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Biodiversity of neglected and underutilized fruits of Nepal: a review

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ABSTRACT

Varied climatic conditions, topography and different agro-ecological zones of Nepal are directly associated with the biodiversity of neglected and underutilized (N&U) fruits. Those fruits play an important role in food, nutrition as well as the economic security of poor people in rural areas. This review has been conducted to assess the diversity of underutilized fruits. This study showed that there were 88 neglected and underutilized fruits from 32 families existed in the country, out of this the highest number of species comes under Rosaceae (19), followed by Rutaceae (12), Moraceae (10), Anacardiaceae (5) while rest families have less than three species. Introduction of high yielding exotic commercial varieties, changing food habit, mono-cropping trends and climate change are major causes of their gradual declination in Nepal. They have multidimensional uses, many formerly neglected commodities have now become globally significant due to consumers' awareness. All Governmental, non-governmental and private organizations should be involved in fruit research. Research and extension organizations should give emphasis to neglected and underutilized fruit species for diversification, food and nutrition security. This paper provides current status, importance and potential of neglected and underutilized fruits. This review also addresses the prospects of long-term conservation of neglected and underutilized fruit species in Nepal.

Keywords: Biodiversity, food security, neglected and underutilized fruits

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1 Introduction

Nepalese economy is dominated by agriculture (MoALD, 2019) and the contribution of agriculture in the National GDP is 27.6% (MoF, 2018). The contribution of the horticultural crops in agriculture gross domestic products (AGDP) is 38.59%, where vegetable sector shares 20.48%, potato 10.51%, fruits 5.13% and spice crops 2.37% (MoF, 2018). Nepal is divided in to seven agro-ecological zone from tropical (60 masl) to arctic (more than 4500 masl) (MPHD, 1990). These climates ensure the cultivation of diverse biotypes of fruit. Most of the crops don't well adapt above 2700 masl due to low solar radiation and high humidity. Out of 6,500 species of flowering plants, Nepal is rich in wild edible, exotic and cultivated fruit genetic resources (Chalise, 1993). The total number of agro horticultural crops found in Nepal is roughly estimated to be about 400 as species and sub-species (Regmi, 1990). Though Nepal constitutes just 0.1% of the world landmass, it accommodates almost all the important fruits of the world due to its diverse geographic location and physiography (Manandhar et al., 2020). It is believed that Nepal is the original home of many fruit species and is rich in wild and local fruit germplasms. About 107 indigenous fruit and nut species have been reported in Nepal (Gotame

et al., 2014). Forty-five species from thirty seven genera are reported as wild edible fruits (Kaini, 1994). About twenty-five fruits are grown in commercial scale and those fruits are eaten as fresh, pickled and preserved in various forms (Manandhar et al., 2020; Shrestha, 1998). The physiographic situation of Nepal has given rise to diverse climatic conditions and that gave large biodiversity (Pradhan et al., 2016). Seasonal fruits harvested from the forests can be seen in many local markets and make a considerable amount of money by selling them at a good price. Most of the tropical fruit species are grown in the plain area while subtropical to warm and cold temperate fruits and nut species are the best suited in mid-hills and high-hills of Nepal. Neglected and underutilized fruit has multiple uses such as fodder, fuelwood, medicinal, religious, social, timber etc, and these fruit also can be used in breeding programs to improve fruit varieties to suit the local environment (Regmi and Shrestha, 2005). Adhikari (2015) emphasized on the need to promote neglected and underutilized species in international conference. Growing fruit trees in the Kitchen garden was practiced in Nepal since time immemorial but their commercial cultivation started only after the establishment of horticulture institutions in the country during sixties (Shrestha, 1993). Therefore, the use of fruit germplasms has high potential for improvement of fruit quality, extension of harvesting season and widening the adaptation to microclimatic niches in Nepal (Gotame et al., 2014). It is recommended that awareness program is urgent for the preservation of the species (Luitel and Pathak, 2013). In spite of various uses of these wild fruits, the conservation and utilization of such fruits are not properly exploited in a scientific way. Government farms under Nepal Agriculture Research Council (NARC) and Department of Agriculture (DoA) have also been introducing and maintaining exotic varieties from abroad for research and demonstration respectively but the inventory documentation, characterization and evaluation of indigenous fruit species are still lacking. There is an urgent need for identification and evaluation of neglected and underutilized fruit species.

The information regarding the biodiversity of neglected and underutilized fruits in Nepal was collected from previous literatures. For this purpose, 13 journals articles, 10 books/ book chapters, 6 proceeding papers, 11 technical reports, and 3 electronic sites were reviewed. The information was categorized into sub-headings *viz*. importance of neglected fruits, causes of genetic erosion, species diversity and future strategies to conserve this valuable resource. The discussion was made with horticulturists, extension workers, researchers, farmers, lecturers/professors of universities, indigenous communities involved in cultivation and exploration of neglected and underutilized fruit species. The objectives of this study were to gather the available information on neglected and underutilized fruit species along with their importance, prospects and challenges in Nepal.

2 List of N&U fruits in Nepal

Underutilized plant species in the study areas with their scientific name, English name, local name (Nepali name) along with their short description are presented in Table 1. During the present study, information was collected on 88 neglected and underutilized fruit species from 32 families existed in the country. Rosaceae was found to be the most common family with 19 species, similarly Rutaceae (11 species), Moraceae (10 species), Anacardaceae (5 species), Fagaceae, Myrtaceae and Rhamnaceae (3 species in each) and nine families (Annonaceae, Berberidaceae, Combretaceae, Ebenaceae, Mimosaceae, Muaceae, Myricaceae, Phyllanthaceae, Sapindaceae) have two species in each family. There are sixteen families of neglected and underutilized fruit crops; each family consists of single species. These families are Actinidiaceae, Apocynaceae, Bromeliaceae, Caricaceae, Elaeocarpaceae, Elaeagnaceae, Euphorbiaceae, Fabaceae, Guttiferae, Juglandaceae, Lauraceae, Melastomataceae, Oleaceae, Palmaceae, Polygonaceae and Punicaceae. Most of the neglected and underutilized fruit species are used for multipurpose such as fruit, medicine, religious purpose, vegetables, oil extraction and pickles making.

3 Importance of N&U fruits

3.1 Economic importance

Neglected and underutilized fruit species (NUFS) can make an important contribution to the rural and national economy. There is always demand from consumers for new, delicious, nutritious and attractive food products. To satisfy this demand, there is a constant effort to develop products from diverse sources. The potentiality of processed products from some minor fruits in the country is still untapped. Tapping into local knowledge of farmers on such less known or less utilized crops has also been found to play an important role in the identification of such often neglected natural resources for commercialization. These fruits mainly contribute to the well being of thousands of poor farmers by enabling them to participate in markets (Dangol, 2002). Those species can play a crucial role in food security and income generation of the rural poor (Shrestha et al., 2020). Economic characters of some indigenous fruit species like sweet orange (Junar), Asian sand pear (Pharping Local), mandarin orange (Dhankuta Local), acid lime (Kagati Lime) are superior as compared to some exotic varieties (Gotame et al., 2014). The price of Timur

(*Zanthoxylum armatum*) has continuously increased from NRs 9 kg^{-1} in 1985 to NRs 22 kg^{-1} in 1993 and NRs 45 kg^{-1} in 1995. This increase was much higher than the rate of inflation (Hertog and Wiersum, 2000).

3.2 Ecological importance

Neglected and underutilized fruits require low input and can produce desirable yield (Shava, 2005), which have a less negative impact on ecology and environment. They have deep root system, which prevent landslides and soil erosion in hilly region of Nepal. Especially in remote areas and marginal land of country, there is plenty of scope for cultivating underutilized plant species and exploiting their products to provide food for poor rural people (ABTRACO, 2005). Those fruit species have very good potential to address the food, nutrition and income security of rural peoples living in drought-prone areas (Chivenge et al., 2015). Neglected and underutilized crops are recorded to be adapted in difficult environment condition which is unfit for other commercially important crops (Mal, 2007). Along with commercial potential, many NUFS well adapted to marginal soil and climate and provide important environmental services (Anonymous, 2020). Fleshy fruits are eaten by birds or animals (mammals) which may not be digested so are spread from the original trees. Uneaten fruits and nuts may germinate the next spring to make new trees. Some seeds are blown away by air and germinate at new places (CoAFE, 2020). Most fruit trees including NUFS provide forage to bees, but apple (*Malus domestica*), plum (*Prunus domestica*) and cherry (*Prunus avium*) trees are some of the most bee-attracting trees (Painter, 2020). Fruit trees has many helpful environmental benefits such as reduce shipping, reduce CO_2 emmission, reduce energy cost, storm water management and green jobs. Fruits trees act as a CO2 absorber, cleaner for the air, expelling fresh oxygen into the atmosphere (Maier, 2020).

3.3 Nutritional importance

Neglected and underutilized fruits have high nutritional value, culturing and gathering of indigenous fruits for both self consumption and sale are still common in Nepal, particularly in remote areas (Manandhar, 1982). Having valuable nutrients like carbohydrates, proteins, fats, vitamins and minerals as well as some bioactive non-nutrients that contribute to dietary health (Hunter et al., 2019). Some underutilized fruits like wood apple is good source of protein (7.10 mg $100g^{-1}$ pulp) and carbohydrate (31.80 mg $100g^{-1}$ pulp), tamarind is the richest source iron (17.01 mg $100g^{-1}$ pulp) and carbohydrate (67.40 mg $100g^{-1}$ pulp), similarly aonla (500-625 mg $100g^{-1}$ pulp) and ber (39-166 mg $100g^{-1}$ pulp) are a good source of vitamin C and (Nandal and Bhardwaj, 2015). During food scarcity periods, people from urban and rural communities heavily depend on gathering those indigenous fruits from their natural habitats (Dangol, 2002). These crops play important role in food security in hills and mountain through improving dietary diversity and income opportunities (Atreya and Kaphle, 2020). Neglected and underutilized crop species play an important role in food, nutrition as well as diverse food culture for poor people who have limited access to major food crops (Shrestha et al., 2020). Most of the species are rich in nutrients and have some proven medicinal values and the promotion of their use would help in combating malnutrition and improving the health status of the local populations (Dansi et al., 2012).

3.4 Suitability in the adverse climate

Many farming areas in Nepal are environmentally marginal and are likely to be at increased risk of land degradation and biodiversity loss as a result of climate trends. The continued availability and use of indigenous fruit diversity in Nepalese farming, particularly by smallholder farmers, is likely to play an important role in adaptation to climate change (Regmi and Paudyal, 2009). Some indigenous fruit species can be grown in the adverse climatic conditions under traditional farming systems (Atreya and Kaphle, 2020). They can be cultivated with low agricultural inputs on marginal lands (Thies, 2000). Having a deep root system, seedling grown from sexual propagation and hardy in nature of those fruits have an advantage over climate change. Indigenous plants materials are more resistant to insects, pests and diseases as well as extreme environmental stresses (Dangol, 2002). They are less susceptible to climate change effects and diseases compared to improved varieties (Jarvis et al., 2008). They contribute to world food production because they are well adapted to adverse environmental condition (Shava, 2005). The high degree of tolerance and having a wide degree of adaptability, they can thrive well under adverse climatic conditions (Vino and Sinija, 2016). These species hold great genetic diversity, and vast heritage of indigenous knowledge is linked to these species (Frison et al., 2000).

3.5 Genetic resources

Neglected and underutilized fruits are building blocks of new varieties and use as genetic resources (Dangol, 2002). Conservation of these crops is one of the best options for genetic resources conservation, which is the main asset of marginality and poor community living in the remote parts of the country (Shrestha et al., 2020). There is ample scope for selection of promising clones from these existing wild relatives through evaluation and selection breeding procedure (Shava, 2005). Characterization of these

Table 1. List of neglected and underutilized fruit crops available in Nepal

SN	English name (Local name)	Botanical name (Family)	Description
1	Wild kiwifruit (Thekifal)	*Actinidia* sp. (Actinidiaceae)	Found in 1000-2000 masl and mostly available in the eastern part of Nepal. Deciduous perennial vine, leaves are roundish somewhat heart shaped, deep green, young leaves and shoots are covered with bright red hairs. Flowering takes place during Feb-March, both male and female flowers are large and showy,
2	Red date (Sati bayar)	*Rhus parviflora* Roxb. (Anacardiaceae)	Found in 800-2000 masl. The plant is bushy shrub flowering during Aug- Nov. Ripe fruits are sour and eaten raw or pickled. Could be used as a biological fence.
3	Nepalese hog plum (Lapsi)	*Choerospondias axillaris* (Roxb.) B.L. Brutt et A.W. Hill (Anacardiaceae)	The trees are available in range of 1200-2000 masl. Trees are dioecious and reaches nearly 20-30 m high. Flowering during April-May. Fruits are smooth, fleshy, oblong, greenish yellows up on maturity with a big stony seed.
4	Indian hog plum (Amaro)	*Spondias pinnata* (Anacardiaceae)	Mostly found in terai and mid hill of Nepal. Deciduous trees having smooth, thick, and aromatic bark. Medium size trunk, compound leaf, 3-5 pair of leaflets having attractive smell. Flowering during March-April.
5	Wild mango (Jangali aanp)	*Mangifera sylvatica* Roxb. (Anacardiaceae)	Mostly found in midhills of Nepal. Evergreen in nature. It is also known as the himalayan mango, pickling mango, or Nepal mango. Tree is 6-20 m height, flowering takes place during March-April, fruit size is small to medium.
6	Macassar kernels (Bakiamilo)	*Rhus javanica* L. (Anacardiaceae)	Found in mid hill of Nepal. Decidious and small to medium plants, bushy in nature. Flowering during Feb-April. Ripe fruits are sour in taste and use as appetizer, grow in forest land,
7	Bullock's heart (Ramphal)	*Annona reticulate* (Annonaceae)	Mostly found in inner valley and mid hill of Nepal. A small deciduous or semi-evergreen tree. Flowering takes place during April-May. Medium sized light green fruits.
8	Custard apple (Sarifa)	*Annona squamosa* (Annonaceae)	Found in inner valley and mid hill of Nepal. Semi deciduous trees up to 6 m tall, greenish yellow flowers during march- july, found warm dry climate with mild winter and frost free condition.
9	Karonda (Karonti)	*Carissa carandas* (Apocynaceae)	Found in tropical and subtropical climate of Nepal. A species of flowering shrub, flowering during March-April, produces berry-sized fruits that are commonly used as a condiment in pickles and spices. It is a hardy, drought-tolerant plant that thrives well in a wide range of soils.
10	Indian barberry or tree turmeric (Chutro)	*Berberis aristata* DC. (Berberidaceae)	Found in mid hill (850-2500 masl) of Nepal. The plant is an erect spinous shrub of 2 to 3 m in height and flowers are stalke, yellow and in clusters. Flowering occurs during March-April, and fruits are globose to ovoid, blue black to violate color.
11	Barberry plant (Chutro)	*Berberis asiatica* Roxb. ex DC. Berberis sp (Berberidaceae)	Mostly found in cool temperate region (2000 -2500 masl) of Nepal. Flowering during March-April, fresh ripe fruits can be eaten, good for making wine. Also have medicinal value.
12	Pineapple (Bhuin Katahar)	*Ananas comosus* (Bromeliaceae)	Mostly found in terai to mid hill of Nepal. Perennial herb, leaves are long, narrow, thick, having marginal prickles, flowering during March-May and best suited in tropical climate, need to commercialize.
13	Mountain papaya (Pahari mewa)	*Carica candamarcensis* (Caricaceae)	Found in tropical and subtropical region of Nepal. The fruit pulp is edible, similar to papaya, and is usually cooked as a vegetable. Flowering takes place March-April. fruits having five broad longitudinal ribs from base to apex, it is green, maturing yellow to orange.
14	Baheda (Barro)	*Terminalia bellerica* (Combretaceae)	Found in forest farm in altitude of 500-1500 masl. Evergreen and has high medicinal value. Flowering occurs during March-April. Could be commercially cultivated to make medicines.
15	Chebulic Myrobalan (Harro)	*Terminalia chebula* (Combretaceae)	Found in forest and farm in altitude of 500-1500 masl. Flowering occurs during March-April. Evergreen and also has high medicinal value. Potential to commercialize for ayurvedic medicine

Table 1 Continued

SN	English name (Local name)	Botanical name (Family)	Description
16	Local Persimmon (Haluwabed)	*Diospyros kaki* (Ebenaceae)	Trees are subtropical in nature, deciduous and moderate sized, rounded crown up to 12 m, flowers are usually unisexual but may be perfect, flowring takes place during March-April and are astringent in taste.
17	Wild Persimonn (Tindu)	*Diospyros malabarica* (Desr.) Kostel. (Ebenaceae)	Mostly fond in tropical and sub tropical climates of Nepal. Grown in forest and marginal land, use as fruit, need to conserve.
18	Bead Tree (Rudraksha)	*Elaeocarpus sphaericus* (Elaeocarpaceae)	Wildly found in forest of midhill (800-1500 masl). Tall trees having a high medicinal and religious value. Flowering during April-May. In some part their ripe fruits can be eaten.
19	Seabuckthorn (Dale chuk)	*Hippophae tibetana* Schltdl. (Elaeagnaceae)	Grown in high hill (more than 1500 masl) of Nepal. Flowering during March-April. Squash, jam, wine syrup prepared from the fruits, have good commercial potential.
20	Emblica, myrobalan tree or Indian gooseberry (Amala)	*Emblica officinalis* Gaertn. (Phyllanthus emblica Linn) (Eurphorbiaceae)	Mostly found in tropical to subtropical region (up to 1450 masl) of Nepal. The wild amala are winter hardy. Flowering occurs during April-May. Fruits are fleshy and almost depressed to globous.
21	Tamarind (Emli)	*Tamarindus indica* L. (Fabaceae)	Found in Terai to mid hill of Nepal. Ripe fruits are sharp sour in taste. Flowering takes place during March-April. Fruits are use to make candies and souring agent. Need conservation and rich source of vitamin C.
22	Hill chestnut (Katush (Masure))	*Castanopsis tribuloides* (Sm.) A. DC. (Fagaceae)	Found in 450-2000 masl. Nearly 20 m tall growing in hill forests. White sessile flowers are seen during March-August. Fruit is nut, harvested in Sept-Nov, and eaten either fresh or roasted.
23	Indian chestnut (Katush (Dhalne))	*Castanopsis indica* (Roxb.) A. DC. (Fagaceae)	Mostly distributed in the mid-hills from 1200-2500 masl. Evergreen trees are about 15 m tall and flowering occurs during Oct-Nov.
24	Chestnut (Katush)	*Castanea crenata* (Fagaceae)	Found in mid hill of Nepal up to 1600 masl. Evergreen and is a small to medium-sized tree growing to 10-15 m tall. Flowering during Oct-Nov. Seeds are enclosed by throny bark.
25	Brindal berry (Kaphal)	*Garcinia cowa* (Guttiferae)	Mostly distributed from inner valley to mid hill of Nepal. An evergreen trees flowering during March-April, yellow to orange fruits are round with a pointed beak at the apex
26	Walnut (Hade Okhar)	*Juglans* sp. (Juglandaceae)	Found in upper part of mid hill and high hill of Nepal (1500-2500 masl).Very large trees up to 20 m of more height, broad and spreading crown leaves are 6-12 cm long, bark is silvery grey and remain smooth for a long time, flowering during April-May.
27	Avocado (Ghuephal)	*Persea Americana* (Lauraceae)	Mostly found in tropical to sub tropical region (upto 1500 masl) of Nepal. Trees are evergreen with dense foliage, may grow up to 20 m, leaf are oval, lanceolate and elliptical. Flowering from April-July.
28	Nepal osbeckia (Angeri, Kali chulesi or kali angeri)	*Osbeckia nepalensis* Hook. f. (Melastomataceae)	Mostly found in mid hill of Nepal. Grows in the forest, terraces and fallow lands, sources of anti-oxidants and ink, use its fruits, stems with leaves used as fodder. Flowering during March-April.
29	Thomas Bean (Paangra)	*Entada phaseoloides* (Mimosaceae)	Found in tropical to sub tropical region (300-1400 masl) of Nepal. Medium sized climber and habitat in forest land. Flowering occurs during March-April.
30	Soap pod (Sikakai)	*Acacia consinna* (Mimosaceae)	Found in 200-1200 masl forest land. It is is a climbing shrub. Alkaloids are found in the tree's fruit.

Table 1 Continued

SN	English name (Local name)	Botanical name (Family)	Description
31	Wild fig (Anjir)	*Ficus palmate* Forsk (Moraceae)	Growing wild up to 1550 masl and are deciduous. Flowering occurs during March-April. Fruit color varied from deep violet to black. Seed are very small, numerous and round.
32	Tree fig (Khanayo)	*Ficus cunia*, *F. semicordata* (Moraceae)	Mostly found in mid hill of Nepal in wild form. Evergreen to deciduous nature. Flowering occurs during March-May. Use as fruits and fodder trees and need to conserve.
33	Hairy Fig, devil fig, tropical fig (Khasreto/Thotne)	*Ficus hispida* L.F. (Moraceae)	Found in mid-hills in shady places. Evergreen in nature. Flowering during March-April. Leaves are opposite and the fruits often borne in pairs are of poor quality.
34	Mulberry or white mulberry (Kimbu (Seto))	*Morus alba* Linn. (Moraceae)	Mostly found in terai to mid hill of Nepal. Tree is small but may go up to 5 m. Flowering is from Feb-March. Ripe fruits are dark purple and available in May-June.
35	Himalayan mulberry (Kimbu)	*Morus serrata* Roxb. (Moraceae)	Found in the higher altitudes but not in the Terai area. It may be wild or cultivated nearly 10-15 m tall. They flower in Feb-March The fruits are sweet, purplish color when ripe.
36	Jackfruit (Rukhkatahar)	*Artocarpus heterophyllus* (Moraceae)	Mostly found in terai, inner terai and mid hill up to 1200 masl of Nepal. Evergreen, monoecious, grows up to 18 m, straight trunk, male inflorescence are more numerous than female and borne ancillary on leaves twig trunk, and main branches above female inflorescence. Flowering and fruiting takes place during March-July.
37	Java Fig (Kabro)	*Ficus lacor* (Moraceae)	Mostly found in mid hill of Nepal. It is a large evergreen tree (15-20 meter tall), used for the treatment of bleeding disorders, herpes, wounds, mouth ulcers, diarrhea and leucorrhea. Also use as fruits and fodder tree.
38	Common fig (Nemaro)	*Ficus carica* (Moraceae)	Distributed in mid hill of Nepal. Medium size evergreen tree (6-12 meter tall). It has been used in traditional medicine for a wide range of ailments related to digestive, endocrine, reproductive, and respiratory systems. Additionally, it is also used in gastrointestinal tract and urinary tract infection.
39	(Ban timilo)	*Ficus foveolata* (Wall. ex Miq.) Miq. (Moraceae)	Found in hilly region of Nepal and is grow in forest land. Medium size tree, Use as fruits and green leaf and small branch as fodder.
40	Monkey jack (Badahar)	*Artocarpus lakoocha* Roxb. (Moraceae)	Mostly found in mid hill of Nepal. Use as 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
41	Plantain (Tarkari kera)	*Musa sapientum* (Musaceae)	Found in tropical and sub tropical area of Nepal. Tree like herbs having a terminal crown of large entire leaves and usually bearing hanging clusters of elongated fruits. It can be use as a fruits, vegetables and pickles after cooking.
42	Wild banana (Jangali kera)	*Musa nepalensis* Wall. (Musaceae)	Found in lower hills of Nepal. Evergreen herbaceous in nature. Flowering and fruiting takes place summer season. Use as fruits as well as vegetables.
43	Box myrtle or bay berry (Kaphal (Rukh Kaphal))	*Myrica nagi* Thumb (M. esculenta Bush and Ham; M. sapida Wall) (Myricaceae)	Mostly found from about 1000-2100 masl. Tree is medium to large sized, woody, dioecious sub temperate evergreen. A globose drupaceous fruit with a hard endocarp and is carmine colored. Flowering starts from Feb-April Fruits can be harvested from a single tree in many pickings.
44	Bay berry (Kaphal)	*Myrica esculanta* Buch. Ham-ex D. Don (Myricaceae)	Mostly distributed in mid hill of Nepal. Grow in forest landand could be cultivated in fallow lands. Flowering occurs during Feb-April. Use as fruit.
45	Jambolan (Jamun)	*Syzgium cumini* (Myrtaceae)	Mostly growing in terai and mid hills (upto 1300 masl), Evergreen trees with whitish brown bark leaves are oval to rectangular, smooth, shiny and large, flowering during March-April. Fruits are also use as medicinal purpose.

Table 1 Continued

SN	English name (Local name)	Botanical name (Family)	Description
46	Surinam cherry (Jamun)	*Eugenia jambolana* Lam. (Myrtaceae)	Mostly found in terai and mid hills of Nepal. Evergreen trees with whitish flowers are seen during Oct-April depending up on the elevations. Fruits are berry, oblong and black with dark-purple juicy pulp and harvested in June-Aug.
47	Rose apple (Gulab-Jamun)	*Syzygium jambos* (L.) Alston (Myrtaceae)	Found in hill region of Nepal and is grown in wild form, It is an evergreen tree with a regular shaped, dense crown of wide-spreading branches, it can grow 6-10 metres tall. Use as fruit, and it need conservation and commercialization.
48	Wild species of olive (Jaitun)	*Olea ferruginea*, *O. glandulifera*, *O. cuspidate* (Oleaceae)	Found in upper mid hill of mid western and far western region of Nepal. Evergreen very hard and strong wood, medium to large tree, flowers are born on many small panicles and are small yellowish white and perfect,
49	Wild date palm, Indian wine palm or Date sugar palm (Khajur)	*Phoenix sylvestris* Roxb. (Palmaceae)	Found up to elevations of 1350 masl. The tree is unbranched, erect, tall, dioecious or evergreen with large persistent compound leaves in a terminal tuft. Flowering takes place in July-Aug. Fruit takes almost one year to mature and ripening is during June-July.
50	(Archal)	*Aporosa octandra* (Buch.-Ham. ex D. Don) Vickery (Phyllanthaceae)	Found in mid hill of Nepal, Evergreen trees and is use as fruits and stem as a fodder. Medium size tree, fruit become red after ripeinig.
51	Gooseberry (Amala)	*Phyllanthus emblica* L., *Emblica officinalis* Gaertn. (Phyllanthaceae)	Found in terai to mid hill of Nepal. Allowed to grow in forests and grass lands. Fruits are rich source of vitamin C, medicines, pickles and candies. Has scope for commercial farming.
52	Asiatic tearthumb, mile-a-minute (Ghumauro-kanda)	*Polygonum perfoliatum* L. (Polygonaceae)	Moslty found in hilly region of Nepal. It is a herbaceous, annual, trailing vine. It generally colonizes open and disturbed areas, along the edges of woods, wetlands, stream banks and roadsides. Use as a fruit.
53	Wild pomegranate (Darim (Anar))	*Punica granatum* Linn. (Punicaceae)	Wild species are found in the vast tract of hilly region of Nepal. Deciduous spreading shrub or tree having woody and thorny stem. Flowers are claret rose color, and appear in April-May. Fruits are globular, possessing a hard outer rind and harvested from July-Sept.
54	Jujube, Chinese date (Bayar)	*Zizyphus jujuba* Mill. (Rhamnaceae)	Grows wild in forests and wastelands up to 1400 masl. Tree is small, spreading and bushy with drooping branches. Fruits are oblong or round, small, marsh orange colors and harvested in Dec-Jan. Could be use as biological fences.
55	Chinese date, Indian plum (Ber)	*Ziziphus mauritiana* (Rhamnaceae)	Mostly found in terai and mid hill of Nepal. Small, spiny and evergreen shrub, smooth, glossy fruit may be oval, obovate, oblong or round depending on the variety. Flowers are white or greenish white.
56	(Hade bayar)	*Ziziphus incurve* Roxb. (Rhamnaceae)	Mostly found in terai and mid hill of Nepal. Grow in forest, fruits are red after ripening. Could be use as biological fences.
57	Wild apple (Jangali syau)	*Malus baccata* (Rosaceae)	Found in 1000-2500 masl. Medium to tall trees having deciduous in nature. Important source of rootstocks for commercial apple sapling production.
58	Wild apple (Edimayal)	*Malus* spp. (Rosaceae)	Found in 1000-2500 masl. Medium to tall trees having deciduous in nature. Important source of rootstocks for commercial apple sapling production.
59	Yellow raspberry (Ainselu (yellow))	*Rubus ellipticus* Smith (*R. rotundifolius* Wall; *R. flavus* Ham.) (Rosaceae)	They are found throughout the mid hill (700-2000 masl). Evergreen shrub, mostly erect and curving down with prickly stems trifoliate leaves and leaflets are irregularly toothed. Flowering observed during Feb-March. Fruit ripens from May-June and is yellow and very easily detachable from the thalamus.

Table 1 Continued

SN	English name (Local name)	Botanical name (Family)	Description
60	Black raspberry (Ainselu (Kalo))	*Rubus niveus* Thunb. (*R. gracilis* Roxb; *R. lasiocarpus* Hock; *R. albexens* Roxb; *R. mysorensis* Heyne.) (Rosaceae)	Grows wild throughout the temperate hilly region, up to 2000 masl. The fruit is black or dark purple. The plant is tall, sub erect, prickly bush, remains leafless for a very short duration. Flowering is observed in April-May. Ripe fruits are deep pink to nearly black at maturity and harvested in June-July.
61	Wild raspberry (Ainselu (Rukhain-selu))	*Rubus paniculatus* Sm. (Rosaceae)	Grows from 500-2700 masl. The plant is a straggling shrub, 2-5 m tall. Flowering observed during Jan-Feb and fruit are red or black when ripe during May-June.
62	Wild straberry (Bhuin ainselu)	*Duchesnea indica* (Jacks.) Focke (Rosaceae)	Mostly found in terai to mid hill of Nepal. Leaves are edible and medicinal. However, the fruit is said to be tasteless, a flavor somewhat akin to a watermelon according to some.
63	Indigenous pear (Indigenous pear)	*Pyrus* spp. (Rosaceae)	Abundantly found in hill and high hill of Nepal. Deciduous medium to tall trees. Can be use as rootstocks for commercial pear sapling production.
64	Wild peach (Jangali Aaru)	*Prunus persica* Batsch. (Rosaceae)	Found in hills and high hills of Nepal. It is a medium sized deciduous woody tree with its bark brown to black color. Flowering period is March-April. Fruit is harvested during Sept-Oct.
65	Wild strawberry (Bhuinaukhe)	*Frageria indica* Andr., *F. vesca* L., *Duchesnia indica* Sm. (Rosaceae)	Commonly found from lower hills to high hills up to 1800 masl. The plant is perennial herb, having prostrate stems, with silky hairs on the stem and has trifoliate leaves. Flowering is in March-June and fruiting in April-Aug.
66	Wild apricot (Jangali Khurpani)	*Prunus cornuta* (Rosaceae)	Mostly found in warm temperate region of Nepal. Large the peach, spreading habit, leaves are broad, heart shaped and dark green, white flower, round to oblong food,
67	Thorny wild pear (Mayal)	*Pyrus pashia* Buch& Ham (Rosaceae)	Commonly distributed in the mid hills (700-2000 masl) and they are sued as rootstocks for pears. Flowering occurs in Feb-March and fruit begins to ripen in Nov-Dec. Fruit is a small oval pome, black at maturity, but soft, gritty and somewhat astringent.
68	Large fruited wild pear (Mayal (Bhote))	*Pyrus serotina* Rehd. (Rosaceae)	Found throughout the mid hill of Nepal. Fruits are larger, less gritty than the Mayal. The tree is tall, thorny, and deciduous. Flowering takes place in March and fruits can be eaten from Oct-Dec.
69	Sand pear (Naspati)	*Pyrus communis* (Rosaceae)	Mostly found in 1000-2000 masl of Nepal. Tall, large , healthy and long lives trees, leaves are oval to oblong, dark green, pubescent, elliptical, leaves margin are coarsely serrated with bristle tips, large and white flowers, deciduous in nature.
70	Wild pear (Jangali naspati)	*Pyrus pashia* (Rosaceae)	Mostly found in mid hill of Nepal. Trees are small to medium size deciduous tree of the small and oval shaped crown with ovate, finely toothed leaves, attractive white flowers with red anthers and small pear-like fruits. It is a fruit bearing tree that is native to southern Asia.
71	Wild cherry (Paiyun/Ban Paiyun)	*Prunus nepalensis* Hook. f. (Rosaceae)	Found in 1200-3000 masl and are about 10-15 m tall. Flowering from Oct to Feb and fruiting from March-May. Fruits are fleshy, oval shaped, small and with stony seed.
72	Straberry (Bhuin Ainselu)	*Fragaria ananassa* (Rosaceae)	Found in mid hill of Nepal up to 1800 masl and are self fertile perennial herb.
73	Wild plum (Wild plum)	*Prunus salicina* (Rosaceae)	Abundantly found in hill tracts of the country. Is a small deciduous tree.
74	(Aiselu)	*Rubus ellipticus* Sm. (Rosaceae)	Found in mid hill of Nepal and is small spiny shrub. Use as medicine against typhoid.
75	Nepalese fire thorn (Ghangaroo)	*Pyracantha crenulata* (Roxb. ex D.Don) M.Roem. (Rosaceae)	Grown in wild form, use as fruit. Need to conserve.

Table 1 Continued

SN	English name (Local name)	Botanical name (Family)	Description
76	Grapefruit (Sankhatro)	*Citrus paradisi* Macfad. (Rutaceae)	Found in mid hill of Nepal. Medium size trees and flowering takes place during March-April. Use as fruit. Grown in homestead gardens or orchards. Potential for commercialization.
77	Sour orange (Kali Jyamir)	*Citrus arantium*, *C. junos* (Rutaceae)	Mostly found in mid hill of Nepal. Trees of medium height up to 8 m having thin thorns, leaves are broad and dark green. Flowering takes place during March-April. Flowers are large, white and very fragrant, fruits are almost round, can tolerate more cold than sweet orange.
78	Sweet lime (Chaaksi)	*Citrus limettioides* Yu. Tanaka (Rutaceae)	Mostly found in mid hill of Nepal. Flowering takes place during March-April. Grown in homestead garden, use as fresh fruit, need conservation and promotion.
79	Hill lemon (Pahari Nibuwa)	*Citrus psuedolimon* (Rutaceae)	Mostly found in mid hill of Nepal. Trees are medium size, evergreen, oblong yellow fruit extensively used in pickle making and juice extraction. Flowering takes place during March-April. It is also known as hill lemon or Kumaon lemon. Found in mid hill of Nepal.
80	Trifoliate orange (Tinpate Suntala)	*Poncirus trifoliate* (Rutaceae)	Mostly found in mid hill of Nepal. This species is unusual among citrus for having deciduous, compound leaves and pubescent fruit. Flowering takes place during March-April. Small to medium size bushy, throny trees. Extensively used as rootstocks for producing grafted citrus sapling in Nepal.
81	Rough lemon (Seti Jyamir/Kathe Jyamir)	*Citrus jambhiri* (Rutaceae)	Mostly found in mid hill of Nepal. Rough lemon is a cold-hardy citrus and can grow into a large tree. Flowering takes place during March-April. Also use as rootstock.
82	Timbur	*Zanthoxylum armatum* (Rutaceae)	Mostly found in forest in 1100-2500 masl. Small trees/shrubs has great medicinal use against blood pressure, carminative, dyspepsia. Flowering takes place during March-May. Ripe fruits are use as spices and high medicinal value.
83	Siltimbur	*Zanthoxylum oxyphyllum* Edgew. (Rutaceae)	Small trees/ shrubs are found in forest in 1100-2500 masl. Has great medicinal use, appetizer, anti-helmintic properties. Flowering takes place during March-May. Their small and ripe fruits are use as spices and high medicinal value.
84	Bengal quinch, golden apple or stone apple (Bel)	*Aegle marmelos* Correa (Rutaceae)	Grows up to 1500 masl. Flowering during June-July and flowers are greenish white, sweetly scented. The fruit takes about one year to mature and peak fruiting season is during May-June. Fruit are yellowish green, with small dots on the outer surface, oblong to globose shape. Fruit and leaves are used for religious offerings, and medicine for stomach problems.
85	Citron (Bimiro)	*Citrus medica* (Rutaceae)	Locally found in low hill to mid hill of Nepal. Flowering takes place during March-April. Fresh fruit use during Tihar (Deepawali) festival. Grow in homestead garden.
86	Sweet lime (Chaksi)	*Citrus limettoides* (Rutaceae)	Mostly found in mid hill of Nepal. Spreading tree, small to medium height with an irregular growth habit. Flowering takes place during March-April. Fruits medium sized; globose to ellipsoid, rind thin, with distinct aroma,soft and sweet, flesh pale yellow.
87	Soap berry or washnut (Rittha)	*Sapindus mukorosii* (Sapindaceae)	Mostly found in forest up to 1500 masl. Medium to tall tree. Flowering takes place during March-May and having hard fruit.
88	Lac tree, macassar oil tree, (Kusum)	*Schleichera oleosa* (Lour.) Oken (Sapindaceae)	Found in forest land up to mid hill of Nepal. Medium to tall tree up to 30 meter. Use as fruit.

Source: Shrestha (1996); Shrestha (1998); Singh (1969); Shrestha et al. (2001); Regmi and Shrestha (2005); Tomiyashu et al. (1999); Khanal et al. (2015); Joshi et al. (2007); Luitel and Pathak (2013); Atreya and Kaphle (2020); Atreya et al. (2020); Karki et al. (2007); Gautam and Gotame (2020).

species with their wild relatives and *ex situ* conservation is important task in fruit breeding program. Some of these fruit species can be released and or registered as landraces. These plants possess rich genetic diversity with unprecedented potential to improve the quality and resilience of future crops, and can be used by plant breeders for future crop improvements (Mabhaudhi et al., 2019).

4 Causes of genetic erosion

Despite their importance for subsistence, income generation and culture, the availability of neglected and underutilized fruits is declining at an alarming rate in all areas of Nepal (Aryal et al., 2009). Expansion of mechanized, intensive agriculture, the introduction of exotic fruit species and improved varieties, loss and degradation of agricultural and forest land (e.g., caused by infrastructure development, soil erosion, and logging of forests to fulfill the demands of the growing population), over-exploiting of wild plants (e.g., for food, fuel, or fodder), climate change and natural disasters, population growth and urbanization (Uprety et al., 2012). Monocropping and indiscriminate use of chemicals (fertilizer, weedicides, insecticides/pesticides) are found some of the causes of genetic erosion of neglected and underutilized fruits in Nepal. Biodiversity and genetic resources deplete faster in an easily accessible region and urban area (Aryal et al., 2009).

5 Conservation activities

Fruit research activities of Nepal, has slowly developed after 1950s and gained momentum after the formation of commodity programmes in 1972 (Shrestha and Shrestha, 1995). After the establishment of 13 horticulture farms during 1960s, germplasm collection and conservation were started. The Citrus Research Programme was established in 1972 in order to coordinate citrus research, development and extension. Since the establishment, National Citrus Development Programme (NCDP) and now National Citrus Research Programme (NCRP) got research mandate for commodity research (*Citrus* spp.). Citrus was given national priority from the fifth five year plan period. Evaluation of *Citrus* spp. was started since 1982. Several germplasm of mandarin, sweet orange, grapefruit, tangor, and tangelo have been collected from local and exotic sources since the establishment of NCRP. During Horticulture Development Project Phase-I (1985-1990) and Phase-II (1992-1997), major research was focused on characterization evaluation of pear, grape, persimmon, and selection of high quality sweet orange (Junar) from local germplasms (Sakuma, 1995). Moreover, a lot of research efforts have been undertaken in different five year plans but all of them failed to streamline the systematic research in fruit commodities. In spite of the development potential and accorded priority in different five year plans and Agriculture Perspective Plan (APP, 1995), research in fruits and nuts are still lagged behind than that of technological demand from the users. The past research scenarios showed that production oriented and farmers problem solving adaptive research were given priority in those periods (Gotame et al., 2014). Generally, fruit growing was limited to homestead garden with few trees scattered here and there (Pradhan et al., 2016). Researches were limited to the introduction of new germplasms in commercial fruit commodity only. Neglected and underutilized commodities couldn't get research priority (Gotame et al., 2014). Underutilized neglected crops are 'underexploited' and under-researched crops (Shrestha et al., 2020). Because of poor external support, perennial in nature, long gestation period, long time need to do research for results, fruit research is in extreme dearth.

Scientific cultivation, conservation and sustainable use of indigenous plant species by ethnic communities would be highly advantageous for the conservation of rare and endangered plant species and the indigenous knowledge for the future generations (Malla and Chhetri, 2009). Having a large number of landraces, cultivars, rare and endangered species in home garden, it regard as a reservoir of plant genetic resources (Galluzzi et al., 2010). Awareness program on benefit of genetic resources and need for conservation of different levels, community, government organizations, non-government organization, entrepreneurs and consumers may play a great role in conservations of the indigenous, neglected and underutilized plant (Rana et al., 1998). Rural women are often the major players in utilizing wild traditional food plants including fruits and vegetables. They conserve and transfer their knowledge regarding availability, seasons, preservation, processing and culinary uses of those plants. Different horticulture farm/center under the Department of Agriculture (DoA) and Nepal Agriculture Research Council (NARC) collect germplasm and conservation of neglected and underutilized fruit species along with local landraces.

6 Issues and challenges

Changing human perception, lack of awareness, increasing dependency on imported food items are leading factors for its expansion (Khanal et al., 2015). Low consumption and low demand for these fruits are main reasons for the farmers' unwillingness to grow these crops (Gautam and Gotame, 2020). Most of the neglected and underutilized fruit species are restricted to marginal land having sloppy, undulated

topography and desert margins maintain by poor farming communities (Padulosi et al., 1999). Farmers are concentrating to the fewer commercial crops with increase mechanization and expectation of modern supply chain (Padulosi et al., 2013). Genetic erosion and even extinction of neglected and underutilized plant species is accelerating throughout the world as a result of overexploitation, overgrazing, land clearance, drought, deforestation, pest and diseases and lack of incentives for farmers to maintain this agro biodiversity (Chivenge et al., 2015). Genetic resource degradation, population growth and urbanization, mechanization and cropping intensity, the incidence of insect, pests and diseases, introduction of exotic varieties, climate change and natural disaster, changing economic, social and cultural value, out-migration are some of the serious issue/challenges of neglected and underutilized fruits development in Nepal.

7 Future conservation strategies

Traditional and indigenous fruits are very important in term of a nutritional and medicinal point of view, although they have mostly been neglected in research and development. Minimize the impending genetic and cultural erosion concerning traditional and neglected fruits, their germplasm should intensively be collected and conserved on-farm as well as in gene banks. The related indigenous knowledge urgently needs to be documented for serving future generations. Cultivation methods of these fruits, for example in home gardens, should be studied and improved. Their nutritional value needs to be analyzed and recognized. Their utilization should be promoted to improve livelihoods in rural and urban Nepal. The documentation of neglected and underutilized fruits and traditional knowledge on their utilization can be useful in devising strategies to check the loss and erosion of these valuable genetic resources. As traditional knowledge, cultures and rituals are passing from generation to generation, so such knowledge needs to be studied and documented. Germplasm collection, conservation and maintenance along with documentation are very important to protect these valuable resources. A value addition program on neglected and underutilized fruit species should be promoted. Creating favorable working environment and development of a suitable plan and policy is an urgent need for advanced research and development of these valuable fruit species.

8 Conclusions

This study documented 88 species of neglected and underutilized fruits having their diverse use from 32 different families. Farmers are reluctant to grow these fruits because of low returns, poor market value, unaware of their nutritional and environmental value. The awareness program is necessary for the preservation of those valuable fruit species. Various health problems can be overcome by using neglected and underutilized fruit as they have high medicinal and curative value. Need to promote value addition process for the promotion and development of these crops. Many of above mention fruit species are well adapted to stress conditions of extreme environments and form part of sustainable farming and also don't require high inputs and can be successfully grown in waste and degraded marginal land. It contributes to increasing national income along with fruit diversification and safe to the environment. These fruit species can play a crucial role in food security, income generation, and diversify the food culture of the rural people. Conservation of these crops is one of the best options for genetic resources conservation, which is the main asset for marginal and poor communities living in the rural area of Nepal. Therefore, indigenous knowledge regarding the utilization of these fruits also need to be protected and promoted through research, education, and extension programs.

Conflict of Interest

The authors declare that there is no conflict of interests regarding the publication of this paper.

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