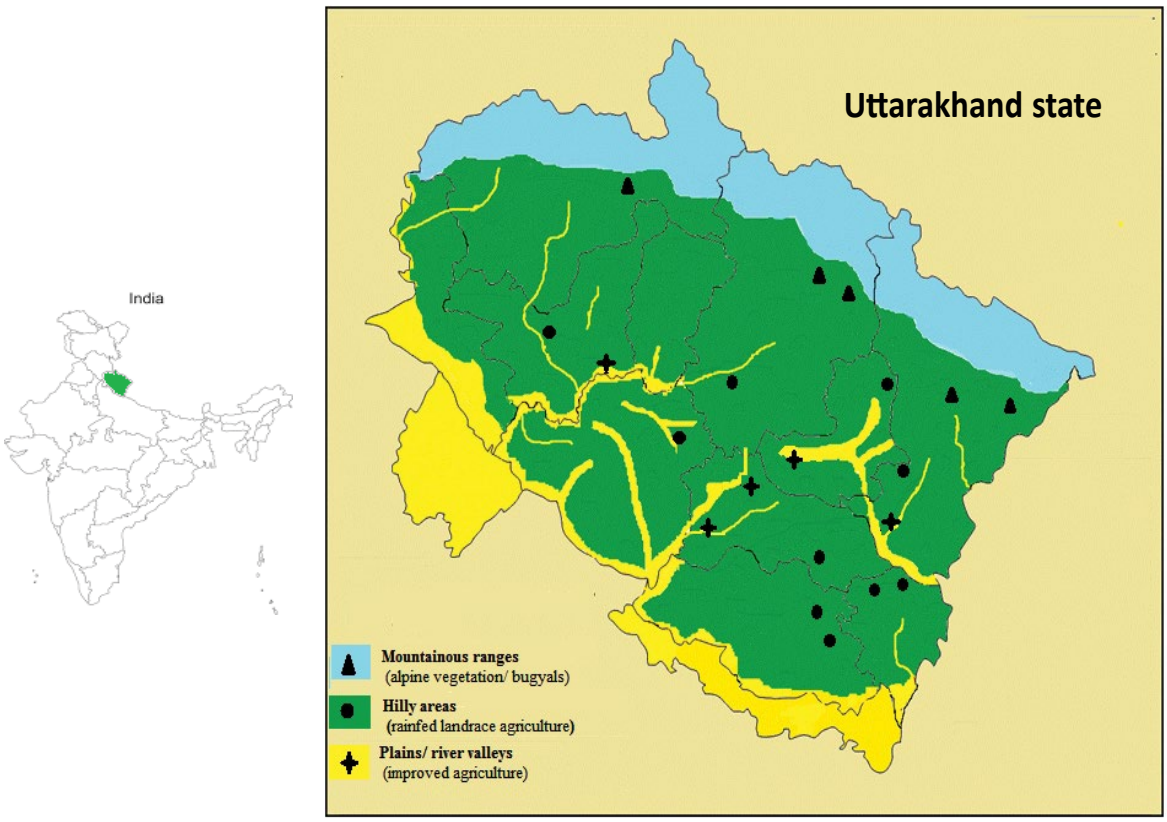

Figure 1 Map of the study area.

© Under License of Creative Commons Attribution 3.0 License

questionnaires. For interviewing the farmer households, a checklist of open ended questions was used. Free listing technique was used for gathering data on indigenous knowledge pertaining to wild edible plants. Each respondent was asked to mention any plant that comes to their mind until they could not mention any more species. It was presumed that people in any community do remember plants which are important to them. Respondents were also requested for field guided walks to all nearby areas in the community including nearby forestry areas to identify/collect the plants listed during the interview. One Focus Group Discussion (FGD) meeting each was held in all agrobiodiversity rich niche target sites to authenticate the data in questionnaires and capture additional responses on value of wild plant foods for household food and nutrition, contribution to household economy, drivers of change in availability and use of wild plant food resources, unsustainable harvesting and changing dynamics, loss of LEK, socio-economic change, etc. Potential of a few prioritized wild plant food resources for marketing interventions was also explored.

The participatory interviews were done separately for men and women farmers of different age groups for LEK on wild harvested foods. Children (<15 years) were also interviewed for LEK. Average 10-15 farmer households were interviewed per niche site.

The nutritional value of a few wild plant food resources was also compiled from secondary sources.

Results

Documenting wild plant food resources of Uttarakhand hills

A complete list of wild plant food resources from different representative niche sites of three distinct agro-ecologies was documented. A total of 335 plant species was recorded in different plant families of Angiosperms, Gymnosperms and Pteridophytes. A total of 97 families of dicotyledons and 12 families of monocotyledons, in Angiosperms; three families of Gymnosperms and one family of Pteridophytes (Ferns) were represented **(Table 2)**. Rosaceae (25), Polygonaceae (15), Fabaceae (12), Asteraceae (11), Lamiaceae (10), Liliaceae (10), Urticaceae (10), Amaryllidaceae (Alliaceae 8), Amaranthaceae (8), Caesalpinaceae (7), Rutaceae (7), etc. were the plant families with greater species representation among angiosperms. Important plant species in different agroecologies and farming situations are listed in **Table 3**.

Domestication programmes are also being initiated by Uttarakhand state to bring many wild species, mainly the local herbs in farming systems. Examples of important plant species for domestication interventions include, *Allium stracheyi, A. humile, A. wallichi, Asendra butyracea, Malus baccata var. himalaica, Sorbus lanata, S. cuspidata, Fragaria nubicola, Rubus macilentus, R. ellipticus/R. biflorus, R. nutans, Hippophae rhamnoides* spp. *salicifolia, Rosa sericea/R. macrophylla, Cleome viscosa* and a few others **(Table 4)**. These species can help provide livelihood support, health and nutritional benefits to local communities.

The economic and nutritional value of wild foods

Table 5 summarizes the findings from economic valuations of direct use values for wild foods in selected farming agro-ecologies of Uttarakhand hills. The exploratory surveys for some important species reveal that wild plants can provide INR 5000-500000 per households in specific agro-ecologies/niche areas of Uttarakhand hills.

It was found that poorer households are normally involved in wild harvesting and marketing of wild plant food resources. **Table 6** presents information on trends in market sale of some wild harvested foods, mainly as vegetables and fruits in the Nainital district of Uttarakhand. A substantial income has been reported by farmer households, those engaged in wild harvesting and their trade in local markets.

Nutritional profile of some wild food plant resources compiled from secondary sources is presented in **Table 7** [22]. It is clear from **Table 7** that many of the wild harvested food resources are often considered superior in energy and micronutrient content compared with those from many cultivated species.

Table 1 Niche sites in different agro-ecologies of Uttarakhand hills for documenting wild harvested food resources.

Representative agro-ecology/ farming situations	No. of sites	Niche locations (districts in parenthesis)
Traditional rain-fed farming areas (crop-livestock mix-farming)	10	Berinag (Pithoragarh), Lohaghat (Champawat), Devidhura (Champawat), Tarikhet (Almora), Sama (Bageshwar), Ramgarh (Nainital), Okhalkanda (Nainital), Ranichauri (Tehri), Gwaldam (Chamoli), Bharsar (Pauri)
Mountainous regions-alpine meadows/ bugyals (nomadic pastoralists)	5	Johar (Pithoragarh) and Darma (Pithoragarh) valley in Kumaon region; Niti and Mana (Chamoli district) and Har-ki-doon (Uttarkashi), in Garhwal region
River valleys (improved farming)	5	Bhilangana (Tehri), Someshwar (Almora), Garur (Bageshwar), Ramganga (Almora) and Saryu (Pithoragarh)

Table 2 Plant species used as wild harvested foods in Uttarakhand hills.

Plant taxa groups	No. of species	Plant families with major species representations
Angiosperms		
- Dicotyledons	286	Rosaceae (25), Polygonaceae (15), Fabaceae (12), Asteraceae (11), Lamiaceae (10), Urticaceae (10), Amaramthaceae (8)
- Monocotyledons	44	Liliaceae (10), Amaryllidaceae (8), Araceae (5), Dioscoreaceae (5)
Gymnosperms	4	Pinaceae (2), Ephedraceae (1), Taxaceae (1)
Pteridophytes	1	Dryopteridaceae (1)

Table 3 A few important wild plant species commonly used by farming communities of Uttarakhand hills.

S. No.	Plant species	Frequency of occurrence	Food and medicinal uses
Plant species used in communities of lower and mid hills			
1	*Aegel marmelos* (Bael, Bengal quince, golden apple)	Rare (wild populations)	Bael fruits are used in traditional medicine and as a food throughout its range. The fruit pulp is used to prepare delicacies and is also used in the treatment of chronic diarrhoea, dysentery, and peptic ulcers, as a laxative and to recuperate from respiratory infections in various folk medicines.
2	*Asparagus adscendens* (Satavar, shatavari, or safed musli)	Common	*A. adscendens* is used as a rejuvenative herb and is also very powerful aphrodisiac. Safed musli is also used as effective anti-diabetic agent, besides several other medicinal uses.
3	*Bauhinia variegata* (Mountain Ebony; Kuiral)	Common	The buds and flowers are cooked as a delicious vegetable or made into pickles. Leaves provide good quality fodder. Ash of dried leaves taken in cough.
4	*Cleome viscosa* (Jakhia; Asian spiderflower, Tickweed)	Common	Leaves and young shoots - cooked as a vegetable. The pungent seed can be pickled or used as a mustard or cumin substitute in curries, pickling spices, vegetables and pulses. The leaves are diaphoretic, rubefacient and vesicant. The seeds are anthelmintic, carminative, rubefacient, stimulant and vesicant. A decoction is used to treat rheumatism, gonorrhoea, diarrhoea and dysentery.
5	*Dioscorea bulbifera* (air yam, potato yam)	Common	Used as vegetable. Air potato has been used as a folk remedy to treat conjunctivitis, diarrhoea, and dysentery, among other ailments.
6	*D. deltoidea* (Yam)	Common	Tubers cooked and eaten. The roots widely used in modern medicine in order to manufacture progesterone and other steroid drugs. These are used as contraceptives and in the treatment of various disorders of the genitory organs as well as other diseases such as asthma and arthritis.
7	*Diplazium esculentum* (a vegetable fern, Lingura or Lungru)	Common	The young fronds are the stars on this plant, as the tender young growth is a delicious addition to stir fries and other veggie rich dishes. It is familiar food available in local markets of Uttarakhand hills. The fern is high in beta carotene and contains a percentage of Vitamin E and riboflavin.
8	*Ficus palmata* (Bedu, Punjab fig)	Common	*F. palmata* is one of the tastiest fruits found growing wild in the mid-Himalayan region. The raw fruits are used as a vegetable. They are principally used as an item of diet in cases of constipation and in the diseases of the lungs and the bladder. They are also used as a poultice.
9	*Ficus racemosa* (Syn. *F. glomerata*; Indian fig tree or gular fig, Timil)	Common	The fruits are a favourite staple of the common Indian macaque. In ancient times both Hindu and Buddhist ascetics on their way to Taxila (Taxsila), travelling through vast areas of Indian forests used to consume the fruit during their travels.
10	*Myrica esculenta* (Kaphal)	Common	*M. esculenta* commonly is amongst highly valued wild edible fruits of Uttarakhand hills. The fruits are an important source of natural antioxidants which can play vital role in reducing the oxidative stress and preventing from certain degenerative diseases.
11	*Perilla frutescens* (Bhanjeera)	Common	Perilla is a minor oilseed crop, also widely used in Uttarakhand cuisines as flavouring substance. It is indicated to ease the symptoms of the common cold, also shown to stimulate interferon activity and thus, the body's immune system.
12	*Rubus ellipticus* (Golden Himalayan raspberry, Hisalu)	Common	*R. ellipticus* fruits are sweet in taste. The bark is used for medicinal purposes, mainly as a renal tonic and an antidiuretic. Its juice can also be used to treat cough, fever, colic and sore throat.
13	*Syzizium cumini* (Black plum, Jamun)	Common	The seed of the fruit is used in various alternative healing systems like Ayurveda, Unani and Chinese medicine for digestive ailments. Wine and vinegar are also made from the fruit. It is a high source of vitamin A and vitamin C.
14	*Ziziphus mauritiana* (Chinese date, ber, jujube, Indian plum)	Common	The fruit is eaten raw, pickled or used in beverages. It is quite nutritious and rich in vitamin C. The flowers are rated as a minor source of nectar for honeybees. The honey is light and of fair flavour. Fruits, leaves and bark have several medicinal uses.
Plant species used by nomadic pastoralists during March to November (for 6-8 months) from alpine meadows/bugyals			
15	*Allium humile* (High altitude alpine onion)	Common	Dried leaves of *A. humile* are used as Jambu or Faran for flavouring. It is also used for Asthma, stomach diseases, jaundice, cold and cough.
16	*A. stracheyi* (Jambu or Faran)	Common	Flowers are picked and dried to be used as a spice known as Jambu or Faran. Leaves contain sulphur compounds and when added to the diet on a regular basis they help reduce blood cholesterol levels, act as a tonic to the digestive system and also tonify the circulatory system.
17	*A. tuberosum* (Garlic chives, Chinese chives)	Rare	Uses have included it as ornamental plants, including cut and dried flowers, culinary herb and traditional medicine.
18	*A. victorialis* (Alpine Leek)	Rare	Flowers are eaten raw or cooked. The juice of the plant is used as a moth repellent. The whole plant is said to repel insects and moles. The root is antiscorbutic, carminative, diuretic and vermifuge. Used in the treatment of profuse menstruation.
19	*A. wallichii* (Himalayan onion, Jambu)	Common	Young leaves - cooked as a vegetable. The dried leaves are used as a condiment in curries and pickles. The bulbs are eaten in the treatment of cholera and dysentery. The raw bulb is chewed to treat coughs and colds, eating the bulbs can ease the symptoms of altitude sickness.
20	*Carun carvi* (Kala jeera or Bhotia jeera)	Common	Fruits used as flavouring or aromatic agent; fruit powder given in dysuria and hematuria; young plants cooked as vegetables. Seeds are rich sources of diverse group of phytochemicals. It has a broad spectrum pharmacological effect in treatment of traditional healing systems in different parts of the world.
21	*Hippophae rhamnoides* ssp. *salicifolia* (Sea-buck-thorn, Chuk)	Common	Fruits eaten raw or made into several preparations, also used in local beverages; syrup of immature fruits used to remove dandruff; flowers useful source of bee-forage.

© Under License of Creative Commons Attribution 3.0 License

Table 4: Wild plants with potential for domestication and genetic improvements in different agro-ecologies.

S. No.	Plant Species	Distribution, diversity and specific adaptations	Domestication and genetic enhancement
		Alpine meadows	
1.	*Allium stracheyi*	*A. stracheyi* grows wild in the montane to upper sub-alpine zone; East Asia - Himalayas from Kashmir to western Nepal at altitudes of 2500-3000 m.	Wide diversity in wild populations is available for human selection.
2.	*A. wallichi*	*A.wallichii* is a plant species native to India, Nepal, Sikkim, Bhutan, Myanmar (Burma), Tibet and parts of China. It grows at elevations of 2300-4800 m.	Enough diversity in wild and cultivated populations suggests for its genetic improvement and commercial cultivation in Uttarakhand hills.
3.	*A. humile*	*A. humile* is an Asian species of wild onion with widespread distribution, south-central China and Tibet, and Indian Subcontinent, Pakistan, and Western Himalaya.	Widespread occurrence and diversity in wild populations for human selection reveals its potential for commercial cultivation and marketing.
4.	*Malus baccata* var. *himalaica*	*M. baccata* is native to Russia, Mongolia, China, Korea, Bhutan, India and Nepal, where it is common to mixed forests on hilly slopes at elevations up to 1500 m.	Most resistant to cold and pests, *M. baccata* is used for experimental breeding and grafting of other crab apples and domesticated apples as well.
5.	*Sorbus lanata*	*S. lanata* is common throughout the Uttarakhand hills from 2400-3200 m. Tolerates light shade, though it fruits better in a sunny position	Closely related to *S. cuspidata* and to *S. aria*, the potential of *S. lanata* needs to be explored for genetic improvement and commercial cultivation.
6.	*Hippophae rhamnoides* spp. *salicifolia*	It is native to the cold-temperate regions of Europe and Asia. In Asia, *H. rhamnoides* can be found in the northern regions of China, throughout most of the Himalayan region, including India, Nepal and Bhutan, as well as in the northern regions of Pakistan and Afghanistan.	The *H. rhamnoides* plant is particularly drought and salt tolerant and can thus be successfully used for land reclamation, against further soil erosion, as shelterbelt or in agroforestry.
		Traditional farming areas across mid-hills	
7.	*Cleome viscosa*	A plant of the moist tropics, where it is found at elevations up to 1,000 m in areas with a distinct dry season as well as in areas with no dry season.	As the plant has diverse uses and widespread distribution, beside food and medicinal value it has agroforestry uses as well.
8.	*Perilla frutescens*	*P. frutescens* is the sole species of the monotypic genus *Perilla* in the mint family, Lamiaceae. This species encompasses several distinct varieties of Asian herb, seed, and vegetable crop.	Perilla varieties are cross-fertile and intra-specific hybridization occurs naturally. Genetic enhancement and commercial cultivation is possible in Perilla as enough diversity is available for human selection.
9.	*Rosa sericea*/*R. macrophylla*	*Rosa sericea*, the silky rose, is a species of *Rosa* native to south-western China, Bhutan, northern India (Uttarakhand, Sikkim), Nepal and Myanmar, at altitudes of 2000-4400 m.	Hybridizes freely with other members of this genus. Widespread distribution and diversity present in the species reveals its potential to be domesticated and commercially cultivated.
10.	*Rubus* spp.	*R. ellipticus*, *R. biflorus*, *R. macilentus*, *R. niveus,* etc. commonly occur in Uttarakhand hills. *R. ellipticus* and *R. biflorus* have greater diversity represented in natural populations.	Breeding potential of different Rubus species occurring in the Uttarakhand hills needs to be explored for their domestication and commercial cultivation particularly in wastelands and agro-forestry systems (CPRs).
		River valleys	
11.	*Asendra butyracea* (Syn. *Diploknema butyracea*, Chiura; the Indian butter tree)	*A. butyracea* is a multipurpose tree. The main product of the tree is ghee (butter oil), extracted from the seeds. *A. butyracea* suits to different edapho-climatic conditions and thus does not compete with the traditional crops. Recently bath soap using butter of *A. butyracea* getting popular.	As the species is widely distributed in lower elevations areas across river valleys in Uttarakhand, it is an important tree species for social forestry/agro-forestry to be grown commercially for livelihood security of native communities.

Leading factors for change in wild food availability and use

The leading factors affecting wild food availability and use are listed in **Table 8**. **Table 8** reveals that resilience to climate change is more by wild species compared to crop species under cultivation and cultivated species of exotic origin that have been naturalized in local farming situations. Land use change and degradation including poor management of CPRs; unsustainable harvesting and changing dynamics; loss of LEK; socio-economic change and the market expansion due to globalization, etc., have been other drivers impacting availability and use of wild plant food resources.

Discussion

Wild foods have long been used by farmers, as 'hidden harvests', and have supplemented their dietary diversity and household income [2,23,24]. In traditional farming systems of Uttarakhand hills, the agroforestry and forestry based wild plant resources supplement household food choices and ensures dietary diversity and better nutrition. Wild gathered tubers, fruits, seeds, twigs, leaves and flowers of several plants still form minor but important food components of the rural communities **(Table 3)**. However, availability and access to these foods is declining as natural habitats are under constant pressure from developmental activities, poor management and conservation-exclusions. The

Table 5 Direct use values of wild plant foods for household consumption or income from sale in niche target areas of three representative farming situations.

Farm household respondents from niche sites of different farming situations	Decline in dietary diversity of cultivated plant species during past 2-3 decades (%)	Average wild plant species contributing to household dietary diversity	Contribution of wild harvested food resources to household cash income (%)*	A few important wild plant resources for household cash income from their market sale
Crop-livestock small scale mix-farming systems (10 niche sites; 150 households)	40	78	14	*Myrica esculenta* (Kaphal), *Diplazium esculentum* (Lingura, a vegetable fern), *Bauhinia variegata* (Kuiral, Mountain Ebony), *Dioscorea* spp. (Yams)
Mountain valleys, alpine meadows/bugyals (5 niche sites; 70 households)	35	35	34**	*Allium* spp. (Jambu or Faran), *Angelica glauca* (Gandhrain), *Carum carvi* (Kala Jeera)
River valleys (5 niche sites; 50 households)	70	14	2	*Diplazium esculentum* (Lingura, a vegetable fern)

* Only those households that are involved in harvesting and trading of wild plant resources

** Also includes wild harvesting and sale (often illegal) of "Keeda Jadi", the caterpillar fungus *Ophiocordyceps sinensis* (syn. *Cordyceps sinensis*). The fungus, considered as 'herbal viagra', is one of the entomogenous Ascomycetes and parasitizes the larvae of Lepidoptera to form the well-known traditional Tibetan medicine "yartsa gunbu" or, in traditional Chinese medicine, "DongChongXiaCao" ("winter worm-summer grass") in alpine meadows

Table 6 Sale of a few important wild harvested plant food resources in local markets of district Nainital.

S. No.	Plant species and market availability	Local Market (s)	Increase in market sale during past one decade (%)	Average cash income per household per annum for those involved in market sale (in INR)
1.	*Asparagus adscendens* (July-August)	Garampani, Nainital,	266.7	1950
2.	*Bauhinia variegata* (April-May)	Bhimtal, Bhowali, Garampani, Nainital	200.0	3500
3.	*Berbaris asiatica* (April-June)	Nainital	300.0	600
4.	*Chenopodium album* (March-November)	Bhowali, Garampani	471.4	1750
5.	*Cleome viscosa* (October)	Garampani	133.3	500
6.	*Dioscorea glabra* (February-March)	Bhimtal, Garampani, Nainital	222.2	260
7.	*Diplazium esculentum* (March-October)	Bhimtal, Bhowali, Garampani, Nainital	560.0	9000
8.	*Ficus glomerata* (May-June)	Nainital	200.0	750
9.	*Ficus palmata* (April-June)	Nainital	250.0	400
10.	*Girardinia diversifolia* (September-January)	Bhimtal	171.4	1500
11.	*Indigofera heterantha* (March-April)	Nainital	300.0	600
12.	*Myrica esculenta* (April-June)	Bhimtal, Bhowali, Garampani, Nainital	371.1	2725
13.	*Phyllanthus emblica* (September-November)	Bhimtal, Garampani, Nainital	185.7	650
14.	*Punica granatum* (September-October)	Nainital	150.0	300
15.	*Rubus ellipticus* (April-June)	Bhimtal, Nainital	250.0	1300

climate change and recurrent droughts are adversely affecting availability of the wild food resources. Further, the 'nutrition transition' and inflow of purchased foods are also negatively impacting the value of wild harvested foods.

It has been observed that most wild harvested plant products are consumed directly within the farmer households, hence it is often difficult to capture the quantity and diversity of the harvest at local or national level [24]. **Tables 5 and 6** confirms that some wild edible plant foods contribute substantially to the household dietary diversity and economy as well, whereas they have the potential to enhance household incomes once fully tapped **(Table 6)**.

It may be emphasized that 'malnutrition is a major health burden in developing countries and use of wild plant foods can be enlisted as policy support to secure wild food use and preserve habitats for wild edible species' [4]. Comprehensive food composition is therefore critical especially for communities most vulnerable to malnutrition [18,19]. We, however, have limited understanding of micro- and macro-nutritional properties of wild foods as compared to cultivated species.

Several wild edible plants are sources of important micronutrients, Fe, Ca, P, Na, K, Zn, etc. **Table 7** lists that many wild food resources of Uttarakhand hills are rich in micronutrients [22]. Many wild backyard plants and plants in agroforestry systems (CPRs) have edible parts that are commonly consumed and are critical suppliers of vitamins A, B2, C, antioxidants, especially during seasonal lean periods. Many are important as famine foods, ensuring year-round nutritional security in the face of possible food shortages.

The food and medicinal uses of wild plant food resources as

© Under License of Creative Commons Attribution 3.0 License

Table 7 Nutritive composition of some wild edible plant resources.

Name of the plant	Nutritional constituents												
	g/100 g								g/100 g				
	Moisture in fresh parts	Moisture	Ash	Crude protein	Crude fat	Crude fibre	Water soluble carbohy-drates	Starch	Na	K	Ca	P	Fe
Nutritive composition of some wild edible leaves													
Allium spp.	86.4	7.8	11.4	15.8	4.8	17.8	-	14.9	100	-	800	184	272
A. victorialis	-	9.3	13.8	10.1	5.3	18.3	18.1	10.9	120	4700	800	116	-
Chenopodium album	77.2	7.8	16	25.4	4.1	6.8	-	10.6	219		1800	377	94
Cleome viscosa	80.4	-	37.5	5.6	1.9	4.1	-	-	-	-	0.88	0.07	24.4
Epilobium roylianum	-	9.8	9.3	13.1	2.7	10.9	12.5	-	65	1250	800	100	97
Impatiens glandulifera (stem)	-	7.6	14	10.9	2.3	12.8	5.6	-	85	4200	950	366	116
Origanum vulgare	71.4	7.4	13.7	22.8	4.5	11	-	15.1	40		650	531	77
Phytolacca acinosa	-	7	16.1	22.4	3.6	11.3	15.2	8.2	130	6100	850	250	8
Rumex acetosa	-	6.2	17.7	23.9	2.2	10.2	2.1	10.5	155	4500	700	233	250
Stellaria media	-	4.8	20.8	18.4	2.5	14.6	-	11.09	58	2250	1780	271	10
Bauhinia variegata	-	6.4	7.3	20.4	2.8	13.9	7.9	-	73	1280	376	284	22
Bombax ceiba	-	7	8.4	7.6	2.3	25.9	-	-	1330	1610	2520	271	12
Rosa brunonii	-	8	8.7	10.6	7.3	15.7	14	-	65	1500	400	183	16
Berberis chitria	-	5.1	5	7.7	6.1	10.9	17.3	-	40	800	200	83	66
Ephedera gerardiana	-	-	-	8.3	3	17.5	40.4	-	219	-	1800	377	94
Hipophae rhamnoides ssp. *salicifolia*	-	5	4.2	12.1	12.3	5.5	9.4	-	45	500	150	50	116
Rosa brunonii	-	8.1	2.7	4.4	5.3	38.1	15.9	-	25	600	600	82	80
Allium rubellum	-	6.2	5.2	7.18	1.96	35.91	12.6	-	105	1350	600	133	383
Codonopsis ovata	-	7.7	9.6	7.43	4.18	18.6	9.5	17.29	165	900	542	16	30
Dioscorea bellophylla	-	5.4	2.55	7.85	0.84	4.02	3.52	61.74	31	-	63	165	565
D. bulbifera	-	5.6	3.05	3.75	0.54	2.52	7.93	61.47	25	-	187	17	31
Polygonatum verticillatum	-	8.9	2.3	4.75	0.56	10	57.6	8.13	30	440	150	130	38

Source: Negi and Gaur [22]

fruits and vegetables is known to lower risk of several oxidative stresses, including cardiovascular diseases, cancer and stroke and such health benefits are mainly ascribed to phytochemicals such as polyphenols, carotenoids and vitamins. Of these phytochemicals, polyphenols are largely recognized as anti-inflammatory, antiviral, antimicrobial and antioxidant agents.

The wild fruits are gaining increased attention now as potential food supplement or cheaper alternative of commercial fruits across the world. Evidences of the health benefits of wild edible fruits, in addition to established role in nutrition are available. In general, enough information is available on the antioxidant potential of fruits of different species. Some examples include: *Actinidia eriantha*, *A. deliciosa*, *Ficus carica*, *F. microcarpa*, *F. racemosa*, *Juglans regia*, *Kadsura coccinea*, *Myrciaria dubia*, *Phyllanthus emblica*, *Punica granatum*, *Randia echinocarpa*, *Ziziphus mauritiana* and so forth. Beside the fruits, antioxidant properties are also known for other plant parts.

There is no comprehensive estimate of the economic value of wild foods [4]. Quantitative analyses face methodological difficulties. Further, the trade of wild foods is often informal or occurs at local markets and is, therefore, missed by conventional accounting mechanisms [25].

A few prioritized species of potential importance in Uttarakhand hills contributing to livelihood and nutritional security of local

Table 8 Drivers of change in wild food availability and use.

	Drivers of change	Impact on wild food availability and use
A	Climate change	Wild food species offer a potentially critical role for buffering against food stress caused by a changing climate. The innate resilience of wild species to rapid climate change could, however, play an increasingly important role during periods of low agricultural productivity associated with climate events which often is lacking in exotic species.
B	Land use change and degradation including poor management of CPRs	Changes in land use and agriculture expansion/urbanization have significant implications for the availability of wild foods. Poor management of CPRs and deforestation has led to a decline in wild food species. Efforts by the local communities to stem this loss by domesticating important species were often unsuccessful, as many species do not survive outside their natural forested habitat.
C	Unsustainable harvesting and changing dynamics/ priorities	In certain niche habitats of Uttarakhand hills, unsustainable harvests have led to declines in wild food species. Unsustainable harvesting is a concern in the case of wild food resources of high elevation areas in Uttarakhand hills, more particularly "Jambu or Faran" (*Allium* spp.) and "Gandhrain" (*Angelica glauca*), the two-important wild harvested commodities from alpine meadows/bugyals of Uttarakhand hills.
D	Loss of indigenous or local ecological knowledge (LEK)	A significant decline was recorded in LEK where communities rely increasingly on market-bought foods and move away from land-based livelihoods. In low income communities from all agro-ecologies of Uttarakhand hills, LEK was found to be higher, and rate of knowledge acquisition rapid from a young age. This suggests that as communities become wealthier, knowledge becomes concentrated in fewer people with a sustained personal interest.
E	Socio-economic change including the expansion of markets due to globalization	The nutrition transition associated with modernization of diets poses challenges to public health in hill communities. The replacement of wild foods by market-bought products is linked to reduced dietary diversity, rising rates of chronic lifestyle-related conditions. Niche habitats where children use wild plant resources, level of malnutrition was low.

communities require science and marketing related policy interventions. *Myrica esculenta*, *Diplazium esculentum* (a vegetable fern), *Phyllanthus emblica*, *Oreganum vulgare*, *Cleome viscosa*, etc. in mid-hill areas under rainfed farming landscapes and *Allium* spp., *Carum carvi*, *Angelica glauca*, etc. from mountainous meadows can be discussed here in greater details **(Table 9).**

A number of important drivers of change for wild food availability and use have been reported [4]. Food insecurity, for instance, is a particular problem among local communities with crop-livestock small-scale mix farming situations followed by nomadic pastoralists and least in households of river valleys in Uttarakhand hills. Cultural identity and agrobiodiversity are strongly associated, culture and ecosystems are known to co-evolve. Thus, a biophysical driver (e.g. climate change) could have knock-on effects on a cultural parameter (e.g. local knowledge), and the effect of the two combined could lead to either an increase or decrease in wild food use [4].

A comparison of farming communities of three distinct agro-ecologies of Uttarakhand hills revealed insufficient evidence to predict the impacts that climate change on both human foraging and the interlinked processes of LEK transmission, cultural continuity and land-based subsistence livelihood. Forecasting the precise impacts of the changing climate on the availability of wild foods is difficult but the supposedly inherent resilience of wild species to rapid climate change as compared to cultivated or exotic species means that they could play an increasingly important role during periods of low agricultural productivity associated with climate events [4].

Decline in management of CPRs including expansion of intensive agriculture and urbanization have significant implications for the availability of wild foods, the commercialization of agriculture—an important driver of land use change-potentially implies decreased reliance on wild foods [26]. Agricultural and land use policy, infrastructure development and widened access to markets all drive land use change and are implicated in declines of wild species [27-29].

Most of the wild food species used by local communities come from well managed CPRs and agroforestry systems rather than mature forests. The 20 niche habitats surveyed in the present exploratory study, poor management of CPRs and deforestation had led to a decline in wild food species. Lack of sustainable intensification calls for a biodiversity-focused strategy in food, public health and poverty-alleviation policies [4].

The Indian Himalayas including the Uttarakhand hills is one of the global hot-spots of biodiversity with areas of greater malnutrition and hunger, also placing pressure on biodiversity for food provision. In certain niche habitats, unsustainable harvests have led to declines in wild food species. Unsustainable harvesting is a concern in the case of wild food resources of high elevation areas in Uttarakhand hills, more particularly "Jambu or Faran" (*Allium stracheyi* and *A. wallichii*) and "Gandhrain" (*Angelica glauca*), two important wild harvested commodities from alpine meadows/bugyals of Uttarakhand hills. The treasure nature has given us for medical purposes, but that does not justify the use of uneven means for any selfish motives.

Loss of LEK has been observed in Uttarakhand hills. A strong inverse correlation has been reported by Pilgrim et al. [30] between ecological knowledge and income levels. Understanding ecological knowledge loss is important to understanding the declining capacities of communities undergoing economic development to manage their natural resources and the future of ecosystem diversity in the light of current patterns of economic growth [30]. It was interesting to note that in low income communities of small-holder crop livestock farming systems and that of resource-dependent low-income communities of higher Himalayan mountainous regions, LEK was found to be higher and rate of knowledge acquisition rapid from a young age. This suggests that as communities become wealthier, knowledge

© Under License of Creative Commons Attribution 3.0 License

Table 9 Discussions on prioritized plant food resources with proven marketing potential in Uttarakhand hills.

	Wild plant species	Discussions on marketing potential
1	*Myrica esculenta* (Kaphal)	*Myrica esculenta* is amongst highly valued wild edible fruits of Uttarakhand hills. Wild populations of *Myrica esculenta* are fairly widespread in Uttarakhand hills particularly Kumaon region between 900 and 2100 masl and contributing substantially to livelihood and nutritional security of local communities.
2	*Diplazium esculentum* (Lingura)	*Diplazium esculentum*, a vegetable fern, is pantropical in distribution and occurs widely and commonly throughout India, China, Cambodia, Laos, Thailand, Vietnam and Malesia, with no threats and hence categorized as Least Concern. Globally, it is used as a leafy vegetable. It is familiar food available in local markets of Uttarakhand hills. *D. esculentum* can be used as a natural antioxidant, antimicrobial and cytotoxic agent [31].
3	*Phyllanthus emblica* (Aonla)	*Phyllanthus emblica*, fruits eaten raw or pickled are rich source of Vitamin C; one of the ingredients of 'Trifala', most widely used for several disorders. There are many habitats in Uttarakhand hills, the warmer valleys, where aonla wild stands are contributing to livelihood security of local communities. The therapeutic potential of *P. emblica* has been described in greater details by Herring [32].
4	*Bauhinia variegata* (Kuiral)	*Bauhinia variegata* is occurring throughout the Himalayas in low- to mid-elevation areas. The buds and flowers are cooked as a delicious vegetable or also made into pickles, but they must be boiled before preparing. Leaves provide good quality fodder; fibre from bark variously used; ash of dried leaves taken in cough, which make it an important tree of social forestry.
5	*Oreganum vulgare* (Bantulsi)	*Oreganum vulgare* has been used as a culinary and medicinal herb for thousands of years. Phyto-chemical 'Quercetin' present in oregano restricts growth of malignant cells in the body and acts like a drug against cancer-centric diseases. *O. vulgare* extracts and essential oil are strong candidates to replace synthetic chemicals used by the industry [33].
6	*Cleome viscosa* ('Jakhia', Asian spiderflower, Tickweed)	*Cleome viscosa* is gathered from the wild and is occasionally cultivated in Uttarakhand, where it is gaining in popularity as a low-cost substitute for cumin. Besides, there are several medicinal uses of *C. viscosa*. The seeds are anthelmintic, carminative, rubefacient, stimulant and vesicant. In excess the seeds can cause flatulence and distension of the stomach. A decoction of the seeds is used as a wash to treat piles. The seed contains 0.1% viscosic acid and 0.04% viscosin. A paste of the root is applied externally in the treatment of earaches [34]. The juice of the leaves has been used to relieve earache.
7	*Allium* spp. ('Jambu' or 'Faran')	'Jambu' or 'Faran' (*Allium stracheyi*, *A. wallichii* and *A. humile*) is a cultural and traditional seasoning commodity of the people of Uttarakhand hills. Almost all families in Tolma, a village in the Nanda Devi Biosphere Reserve, practise Faran farming. Likewise, many villages in Malari valley of Chamoli in Garhwal and Johar and Darma valley of Pithorgarh district in Kumaon region cultivate Jambu. Marketing of Jambu or Faran is not a problem; it is always in high demand.
8	*Angelica glauca* (Gandhrain)	*Angelica glauca* is harvested for its roots. During collection, the whole plant is uprooted and individuals are disturbed by this unsustainable collection practice. This collection practice has resulted in decline of its area of occupancy, extent of occurrence and habitat quality based on observations, as well as circumstantial evidence. The wild population has declined by c. 70% over the last 10 years. The species is therefore assessed as Endangered (EN).
9	*Carum carvi* (Kala jeera or Bhotia jeera)	*Carum carvi* seeds are used as flavouring or aromatic agent. Major phytochemicals reported in *C. carvi* seeds are limonene, carvacrol, carvone, carvenone, γ-terpinene, α-pinene, linalool and p-cymene. New researches on caraway proved it as a source of new entities to perform different pharmacodynamic properties, responsible for their pharmacological effects. It has also been recommended that aromatherapy could be applied as a complementary therapy for people with anxiety symptoms using essential oil of *C. carvi*.

becomes concentrated in fewer people with a sustained personal interest.

The distribution of LEK between individuals in a community has been reported to be differentiated by gender, age or social role [4]. Data from the 20 niche sites, women above 40 years of age were able to describe the uses of about 70 per cent of all edible species, while young men could only describe 15-20 per cent. Similar findings have been reported from a study from Nepal [5]. Men and women might also hold specialized LEK. LEK is also differentiated by age [5].

A significant decline was recorded in LEK where communities rely increasingly on market-bought foods and move away from land-based livelihoods [30]. In certain farming landscapes, it was observed that the grown-ups usually succumb to the culture of the society where consumption of wild fruits is regarded as an inferior act. Further, the LEK decline (in terms of species names and uses) is associated with increasing disconnection and livelihood independence from agricultural and wild systems as a consequence of modern economic growth.

LEK is likely to be substituted by modern environmental knowledge about global warming, energy saving techniques and organic foods for example. This global knowledge is, of course, essential but should not replace that of our local ecosystems [4].

The nutrition transition associated with modernization of diets poses challenges to public health in hill communities. The replacement of wild foods by market-bought products is linked to reduced dietary diversity, rising rates of chronic lifestyle-related conditions such as obesity and type II diabetes, poor intake of micronutrients and malnutrition. Traditional species become undervalued and underused as exotic ones become available.

Yet, the importance of wild foods to nutritional security means that they are not necessarily replaced by market-bought foods providing the same amount of calories. When more people depend solely on market-bought (cultivated foods), consuming wild foods will be marginalized [4].

As Uttarakhand hills have a strong food culture, traditional food systems can persist, and wild foods are still prevalent enough to be considered an important part of local diets particularly in crop-livestock mix farming systems and pastoralist communities of higher Himalayan ranges.

The nutrition transition is driven by a changing climate as well as large-scale cultural changes and is expected to produce significant negative effects to physical and mental health at community level. Niche habitats where children use wild edible fruits and vegetables, level of malnutrition was low and the benefits of consuming traditional wild foods were clearly evident. Though wild foods have played a critical role several traditional farming area across the globe including circumpolar communities, public health policy generally operate within a model of food security that discounts the traditional food practices of native communities [4,31,32].

Conclusion

Wild plant food resources form a significant portion of the dietary diversity of the farmer households of Uttarakhand hills. However, the contribution of wild harvested foods to total food and nutritional security is under-researched. Constant efforts to increase agricultural production and enhance economic development have threatened the continued contribution of wild species to food and nutritional security. Further, the sustainable harvesting of wild economic species requires a strong policy support by ensuring its continued availability for livelihood and nutritional security of local communities.

Use of wild food resources is part of culture and traditions of hill communities of Uttarakhand and is part of their living link with the land. Decline in traditional ways of life is interlinked with decreased wild food use. Wild food species, therefore, provide more than just food and income to hill communities. Policies on conservation, food-security and agriculture, therefore, need to be integrated to recognize and preserve the importance of wild foods.

Traditional food revitalization projects aimed at increasing the consumption of wild foods, in order to provide health and cultural benefits to traditional communities otherwise subject to the nutrition transition is considered a necessity. It is a well-recognized fact now that wild species and intra-species biodiversity have key roles in global nutrition security. The wild foods still provide substantial health and economic benefits to those who depend on them globally. The efforts to conserve biodiversity and preserve traditional food systems and farming practices, therefore, need to be combined and enhanced.

Acknowledgement

The authors thank the Director, ICAR-NBPGR, New Delhi for providing facilities for the exploratory surveys in parts of Uttarakhand hills. The farmer households from different niche habitats of Uttarakhand state deserve our thanks for interacting with the research team and sharing the valuable information they possess on traditional agricultural innovations, native resources and food systems.

Funding

Financial support received from the Jawaharlal Nehru University, New Delhi for a case study titled “Indigenous land and food systems in Uttarakhand: A case study on traditional knowledge and use of wild foods in agricultural systems” under DST Network Programme on Traditional Knowledge Systems in the Indian Himalayan region is duly acknowledged.

Disclosure statement

No potential conflict of interest was reported by the authors.

References

1 Jaenicke H, Höschle-Zeledon I (2006) Strategic framework for underutilized plant species research and development. Rome, Italy: ICUC, Colombo and Global Facilitation Unit for Underutilized Species.

2 Grivetti LE, Ogle BM (2000) Value of traditional foods in meeting macro and micronutrient needs: The wild plant connection. Nutr Res Rev 13: 31-46

3 Rathore M (2009) Nutrient content of important fruit trees from arid zone of Rajasthan. J Hort Forestry. 1: 103-108.

4 Bharucha Z, Pretty J (2010) The roles and values of wild foods in agricultural systems. Philos Trans R Soc B Biol Sci 365: 2913-2926.

5 Shrestha PM, Dhillon SS (2006) Diversity and traditional knowledge concerning wild food species in a locally managed forest in Nepal. Agroforest Syst 66: 55-63.

6 Johns T, Mohoro EB, Sanaya P (1996) Food plants and masticants of the Batemi of Ngorongoro District, Tanzania. Econ Bot 50: 115-121.

7 Ogle BM, Tuyet HT, Duyet HN, Dung NX (2003) Food, feed or medicine: The multiple functions of edible wild plants in Vietnam. Econ Bot 57: 103-117.

8 King FB (1994) Interpreting wild food plants in archaeological record. In Eating on the Wild Side. Edited by: Etkin NL. Tucson: University of Arizona Press.

9 Diamond J (2002) Evolution, consequences and nature of plant and animal domestication. Nature 418: 700-707.

10 Leonti M, Nebel S, Rivera D, Heinrich M (2006) Wild gathered food plants in the European Mediterranean. Econ Bot 60: 130-142.

11 Walters M, Hamilton A (1993) The Vital Wealth of Plants. Gland Switzerland: WWF.

12 Simpson BB, Ogorzaly MC (1995) Economic botany: Plants in our world. New York: McGraw Hill.

13 FAO (2009) The State of Food Insecurity in the World. Rome: FAO.

14 Balemie K, Kebebew F (2006) Ethnobotanical study of edible wild

© Under License of Creative Commons Attribution 3.0 License

plants in Derashe and Kucha districts, South Ethiopia. J Ethnobiol Ethnomed 2: 53.

15 Lockett CT, Calvert CC, Grivetti LE (2000) Energy and micronutrient composition of dietary and medicinal wild plants consumed during drought. Int J Food Sci Nutr 51: 195-208.

16 Agea JG, Okia CA, Abohassan RAA, Kimondo JM, Obua J, et al (2011) Wild and semi-wild food plants of Bunyoro-Kitara Kingdom of Uganda: Growth forms, collection niches, parts consumed, consumption patterns, main gatherers and consumers. Environ Res J 5: 74-86.

17 Ojelel S, Kakudi EK (2015) Wild edible plant species utilized by a subsistence farming community in Obalanga sub-county, Amuria district, Uganda. J Ethnobiol Ethnomed 11: 7.

18 Afolayan AJ, Jimoh FO (2009) Nutritional quality of some wild leafy vegetables in South Africa. Int J Food Sci Nutr 60: 424-431.

19 Misra S, Maikhuri RK, Kala CP, Rao KS, Saxena KG (2008) Wild leafy vegetables: A study of their subsistence dietetic support to the inhabitants of Nanda Devi Biosphere Reserve, India. J Ethnobiol Ethnomed 4: 15.

20 Panda T (2014) Traditional knowledge on wild edible plants as livelihood food in Odisha, India. J Biol Earth Sci 4: 1.

21 Namrata L, Kumar D, Ghosh SC, Dwivedi, Singh B (2011) Wild edible plants of Uttarakhand Himalaya: A potential nutraceutical source. Res J Med Plant 5: 670-684.

22 Negi KS, Gaur RD (1994) Principal wild food plants of western Himalaya, Uttar Pradesh, India. In: Higher Plants of Indian Sub-continent 3: 1-78.

23 Heywood VH (2011) Ethnopharmacology, food production, nutrition and biodiversity conservation: Towards a sustainable future for indigenous peoples. J Intercult Ethnopharmacol 137: 1-15.

24 IIED (1997) The hidden harvest: The role of wild foods in agricultural systems. 3: 93.

25 Jaarsveld AS, van Biggs R, Scholes RJ, Bohensky E, Reyers B (2005) Measuring conditions and trends in ecosystem services at multiple scales: The Southern African Millenium Ecosystem Assessment (SAfMA). Phil Trans R Soc B 360: 425-441.

26 Treweek JR, Brown C, Bubb P (2006) Assessing biodiversity impacts of trade. Impact Assess Project Appraisal 2: 299-309.

27 Schmidt-Vogt D (2001) Secondary forests in swidden agriculture in the highlands of Thailand. J Trop Sci 13: 748-767.

28 Padoch C, Coffey K, Mertz O, Leisz SJ, Fox J (2007) The demise of swidden in Southeast Asia? Danish J Geogr 107: 29-41.

29 Xu J, Lebel L, Sturgeon J (2009) Functional links between biodiversity, livelihoods and culture in a Hani swidden landscape in southwest China. Ecol Soc 14: 20.

30 Pilgrim SE, Cullen LC, Smith DJ, Pretty J (2008) Ecological knowledge is Lost in wealthier communities and countries. Environ Sci Technol 42: 1004-1009.

31 King U, Furgal C (2014) Is hunting still healthy? Understanding the interrelationships between indigenous participation in land-based practices and human-environmental health. Int J Environ Res Public Health 11: 5751-5782.

32 Herring RJ (ed) (2015) The Oxford Handbook of Food, Politics and Society. Oxford University Press.

33 Namrata L, Kumar D, Ghosh SC, Dwivedi, Singh B (2011) Wild edible plants of Uttarakhand Himalaya: A potential nutraceutical source. Res J Med Plant 5: 670-684.

34 Akter S, Hossain MM, Ara I, Akhtar P (2014) Investigation of in vitro antioxidant, antimicrobial and cytotoxic activity of *Diplazium esculentum* (Retz). SW. Int J Adv Pharm Biol Chem 3: 723-733.