Heliyon 7 (2021) e05887

Contents lists available at ScienceDirect

Heliyon

journal homepage: www.cell.com/heliyon

Research article

Documentation and on farm conservation of neglected and underutilized plant species in Lamjung district, Nepal

Bipin Neupane *, Sadikshya Poudel

Institute of Agriculture and Animal Science, Lamjung Campus, Nepal

ARTICLE INFO

Keywords:
Conservation
Diversity
NUS
Socio-demographic
Superfoods

ABSTRACT

Neglected and underutilized species (NUS) are proven superfoods, but still many of those species are not mainstreamed in our food system. In this regard, research was carried out to explore diversity and identify prioritized species, explore use-values, and identify the role of a socio-demographic factor in its conservation and promotion. For this, a survey was conducted at two rural municipalities' viz. Marsayndi Rural Municipality-01 (Ghanpokhara) and Kwhlosothar Rural Municipality (ward no-03, Ghalegaun & ward no-04, Bhujung) in Lamjung district of Nepal. Location wise cluster sampling was conducted for data collection and the techniques employed were direct field observation, household sampling, key informant interview, personal interviews, and field studies. 92 species were documented during the study, moreover, a significant role of socio-demographic factors was seen in characterizing, evaluating, and conserving NUS on-farm. The results indicated that the education status and primary occupation of the household head had a major role whereas ethnicity had a certain level of the role while gender had no role to play on on-farm conservation of NUS. People with basic education status and agriculture as their primary occupations showed a higher influence on conservation. The result concludes with some insight on the way forward for NUS and addresses a need to establish a research and development program including all potential participants such as with government, academics, entrepreneurs, and producers to promote NUS.

1. Introduction

The transformation of our agriculture system has contributed to increasingly organized patterns of crop production and consuming habits around the world. In the world, 250,000 to 400,000 species belong to higher plants. Among them, 95% of the world's food supplies are provided by about 30 crop species, and it is considered that 7,000 species are being used for food and are either partially or completely cultivated (Williams and Haq, 2000). Only 12 species cover 75% of food and 4 species cover 50% of the food we consume. Nonetheless, when studying food supply at the sub-regional level, more crops emerge as essential that are dietary staples and play a crucial role in the food certainty, nutriment, and livelihood development of millions of the world poorest people. These are neglected and underutilized species (NUS) that attract little recognition or are completely overlooked by academics, breeders, and decision-makers (Padulosi et al., 2009). They are native or sub-domesticated species, and non-wood tree plants suited to specific local ecosystems that have the ability, which has not been completely exploited, to lead to nutrition security and hunger amelioration.

Nepal is an agro-biodiversity rich mountainous country. The three agro-ecological regions of Nepal (Terai, Mid Hill, and High Hill) are experiencing a wide range of climates from sub-tropical to temperate and alpine cold semi-desert, resulting in the evolution and maintenance of various crop gene pools. Nepal is ranked 49th throughout globe for its biodiversity richness (Joshi et al., 2019). Of Nepal's 577 cultivated species approximately 85 percent of these crop species are neglected and underutilized (Joshi et al., 2019). Plant estimates were made for 6,500 flowering plant species in Nepal (WCMC, 1994) 1,500 of which are labeled beneficial (Manandhar, 2002). Of aforementioned 651 species including 440 wild species are commercially valuable, and nearly 200 are consumed as vegetables (Shrestha, 2013), but most are considered to be underutilized or neglected.

In recent years, agricultural intensification has become largely dependent on a limited variety of crops (Schmidt et al., 2010). The dependency on this comparatively limited number of food species creates severe concerns regarding sustainability today as well as the future of feeding the world (Raschke and Cheema, 2008). Currently, more than 100 million people suffer from hunger and food scarcity, although the challenge of adequate diet seems to be more severe (FAO, 2009). It has

* Corresponding author.
E-mail address: neupanebpn63@gmail.com (B. Neupane).

https://doi.org/10.1016/j.heliyon.2020.e05887
Received 6 November 2020; Received in revised form 29 November 2020; Accepted 24 December 2020

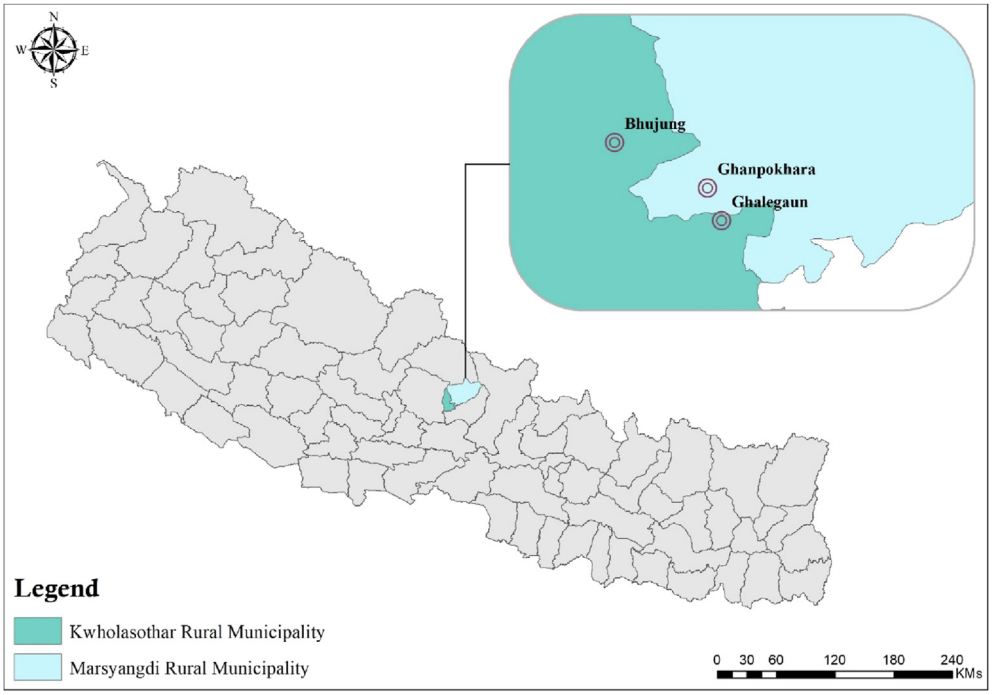

Figure 1. Study area map of research areas.

also been confirmed that NUS is rapidly disappearing due to uniformity of farming practices, mono-cropping patterns, and shifts in food preferences resulting in a few staple crops that dominate local, national and international food systems (Rojas et al., 2009).

There is a need for more research investment to investigate the ways to improve on-farm NUS conservation. It is also necessary to address a range of critical factors such as the understanding on-farm distribution of conventional varieties, the status of custodian farmers, and the difficulties they encounter. The research thus aimed to explore the diversity and identify the prioritized species, explore the use-values, and identify the role of a socio-demographic factor in its conservation and promotion in the Lamjung district of Nepal. In particular sociodemographic factors and related hypothesis is presented as "Education status, primary occupation, ethnicity, and gender of the household head help in the characterization and conservation of NUS in the research area."

2. Methodology

2.1. Data collection and analysis

Data were collected from different sites during research using techniques such direct field observation, household sampling, key informant interview, personal interviews, and field visits during January 2020. The research was performed in two rural municipalities viz. Marsayndi Rural Municipality-01, Ghanpokhara (28.2905° N, 84.30326° E) and Kwhlosothar Rural Municipality; ward no-03, Ghalegaun (28.2783° N,

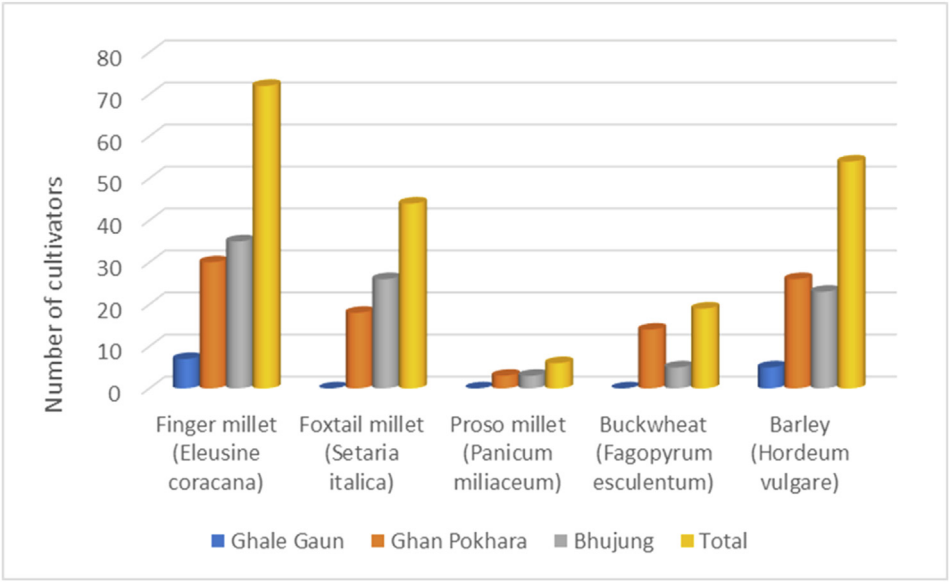

Figure 2. Number of respondents cultivating crops in research areas.

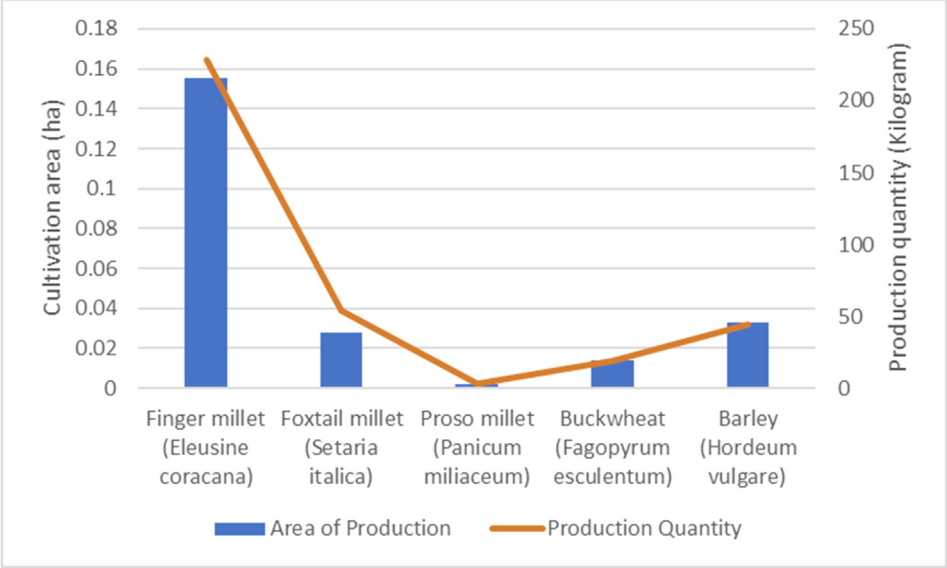

Figure 3. Total average cultivation area (ha) and production quantity (Kg) in research areas.

84.3088° E) & ward no-04, Bhujung (28.3309° N, 84.2595° E) of Lamjung District of mid-hills of Nepal (Figure 1).

Location wise cluster sampling was conducted where a structural and semi-structural questionnaire was used to interview 105 respondents (35 respondents from each study area). Furthermore, a checklist was designed for interviews with key informants. Key informants were the president of the rural municipalities, the coordinators of the home-stay, and the lead farmers. The respondents of the research were chosen by convenient sampling concerning the objective of the study where the respondents were directly or indirectly involved in agriculture and conservation of NUS. The authors confirm that informed consent was obtained from all the patients of experiments i.e., rural municipalities, homestay management committee, and both the Gurung and Dalits community during the field survey. For documentation, key informants were identified and focused group discussion (FGD) was carried out. In Bhujung, FGD was carried out with the staffs of the National Trust for Nation Conservation (NTNC). Moreover, FGDs were carried out in the rural municipality of Ghanpokhara and Ghalegaun along with the local leaders and lead farmers of that area.

The well identifiable pictures of the plants listed in the documentation were shown to the respondents for assurance of correct documentation. Plants other than those listed were identified by direct observation on-site with the help of the respondents. Some main information on each of the identified species was reported through discussion. These were local names of the species, plant form, uses, importance, and parts used. Five cereals and pseudo-cereals among those species were addressed for three different headings (area of cultivation, production quantity, and food sufficiency). It was then accompanied by a listing of value-added products with their price.

SPSS 25 and Microsoft Office 16 were used for data analysis. Descriptive (frequencies, percentages, means, etc.) and inferential statistics were used to interpret the data to create summaries and tables at various levels. Observations for the non-parametric test included finger millet area, finger millet production, foxtail millet area, foxtail millet production, proso millet area, proso millet production, buckwheat area, buckwheat production, barley area, and barley production. Data were assigned to Kruskal-Wallis test for primary education status (basic, secondary, and higher secondary) of household head and Mann-Whitney U

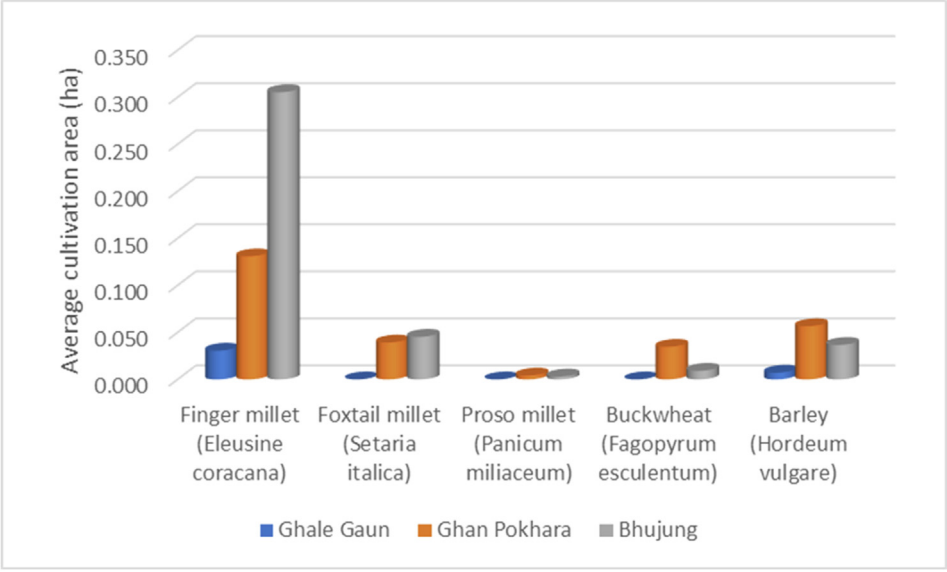

Figure 4. An average cultivation area (ha) in research areas.

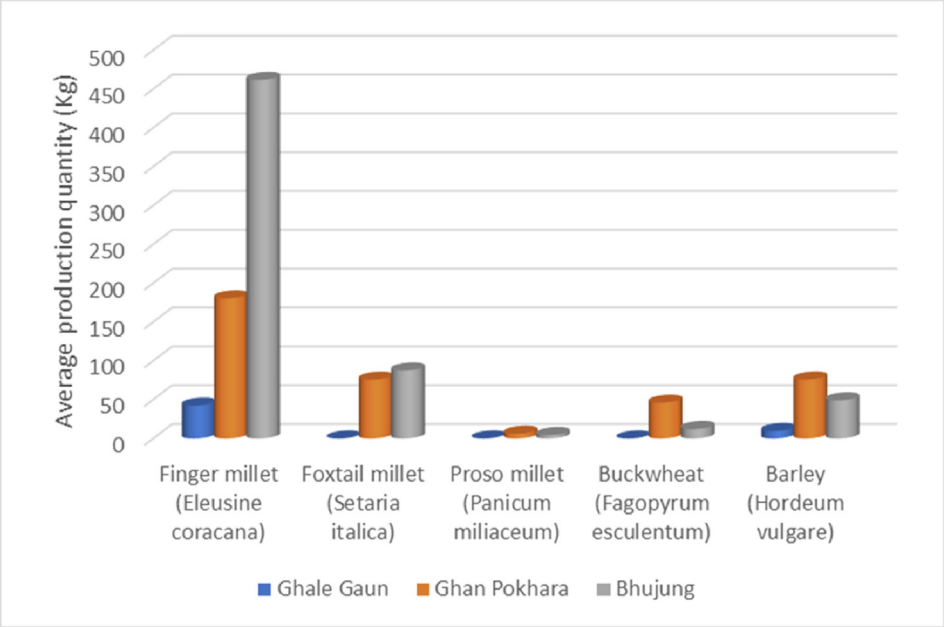

Figure 5. An average production quantity (kg) in research areas.

Table 1. An average food sufficiency status of different crops in the research areas.

Crops	Ghalegaun	Ghanpokhara	Bhujung
Finger millet (*Eleusine coracana*)	6–9 months	6–9 months	>12 months
Foxtail millet (*Setaria italica*)	-	>12 months	9–12 months
Proso millet (*Panicum miliaceum*)	-	9–12 months	9–12 months
Buckwheat (*Fagopyrum esculentum*)	-	3–6 months	<3 months
Barley (*Hordeum vulgare*)	3–6 months	3–6 months	3–6 months

Table 2. An availability of crops and their products with price detail in the research areas.

Crops	Research areas					
	Ghalegaun		Ghanpokhara		Bhujung	
	Products	Unit Price	Products	Unit Price	Products	Unit Price
Finger millet (*Eleusine coracana*)	Bread	35	Bread	30	Bread	35
	Nepali Doughnut	35	Nepali Doughnut	25	Nepali Doughnut	35
	Porridge	150	Porridge	100	Porridge	150
	Alcohol	25	Alcohol	35	Alcohol	50
	Soup	50	-	-	Cake	200
Foxtail millet (*Setaria italica*)	-	-	Bread	30	Bread	35
	-	-	Nepali Doughnut	30	Nepali Doughnut	35
	-	-	Porridge	100	Porridge	150
	-	-	Rice	150	Rice	170
	-	-	Alcohol	35	Alcohol	50
Proso millet (*Panicum miliaceum*)	-	-	Bread	30	Bread	35
	-	-	Alcohol	50	Alcohol	50
Buckwheat (*Fagopyrum esculentum*)	-	-	Bread	30	Bread	35
	-	-	Porridge	100	Porridge	150
	-	-	Alcohol	35	Alcohol	50
	-	-	Flour	300	-	-
Barley (*Hordeum vulgare*)	Bread	35	Bread	30	Bread	35
	Porridge	150	Porridge	100	Porridge	150
	Alcohol	25	Alcohol	35	Alcohol	50

Table 3. Detail of neglected and underutilized species recorded in research areas.

Name	Scientific Names	Family	Habit	Parts used	Uses	Importance	Location
Phapar	*Fagopyrum esculentum* Moench	Polygonaceae	Herb	Seed	Pancake, Fodder	Medicinal	*1* **2** *3*
Kodo	*Eleusine coracana* (L.) Gaertn.	Gramineae	Shrub	Seed	Pancake, Beverages, Fodder, Porridge	Nutritional	*1 2 3*
Cino	*Panicum miliaceum* L.	Gramineae	Shrub	Seed	Pancake, Beverages, Fodder, Porridge	Nutritional, medicinal	**1 2** *3*
Kaguno	*Setaria italica* (L.) Beauvois	Gramineae	Shrub	Seed	Pancake, Beverages, Fodder, Porridge	Nutritional, medicinal	*1* **2** *3*
Silam	*Perilla frutescens* (L.) Britton	Lamiaceae	Shrub	Seed	As pickle	Nutritional	**1 2** *3*
Latte dana	*Amaranthus viridis* L.	Amaranthaceae	Herb	Leaves, Seeds	Used as vegetable, sweets	Nutritional, medicinal	*1 2 3*
Bethe	*Chenopodium album* (L.)	Chenopodiaceae	Herb	Leaves, Seeds	Vegetable	Nutritional	*1 2 3*
Sakhara khand	*Ipomoea batatas* (L.) La	Convolulaceae	Herb	Tuber	Eaten raw or roasted	Religious	*1 2 3*
Til	*Sesamum orientale* L.	Pedaliaceae	Herb	Seed	Pickles, religious worship	Religious	**1** *2 3*
Masyan	*Vigna umbellata* (Thunb.) Ohwi & Ohashi	Leguminosae	Climber	Seed	Pulse	Nutritional	*1 2 3*
Ghar tarul	*Dioscorea alata* L.	Dioscoreaceae	Climber	Stem, twigs, fruit	As vegetable and sometime by boiling	Nutritional	*1 2 3*
Ban tarul	*Dioscorea bulbifera* L.	Dioscoreaceae	Climber	Underground stem	Vegetable, Medicine	Nutritional	*1 2 3*
Gaba	*Colocasia esculenta* (L.) Schott	Araceae	Shrub	Leaves, tuber	Vegetable	Nutritional	*1 2 3*
Gahat	*Macrotyloma uniflorum* (Lam.) Verdc	Leguminosae	Shrub	Seed	Pulses, medicine to cure kidney stone	Nutritional, medicinal	*1* **2** *3*
Kubindo	*Benincasa hispida* (Thunb.) Cogn	Curcurbitaceae	Climber	Fruit	Vegetable, used to prepare pickle and sweets	Nutritional	*1 2 3*
Asare simi	*Phaseolus vulgaris* L	Leguminosae	Climber	Pod, seed	Vegetable and Pulses	Nutritional	*1 2 3*
Khesari	*Lathyrus sativus* L.	Leguminosae	Herb	Seed	Pulses, fodder	Nutritional	*1 2 3*
Rayo	*Brassica nigra* (L.) Koch	Cruciferae	Herb	Leaves	Vegetable	Nutritional	*1 2 3*
Skush	*Sechium edule* (Jacq.) Sw.	Curcurbitaceae	Climber	Twigs, fruit	As vegetable, pickle or eaten by boiling	Nutritional	*1 2 3*
Kaphal	*Myrica esculenta* BuchHam.ex D. Don	Myricaceae	Tree	Fruit	Fruit	Nutritional, aesthetic	*1 2 3*
Bel	*Aegle marmelos* (L.) Correa	Rutaceae	Tree	Leaves, Fruits	Fruit	Medicinal, religious	*1 2 3*
Chyuri	*Aesandra butyraceae* (Roxb.) Baehni	Sapotaceae	Tree	Fruit	Fruit, seedsto prepare ghee	Aesthetic	**1** *2 3*
Aamala	*Phyllanthus emblica* L.	Euphorbiaceae	Shrub	Fruit	Fruits, Pickle	Medicinal	*1 2 3*
Bhogate	*Citrus maxima* (Burm. ex Rumph.) Merr	Rutaceae	Tree	Fruit	Fruit	Nutritional	*1 2 3*
Jamun	*Syzygium cumini* (L.) Skeels	Myrtaceae	Tree	Fruit	Fruit	Medicinal	*1 2 3*
Niuro	*Dryopteris cocheleata* (D. Don) C. Chr.	Aspidiaceae	Herb	Stem	As vegetable	Nutritional	*1 2 3*
Besar	*Curcuma angustifolia* Roxb.	Zingiberaceae	Shrub	Root	As condiments in vegetables	Medicinal	*1 2 3*
Mas	*Vigna mungo* (L.) Hepper	Leguminosae	Shrub	Seed	As pulses	Nutritional	*1 2 3*
Pharsi	*Cucurbita pepo* L.	Curcurbitaceae	Shrub, Creeper	Fruit, Young twigs	As vegetable	Nutritional, medicinal	*1 2 3*
Kurilo	*Asparagus racemosus* Willd	Liliaceae	Shrub	Twigs, stem	As vegetable, and pickle	Medicinal, Religious	*1 2 3*
Palungo	*Spinacia oleracea* L.	Chenopodiaceae	Herb	Leaves	As vegetable	Medicinal	**1** *2 3*
Kagati	*Citrus aurantifolia* (Christ.) Swingle	Rutaceae	Tree	Fruit	Fruit, pickle	Medicinal	*1 2 3*
Nibuva	*Citrus limon* (L.) Burn f.	Rutaceae	Tree	Fruit	Fruit, pickle	Medicinal	*1 2 3*
Jira	*Cuminum cyminum* L.	Umbelliferae	Herb	Seed	Condiments	Nutritional	**1 2** *3*
Kali jyamir	*Citrus junos* Tanka	Rutaceae	Tree	Fruit	Fruit	Nutritional	*1 2 3*
Mula	*Raphanus sativus* L.	Crucifereae	Herb	Stem, leaves	As vegetable, pickle	Nutritional, medicinal	*1 2 3*
Bakula	*Vicia faba* L.	Leguminosae	Herb	Pod, seeds	Vegetable, Pulses	Nutritional	**1** *2 3*
Bhatmas	*Glycine max* (L.) Merr.	Leguminosae	Herb	Seed	Vegetable pulses, oil extraction	Nutritional	*1 2 3*
Amba	*Psidium guajava* L.	Myrtaceae	Tree	Fruit	Fruit	Nutritional, aesthetic	**1 2 3**
Dhaniya	*Coriandrum sativum* L.	Umbelliferae	Herb	Seed	Used as condiments	Nutritional	*1 2 3*
Khursani	*Capsicum annuum L.*	Solanaceae	Shrub	Fruit	As spicy condiments	Nutritional	*1 2 3*
Okhar	*Juglans regia L*	Juglandaceae	Tree	Fruit	As fruit and oil extraction	Nutritional, medicinal	*1* **2** *3*
Jau	*Hordeum vulgare L*	Gramineae	Shrub	Seed	Beverage, used in baking industries	Religious	*1 2 3*
Ghiu toria	*Luffa cylindrica (L.) Roem*	Cucurbitaceae	Herb	Fruit	As vegetable	Nutritional	*1 2 3*

(*continued on next page*)

Table 3 (*continued*)

Name	Scientific Names	Family	Habit	Parts used	Uses	Importance	Location
Junelo	*Sorghum vulgare Pers*	Gramineae	Shrub	Seed	Used as food after frying, fodder	Nutritional	*1 2 3*
Sisnu	*Urtica dioca* L.	Urticaceae	Herb	Leaf	Vegetable, Hedge	Medicinal	*1 2 3*
Bhang	*Cannabis sativa L.*	Cannabaceae	Shrub	Seed	To make pickle	Nutritional	*1 2 3*
Angheri	*Melastoma melabathricum L.*	Melastomataceae	Shrub	Fruit	Fruit	Nutritional	*1 2 3*
Ankhe timur	*Zanthoxylum armatum DC.*	Rutaceae	Shrub	Fruit	Vegetable	Nutritional	*1 2 3*
Ausali	*Rubus ellipticus Sm.*	Rosaceae	Shrub	Fruit	Fruit	Nutritional, aesthetic	*1 2 3*
Padina	*Mentha spicata* L.	Lamiaceae	Herb	Whole part	Vegetable	Nutritional, medicinal	*1 2 3*
Ban lasun	*Allium wallichii* Kunth	Amaryllidaceae	Herb	Whole part	Vegetable	Nutritional, medicinal	*1 2 3*
Tama	*Dendrocalamus hamiltonii* Nees & Am.	Poaceae	Tree	Young stem	Vegetable	Nutritional	*1 2 3*
Vyakur	*Dioscorea deltoidei* Wall.ex Griseb.	Dioscoreaceae	Tree	Fruit	Vegetable, Medicine	Nutritional	*1 2 3*
Thotne	*Polygonum molle* D. Don	Polygonaceae	Shrub, Climber	Young Leaf	Vegetable	Nutritional	*1 2 3*
Chhatre	*Cyanthea spinulosa* Wall. Ex Hook.	Cyatheaceae	Shrub	Young Leaf	Vegetable	Nutritional	*1 2 3*
Chiple	*Oreocnide frutescence* (Thunb.) Miq.	Urticaceae	Climber	Root	To make Nepalese Bread (Like Ring)	Nutritional	*1* **2** *3*
Chutro	*Berberis asiatica* Roxb. Rx DC	Berberidaceae	Shrub	Fruit	Fruit, Medicine and Hedge	Nutritional	*1 2 3*
Dalchini	*Cinnamomum verum* J.Presel	Lauraceae	Tree	Bark, leaf	Spices and Tea	Nutritional	*1 2 3*
Ghodtapre	*Centella asiatica* (L.) Urb	Apiaceae	Herb	Whole part	Pickle and Medicine	Nutritional, medicinal	**1 2 3**
Golkakro	*Coccinia grandis* (L.) Voigt	Cucurbitaceae	Climber	Fruit	Salad, Vegetable and Fruit	Nutritional	*1 2 3*
Halhale	*Rumex nepalensis* Spreng.	Polygonaceae	Herb	Whole part	Vegetable	Nutritional	**1 2 3**
Jamune mandro	*Mahonia nepalensis* DC.	Berberidaceae	Shrub	Fruit	Fruit	Nutritional	*1* **2** *3*
Chatre Chyau	*Agaricus campestris* L.	Agaricaceae	Herb	Whole part	Vegetable	Nutritional	*1 2 3*
Rate Chyau	*Amanita muscaria*	Amaitaceae	Herb	Whole part	Vegetable	Nutritional	*1 2 3*
Berulo	*Ficus sarmentosa* Buch – Ham. ex. Sm.	Moraceae	Tree	Fruit	Fruit	Nutritional, aesthetic	*1 2 3*
Katus	*Castanopsis indica* (Roxb. ex Lindl.)	Fagacae	Tree	Fruit	Fruit, Fodder and Timber	Nutritional	*1 2 3*
Kaulo	*Persea odoratissima* (Nees) Kosterm.	Lauraceae	Tree	Bark	To make Nepalese Bread (Like Ring)	Nutritional	*1 2 3*
Kavro	*Ficus lacor* Buch-Ham	Moraceae	Tree	Flower	Pickle	Nutritional	*1* **2 3**
Khole sag	*Nasturtium officinale* R.Br.	Brassicaceae	Herb	Whole part	Vegetable	Nutritional	*1 2 3*
Kurilo	*Asparagus racemosus* Willd.	Asparagaceae	Climber	Young twig, Root	Vegetable, Medicine	Nutritional	*1 2 3*
Laligurans	*Rhododendron arboretum* Smith	Ericaceae	Tree	Flower, Fruit	Ornament, Medicine	Medicinal, aesthetic	*1 2 3*
Lapsi	*Choerospondias axillaris* (Roxb.) B.L. Brutt & A.W. Hill	Anacardiaceae	Tree	Fruit	Make Pickle, As Fruit	Nutritional	*1 2 3*
Hunkholo	-		Tree	Fruit	As pickle	Nutritional	*1 2* **3**
Nigalo	*Arundinaria falcata*	Poaceae	Tree	Young Stem	As vegetable	Nutritional	*1 2 3*
Gophla	-	-	Tree	Fruit	As fruit	Nutritional	*1* **2 3**
Ghangur	-	-	Shrub, Climber	Fruit	As fruit	Nutritional	*1 2* **3**
Jibre Saag	*Ophioglossum vulgatum L.*	Ophioglossaceae	Herb	Leaves, stem	As vegetable	Nutritional	*1* **2 3**
Seuda Saag	-	-	Herb	Leaves, stem	As vegetable	Nutritional	*1 2 3*
Khauda Saag	-	-	Herb	Leaves, stem	As vegetable	Nutritional	*1 2 3*
Nausitha Saag	-	-	Herb	Leaves, stem	As vegetable	Nutritional	*1 2 3*
Naigya	-	-	Climber	Fruit	As fruits	Nutritional	*1 2 3*
Guyeli	-	-	Tree	Fruit	As fruit	Nutritional	*1 2 3*
Kairo	-	-	Tree	Fruit	As fruit	Nutritional	*1 2 3*
Nauri	-	-	Climber	Fruit	As fruit	Nutritional	*1 2 3*
Kabu Saag	-	-	Herb	Leaves, stem	As vegetable	Nutritional	*1 2 3*
Aalmale Saag	-	-	Herb	Leaves, stem	As vegetable	Nutritional	*1 2 3*
Badmale Saag	-	-	Herb	Leaves, stem	As vegetable	Nutritional	*1 2 3*
Bhadaure niuro	*Dryopteris sps*	Aspidiaceae	Herb	Stem	As vegetable	Nutritional	*1 2 3*
Ekle nuiro	*Dryopteris sps*	Aspidiaceae	Herb	Stem	As vegetable	Nutritional	*1 2 3*
Tangalide nuiro	*Dryopteris sps*	Aspidiaceae	Herb	Stem	As vegetable	Nutritional	*1 2 3*
Mnolide nuiro	*Dryopteris sps*	Aspidiaceae	Herb	Stem	As vegetable	Nutritional	*1 2 3*

1 = "Ghanpokhara", 2 = "Ghalegaun" and 3 = "Bhujung".
Italic signifies presence while bold signifies absence of NUS.

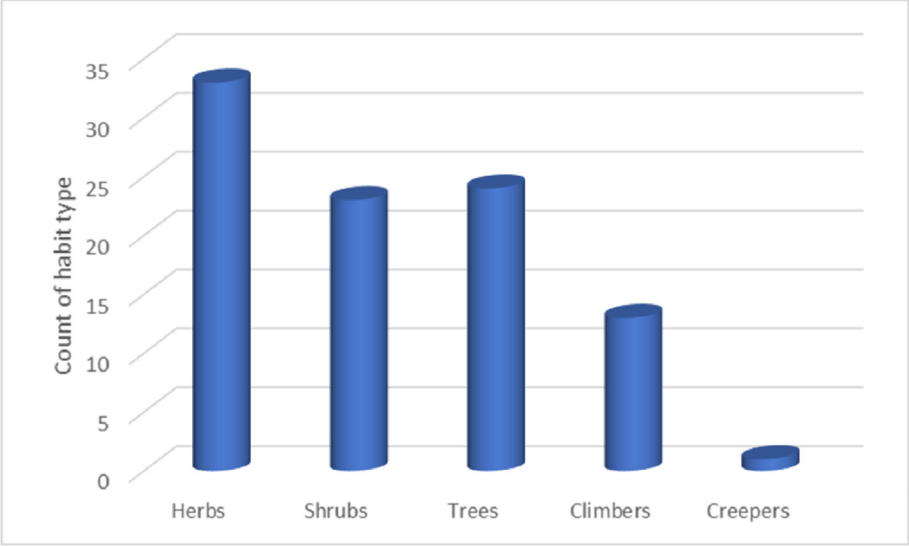

Figure 6. Habit type of the neglected and underutilized species in research areas.

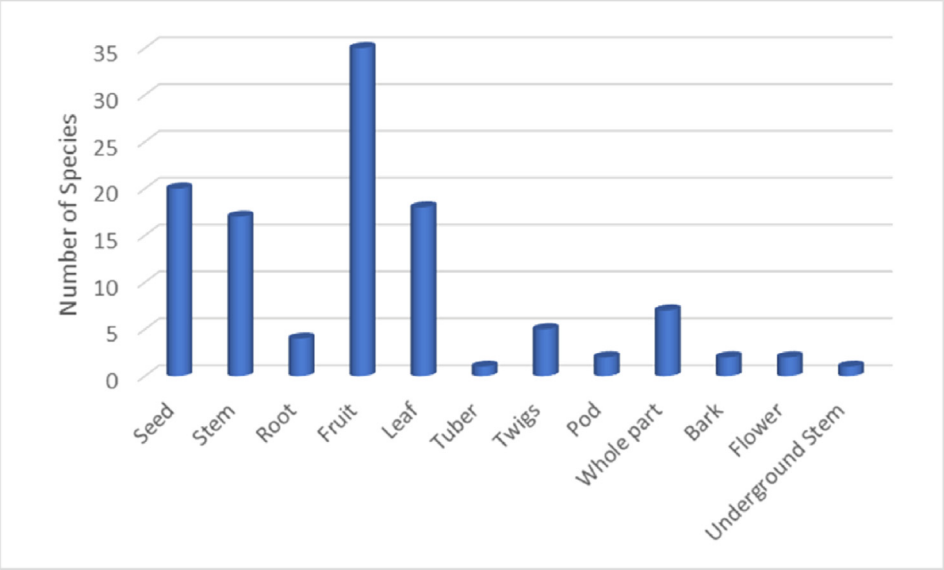

Figure 7. Diversity of plants part used in research areas.

test for primary occupation (agriculture and non-agriculture), ethnicity (marginalized and touchable and marginalized and untouchables), and gender (men and women) of the household head.

3. Result and discussion

3.1. Descriptive comparison of characters

3.1.1. Overall cultivation status of research areas

Out of 35 respondents, seven (20%) cultivated finger millet (*Eleusine coracana*) and five (14%) cultivated barley (*Hordeum vulgare*) in Ghalegaun. 30 (85%) cultivated finger millet, 18 (51%) cultivated foxtail millet (*Setaria italica*), 3 (8%) cultivated proso millet (*Panicum miliaceum*), 14 (40%) cultivated buckwheat (*Fagopyrum esculentum*) and 26 (74%) cultivated barley in Ghanpokhara. 35 (100%) cultivated finger millet, 26 (74%) cultivated foxtail millet, 3 (8%) cultivated proso millet, 5 (14%) cultivated buckwheat and 23 (66%) cultivated barley in Bhujung. In total, 72 (68%) out of 105 respondents cultivated finger millet, 44 (42%) cultivated foxtail millet, 6 (5%) cultivated proso millet, 19 (18%) cultivated buckwheat and 54 (51%) cultivated barley (Figure 2).

The average total production area was 0.155 ha for finger millet, 0.028 ha for foxtail millet, 0.002 ha for proso millet, 0.014 ha for buckwheat, and 0.033 ha for barley. Similarly, the average total production was 228.08 kg for finger millet, 54.32 kg for foxtail millet, 3.42 kg for proso millet, 19.35 kg for buckwheat, and 44.77 kg for barley (Figure 3). Nepal is experiencing an increased trend of cultivation area, production, and productivity of these crops. The average productivity of finger millet has increased by 6.25% from the year 2011 (1120 kg/ha) to 2019 (1190 kg/ha). Similarly, for buckwheat it has increased by 29% from year 2011 (860 kg/ha) to 2019 (1110 kg/ha) and for barley it has increased by 25% from year 2011 (1000 kg/ha) to 2019 (1250 kg/ha) (MoALD, 2020). Our result has also supported this increasing data trend with the productivity of 1472 kg/ha for finger millet, 1382 kg/ha for buckwheat, and 1357 kg/ha for barley.

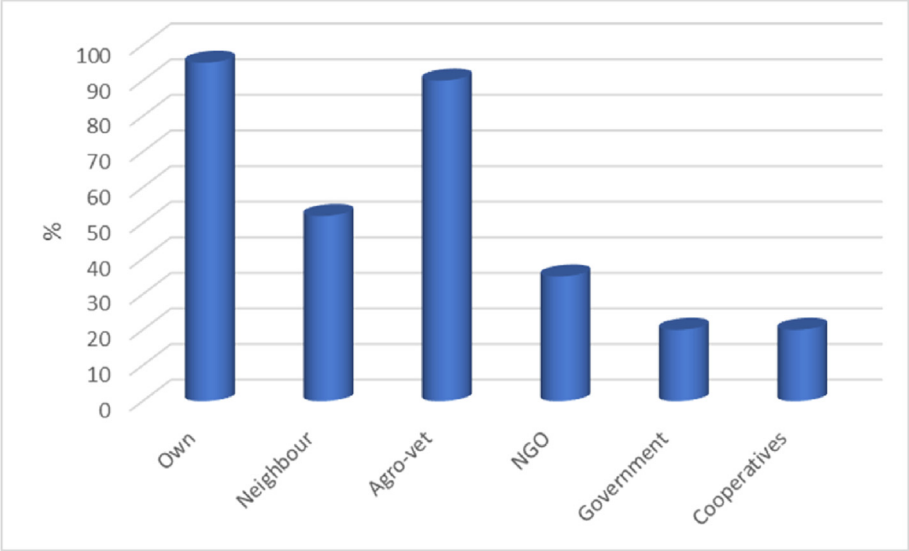

Figure 8. Source of seeds used by the respondents in research areas.

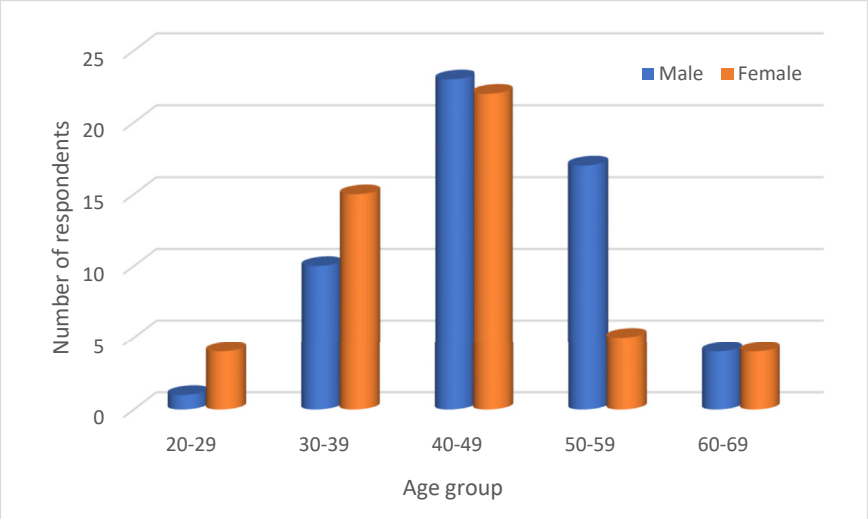

Figure 9. The age and gender distribution of the respondents.

3.1.2. *Average cultivation area and production quantity of research areas*

A survey of research areas found that the average production area was 0.031 ha for finger millet and 0.007 ha for barley in Ghalegaun. 0.131 ha for finger millet, 0.039 ha for foxtail millet, 0.004 ha for proso millet, 0.035 ha for buckwheat, and 0.056 ha for barley in Ghanpokhara. Whereas 0.305 ha for finger millet, 0.045 ha for foxtail millet, 0.003 ha for proso millet, 0.009 ha for buckwheat, and 0.037 ha for barley in Bhujung (Figure 4).

The total average production was found to be 42.2 kg for finger millet and 9.51 kg for barley in Ghalegaun. 180.36 kg of finger millet, 75.6 kg of foxtail millet, 5.96kg of proso millet, 45.9 kg of buckwheat, and 75.77 kg of barley in Ghanpokhara. Whereas 461.67 kg of finger millet, 87.36 kg of foxtail millet, 4.32 kg of proso millet, 12.14 kg of buckwheat, and 49.05 kg of barley in Bhujung (Figure 5).

3.1.3. *Average food sufficiency status of research areas*

An average food sufficiency status ranges from 3-6 months to >12 months for different crops in three different research areas (Table 1). A previous study in four mountainous districts of Nepal including Lamjung shows that the food sufficiency of cereals and vegetables is not adequate for even six months (Gauchan et al., 2020). However, people in research areas are using these crops as a source of income too. The value-added products of these crops along with their unit price are listed in (Table 2).

3.2. *Descriptive comparison of documented neglected and underutilized species*

A list of 92 plant species was documented as neglected and underutilized from the field survey (Table 3). The plant belonging to herbs was 33, shrubs 23, trees 24, climbers 13, and creeper one (Figure 6). Of the 92 plant species, 20 species were used for seed, 17 for stems, four for roots, 35 for fruits, 18 for leaves, one for the tuber, five for twigs, two for pods, seven for whole parts, two for barks, two for flowers and one for underground stem (Figure 7). According to respondents, the source of seeds they used was found to be 95 by their savings, 52 by a neighbor, 90 by agro-vet, 35 by NGO, 20 by government, and 20 by cooperatives (Figure 8).

Table 4. Comparison of means of sociodemographic factors for ten parameters.

Parameters	Mann-Whitney U test									Kruskal-Wallis test		
	Primary occupation			Ethnicity			Gender			Education status		
	U value	Sig.	Mean value	U value	Sig.	Mean value	U value	Sig.	Mean value	H value	Sig.	Mean value
Finger millet area	324.00	0.00	64.56	538.50	0.11	63.84	1209.50	0.27	56.31	35.21	0.00	63.22
Finger millet production	339.50	0.00	64.35	552.00	0.14	63.00	1192.50	0.27	56.65	34.28	0.00	63.05
Foxtail millet area	657.50	0.00	59.99	372.50	0.00	74.22	1346.50	0.83	53.52	18.17	0.00	59.29
Foxtail millet production	657.50	0.00	59.99	372.50	0.00	74.22	1346.50	0.83	53.52	18.17	0.00	59.29
Proso millet area	1104.50	0.27	54.98	664.00	0.28	53.54	1329.00	0.46	53.84	20.01	0.00	52.02
Proso millet production	1104.50	0.27	54.98	664.00	0.28	53.54	1329.00	0.46	53.84	20.01	0.00	52.02
Buckwheat area	976.50	0.04	55.62	638.00	0.32	57.63	1250.00	0.23	55.27	8.24	0.01	56.45
Buckwheat production	976.50	0.04	55.62	638.00	0.32	57.63	1250.00	0.23	55.27	8.24	0.01	56.45
Barley area	727.50	0.00	58.94	467.50	0.02	68.28	1207.50	0.25	56.05	17.81	0.00	58.77
Barley production	734.50	0.00	59.99	460.00	0.01	68.75	1211.50	0.26	55.97	17.65	0.00	58.69

3.3. Comparison of means of socio-demographic factors for characters

Out of the population interviewed, 52 percent were men and 48 percent were women. The respondents' average age was around 45 years with 66 years of the eldest and 24 years of the youngest (Figure 9).

3.3.1. Effect of education status on NUS cultivation

Kruskal-Wallis test had been used to compare the means of education status of household head as basic, secondary, and higher secondary. Results indicate that all the parameters were statistically significant (Table 4). A household with basic education status has the highest mean for all parameters viz. buckwheat area (56.45), buckwheat production (56.45), finger millet area (63.22), finger millet production (63.05), barley area (58.77), barley production (58.69), foxtail millet area (59.29), foxtail millet production (59.29), proso millet area (52.02), and proso millet production (52.02). It signifies that the people with higher education status have either migrated to the city areas or are not actively involved in agriculture for their livelihood while the people with basic education status are still entirely dependent on agriculture resulting in NUS conservation.

3.3.2. Effect of primary occupation on NUS cultivation

Mann-Whitney U test was used to compare the means for primary occupation of household head as agriculture and non-agriculture. Results indicate that except for proso millet area and proso millet production, all other parameters were statistically significant (Table 4). Agriculture group has the highest mean for buckwheat area (55.62), buckwheat production (55.62), finger millet area (64.56), finger millet production (64.35), barley area (58.94), barley production (59.99), foxtail millet area (59.99), and foxtail millet production (59.99). Non-agriculture has the highest mean for proso millet area (54.98) and proso millet production (54.98). Farmers' primary occupation as agriculture has shown to promote the conservation of NUS. For people with agriculture as a primary occupation, there is no alternative to earn a living. Moreover, people here are still unaware of the proso millet's importance. Only the progressive farmers with a strong link to NGOs and government officials had tried to preserve and promote NUS in these areas. However, LI-BIRD-Nepal is playing a remarkable role in the promotion of foxtail millet in these areas mainly, in Ghanpokhara.

3.3.3. Effect of ethnicity on NUS cultivation

Mann-Whitney U test had been used to compare the means for the ethnicity of household head as marginalized and touchable and marginalized and untouchables. Results indicate that only four parameters namely barley area, barley production, foxtail millet area, and foxtail millet production were significant while all other parameters were found to be insignificant (Table 4). Marginalized and untouchables have the highest mean for buckwheat area (57.63), buckwheat production (57.63), foxtail millet area (74.22), foxtail millet production (74.22), finger millet area (63.84), finger millet production (63.00), barley area (68.28), and barley production (68.75). Likewise, marginalized and touchable has the highest mean for proso millet area (53.54), and proso millet production (53.54). Marginalized and untouchables are more involved in NUS conservation and preservation. They have been using and safeguarding NUS for generations (Padulosi et al., 2013). This scenario can be supported by the poor economic condition of these individuals and agriculture as the only way of life.

3.3.4. Effect of gender on NUS cultivation

Mann-Whitney U test had been used to compare the means for the gender of household head as men and women. Results indicate that none of the parameters were statistically significant (Table 4). Men have the highest mean for buckwheat area (55.27), buckwheat production (55.27), barley area (56.05), barley production (55.97), foxtail millet area (53.52), foxtail millet production (53.52), proso millet area (53.84), and proso millet production (53.84). Likewise, women have the highest mean for finger millet area (56.31) and finger millet production (56.65). Both men and women are actively involved and there is no significant difference between their work performance to maintain and protect NUS. The men respondent in the research area was relatively more acquainted with the crop species than the women respondent. A previous study in Nepal shows that women over the age of 35 was able to depict the usage of 65 percent of all consumable species whereas young men was able to depict just 23 percent (Shrestha and Dhillon 2006).

4. Conclusion

The findings support the significance of socio-demographic factors in characterizing, evaluating, and conserving neglected and underutilized species on-farm. Results indicated that education status and primary occupation of the household head have a great role whereas ethnicity has a certain level of role while gender has no the role to play on-farm conservation of NUS. People with basic education status and agriculture as their core occupation showed a higher influence on conservation. Nepal has a great diversity of crop species that are neglected and underutilized. These very species provide tremendous nutrimental, medical, and profitable values. If encouraged, it would significantly contribute to reduce poverty, particularly in rural communities, and to improving of local populations' nutrimental and medical status. To promote these NUS in Nepal, it is necessary to establish a research and development program including all possible potential participants such as with government, academics, entrepreneurs, and producers to promote NUS.

Declarations

Author contribution statement

Bipin Neupane, Sadikshya Poudel: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

Funding statement

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Data availability statement

Data will be made available on request.

Declaration of interests statement

The authors declare no conflict of interest.

Additional information

No additional information is available for this paper.

Acknowledgements

The authors share their heartfelt appreciation to the ethnic groups and local residents of Lamjung district for their valuable assistance throughout a field study. We are also thankful to Asst. Professor Subodh Khanal and Asst. Professor Ganesh Rawal for their continuous help from research design to manuscript writing.

References

FAO, 2009. Food Insecurity in the World. FAO, Rome, Italy.

Gauchan, D., Joshi, B.K., Sthapit, S., Jarvis, D., 2020. Traditional crops for household food security and factors associated with on-farm diversity in the mountains of Nepal. The Journal of Agriculture and Environment 21, 31–43.

Joshi, B.K., Shrestha, R., Gauchan, D., Shrestha, A., 2019. Neglected, underutilized, and future smart crop species in Nepal. J. Crop Improv. 34 (3), 291–313.

Manandhar, N.P., 2002. Wild Edible Plants of Nepal. Bulletin of Department of Medicinal Plant No. 11.

MoALD, 2020. Statistical Information on Nepalese Agriculture 2016/17. Singha Durbar. Ministry of Agriculture and Development, Agri-Business Promotion and Statistics Division, Kathmandu Nepal.

Padulosi, S., Thompson, J., Rudebjer, P., 2013. Fighting poverty, hunger and malnutrition with neglected and underutilized species. Bioversity International.

Padulosi, S., Mal, B., Bala Ravi, S., Gowda, J., Gowda, K.T.K., Shanthakumar, G., Yenagi, N., Dutta, M., 2009. Food security and climate change: role of plant genetic resources of minor millets. Indian Journal of Plant Genetic Resources 22 (1), 1–16.

Raschke, V., Cheema, B., 2008. Colonisation, the New World Order, and the eradication of traditional food habits in East Africa: historical perspective on the nutrition transition. Publ. Health Nutr. 11 (7), 662–674.

Rojas, W., Valdivia, R., Padulosi, S., Pinto, M., Soto, J.L., Alcocer, E., Guzman, L., Estrada, R., Apaza, V., Bravo, R., 2009. From neglect to limelight: issues, methods and approaches in enhancing sustainable conservation and use of Andean grains in Bolivia and Peru. In: Buerkert, A., Gebauer, J. (Eds.), Agrobiodiversity and Genetic Erosion. Contributions in Honor of Prof. Dr Karl Hammer. Supplement 92 to the Journal of Agricultural and Rural Development in the Tropics and Subtropics. Kassel University Press GmbH, pp. 87–117.

Schmidt, M., Lam, N.T., Hoanh, M.T., Padulosi, S., 2010. Promoting neglected and underutilized tuberous plant species in Vietnam. pp. 183–193. In: Haas, R., Canavari, M., Slee, B., Tong, C., Anurugsa, B. (Eds.), Looking East Looking West: Organic and Quality Food Marketing in Asia and Europe. Wageningen Academic Publishers, The Netherlands.

Shrestha, D., 2013. Indigenous vegetables of Nepal for biodiversity and food security. Int. J. Biodivers. Conserv. 5 (3), 98–108.

Shrestha, P.M., Dhillon, S.S., 2006. Diversity and traditional knowledge concerning wild food species in a locally managed forest in Nepal. Agrofor. Syst. 66, 55–63.

WCMC, 1994. In: Groombridge, B. (Ed.), Biodiversity Data Source Book. World Conservation Press, Cambridge, United Kingdom.

Williams, J.T., Haq, N., 2000. Global Research on Underutilized Crops. An Assessment of Current Activity and Proposal for Enhanced Cooperation. International Center for Underutilized Crops, Southampton, UK.