Conservation and Utilization of Agricultural Plant Genetic Resources in Nepal

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Minor Fruits in Nepal: Utilization and Conservation Efforts

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ABSTRACT

Varied topography and diverse micro-climatic conditions of Nepal allow cultivation of all types of fruit species ranging from tropical to subtropical to temperate. More than 100 indigenous fruit and nut species have been reported in Nepal. This diversity is rapidly declining as farmers grow selected varieties of few fruits such as banana, mango, litchi, apple, and mandarin orange which are more productive and marketable. These fruits are cultivated at large scale and are commercially available throughout the country, whereas, fruits such as kafal (*Myrica esculenta* Buch.-Ham. ex D.Don), lapsi (Nepalese Hog Plum, *Choerospondias axillaries* (Roxb.) B.L.Burtt & A.W.Hill), amala (*Emblica officinalis* Gaertn.) harvested from forest are sold in local markets which generate a considerable amount of income to the vulnerable communities by selling them at a good price. Other fruits like pummelo (*Citrus maxima* (Burm.) Merr.), citron (*Citrus medica* L.) and walnut (*Juglans regia* L.) are used during special rituals such as for Bhaitika in Tihar and are sold during those festival times. Bael (Wood apple, *Aegle marmelos* (L.) Correa) is used by Newari community during the Bael Bibah of their daughters. Similarly, certain fruits like avocado, almond, pear, peach, plum, prunes, berries, persimmon, cherry, strawberry, and nuts are not extensively cultivated in Nepal, and their consumption and trade are limited. Fruits which are not commercially cultivated or not adequately utilized but have great potential for commercialization are referred to as the "minor fruits." Minor fruits are of considerable economic importance in their locality due to their nutritional, medicinal and cultural values. Pharping Naspati (*Pyrus pyrifolia* (Burm.f.) Nakai), a local pear in Nepal has low chilling requirements and hence is adaptable to grow even at lower altitudes. Likewise, several indigenous fruit plants and their wild relatives such as Mayal or Mel (*Pyrus pashia* Buch.-Ham. ex D.Don), Jyaamir (Rough lemon, *Citrus jambhiri* Lush.) and local olive which are resistant to diseases, pests, and climatic adversities have been used as rootstocks for grafting scions of high yielding varieties. We don't have an integrated digital database of the available fruit germplasm collection which is constraining the researchers from maximizing the use of the valuable genetic resources in research and varietal development. There is an urgent need for identification, evaluation, conservation, registration, and protection of the indigenous fruits through *sui generis* system as per the Trade Related Aspects of Intellectual Property Rights (TRIPs) and their promotion to increase cultivation, domestic consumption and export.

Keywords: Backyard, conservation, database, diversity, germplasm, minor fruits

INTRODUCTION

Fruits are an integral part of the Nepalese agriculture, and form prestigious and serene component of culture and tradition. Fruits have been widely used for rituals and cultural purposes since ancient time in the country. Recently, fruit cultivation has been emerging as a commercial enterprise. Nepal is center of the origin for many fruit species and is rich in local fruit germplasm. Several genus, species and cultivars of fruits are found in Nepal. There are no complete records of edible fruits growing in the wild. Geographic situation and topography of Nepal has given rise to diverse climatic conditions that provide required micro-climatic condition to a large biodiversity (Pradhan et al 2016). Tropical fruit species such as mango, jackfruit, litchi, and custard apple are grown in Tarai region while subtropical to warm and cold temperate fruits and nut species grow well in Mid Hill and High Hill of Nepal. Gotame et al (2014) reported 107 indigenous fruit and nut species in Nepal. At least 45 species belonging to 37 genera are reported as wild edible fruits (Kaini 1994). These fruits are consumed fresh, pickled, roasted or preserved in various forms (Shrestha 1998). Kafal, amala, lapsi, aiselu, katus fruits harvested from the forests are sold in local markets by the local people at a good price. Similarly, the local peach, pear, plum, walnut, citron, nibuwa (Hill lemon), pummelo, etc are grown in scattered locations and mainly sold in the local markets. These fruit species and their wild relatives can be used in breeding programs to improve fruit varieties to suit the local environment (Regmi and Shrestha 2005). Commercial cultivation of fruits in Nepal started only in the 19th century. Department of Agriculture (DoA) was established in 1925. Several temperate fruits were introduced to Balaju and Godawari orchards. Nepal received assistance

from USAID in the 1950s and from India in 1960s. Promotional activities on fruit development started after 1950. Horticulture Development Section under DoA was established in 1955. Within a decade, improved cultivars of apple, cherry, pear, peach, persimmon, plum, etc were introduced in Nepal and grown at Singhadurbar and Kakani farms. Cultivar performance studies and propagation activities were carried out. The Government of Nepal began to emphasis fruit development in the Hills. Fourteen horticulture farms/stations were established during the 1960s at different agro-ecological zones and 10 more were added during the seventies (HDP 1999). Cultivar performance studies, planting material production and distribution, and training of farmers were also started resulting in commercial fruit cultivation in Nepal (Shrestha 1993). Between 1977 and 1980, the Hill Agriculture Development Project assisted by Food and Agriculture Organization (FAO) helped in the cultivation of both deciduous and temperate fruits. Similarly, in 1988/89 Hill Fruit Development Project under the loan assistance of Asian Development Bank and technical assistance of United Nation Development Program (UNDP) was launched in 11 hilly districts of Eastern development region. Focus of these programs was on a few selected fruits that rest of the fruits became minor fruits because of their limited utilization and availability. Cultivation and characterization of the indigenous and wild fruits are not exploited and studied.

Government bodies like National Agricultural Research Council (NARC) and DoA have been introducing a few exotic cultivars of major fruits from abroad. They are well researched and characterized. Similar documentation, characterization, conservation and evaluation of indigenous fruit species are still lacking. There is an urgent need of identification, registration and evaluation of neglected and underutilized fruit species of Nepal which are referred to as the "minor fruits." Aim of this paper is to gather available information related to various aspects of the minor fruit species of Nepal, their existing conservation and utilization practices.

DIVERSITY OF FRUITS IN NEPAL

Nepal is very rich in fruit diversity. Due to diverse eco-climatic conditions in Nepal, there are certain kinds of seasonal fruits available in nature and thus the country has one kind or the other kind of fruit throughout the year. All the seasonal fruits in Nepal are tree-ripened and have a delicious taste, texture, flavor and color. Different types of citrus fruits such as suntala (mandarin orange or tangerine, *Citrus reticulata* Blanco), nibuwa (lemon, *Citrus limon* (L.) Osbeck), mausham (sweet orange, *Citrus sinensis* (L.) Osbeck), bimiro (citron, *Citrus medica* L.), kagati (lime, *Citrus aurantifolia* (Christm.) Swingle), chaaksi (sweet lime, *Citrus limettioides* Yu. Tanaka), bhogate (pummelo, *Citrus grandis* or *Citrus maxima* (Burm.) Merr.), junar (sweet orange, *Citrus sinensis* (L.) Osbeck), muntala (kumquat, *Fortunella japonica* (Thunb.) Swingle), jyaamir (rough lemon, *Citrus jambhiri* Lush.) grow in Mid Hill of Nepal out of which only mandarin, sweet orange and acid lime are commercially cultivated. Many cultivars of lime and lemon are indigenous to Mid Hill of Nepal and are popular even in neighboring countries India and Bhutan. These cultivars perform better than exotic clones due to many desirable economical characters. Likewise, tropical fruits such as aamp (mango), rukh katahar (jackfruit), litchi (lychee), kera (banana), sarifa/ seetaphal (custard apple) and many other varieties are grown in the southern belt of the country. While few varieties have been grown in large scale, there are cultivars of the same species that are either grown just in home gardens or grow as stray fruit. Many fruit trees are not grown in large scale due to their lower yield than the imported improved varieties, but are still preserved for their aromatic or delicious traits.

Numerous indigenous or endemic fruit species flourish in diverse landscape of Nepal. Many wild relatives of domesticated fruit species are found in Nepal (**Table** 1).

Table 1. Wild species of cultivated fruits found in Nepal

English name	Nepali name	Botanical name
Wild apple	Jangali syau	Malus baccata var. himalaica (maxim.) C.K.Schneid.
Wild apricot	Jangali khurpani	Prunus cornuta (Wall. ex. Royle) Steud.
Wild banana	Jangali kera	Musa nepalensis Wall.
Wild cherry	Paiyun	Prunus nepalensis Hook.f.
Wild grape	Jangali angur	Vitis lanata Roxb.
Wild mango	Jangali aamp	Mangifera sylvatica Roxb.
Wild pear	Jangali naspati	Pyrus pashia Buch.-Ham. ex D.Don
Wild strawberry	Bhui aiselu	Duchesnea indica (Jacks.) Focke

CLASSIFICATION OF FRUITS

Exact classification of fruits is a challenging task as these are highly diverse commodities which have different centers of origin. A broad classification of the entire fruit germplasm available in the country is proposed in this article (**Figure** 1).

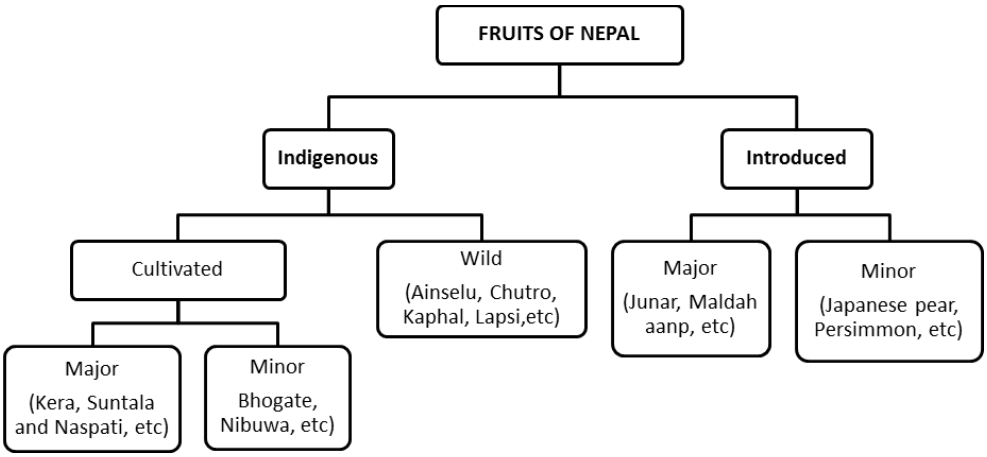

Figure 1. Classification of fruit germplasm in Nepal.

Depending on the scale of cultivation, consumption, and marketing; domesticated fruits in Nepal can be broadly divided into two categories: major fruits and minor fruits.

Major Fruits

Major fruits cultivated commercially in large areas include apple (*Malus pumila* Mill.) in High Hill from 1800 to 2800 meter above sea level (masl) of Jumla, Kalikot, Mugu, Mustang, Manang, Solukhumbu (Amgai et al 2015); banana (*Musa* spp.), mango (*Mangifera indica* L.), litchi (*Litchi chinensis* Sonn.), papaya (*Carica papaya* L.), pineapple (*Ananas comosus* (L.) Merr.), water melon (*Citrullus vulgaris* Schrad.) in the southern parts of the country; and citrus fruits mainly suntala (mandarin orange or tangerine, *Citrus reticulata*) and junar (sweet orange, *Citrus sinensis*) in the Mid Hill from east to west. Suntala (**Figure** 2) is Nepal's indigenous citrus fruit whereas junar was introduced in Sindhuli from England during Rana regime which has been well adapted and performing well (DB Thapa 2017, personal communication) in Sindhuli and Ramechhap areas. Similarly, Pharping pear is popular among farmers in Kathmandu valley and is exported to India. It is high yielding with large fruit size and long storage life. Local limes of Tehrathum district are large in size and rich in juice content. It can be cultivated up to the elevation of about 1,500 masl. Local banana varieties, namely `Malbhog' and `Siukera', have higher market price. The `Malbhog' variety has good flavor and sweet taste when ripened, and is considered healthy to consume even for the sick people. Grapes (*Vitis labrusca* L.) and pomegranate (*Punica granatum* L.) are popularly consumed all through the year but are cultivated only in few districts of Nepal. These fruits are consumed throughout the country and their demands remain largely unfulfilled from the domestic production. Therefore, we still need to expand area of cultivation and practice good orchard management technologies as well as develop high yielding improved varieties to increase the production of major fruits as well.

Figure 2. Banana, mango, mandarin orange, lychee (or litchi), grapes and pomegranate are some of the major fruits of Nepal which are widely consumed throughout the country and are commercially cultivated.

Minor Fruits

Minor fruits are those which are important locally or regionally thus are cultivated in limited amount of land and sold during their maturity season. Popular minor fruits of Nepal cultivated in scattered areas within the warm temperate regions of Nepal include local peach, plum, persimmon, pear (**Figure** 3), and apricot. Similarly, some citrus fruits like pummelo, grapefruit, kumquat, nibuwa, chaaksi are grown in limited areas in Mid Hill of Nepal. Katus (local chestnut) are collected from forest during October/ November and are roasted to consume as popular afternoon snacks in the hilly areas, however a few improved Japanese cultivars are grown in horticultural farms of the nation. Botanical (scientific) names of these fruits are provided in **Table** 1.

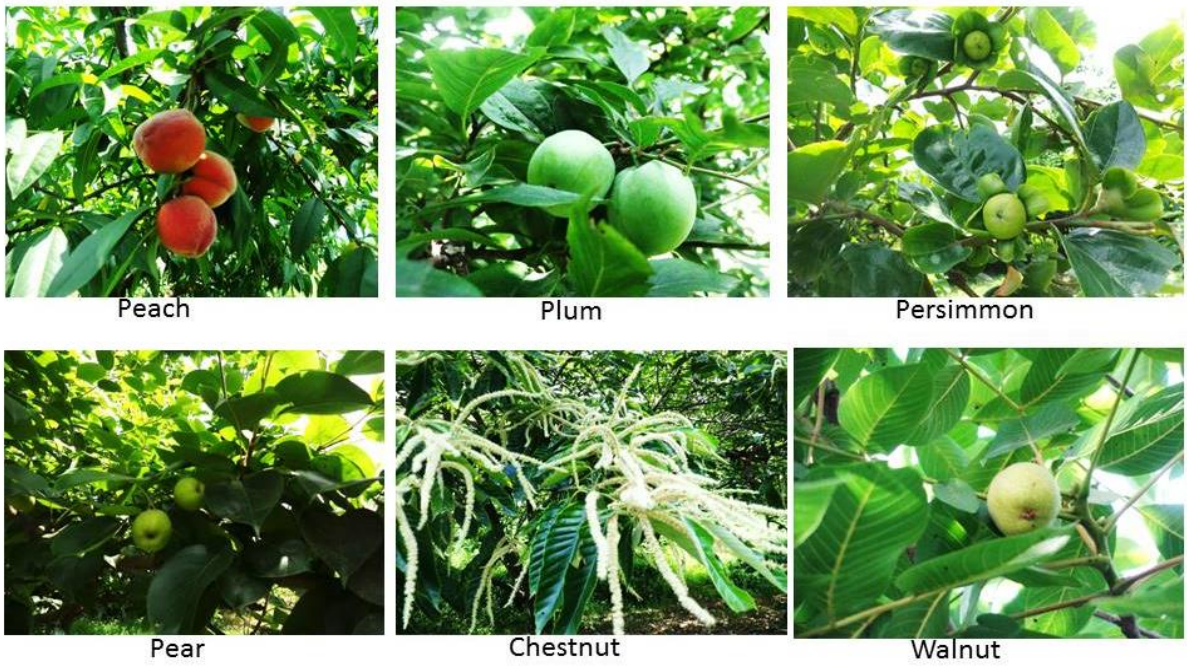

Figure 3. Representative minor fruits of Nepal. These fruits have scope for wider cultivation and trade.

Major Fruit in other Countries but Minor in Nepal

Avocado, almond, cashew, chestnut, custard apple, cherries, hazelnut, kiwi, macadamia nut, mangostein, pecan nut, persimmon, pummelo, sapota, strawberry (**Figure** 4), walnut are major fruits in international market. They are not extensively grown at a commercial scale in Nepal. Kiwi and avocado are emerging fruits which are now considered by many farmers to go for a commercial plantation. Nuts have high nutritional and economical value. They can be stored as dry nuts for a long time. Climate of Mid and High Hills of Nepal is suitable for macadamianut, hazelnut and chestnut cultivation. Avocado (*Persea Americana* Mill.) and strawberry (*Fragaria x ananassa* (Duchesne ex Weston) Duchesne ex Rozier) are considered to be very good fruits for heart health, therefore increasing their production would provide good nutrition to people. Commercial cultivation of such nutritionally demanded fruits will provide good income to the growers.

Figure 4. Representative major fruits in the international market but are minor fruits in Nepal.

Figure 5. Green fruits of Padel, a wild fruit that grows in the Mid Hill of Nepal is slowly disappearing. It needs to be conserved and utilized.

Wild Fruits of Nepal

There are indefinite numbers of indigenous wild fruits in Nepal which remain as unresearched thus underutilized fruit germplasm of the country. Ainselu (*Rubus ellipticus* Sm.), commonly known as the golden Himalayan raspberry or yellow Himalayan raspberry (**Figure** 6) grows in Nepal as well as in China, India, Indo-China region and the Philippines. No research or molecular verification has been carried out to study the origin and distribution of this Asian thorny shrub species. There are unverified reports that roots of aiselu contain nodules, which fix nitrogen. If this could be confirmed by further study and research, such trait could be widely used to reclaim the marginalized and degraded lands.

Similarly, fruits of kafal, katus (*Castanea indica* Roxb. ex Lindl.), jamun (*Syzygium cumini* (L.) Skeels), and kyamuna (*Cleistocalyx operculatus* (Roxb.) Merr. & L.M.Perry) which grow in jungles play a significant role in supplying nutrition, particularly to poor and marginalized people in Mid Hill and High Hill. In addition to the ripened fruits, these plants are chief sources of fodder, fire wood and timber for the local community. Lapsi (*Choerospondias axillaris* (Roxb.) B.L.Burtt & A.W.Hill and bael (*Aegle marmelos* (L.) Correa) fruits are unique to

Nepal. Local people of Kathmandu, Bhaktapur and Kavre make candies using lapsi fruit which are very popular. Amala, lapsi, and tamarind candies and pickles are popular among the Nepalese people. Commercially grown but in small scale, the bael fruit juice is bottled and marketed as *marmelous* (the name derived from bael's Latin name, *Aegle marmelos*) by some private companies. People drink bael fruit juice for health benefits.

Figure 6. Ainselu, bael, lapsi and mel or mayal are some of the popular wild fruits of Nepal that are seasonally collected by local people.

Rough lemon (*Citrus jambhiri* Lush.) is a citrus hybrid from a cross between citron and lemon. Its traits are similar to mandarin orange. Rough lemon is a cold-hardy citrus and can grow into a large tree. There are several cultivars of rough lemon in farmers' fields. Shrubs are often grown as biological fences. They can be grown around national parks, botanical gardens as eco-friendly fences. They are also effective to reclaim erosion prone hills to prevent soil erosion. Kafal, kali angeri, tindu, bhalayo, padel (**Figure** 5), amaro, phalat, jamun, badahar, archal, local bayer etc are favorite fruits among Nepalese children of rural areas of Mid Hill. The chiuri tree (*Madhuca butyracea* (Roxb.) J.F.Macbr.), a native to Nepal grows mainly in the sub-Himalayan tracts on steep slopes, ravines and cliffs at an altitude of 400 to 1400 masl. Chepang communities process plant fat from chiuri fruit seeds. Another important wild fruit with high potential is chutro (*Berberis asiatica* Roxb. Ex. Dc.), a shrub with many historical uses in Nepal (Komal et al 2011). It has a potential to be promoted internationally due to high quality wine making fruits.

Most of these indigenous fruits are in wild state and some are conserved by the people for their specific consumption. They mostly grow into large trees and there are no recommended practices of training and pruning of these trees and shrubs. Nepal has good quality walnut, prunes, pear, mel, bael, chestnut, citron, figs, olive, etc. Unfortunately, we import these fruits to meet the public demand. It shows an unlimited potential of these fruits in Nepal.

Table 2. Summary of different types of indigenous and minor fruits of Nepal

English name	Nepali name	Botanical name	Utilization	Conservation practices	Remarks
	Ainselu	Rubus ellipticus Sm. Rubus obcordatus (Franch.) Thuan	Fresh fruits consumed by humans and birds	Grown in forests, borders to control soil erosion	Could be promoted as biological fencing with proper maintenance

English name	Nepali name	Botanical name	Utilization	Conservation practices	Remarks
	Angeri, Kali chulesi or kali angeri	Osbeckia nepalensis Hook. f.	Fruits, stems with leaves used as fodder	Grows in the forest, terraces and fallow lands	Sources of anti-oxidants and ink
	Archal	Aporosa octandra (Buch.-Ham. ex D. Don) Vickery	Fruits, stems as fodder	Grows in upland terraces	Should be conserved
	Bayar	Ziziphus jujuba Mill.	Fresh fruit and dried fruit	Grows in the forest	Could be used as biological fence and harvest fruits
	Hade Bayar	Ziziphus incurva Roxb.	Fruits	Grows in the forest	Could be used as biological fence to harvest more fruits
	Satibayar	Rhus parviflora Roxb.	Fruits	Grows in the forest	Could be used as biological fence to harvest more fruits
	Ban timilo	Ficus foveolata (Wall. ex Miq.) Miq.	Fruits	Grows in the forest	Needs conservation
	Chutro	Berberis asiatica Roxb. ex DC. *Berberis sp.*	Fruits	Grows at an elevation between 2000 and 2500 masl	Good for making wine
	Ghumauro-kanda	Polygonum perfoliatum L.	Fruits	Grows in forest	Needs conservation
	Harro	Terminalia chebula Retz.	Fruits have high medicinal value	Grows in forest and in uplands	Potential to commercialize for ayurvedic medicine
	Kusum	Schleichera oleosa (Lour.) Oken	Fruits	Found in wild	Should be conserved
	Barro	Terminalia bellirica (Gaertn.) Roxb.	Fruits (used for stomach disorders and cough).	Grown in uplands	Could be commercially cultivated to make medicines
	Bhakiamilo	Rhus javanica L.	Ripe fruits are used as appetizer	Grows in forest	In situ conservation needed
	Jamuna	Syzygium cumini (L.) Skeels	Fruits	Grows in forest	Fruits and also used for medicinal purpose.
Apricot	Khurpani	Prunus armeniaca L.	Fresh and dried fruits	Grown in home gardens and orchards	Could expand its cultivation. Rich source of anti-oxidants, minerals and vitamins
Bassia	Chiuri	Bassia/Madhuca/ Diploknema butyracea (Roxb.) H.J.Lam	Fruit is eaten fresh and ghee is extracted from seeds	Grows and conserved in the forest	High potential for commercial farming
Bay berry	Kafal	Myrica esculenta Buch.-Ham. ex D. Don	Fruits	Grows in forest	Could be cultivated in fallow lands
Chestnut	Katus	Castanopsis hystrix Hook. f. & Thomson ex A. DC., Castanopsis indica (Roxb. ex Lindl.) A.D.C., Castanea crenata	Fruits (Roasted or as such)	Local landraces grow in forest, some Japanese and Chinese varieties are grown in horticultural centers	Potential to expand its cultivation

English name	Nepali name	Botanical name	Utilization	Conservation practices	Remarks
		Siebold & Zucc.			
Citron	Bimiro	Citrus medica L.	Fresh fruit used during Tihar	Grown in homestead gardens	Needs conservation
Coffee plum	Padel	Flacourtia jangomas (Lour.) Raeusch.	Fruits, leaves and twigs are used as fodder	Grows in forest and marginal lands	Due to large thorns at the base of the tree, farmers are clearing the bushes. Needs conservation
Custard apple	Seetaphal or Sarifaa	Annona squamosal L.	Fruits	Grown in homestead gardens or backyard	Could be commercially cultivated
Fig	Nivaro	Ficus carica L.	Fruits and fodder	Grown in uplands	Needs conservation
Gooseberry	Amala	Phyllanthus emblica L., Emblica officinalis Gaertn.	Fruits are rich source of vitamin C, medicines, pickles and candies	Allowed to grow in forests and grass lands	Has scope for commercial farming
Grapefruit	Sankhatro	Citrus paradisi Macfad.	Fruits	Grown in homestead gardens or orchards	Potential for commercialization
Guava	Amba, Belauti	Psidium guajava L.	Fruits, Medicine	Local varieties grown in homestead, improved varieties in orchards	Scope to increase production exists
Himalayan wild cherry	Painyu	Prunus cerasoides Buch.-Ham. ex D. Don	Fruits	Grows in forest	In situ conservation needed
Hog-plum	Amaro	Spondias pinnata (L. F.) Kurz., Spondias mangifera Willd., Spondias acuminata Roxb.	Fruits, Medicine	Grows in forest	Needs conservation
Jackfruit	Rukh katahar	Artocarpus heterophyllus Lam.	Fruits (both immature and ripe)	Grown in homestead gardens or orchards	Potential for commercialization
Kiwifruit, Chinese gooseberry	Thekifal	Actinidia deliciosa (A.Chev.) C.F.Liang & A.R.Ferguson	Fruits	Few modern varieties have been grown commercially	Scope to further expand cultivation area to increase production
Kumquat	Muntala	Fortunella japonica (Thunb.) Swingle	Fruits	Grown in homestead gardens and in containers in terraces.	Being a small tree and maturity time later than mandarin orange, it could be cultivated to extend availability in the market
Lemon	Nibuwa	Citrus limon (L.) Osbeck	Fruit juice used for making vinegar	Grown in homestead gardens or backyard	Could be commercially cultivated to extract juice
Local/wild strawberry	Bhuinkaphal	Fragaria vesca L.	Fruits	Grows in upland farms	Could be used as cover plant

English name	Nepali name	Botanical name	Utilization	Conservation practices	Remarks
Loquat	Laukaat	Eriobotrya japonica (Thunb.) Lindl.	Ripened fruits	Grown in homestead gardens	Scope to further expand cultivation area
Monkey Jack	Badahar	Artocarpus lakoocha Roxb.	Fodder, fire wood, timber and fruit	Grown on bunds of upland areas and grasslands	Could be planted in upland areas as people leave it barren
Mulberry	Kimbu	Morus alba L., Morus nigra L., Morus rubra L.	Fruits as table purposes, leaves and twigs are used as fodder	Grown in marginal lands as fodder plant, extensively cultivated for silkworm rearing	Postharvest and processing technology is necessary. Used in silk worm rearing for silk production.
Mulberry	Kimbu	Morus alba L., Morus serrata Roxb., Morus indica L.	-Fruits are eaten when ripened - Leaves are used for feeding silkworms	Grown in homestead gardens or backyard	Could be commercially cultivated
Nepalese fire thorn	Ghangaroo	Pyracantha crenulata (Roxb. ex D.Don) M.Roem.	Fruits	Grows in wild	Should be conserved
Nepalese hog plum	Lapsi	Choerospondias axillaris (Roxb.) B.L.Burtt & A.W.Hill	Fruits are used to make pickles and candies	Grows in forest and grown in homestead gardens	Could be cultivated in fallow lands. A rich source of vitamin C
Peach	Aaru	Prunus persica L. Batsch	Ripened fruits	Grown in backyards and small orchards	Has scope for commercial farming
Pear	Naspati	Pyrus pyrifolia (Burm.f.) Nakai, Pyrus communis L.	Fruits	Grown commercially but in small scale	Could be cultivated at larger scales in Mid and High Hills
Persimmon	Haluwabed	Diospyros kaki L.f.	Local varieties less popular due to astringency but tasty when fully ripen. Important during Tihar festival.	Grown in home gardens	Dhaula and Teku are promising Nepalese varieties
Plum	Aaru bakhada	Prunus domestica L.	Ripened fruits	Grown in orchards	Has scope for commercial farming
Pummelo	Bhogate	Citrus maxima (Burm.) Merr.	Fruit used during festivals and also during sunny days	Grown in homestead gardens	Possibility of commercial cultivation of improved varieties for fresh fruit and juice
Rose apple	Gulab-Jamun	Syzygium jambos (L.) Alston	Fruits	Grows in wild	Needs conservation and commercialization
Seabuckthorn	Dale chuk	Hippophae tibetana Schltdl.	Squash, jam, wine syrup prepared from the fruits	Grows in High Hills	God commercial potential
Sweet lime	Chaaksi	Citrus limettioides Yu. Tanaka	Fresh fruit	Grown in homestead gardens	Needs conservation and promotion
Tamarind	Emli	Tamarindus indica	Fruits used to	Grows in wild	Needs conservation,

English name	Nepali name	Botanical name	Utilization	Conservation practices	Remarks
		L.	prepare candies and as souring agent		rich source of vitamins
Thin shelled walnut	Dante Okhar	Juglans regia L.	Fruits	Conserved in forest and personal lands	Has religious importance, rich in unsaturated fatty acids.
Tree fig	Khanayo	Ficus semicordata Buch.-Ham. ex Sm., Ficus cunia Buch.-Ham. ex Roxb.	Ripened fruits	Grown on upland farms	Should be conserved
Wild cucumber	Golkankri	Solena heterophylla Lour.	Fruits	Grows in forest	Fruits and also used for medicinal purpose
Wild pear	Mel or mayal	Pyrus pashia Buch.-Ham. ex D.Don	Fruits	Allowed to grow in the wild and in farms	Used as rootstock for grafting
Wild Persimonn	Tindu	Diospyros malabarica (Desr.) Kostel.	Fruits	Grows in forest and marginal lands	Needs conservation
Wood apple	Bael	Aegle marmelos (L.) Correa	Fruit and leaves are used for religious offerings, and medicine for stomach problems.	Allowed to grow in forests and some households plant in the back yard	Possibility of commercial cultivation of improved varieties for fresh juice and processing

Exotic Fruits with Commercial Potential in Nepal

There are various tropical and subtropical exotic fruits that can be grown in different geographical regions of Nepal. Some of these fruits that can fetch good price in the market but are yet to be introduced for commercial cultivation in Nepal include rambutan (*Nephelium lappaceum* L.), longan (*Dimocarpus longan* Lour.), calamansi (*Citrofortunella microcarpa* (Bunge) Wijnands), durian (*Durio zibethinus* L.), dragon fruit (*Hylocereus undatus* (Haw.) Britton & Rose), lanzones (*Lansium domesticum* Correa) and passion fruit (*Passiflora edulis* Sims). Similarly, high value nuts such as pistachio (*Pistacia vera* L.), cashew (*Anacardium occidantale* L.), and almond (*Prunus dulcis* (Mill.) D.A.Webb) could be commercially cultivated to meet the domestic demand and export high quality nuts abroad.

UTILIZATION OF MINOR FRUITS

Indigenous and minor fruits are utilized in several ways in the rural households. Lapsi, amala, tamarind etc are popularly used to prepare pickles and candies. They are rich sources of vitamins and minerals. They are preserved for long term and used throughout the year. Small quantities of candy and pickles are imported by Nepalese communities abroad. Kafal, aiselu, bael, jamuna are eaten or sold fresh as they ripen. Such fruits contribute substantially to the people's diet.

Bael fruit is used widely by the Newar community to perform "Bael Bibah" of young girls when they are five to nine years old. Leaves of bael tree are offered to Shiva temples as his favorite leaves. Due to medicinal properties of bael, its juice is becoming popular. People drink bael leaf to cure diabetes (Joshi and Joshi 2011). Chiuri fruit is consumed fresh and its seeds are processed to produce ghee, the latter is popular among the Chepang community. Citron and pummelo are used during "Tihar and Chhat" and are also consumed fresh. Apart from them, Newar communities use katus, hadebayer, satibayer, persimmon, walnuts during the Tihar festival. While, in Brahman-Chetri communities, walnut is broken during "Bhaitika" by sisters to symbolically smash the enemies of their brothers. Due to nutritional value and beneficial health effects of nuts, the demands for different types of nuts are increasing.

Recently, people are increasingly aware of the nutritional values, especially the fruits high in various types of vitamins, minerals, antioxidants and several micro-nutrients. The fruit consumption and demand are sharply increasing. Awareness on balanced diet among the people has further raised the demand of fruit all over the country. Availability of nutritional information and awareness on their organic nature from international sources on various fruits is increasing the consumers search for the minor fruits. Similarly, use of juice during parties and family gatherings is encouraging farmers to grow fruits at larger scale for processing. Consumption of fruits and fruit juice by the sick people has increased the demand of fruit products in and around hospitals. Pomegranate is one such kind of healthy fruit which fetches very high price in the market. Walnuts and other nuts are rich sources of dietary unsaturated fats, proteins, vitamins, minerals and low fatty acid oils which are recommended as healthy fats for heart. Therefore, daily consumption of these nuts is sharply increasing thereby increasing their demand.

Most of the indigenous and underutilized fruits have medicinal properties. The bark of ainselu plant is used in Tibetan medicine, mainly as a renal tonic and an anti-diuretic. Root paste is used as wrapping for the treatment of fractured bone. Ripe fruits are laxative and are used in case of constipation. Paste of young fruits, 10-20 gm at a time, is taken twice or thrice in a day in case of gastritis, as an antacid and to check diarrhea and dysentery (Maity et al 2004). Further research works need to confirm such medicinal and nutritious values of indigenous fruit species of Nepal. There is very little information available regarding varietal performance, multi-location yield trials, and genetic evaluation of the germplasm, appropriate propagation methods and integrated insect and pest management of minor fruits. The use of available diverse fruit germplasm has huge potential for improvement of fruit quality and quantity, extension of harvesting season and widening of cultivation area based on micro-climatic niches of the country. However, detailed research works on fruits in Nepal are few and far behind farmer's commercial needs.

CONSERVATION PRACTICES

Cultural Conservation

The growing fruit trees in the home gardens were practiced in Nepal since time immemorial. These plants help in providing essential nutrition to the family and special care is provided. People take such home produced fruits to their relatives and honorable person as gifts. Most of the minor fruits are grown in the backyard or in the homestead garden for their specific usage. Fruits are considered as sacred foods which are consumed during festivals and while undergoing fast. Public and community orchards in temple compound, in guthi land and areas designated for pilgrimages also harbor local fruits.

Chepangs are known for their immense knowledge on forestry products, their collection and preparation methods. They have special relationship with the chiuri trees as they have custom of giving a chiuri tree as dowry to their daughters during marriage. Hence, it is regarded as a private resource. Chiuri is a source of livelihood to this community. Therefore, it is conserved by Chepang community in Chitwan.

In Nepali culture, fruits play an important role in many festive occasions and religious rituals. They are considered one of the most auspicious foods offered to deities as a part of devotional worship offerings. Hence people grow various fruit species in their home gardens, hedges and curtilages. The Nepalese religious rituals are incomplete without offering some fruits (coconut, banana, bael fruit, and sugarcane) along with flowers to the deities. Different fruits are used for specific religious occasions. Fruits like bananas are considered auspicious during travels and are given to people at the start of their journey. People have a culture of preserving the fruit products in the form of dried fruit chips, fermented fruits, pickles, wines, and chuck amilo (locally prepared vinegar used as souring agent and preservative). Therefore, people conserve fruit trees in their grassland and terraces as well.

Nepal is housing not only healthy and delicious indigenous fruits but some poisonous and deadly fruits and shrubs in its wild forest. Such plants need to be well characterized and marked as such to avoid fatal accidents. Some are toxic to animals, birds and some to humans too. Many fruits are allergic and some give minor to major upsets. The fruits of jangali darim (mountain pomegranate, *Catunaregam spinosa* (Thunb.) Tirveng.) are used in Nepal to kill fish in rivers and ponds (Kulakkattolickal 1989). Their toxins can be used as herbal and eco-friendly pesticides.

In-situ Conservation

Indigenous minor fruits like amala, badahar, bael, kafal, katus (local chestnut), and lapsi are selectively allowed to grow in the public and community forests, along the river banks and in the farmer's grasslands. These are also grown in private home gardens, hedges and bunds of upland fields for fodder, fire wood, medicinal use and timber besides their edible fruits. Wild fruit trees are also protected inside botanical gardens, national parks, community forests and protected areas. Chepang communities conserve chiuri (Aryal et al 2009). Cultivated minor fruit species are conserved in homestead gardens, in community and public places around temples as well as in private orchards where the plant was identified. As mentioned above, some communities require some specific fruits in certain occasions thereby requiring them to conserve them in their localities.

Ex-situ Conservation in Government Farms and Research Centers

National botanical gardens, public and private farms, field genebanks and horticultural research and development centers have conserved many but not all the minor fruit crops. Long life span, long waiting period for first fruiting and large land requirement for cultivation has been the constraints in maintaining a fruit germplasm. A dedicated governmental program on the collection and preservation of fruit species is essential to conserve the available vast diversity of the fruits in the country.

CHALLENGES AND OPPORTUNITIES

Changing human perception, stewardship, food habits, market trends and effect of globalization are some of the major factors leading to low priority to the local crop products (Khanal et al 2014). Many fruits that grow in wild are feared poisonous and some of them are indeed deadly. Many minor, indigenous and wild grown fruits are yet to be named, characterized and tested. Even the same fruit is known by different names in different regions. There is no standard single nomenclature both in Nepali and English for such fruits. For the domesticated minor fruits, there are no standard cultivation and management practices developed. They are grown in marginalized and poor soils due to which their production capacity is less than that of modern cultivars. There is no easy access to technical knowledge and facilities of proper harvest and storage. Many temperate fruits like apricot, peach, plum etc grown in remote areas are hard to transport due to lack of basic transportation facility. As a result, markets and customers of minor fruits are unpredictable. Farmers take fruits like green gooseberry, lapsi, guava, and tangerines to market. If the products taken to the market are not sold instantly or within a day, they are thrown into drain because of the lack of storage, costly transportation and short shelf life. The everyday losses indicate that there is a big potential for fruit processing industries in Nepal which can contribute to commercialization of fruit cultivation that will improve people's health and national economy. To convert minor fruits into major fruits, we need to build technical capacity of the farmers, provide them production and marketing support and appropriate value chain development of the products.

Commercial fruit cultivation will help in beneficial utilization of wasted lands in the hilly areas of the country. It requires less labor force than cereal and vegetable cultivation which is beneficial in this labor scarcity period caused by youth migration. Mechanical fruit farming will attract foreign investment. Fruits will adapt better and have wider scope to combat climate change calamity and these minor fruits can cope well with such phenomena as they are hardier than the introduced germplasm. Moreover, nutritive value analysis of forty edible wild fruits of Nepal showed that most of the wild fruits are comparable to cultivated fruits in nutritive values suggesting that these indigenous wild fruits can be considered for cultivation (Bajracharya 1980).

WAY FORWARD

The use of available diverse fruit germplasm has huge potential for improvement of fruit quality and quantity, extension of harvesting season and widening of cultivation area based on micro-climatic niches of the country. However, research works on fruits in Nepal are few and far between. There is very little information available regarding varietal performance, multi-location yield trials, genetic evaluation of the germplasm, appropriate propagation methods and integrated insect pest management of minor fruits. The major constraints of pomology in Nepal and underutilization of the existing natural diversity are: low priority for fruit research programs consequently poor allocation of annual fiscal resources in the agricultural programs, lack of trained human resources, labor shortages, weak extension system, poor record keeping system and unavailability of adequate technical information. For appropriate utilization and commercialization of different fruit crops, we need to have a thorough research on each of the indigenous germplasm regarding their fruit quality traits, physiological characteristics and genetic characterization. We need skilled manpower to implement research activities rationally for which we need to train our technical and extension human power with modern skills of fruit cultivation, orchard management and modern propagation techniques. There is a huge potential for

commercialization of different fruit species in the country which will not only meet the domestic demand but also promote export resulting into improvement of the farming community's economy. Establishment of aesthetic orchards or fruit parks will conserve the fruits as well as the environment and generate income. There is equally good scope of fruit technology in order to preserve and process fruits.

There is an urgent need to establish an online inventory system for appropriate documentation, characterization, registration and detailed evaluation of indigenous fruit species in Nepal that can be used for improving our existing fruit varieties. Due to rapid increase in the demand of fruits, the use of diverse fruit germplasm has great potential for improvement of fruit quality, extension of harvesting period and expansion in the cultivation area based on suitable micro-climatic niches in Nepal. Due to unethical use and absence of appropriate conservation mechanisms, genetic erosion of natural resources is occurring at an alarming rate. There should be a well-established legal mechanism to protect our indigenous species. These will serve as future crops as the currently grown high yielding varieties will become saturated in their yield potential in coming few decades. The TRIPs agreement has provision of protecting plant varieties either through plant patents or an effective *sui generis* system or a combination of both. Therefore, it is recommended to develop and implement such system as soon as possible to protect our plant varieties, indigenous knowledge and farmer's rights which will motivate local community to preserve these species and grow them commercially.

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