Vegetable Genepools in Nepal: An Update on Semi- domesticated, Wild and Wild Relatives Awaiting Conservation and Sustainable Utilization

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Chapter 3

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Complex landscapes in mountainous areas of Nepal are not only the habitat for unique biodiversity, such diversity has also provided immense opportunities for local livelihood and food and nutritional security of indigenous people. Nepal is rich in plants and associated traditional knowledge of their uses on domesticated and semi-domesticated species, landraces of various crops and wild edible species. From time immemorable, native communities of Nepal are consuming varieties of wild and semi-domesticated plants as seasonal vegetables. Such species are highly preferred among the people living in periurban and urban areas too. Unsustainable collection and over exploitation of such resources could limit our capacity in developing cultivars with quality traits that can be commercialized in global scale. Moreover several wild and semi-domesticated vegetable species have multiple use values as medicine and food supplements, which can be exploited for economic benefits of the communities. In this chapter, we have provided a revised list of domesticated, wild and semi-domesticated vegetable species including vegetables wild relatives distributed in different ecological zones of Nepal. Genomics of domesticated vegetables, importance of vegetables wild relatives in developing high quality cultivars and available techniques, hotspots of wild vegetables and vegetable wild relatives, methods adopted in conservation assessment, ongoing conservation practices, existing threats and challenges in sustainable management are discussed.

Keywords: Biodiversity; domestication; landraces; nutritional security; wild cousin.

Introduction

Nepal Himalaya lies in the middle of 3,000 km long complex mountain system which was formed when Indian plate collided into central Asiatic Tibetan plate at north about 50

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million years ago. Formation of Himalaya has created diverse array of habitats for the flora and fauna around this region (Searle & Treloar, 2019). Impressive diversity of plants and animals along Himalaya is attributed to migration of different species into this incredible area from all directions. Nepal Himalaya host around 13,067 species of flora and 17,097 species of fauna (GoN/MoFSC, 2014). These biodiversity resources are source of livelihood and income for diverse communities who moved to this small paradise from different region of Asia over the ages. Our ancestor foraged plants and animals for different purposes. Traditional knowledge on uses was developed by trial and error over long periods. Tested knowledge thus obtained was then transferred from generation to generation through oral teaching and practice (Manandhar, 2002). Therefore, multi-ethnic country Nepal is rich in traditional knowledge and cultural practices. Manandhar (2002) has documented about 20% of total flora used by different ethnic groups of Nepal for different purposes. Out of 651 wild and semi-domesticated species reported for their food value, more than 36% are used as vegetables. Wild and semi-wild vegetables have significant role in nutritional diet and food security of Nepalese rural people (Uprety et al., 2012). Similarly, 65% population in Nepal are dependent in agriculture and they grow 599 species of food plants and among them 200 species are vegetables (Regmi, 1982). Collection of vegetables from wild and semi-wild condition and growing seasonal landraces and varieties are an important part of locals livelihood (Manandhar, 2002; Miehe et al., 2015; Pandey et al., 2017). In the following sections information on wild, semi-wild and cultivated vegetable species including their wild relatives are dealt in detail.

Vegetables, a Major Source of Human Diet

Vegetables are an important part of human diet because they provide a major portion of caloric and protein intake. Additionally leafy and other green vegetables are good supplies of vitamins, minerals and dietary fibers (Pandey et al., 2017). Most probably, vegetables were the first plants those were tested and started to regularly consume by early human. Different types of seasonal vegetables account substantially to the food of human that comes from plant.

Vegetables and History of Domestication

Around 10,000 years ago, semi-nomadic early human who has also started sedentary life were assumed to begin domestication of plants in the areas where abundant supply game and diversity of edible food were present (Harlan, 1992; Rubatzky & Yamaguchi, 1997). First cultivated plant or plants naturally growing near human settlements or in disturbed area were definitely from wild origin. Early human might have selected those species for domestication in successive generations. Such species could become established through domestication because of less competition in disturbed area as well as human protection nearby settlements. After thousands of years of such practice semi-domesticated species were evolved and fully adopted in more organized cultivation system. Depending on the geographic and climatic zones of the regions, first domesticated plants were propagated through vegetative parts or seeds. Vegetative propagation through roots and tubers is most likely the first means of domestication rather than from seeds. Study suggests that vegetative means of reproduction is prevalent in lowlands of Americas, southeast Asia, and Africa having humid tropical and semi-tropical climate, while seed based propagation was dominant in the regions with marked wet and dry seasons where environment was favorable for plants to flower and permit seed maturation (Rubatzky & Yamaguchi, 1997).

Domestication has resulted unprecedented changes on the morphology in the cultivated species compared to their wild progenitors. Through artificial selection and systematic breeding, domesticated plants have accumulated several valuable characters to humans. According to specific usage and preferences, domesticated vegetables show typical characteristics like varied sized leaves, flower, fruits, stems and roots, less seeds, absence of bitterness/toxins, loss of self-propagation capabilities and range of physiological adaptations.

Vegetables are mostly succulent, bulky and fresh thus must be consumed or processed within short period. Nowadays, vegetables produced in one area are widely distributed through national and international transportation facilities (Khoury et al., 2016). Some of the vegetables are perishable within a short time. Perishable vegetables can be transported adopting improved packaging or in refrigerators.

Indigenous people inhabiting different parts of the world started domestication of indigenous plants as crops including vegetables (Harlan, 1992). Such plants were transferred widely between different continents through international trade, colonization and by scholars and immigrants. Transfer of such plants took place from the centres of origin to other areas, which were later developed into centre of diversity as well (Sauer, 1993; Smith, 1969; Vavilov, 1952). Continuous movements of people have also led to change in food use patterns in many parts of the world (Rubatzky & Yamaguchi, 1997).

Classification of Vegetables

Plant or parts of plant that are eaten raw or cooked are termed as vegetables. Vegetables are grouped according to their habit or plant life span, their edible parts and climatic conditions, and preferred habitat in which they grow (Figure 3.1). In most of the cases, such classifications are not universal, loosely grouped and do overlaps (Rubatzky & Yamaguchi, 1997). Most of the world's vegetables belong to succulent, starchy and leguminous vegetables. Green pods and green leaves of legume crops grown for dry seeds are also widely consumed as vegetables. Starchy vegetables comprising tuberous and rhizome crops are important source of energy food. These types of vegetables are grown widely in the tropical-temperate regions. Among the starchy vegetables, potatoes, yams and taro are predominant. Succulent vegetables are extensively cultivated and are comparatively widely used worldwide as a source of vitamin, minerals and fibres. Vegetable, like tomato, has broadest use throughout the world (Khoury et al., 2016). Starchy, succulent and leguminous vegetables are also classified into three groups as leafy vegetable, fruity vegetable, and tuberous and rhizomatous vegetables.

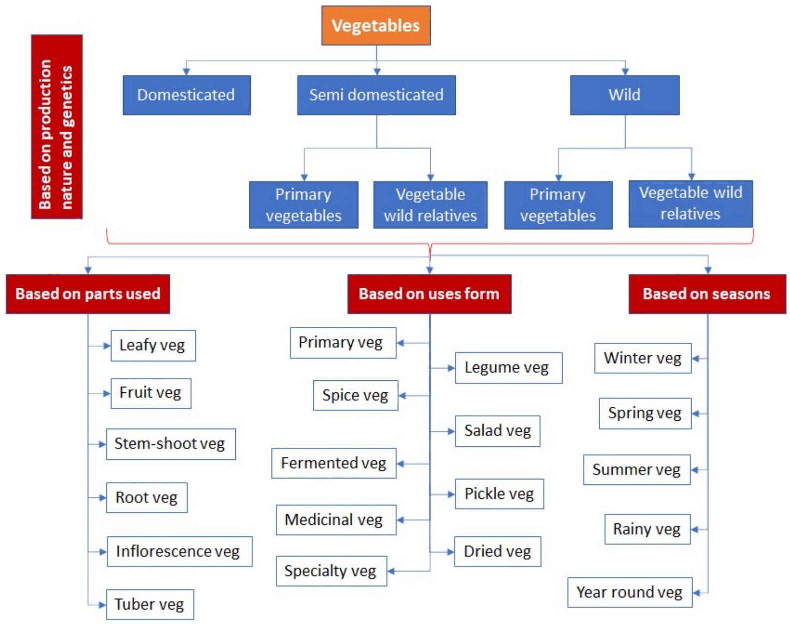

Figure 3.1. Classification of vegetables based on different criteria. Further groups of vegetables can be based on (i) growth habit, e.g. herb, shrub, tree, climber and creepers; (ii) lifespan, e.g. annual, biannual and perennial; and (iii) mode of propagation, e.g. self pollinated, cross-pollinated and vegetatively propagated.

Sources of Vegetables

Vegetables are collected from wild, semi-wild or grown for edible parts, which are consumed as a part of a meal. Rich biodiversity and agro-biodiversity have greater impact on food habits and livelihood of Nepalese communities inhabiting different parts of the country. Local people are known to rely on vegetables from wild and semi-wild conditions since time immemorial. Rural communities are still using diverse kind of edible species in myriad of ways. In some rural areas of Nepal, people consume wild vegetables for more than three months of the year (Aryal et al., 2018; Uprety et al., 2012). Depending on the availability in wild or semi-wild conditions, various seasonal vegetables reach in Nepalese kitchen of both rural and urban areas throughout the year (see: Tables 3.1, 3.2 and 3.3). A large number of people consider wild vegetables are tastier, highly nutritious, organic and relatively cheap than cultivated exotic varieties (Uprety et al., 2012). People in rural areas are widely practicing subsistence farming where they keep indigenous breeds of goat, cattle and chicken, and grow local landraces of crops including vegetables (Joshi et al., 2020b). Extension of rural hill road networks and expansion of market oriented activities have increased introduction of exotic crop varieties causing imbalance on traditional organic farming practices. Many introduced vegetables species provide higher yield but they need intense care and high amounts of chemical fertilizers and pesticides. Exotic vegetables have caused complete loss of indigenous varieties in many semi-urbanized and remote areas.

Vegetables in Nepal

Vegetables are an integral part of Nepalese cuisine. Vegetables, both wild and farm origin, are playing important roles in nutrition security, food security and livelihood improvement of the people inhabiting different agro-climatic zones of Nepal. Indigenous people of Nepal collect different types of wild vegetables from forest and pasture land. Such vegetables are also marketed in nearby town (Manandhar, 2002). In addition to collection from wild, unique agro-ecological setting of the country has also favoured cultivation of different local landraces of vegetables such as broad leaf mustard (rayo), beans, cowpeas, gourds, pyuthane radish, pumpkin, yam, taro etc.; those have been traditionally maintained by local communities since long. Exotic vegetables were occasionally introduced by pilgrimage from India; however, recorded cultivation of introduced species from India and England was in the time of Rana prime minister Jung Bahadur Rana, during mid 19th century (Pandey et al., 2017; Regmi, 1982).

Domesticated Vegetables in Nepal

An estimated 200 species of vegetables are grown in different agro-ecological zones of Nepal; however, among the estimated figure about 127 species are reported to be in common use; out of them the majority i.e. 57 are leafy followed by 38 fruit, 13 root and tubers, 11 legume, and 8 stem vegetables (Pandey et al., 2017). There are many species that are nutritionally and geographically unique but most of them are neglected (Joshi et al., 2019, 2020a). Table 3.1 presents commonly grown vegetables in Nepal.

Table 3.1. Different kind of cultivated vegetables with their Nepali, English, scientific names and botanical family (modified from Pandey et al. (2017)).

S. N.	Nepali name	English name	Scientific name	Family
		Leafy vegetables		
1	Banda Kopi	Cabbage	*Brassica oleracea* var. *capitata* L.	Brassicaceae
2	Bethe	Lamb's quarter	*Chenopodium album* L.	Chenopodiaceae
3	Chamsur	Cress	*Lepidium sativum* L.	Brassicaceae
4	Chervil	Chervil	*Anthriscus cerefolium* (L.) Hoffm.	Apiaceae
5	Chhyapi	Leek	*Allium porrum* L.	Amyrillidaceae
6	Chhyapi	Shallot	*Allium ascalonicum* L.	Amaryllidaceae
7	Chikori	Chicory	*Cichorium intybus* L.	Asteraceae
8	Chinese Banda	Cabbage (Chinese)	*Brassica chinensis* L.	Brassicaceae
9	Dandu	Onion (fragrant)	*Allium tuberosum* Rottler ex Spreng.	Amaryllidaceae
10	Dhaniya	Coriander	*Coriandrum sativum* L.	Apiaceae
11	Indive	Endive	*Cichorium endivia* L.	Asteraceae
12	Ishkush	Chayote	*Sechium edule* (Jacq.) Sw.	Cucurbitaceae
13	Jimbu	Garlic (aromatic leaf)	*Allium hypsistum* Stearn	Amaryllidaceae
14	Jiriko Saag	Lettuce leaf	*Lactuca sativa* L.	Lamiaceae
15	Jiriko Saag	Mustard (curly)	*Brassica japonica* (Thunb.) Siebold ex Miq.	Brassicaceae
16	Kalo Bethe	Goose foot	*Chenopodium murale* L.	Chenopodiaceae

17	Kalo Tori	Mustard (black)	*Brassica nigra* (L.) K.Koch	Brassicaceae
18	Lasun	Garlic	*Allium sativum* L.	Amaryllidaceae
19	Latte Dana	Amaranth (grain)	*Amaranthus cruentus* L.	Amaranthaceae
20	Latte Dana	Amaranth (grain)	*Amaranthus caudatus* L.	Amaranthaceae
21	Methi	Fenugreek	*Trigonella foenum-graecum* L.	Papillenaceae
22	Nepali Rayo	Mustard (Nepali)	*Brassica juncea* var. *rugosa* (Roxb.) Kitam.	Brassicaceae
23	Neuzealand Palungo	Spinach (New Zealand)	*Tetragonia expansa* Murray	Aizoaceae
24	Palungo	Spinach	*Spinacia oleracea* L.	Chenopodiaceae
25	Parsale	Parsley	*Petroselinum crispum* (Mill.) Fuss	Apiaceae
26	Parsanip	Parsnip	*Pastinaca sativa* L.	Apiaceae
27	Pidalu/Karkalo	Colocation/Taro	*Colocasia esculenta* (L.) Schott	Araceae
28	Pudina/Babari	Mint	*Mentha longifolia* (L.) L.	Lamiaceae
29	Pyaj	Onion	*Allium cepa* L.	Ámaryllidaceae
30	Rato Latte	Amaranth (red)	*Amaranthus tricolor* L.	Amaranthaceae
31	Rayo	Mustard (leaf)	*Brassica juncea* var. *crispifolia* L.H.Bailey	Brassicaceae
32	Rayo	Mustard (Indian)	*Brassica juncea* (L.) Czern.	Brassicaceae
33	Rayo	Mustard	*Brassica juncea* var. *cuneifolia* Prain	Brassicaceae
34	Sakharkhanda	Sweet potato	*Ipomoea batatus* (L.) Lam.	Convolvulaceae
35	Salagam	Turnip	*Brassica rapa* L.	Brassicaceae
36	Sarshiyu	Mustard (Colza)	*Brassica campestris* var. *sarson* Prain	Brassicaceae
37	Seleri	Celery	*Apium graveolens* L.	Apiaceae
38	Swap	Fennel	*Foeniculum vulgare* Mill.	Apiaceae
39	Swish Chard	Swiss Chard	*Beta vulgaris* var. *cicla* L.	Chenopodiaceae
		Stem vegetables		
1	Chini Kale	Kale (Chinese)	*Brassica oleracea* var. *acephala* DC.	Brassicaceae
2	Gyath	Knol khol	*Brassica oleracea* L.	Crucifareae
3	Kauli	Cauliflower	*Brassica oleracea* var. *botrytis* L.	Brassicaceae
4	Kurilo	Asparagus	*Asparagus officinalis* L.	Liliaceae
5	Ool	Devil's tongue	*Amorphophallus campanulatus* Decne.	Araceae
6	Tama	Bamboo shoot	*Bambusa* spp.	Poaceae
		Fruit vegetables		
1	Badaure Kakro	Cucumber (garden)	*Cucumis sativus* var. *sikkimensis* HooK. f.	Cucurbitaceae
2	Ban Chichindo	Gourd (snake wild)	*Trichosanthes cucumerina* L.	Cucurbitaceae
3	Ban Karela	Gourd (Chattel)	*Momordica cochinchinensis* (Lour.) Spreng.	Cucurbitaceae
4	Barela	Balsam apple	*Momordica balsamina* L.	Cucurbitaceae
5	Bhanta	Brinjal/eggplant	*Solanum melongena* L.	Solanaceae
6	Bhede Khursani	Chili/Bell pepper	*Capsicum frutescens* var. *grossum* (Mill.) L.H. Bailey	Solanaceae
7	Chichindo	Gourd (snake)	*Trichosanthes anguina* L.	Cucurbitaceae

8	Ghiraula	Gourd (sponge)	*Luffa cylindrica* (L.) M.Roem.	Cucurbitaceae
9	Ghurmi	Melon (orange)	*Cucumis melo* var. *agrestis* Naudin	Cucurbitaceae
10	Golbheda	Tomato	*Lycopersicon esculentum* Mill.	Solanaceae
11	Hatti Sude Khursani	Chili/Cone pepper	*Capsicum frutescens* var. *conoides* (Mill.) L.H.Bailey	Solanaceae
12	Hiude Pharsi	Pumpkin (winter)	*Cucurbita maxima* Duchesne	Cucurbitaceae
13	Jhine Khursani	Chili/red cluster	*Capsicum frutescens* var. *longum* (Sendtn.) L.H. Bailey	Solanaceae
14	Jire Golbheda	Tomato (cherry)	*Lycopersicon cerasiforme* Dunal	solanaceae
15	Jire Khursani	Chili/Bird's eye	*Capsicum microcarpum* Cav.	Solanaceae
16	Kakadi/ Lamkakro	Cucumber (long)	*Cucumis melo* var. *utilissimus* (Roxb.) Duthie &Fuller	Cucurbitaceae
17	Kakro	Cucumber (field)	*Cucumis sativum* L.	Cucurbitaceae
18	Kharbujha	Melon (Musk)	*Cucumis melo* var. *reticulatus* Ser.	Cucurbitaceae
19	Kubhindo	Ash gourd	*Benincasa hispida* (Thunb.) Cogn.	Cucurbitaceae
20	Lamche Piro Khursani	Chili/Long pepper	*Capsicum frutescens* var. *fasciculatum* (Sturtev.) L.H.Bailey	Solanaceae
21	Lauka	Gourd (bottle)	*Lagenaria siceraria* (Molina) Standl.	Cucurbitaceae
22	Parawal	Gourd (pointed)	*Trichosanthes dioica* Roxb.	Cucurbitaceae
23	Pate Ghiraula	Gourd (ridge)	*Luffa acutangula* (L.) Roxb.	Cucurbitaceae
24	Pharsi	Pumpkin (Nepali)	*Cucurbita moschata* Duchesne	Cucurbitaceae
25	Phut Kakri	Snap melon	*Cucumis melo* var. *momordica* (Roxb.) Cogn.	Cucurbitaceae
26	Ramtoriya	Lady's finger/okra	*Abelmoschus esculentus* (L.) Moench	Malvaceae
27	Rukha Golbheda	Tomato (tree)	*Cyphomandra betacea* (Cav.) Sendtn.	Solanaceae
28	Silam	Perilla	*Perilla frutescens* (L.) Britton	Lamiaceae
29	Skwas Pharsi	Pumpkin (Squash)	*Cucurbita pepo* L.	Cucurbitaceae
30	Suryamukhi	Sun flower	*Helianthus annuus* L.	Asteraceae
31	Tarbhujha	Melon (water)	*Citrullus lanatus* (Thunb.) Matsum. & Nakai	Cucurbitaceae
32	Tinda	Gourd (round)	*Citrullus vulgaris* var. *fistulosus* Steward	Cucurbitaceae
33	Tite Karela	Gourd (bitter)	*Momordica charantia* L.	Cucurbitaceae
			Legume vegetables	
1	Bhatmas	Bean (soya)	*Glycine max* (L.) Merr.	Fabaceae
2	Bodi	Cow-pea (kattike)	*Vigna unguiculata* (L.) Walp.	Fabaceae
3	Gwar Simi	Bean (cluster)	*Cyamopsis tetragonoloba* L.	Fabaceae
4	Hiude/Tate Simi	Bean (Hyacinth)	*Dolichos lablab* L.	Fabaceae
5	Kause Simi	Bean (Velvet)	*Mucuna cochinchinensis* (Lour.) A.Chev.	Fabaceae
6	Kerau	Pea	*Pisum sativum* L.	Fabaceae

7	Khude Simi	Bean (sword)	*Canavalia gladiata* (Jacq.) DC.	Fabaceae
8	Pakhate Simi	Bean (winged)	*Tetragonolobus purpureus* Moench	Fabaceae
9	Sajiwan	Drum stick	*Moringa oleifera* Lam.	Moringaceae
10	Tanebodi	Cow-pea (Tane)	*Vigna unguiculata* var. *sesquipedalis* (L.) Bertoni	Fabaceae
11	Tarbare Simi	Bean (sword)	*Canavalia ensiformis* (L.) DC.	Fabaceae
		Roots and tubers		
1	Aalu	Potato	*Solanum tuberosum* L.	Solanaceae
2	Chukandar	Beet root	*Beta vulgaris* L.	Chenopodiacea e
3	Gajar	Carrot	*Daucus carota* L.	Apiaceae
4	Ghar Tarul	Yam (white)	*Dioscorea alata* L.	Dioscoreaceae
5	Ghyampe Tarul	Yam (giant taro)	*Alocasia macrorrhizos* (L.) G.Don	Dioscoreaceae
6	Mula Seto	Radish (white)	*Raphanus sativus* var. *longipinnatus* L.H. Bailey	Brassicaceae
7	Pyuthane Mula	Radish (Pyuthane)	*Raphanus sativus* L.	Brassicaceae
8	Rutabaga	Rutabaga	*Brassica napus* var. *napobrassica* (L.) Rchb.	Brassicaceae
9	Simal Tarul	Cassava	*Manihot esculenta* Crantz	Euphorbiaceae
10	Tarul Suthani	Yam (Karenpotato)	*Dioscorea esculenta* (Lour.) Burkill	Dioscoreaceae

Semi-domesticated Vegetables in Nepal

Semi-domesticated plants are the species those are accustomed to regular disturbance of the people. Such species generally grow in and around the farmlands and disturbed habitats. These plants are sometime known as underutilized, minor or undomesticated species (KC et al., 2017; González-Insuasti et al., 2011). Semi-domesticated species are regarded to be in between wild plants and domesticated crops because these species are conserved in the marginal or in farmland for their use values and very little or no attention is given to manage them. Sometime confusion occurs when wild plants are documented as semi-domesticated or vice versa. This is mainly due to the difference in use pattern of a species in different areas (Meyer et al., 2012). KC et al. (2017) has reported 42 semi-domesticated species, which are distributed in different ecological zones of Nepal. Among 42 species, 22 (53%) are used as vegetables. The revised list of semi-domesticated vegetables with 56 species is given in Table 3.2.

Table 3.2. Semi-domesticated vegetables in Nepal.

S. N.	Representing species/Family, Habit	Local name	Distribution (masl)
1	*Acmella calva* (DC.) R.K.Jansen/Asteraceae, Herb	Marauthi	WC (1,600)
2	*Acmella paniculata* (Wall. ex DC.) R.K. Jansen/Asteraceae, Herb	Marauthi	C (104)
3	*Amaranthus lividus* L./Amaranthaceae, Herb	Banlude	WC (1,500–2,300)
4	*Amaranthus spinosus* L./Amaranthaceae, Herb	Banlude	WCE (150–1,560)
5	*Amaranthus viridis* L./Amaranthaceae, Herb	Latte, Lunde	CE (150–1,200)
6	*Amorphophallus campanulatus* Blume/Araceae, Herb	Ol	WCE (1,000)

7	*Bauhinia purpurea* L./Fabaceae, Tree	Taki	WCE (300–1,600)
8	*Bauhinia variegata* L./Fabaceae, Tree	Koiralo	WCE (150–1,900)
9	*Canna chinensis* Willd./Cannaceae, Herb	Bhuinchapo	C
10	*Canna glauca* L./Cannaceae, Herb	-	-
11	*Canna indica* L./Cannaceae, Herb	Sarbada phool	CE (900)
12	*Cassia fistula* L./Fabaceae, Tree	Rajbriksha	WCE (150–1,400)
13	*Centella asiatica* (L) Urban/Apiaceae, Herb	Godtapre	WCE (500–2,100)
14	*Chenopodium album* subsp. *album* L./Chenopodiaceae, Herb	Bathu	WC (2,000–4,000)
15	*Chenopodium album* subsp. *amaranticolor* Coste & Reyn./Chenopodiaceae, Herb	Bethe, Rato latte	C (1,800–2,200)
16	*Chenopodium murale* L./Chenopodiaceae, Herb	Kalo bethe	WCE
17	*Cleome viscosa* L./Capparaceae, Herb	Tori Jhar	WCE (100–2,800)
18	*Corchorus aestuans* L./Tiliaceae, Shrub	Balu jhar	CE (100–1,200)
19	*Crateva unilocularis* Buch.-Ham./Capparaceae, Tree	Sipligan	WCE (250-1,500)
20	*Dendrocalamus giganteus* Munro/Poaceae, Bamboo	Bhalu bans	CE (200–1,300)
21	*Dioscorea bulbifera* L./Dioscoreaceae, Climber	Ban tarul	WCE (150–2,100)
22	*Dioscorea kamoonensis* Kunth/Dioscoreaceae, Climber	Bhyakur	WCE (1,600–2,200)
23	*Dioscorea pentaphylla* L./Dioscoreaceae, Climber	Bhyakur	WCE (190–1,500)
24	*Dysolobium grande* (Wall. ex Benth) Prain/Fabaceae, Herb	-	C
25	*Dysolobium pilosum* (Klein ex Willd.) Marechal/Fabaceae, Herb	-	E
26	*Eclipta prostrata* (L.) L./Asteraceae, Herb	Bhringiraj	WCE (500–1,500)
27	*Eichhornia crassipes* (Martius) Solms/Pontederiaceae, Herb	Teli phul	WCE (200–1,500)
28	*Emilia sonchiholia* (L.) DC. ex DC./Asteraceae, Herb	Chaulene jhar	WCE (1,700)
29	*Euphorbia hirta* L./Euphorbiaceae, Herb	Dudhe	WCE (1,800)
30	*Fagopyrum dibotrys* (D. Don) H. Hara/Polygonaceae, Herb	Salsale	WCE (1,500–3,400)
31	*Ficus hispida* L.f./Moraceae, Tree	Khasreto	WCE (450–1,100)
32	*Ficus lacor* Buch.-Ham./Moraceae, Tree	Kabro	C (500–1,400)
33	*Himalayacalamus fimbriatus* Stapleton/Poaceae, Bamboo	Tite nigalo	WE (1,100–1,800)
34	*Jatropha curcas* L./Euphorbiaceae, Shrub	Sajiwan, Sajyon	WCE (1,300)
35	*Justicia adhatoda* L./Acanthaceae, Shrub	Asuro	WCE (2,700)

36	*Leucaena leucocephala* (Lam.) de Wit/Fabaceae, Tree	Epil	WC (1,400)
37	*Leucas cephalotes* (Roth) Spreng./Lamiaceae, Herb	Tauke jhar	WCE (2,400)
38	*Macropanax undulatus* (Wall. ex G. Don) Seem./Araliaceae, Tree	Chinde	E (2,200–2,900)
39	*Megacarpae polyandra* Bentham/Brassicaceae, Herb	Rubiko sag	WC (900–3,800)
40	*Melochia corchorifolia* L/Sterculiaceae, Herb	Ban pate	CE (1,300)
41	*Mirabilis jalapa* L/Nyctanginaceae, Herb	Malati	WCE (1,600)
42	*Monochoria hastata* (L) Solms/Pontederiaceae, Herb	Dhape jhar	CE (80–500)
43	*Oroxylum indicum* (L.) Kurz/Fabaceae, Tree	Tatelo	WCE (500–1,400)
44	*Phytolacca acinosa* Roxb./Phytolaccaceae, Herb	Jaringo sag	WC (2200–3200)
45	*Plantago erosa* Wallich/Plantaginaceae, Herb	Esabgol	WCE (2,000–4,600)
46	*Plantago lanceolata* L./Plantaginaceae, Herb	Isapgol	CE (1,700)
47	*Portulaca oleracea* L./Portulaceae, Herb	Nundhiki	WCE (1,600)
48	*Rumex hastatus* D. Don/Polygonaceae, Herb	Amili	WC (1,100–2,600)
49	*Rumex nepalensis* Spreng./Polygonaceae, Herb	Halhale	WCE (1,200–4,200)
50	*Senna floribunda* (Cav.) H.S. Irwin & Barneby/Fabaceae, Herb	Bhatte	WCE (700–2,200)
51	*Senna tora* (L.) Roxb./Fabaceae, Herb	Chhinchhine	WCE (400–1,500)
52	*Thysanolaena latifolia* (Roxb. Ex Hornem) Honda/Poaceae, Grass	Amriso	WCE (150–2,000)
53	*Trevesia palmats* (Roxb) Visiani/Araliaceae, Tree	Chuletro	CE (250–2,500)
54	*Trianthema portulacastrum* L./Aizoaceae, Herb	Gadapurina	WCE (150–300)
55	*Urtica dioica* L./Urticaceae, Herb	Sisnu	C (3,500–4,000)
56	*Urtica parviflora* Roxb./Urticaceae, Herb	Sisnu	WCE (600–4,100)

masl = meter above sea level. W = west, C = central and E = east.

Wild Vegetables in Nepal

Globally wild vegetables have noteworthy contribution by supplying diet with supplement protein, vitamins and other minerals necessary for rural people. Consumption of wild edible plants including vegetables is a traditional culinary practice in Nepal. Importance of wild vegetables is more pronounced during critical food shortage, particularly for the people who do not have enough land to grow foods that can feed them round the year (Manandhar, 2002; Uprety et al., 2012). Globally wild vegetables have offered alternate source of income for millions of low income rural people as well (Hickey et al., 2016; Oladele, 2011; You-kai et al., 2004). Many studies had documented food, livelihood, cultural and religious importance of wild vegetables in Nepalese communities inhabiting different parts of the country (Dangol et al., 2017; DMPN, 1982; Manandhar, 2002; Singh, 1968; Uprety et al., 2012). The revised list of wild vegetables comprising 143 species is given in Table 3.3.

Table 3.3. Wild vegetables consumed by different communities in Nepal. Botanical names are based on Fraser-Jenkins et al. (2015), Fraser-Jenkins and Kandel (2019), NPHL (2011, 2012), and Rajbhandari and Rai (2017, 2019).

S. N.	Species/Family, Habit	Local name	Distribution (masl)
1	*Abrus precatorius* L./Fabaceae, Climber	Ratigedi	WCE (100–1,200)
2	*Aconogonon campanulatum* (Hook.f.) H. Hara/Polygonaceae, Herb	Rapre ghans	CE (2,100–4,000)
3	*Aconogonon molle* (D.Don) H. Hara/Polygonaceae, Herb	Thotne	CE (1,200–2,400)
4	*Aesculus indica* (Colebrooke ex Cambessedes) Hooker/Sapindaceae, Tree	Lekh pangro	WC (1,900–2,700)
5	*Allium wallichii* Kunth/Amaryllidaceae, Herb	Ban lasun	WCE (2,100–4,400)
6	*Alternanthera sessilis* (L.) de Candolle/Amaranthaceae, Herb	Bhiringi jhar	WCE (200–2,000)
7	*Anagallis arvensis* L./Primulaceae, Herb	Armale, Krishna nil	C (1,650)
8	*Arisaema tortuosum* (Wallich) Schott/Araceae. Herb	Bir banko	WCE (1,300–2,900)
9	*Arthromeris wallichiana* (Sprengel) Ching/Polypodiaceae, Fern	Niguro	-
10	*Asparagus filicinus* D. Don/Asparagaceae, Herb	Kurilo	WC (2,100–3,450)
11	*Asparagus racemosus* Willd./Asparagaceae, Herb	Kurilo	WCE (150–2,100)
12	*Barbarea intermedia* Boreau/Brassicaceae, Herb	Khole saag	WC (3,000–3,500)
13	*Basella alba* L./Basellaceae, Herb	Poi saag	WCE (500)
14	*Bidens bipinnata* L./Asteraceae, Herb	Kuro	WCE (700–2,000)
15	*Boehmeria ternifolia* D.Don/Urticaceae, Small tree	Kamle	WCE (900–2,300)
16	*Boerhavia diffusa* L./Nyctaginaceae, Herb	Punarnava	WCE (300–1,200)
17	*Bombax ceiba* L./Malvaceae, Tree	Simal	WCE (200–1,000)
18	*Botrychium lanuginosum* Wall.ex Hook. & Grev./Ophioglossaceae, Fern	Jaluko	WCE (1,600–3,000)
19	*Brachycorythis obcordata* (L) Summerhayes/Orchidaceae, Herb	Gamdol	WCE (1,000–2,600)
20	*Capparis spinosa* L./Capparaceae, Shrub	Bagh mukhe	WCE (2,000)
21	*Capsella bursa-pastoris* (L.) Medikus/ Brassicaceae, Herb	Chalne, Tori ghans	WCE (100–4,900)
22	*Caragana brevispina* Royle/Fabaceae, Shrub	Jyaure kanda	WC (2,500–3,100)
23	*Cardamine impatiens* L./Brassicaceae, Herb	Sim sag	WCE (100–400)
24	*Cardamine loxostemonoides* O.E. Schulz/Brassicaceae, Herb	Chamsure ghans	WCE (2,400–5,500)
25	*Cardamine violaceae* (D.Don) Wall. ex Hook.f. & Thomson/Brassicaceae, Herb	Tuki jhar	CE (1,800–4,000)
26	*Cardiospermum halicacabum* L./Sapindaceae, Climbing herb	Kesh lahara	WCE (500–1,500)
27	*Carum carvi* L./Apiaceae, Herb	Jangali jira	WC (2,500–4,500)
28	*Cautleya spicata* (Sm.) Baker/Zingiberaceae, Herb	Pani saro	WCE (1,800–2,800)
29	*Ceratopteros thalictroides* (L.) Brongn./Parkeriaceae, Fern	Pani dhaniya	WCE (450–1,000)
30	*Ceropegia pubescens* Wall./Asclepiadaceae, Climber	Mirke laharo	WCE (600–2,700)
31	*Cheilocostus speciosus* (J. Koenig) C.D. Specht/Costaceae, Herb	Betlauri	WC (400–1,500)
32	*Chlorophytum nepalense* (Lindl.) Baker/Asparagaceae, Herb	Ban pyaj	WCE (1,400–3,000)
33	*Clematic acuminata* DC./Ranunculaceae, Climbing shrub	Ransag	WCE (200–3,000)
34	*Clematis buchananiana* DC/Ranunculaceae, Climbing shrub	Junje lahara	WCE (900–3,900)
35	*Clerodendrum indicum* (L) Kuntze/Lamiaceae, Shrub	Ekle bir	WCE (200–1,400)
36	*Clerodendrum japonicum* (Thunberg) Sweet/Lamiaceae, Shrub	Dhago phool	CE (700–1,600)

37	*Clerodendrum viscosum* Ventenat/Lamiaceae, Shrub	Bhat	WCE (300–1,500)
38	*Clintonia udensis* Trautv. & C.A. Mey./Liliaceae, Herb	-	WCE (3,200–4,000)
39	*Clitoria ternatea* L./Fabaceae, Herb	Aparajita	WCE (100–200)
40	*Commelina paludosa* Blume/Commelinaceae, Herb	Buki	WCE (300–3,500)
41	*Commellina benghalensis* L./Commelinaceae, Herb	Kane jhar	WCE (300–2,100)
42	*Cordia dichotoma* Forster fil./Boraginaceae, Tree	Bori	CE (300–1,600)
43	*Cortia depressa* (D.Don) C.Norman/Apiaceae, Herb	Bhutkesh	WCE (3,300–4,500)
44	*Cycas pectinata* Buchanan-Hamilton/Cycadaceae, Shrub	Thulo nyauro	WCE (500–1,400)
45	*Cynanchum auriculatum* Wight/Asclepiadaceae, Climbing shrub	Latikoseli	WCE (1,800–3,300)
46	*Cypripedium cordigerum* D. Don/Orchidaceae, Herb	Jibre	WC (2,100–4,000)
47	*Dactylorhiza hatagirea* (D.Don) Soo/Orchidaceae, Herb	Panchaunle	WCE (2,800–4,000)
48	*Deeringia amaranthaoides* (Lam.) Merr./Amaranthaceae, Climbing shrub	-	WCE (600–1,500)
49	*Deparia boryana* (Willd.) M. Kato subsp. *boryana*/Athyriaceae, Fern	-	WC (1,400–3,000)
50	*Didymocarpus villosus* D.Don/Gesneriaceae, Herb	Kiya	CE (1,000–2,400)
51	*Dienia cylindrostachya* Lindl./Orchidaceae, Herb	-	WCE (2,600–3,500)
52	*Dillenia indica* L./Dilleniaceae, Tree	Ramphal	CE (300)
53	*Dillenia pentagyna* Roxb./Dilleniaceae, Tree	Tantari	CE (1,200)
54	*Diplazium esculentum* (Retz.) Sw./Athyriaceae, Fern	Masino niuro	WCE (100–2,200)
55	*Disporum cantoniense* (Loureiro) Merrill/Convallariaceae	Mahajari	WCE (1,100–2,900)
56	*Drymaria cordata* (L.) Willd. ex Schult./Caryophyllaceae, Herb	-	WCE (2,200–4,300)
57	*Drymaria villosa* Chamisso & Schlechtendal/Caryophyllaceae, Herb	Abhijalo	CE (1,000–1,900)
58	*Dryopteris cochleata* (D. Don) C.Chr./Dryopteridaceae, Fern	Niuro, Kuthurke	WC (1,600)
59	*Edgaria darjeelingensis* C.B.Clarke/Cucrubitaceae, Herbaceaous climber	-	CE (900–3,200)
60	*Elatostema platyphyllum* Wedd./Urticaceae, Herb	Sano gagaleto	C (1,100–2,200)
61	*Elatostema sessile* J.R.Forst. & G.Forst./Urticaceae, Herb	Gagaleto	WCE (500–3,000)
62	*Eryngium foetidum* L./Apiaceae, Herb	Barmeli dhaniya	E (1,000)
63	*Fritillaria cirrhosa* D.Don/Liliaceae, Herb	Kakoli	WCE (3,000–4,500)
64	*Galinsoga quadriradiata* Ruiz & Pavon/Asteraceae, Herb	Jhuse chitlange	WCE (2,500)
65	*Gentiana pedicellata* (D.Don) Grisebach/Gentianaceae, Herb	Tauke phool	WCE (800–3,800)
66	*Girardinia diversifolia* (Link) Friis/Urticaceae, Stout Herb	Chalne sisnu	WCE (1,700–3,300)
67	*Grangea maderaspatana* (L.) Poir./Asteraceae, Herb	Gobre jhar	WC (2,000)
68	*Habenaria furcifera* Lindley/Orchidaceae, Herb	Sankalo	WC (150–800)
69	*Habenaria intermedia* D. Don/Orchidaceae, Herb	Thunma	WC (1,800–3,000)
70	*Helminthostachys zeylanica* L./Ophioglossaceae, Fern	Kamraj	WCE (500)
71	*Holarrhena pubescens* Wall. ex G.Don/Apocynaceae, Small tree	Dudhe	WCE (1500)
72	*Houttuynia cordifolia* Thunb./Saururaceae, Herb	Kalancha	CE (1,300–2,500)
73	*Hydrolea zeylanica* (L) Vahl/Hydrophyllaceae, Herb	-	CE (1,200)
74	*Impatiens bicornuta* Wall./Balsaminaceae, Herb	-	WCE (1,900–2,600)
75	*Impatiens falcifer* Hook f./Balsaminaceae, Herb	-	CE (2,200–3,400)
76	*Indigofera cassioides* Rottler ex DC./Fabaceae, Herb	-	WCE (2,400–2,800)
77	*Indigofera pulchella* Roxb./Fabaceae, Herb	Phusre ghans	WCE (200–3,600)
78	*Launaea aspleniifolia* (Willdenow) Hook.f./Asteraceae, Herb	Dudhe jhar	WCE (390–1,500)

79	*Lecanthus peduncularis* (Wall. ex Royle) Wedd./Urticaceae, Herb	Gakaleti	WCE (1,200–3,700)
80	*Ligularia fischeri* (Ledeb.) Turcz./Asteraceae, Herb	-	WCE (2,200–4,600)
81	*Lilium nepalense* D.Don/Liliaceae, Herb	Ban lasun	WCE (1,500–3,400)
82	*Lygodium flexuosum* (L.) Sw./Lygodiaceae, Fern	Ankhle jhar	WCE (150–2,500)
83	*Lygodium japonicum* (Thunb.) Sw./Lygodiaceae, Fern	Bahune lahara	WCE (500–2,000)
84	*Macropanax dispermus* (Blume) Kuntze/Araliaceae, Tree	Chinde	CE (1,200–2,200)
85	*Maianthemum purpureum* (Wallich) LaFrankie/Convallariaceae, Shrub	Seto jara	WCE (2,600–4,200)
86	*Meeboldia achilleifolia* (DC.) P.K. Mukherjee & Constance/Apiaceae, Herb	Najo	WCE (1,200–3,200)
87	*Murdania nudiflora* (L) Brenan/Commelinaceae, Herb	Kane jhar	WCE (65–1,500)
88	*Ophioglossum parvifolium* Grev. & Hook./Ophiglossaceae. Fern	Ek patiya	WCE (1,800)
89	*Ophioglossum petiolatum* Hook./Ophiglossaceae, Fern	-	WCE (2,000–3,000)
90	*Ophioglossum reticulatum* L./Ophiglossaceae, Fern	Jibre sag	WCE (1,400)
91	*Oreocnide frutescens* (Thunb.) Miq./Urticaceae, Shrub	Chiple ghans	WCE (500–2,500)
92	*Osmunda claytoniana* L. subsp. *vestita* (Wall. ex Milde) A. Love & D. Love/Osmundaceae, Fern	Khuturke	WCE (1,400–3,300)
93	*Phlogacanthus thyrisiformis* (Roxburgh ex Hardwicke) Mabberley/Acanthaceae, Shrub	Tite	WE (200–1,700)
94	*Phoenix loureiroi* Kunth var. *pedunculata* (Griff.) Govaerts/Arecaceae, Shrub	Khajur, Thakal	WCE (150–900)
95	*Pilea glaberrima* (Blume) Blume/Urticaceae, Herb	Gageleto	CE (300–1,700)
96	*Pilea racemosa* (Royle) Tuyama/Urticaceae, Herb	Lede sag	WCE (2,000–4,000)
97	*Pilea symmeria* Weddell/Urticaceae, Herb	Kamle	WCE (1,700–3,300)
98	*Pilea umbrosa* Blume/Urticaceae, Herb	Chholyang	WCE (1,200–2,700)
99	*Polygonatum cirrhifolium* (Wall.) Royle/Asparagaceae, Herb	Khinraulaa	WCE (1,700–4,600)
100	*Polygonatum verticillatum* (L.) All./Asparagaceae, Herb	Khinraulaa	WCE (2,100–4,800)
101	*Polygonum plebeium* R. Br./Polygonaceae, Herb	Masino pirre	WCE (3,200)
102	*Polystichum squarrosum* (D.Don) Fée/Dryopteridaceae, Fern	-	WCE (1,000–3,000)
103	*Pouzolzia sanguinea* (Blume) Merr./Urticaceae, Shrub	Lipe	CE (1,000–3,000)
104	*Pteridium aquilinum* (L.) Kuhn/Dennstaedtiaceae, Fern	-	WC (1,200–3,400)
105	*Ranunculus diffusus* DC/Ranunculaceae, Herb	Sano saro	WCE (1,000–3,000)
106	*Ranunculus sceleratus* L./Ranunculaceae, Herb	Nagakor	WCE (200–2,800)
107	*Rotala rotundifolia* (Buch.-Ham ex Roxb.) Koehne/Lytharaceae, Herb	Sim jhar	WCE (300–3,000)
108	*Rungia pectinata* (L.) Nees/Acanthaceae, Herb	Ukuche jhar	WCE (200–2,000)
109	*Sambucus adnata* Wall. ex DC./Caprifoliaceae, Shrub	Chare bhango	WCE (2,000–3,700)
110	*Satyrium nepalense* D. Don/Orchidaceae, Herb	Gamdol	WC (600–4,600)
111	*Sauromatum brevipes* (Hooker fil.) N.E. Brown/Araceae, Herb	-	WC (2,300–2,800)
112	*Sauromatum diversifolium* (Wall. ex Schott) Cusimano & Hett./Araceae, Herb	-	WC (1,400–4,300)
113	*Scutellaria repens* Buch.-Ham. ex D. Don/Lamiaceae, Herb	Charpate	WCE (600–2,100)
114	*Selinum tenuifolium* Wallich ex C.B. Clarke/Apiaceae, Herb	Bhutkesh	WCE (2,500–4,800)
115	*Smilax aspera* L./Smilacaceae, Shrub	Kukurdaino	WCE (1,200–2,900)
116	*Smilax elegans* Wall. ex Kunth/Smilacaceae, Shrub	Kukurdaino	WCE (1,500–2,700)
117	*Smilax ferox* Wallich ex Kunth/Smilacaceae, Shrub	Kukurdaino	CE (1,100–2,700)
118	*Smilax lanceifolia* Roxb./Smilacaceae, Shrub	Kukurdaino	C (1,500–2,200)
119	*Smilax menispermoides* A.de Candolle/Smilacaceae, Climbing shrub	-	WCE (1,600–3,400)

120	*Smilax munita* S.C. Chen/Smilacaceae, Shrub	-	CE (2,100–2,900)
121	*Smilax perfoliata* L./Smilacaceae, Shrub	-	WCE (500–900)
122	*Spermadictyon suaveolens* Roxb./Rubiaceae, Shrub	Bhakhar pirre	WCE (600–2,300)
123	*Sphenoclea zeylanica* Gaertner/Sphenocleaceae, Herb	Dhansejuwa	CE (1,600)
124	*Stellaria media* (L) Villars/Caryophyllaceae, Herb	Armale jhar	WC (1,800–2,700)
125	*Stellaria monosperma* Buch.-Ham. ex D. Don/Caryophyllaceae, Herb	Sanhali sag	WC (2,200–3,200)
126	*Stellaria vestita* Kurz/Caryophyllaceae, Herb	Armane	WCE (1,500–2,500)
127	*Tamilnadia uliginosa* (Retz.) Tirveng. & Sastre/Rubiaceae, Tree	Pidar	C (250)
128	*Taraxacum parvulum* Wall. ex DC./Asteraceae, Herb	Tuki phool	WCE (1,000–4,000)
129	*Tectaria coadunata* (J.Sm.) C. Chr./Tectariaceae, Fern	Kali neuro	WCE (1,000–2500)
130	*Telosma pallida* (Roxb) Craib/Asclepiadaceae, Twining shrub	Asare phul	WCE (300–1,200)
131	*Thamnocalamus spathiflorus* (Trin.) Munro/Poaceae, Bamboo	Nigalo	CE (2,800–3,500)
132	*Thelypteris auriculata* (J. Sm.) K. Iwats/Thelypteridaceae, Fern	Koche	WCE (1,500–2,800)
133	*Thelypteris nudata* (Roxb.) C.V. Morton/Thelypteridaceae, Fern	-	WCE (300–1,500)
134	*Thelypteris procera* (D. Don) Fraser-Jenk./Thelypteridaceae, Fern	-	WCE (500–2,400)
135	*Thlapsi arvensis* L/Brassicaceae, Herb	Tite	WC (2,000–5,200)
136	*Thunbergia coccinea* Wallich ex D. Don/Acanthaceae, Climber	Sigane lahara	WE (300–1,800)
137	*Typha angustifolia* L./Typhaceae, Herb	-	WCE (80–200)
138	*Typha elephantina* Roxb./Typhaceae, Herb	-	WE (80–300)
139	*Veronica baccabunga* L/Scrophulariaceae, Herb	Phuli jhar	W (2,200–3,100)
140	*Wallichia oblongifolia* Griff./Arecaceae, Shrubby palm	-	WCE (250–1,400)
141	*Woodwardia unigemmata* (Makino) Nakai/Blechnaceae, Fern	Danthe unyu	WCE (840–2,600)
142	*Youngia japonica* (L) de Candolle/Asteraceae, Herb	Chaulane, Dudhe	WCE (230–2,900)
143	*Yushania maling* (Gamble) R.B.Majumdar & Karthik./Poaceae, Tall herb	Malingo	E (2,000–3,000)

masl = meter above sea level. W = west, C = central and E = east

Genomics of Vegetables

How Did Modern Vegetables Develop?

When our hunter and gatherer ancestors understood the dispersal mechanisms in different plant species, they then started to gather propagules of wild plants and planted them in the area with right amount of manure, sun and water (Rubatzky & Yamaguchi, 1997). However, it is difficult to get explicit records that clearly mention when our ancestors realized the importance of seeds and how they started planting them. During hunting and gathering, collection of propagules and their dispersal around caves or resting sites might have occurred unknowingly which later helped our forefathers to understand the mechanisms of plant propagation (Harlan, 1992; Hoyt, 1988; Vavilov, 1952).

Human involvement in plantation or growing plants over centuries has induced tremendous evolutionary changes in the species subject to regular farming since generations. Once cultivated, these planted species depend on human for their complete development from the seed to mature fruiting plants (Hoyt, 1988; Zhang et al., 2017). Human has been selecting plants with desired characters since historic time for their need of food, clothing, shelter and pleasure. Artificial selection thus is a practice of selecting genetically better individuals of plants and animals. Number of improved varieties of several domestic plants and animals i.e. potatoes, tomatoes, corn, pigeons, pigs, horses, poultry, cows, sheep, etc. have been developed from their wild ancestors by artificial selection. Farming began about 7,000–10,000 years ago independently in different parts of the world (Harlan, 1992). Our ancestors might have gathered the seeds of wild plants, which later developed, to modern crops like barley, wheat, potatoes, maize, etc. These modern crops are the most reliable source of food now than their wild progenitors naturally growing in the native habitats centuries ago. Selection of useful traits in those cultivated species was a continuous process. Since ancient times, farmers are selecting relatively few traits in the crops related to overall yield, harvesting and edibility (Hua et al., 2015). Such types of strong selection usually resulted in a substantial reduction in genetic variation among cultivated species (Meyer et al., 2012) (Figure 3.2). More than half of the genetic variation was found reduced in some crops (e.g. soybean), while even more reductions can be observed in other crops (e.g. rice) (Xu et al., 2012; Zhou et al., 2015). Selection of targeted traits in domesticated crops can also results in a complete loss of closely linked loci related to dispersal or seed quality (selective sweep) (Zhang et al., 2017). Due to the process of narrowing down the genetic base through selective domestication, the cultivated species contain only a fraction of genetic diversity present in their wild relatives (WRs) (Guarino & Lobell, 2011). The reduced genetic diversity in domesticated plants can be retained from cross-pollination with their wild cousins. Moreover, artificial selection of desired traits on plants, during the past 10,000 years, has evolved the species with adaptive syndromes to human maintained ecology. They can no more survive independently in the wild as their progenitors. Cultivated crops grow in human-maintained ecology or agricultural niches with the help of human mediated sowing, manuring, irrigation and dissemination, but their wild relatives should develop capacity by their own to cope against drought and floods, pests and diseases, and other natural hazards (Harlan, 1992). Wild relatives are evolved with nature and changing climate, therefore, they show greater resilience toward various stresses. Wild species of tomato has retained more than 90% of genetic diversity than the cultivar growing in our garden (Tanksley & McCouch, 1997).

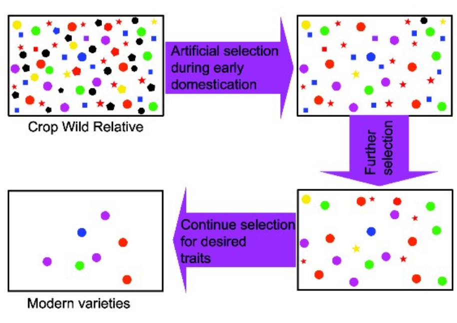

Figure 3.2. Schematic representation of gradual reduction in genetic variation in cultivated species.

Wild Cousins Are Relatives of Domesticated Plants

Our ancestor started modifying some population of plants as crops for their use while remaining population of the same species left in wild are still surviving in the natural habitat. Human mediated artificial selection for desired traits has changed the phenotypic and genotypic characteristics of the cultivated crops but their other populations and relatives keep evolving in the natural habitats through natural selection. These left populations and phylogenetically close cousins surviving in the wild are known as “Wild cousins or Wild Relatives (WRs)” (Harlan & de Wet, 1971; Maxted et al., 2006; Singh, 2017). WRs possess strong genetic affinities with their related cultivated species. Many of these wild relatives are cross compatible with their cultivated relatives. Depending on genetic relatedness, cultivated and wild relatives exchange genes, and produce fertile offsprings. WR generally comprises wide variety of taxa ranging from immediate wild ancestor, congener and closely related taxon. Sometimes definition of WRs also incorporates various values as food, fodder, medicinal plants, spices, fiber yielding plants, etc., which can be improved through their use in the domesticated species. A broader concept of WRs presented by Singh (2017b) includes – *landraces*, which are genetically compatible wild, semi-cultivated and cultivated forms of domesticated species; *wild progenitors*, which are ancestral forms of cross-compatible wild species, sub-species or varieties to cultivated species; *wild/weedy relatives*, which are wild congeners but reproductively isolated to different degree with cultivated species; and finally *naturalized species*, these species are not the native species but show wider distribution range across region or continents through human mediated or other natural dispersal mechanisms.

Harlan and de Wet (1971) have defined wild relatives in the concept of gene pool (GP) based on the relative ease of gene exchange with cultivated crops. According to this definition WRs are classified into primary, secondary, tertiary and quaternary gene pools (GP-1, 2, 3, 4). Primary gene pools (GP-1) and secondary gene pools (GP-2) normally exchange genes through crossing and produce fertile hybrids; however, gene exchange between GP-1 and tertiary gene pool (GP-3) may not be always easy and possible. GP-3 gene pool comprises individuals from different species but from same genus. Exchange of gene pool between GP-1 and GP-2 is a common practice. There are cases where certain useful alleles from GP-3 are also used in the improvement of crops (Abedinia et al., 2000; Saintenac et al., 2013). Sophisticated techniques, such as embryo rescue, somatic fusion, grafting and bridge are adopted for gene transfer from the species of tertiary gene pool. Gp-4 species are distantly related belonging to different families, thus gene transfer possible only through genetic engineering. Smartt (1990) has extended the gene pools concept of Harlan and de Wet (1971) and further classified gene pools to six orders, which make distinction between domesticated and wild components in each gene pool.

Some plant taxonomists have different opinion on the definition of WRs (Miller & Khoury, 2018). They think that this concept has utilitarian value in crop science and plant breeding only, and it does not present any evolutionary or taxonomic relevance. Gene pool concept mainly focuses on level of interfertility between taxa. The pioneer of gene pool concept, Harlan and de Wet (1971) tried to reconcile gene pool concept with sub-species of traditional taxonomic categories. While placing crop wild relatives (CWRs) into different tiers of gene pool, tremendous efforts are needed on extensive garden experiments (Plazas et al., 2016). Therefore, people are searching for alternative ways to assign crop WRs to gene pools. Maxted et al. (2006) proposed 'taxon group concept'. Taxon group concept can be used, as proxy for classification where different taxon groups equivalent to taxonomic classification can be categorized into different types of gene pools. Taxon group concept assumes that taxa within a taxonomic group are genetically related thus are more likely to cross easily. However, this method is still more subjective and less realistic because genetic relatedness differs even among same taxa. Such type of deviations are mainly due to uneven rate of speciation across lineages (Givnish, 2010). Detailed phylogenetic analysis and rigorous studies on patterns of interfertility would provide deeper understanding needed to assign species in an appropriate gene pool of CWRs (Wiersema & León, 2016). Rapid advances in genomic technologies are providing valuable data to elucidate evolutionary relationship among cultivated species and their wild relatives. Characters like species divergence, phylogenetic relationships, morphological and biogeographic differences and reproductive isolation in different species should be the primary focus to categorize CWRs across defined crop gene pools. Standardized and widely applicable system can be developed to evaluate potentially useful species as crop WRs (Vincent et al., 2013; Wiersema & León, 2016).

Global Distribution of Wild Relatives

Wild relatives of crops are distributed naturally in all continents except Antartica; however, they are concentrated mainly on Vavilov centers of diversity viz. Mediterranean, the near east, western and southern Europe, south-east and east Asia, and South America (Vavilov et al., 1992). Vavilov's concept of 'Centers of Origin' of cultivated plants (Vavilov et al., 1992) has been later revised to 'Centers of Diversity' and this term is now widely used (Khoury et al., 2016; Zeven & Zhukovskiĭ, 1975). Centers of diversity are often not centers of origin. Species may have originated in some region but are domesticated extensively in different geographic areas. Dispersal of crops from center of diversity to different places are designated as 'Primary center of diversity' and 'Secondary center of diversity' (FAO, 2010; Zeven & Zhukovskiĭ, 1975). Primary regions of crop diversity are the geographic localities of the initial domestication of crops where species richness is relatively high (Khoury et al., 2016). Primary region of diversity of major vegetables, fruits and few crops is given in Figure 3.3.

Himalaya region, including Nepal, falls in and around three regions (central Asiatic region; Indian region and Chinese region) out of eight primary regions of crop diversity recognized by Vavilov. These regions are the oldest independent centers for vegetables like radish, cowpea, rajma, turnip, chickpea, pigeonpea, eggplant, cucumber, taro, yam, spinach, carrot, etc. Around 50,000–60,000 species of crops and wild relatives are estimated to be available for human use. Among the estimated number 10,739 species are listed useful for food security alone (Maxted & Kell, 2009). Distribution of crop and vegetable and their relatives worldwide are shown in Figures 3.3 and 3.4.

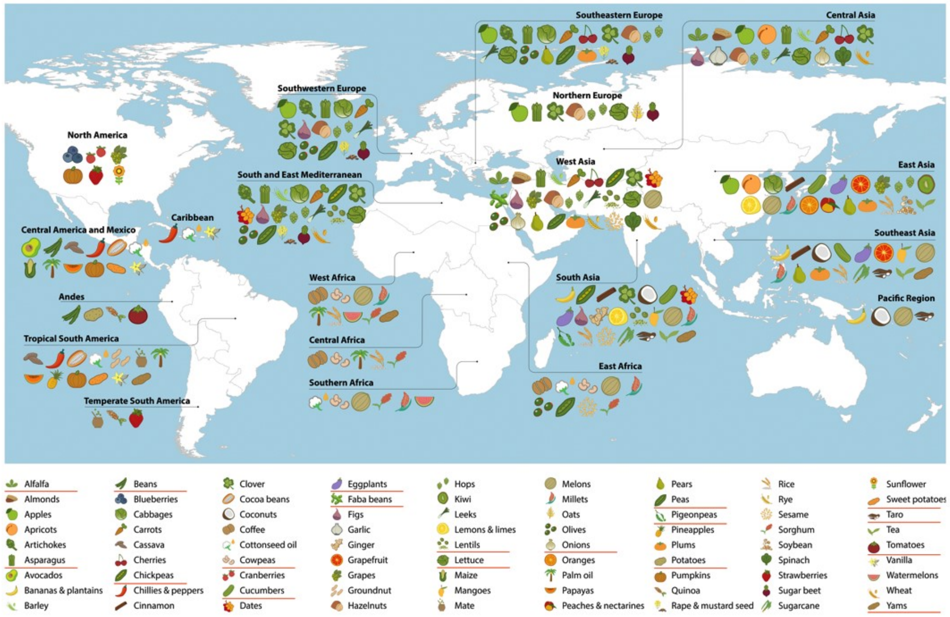

Figure 3.3. Global distribution of primary diversity areas of crops and vegetables (Map adopted from Khoury et al. (2016)). Underlined vegetables are found naturally growing in the wild/semi-wild habitat of Himalayan region including other places.

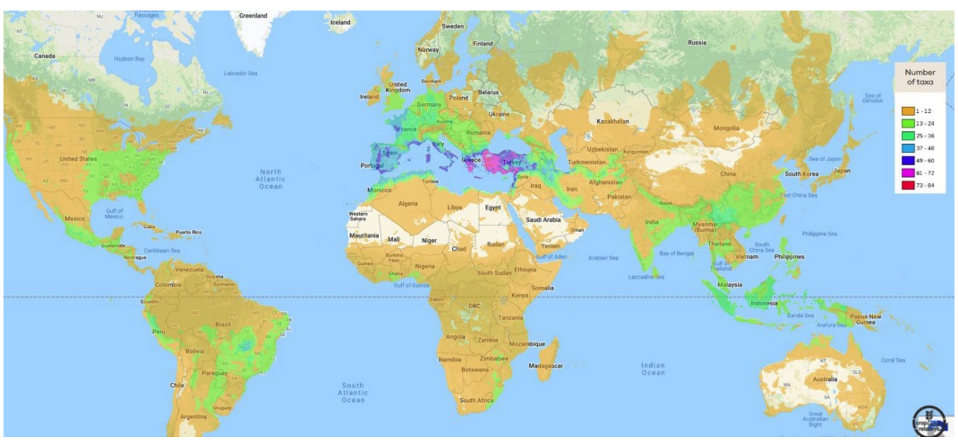

Figure 3.4. Distribution of CWRs (Source: Web, 1)

Wild Relatives of Cultivated Vegetables in Nepal

Nepal is in the crossroads between several floristic regions. Nepalese flora shows close affinities to Sino Japanese flora to east, Irano-Turanian flora to west, The Central Asian flora to the north and Indian and Indo-Chinese flora to the south and south-east, respectively. Experts has estimated more than 6,500 species of flowering plants in Nepal, of which 30% are restricted to Himalayas and 5% are endemic to Nepal (Miehe et al., 2015; Rajbhandari et al., 2017). This figure will increase substantially if extensive explorations are carried out from low lands to high alpine meadows. Despite occupying 0.1 percent of global area, Nepal harbour about three percent of world's known flora. Therefore, beta diversity is particularly high in Nepal. Diverse topographic conditions have also led to maximum diversity of agriculture crops that grow in tropical climate prevalent in the southern plain with as low as 60 m altitudes. In the northern hilly and mountainous belt, temperate-subalpine climate is prevalent where farming is done up to an altitude of 4,700 m (MoFE, 2018). Rice is planted up to two times in the plain areas with high rainfall, while potato is the main crop in higher altitudes. Agro-biodiversity of Nepal comprises about 790 food plant species in which 577 are cultivated species including forage species (Joshi, 2017b; Joshi, et al., 2017a). Among 577 cultivated species, around 84% species are indigenous. Having diverse geography, Nepal shows extreme variations on vegetation patterns and composition of biodiversity. This unique geographic and climatic setting has created suitable habitats for impressive diversities of CWRs. CWRs are wild relatives of cultivated food plants growing naturally in wild habitats or in the proximity of cultivated lands or in disturbed lands. Wild relatives are sometimes regarded as wild cousins of cultivated plants. WRs are mostly genetically related to the cultivated crops. Based on the genetic closeness and inter-mating capacities to exchange gene with cultivated relatives, naturally growing species are classified as primary gene pool, secondary gene pool and tertiary gene pool (Harlan & de Wet, 1971).

Many studies have documented several species of CWRs growing naturally in different ecological zones of Nepal. Regmi (1995) and Shrestha and Shrestha (1996) have reported 64 and 83 wild species of 43 and 36 agriculture crops respectively. Upadhaya and Joshi (2003) have reported about 157 species of food crops in which 56 species of 17 vegetables crops were wild relatives. FAO (2008), however, extended the list of wild relatives of food plants to 599. Out of 599, about 200 species were reported to be wild relatives of vegetable crops.

Primary Wild Vegetables (PWV) in Nepal

Plants we are growing now were once wild. Through series of human mediated breeding and selection, several plants are evolved under domesticated crops. Many of the plants growing around us are either wild or some of them are gradually adapted to semi-domesticated habitats. Himalayan country Nepal is proximal to the primary and secondary sources of origin of many cultivated crops. There are about 15 species of cereals, 18 species of cultivated grain legume crops, 23 species of fruits crops and more than 100 species of vegetables crops growing in different parts of the country (Shrestha & Shrestha, 1999). Farming areas extended in different ecological zones of the country are rich in numerous local landraces and at the same time many of their primary wild relatives also exist in the surrounding natural vegetation. Nepal is one of the northern most country of rice origin where at least 5 wild species of rice and some their weedy varieties are present. Wild relatives of wheat have been reported from Jumla and Humla districts. Wild weedy species of *Hordeum*, *Fagopyrum* and *Eleusine* are reported from Nepal. Wild species of grain legumes belonging to *Atylosis*, *Cicer* and *Lathyrus* are locally used as ornamental plants, fodder and feed (Manandhar, 2002; Shrestha &

Shrestha, 1999). Some notable fruits and their wild relatives distributed in Nepal are *Prunus*, *Castanopsis*, *Malus*, *Morus*, *Pyrus* and *Mangifera*. They are found in tropical to temperate region of Nepal. Similarly, numerous wild relatives of Primary wild vegetables are widely distributed in tropical to subalpine zones of Nepal. About 37 species of crops, including vegetables and fruits of Nepal, fall in the primary gene pool concept suggested by Vavilov (1952) and Harlan and de Wet (1971). Among 37 species, primary gene pools of vegetables are represented by leguminous vegetables like beans, chickpea, cowpea, pigeon pea, egg plant and Swisschard (Joshi et al., 2017a). Diverse kinds of vegetables under genera *Amaranthus*, *Alocasia*, *Asparagus*, *Cajanus*, *Cicer*, *Chenopodium, Cucumis*, *Dioscorea*, *Dolichos*, *Ipomoea*, *Lactuca*, *Lathyrus, Momordica*, *Rumex*, *Solanum*, *Trichosanthes*, *Trigonella*, *Vicia* and *Vigna* are commonly found in disturbed and forested areas. Updated list of primary wild vegetables is presented in Table 3.4.

Updated Checklist of Vegetables Wild Relatives (VWRs) in Nepal

A revised list of 68 wild relatives of 18 vegetables has been presented by Singh et al. (2017). In this paper, the list of vegetable wild relatives (VWR) in Nepal presented by Neupane et al. (2017) and Singh et al. (2017) has been further revised and updated. This revised list presents a total of 148 representing species under 55 genera comprising a broad range of green vegetables under categories fruity and flower; leafy; root, tuber and bulbous; and leguminous vegetables (Table 3.4). In terms of diversity, the presented list comprises a wide range of wild taxa found in Nepal as the primary, secondary and tertiary gene pools of wild relatives, those could be available to enhance and enrich quality of cultivated vegetables.

Table 3.4. Checklist of VWRs in Nepal. Number of wild species are based on NPHL (2011, 2012) and Rajbhandari and Rai (2017, 2019).

S. N.	Genus/Number of species in Nepal	Representing species	Distribution range (altitude)	Chromosome number (2n)/ Genome size
1	*Abelmoschus* / 3	*Abelmoschus crinitus* Wall. *Abelmoschus manihot* subsp. *tetraphyllus* var. *pungens* (L.) Medik. *Abelmoschus moschatus* Medik.	WC (150–1,000) WCE (700–1,700) WCE (600–1,100)	56–144/1.6 Gb
2	*Allium* / 10	*Allium carolinianum* DC. *Allium fasciculatum* Rendle *Allium hypsistum* Stearn *Allium prattii* C. H. Wright apud Forbes & Hemsl. *Allium przewalskianum* Regel *Allium sikkimense* Baker *Allium stracheyi* Baker *Allium tuberosum* Rottler ex Spreng.	WC (3,300–5,100) WCE (4,800–4,500) C (5,500) WCE (2,400–4,500) WC (3,600–4,200) C (3,000–5,100) W (2,700–4,000) WC (2,300–2,600)	16–40/1C = 16.25 pg-31.45

3	*Alocasia* / 3	*Alocasia fornicata* (Roxb.) Schott *Alocasia macrorhizos* (L.) G. Don *Alocasia navicularis* (K. Koch & Bouche) Koch & Bouche	E (250) C (700–800) E (450)	28
4	*Amaranthus* / 5	*Amaranthus hybridus* subsp. *cruentus* (L.) Thell. *Amaranthus hybridus* subsp. *hypochondriacus* (L.) Thell. *Amaranthus quitensis* Kunth *Amaranthus retroflexus* L. *Amaranthus tricolor* L.	C (2,600) CE (1,500–1,700) W (200)	32/466 mb
5	*Amorphopallus* / 3	*Amorphophallus bulbifer* (Roxb.) Blume *Amorphophallus napalensis* (Wall.) Bogner & Mayo *Amorphophallus paeoniifolius* C. Y. Wu ex H. Li, Y. Shiao & S.L. Tseng	CE (300–900) WCE (280–1,600) -	26, 28
6	*Arisaema* / 17	*Arisaema consanguineum* Schott *Arisaema flavum* (Forsskal) Schott *Arisaema jacquemontii* Blume *Arisaema utile* Hooker fil. Ex Schott	CE (1,600–2,700) WC (2,400–2,900) WCE (2,700–4,400) WCE (2,500–4,600)	
7	*Arundinaria* / 1	*Arundinaria racemosa* Munro	E (3,000–3,600)	
8	*Asparagus* / 7	*Asparagus curillus* Buch.-Ham. ex Roxb. *Asparagus penicillatus* H. Hara,	WC (1,100–1,700) W (2,000–2,400)	20/720 mb
9	*Bambusa* / 3	*Bambusa nepalensis* Stapleton *Bambusa tulda* Roxb.	CE (500–1,700) C (200–1,200)	
10	*Bauhinia* / 6	*Bauhinia malabarica* Roxb. *Bauhinia vahlii* Wight & Arn.	WCE (200–650) WCE (200–1,300)	28
11	*Cajanus* / 4	*Cajanus crassus* (Prain & King) Maesen *Cajanus elongatus* (Benth.) Van der Maesen *Cajanus mollis* Van der Maesen *Cajanus scarabaeoides* (L.) houars	WC (200–1,000) CE (1,200–2,000) WCE (1,100–2,000) WC (300–1,200)	22/833 Mbp
12	*Celosia* / 1	*Celosia argentea* L.	WCE (100–1,600)	
13	*Chenopodium* / 7	*Chenopodium ambrosioides* L. *Chenopodium botrys* L. *Chenopodium ficifolium* Sm. *Chenopodium foliosum* (Moench) Asch. *Chenopodium opulifolium* Schrad. ex Koch & Ziz *Chenopodium quinoa* Willd.	WCE (300–2,600) C (4,000) WC (1,100–2,100) C (2,600–3,800) CWE -	9, 36/145–150Gb

14	*Cicer* / 1	*Cicer microphyllum* Benth.	C (3,700–4,800)	8, 16/738–931Mbp
15	*Coccinia* / 1	*Coccinia grandis* (L.) Voigt	WCE (200–900)	24, 28/719, 904Mb
16	*Colocasia* / 2	*Colocasia affinis* Schott *Colocasia fallax* Schott	C (1,100–2,000) WCE (80–2,200)	26, 28, 38, 42, and 56/3.29–12.51 pg/2C
17	*Crotalaria* / 16	*Crotalaria spectabilis* Roth *Crotalaria tetragona* Andrews	CE (200–300) WCE (200–1,700)	14, 16, 18
18	*Cucumis* / 2	*Cucumis maderaspatanus* L. *Cucumis sativus* var. *hardwickii* (Royle) Kitam.	WCE (200–1,400) C (1,300–1,700)	14, 24/367–450Mbp
19	*Dendrocalamus* / 2	*Dendrocalamus hamiltonii* Nees & Arn. ex Munro *Dendrocalamus hamiltonii* Nees & Arn. ex Munro var. *undulatus* Stapleton	CE (1,000–2,000) E (1,300–1,500)	22, 24, 48, 72/2.075Gbp
20	*Descurainia* / 1	*Descurainia sophia* (L) Webb ex Prantl	WC (2,200–4,200)	
21	*Dioscorea* / 11	*Dioscorea belophylla* (Prain) Voigt ex Haines *Dioscorea deltoidea* Wall. ex Griseb. *Dioscorea glabra* Roxb. *Dioscorea hamiltonii* Hook. f. *Dioscorea hispida* Dennst. *Dioscorea melanophyma* Prain & Burkill *Dioscorea prazeri* Prain & Burkill *Dioscorea pubera* Blume	WE (200–2,400) WCE (500–3,100) WCE (150–2,200) WCE (1,200–1,700) WCE (150–900) WC (2,000–2,500) CE (900–1,400) WCE (150–1,100)	4, 60, 80/454–562-594Mb
22	*Diplocyclos* / 1	*Diplocyclos palmatus* (L.) C. Jeffrey	WCE (200–1,500)	
23	*Dolichos* / 2	*Dolichos staintonii* H. Ohashi & Tateishi *Dolichos tenuicaulis* (Baker) Craib	WC (1,000–3,000) E (300–1,200)	22/367Mbp
24	*Drepanostachyum* / 3	*Drepanostachyum falcatum* (Nees) Keng f. *Drepanostachyum intermedium* (Munro) Keng f. *Drepanostachyum khasianum*(Munro) Keng f.	CE (1,000–2,200) E (1,000–2,000) C (1,950)	
25	*Ensete* / 1	*Ensete glaucum* (Roxb.) Cheesman	C (1,200)	
26	*Erysimum* / 2	*Erysimum hieraciifolium* L.	WCE (1,600–3,800)	
27	*Flemingia* / 4	*Flemingia procumbens* Roxb.	WC (2,100–2,900)	22
28	*Herpetospermum*/3	*Herpetospermum pedunculosum* (Seringe) Baillon	WCE (1,000–3,000)	

29	*Himalayacalamus*/7	*Himalayacalamus brevinodus* Stapleton *Himalayacalamus falconeri* (Hooker fil ex Munro) Keng fil.	E (1,800–2,200) CE (2,000–2,500)	
30	*Ipomoea* / 16	*Ipomoea aquatica* Forsskal *Ipomoea arachnosperma* Welw. *Ipomoea cairica* (L.) Sweet *Ipomoea turbinata* Lag.	WCE (500) W (610) E (200) WC (900–1,400)	15, 90/4.4Gb
31	*Lactuca* / 6	*Lactuca dissecta* D. Don	WCE (500–3,100)	18/2.7Gb
32	*Lathyrus* / 5	*Lathyrus aphaca* L. *Lathyrus laevigatus* subsp. *emodi* (Waldst. & Kit.) Gren. *Lathyrus pratensis* L. *Lathyrus sativus* L. *Lathyrus sphaericus* Retz.	WCE (100–1,500) W (2,100–3,100) WC (2,300–3,000) WCE (200–1,200) W (1,300–1,600)	14/6.3–8.2Gb
33	*Malva* / 4	*Malva sylvestris* L. *Malva verticillata* L.	C (2,400) WC (2,500–3,550)	42/1.87–3.82 pg
34	*Megacodon* / 1	*Megacodon stylophorus* (C.B. Clarke) H. Smith	E (3,000–4,000)	
35	*Momordica* / 4	*Momordica balsamina* L. *Momordica dioica* Roxb. ex Willd.	W (600) E (1,100)	16, 22, 28, /339, 710.68–1141Mbp
36	*Mucuna* / 3	*Mucuna macrocarpa* Wall. *Mucuna nigricans* (Lour.) Steud. *Mucuna pruriens* (L.) DC.	CE (1,200–2,200) CE (300–1,200) WCE (100–1,200)	22/1281–1361Mbp
37	*Musa* / 1	*Musa balbisiana* Colla	-	
38	*Nasturtium* / 1	*Nasturtium officinale* R. Br.	WCE (900–3,800)	16, 32, 64, 48/0.76–0.77
39	*Natsiatum* / 1	*Natsiatum herpeticum* Buch.-Ham. ex Arn.	WCE (250–1,400)	
40	*Nelumbo* / 1	*Nelumbo nucifera* Gaertner	WCE (80–1,400)	
41	*Panax* /1	*Panax pseudoginseng* Wall.	WCE (2,000–3,000)	
42	*Peperomia* / 3	*Peperomia pellucida* (L.) Kunth	WCE (200–2,000)	
43	*Persicaria* / 29	*Persicaria barbata* (L.) H. Hara *Persicaria chinensis* (L.) H. Gross *Persicaria microcephala* (D. Don) H. Gross *Persicaria nepalensis* (Meisn.) H. Gross *Persicaria perfoliata* (L) H. Gross *Persicaria runcinata* (Buch.-Ham. ex D. Don) H. Gross	WCE (200–1,100) WCE (1,200–2,900) CE (1,200–2,700) WCE (1,200–4,100) CE (900–1,400) CE (1,600–3,800)	20, 24, 36, 40
44	*Remusatia* / 3	*Remusatia pumila* (D.Don) H.Li & A.Hay *Remusatia vivipara* (Roxb.)Schott	WCE (1,200–2,400) WCE (900–2,100)	
45	*Rhynchosia* / 7	*Rhynchosia himalensis* Benth. ex Baker	WC (1,900–2,900)	

46	*Rorippa* / 4	*Rorippa benghalensis*(DC.) H. Hara *Rorippa dubia* (Pers.) H. Hara *Rorippa indica* (L). Hiern *Rorippa palustris* (L.) Besser	E (200–300) CE (1,200–2200) WE (100–2,600) CE (1,300–2,800)	28
47	*Rumex* / 5	*Rumex acetosa* L. *Rumex dentatus* subsp. *klotzschianus* L. *Rumex patientia* subsp. *pamiricus* L. *Rumex vesicarius* L.	WC (2,100–4,100) C (1,400) C (400) E (200)	14/7.04
48	*Solanum* / 8	*Solanum aculeatissimum* Jacq. *Solanum alatum* Moench *Solanum anguivi* Lam. *Solanum erianthum* D. Don *Solanum nigrum* L. *Solanum surattense* Burm. f. *Solanum torvum* Sw. *Solanum viarum* Dunal	CE (1,600) CE WCE (250–2,300) WCE (200–1,400) WCE (900–2,900) WCE (300–900) CE (250–750) CE (900–2,600)	24, 48/727–844 Mbp; 798–931 Mb
49	*Solena* / 2	*Solena heterophylla* Lour.	WCE (1,600–3,200)	24
50	*Sonchus* / 2	*Sonchus asper* (L) Hill *Sonchus oleraceus* L. *Sonchus wightianus* de Candolle	CE (1,000–1,800) WC (2,000–2,800) WCE (600–2,500)	
51	*Thladiantha* / 1	*Thladiantha cordifolia* (Blume) Cogn.	CE (400–2,500)	18
52	*Trichosanthes* / 6	*Trichosanthe pilosa* Lour. *Trichosanthes lepiniana* (Naudin) Cogn. *Trichosanthes cordata* Roxb. *Trichosanthes costata* Bl. *Trichosanthes tricuspidata* Lour. *Trichosanthes wallichiana* (Ser.) Wight	WCE (1,200–1,800) WCE (1,500–1,900) C (500) WE (1,100–1,800) WCE (700–2,300) WCE (600–2,700)	22, 44, 88
53	*Trigonella* / 5	*Trigonella corniculata* (L.) L. *Trigonella emodii* Benth. *Trigonella fimbriata* Royle ex Benth. *Trigonella gracilis* Benth. *Trigonella pubescens* Baker	C (3,700) WC (1,300–4,900) C (1,800–2,200) WCE (2,200–3,400) WC (2,200–3,600)	14, 16, 18
54	*Vicia* / 5	*Vicia tetrasperma* (L.) Schreber *Vicia bakeri* Ali *Vicia hirsuta* (L.) Gray *Vicia sativa* L. var. *angustifolia* (L.) Wahlenb. *Vicia tenuifolia* Roth	C (1,500–1,600) WC (2,700–3,200) WCE (200–2,700) WCE (200–4,000) WC (1,600–2,200)	10, 12, 14/~13 Gbp
55	*Vigna* / 12	*Vigna nepalensis* Tateishi & Maxted *Vigna radiate* (L.) R.Wilczek *Vigna vexillata* (L.) A. Rich	E (300–1,700) - -	22/416–1394Gb

W = west, C = central and E = east

Hotspots for Wild Vegetables in Nepal

Phytogeographically, Nepal is in the western edge of the eastern Himalayan biodiversity hotspot; however, almost all types of world climate exist in Nepal. Speciation of plants in this region happened during uplift of the Tibetan pleatue and evolution of regional climate (shift of temperature and precipitation) in different periods (Miehe et al., 2015). Midlands and sub-tropical evergreen broad-leaved forests are rich in plant species, as this zone lacks severe frosts, experiences high rainfall and moderately high temperatures (Kessler et al., 2011). Most of the vegetation types found in Nepal have wider range of distribution across Himalaya. Diverse vegetation types are not only habitats for varied species but also home for wild species that are genetically related to the cultivated crops including vegetables. Nepal is reputed for primary and secondary origin of crops like rice, wheat, buckwheat, fruits and several vegetables. Global analysis on 81 gene pools of wild relatives revealed that Nepal possess 22–36 taxa of CWRs (Crop Wild Relatives Occurrence Data Consortia, 2018). In the national study, wild relatives of wheat are reported from Jumla and Humla district of western Nepal (Joshi et al., 2006). Similarly, wild types of common buckwheat; *Fagopyrum cymosum* (Trevir.) Meisn., *Fagopyrum megacarpum* H. Hara and *Fagopyrum tataricum* ssp. *potanini* have also been reported in mid hills and high hills in western and far-western regions (Baniya, 2001; Joshi, 2008). FAO (2008) highlighted several indigenous species of cultivated vegetables and their wild relatives viz. *Allium*, *Amaranthus*, *Chenopodum*, *Colocasia*, *Curcuma*, *Dioscorea*, *Ipomoea*, *Mentha*, *Pisum*, *Rumex, Solanum* and *Trigonella*. These species are mainly distributed in terai and mid hills of Nepal. Majority of wild relatives of crops are distributed naturally in the tropical to temperate belt of Nepal.

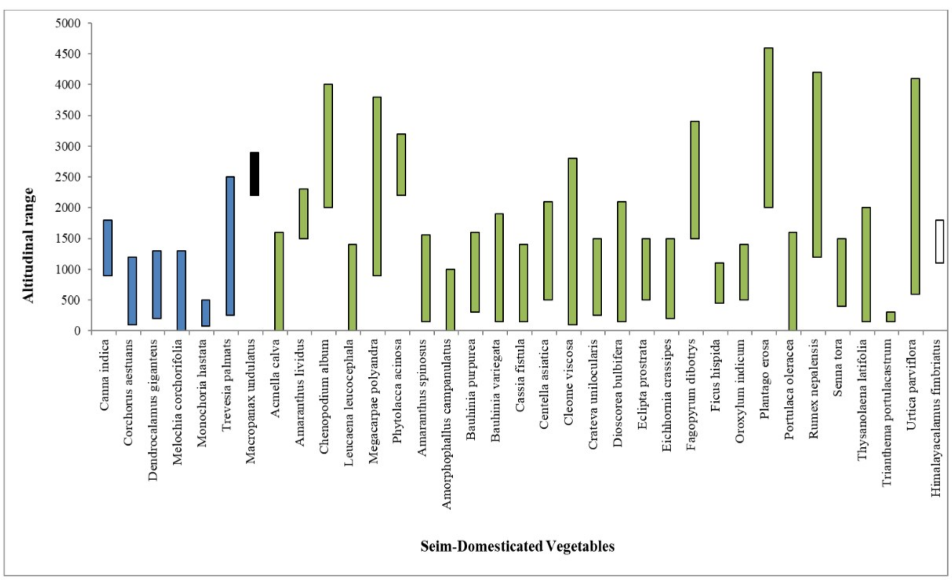

Figure 3.5. Semi-domesticated vegetables distributed in central-east Nepal (blue bars), west-cenral-east Nepal (green bars), and east Nepal (white bar).

Several semi-domesticated vegetable species can be seen growing along the edge of farm lands. Out of 56 species recorded here (see: Table 3.2), 31 species are distributed throughout Nepal (west, central and east) followed by 8 species in central-east Nepal, 7 species in west-central Nepal, 6 species in central Nepal, 2 species in east Nepal, and one in west and east Nepal (Figure 3.5).

As presented above, a total of 143 species of wild vegetables have been recorded (see: Table 3.3). Majority of them (93 species) are distributed throughout Nepal, followed by 21 species in cental-east Nepal and 19 species in west-central Nepal. A total of 4, 2 and 1 species are limited to central, east and west Nepal, respectively. Three species showed distribution in west and east. Among the total reported species, more than 72% species are found in the altitudinal range of 1000–3500 m. Distribution of a few commonly used species are shown in Figure 3.6.

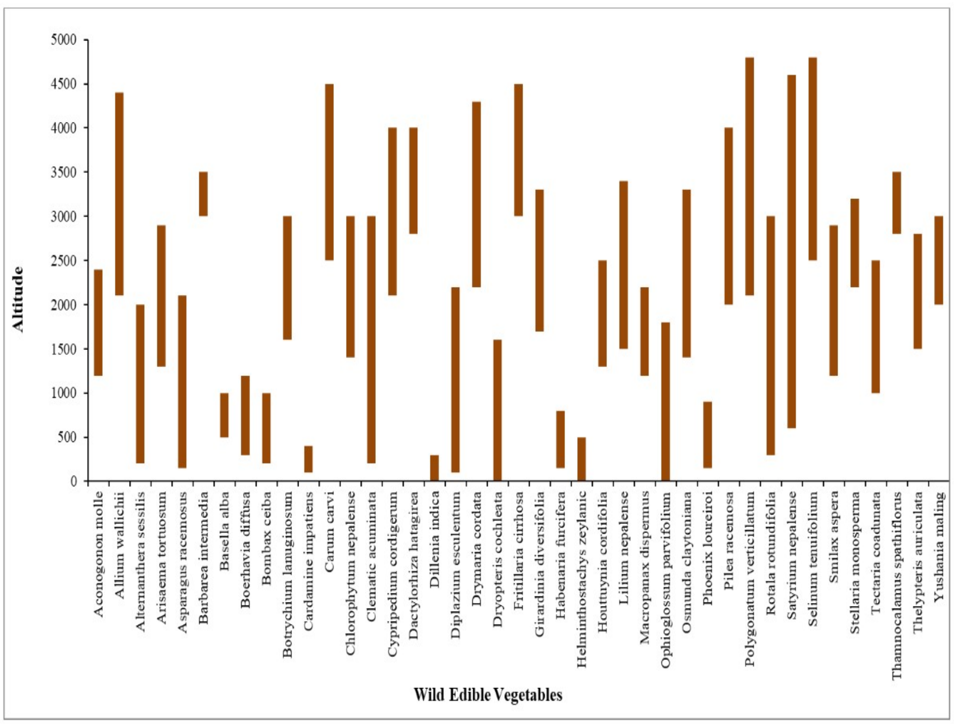

Figure 3.6. Wild vegetables that are distributed throughout (west-central-east) Nepal.

Similarly, out of a total of 148 species of VWRs presented in this paper (see: Table 3.4), 52 species are distributed from west-central to east Nepal followed by 27 species in west to central, and 24 species in central to east Nepal. Species found to be distributed only in west, central and east Nepal are 7, 19 and 16, respectively. Three species were reported from west and east Nepal (Figure 3.7).

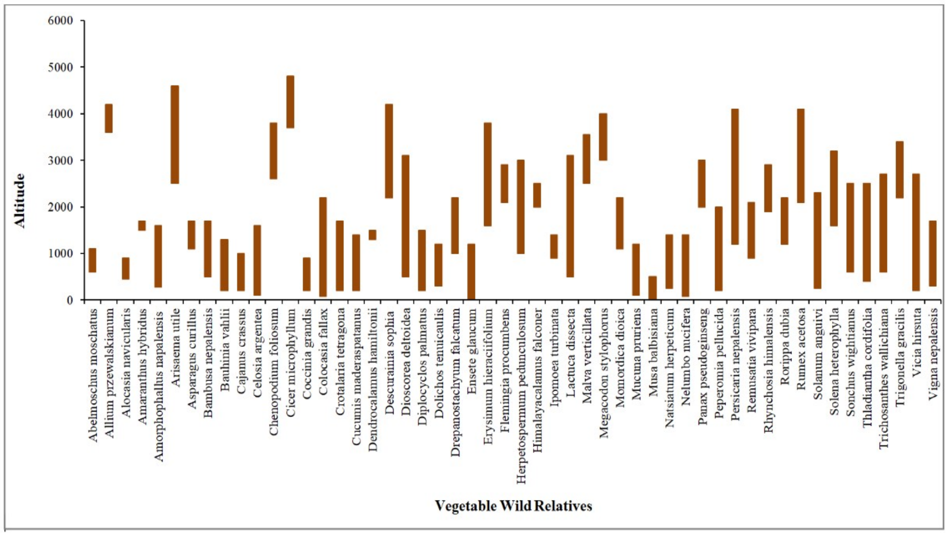

Figure 3.7. Distribution of VWRs in different altitudinal range of Nepal.

Wild Vegetables to Enhance Domesticated Gene Pool

Wild relatives are the major source to improve genetic base of cultivated species. Over thousands of years of artificial selection for developing varieties of vegetables and other crops has led to the estimated loss of over 75% genetic diversity in crops (Singh, 2017). Continuous selections of thousands of years turned wild crops to very high yielding crops; however, they were separated from their wild progenitor very long ago and now loosed greater genetic versatility that helps to survive on much wider range of environment and associated climatic and edaphic stresses. Such qualities can be introduced back to cultivars from wild relatives (see: Table 3.5). Transferring desirable traits to cultivated progenitors sometimes become very challenging (Nair, 2019). Many traits in plants are closely linked with other traits. Among closely linked genes desirable gene sometimes could be linked with undesirable gene e.g. desired genes linked with traits which favour survival in wild rather than in human maintained ecosystem, that such linked gene should be excluded through repeated backcrossing or from genetic manipulations. Incorporation of wild gene diversity to the gene pool of cultivated species for better traits is being in practice in different vegetables. Enhancement of gene pool in cultivated vegetables is important for developing promising cultivars with higher yield and adaptabilities like disease resistance and biotic and abiotic tolerances. Utilization of wild gene pools depends on factors like cross compatibilities, genetic relatedness of available wild relatives, fertility of hybrid progeny and finally local need and availability of adequate financial support for the breeding program (Zhang et al., 2017). Major advances in broadening of the genetic base of vegetables using wild relative is well documented (Jansky, 2010; Kaur et al., 2018; Chittaranjan, 2011; Kunchge et al., 2012; Singh, 2017). Studies on utilizing wild gene pool in the improvement of selective vegetables are given in Table 3.5.

Table 3.5. Enriching traits on cultivated vegetables utilizing wild gene pools.

S. N.	Vegetables	Wild relatives	Quality traits (References)
1	Tomato	*Solanum chilense*, *S. habrochaites*, *S. hirsutum*, *S. pennellii*, *S. pimpinellifolium*	Drought tolerance (Arms et al., 2015), leaf curl virus resistance (De Castro et al., 2007), pest resistance (Mirnezhad et al., 2010), enhance fruit quality (Wu et al., 2015), yield improvement trait (Haque et al., 2015)
2	Potato	*Solanum berthaultii*, *S. bulbocastanum*, *S. chacoense, S. commersonii*, *S. demissum, S. etuberosum, S. ruiz-zeballosii, S. stoloniferum*, *S. tarijense*, *S. torvum*	Late blight resistance (Bradshaw et al., 2006; Śliwka et al., 2012; Song et al., 2003), virus resistance (Duan et al., 2012), moth resistance (Horgan et al., 2007), pathogen resistance (Zuluaga et al., 2015), multiple traits improvement (Jansky, 2011)
3	Brinjal, eggplant	*Solanum linnaeanum*, *S. viarum*	Resistance to *Verticillium* wilt (Liu et al., 2015), resistance to *Leveillula taurica* (Bubici & Cirulli, 2008), resistance to shoot and fruit borer (Pugalendhi et al., 2010), resistance to bacterial wilt (Bainsla et al., 2016)
4	Cucumber	*Cucumis figarei*, *C. hardiwickii*, *C. hystrix*	Cucumber mosaic virus resistance, Downy mildew resistance, gummy stem blight resistance (Chen et al., 2008), green mottle mosaic virus resistance (Pan & More, 1996), resistance to powdery and downy mildew diseases (Pitchaimuthu et al., 2012), yield enhancing (Chen & Zhou, 2011)
5	Oakra	*Abelmoschus caillei*, *A. manihot*, *A. moschatus*, *A. tuberculatus*	Resistance to yellow vein mosaic virus, shoot and fruit borer, and leaf hopper (Gangopadhyay et al., 2017; Rana et al., 1991; Singh et al., 2007)
6	Pigeon pea	*Cajanus* spp.	Cytoplasmic male sterility (Mallikarjuna et al., 2012)
7	Chickpea	*Cicer reticulatum*, *C. echinospermum*	Yield enhancement related traits (Singh & Ocampo, 1997; Singh et al., 2008); resistance to *Ascochyta* blight (Singh et al., 2014), drought tolerance (Toker et al., 2007; Canci & Toker, 2009)
8	Garlic/Onion/Leek/shallots	*Allium roylei*, *A. ursinum*, *A. galanthum;*	Resistance to downy mildew and botrytis leaf blight (Kofoet et al., 1990), novel flavonoids introgressed into garlic (Simon & Jenderek, 2010), develop a male sterile line for shallot and bunching onion (Yamashita et al., 1999)
9	Amaranthus	*Amaranthus hybridus*, *A. Tuberculatus*	Transmission of herbicide resistance gene (Tranel et al., 2002), improving grain harvestability and grain shattering (Baltensperger et al., 1992; Brenner et al.,2010)
10	Asparagus	*Asparagus densiflorus*, *A. kiusianus*, *A. maritimus*	Leaf spot rust resistance, stem blight resistance (Falavigna et al., 2008; Iwato et al., 2014)
11	Lettuce	*Lactuca virosa*	Mirafiori lettuce big vein virus (MLBVV) resistance (Hayes & Ryder, 2007), lettuce aphid resistance (McCreight, 2008), drought resistance (Argyris et al., 2008), introgression of genes from wild (Davey et al., 2007)
12	Bitter gourd	*Momordica balsamina*	Resistance to leaf damage from Aulocophora and other diseases (Njoroge & van Luijk, 2004)

Advance Tools to Use Wild Vegetables (PWV and VWR) for Developing Quality Traits

The potential of wild relatives as a source of quality traits to bring in cultivated species has been realized as early as 20th century. However, the process of incorporating genetic diversity from wild into cultivars requires tremendous amount of time, money and dedicated human resources. In fact, this process involve a list of peoples having expertise on plant taxonomy, phytogeography, genebank curation, genetics, agronomy, pathology, breeding and finally mass farming (Dempewolf et al., 2017). In last two decades, substantial numbers of inbreeding programs have successfully transferred genes of interest from wild relatives to cultivated vegetables. Acceleration in gene transfer and improvement of cultivated crops is attributed to modern biotechnological approaches that have facilitated identifying genes or genomic region controlling complex traits (Varshney et al., 2005; Zhang et al., 2017). Widely used advanced methodologies for gene discovery in WRs are discussed below.

Genomics: Genomic studies conducted using genetic analyzers produce tremendous amount of genomic data that helps in identification and evaluation of germplasm resources, heterosis prediction, linkage and association mapping and marker-assisted breeding (Zhang et al., 2017). High throughput next generation sequencing techniques has accelerated the use of wild crop relatives gene through efficiently identifying Single Neucleotide Polymorphisms (SNPs) associated with important traits. Next generation sequencing techniques offer low cost genotyping of thousands of WRs in a short period building libraries of their SNPs and phenotypic data. Such libraries are useful to validate previously identified genes and discover new genes of valuable agronomic traits through association mapping (Li et al., 2014; Zhang et al., 2017). Similarly, sequencing of heterozygous plants and segregating populations helps in the construction of high resolution linkage maps (Uitdewilligen et al., 2013). High throughput sequencing enables genotyping of all available cultivars and deposits them in public database or gene banks. Breeders can access those genomic data and work on core germplasm representing allelic richness of stored resources for the evaluation of desired traits. This approach of evaluating cultivars is highly effective and efficient in terms of saving both time and money.

Quantification of functional molecules: Unlike genomics, analysis of functional molecules ‘functional omics’ focus on quantification of metabolites, proteins and transcriptomes, which are produced by the plant due to biotic and abiotic stresses. Omic scale technologies i.e. proteomics, transcriptomics and metabolomics approaches quantify regulatory genes, expressed proteins and metabolites candidates underlying important traits present in CWRs. In functional omic analysis, CWRs are grown under certain biotic or abiotic stresses and stress resistant genes thereby expressed in the form of transcriptomes, proteins and metabolites are quantified. Combining phenotypic data with genotypic data helps to fine map known genes and discover novel genes underlying valuable agronomic traits in wild relatives through association mapping (Zhou et al., 2015). Omics databases of different gene or gene family members are proved to be highly effective for novel gene identification within target Quantitative Trait Loci (QTL). Omics approaches helps to dissecting and characterizing complex traits in WRs under diverse treatments like in wild tomato (Fischer et al., 2013). Such methods are successful to transfer identified quality traits related matabolic pathways from WRs into cultivated species (Bleeker et al., 2012; Paudel et al., 2019). Transcriptomics, proteomics and metabolomics are thus powerful tools to study gene functions at different levels; however, these approaches are relatively costly than other available methods. Genome wide metabolomics mapping in CWRs can be useful in plant breeding because wild species mostly subject to different types of stress during evolutionary process than their cultivated descendants. High density SNPs markers developed in Brassica, eggplant, tomato, capsicum (Aflitos et al., 2014; Cericola et al., 2014; Clarke et al., 2016; Taranto et al., 2016) will have tremendous benefits for metabolomics mapping which can be used in future for breeding programs in vegetables.

Gene manipulation: Gene manipulation induces mutation to the existing gene of the crops which includes genome editing, cisgenesis, intragenesis, RNA-dependant DNA methylation, etc. Late blight resistant potatoes were developed through cisgenesis approach (Haverkort et al., 2009). Transfer of desired traits through induced mutation also reduces the time involved using traditional breeding techniques (Zhang et al. 2015).

Global Potential of Nepalese Wild Vegetables

Studies have shown that nutritional values of numerous wild plants are comparable to cultivated ones (Bajracharya, 1980). In these regard, there are tremendous potentialities to tame several of the wild vegetables found in Nepal and diversify their use in a local and global scales (Uprety et al., 2012). Many wild vegetables can be used in breeding programs and develop high yielding, nutritious varieties that can contribute to global food security. As the effect of climate change is likely to increase in various parts of the world, many drought tolerant genes in WRs can be transferred to cultivated species. Therefore, number of wild, semi-domesticated species and local landraces has immense value for develping resistance/ tolerance to drought, diseases and pests in the cultivated species necessary to feed the global population.

Conservation of VWRs and PWV in Nepal

Nepal is considered one of the rich countries in agricultural crops with about 484 indigenous crops and an estimated 30,000 native landraces (Joshi & Upadhaya, 2019). Native crop diversity has supported different aspects of livelihood of local people. Indigenous crops are the source of food, fibre, medicine, organic manure, pesticides, etc. Conservation and sustainable use of agriculture plant genetic resources including their WRs are emphasized following 20 different conservation methods and the same number of actions plans under four different conservation strategies (on-farm, ex-situ, in-situ and use for breeding) (Joshi et al., 2017a, 2017d). Different conservation methods are in practice so that each approach complement to another, which helps to maximize the efforts on sustainable use and conservation of cultivated and wild crop gene pools (Figure 3.8).

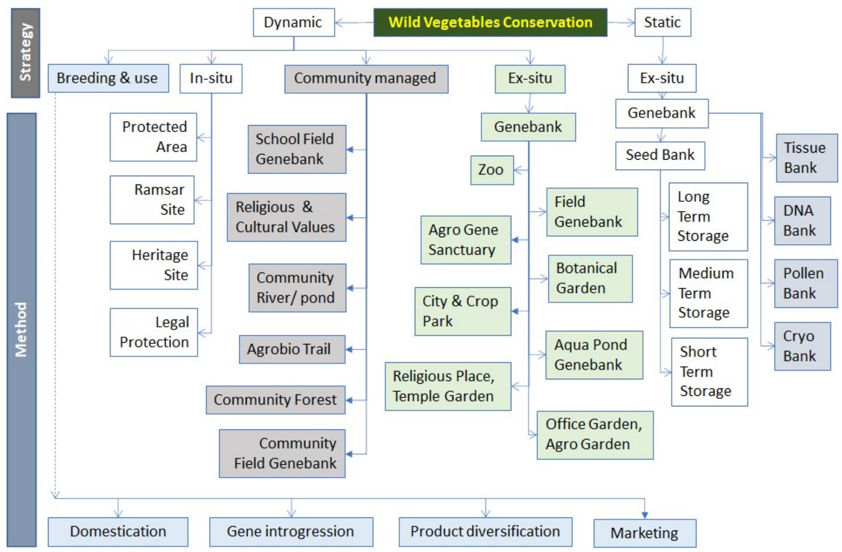

Figure 3.8. Strategies and methods for conservation of wild vegetables in Nepal (Source: Joshi et al 2020a).

In situ Conservation

Crop diversities are being maintained for centuries by local communities on farm and around their surroundings (Joshi et al., 2017a, 2017b). There are 20 protected areas in Nepal. Out of 118 ecosystems of Nepal, about 80 are managed inside protected area systems. Networks of protected areas cover 23.39% of total land area of Nepal (DNPWC, 2018). In addition to protected areas, community managed forest (community forest, religious forest, leasehold forest, private forest, collaborative forest and protected forest) cover more than 18% of total land area (DoFSC, 2018). Therefore, in situ conservation of CWRs and other plant resources are being protected and managed within 43% of total land area. Agro-diversity in Nepal is high in all five levels of agro-biodiversity (agro-ecosystem, species, variety, genotype and allele). Moreover, there are 12 agro-ecosystems in Nepal and all of these agro-ecosystems and their surroundings are rich in semi-domesticated and WRs of crops (Joshi et al., 2020a, 2020b).

Ex situ Conservation

The Agriculture Botany Division, Khumaltar, has started collection and preservation of indigenous crop landraces since 1984 (Joshi, 2017a, 2017b). Division has stored a collection of 10,781 accessions until 2010; however, most of them lost their viability due to lack of proper storage facility (Ghimire et al., 2017). National Agriculture Genetic Resource Centre (NAGRC) holds 11,200 accessions of 130 crops collected from 75 districts, among these accessions 8,410 accessions were collected from 67 districts, after the establishment of genebank in 2010 (Ghimire et al., 2017). Similarly, a total of 2,045 accessions are safely backed up in seven genebanks of different countries. More than 21 countries have conserved around 23,600 Nepalese accessions of different crops (Joshi et al., 2017a).

Conservation of seeds at community level as community seed bank and community field gene bank are another widely adopted practices in Nepal. The first community seed bank was established in Lalitpur district of Nepal. Now there are 120 community seed banks in operation by different organizations at local level. In addition to seed banks, Nepal has adopted other types of ex-situ conservation practices such as Botanical Garden, Cryo Bank, DNA Bank, Field Gene Bank, Farm and Parks, and Tissue Bank for recalcitrant seeds and vegetatively propagated crops. Farmers managed household and community seed banks, and gene banks are another effective method of on-farm conservation of landraces in Nepal.

Conservation through Uses

Conservation of several domesticated, semi-domesticated and wild vegetable species is happening traditionally by farming communities in the forest and agro-ecosystems. On farm conservation is traditionally practiced as dynamic conservation. In this technique, farming community manages diverse set of vegetable populations in agro-ecosystem and store in community gene bank and field gene bank. Seed networks are also very effective approach of conservation in the farming communities of Nepal. Wild and semi-domesticated vegetables are conserved in community forests, culturally and religious important areas and along the periphery and margins of farm lands. Sustainable collection methods are adopted while harvesting seasonal vegetables from natural vegetations.

Red Zoning and Red Listing of VWR and PWV

IUCN Red List is an important tool that helps to assess the conservation status of species, which then complements the setting of conservation priorities to that species. CWRs are also included on the Red List by IUCN. IUCN red listing further helps to scientifically access and communicate the conservation status of crop WRs of certain area and or region. IUCN conservation assessment has been done for animals and economically important medicinal and high value plants in Nepal (Jnawali et al., 2011; Shrestha & Joshi, 1996). Joshi et al. (2004) has emphasized the importance of red listing agriculture crop species, landraces and varieties in Nepal, and they have also proposed a slightly modified version of assessment criteria, which are appropriate for agricultural crop species. Following Joshi et al. (2004) red listing of crop landraces has been done and red list groups are identified for some crops as common, vulnerable, endangered, extinct and not evaluated. Red list groups are assessed through techniques like survey, distribution and population size analysis (commonly called five cell analysis), trait distribution analysis, red zoning farming areas and collection gap analysis (Joshi et al., 2004; Joshi & Gauchan, 2017). Schematic representations of distribution and population size analysis and trait distribution analysis are given in Figures 3.9 and 3.10. Rescue missions are conducted in different district by National Genebank to collect endangered landraces and to conserve ex-situ. Rescue missions also aware local communities to protect seeds in community seed bank at the same time encourage them to plant regularly so as to restore genetic diversity present in the crop. NAGRC has rescued 34 crop landraces in 2014 and 2016, that includes 13 landraces of vegetables (Joshi & Gauchan, 2017). An additional list of 36 crop landraces and 8 vegetable landraces have also been suggested for germplasm rescue missions (Joshi, 2017a; Joshi et al., 2017c). An exhaustive list of native crop landraces was prepared and red listed from 10 districts severely affected from 7.5 rectscale earthquake that hit central Nepal in 2015. Red listed landraces were assessed as 104 landraces extinct, 26 landraces rare and 73 landraces endangered from earthquake, and an additional 185 landraces endangered due to other associated factors. This comprehensive list comprises 10 types of leguminous vegetables, 10 kinds of cucurbits and 8 different root and tuberous and fruity vegetables. This study was able to collect 921 accessions of 61 crops, which are conserved in National Genebank (Joshi et al., 2017c; Joshi & Gauchan, 2017). Red zonation of agriculture areas is considered effective approach in Nepal to identify vulnerable and endangered landraces. Endangered and vulnerable native landraces are collected through collection visits, requesting relevant farmers to collect, by organizing germplasm diversity fairs, participatory seed exchange program among communities and announcement from the mass media to collect endangered landraces from larger areas (Joshi & Gauchan, 2017).

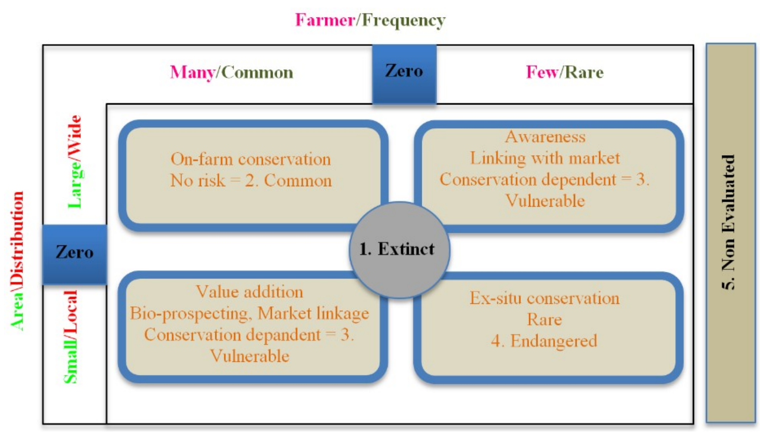

Figure 3.9. Categorization of crop landraces based on the distribution and population size (Source: Joshi & Gauchan, 2017; Joshi 2017a).

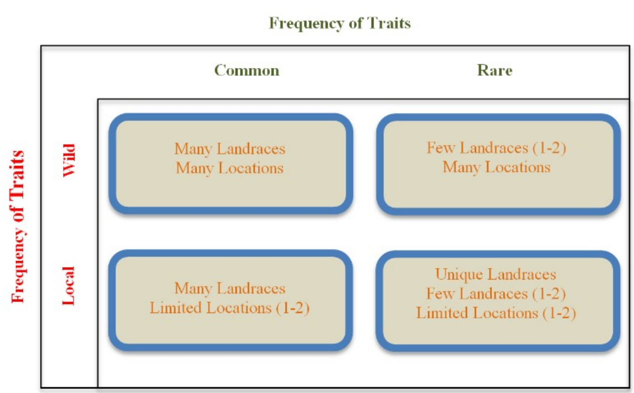

Figure 3.10. Categorrization of crop landraces based on the distribution of traits. (Source: Joshi & Gauchan, 2017; Joshi, 2017a).

In Europe, North America and North Africa, conservation status assessment of CWRs had been done following ICUN red list criterias. In Europe, a total of 572 species of CWRs were assessed. Among the total studied species, maximum 137 species were represented from Brassica complex. Other vegetables species included in the list were: onion, leek, garlic, etc. –115 species, legume forage – 89 species, lettuce – 27 species, asparagus – 19 species, grass pea – 19 species, carrot – 12 species, cultivated beets – 10 species, chicory – 3 species. Out of total assessed vegetable species, 50% species of cultivated beets were threatened followed by 26.3% species of asparagus, 18.2% species of Brassica complex, 11.1% species of lettuce, 7.9% species of legume forage, and 5.2% species of onion, leek, garlic, etc (Bilz et al., 2011). Similarly, 502 CWRs taxa identified as a priority for conservation in North Africa were assessed through IUCN red list from a checklist of 5,780 CWRs taxa. Approximately 119 (2%) taxa were assessed as threatened, 21 taxa as critically endangered, 53 as endangered and 45 as vulnerable. Major vegetables having centre of diversity in Africa viz. Brassica group, onion, garlic, lettuce, safflower, asparagus and peas were included in the study (Lala et al., 2018). Frances et al. (2018) reviewed conservation status and threat assessment for North American CWRs. This study has reviewed two methods Nature Serve and IUCN Red list conservation assessment followed for the conservation assessment or red listing of taxa. A total of 871 native species of China related to crop were enlisted and assessed for their red list status. These species included primarily rice, wheat, soybean, potato, sweet potato, millet and yam, which are predominantly related with food and economic security in China and other parts of the world (Kell et al., 2015).

Threats to Domesticated and Wild Vegetables

a. Climate Change and Stresses

Climate of the world is predicted to be warmer in the future (Hausfather et al., 2020). Climate is one of the key factors that determine the growth, reproduction and dispersal of plants. Vegetables we are farming since long in certain areas would have decreased performance in yield due to more variable rainfall and temperature patterns. In this context, we can either move crops in more favourable areas or modify the genetic makeup of current crops through advance biotechnologies. Due to continuous selections of hundreds of years, domesticated crops, like vegetables, lack adaptabilities needed for tolerance to heat, drought, pest, low manuring and several other stresses (Nair, 2019). Wild plants are evolved to survive in different and difficult climatic and edaphic conditions, including in the presence of pests and diseases. Climate change is projected to increase the spread of pests and diseases and the situation would become even worst in the days ahead. CWRs might have wide range of genetic diversities to combat climate change (Nair, 2019). Even though WRs of cultivated crops might have been evolved with greater genetic versality, they would also face series of unprecedented abiotic stresses due to abrupt climate changes. Furthermore, some CWRs that grow on disturbed habitats were found less resilient to climate change. Endemic or species with narrow range of distribution are especially vulnerable to climate change. Indirect impact of climate change will be changes in biotic interactions including increased competition among species and pressure from pest and diseases (Newton et al., 2008). WRs those having wide range of climatic adaptabilities can migrate to higher altitude and higher latitude but for species with narrow distribution range, shrinkage in their population will be an ultimate fate (Menéndez et al., 2006). Migration of pests and epidemics of diseases are largely dependent on climatic conditions. Shift in climatic patterns contribute to increase pathogen and pest populations. Study conducted by Jarvis et al. (2008) showed that climate change will cause extinction of around 16–22% species of major crops (potato, peas and peanut) and most species lose over 50% of their current range size within 50 years.

b. Habitat Degradation

In addition to climate change, CWRs are facing several other threats like habitat degradation, infrastructure development, pollution, forest fire, over grazing, invasive species enchroachment, logging, expansion of agriculture land into their habitat, forest clearance, desertification and urbanization (Hoyt, 1988). CWRs are more likely to be distributed in marginal forest areas where human activities are relatively more. These habitats are also not adequately conserved by protected areas; therefore, human activities are serious threats to CWRs. Loss of agricultural genetic resources has been estimated to around 40% in the country. In some areas, up to 100% loss of native landraces has also been recorded from many parts of Nepal (Joshi & Gauchan, 2017). Overgrazing, rampant collection of wild resources, deforestation and encroachment of natural forest, grasslands and fallows by moterable roads, settlements, water dams, powerhouses and agriculture lands have fragmented and shrank the population sizes of WRs.

c. Human Activities

Genetic erosion in CWRs and native landraces due to anthropogenic activities is a very serious threat globally including in Nepal. Agriculture land expansion, overgrazing and introduction of invasive species have replaced many CWRs growing along the margin of farmlands. In addition to the human mediated habitat destruction and degradation, continuous replacement of indigenous landraces by modern varieties has led to the extinction of genetically rich native landraces of crops including many vegetables. Commercialization of agriculture and high market demand are also main reasons that have discouraged communities to grow native landraces with wild genotypes (Joshi et al., 2020a). In semi-urbanized area, excessive pressure on natural habitat, and uncontrolled and over harvesting of wild vegetables have been causing irreversible losses of wild germplasms that can withstand several biotic and abiotic stresses, contain high yield and nutritional quality and other desired traits.

Utilization of VWRs and PWVs

Several species of vegetables are regularly consumed in villages and urbanized areas in Nepal. A large part of seasonal nutrition comes from both VWRs and PWVs collected from forest and nearby areas. Selective vegetable species representing *Asparagus*, *Bauhinia*, *Colocasia*, *Dioscorea*, *Dendrocalamus*, etc. have high market value in the town and city areas. Development of proper market plan and promotion of commercial activities through micro-enterprises can have remarkable impacts on sustainable utilization and conservation of semi-wild and wild vegetables of Nepal. Market promotion of seasonal vegetables provides economic opportunities to rural farmers, village based traders and enterprenuers. Wild vegetables are also an important resources used in the treatment of diseaseas and various kinds of health aliments by rural, peri-urban and semi-urban communities of Nepal. Wild vegetables have contributed immensely to enhance food and livelihood security of rural people of Nepal. Beyond these benefits, the use of wild species as donor source of resistance, biotic and abiotic stresses and yield improvement in cultivated crops needs to be intensified (GoN/MoFSC, 2014; Joshi et al., 2020b; Neupane, 1999).

Conclusion

Vegetables in general and their WRs are not considered cereal commodities; therefore, they get less attention. For nutrition and health reasons, these foods should get equal emphasis with other cereals. Because of high genetic values of WRs in the development of novel cultivar, there is urgency for their conservation. Conservation of WRs and wild edibles is even more urgent in the mounting scenario of biodiversity loss due to climate change and anthropogenic activities in their natural habitats. Nepal has adopted four different methods of conservation viz. on-farm, in-situ, ex-situ and conservation plant breeding. Conservation of wild vegetables (both VWRs and PWVs) can be possible only after getting information about their distribution and population status. Detailed maps that show distribution of vegetable WRs with their density and diversity are very helpful to conservationists and policy makers for prioritization of collection and conservation activities. Such information is crucial to plant breeders in the development of novel varieties. Moreover, germplasm rescue activities would become effective, if detailed maps of WRs are in place.

This paper has presented a revised list of wild and semi-wild vegetables including relatives of domesticated vegetables distributed along different climatic zones and ecosystems of Nepal. Further studies and inventories are necessary and those should be made in a systematic manner covering each municipalities/rural municipalities at districts and provincial levels. Indiscriminate use and over exploitation of wild vegetables should be controlled immediately. Inventory of vegetables WRs can be started in different phases based on the priorities set for different vegetable types like leafy, fruity, stem, roots and tuberous, and legumenous, etc. Guidelines for inventory and prioritizing species would depend on availability of technical, physical and skilled manpower in the country. Intensive, rigorous and regular organization of collection trips should be undertaken considering species and places where there are critical collection gaps and includes under red zones. Conservation efforts should be focused on inventory and collection of primary gene pools in the initial stage and later on secondary and tertiary gene pools can be managed subsequently. Although National Gene Bank has already collected and stored WRs of few vegetables; systematic collection and priority settings for collecting more species should be based on their overall significance. In addition to some important traits potentially present in certain species of WRs giving higher weightage to overall genetic variations, and adaptive value should be valued during the conservation of each wild gene pools.

Safe guarding WRs in their natural habitats warrants genetic variations and evolutionary processes, but seed conservation in national and local level gene banks and seed banks are also very successful approaches in Nepal. However, different methods of conservation plant breeding need to be implemented extensively in different agro- and eco- climatic zones of the country. In this context, there is an increasing need of collaboration and co-operations among plant breeders, ecologist, botanist and population geneticists for the long term conservation and sustainable utilization of WRs and indigenous landraces of vegetables.

Along with the inventory and collection of WRs, their adaptive ability to different biotic and abiotic stresses including enhanced productivity is necessary to be evaluated and documented. Advanced biotechnological tools available thus far are largely useful and effective to exploit wild germplasm for incorporating desired traits in cultivated vegetables. The local, provincial and central governments should implement national conservation actions devised by NAGRC with high priority. Such programmes entail international supports and cooperation to assure long term survival of indigenous landraces and wild germplasm of Nepal which eventually will strengthen and enhance our capacity to tackle increasing challenge of food security and malnutrition prevalent in the national, regional and global scale.

Abbreviations: CWRs = Crop Wild Relatives; FAO = Food and Agriculture Organization; IUCN = International Union for Conservation of Nature; NAGRC = National Agriculture Genetic Resource Centre; PWV = Primary Wild Vegetables; VWRs = Vegetable Wild Relatives; WRs = Wild Relatives.

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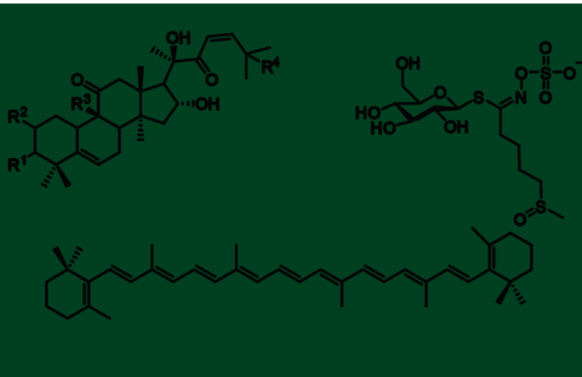

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