Diversity and use of wild and non-cultivated edible plants in the Western Himalaya

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Abstract

Background: Local people in the Himalayan region use a wide range of wild and non-cultivated edible plants (WNEPs) for food, spice, medicinal, and cultural purposes. However, their availability, use, status and contribution to livelihood security are poorly documented, and they have been generally overlooked in recent agro-biodiversity conservation and management programmes. The study aimed to investigate WNEP diversity and current status in a part of the Kailash Sacred Landscape—a transboundary landscape shared by Nepal, India and PR China—in terms of collection, use, management and conservation initiatives.

Methods: Multiple methodologies and tools were used for data collection. A series of participatory tools (45 key informant interviews, 10 focus group discussions, a crop diversity fair, direct observation of species through a transect walk and rapid market assessments) was followed by a household survey (195 respondents) and complemented by a literature review.

Results: The study recorded 99 WNEPs belonging to 59 families of which 96 were angiosperms, one gymnosperm and two pteridophytes. Species were used for food, spice, medicine, rituals and income generation. Thirty-five species had multiple uses, including these: 40 species were used for fruit and 31 for vegetables. WNEPs contribute significantly to daily food requirements, especially the vegetables. The use value of Dryopteris cochleata was found highest (0.98) among frequently used vegetable species. The values of informant consensus factor were found maximum for worms in the stomach (0.99) and minimum for skin disease treatment (0.67). Nearly 85% of households depended exclusively on WNEPs for at least more than a month per year. Results on the importance and use of different species, gender roles in WNEP activities and conservation approaches are presented.

Conclusions: People living in the Kailash Sacred Landscape depend significantly on WNEPs, and this is especially critical in times of food shortage. The WNEPs have considerable potential as an important supplement to cultivated food crops. Farmers prioritise species with multiple use values and popular vegetables. However, there are numerous challenges and interventions needed to ensure conservation and management of species and their continued availability to support food security and local livelihoods.

Keywords: Wild and non-cultivated edible plants, Kailash Sacred Landscape, Traditional knowledge, Food security
Background

The majority of rural communities living in mountain and hill regions use wild and non-cultivated edible plant species (WNEPs) for food, medicine and other purposes [1–3]. WNEPs cover a wide range; they include wild fruit, nuts, leaves, roots, shoots and whole plants collected from forests, hedges and grassland; plants growing naturally alongside the actual crop in cultivated and fallow agricultural land; and plants established in the wild or in fields from seed that has dispersed from previously grown crops [4–9]. On occasion, plants that grow in the wild around some villages are collected as WNEPs and may be protected and managed in home gardens or agricultural fields in other villages where they count as crops.

Throughout the Himalayan region, WNEPs contribute substantially to food security, help maintain health and offer economic opportunities for millions of mountain people [10–12]. They are eaten in a myriad of ways—raw in salads and pickle, boiled in curries and soups, fried and steamed—depending on preference and taste [13, 14]. Many of these plants have cultural values, while some are considered sacred and used in religious and cultural events [11–13]. A number of studies in the Himalaya have documented WNEP species used as regular food [1, 2, 10–12] and shown that WNEPs play a significant role in fulfilling daily food requirements, especially in rural areas.

Notwithstanding the contribution to livelihoods and well-being, WNEPs have received little attention in the Himalayan region, with the exception to some extent of medicinal plants. There have been only a few studies of the diversity, use and local management practices of WNEPs [2, 11, 13, 15] and none on status and availability. Little is known about household consumption patterns or their role in household-level food and nutrition security and healthcare. Many studies have focussed simply on listing wild edible species and noting their use as food or medicine [1, 2, 9–13, 15, 16]. Furthermore, most research and development interventions under government programmes have paid little or no attention to this important sector [17–19]. Quantitative information on the presence, abundance, use and management of WNEPs is essential as a basis for developing effective conservation and management strategies that ensure that these species can continue to contribute to and, where possible, be used to improve food security.

The Kailash Sacred Landscape (KSL) is a transboundary landscape culturally linked to the region around Mount Kailash and shared by Nepal, India and the People’s Republic of China. It is home to many ethnic communities and is a rich repository of WNEPs. Local people are known to rely heavily on these plant species for their livelihoods [20], but the actual availability, use, contribution to livelihoods and engagement of household members are poorly documented. The present study selected Khar Village Development Committee (VDC) in Darchula District in KSL Nepal to investigate the diversity of WNEPs, how each species is being used, the role in and implications for livelihoods and local perceptions on conservation and management differentiated by gender.

Methods

Study site and people

The study was conducted in all nine wards of Khar VDC of Darchula District in the Far Western Development Region of Nepal, located at 29.761128 to 29.817314 N latitude and 80.597531 to 80.683363 E longitude (Fig. 1). Khar VDC is a predominantly rural mid-hill area, with a total area of 26 km² at an elevation of 1353–3236 masl. The vegetation is sub-tropical in the lower parts and temperate at higher elevation with mostly fragmented areas of deciduous, coniferous and mixed forest and areas of cultivated land along the hill slopes (mostly rain-fed terraces) and valley bottoms (mostly irrigated). Close to half of the VDC area (51%) is covered by forest, 44% is agricultural land, 4% shrub land, 0.3% water bodies, 0.1% grassland and 0.07% settlement area [21]. The VDC is about a 3-h walk from Khalanga Bazaar, the district headquarters of Darchula. It is also connected by a rural road to the bazaar (ca. 14 km), but vehicular access is only possible during winter and spring.

In 2010, the VDC had a population of 4272 (2056 male, 2216 female) in 698 households [22]; the average household size of 7.1 is high compared to the national average of 4.9. The literacy rate is low (61% of respondents were non-literate). The dominant castes are Chhetri and Brahmin with a few households of Dalits. The major castes in the village include Manyal, Sitoli, Dobal, Mahar, Tamata, Bisht, Dadal, Bohara and Thagunna.

Research approach and methodology

Figure 2 shows the research study framework. Three broad approaches were used with multiple tools. Quantitative and qualitative primary data were collected using a range of participatory tools followed by a household survey; the results were supplemented with secondary data obtained from a literature review.

Participatory tools

A range of participatory rural appraisal tools was used to gather a wide range of information. A total of 45 key informants (18 female, 27 male) aged from 28 to 78 and representing all nine wards were interviewed individually. Key informants were selected at the village level with the help of the Api-Nampa VDC level conservation committee members, focussing on people expected to have extensive
knowledge of WNEPs. Nine were specifically selected as local healers (one from each ward) who had been treating people for various health-related problems. Key informants were interviewed about their perceptions of the availability, uses and status of WNEPs and their contribution to local livelihoods.

Ten focus group discussions (one in each ward and one with representatives from the nine wards and other key institutions) were organised with 7–12 people in each group (82 participants: 40 women, 42 men). The discussions focused on the general status and use of WNEPs in the VDC and local issues and initiatives on WNEP management.

Rapid market assessments were conducted at a local market (Dallekh Bazar) and the market at district headquarters (Khalanga Bazar) to identify the WNEPs available in different seasons, their market value and trends in use from the viewpoint of buyers and sellers.

A VDC level local crop diversity fair was organised in February 2015 to which farmers brought samples of all the WNEP species that they use that were available at the time. The aim was to make a rapid assessment of the general richness and status of non-cultivated plants available at that time. This fair provided a unique opportunity for individuals and community members to display their local plant material, as well as to share and document associated knowledge. During the fair, specimens of uncultivated plant species were collected and identified and herbarium were prepared.

WNEPs were also collected and identified in four field visits held in winter (February 2015), spring (May 2015), summer (July, 2016) and autumn (October 2016) by a multidisciplinary team consisting of a socio-economist, natural resources management expert, taxonomist and social mobiliser. Each field visit lasted for 15 days and covered all nine wards. The study team visited areas where species were found extensively in situ with the help of a social mobiliser and collected unidentified specimens for discussion with key informants. Information about species habitats was recorded, and photos were taken for future reference. Specimens were identified, and recent family and scientific names were assigned with the help of reference collections [23–27] and an expert taxonomist from the Central Department of Botany, Tribhuvan University.

### Household survey

A detailed household survey with a structured questionnaire was used to obtain information about the use of
WNEPs and any local-level management initiatives and the socio-economic and demographic features of the local population. The information gathered using the participatory tools was used in the survey design.

The sample size was determined using the following formula:

\[
\text{Number of households to be interviewed} = \frac{Z^2 \times N \times P(1-P)}{(e^2 \times N) + (Z^2 \times P(1-P))}
\]

where \( N \) is the total number of households \((N = 698)\), \( Z \) is the level of confidence (assumed value for 90% level of confidence is 1.65), \( P \) is the estimate of the indicator to be measured (assumed value 50% in the absence of any prior information) and \( e \) is the margin of error to be attained (assumed level of precision is set at 5%).

This gave a sample size of 195 households. In order to ensure proper representation from each ward, the sample was distributed proportionally according to the number of households in each ward. Within each ward, households were selected by random sampling with the help of computer-generated random numbers.

**Analytical tools**

Data was analysed using descriptive analysis and frequency calculation techniques, and results are presented in figures. In addition, informant consensus factor (ICF) was calculated to determine the homogeneity of the information and degree of overall agreement in using plant species with medicinal values—the species that are used for treating health-related problems at household level. The following formula was used [28]

\[
\text{ICF} = \frac{\text{Nur} - \text{Nt}}{\text{Nur} - 1}
\]

Here, Nur is the number of use reports mentioned by the informant for the given species and Nt is the number of taxa (species) used by majority of the households.

Use value (UV) was calculated for individual plant species to give quantitative measures of its relative importance to the informants objectively [29]. Use value was calculated by using the following equation: \( \text{UVs} = \frac{\Sigma U}{n} \), where UV refers to the use value of a species, \( U \) is the number of use reports mentioned by the respondents and \( n \) is the total number of respondents interviewed.

**Prior informed consent**

Before the study commenced, we shared the purpose and objectives with the community and relevant stakeholders in a half-day interactive meeting held in Dallekh village in Khar VDC. Prior informed consent was taken from the household respondents as well as all participants in the participatory interviews and discussions about the documentation and dissemination of local knowledge and use of WNEP species for study purposes.
Results

Agriculture and food security

Agriculture was the major source of livelihoods for the majority of households (92%); the major crops are maize, barley, wheat, finger millet and potato. However, only 5% of households were able to meet all their annual food requirements from their own production; the remainder were only food sufficient for 10 months or less. Households adopted multiple coping strategies during the food deficit months to meet their food requirements, including seasonal migration for work to the district headquarters and various parts of India, sale of agricultural and livestock products, collection and selling of yarsagumba (Cor- dyceps sinensis) and collection of WNEPs.

Diversity of WNEP species

A total of 99 WNEPs belonging to 59 families were identified and documented (Table 1). They included 96 angiosperms, 1 gymnosperm and 2 pteridophytes, with 7 in the family Moraceae, 6 Rosaceae, 5 Urticaceae, 4 Polygonaceae and 3 each in Araceae, Dioscoreaceae, Amaranthaceae, Lamiaceae and Combretaceae. Herbs and trees were the most common life forms (Fig. 3).

Diversity of use

All households were using a range of different WNEPs for food, spice, medicinal and religious purposes. The most common uses were as food (fruit 40 species, vegetables 31 species), medicine (30 species), others (16 species) and spice (10 species). In a few cases, WNEPs formed the main meal for a short period (e.g. boiled Dioscorea spp.). Other uses included religious and traditional rituals, making pickles, ripening bananas, extracting cooking oil, washing and dyeing, and income generation; 35 species had multiple uses (Fig. 4, Table 1).

The most commonly used parts were the fruit (45), leaves (31), and stems/shoots (17). Bark, buds, bulbs, flowers, tubers and corms, roots and seeds were also used (Table 1). Most uses (about 66%) were specific to a particular plant part, although sometimes plant parts had multiple uses (e.g. as religious offerings and as medicine). In around two thirds of the species, only one plant part was used; in the others, multiple parts were used.

A total of 30 plant species have been used for household-level healthcare (Table 1). Diseases cured through the local knowledge system in the study sites were grouped into eight major types, and ICF was calculated for those diseases and health-related problems (Table 2). These include stomach disorder (diarrhoea/dysentery), cuts and wounds, fever and headache, skin diseases/skin irritation, worms in stomach, nausea and vomiting, snake and scorpion bites and cough and cold. The values of ICF was found maximum for worms in the stomach (0.99) and minimum for skin disease treatment (0.67). Eight species were used to cure stomach disorder having maximum (178) number of use reports followed by cuts and wounds (160), and lowest use reports was found for skin disease (4) treatment (Table 2).

WNEPs used as vegetables for nutrition and food security

In terms of regular food, one of the most important contributions of WNEPs was as a vegetable (Fig. 4). All respondents reported that they regularly used WNEPs as a vegetable. The most frequently collected species were Dioscorea bulbifera L., Dioscorea deltoidea Wall. ex Griseb., Urtica dioica L., Fagopyrum esculentum Moench, Dryopteris cochleata (D. Don) C. Chr. and Paeonia emodi Royle. Almost all respondents (92%) used WNEPs to meet their daily vegetable requirements, with 75% depending exclusively on WNEPs for 1–3 months of the year and 10% for more than 3 months (Fig. 5).

The key perceptions of households on WNEPs and reasons for using them as vegetables are summarised in Fig. 6. The most common advantages of WNEPs were considered to be that they were tasty and nutritious (85%) and also freely available (68%).

Annual extraction and use

The estimated annual mean harvested weight of eight important species is shown in Fig. 7. The largest harvest was of P. emodi, a local seasonal vegetable locally known as heto found in the forest (150 kg), followed by F. esculentum and D. cochleata. Species like D. bulbifera (a tuber boiled as a vegetable) and U. dioica L. are also important as sources of income as they can be sold in the local market. A few species have a significant local economic value, and people have started collecting and marketing some high-demand species like P. emodi, whose leaves are used to treat diarrhoea, and D. cochleata, an edible fern shoot which is even popular in big cities. Some 13% of households sell these plants, earning an average of US $150 per season. However, WNEPs are not a major source of cash income for most households.

The estimation of UV or relative importance of the frequently used vegetable species in the study site revealed that although the mean annual harvest of the species like Paeonia emodi and Fagopyrum esculentum is higher than Dryopteris cochleata (Fig. 7), the use value of Dryopteris cochleata (0.98) is higher than Paeonia emodi (0.96) and Fagopyrum esculentum (0.74). The use value (UV) of most important species used as vegetables in the study site is presented in Fig. 8.

Gender roles in WNEP collection, utilisation, and management

Respondents were asked who in the household did what related to WNEP use. Overall, the roles and responsibilities
| Family         | Botanical name                                      | English name                          | Nepali name | Local name | Use/ Parts used | Remarks                     | Specimen number |
|---------------|-----------------------------------------------------|---------------------------------------|-------------|------------|----------------|-----------------------------|-----------------|
| Acoraceae     | Acorus calamus L.                                   | Flag root, myrtle flag               | Bojho       | Bojho      | M R             | Dried rhizome used to treat sore throat, coughs and colds | D142            |
| Adoxaceae     | Viburnum erubescens Wall.                          | Bajjang                              | Ganaule     | F F        | Fruit eaten    |                            | D305            |
| Adoxaceae     | Viburnum mistulae Buch.-Ham. D. Don                 | Kavase                               | Timelau     | F F        | Fruit sour but eaten |                            | D278            |
| Amaranthaceae | Amaranthus lividus L.                               | Amaranth                             | Latte       | V L Sh     | Leaves and young shoots eaten as a green vegetable | D500            |
| Amaranthaceae | Amaranthus spinosus L.                              | Amaranth                             | Kanya marshi/chuwa | V L Sh     | Young leaves and shoots eaten as a green vegetable | D283            |
| Amaranthaceae | Amaranthus spinosus L.                              | Amaranth                             | Ghya marshi | V O L Sh Se | Young shoots and leaves eaten as a green vegetable; seeds ground to flour and used to make chapattis; seeds fried in ghee and honey and made into round balls to be eaten (ladoo/geda) | D316            |
| Amaryllidaceae| Allium spp.                                          | Dhuunu                               | S L         |            | Dried plant leaves used in curries | D160            |
| Amaryllidaceae| Allium wallichii Kunth                             | Jimbur or Himalayan onion            | Jimbu Jhar  | S W        | Dried plant used in dal and curries | D50             |
| Anacardiaceae | Pistacia chinensis subsp. integerrima (J.L. Stewart ex Brandis) Rech.f | Insect gall in Pistacia              | Kakasingee  | M Gall     | Gall used to treat snake and scorpion bites | D294            |
| Apiaceae      | Angelica archangelica L.                            | Ganano                               | S M R Se    |            | Root ground and made into soup to treat stomach pain. Seeds ground to flour and used as spice in curry | D101            |
| Araceae       | Arisaema flavum (Forsk.) Schott.                    | Bako                                 | Bako        | V T        | Coms (tubers) boiled in ash and salt to remove toxic elements, cleaned, made into a paste and mixed with buckwheat flour to prepare curry | D196            |
| Araceae       | Arisaema tortuosum (Wall.) Schott.                  | Whipcord cobra lily                  | Bako        | Bako       | Boiled tubers eaten as vegetable | D412            |
| Araceae       | Colocasia esculenta (L.) Schott.                    | Taro                                 | Pidaalu     | V R S L    | Rhizome boiled and eaten as a vegetable; young stem and leaves used as a vegetable and in pickle | D119            |
| Arecaceae     | Phoenix humilis Royle                              | Thakal                               | Thakil/thakilo | F O F S   | Fruit eaten; pith from stem eaten; stem used to make thatched roofs | D284            |
| Asparagaceae  | Asparagus, wild Asparagus                          | Kurilo                               | Jhijhirkani | V M R Sh   | Shoots and leaves eaten as a vegetable | D140            |
| Family       | Botanical name                        | English name                   | Nepali name | Local name | Usea Parts usedb Remarks Specimen number |
|--------------|--------------------------------------|--------------------------------|-------------|------------|-----------------------------------------|---------------------------------|
| Asteraceae   | Asparagus racemosus Willd.           |                                |             |            | roots used to treat urinary and liver problems |                                |
|              | Ageratina adenophora (Spreng.) R.M.  | Crofton weed                   | Banmara     | Banmara    | Juice from crushed leaves used to treat wounds and cuts |                                |
|              | Ageratum corymoides (L.) L.          | Billygoat-weed                 | Gandhe      | Gandhe     | Leaves crushed and juice used to treat cuts and wounds | D73                             |
| Asteraceae   | Artemisia indica Willd.              | Mug-wort, Indian worm wood fleabane | Titepati   | Kuljo      | Leaves used in death ceremonies; leaves crushed and cut and juice used to treat skin problems (irritation) | D506                             |
| Berberidaceae| Berberis aristata DC.                | Barberry/ Nepal Barberry/ common Barberry | Chutro     | Chutro     | Fruit eaten; bark used as a dye and to treat diarhoea, piles and malaria | D190                             |
|              | Berberis asiatica Roxb. ex DC.       | Barberry/ Nepal Barberry       | Kirmando    | Kirmada    | Fruit eaten; bark used as a dye | D116                             |
| Bombacaceae  | Bombax ceiba L.                      | Silk cotton tree, Simal tree   | Simal       | F, O, F, Ba | Flowers used in a vegetable curry | D230                             |
| Cannabaceae  | Cannabis sativa L.                   | True hemp, Indian hemp, marijuana | Bhang      | Bhango     | Roasted seeds used to make pickle or eaten raw; green leaves occasionally used to make snacks (pakauda); green leaves made into a paste and applied to the forehead to treat high fever | D402                             |
| Chenopodiaceae| Chenopodium album L.                 | Lamb’s quarter                 | Bethe Sag   | Betu/ charchare | Leaves and young shoots eaten as a green vegetable | D229                             |
| Combretaceae | Terminalia bellirica (Gaertn.) Roxb. | Belleric myrobalan             | Barro       | Barado     | Ripe fruit eaten; seeds used to treat coughs and colds | D100                             |
|              | Terminalia chebula Retz.             | Chebulic myrobalan, yellow myrobalan | Harro       | Harado     | Fruit eaten; fruit and seeds used to treat coughs and colds | D154                             |
| Commelinaceae| Commelina benghalensis L.            | Day flower                     | Kane Sag    | Kanya sag  | Young leaves and shoots eaten as a green vegetable | D131                             |
| Convolvulaceae| Cucurbita reflexa Roxb.              | Dodder                         | Askas beli  | Megh       | Whole plant used to prepare medicine to treat livestock with cough and throat allergy | D300                             |
| Cucurbitaceae| Coccinia grandis (L.) Voigt.         | Ivy gourd, Kavai fruit         | Golkakri    | Golyakakadi | Fruits eaten as a vegetable | D280                             |
| Cucurbitaceae| Momordica dioica Roxb. ex Wild.      |                                | Bankarela   | Bankarela  | Immature fruit eaten as a green vegetable | D205                             |
| Dioscoreaceae| Dioscorea bulbifera L.              | Palmate leafed yam             | Githi       | Githo      | Tubers boiled and eaten as a vegetable | D429                             |
|              | Dioscorea deltoides Wall. ex Griteb. | Cush-cush yam                 | Bhyakur     | Bhyakur    | Bulbils and tubers boiled and eaten as a vegetable | D432                             |
| Dioscoreaceae| Ban tarul                          |                                | Ban taud    | V, R, B, T |                                | D438                             |
| Family           | Botanical name            | English name | Nepali name | Local name | Usea Parts usedb Remarks Specimen number |
|------------------|---------------------------|--------------|-------------|------------|----------------------------------------|---------------------------------|
| Dioscoreaceae    | Dioscorea hamiltonii      | Air potato, potato yam | Niuro      | Liundo    | V, O L Sh Tubers and bulbils cooked and eaten. Boiled tubers are used during religious event first day of Nepali Month Magh (January) | D113                            |
| Dryopteridaceae  | Dryopteris cochleata     | Edible fern shoot | Niuro      | Liundo    | V, O L Sh Young coiled fronds and shoots cooked and eaten as a vegetable; sold in urban markets (high demand) | D113                            |
| Elaeagnaceae     | Elaeagnus parvifolia Wall. ex Royle | Oleaster | Kankoli | Guyaalo  | F F Fruit eaten                        | D266                            |
| Ericaceae        | Rhododendron arboreum Sm. | Indian gooseberry | Amala | Aula     | F, M F Fruit eaten raw and dried; fruit used in preparation of some Ayurvedic medicines for treating indigestion | D218                            |
| Euphorbiaceae    | Phyllanthus emblica L. | Mountain ebony, White bauli | Koiralo  | Koiral   | V, M Bu, F Fruit eaten and offered to gods during rituals | D236                            |
| Fabaceae         | Albizia procera (Roxb.) Benth. | White siris | Siris     | Siris (not edible) | O, L Leaves used to cover bananas to ripen them | D85                             |
| Fabaceae         | Bauhinia variegata L. | White siris | Siris     | Siris (not edible) | O, L Leaves used to cover bananas to ripen them | D85                             |
| Fagaceae         | Castanopsis tribuloides (Sm.) A.DC. | Chestnut | Katus     | Katauj    | F, R F Fruit eaten and offered to gods during rituals | D145                            |
| Fagaceae         | Quercus lanata Sm. | Woolly-leaved oak | Baanjha  | Baanjha  | F, F Fruit eaten (lekaal) eaten | D480                            |
| Gentianaceae     | Swertia chirayita (Roxb. ex Fleming) Karsten | Chiretti | Chirita  | Chiraita | M, W Whole plant used to treat fever, diabetes, and skin diseases | D480                            |
| Hippocastanaceae | Aesculus indica (Wall. ex Cambess.) Hook. | Indian horse chestnut | Pangar    | Pangar   | M, O F Roasted fruit eaten to kill stomach worms; fruit used for washing clothes | D214                            |
| Juglandaceae     | Juglans regia L. | Walnut | Otkhar | Okhad     | F, R F Fruit eaten and offered to gods during festivals | D233                            |
| Lamiaceae        | Mentha indica L. | Mint | Pudina | Padamchel | S, M L Leaves used in pickle; juice from leaves used for cooling in summer | D110                            |
| Lamiaceae        | Mentha spicata L. | Mint | Pudina | Padamchel | S, M L Leaves used as spice in pickle; leaves used as medicine to reduce ‘body heat’ | D248                            |
| Lamiaceae        | Peperomia frutescens (L.) Britton | Penilla | Silame | Bhangiro | S, Se Seeds roasted and ground to use in pickle | D138                            |
| Lardizabalaceae  | Holboellia latifolia Wall. | Ghopala | F F | Ripe fruit eaten | D493                            |
| Lauraceae        | Cinnamomum grandifolium (Wall.) Mett. | Nepal camphor tree | Singhandhaakokila | Singhandhaakokila | M, R Ba, F Bark and fruit used to treat coughs and colds, toothache, and swelling of muscles; leaves and fruit offered to gods during rituals | D96                             |
| Lauraceae        | Cinnamomum tamala (Buch.-Ham.) T.Nees & Eberm. | Bay leaf | Tejaat | Tejaat/dalchini | S, L Dried leaves used as spice for curries to add flavour and smell | D82                             |
| Family            | Botanical name          | English name | Nepali name | Local name | Use | Parts used | Remarks | Specimen number |
|-------------------|-------------------------|--------------|-------------|------------|-----|------------|---------|-----------------|
| 50 Loranthaceae   | Loranthus odoratus Wall. | Ajeru        | Anjedu      | F          | F   | F          | Fruit very tasty | D178            |
| 51 Moraceae       | Ficus aureiculata Lour. | Eye's apron, Moretan-bay fig | Timilo | Timilo | F | F | Fruit eaten | D352            |
| 52 Moraceae       | Ficus hispida L.f.      | Khasreto     | Khasattyya  | F          | F   | F          | Fruit eaten | D132            |
| 53 Moraceae       | Ficus lacor Buch.-Ham  | Kabhro       | Kapado      | V          | Bu, R | Buds and flowers boiled and eaten as a vegetable and pickle | D100            |
| 54 Moraceae       | Ficus nentofolia Sm.    | Dudhilo      | Dudilo      | V, F       | Sh, F | Young shoots eaten as a vegetable; fruit eaten | D328            |
| 55 Moraceae       | Ficus semicordata Buch.-Ham. ex Sm. | Nepal fodder fig | Khaniyo | Khannyo/ khatine | F | F | Fruit eaten | D211            |
| 56 Moraceae       | Ficus subincola Buch.-Ham. ex Sm. | Berlo | Belto/ beldo | F | F | Ripe fruit eaten | D48             |
| 57 Moraceae       | Morus serrata Roxb.     | Mulberry     | Kimbu       | F, O       | F, L | Fruit eaten, very popular among children; leaves used as fodder, preferred by goats | D333            |
| 58 Musaceae       | Musa balbisiana Colfa   | Banana       | Bankera     | F, R       | F   | F          | Fruit eaten and offered to gods during rituals | D127            |
| 59 Myricaceae     | Myrica esculenta Buch.-Ham. ex D. Don | Box byrke | Kafal | Kafal | F | F | Fruit tasty and popular | D318            |
| 60 Myrtaceae      | Syzygium cumini (L.) Skeels | Black plum, Java plum, Indian black berry | Jamun | Jamno | F | F | Fruit eaten | D246            |
| 61 Myrtaceae      | Syzygium spp.           | Phalda       | F | F | Fruit eaten | D329            |
| 62 Nephrolepidaceae | Nephrolepis cordifolia (L.C. Presl) | Sword fern | Pani amala | Rasmada | M | T | Tubers eaten to treat worms | D72             |
| 63 Oxalidaceae    | Oxalis cernulata L.     | Indian sorrel, creeping sorrel | Chari amilo | Chalmado | S | L | Leaves used in preparing pickle | D99             |
| 64 Paeoniaceae    | Paeonia emodi Royle     | Hetto        | V | L, Sh | Young shoots and leaves eaten as a green vegetable; fresh or sundried, rehydrated, and cooked (in winter) | D32             |
| 65 Phytolaccaceae | Phytolacca acinosa Roxb. | Jarko        | Jarka/Jarka | V, M       | L, R | Young leaves and shoots eaten as a green vegetable; root used to treat sickness after eating buckwheat leaves | D4001           |
| 66 Pinaceae       | Pinus roxburghi Sarg.   | Chir pine, Himalayan long-leaved pine | Salla | Sallo khote | M | La | Resin used to clear blood clots | D70             |
| 67 Poaceae        | Dendrocalamus hamiltonii Neer & Am. ex Munro | Tufted bamboo | Bans | Bans | V | Sh | Young shoots (tama) eaten as a vegetable | D174            |
| Family     | Botanical name                                      | English name       | Nepali name  | Local name | Usea, Parts usedb | Remarks                                                                 | Specimen number |
|------------|-----------------------------------------------------|--------------------|--------------|------------|-------------------|--------------------------------------------------------------------------|-----------------|
| 68 Poaceae | *Drepanostachyum falcatum* (Munro) Keng. f.        | Himalayan Bamboo   | Nigaalo      | Nigaalo    | V, O S, Sh        | Stem used to make mats; young shoots eaten as a vegetable               | D290            |
| 69 Polygonaceae | *Fagopyrum esculentum* Moench                     | Buckwheat          | Phapar       | Phapar     | V L, Sh           | Young shoots and leaves eaten as a vegetable                             | D443            |
| 70 Polygonaceae | *Fagopyrum tataricum* (L.) Gaertn.                | Buckwheat          | Phapar       | Phapar     | V L               | Young shoots and leaves eaten as a vegetable                             | D205            |
| 71 Polygonaceae | *Polygonum* spp.                                   | Halaudo            | S L          |           |                   | Young leaves used to make pickle                                         | D8              |
| 72 Polygonaceae | *Polygonum verticillatum* Binelli ex Colla        | Nigal sag          | Khinaudo     | V L        |                   | Young leaves eaten as a vegetable                                         | D112            |
| 73 Ranunculaceae | *Aconitum heterophyllum* Wall. ex Royle             | Aconite            | Atis         | Atis       | M W, R            | Whole plant and roots used to treat high fever and abdominal pain       | D260            |
| 74 Rosaceae | *Fragaria nubicola* (Lindl.ex. Hook.f) Lacicata    | Gande kafal        | F, R, M      | F, W       | Fruit eaten; whole plant used in death rituals; whole plant used to treat stomach disorders | D68             |
| 75 Rosaceae | *Polygonum crenulatum* (Roxb. ex D. Don) M. Roem.  | Fire horn           | Ghangyar/ kaatha gedi | Ghangyar | F F               | Ripe fruit eaten in large quantities                                     | D108            |
| 76 Rosaceae | *Rubus niveus* Thunb.                               | Golden evergreen   | Ainselu      | Ainselu    | F F               | Fruit very popular                                                        | D348            |
| 77 Rosaceae | *Rubus ellipticus* Sm.                             | Rasberry           | Ainselu      | Kalo anselu | F, R F, L, W     | Fruit eaten; leaves or whole plant used in death ceremonies              | D501            |
| 78 Rosaceae | *Rubus foliolosus* D. Don                          |                    | Ainselu      | Kalo anselu | F F               | Fruit eaten; leaves used to treat cuts and wounds                        | D98             |
| 79 Rosaceae | *Rubus niveus* Thunb.                               | Ainselu            | Katnya anselu |           | F F               | Fruit eaten; leaves used for religious purposes, especially offering to gods during rituals | D103            |
| 80 Rubiaceae | *Rubia manjith* Roxb. ex Fleming                   | Indian madder      | Majitho      | Majitho    | M S, L            | Stem and leaves used to treat cuts and wounds                             | D187            |
| 81 Rutaceae | *Aegle marmelos* (L.) Correa                       | Bael fruit         | Bel          | Bel        | F, R F, L        | Fruit pulp eaten; leaves used for religious purposes, especially offering to gods during rituals | D234            |
| 82 Rutaceae | *Zanthoxylum armatum* DC.                          | Nepal pepper, prickly ash | Timur      | Timur     | S, M F            | Fruit dried and used as a spice in pickles and curries; dried fruit used in various allopathic medicines like indigestion and nausea | D431            |
| 83 Sapindaceae | *Sapindus mukorossi* Gaertn.                        | Soap nut           | Reetha       | Reetha (not edible) | O F               | Fruit pulp used to wash hair                                              | D268            |
| 84 Sapotaceae | *Diplaknema buynacens* (Roxb.) H.J.Lam             | Nepal butter fruit | Chiuri       | Chyuro     | O, F               | Nectar from flowers and ripened fruit (bhina) eaten; seeds used to make a butter |               |
in activities and decision-making on collection, processing, food preparation, storage and marketing of WNEPs were shared between men and women (Table 3). Irrespective of gender, about half of the respondents (49%) stated that decisions and activities related to collection and harvesting were shared by men and women, with the remainder divided almost equally between women or men. Responsibility for processing was generally thought to be shared for cooking vegetables and others.

### Table 1 Wild and non-cultivated edible plants identified in Khar VDC, Kailash Sacred Landscape, Nepal (Continued)

| Family            | Botanical name            | English name | Nepali name | Local name | Usea | Parts usedb | Remarks | Specimen number |
|-------------------|---------------------------|--------------|-------------|------------|------|-------------|---------|-----------------|
| 85 Saurauaceae    | Saurauia napaulensis DC.  | Gogan        | Gogan       | F          | F    |            | Fruit eaten | D15             |
| 86 Saxifragaceae  | Bergenia ciliata (Haw.)  | Rock foil    | Pakhanbed   | M          | R    |            | Rhizome used to make medicine to treat kidney stones | D134            |
| 87 Schisandraceae | Schisandra grandiflora    | Magnolia Vine| Haliyude    | F          | F    |            | Ripe fruit eaten | D245            |
| 88 Smilacaceae    | Smilax aspera L.          | Green briers | Kukurdaino  | F, V       | Sh, F|            | Fruit eaten; young shoots eaten as a vegetable | D218            |
| 89 Smilacaceae    | Smilax oasifolia Roob. ex D. Don | Green briers | Kukurdaino  | F, V       | Sh, F|            | Fruit eaten; young shoots eaten as a vegetable | D68             |
| 90 Solanaceae     | Solanum nigrum L.         | Kalokamai    | Ninauni     | F          | F    |            | Fruit eaten | D149            |
| 91 Trilliaceae    | Paris polyphylla Sm.      | Satuwa       | Satuwa      | V, M       | L, R |            | Tender leaves eaten as a vegetable; root made into paste and applied to snake bite to control the poison | D179            |
| 92 Urticaceae     | Boehmeria nagulosa Wedd. | Getha        | Githi       | O          | Ba   |            | Bark paste/powder mixed with rice flour to prepare sel roti (form of rice doughnut); bark paste used as soda and to wash clothes | D22             |
| 93 Urticaceae     | Debregeasia s asicifolia (D. Don) Rendle | Tusaare | Tusaaro | F | F |        | Fruit eaten | D55             |
| 94 Urticaceae     | Girardinia diversifolia (Link) Friis | Himalayan Nettle | Allo Sisnu | V, O | L, Sh, S | Young leaves and shoots eaten; fibre extracted from stems used to make clothes and bags | D17             |
| 95 Urticaceae     | Gonostegia hirta (Blume ex Hassk.) Miq. | Attinno | O | R | Ground root used to prepare chapatti; ground root used for washing hair | D458            |
| 96 Urticaceae     | Urtica dioica L.          | Stinging nettle | Sisnu      | V          | L, Sh | Young leaves and shoots used as a vegetable | D16             |
| 97 Verbenaceae    | Calycicarpa arborea Roob. | Beauty berry | Guvalo    | F | F |            | Tasty fruit | D67             |
| 98 Violaceae      | Viola L.                  | Juke jhaar   | M           | L, R       |      |            | Leaves and roots used to treat worms in children | D481            |
| 99 Vitaceae       | Tetragastris spp.         | Pudaayen     | F | F |            | Fruit eaten | D344            |

*aUse: F fruit, V vegetable, M medicine, O other, R religious, S spice
*bPart of plant used: W whole plant, B bulb, B buds, F fruit, F flowers, L latex, L leaf, O other, R root/rhizome, S stem, S seeds, Sh shoots, T tuber/corm
equally (around 80%) as was responsibility for conservation and management. However, women had much greater responsibility for preparation and storage.

Local perceptions

Respondents were asked about the existing and potential issues of concern related to WNEPs. The primary issues identified were premature and unsustainable harvesting (147), inadequate labour resources within the family (134) and time taken for collection (120) (Fig. 9). Other issues included neglect of local food, availability of ready-made food and problems identifying whether species are edible, especially among young collectors. We discussed these issues further in the FGDs. Of the ten FGDs (82 participants), eight groups also thought that the major issues for utilisation and management were lack of human resources due to migration for seasonal work, unsustainable harvesting and changing human lifestyles and taste. We also asked about current management practices. In all ten groups, participants mentioned in situ conservation of important species by almost all people in the village, with domestication of important species as the second most important strategy. This perception was supported by the data from the household survey. The great majority of respondents (86%) reported practising in situ conservation and domestication (38%) of key species in their home gardens and agricultural fields.

Discussion

Diversity of WNEPs and their use

It is estimated that at least a billion people use WNEPs in their diet [30]. Millions of people in the Himalayan region depend on WNEPs for their daily food and vegetable requirements as well as for fresh fruit and medicines [30–33]. Our study documented 99 WNEP species currently used in various forms by the local people in the Kailash Sacred Landscape area in far west Nepal. A number of studies by other authors have documented a diverse range of WNEP species and uses in different parts of the Himalayan region, but most have not assessed status and availability, household consumption patterns or local management practices. The study in Tibetan community of China documented the use of 54 species for household consumption [34]. Similar study conducted in Tibetan communities of Nepal, China and India also documented 75 wild food plants of diverse uses at household level [35]. Singh et al. [36] documented 111 WNEPs used in Bandipora district in Kashmir, while other authors identified 112 WNEPs in

| Use categories                          | No. of taxa | No. of use reports | Consensus factor |
|----------------------------------------|-------------|--------------------|-----------------|
| Stomach disorder (diarrhoea/dysentry)  | 8           | 178                | 0.96            |
| Cuts and wounds                         | 4           | 160                | 0.98            |
| Fever and headache                      | 6           | 125                | 0.96            |
| Skin diseases/skin irritation           | 2           | 4                  | 0.67            |
| Worms in stomach                        | 2           | 120                | 0.99            |
| Nausea and vomiting                     | 2           | 73                 | 0.98            |
| Snake and scorpion bites                | 2           | 8                  | 0.85            |
| Cough and cold                          | 4           | 186                | 0.98            |

Fig. 3 Frequency of different life forms of WNEPs

Fig. 4 Uses of WNEPs (single use, black-shaded; multiple use, grey-shaded)

Fig. 5 Dependence on WNEPs on daily vegetable requirements (N = 195)
Dhading and Kaski districts in Nepal [16] and 62 in Bhutan [37]. Khan et al. [38] conducted assessment of wild edible plants of Sewa catchment area in Northwest Himalaya of India and listed 97 plant species used by local inhabitants for various uses. More than 380 non-timber forest products (NTFPs) were identified in Meghalaya in North East India [39] and 739 in the Kangchenjunga Landscape (India, Nepal and Bhutan) [40] of which many were WNEPs, although these were not separately listed.

WNEPs contributed substantially to the food requirements of the households in the study area. People preferred to collect species with multiple use value, but they also collected large quantities of species used purely as a vegetable. *P. emodi*, *U. dioica*, *F. esculentum* and *D. cochleata* were particularly popular and constituted an important source of vegetables in household food. A large quantity of *P. emodi* and *F. esculentum* is harvested, but the use value of *D. cochleata* was found higher, which might be attributable to their widespread distribution and abundance of the later species across the study area making them the first choice for collection and consumption. The average annual extraction of species used as vegetables was very high; this has also been observed by others. For example, in Dhusa VDC in Dhading district, Nepal, individual households were observed to collect an average 200 kg of *D. bulbifera* per annum [13], while Chepang households in Gorkha district of Nepal consumed an average 364 kg of *D. bulbifera* and 96 kg of *U. dioica* per annum [41]. A diverse range of *Dioscorea* spp. is widely used and consumed by the local community in himanchal and Similipal Biosphere Reserve in India [31, 42]. Together, these figures suggest that people are harvesting at least some WNEPs in large quantities, which has also been observed in studies conducted in other parts of the world [1, 2, 11, 15, 31, 32, 43–51]. Most people at the study site depended on WNEPs to fill their vegetable requirements for between 1 and 3 months or more a year. A study carried out among the Chepang people in Nepal reported that 58% of households depended on WNEPs for

| Role and responsibility | N = 195 |
|-------------------------|--------|
|                         | Women  | Men   | Both  |
| Activities              |        |       |       |
| Harvesting/collection   | 55 (28)| 45 (23)| 99 (50) |
| Processing              | 25 (13)| 20 (10)| 150 (77) |
| Preparation             | 165 (84)| 10 (5) | 20 (10) |
| Storage                 | 135 (69)| 10 (5)| 50 (26) |
| Marketing/exchange      | 75 (38)| 37 (19)| 83 (43) |
| Conservation and management | 20 (10)| 35 (18)| 140 (72) |
| Decision-making         |        |       |       |
| Harvesting/collection   | 45 (23)| 55 (28)| 95 (49) |
| Processing              | 25 (13)| 12 (6)| 158 (81) |
| Preparation             | 185 (95)| 5 (3) | 5 (3) |
| Storage                 | 160 (82)| 10 (5)| 25 (13) |
| Marketing/exchange      | 45 (23)| 85 (44)| 65 (33) |
| Conservation and management | 48 (25)| 30 (15)| 117 (60) |

Note: figures in brackets are percentage of respondents
vegetables for up to 5 months a year [2], and in one village in India, people ate WNEPs as vegetables for at least 50–80 days per year [47]. A study in Burkina Faso showed 20% of all food items to come from wild/non-cultivated sources [43], while non-cultivated greens are one of the major sources of vegetables in rural areas of Vietnam, eaten by almost all households [43]. Wild leafy vegetables are an important part of diet of people of Shiri in Daghestan, and 70% of them are used as snacks. They are important in maintaining social life as the dried vegetables are sent as gifts to distant relatives and people visiting them at their place [52]. So, the wild vegetables are also culturally associated with the indigenous communities.

The studies highlight the importance of WNEPs in local diets but also indicate that the current trends in harvesting of some species may not be sustainable and could affect species availability in the future [1, 2, 4, 53].

WNEPs are considered to be an important source of vitamins and minerals [32, 54–56] and to contribute to energy and micronutrients for farm families throughout the year [43, 57]. The study conducted in Naxi community of China depicted that wild edible plants play a very important role in safeguarding food and nutritional security [58]. This is also supported by other two studies conducted in India [59, 60]. However, the precise nutritional composition of most of these foods is not known [61], although one study showed, for example, that the root crop from Dioscorea spp. contains five times more protein and fibre than potato and sweet potato [62]. Similarly, little is known about the actual contribution of WNEPs to people’s daily food requirements, and this remains poorly studied. In addition to contributing to food and nutritional security, a wide range of WNEPs contribute to health and well-being as medicinal plants [4, 10, 40, 44, 49, 63–67]. For example, most diseases in far west Nepal are treated by individuals and local healers using traditionally handed-down ethno-medicinal knowledge of plants, which have been protected and have flourished where ethnic traditions and beliefs are still strong [44, 68, 69]. The informant consensus factors for the medicinal plant use suggest that a number of plant species have been used for treating various ailments such as stomach disorder, colds and cough, wounds and cut, skin diseases, fever/headache, nausea and vomiting, worms in the stomach and snake and scorpion bites. Rural people, particularly in remote villages, have been using these plant species for generations to treat different diseases based on their indigenous knowledge. Similar treatments of various diseases were also documented in the other studies from the region [70–72]. Especially, local healers know how to prepare drugs from raw herbs through personal experience and ancestral prescription. Such drugs are regularly used and have proven to be effective, inexpensive and beneficial and with few side effects compared to allopathic drugs [2, 4, 10, 73]. The use of herbs by traditional health practitioners is based on trust gained over generations and religious connections to such practices [4]. However, the use of plants as medicines is declining [69, 74], partly because there are fewer traditional healers due to lack of knowledge transfer. The younger generation has little interest in studying traditional forms of medicine.

Although WNEPs make a significant contribution to the livelihoods of local people in the more remote mountain regions, these species are less used in the daily diets of households in other areas [2, 11, 13, 15]. WNEPs have the potential to play an important role in maintaining and improving food security in the many rural areas where food security remains a cause for concern and in supplementing nutritionally poor diets that are otherwise low in vitamins and minerals. However, changing food habits, taste, and lifestyles and availability of ready-made foods in the market are contributing to an increasing neglect of traditional foods in rural diets. Collection and use of WNEPs is considered risky and time-consuming, and young people are becoming less familiar with WNEP species and forest environments and less able to identify suitable species for harvesting. Little is known about the sustainability of harvesting practices [1, 2, 6, 9, 13, 16, 40], and reduced availability is also cited by various studies as one of the underlying causes of the declining use of WNEPs [1–3, 10–16]. The use of WNEPs is likely to decrease further, threatening the retention of knowledge about this important component of livelihoods, culture and tradition [11, 13]. At the same time, sustainable use and management of these resources remain a prime concern for the millions of mountain people whose lives still depend on them [49], as well as being essential to ensure the basis for further exploitation of their potential.
Conservation and management of WNEPs

The true status of WNEPs, their contribution to livelihoods and the interrelationship with other species in the region has yet to be studied systematically [33, 36, 44]. Recent and past studies remain inadequate as they have focussed more on compiling lists of species and less on analysing their contribution to nutrition and food security [40, 42]. Despite their important contribution to nutrition, WNEPs have also received little attention in government food and nutrition programmes in the region [2, 33, 44].

A number of studies have noted the decreasing availability of WNEPs [2, 15]. The loss of WNEPs has many causes, including habitat degradation, rapid urbanisation and over exploitation, as well as changes in food habits [75, 76]. Changes in agricultural practices towards increased monocropping, use of herbicides and pesticides and increased mechanisation and changes in forestry practices towards more managed regimes and plantation may all play a role. At the same time, some WNEP species are becoming more heavily exploited as urbanised populations become motivated to eat local products and farmers collect plants for sale in urban markets rather than personal consumption [15, 33, 44, 47, 74, 77–80]. Species with high use value are subjected to higher extraction, which may be unsustainable. Control of overexploitation and illegal harvesting will be essential to ensure sustainable management. A coordinated effort is needed from all sectors to develop and implement in situ conservation, domestication and other conservation and management strategies for long-term management of WNEP species [1–5, 13, 19, 31, 33]. Furthermore, WNEPs can be promoted through the large-scale cultivation by integrating them into agricultural systems and making markets profitable for the benefit of the people [59, 60] With the participation of local people and a wide range of other stakeholders, it will be possible to craft more holistic and culturally appropriate strategies for utilisation and management of WNEPs in the Western Himalayas [67].

Maintenance and use of WNEPs in the Kailash region, as in Nepal overall, is not just important for botanical studies or as an ecological exercise. The conservation and wise utilisation of the indigenous knowledge of useful plants can help in the improvement of living standard of poor people of Nepal. It equally holds true for several developing countries where similar ecological and socio-cultural landscapes exist [81]. These plants play a significant role in meeting the daily food requirements of thousands of people living in rural villages like Khar, and play an important part in their survival strategies [1, 2, 31, 37, 45, 82]. WNEPs are not only important in times of famine or stress [74], they are an essential part of a mineral rich normal diet for millions of people [83–85]. WNEPs are important resources, and further study is essential to provide updated inventories and information about their availability and use. Local people must be involved in conservation and management, as they are both the guardians and users of the resources and have the greatest knowledge about them. It is also important to organise local-level WNEP fairs and local food festivals to raise awareness about the importance of WNEP species, revive interest among the younger generation, and motivate communities towards proactive management of these resources. Domestication of WNEPs where possible will be needed to ensure continued availability; thus, it would be beneficial to encourage cultivation and/or domestication of plants used for food, fodder, medicine and other purposes. Technical and material support will be very much needed in the initial stages. Domestication in home gardens would be a good starting point, as they offer increased availability of water, a mostly organic-based production system, easier protection against predators and close monitoring by the household members.

Conclusions

A total of 99 WNEPs species with high diversity and multiple use values were documented in the KSL Nepal. These plants play a significant role in household-level food and nutrition as well as health security. The local livelihood system depends heavily on traditions and values that are rooted in nature. WNEP species, now often used most heavily in times of food shortage, have the potential to become important alternatives to the usual food crops cultivated by farmers. Farmers gave priority to those species that provide them with a multitude of benefits such as food and nutritional security as well as household-level healthcare but also harvested large amounts of species popular as vegetables. Species like P. emodi, D bulbifera L., D. deltoidea, U dioica, and F. esculentum are an important part of local peoples’ livelihoods. However, there is a growing pressure on such species, which suggests that there is an urgent need for conservation and management, which requires proper research and policy advocacy. These wild and non-cultivated resources are crucial to local peoples’ traditions and contribute strongly to subsistence. It is important to consider how such species can contribute to future food security. This requires an understanding of how to manage the cultural changes affecting the use of WNEPs and how to ensure sustainable availability. Integrated research and development programmes are urgently needed to address the issue.

Abbreviations

FGDs: Focus group discussions; KSL: Kailash Sacred Landscape; VDC: Village Development Committee; WNEP: Wild and non-cultivated edible plant species
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Availability of data and materials
Availability of the structured and organised version of the data is available from the first author upon request. The voucher specimens are kept at Central Department of Botany at Tribhuvan University, Nepal, and will be available upon request.

Disclaimer
The views and interpretations in this publication are those of the authors and not necessarily attributable to their organisations.

Authors’ contributions
KA, SP, RCP, NC, RC and WN designed the study. KA and SP carried out the literature review and did the field study and data collection. KA, SP, RCP, NC, PC and WN analysed the data and wrote the manuscript. All authors approved the final version of the manuscript.

Ethics approval and consent to participate
A prior informed consent was taken from the farmers and local communities in the study sites. The study was conducted in Api-Nampa Conservation Area of Department of National Parks and Wildlife Conservation of Government of Nepal, and prior approval and consent was taken from the government for this study.

Consent for publication
The manuscript does not include the individuals’ photographs and images, videos, reprints and personal information; hence, no need of submitting the consent for publication.

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