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CGIAR Fruit and Vegetables for Sustainable Healthy Diets

Diversity of underutilized vegetables and fruit in Sri Lanka: prioritization for collection, conservation, genetic improvement, and promotion

Pushpakumara, G., Silva, R., Borelli, T., Hunter, D., Ariyarathne, M., Eeswara, J., Fonseka, R., Fonseka, H., Karunarathne, A., Dissanayake, S., Lowe, A., Rankoth, L., Dissanayake, K., Ranawaka, L., Kumarihami, P., Liyanage, N., Sugathadasa, S., Abhayagunasekara, C., Godamulla, D., Samarasinghe, G., Nanayakkara, S. and Liyanage, A.

University of Peradeniya/Wayamba University of Sri Lanka

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The CGIAR Research Initiative on Fruit and Vegetables for Sustainable Healthy Diets (FRESH) aims to use an end-to-end approach to increase fruit and vegetable intake and in turn improve diet quality, nutrition and health outcomes while also improving livelihoods, empowering women and youth and mitigating negative environmental impacts.

The FRESH Initiative activities are bundled into six packages, namely:

- Work Package 1: Understanding and Influencing Consumer Behaviour
- Work Package 2: Biodiversity, genetic innovation, and seed systems
- Work Package 3: Safe and sustainable production systems
- Work Package 4: Post-harvest and inclusive markets
- Work Package 5: Food Environments
- Work Package 6: Strengthening the enabling environment.

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Diversity of underutilized vegetables and fruit in Sri Lanka including prioritization for collection, conservation, genetic improvement, and promotion

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Summary

Despite their crucial role in combating hunger, malnutrition, and poverty, many plant species cultivated as fruits, vegetables, roots, and tuber crops remain neglected and underutilized worldwide, and Sri Lanka is no exception. Integrating these crops into farming systems has the potential to create nutrient-dense, climate-resilient, and sustainable agricultural practices. The study titled "Diversity of underutilized vegetables and fruit in Sri Lanka: prioritization for collection, conservation, genetic improvement, and promotion" highlights the significance of underutilized vegetables and fruits in Sri Lanka's agricultural biodiversity. These often-overlooked crops possess unique nutritional and agronomic traits that could benefit both farmers and consumers. However, they have been overshadowed by more commonly cultivated species and varieties. To safeguard the genetic diversity and potential contributions of these underutilized crops to food security and nutrition, the study emphasizes the need for prioritizing their collection and conservation. Preserving their genetic resources enables researchers and farmers to access a broader range of traits, enhancing resilience to environmental challenges. Additionally, the research underscores the importance of genetic improvement efforts to boost the productivity and adaptability of underutilized vegetables and fruits. Breeding programs focused on priority species can lead to the development of new cultivars with desirable traits, such as increased yield, disease resistance, and improved nutritional content. Moreover, promoting underutilized crops is essential to raise awareness among consumers, retailers, and policymakers about their nutritional benefits and economic potential. By creating market demand and integrating these crops into agricultural systems, their sustainable cultivation and utilization become more viable. In summary, recognizing and prioritizing the diversity of underutilized vegetables and fruits in Sri Lanka is crucial. Through strategic collection, conservation, genetic improvement, and promotion efforts, these crops can significantly contribute to enhancing food security, preserving biodiversity, and supporting sustainable agricultural practices in the country.

Keywords

Underutilized fruits, underutilized vegetables, Sri Lanka, priority setting, constraints, future potential

Contents

Tables

Figures

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Fruit and Vegetables
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1. Introduction

Many plant species that are cultivated as fruits, vegetables, and for their roots and tubers are neglected and underutilized across the world despite their vital role in fighting hunger, malnutrition, and poverty. Their incorporation into farming systems has been shown to have the potential to lead to nutrient-dense, climate resilient, and sustainable agricultural systems (Li et al., 2020; Rathnayake et al., 2023).

Although some have been domesticated, underutilized crops remain inadequately documented and characterized and are often neglected by research systems and conservation programmes due to the underestimation and under-exploitation of their potential. However, they continue to be maintained and used by local people across geographies and a wide range of ecologies and farming systems due to cultural reasons that are linked with traditional knowledge and practices (Rathnayake et al., 2023). Local communities often collect these species for their own consumption. The surplus is sometimes sold in village fairs, to collectors, and more rarely to supermarket channels to supply their niche markets.

Although these crops can contribute significantly to maintaining stable and more diverse agroecosystems, they are in danger of continued genetic erosion and disappearance from farming systems and a wide range of ecologies, due to the limited incentives that exist to conserve and grow them. They are also threatened by unsuitable land use practices, habitat destruction and over-harvesting (Rathnayaka et al., 2023).

Their genetic erosion can have immediate consequences on the food security and nutritional status of local communities. In addition, genetic erosion of this resource base can reduce their enhanced use, which can bring solutions for better food and nutrition, and to fight hidden hunger. Further, with the loss of these species and their traditional varieties, loss of valuable indigenous knowledge related to farming practices and their food preparation practices is inevitable.

In general, as for ecosystem and cultural diversities, the diversity of agricultural genetic resources is also high in Sri Lanka in terms of species, their growth form, suitability to various farming systems and climatic conditions. Sri Lanka is endowed with a wide range of ecosystem diversity, which is ideal for growing many species of tropical and sub-tropical fruit, vegetables and root and tuber crops (Pushpakumara and Silva, 2008; 2018). Due to its long farming history, dating back to 3000 years before present, farming systems in Sri Lanka are also very diverse and support a wide range of agricultural species. However, as in elsewhere in the world, current fruit and vegetable production in Sri Lanka is based on a limited number of commercial crops and varieties therein (Pushpakumara and Silva, 2008; 2018). Existing pressure to increase production levels, together with technological advances in crop production, has pushed agricultural production requirements to the limit. As a result, agrobiodiversity in Sri Lanka has been adversely affected by the adoption of a few high- yielding varieties from a uniform genetic stock. Overall, the narrowing of the genetic base of agricultural genetic resources is bound to reduce options for breeding and identification of new crops in the future, thereby increasing vulnerability to pests and diseases, climate change and reducing human dietary diversity. Such a situation will further increase the future reliance of farmers on agrochemicals to maintain high yields. In addition, because of deforestation, the expansion of agricultural lands and urbanization, many underutilized endemics and indigenous species have become rare, or extinct in their natural environment (Pushpakumara and Silva, 2008; 2018; Ranil et al., 2020).

Recognizing the loss of valuable germplasm of underutilized species, the Department of Agriculture (DOA), with USAID funding, has begun to establish collections and small orchards of underutilized fruit tree species for their conservation (Pushpakumara et al. (2007; 2011). The Sri Lanka Council for Agricultural Research Policy (CARP) has also awarded several research grants to the national agricultural research system for the collection, characterization and evaluation of these fruit and vegetable species. The tree Domestication Project, a joint activity between the Regional Office for South Asia of the World Agroforestry Centre (ICRAF), New Delhi, India and CARP has also undertaken research and development on many of the underutilized crops in the country (Pushpakumara et al., 2007; 2011). The International Centre for Underutilized Crops (ICUC) and the Asian Centre for Underutilized Crops (ACUC), based in Sri Lanka, have also contributed immensely to the development of underutilized fruits in Sri Lanka and Asia over the past decades (El-Siddig et al., 2006). Both ICUC and ACUC have also recognized the importance of product development and value addition to these species as a sustainable income opportunity for small-scale processors and farming communities.

The recent GEF (Global Environment Facility)-supported Biodiversity for Food and Nutrition (BFN) project, implemented in Sri Lanka, Brazil, Kenya and Turkey offered a unique approach to linking neglected and underutilized plant foods (NUPFs), diets and nutrition by (i) strengthening the evidence of the nutritional value and social-ecological importance of NUPFs; (ii) targeting policies that promote NUPFs and emerging markets; and (iii) raising awareness of NUPFs among consumers as alternative food options. The approach helps identify entry points for greater mainstreaming of NUPFs into policies and programs that target food and nutrition security and offers numerous insights into how to do this practically (Beltrame et al., 2019; Borelli et al., 2021; Rathnayake et al., 2023). The other recent GEF Funded project on Mainstreaming Agrobiodiversity Conservation and use in Sri Lankan agro-ecosystems for Livelihoods and Adaptation to Climate Change (BACC Project) adopted an integrated approach to agrobiodiversity management and use that used agrobiodiversity to support improved livelihoods, adaptation to climate change and sustainable production. Implemented in three sites in Sri Lanka, the project undertook: (a) an assessment of the diversity of crops, animals, fish, and useful wild species present in the three ecosystems; and (b) an analysis of the ways in which agronomic practices could be altered to strengthen agro-ecological approaches to production (Kulasinghe et al., 2019).

Although underutilized species have gained some popularity in Sri Lanka since 2000 thanks to various national and international initiatives, many species remain underutilized and threatened by genetic erosion. Only a few species such as '*Kohila*' (*Lasia spinosa* (L.) Thw.) (Ranil et al., 2022) and Spine gourd or '*Thumba Karawila*' (*Momordica dioica* ex Roxb. Willd) (DOA, 2018) have gained popularity because of coordinated and continuous research investments and strengthening of extension activities. Further, because of decades of underinvestment, the human and institutional capacity required for research, extension, marketing, and knowledge sharing on underutilized species is weak or absent. This working paper documents current information on the underutilized fruit and vegetables of Sri Lanka, on their importance, diversity, conservation status, research gaps, and priority setting, using information from completed and ongoing studies. Recommendations are made to address these gaps by both national and international communities for future use and wider utilization.

Many species remain underutilized and threatened by genetic erosion due to the lack of coordinated strategy and research investments.

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2. Methodology

A literature review carried out in 2022 on underutilized plant species in Sri Lanka identified 43 publications from national and international scientific forums and journals for in depth evaluation. Of the 43 documents, 38 were scientific publications (journal articles, abstracts, and conference proceedings), and 5 were reports from regional and international programmes and centers. The geographical scope ranged from the Asia-Pacific region to Asia, India, and Sri Lanka. Only a limited number of studies from the Asia region focused on underutilized fruit and crop species, and most of these were from the Indian subcontinent (Kumar et al., 2018; Sahoo et al., 2021; Thakur, 2014).

Within Sri Lanka, only a few studies narrow down to the District Secretariat (DS) level (Chamara et al., 2021). Interestingly, most Sri Lankan studies focus on household level consumption and utilization, concentrating on small to medium scale farming of underutilized crops as an additional source of household income (Bandula et al., 2016). Much of the data gathered concerns the promotion of various underutilized species (El-Siddig et al., 2006; Pushpakumara et al., 2007; 2011; Pushpakumara and Heenkenda, 2008; Pushpakumara and Ketipiarachchi, 2008). The status of utilization and conservation of underutilized species was discussed with national entities, including the Plant Genetic Resources Centre (PGRC), the Fruit Research and Development Institute (FRDI), the Horticultural Crop Research and Development Institute (HORDI) and the Community Development Centre, in Aranayake. In addition, an experts' workshop was conducted on 3 April 2023 in Kandy to share information and verify activities on underutilized species in Sri Lanka.

3. Results

3.1 Underutilized species defined

Different terms are used in literature to describe underutilized fruit and crop species. Hunter et al. (2019) and Mudau et al. (2022) use the term *orphan crops* and *wild edibles*. Ratnayake et al. (2021) used 'crop wild relatives' as a synonym to describe underutilized fruit species in their study focusing on the distribution of crop wild relatives and climate change in Sri Lanka. As stated by Rathnayake et al. (2023), deciding whether a particular plant or crop is neglected or underutilized is challenging due to the degree of its utilization, which may be based on the social, ecological, economic, cultural, climatic, and farming characteristics of a particular area. Thus, the authors defined both neglected and underutilized species separately using 25 statement criteria linked to the species social, ecological, economic, cultural, climatic, and farming characteristics. However, for this paper, underutilized crop species are considered plant species that can be consumed as food, oil, fruit, or medicine, and possess the following characteristics as defined by Thakur (2014):

(a) Have a scientific or ethnobotanical proof of food value

(b) Have been cultivated, either in the past, or in a specific geographical area

(c) Are cultivated less than other conventional crops

(d) Have a weak or no formal seed supply system

(e) Have indigenous uses in localized areas

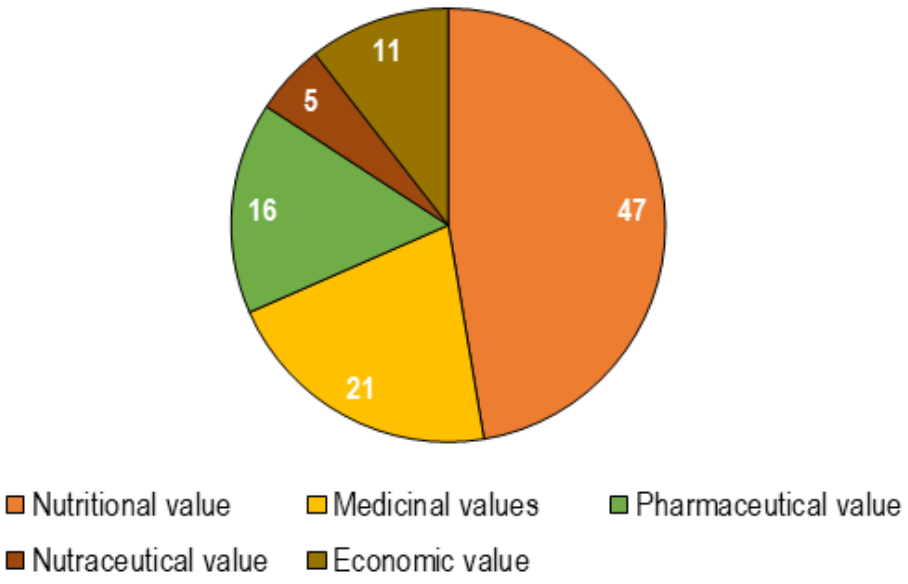
(f) Receive less attention from research, extension services, farmers, policy and decision makers and technological interventions

(g) Produce nutritious foods and/or have therapeutic or medicinal properties or multiple uses.

3.2 Importance of underutilized species to Sri Lanka

Figure 1 summarizes the important perceived values and beneficial uses of underutilized fruit and vegetable species. The pie chart highlights how nutritional value plays a key role in people's choice to grow/purchase underutilized species. Although they are sometimes wild relatives of modern crops or fruits and vegetables, they are equally, if not more healthful compared to modern varieties. Medicinal value is also a common characteristic recognized in underutilized fruit and vegetable species, especially when it comes to therapeutic uses. However, it is important to note that for most of these underutilized species the chemical composition is unknown. When people consume these species, the known and unknown chemical constituents may provide benefits or some harmful effects that are yet to be identified.

Figure 1: Beneficial uses of underutilized fruits and vegetables gathered from reference literature.

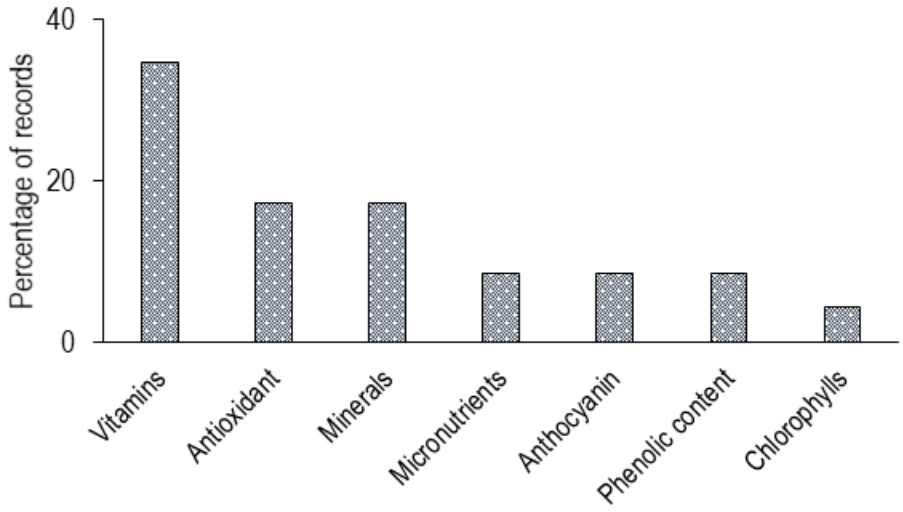


Chamara et al. (2021) and Li et al. (2020) have focused on empowering the rural women to use these underutilized species as a source of income. In general, women farmers are engaged in less taxing agricultural practices such as planting, weeding, and harvesting while men are usually involved in land preparation, land protection from wild animals and water management. Women may thus have more time and be better placed to exploit underutilized crops (Chamara et al., 2021). Bandula et al. (2016) also conclude that underutilized fruits and vegetables are a potential source of income for households that can alleviate food and economic insecurity.

In a recent study by Chamara et al. (2021), rural women expressed interest in exploiting these underutilized crop species. The respondents valued the agrochemical-free nature of these crops, which they could easily harvest from home gardens, or collect from roadsides, lowlands, and paddy lands. However, Bandula et al. (2016) note that wild harvest vegetables and fruits are primarily used for household consumption. When cultivated or harvested, surplus is shared among close neighbors and friends while farmers tend to use four major channels to sell their surplus and obtain additional income: seasonal roadside stalls, casual village collection centers, weakly fairs in suburban areas and traditional village fairs (Bandula et al., 2016).

Chamara et al. (2021) explored the traditional knowledge, processing techniques and cooking methods, and nutritional value associated with these species while highlighting the negative opinions younger generation towards these crops. Similarly, Herath (2019) explored the determinants and attitudes of undergraduates towards fruit consumption. Students were attracted by their nutrient content, viz. vitamins, minerals, antioxidants, micronutrients, and active compounds (Figure 2). Most studies conducted on the importance of underutilized fruits have discussed their nutritional value and importance as plant-based food alternatives for diversified diets (Bandula et al., 2016; Chamara et al., 2021; Hunter et al., 2019; Li et al., 2020; Ratnayake & Kumar, 2020; Sahoo et al., 2021). Studies by Chamara et al. (2021), Singh & Bhatnagar (2019) and Weerasinghe & Dahanayake (2021) focus on the significance of certain underutilized fruit species for their medicinal value.

Figure 2: Nutrient content of underutilized crops as inferred from reference literature.



Knowledge of the preparation and processing of underutilized crops has an enormous impact on its demand. In a study undertaken by Chamara et al. (2021), 70% of respondents agreed that this knowledge is fundamental to raising awareness of underutilized crops, especially vegetables. Households that ignored how to prepare them did not use the crops even when available. The same study found that underutilized species are often stigmatized and considered poor man's food. Younger generations are increasingly attracted to modern food varieties, which they eat daily, thus making it more challenging to raise interest in underutilized species.

A total of 118 species (perennials and annuals) were recorded, mentioned and/or studied in the reviewed articles. A limited number of species underwent nutritional and genetic assessments for nutritional value and genetic variation. *Syzygium* spp., Indian bael (*Aegle marmelos*) (Pathirana et al., 2020), 'laulu' (*Pouteria campechiana*), emblic or amla (*Phyllanthus emblica*), *Annona* spp. and *Vigna* spp. were common to most articles and cited as nutrient rich.

3.3 Diversity of underutilized fruits, vegetables, leafy vegetables and root and tuber crops

Agriculture is the result of the many interactions between the environment, the genetic resources growing within this and the management systems, where culturally diverse people attempt to optimize production in different ways. Sri Lanka's agroecological diversity, its biogeography, geographic location and cultural diversity, coupled with its traditional dual agricultural system (small vs large and subsistence vs commercial), as well as its unique and ancient irrigation system (i.e., village tank cascade systems), and different natural vegetation have all played a major role in shaping Sri Lanka's agrobiodiversity (Pushpakumara & Silva, 2008; 2018).

Along with native and endemic species, Sri Lanka's agrobiodiversity has been enriched by the historic introduction of many economically important plant and animal species and their varieties/breeds. As a result, despite its small land area, Sri Lanka is recognized as an agrobiodiversity hotspot and a valuable repository of agricultural genetic resources (MFE, 1999). So much so that the country is included in the Indo-Burma mega-center of cultivated plants and the 12 regions of cultivated plant diversity as proposed by Zeven & de Wet (1982).

At present, Sri Lanka's agricultural landscape consists of cultivation mosaics of rice, subsidiary food crops, fruit crops, plantation crops (tea, rubber, and coconut) and export agriculture crops and home gardens. Around 50% of the country's total land area is under some form of cultivation and hosts a farming population of 10-11 million strong in its diverse agroecosystems. A systematic classification and characterization of Sri Lanka agroecosystems has not yet been undertaken. At present, land classification is only based on the extent of cultivation of different crops (MFE, 1999). Accordingly, rice, annual crops, tea, coconut, rubber, fruit orchards, home gardens and chena based systems are recognized and managed in different production systems distributed in 46 agroecological regions.

Over 792 plant species can be found in Sri Lanka's agroecosystems. Of these, 6%, 44% and 50% are respectively endemic, native, and introduced (Ranil & Pushpakumara, 2015). Plant diversity has been described in rice, other cereal crops, pulses and oil seed crops, root and tuber crops, fruits, vegetables, and leafy vegetables, spices and condiments, fumitory and masticatory crops, plantation crops, ornamental plants, medicinal plants, as well as in agroforestry and timber trees (Pushpakumara and Silva, 2008; 2018). Sri Lanka's crop genetic resources consist of the diversity of genetic material present in agriculturally important plants including traditional varieties, introduced varieties, landraces, wild relatives, advanced breeding lines, primitive cultivars and modern cultivars including hybrids. However, the composition of genetic material of different crop categories are varied according to the status of their domestication (Pushpakumara and Silva, 2018). Sri Lanka also harbors 410 crop wild relatives, belonging to 47 families and 122 genera. Of these 15%, 74% and 11% are respectively endemic, native, and naturalized exotic species. Eco-geographic surveys and mapping exercises have been conducted only for wild relatives of rice, banana, *Vigna* spp., cinnamon, and pepper (Liyanage, 2010). For this paper, only the diversity of fruits, vegetables, leafy vegetables and root and tuber crops are considered (Table 1). Within the text, the species are introduced with their common English, Sinhala and Tamil names and their respective botanical names.

Table 1: Diversity of underutilized fruits, vegetables, leafy vegetables and root and tuber crops found in Sri Lanka.

Underutilized crop category	No. of families	No. of species
Fruits	56	237
Vegetables (including leafy vegetables)	47	105
Leafy vegetables	19	32
Root & tuber crops	5	19

Source: Pushpakumara and Silva (2008)

3.3.1 Fruit genetic resources and their diversity

The diversity of fruit species in Sri Lanka's natural and cultivated systems is represented by about 230 species belonging to 57 families (Pushpakumara & Silva, 2008). However, compared to cereals, only a few species have undergone intensive selection and breeding and much of the genetic resources remain in home gardens as traditional cultivars, landraces, and farmer selections.

Banana (*Musa* spp.), mango (*Mangifera indica*), pineapple (*Ananas comosus*), papaya (*Carica papaya*), rambutan (*Nephelium lappaceum*), avocado (*Persea americana*), pomegranate (*Punica granatum*), sweet orange (*Citrus sinensis*), watermelon (*Citrullus lanatus*), durian (*Durio zibethinus*) and guava (*Psidium guajava*) are the most grown fruit species. Besides these, there are several underutilized fruit species grown in various parts of the country that have only recently gained popularity (Pushpakumara et al., 2011).

Among the different land uses, Kandyan and other homegardens across the country recorded the highest underutilized fruit species diversity in Sri Lanka (Pushpakumara et al., 2016; DOA, 2005). More than 50% percent of the country's underutilized fruits are in fact found as wild/forested food tree resources (DOA, 2005). Most fruit trees have multiple uses and communities use these fruit and tree resources for different purposes such as food and nutrition, for medicinal value, as herbicides and insecticides, fodder, timber, raw material, cultural value, aesthetic value, ecological value, as soil organic matter, fuelwood, and wood charcoal (Pushpakumara et al. 2008; 2011). The diversity of underutilized fruit species recorded in Sri Lanka is listed in Table 2.

Table 2: Underutilized fruit genetic resources of Sri Lanka.

Family	Botanical name	Common name(s)	Plant habit
Anacardaceae	*Spondias dulcis* Sol. ex Parkinson	Amberella (S), Golden apple (E)	Tree
	Anacardium occidentale L.	Kaju-puhulan (S), Cashew (E)	Tree
	Mangifera indica L.	Mee-amba (S)	Tree
	Mangifera zeylanica L.	Etamba/Wal-amba (S), Wild mango (E)	Tree
Annonaceae	*Annona cherimola* Miller	Cherimoya (S/E)	Shrub or Tree
	Annona muricata L.	Katu-annoda/Katu-attha/Rata-anoda (S), Soursop (E)	Tree
	Annona reticulata L.	Weli-anoda/Weli-artha (S), Bullock's heart (E)	Tree
	Annona squamosa L.	Sini-anoda/Seeni-artha (S), Custard apple (E)	Shrub or Tree
Apocynaceae	*Carissa carandas* L.	Mahakaramba (S), karonda (E)	Shrub or tree
	Carissa grandiflora A. DC.	Damson (S), Natal plum (E)	Shrub or tree
	Carissa spinarum L.	Heenkaramba (S), Conkerberry, bush plum (E)	Shrub or tree
Arecaceae	*Nypa fruticans* Wurmb	Gin-pol (S), Nipa palm fruit (E)	Mangrove palm, small tree
	Phoenix farinifera Roxb.	Indi/Wal-indi (S), Ceylon date palm (E)	Palm tree
Celastraceae	*Salacia chinensis* L.	Heen-himbutuwel (S), Lolly berry (E)	Scrambling shrub or liana
	Salacia reticulata L.	Himbutu/Himbutu-wel (S)	Large woody climber
Combretaceae	*Terminalia catappa* L.	Kotamba (S), Indian almond (E)	Tree
Elaeagnaceae	*Elaeagnus latifolia* L.	Katu-embilla/Wel-embilla (S), Bastard oleaster (E)	Scrambling shrub
Elaeocarpaceae	*Elaeocarpus serratus* L.	Veralu (S), Ceylon olive (E)	Tree
	Elaeocarpus granitrus Roxb.	Nil veralu (S), Blue olive (E)	Tree

Family	Botanical name	Common name(s)	Plant habit
Fabaceae	*Cynometra cauliflora* L.	Nam-nam (S/E)	Shrub or Tree
	Dialium ovoideum Thw.	Galsiyabala (S), Valvet tamarind (E)	Tree
Fabaceae (cont.)	*Pongamia pinnata* (L.) Pierre	Gal-karanda/Karanda/ Magul-karanda (S),	Shrub or Tree
	Tamarindus indica L.	Siyabala (S), Tamarind (E)	Tree
Malvaceae	*Grewia tiliifolia* Vahl	Daminiyaa (S/E)	Tree
	Sterculia foetida L.	Telabu (S), Wild almond (E)	Tree
Meliaceae	*Lansium domesticum* Corrêa	Gaduguda(S), Rambi (E)	Tree
Moraceae	*Artocarpus nobilis* Thwaites	Wal-del/Bedi-del/ Hingala-del(S), Ceylon breadfruit (E)	Tree
	Morus alba	Mulberry (S/E)	Small tree
Muntingiaceae	*Muntingia calabura* L.	Jam (S), Manila cherry (E)	Tree
Myrtaceae	*Psidium cattleianum*	Cheenapera (S), Chinese guava (E)	Shrub or Tree
	Psidium guajava L.	Pera (S), Guava (E)	Tree
	Psidium guineense Sw.	Embulpera (S), Sour guava (E)	Tree
	Syzygium caryophyllatum (L.) Alston	Heendan (S), Indian blackberry (E)	Shrub or Tree
	Syzygium cumini (L.) Skeels	Madan (S), Malabar plum, Black plum (E)	Tree
	Syzygium jambos (L.) Alston	Seeni-jambu/Veli-jambu (S), Rose apple (E)	Tree
	Syzygium nervosum A. Cunn. ex DC	Bata damba (S), Damba (E)	Tree
	Syzygium samarangense (Blume) Merr. & L.M. Perry	Pini-jambu (S), Malay apple (E)	Tree
Oxalidaceae	*Averrhoa bilimbi* L.	Biling (S), Bilimbi (E)	Tree

Family	Botanical name	Common name(s)	Plant habit
	Averrhoa carambola L.	Kamaranga (S), Star fruit (E)	Tree
Passifloraceae	*Passiflora quadrangularis* L.	Desi-puhul/Tun-tun (S), Giant granadilla (E)	Climber
Phyllanthaceae	*Antidesma alexiteria* L.	Heen-embilla (S)	Shrub or tree
Phyllanthaceae (cont.)	*Antidesma bunius* (L.) Spreng.	Karawala-kebella (S), Bignay, Queensland-cherry (E)	Tree
	Phyllanthus acidus (L.) Skeels	Rata-nelli (S), Star gooseberry (E)	Tree
	Phyllanthus emblica L.	Beheth-nelli (S), Emblic, Amla (E)	Tree
Primulaceae	*Ardisia elliptica* Thunb	Baludan (S), Coralberry (E)	Shrub
	Embelia ribes subsp. *ribes* Burm.f.	Wel embilla (S), False black pepper (E)	Climber
Punicaceae	*Punica granatum* L.	Local-delum (S), Pomegranate (E)	Large shrub or small tree
Putranjivaceae	*Drypetes sepiaria* (Wight & Arn.) Pax & K. Hoffm	Weera (S/E)	Tree
Rhamnaceae	*Ziziphus mauritiana* var. *mauritiana* Lam.	Masan/Debara/Maha-debara (S), Indian jujube (E)	Tree
	Ziziphus rugosa Lam.	Maha eraminiya (S), Wild jujube (E)	Scrambling shrub or tree
Rubiaceae	*Canthium coromandelicum* (Burm.f.) Alston	Kara (S/E)	Shrub
Rutaceae	*Aegle marmelos* (L.) Corrêa	Beli (S), Baelfruit (E)	Tree
	Citrus × *aurantium* f. *deliciosa* (Ten.) M.Hiroe	Heen-naran(S), Mandarin (E)	Shrub or Tree
	Citrus × *aurantium* L.	Ambul dodam (S), Sour orange (E)	Shrub or Tree
	Citrus × *aurantium* L.	Pani dodam (S), Sweet orange (E)	Shrub or Tree
	Citrus grandis (L.) Osbeck.	Jambola (S), Pumelo (E)	Tree

Family	Botanical name	Common name(s)	Plant habit
	Citrus reticulata Blanco	Mandarine (S/E)	Tree
	Limonia acidissima L.	Divul (S), Woodapple (E)	Tree
Salicaceae	*Dovyalis hebecarpa* (Gardner) Warb.	Ketambilla (S), Ceylon gooseberry (E)	shrub or tree
	Flacourtia indica (Burm.f.) Merr	Uguressa (S), Indian plum (E)	Shrub or Tree
Salicaceae (cont.)	*Flacourtia inermis* Roxb.	Lovi (S), Batoko plum, lovi-lovi (E)	Tree
Sapindaceae	*Dimocarpus longan* Lour	Mora/Penni-mora/Rasa-mora (S), Longan, Dragon's eye (E)	Tree
	Pometia pinnata J.R. Forst. & G. Forst.	Galmora/Bulu-mora, Na-imbul (S), Tava (E)	Tree
	Schleichera oleosa (Lour.) Oken	Koon (S), Ceylon oak (E)	Tree
Sapotaceae	*Manilkara hexandra* (Roxb.) Dubard	Palu (S/E)	Tree
	Manilkara zapota (L.) P. Royen	Sapodilla (S/E)	Tree
	Pouteria campechiana (Kunth) Baehni	Ratalawulu (S), Canistel, yellow sapote (E)	Tree
	Synsepalum dulcificum (Schumach. & Thonn.) Daniell	Peni-gedi (S), Miracle berry (E)	Large shrub
Tiliaceae	*Grewia arborea* Roxb. ex Rottler*	Daminiya (S), Salvia leaved crossberry (E)	Large shrub or small tree

*(S)=Sinhala; (E) = English

3.3.2 Vegetable genetic resources and their diversity

The taxonomic diversity of indigenous vegetables and leafy vegetables in Sri Lanka comprises over 105 species from 47 families (Ranil et al., 2021; Pushpakumara and Silva, 2008; 2018). Currently, vegetable production in the country is heavily dependent on around 25-40 species (Chamara et al., 2021; Ranil et al., 2020; 2021). These vegetable species are grown throughout the country, and most are cultivated commercially. Indigenous varieties are mostly found in the wet zone in low- and mid-country, home gardens, 'owita' systems and 'chena' (slash and burn cultivation system) lands of the tank cascade systems (Rathnayake et al., 2023).

Sri Lanka's vegetable genetic resources include variations of popular varieties, hybrids, and traditional varieties of legumes, solanaceous species, cucurbits, brassicas, leafy vegetables, and others such as moringa (*Moringa oleifera*) 'kohila' (*Lasia spinosa*), and okra (*Abelmoschus esculentus*). At present, the country is almost self-sufficient with respect to its vegetable requirements, largely due to the use of exotic hybrid varieties of 25-40 species. Alongside the commonly grown vegetables, there are many underutilized species that are locally specific that are recently gaining popularity. Some years ago, the Department of Agriculture (DOA) launched a program for the collection and seed production of traditional vegetables varieties. The program revealed that considerable variation exists among traditional vegetable varieties, which are yet to be characterized, purified, and isolated (Personal Communication, Dr. Hemal Fonseka, former Director, HORDI; Director, Onesh Agriculture Private Limited, Colombo). The list of underutilized vegetables including leafy vegetables is provided in Table 3.

3.3.3 Root and tuber crop diversity and their genetic resources

Rathnayake et al. (2023) suggest that about 60 neglected and underutilized varieties of roots and tuber crops exist in Sri Lanka. Their diversity is represented by 19 species belonging to 5 families (Godamulla, 2018; Pushpakumara & Silva, 2008; Pushpakumara and Silva, 2018). They differ by variety and variability based on color, shape, taste, nutritional value, habit etc. Underutilized root and tuber crops include species of *Dioscorea* yams, edible aroids and other rhizomatous plants as shown in Table 4 and are grown small-scale as well as in demonstration units. Most of these species are introduced to Sri Lanka and exhibit secondary genetic diversity. Potato (*Solanum tuberosum* L.), cassava (*Manihot esculenta* Crantz) and sweet potato (*Ipomoea batatas* (L.) Lam.) have not been included in the list as they are the most widely used root and tuber crops.

Roots and tubers are important in Sri Lankan diets contributing to dietary diversity. In addition to their main role as dietary energy contributors, they have several desirable nutritional and health traits. They are antioxidative, hypoglycemic, hypocholesterolemic, antimicrobial, and have immunomodulatory properties. A variety of foods can be prepared using roots and tubers and the type and usage vary with the area of cultivation. The processing affects the crops' bioactive compounds. Tubers may serve as functional foods and contain nutraceutical properties that can help to ease the chronic symptoms of non-communicable diseases while maintaining wellness (Chandrasekara and Kumar, 2016).

Table 3: Underutilized vegetable and leafy vegetable crops of Sri Lanka.

Family	Botanical name	Known varieties	Common name	Part used
Amaryllidaceae	*Allium hookeri* Thwaites		Wal-lunu (S)	Leaves, bulb
Acanthaceae	*Hygrophila schulli* (Buch.-Ham.) M.R. & S.N. Almeida		Neera-mulliya (S), Niramulli (T)	Leaves, tender shoots
Aizoaceae	*Sesuvium portulacastrum* (L.) L.		Sea purslane (E), Maha-sarana (S), Vankiruvilai (T)	Leaves, tender shoots
	Trianthema decandra L.		Desert horsepurslane (E), Maha-sarana (S)	Leaves, tender shoots
	Trianthema portulacastrum L.		Desert horsepurslane (E), Heen-sarana (S)	Leaves, tender shoots
	Zaleya decandra (L.) Burm. f. (*Trianthema decandra* L.)		Maha-sarana (S), Charania (T)	Leaves, tender shoots
Amaranthaceae	*Aerva lanata* (L.) Juss.		Mountain knotgrass(E), Pol-pala (S)	Leaves, tender shoots
	Alternanthera sessilis (L.) R.Br. ex DC	Weda mukunuwenna	Sissoo spinach(E), Mukunu-wenna (S), Ponankani (T)	Leaves, tender shoots
	Amaranthus spinosus L.		Spiny amaranth (E), Katu-kera, Katu-tampala (S), Mudkirai (T)	Leaves, tender shoots
	Amaranthus tricolor L.		Amaranth (E), Tampala (S), Mudkirai (T)	Leaves, tender shoots
	Amaranthus viridis L.		Slender amaranth (E), Kura-tampala (S), Araikkirai (T)	Leaves, tender shoots
	Celosia argentea L.		Kiri-henda (S), Plumed Cockscomb (E)	Leaves, flowers
Apiaceae	*Centella asiatica* (L.) Urb.	Wel gotukola	Gotukola (S), Vallarai (T)	Leaves

Family	Botanical name	Known varieties	Common name	Part used
	Trachyspermum involucratum (Roxb.) Maire		Asamodagam (S)	Leaves
Apocynaceae	*Dregea volubilis* (L.f.) Benth. exHook.f. *(Wattakaka volubilis* (L. f.) Stapf)		Anguna, anguna-kola, Tiththa-anguna (S), Kodi-palai, Kurincha (T)	
	Gymnema lactiferum (L.) R. Br. ex Schult.		Kurinnan(S), Kurinnan (T), Ceylon cow-tree, Ceylon cow plant (E)	Leaves
	Tylophora sp.		Kiri-anguna (S)	Leaves
Aponogetonaceae	*Aponogeton crispus* Thunb.		Wavy-edged Aponogeton (E), Kekatiya (S)	Inflorescence, petiole
	Aponogeton natans (L.) Engl. & K. Krause		Wel-kekatita (S)	Inflorescence, petiole
	Aponogeton rigidifolius Bruggen		Kekatiya (S)	Inflorescence, petiole
Araceae	*Amorphophallus paeoniifolius* (Dennst.) Nicolson		Kidaran (S), Elephant foot yam (E)	Corm
	Colocasia esculenta (L.) Schott		Taro (E), Gahala, kiriala (S)	Stolon
	Lasia spinosa (L.) Thw.		Kohila (S)	Rhizome, immature leaf with petiole
	Pothos scandens L.		Pota-wel (S)	Immature leaves
	Typhonium roxburghii Schott		Panu-ala (S)	Whole plant
	Typhonium trilobatum (L.) Schott		Panu-ala (S)	Whole plant

Family	Botanical name	Known varieties	Common name	Part used
	Xanthosoma sagittifolium (L.) Schott	Isuru	Desi ala, Kiri ala (S), American taro (E)	Tuber
Asclepiadaceae	*Gymnema lactiferum* (L.) RBr ex Schult.		Kiri anguna, Anguna kola (S)	Leaves
	Wattakaka volubilis (L.f.) Stapf.		Kurinnam kola (S), Ceylon cow plant	Leaves
Asparagaceae	*Asparagus falcatus* L.		Hatawariya (S)	Tuber
	Asparagus racemosus Willd.		Hatawariya (S). Chattavari (T)	Tuber
Asteraceae	*Cyanthillium cinereum* (L.) H.Rob.		Monara-kudumbiya (S), Neichatti-kirai (T), Little ironweed (E)	Leaves
	Eclipta prostrata (L.) L.		Kikirindi (S), Kaikechi (T)	Leaves
Basellaceae	*Basella alba* L.	Red stem type, green stem type	Nivithi (S), Pasalai (T), Malabar spinach (E)	Leaves, young shoots and stem
Begoniaceae	*Begonia cordifolia* (Wight) Thwaites		Gal-ambala (S)	Leaves
	Begonia malabarica Lam.		Hak-ambala (S)	Leaves
Boraginaceae	*Cordia dichotoma* G. Forst.		Lolu (S), Sebesten plum (E), Naruvilli, Vidi (T)	Leaves, fruits
	Ehretia microphylla Lam. (*Carmona retusa* (Vahl) Masamune)		Heen-tambala (S), Pakkuvetti (T), Fukien tea tree (E)	Leaves, young shoots
Brassicaceae	*Cardamine africana* L.		Wel-aba-kola (S)	Leaves
	Cardamine hirsuta L.		Wel-aba-kola (S), Hairy bittercress (E)	Leaves

Family	Botanical name	Known varieties	Common name	Part used
Blechnaceae	*Blechnum orientale* L.		Baru-koku (S)	Circenatly coiled Leaves
Cannaceae	*Canna indica* L.**	Red buthsarana, white buthsarana	Buthsarana (S), Indian shot, Canna (E), Kalvazhai	Rhizome
Caryophyllaceae	*Drymaria cordata* subsp. *diandra* (Blume) J.A. Duke		Kukulu-pala (S), tropical chickweed (E)	Leaves
Commelinaceae Commelinaceae (cont.)	*Commelina benghalensis* L.		Diya-meneiya (S), Benghal dayflower (E)	Leaves, young shoots
	Commelina diffusa Burm.f.		Gira-pala (S), Climbing dayflower (E)	Leaves, young shoots
	Murdannia esculenta (Wall. ex C.B. Clarke) R.S. Rao & Kammathy		Kiri-bada-tel (S)	Leaves, young shoots
	Murdannia nudiflora (L.) Brenan		Kiri-bada-tel (S)	Leaves, young shoots
Convolvulaceae	*Argyreia populifolia* Choisy**		Giri-tilla (S)	Leaves
	Bonanox indica Raf. (*Ipomoea alba* L.)		Alamnga (S), Moon vine (E), Naganamukkorai (T)	Fruits without seed parts
	Ipomoea aquatica Forssk.		Kankun (S), Water spinach (E)	Leaves, young shoots and stems
	Ipomoea littoralis Blume		Tel-kola (S)	Leaves
Costaceae	*Cheilocostus speciosus* (J. König) C. Specht		Tebu (S), Crêpe ginger (E)	Leaves, young shoots
	Costus speciosus (Koenig) Smith		Thebu kola (S), Crêpe ginger	Leaves, stem

Family	Botanical name	Known varieties	Common name	Part used
Cucurbitaceae	*Benincasa hispida* (Thunb.) Cogn.		Alupuhul (S), Ash pumpkin, Ash gourd (E), Puchini, Neer poosanikai, Pooshnikai(T)	Fruit
	Coccinia grandis (L.) J. Voigt		Kowakka (S), Ivy gourd (E), Kovvai (T)	Leaves
	Diplocyclos palmatus (L.) C. Jeffrey		Pasagilla-gedi (S), Native bryony, striped cucumber (E)	Fruits
	Momordica charantia L.		Karavila (S), Bitter gourd (E), Pakal (T)	Fruits
	Momordica denudata (Thw.) C.B. Clarke		Batu-karavila (S)	Fruits
	Momordica dioica Roxb. ex Willd		Tumba-karavila (S), Spine gourd (E), Paluppakal (T)	Fruits
	Mukia maderaspatana (L.) M. Roem. (*Cucumis maderaspatanus*)		Gon-kekiri (S), Mochumochukka (T)	Fruits
	Solena amplexicaulis (Lam.) Gandhi		Kawdu-kekiri (S), Peyppudal (T)	Fruits
	Trichosanthes anguina L.		Pathola (S), Snake gourd (E)	Fruits
	Trichosanthes cucumerina L.		Dum-mella, Kunu-mella (S), Pudal (T)	Fruits
Cycadaceae	*Cycas circinalis* L.		Madu (S)	Immature stem/Leaves
	Cycas nathorstii J. Schust.		Madu (S)	Immature stem/Leaves
Dioscoreaceae	*Dioscorea alata* L.	Raja ala, Kakulu ala	Raja ala, Rata ala (S), King yam, Greater yam (E), Urumpirai (T)	Stem-tuber

Family	Botanical name	Known varieties	Common name	Part used
	Dioscorea bulbifera L.		Udala, Panu-kondol (S), Aerial yam (E), Mothaka (T)	Stem-tuber
	Dioscorea esculenta (Lour.) Burkill.	Suta kukulala	Heen kukulala, Katu kukulala (S), Asiatic yam, Chinese yam (E), Siru valli (T)	Stem-tuber
	Dioscorea koyamae Jayasuriya**		Gonala, Kahata-gonala (S)	Stem-tuber
	Dioscorea oppositifolia L.		Hiritala, Kitala (S)	Stem-tuber
	Dioscorea pentaphylla L.		Katu-ala (S), Allai (T)	Stem-tuber
	Dioscorea spicata Roth		Gonala (S)	Stem-tuber
	Dioscorea tomentosa Koenigh ex Spreng.		Uyala (S)	Stem-tuber
	Dioscorea trimenii Prain & Burkill**		Dahiya-ala (S)	Stem-tuber
Euphorbiaceae	*Acalypha indica* L.		Kuppameniya (S), Kuppameni (T)	Leaves
Fabaceae	*Canavalia gladiata* (Sw.) DC.		Awara (S), Sword bean (E)	Immature pod, seed
	Cyamopsis tetragonoloba (L.) Taub.		Kotaranga (S), Koth-averay (T), Guar, Cluster bean (E)	Immature pod
	Lablab purpureus (L.) Sweet		Lablab bean (E), Kos-eta-dambala (S)	Immature pods, seed
	Mucuna pruriens (L.) DC.		Cowage, Velvet bean (E), Wanduru-me (S), Chunao-varai (T)	Seeds
	Psopocarpus tetragonolobus (L.) DC		Dambala (S), Winged bean (E)	Fruit/Leaves

Family	Botanical name	Known varieties	Common name	Part used
	Senna auriculata (L.) Roxb. (*Cassia auriculata* L.)		Rana-wara (S), Matara tea (E), Avarai (T)	Leaves
	Senna tora (L.) Roxb. (*Cassia tora*)		Peti-tora (S), Vaddutakarai (T)	Leaves
	Sesbania grandiflora (L.) Poir.	Red flower type, white flower type, haritha (rarely flowered)	Kathurumurunga (S), Hummingbird tree (E)	Leaves, flowers
	Vigna marina (Burm.) Merr.		Field bean (E), Karal-li-me (S), Kodippayaru (T)	Leaves, Pods
Gleicheniaceae	*Dicranopteris linearis* (Burm.f.) Underw.		Kekilla (S)	Circinately coiled Leaves
Lamiaceae	*Leucas zeylanica* (L.) W. T.Aiton		Geta-tumba (S), Mudi-tumpai (T), Ceylon slitwort (E	Leaves
	Pogostemon heyneanus Benth.		Gas-kollan-kola (S)	Leaves
	Plectranthus rotundifolius (Poir.) Spreng. (*Coleus rotundifolius* (Poir.) A. Cheval. & Hook. F.)	Binari	Innala (S), Country potato, Chinese potato (E)	Root
	Premna procumbens Moon**		Le-kola-pala (S), Mulla, Mullai (T)	Leaves
	Rotheca serrata (L.) Steane & Mabb. (*Clerodendrum serratum* (L.) Moon)		Kan-henda (S), Chiru-dekku (T), Blue fountain bush (E)	Leaves
Lecythidaceae	*Careya arborea* Roxb.		Patana-oak (E), Kahata (S), Kachaddai (T), Wild guava, Ceylon oak, patana oak (E)	Flowers, Fruits

Family	Botanical name	Known varieties	Common name	Part used
Malvaceae	*Abelmoschus moschatus* Medik.		Kapu-kinissa (S), Katukkasturi (T)	Immature fruits
	Hibiscus surattensis L.			
Marantaceae	*Goeppertia allouia* (Aubl.) Borchs. & S.Su rez		Artichoke	Tuber, inflorescence
	Maranta arundinacea L.		Hulan-kiriya (S)	Rhizome
Marattiaceae	*Angiopteris evecta* (Forst.) Hoffm.		Wal-menda (S), Elephant Fern (E)	Circinately coiled leaves
Melastomataceae	*Osbeckia octandra* (L.) DC.**		Heen-bovitiya (S) Eight stamen osbeckia (E)	Leaves
Molluginaceae	*Glinus oppositifolius* (L.) Aug. DC.		Heen-pala (S), Kachantarai (T)	Leaves
Moraceae	*Ficus racemosa* L.		Attikka (S), Atti (T), Cluster fig, red river fig (E)	Leaves, fruits
Moringaceae	*Moringa oleifera* Lam.		Drumstick tree (E), Murunga (S), Murungamaram (T)	Pod, leaves
Nelumbonaceae	*Nelumbo nucifera* Gaertn.		Nelum (S), Tamarai (T), Lotus (E)	Rhizome
Nyctaginaceae	*Boerhavia diffusa* L.		Pita-sudu-pala (S), Karichcharanai (T), Red spiderling, spreading hogweed (E)	Leaves, young shoot
	Pisonia grandis R.Br.		Watha-banga (S), Chandi (T), Lettuce tree (E)	Leaves
Nymphaeaceae	*Nymphaea nouchali* Burm.f.		Maneal (S), Blue lotus, star lotus (E)	Rhizome, flower stalk

Family	Botanical name	Known varieties	Common name	Part used
	Nymphaea pubescens Willd.		Et-olu (S), Hairy water lily, pink waterlily (E)	Rhizome
Olacaceae	*Olax imbricata* Roxb.		Telatiya (S)	Young shoot, fruits
	Olex zeylanica (L.) R. Br.		Mella kola	Leaves
Phyllanthaceae	*Antidesma bunius* (L.) Spreng.		Karawala-kebella	Leaves
	Aporosa cardiosperma (Gaertn.) Merr. (*Aporosa lindleyana* (Wight) Baill.)		Kebella (S)	Leaves
	Sauropus androgynus (L.) Merr.		Japan–batu (S), Katuk, Star gooseberry, or sweet leaf (E)	Leaves
Plantaginaceae	*Bacopa monnieri* (L.) Wettst.		Lunu-wila (S), Water hyssop (E)	Leaves
Pteridaceae	*Acrostichum aureum* L.		Karen-koku (S), Golden leather fern (E)	Circinately coiled leaves
Pontederiaceae	*Monochoria hastata* (L.) Solms		Diya-habarala (S), Arrow leaf pondweed (E)	Leaves, young shoot
	Monochoria vaginalis (Burm.f.) C. Presl		Diya-habarala (S), Heartshape false pickerelweed, oval-leafed pondweed (E)	Leaves, young shoot
Portulacaceae	*Portulaca oleracea* L.		Genda-kola (S), Pulikkirai (T), Common purslane (E)	Leaves, young stem
	Talinum paniculatum (Jacq) Gaertn.		Gas nivithi (S), Flame flower (E)	Leaves, young stem
Rubiaceae	*Canthium coromandelicum* (Burm. f.) Alston		Kara (S), Pulikkirai (T)	Leaves
	Hedyotis fruticosa L.		Weraniya (S)	Leaves

Family	Botanical name	Known varieties	Common name	Part used
	Hedyotis neesiana Arn.		Pita-sudu-pala (S)	Leaves
	Psychotria sarmentosa Blume		Wal-gonika (S)	Leaves
	Tamilnadia uliginosa (Retz.) Tirveng. & Sastre		Wadiga (S), Divine Jasmine (E)	Fruits
Sapindaceae	*Cardiospermum halicacabum* L.		Penela (S), Lesser balloon vine, balloon plant (E)	Leaves
Solanaceae	*Physalis micrantha* Link		Andibatu kola	Leaves
	Solanum violaceum Ortega		Thitta-Tibbatu (S)	Fruits
	Solanum macrocarpon L.		Elabatu (S)	Fruits, young leaves
	Solanum americanum Mill.		Kalukamveriya (S)	Leaves, Fruits
	Solanum trilobatum L.		Wel-tibbatu (S)	Fruits
	Solanum nigrum L.		Kalukanberiya (S)	Leaves, fruit
Tilinaceae	*Talinum paniculatum* (Jacq) Gaertn		Gasnivithi (S), Fameflower, Jewels-of-Opar (E)	Leaves, stem
Woodsiaceae	*Diplazium esculentum* (Retz.) Sw.		Miyena-dalu (S), Vegetable fern (E)	Circinately coiled Leaves

Note: (S)=Sinhala; (E) = English; (T)=Tamil

** Species endemic to Sri Lanka

Table 4: Underutilized root and tuber crops of Sri Lanka

Family	Botanical name	Known varieties	Common name	Part used
Araceae	*Alocasia macrorrhizos* (L.) G. Don		Habarala (S), Giant taro (E)	Root
	Amorphophallus paeoniifolius (Dennst.) Nicolson		Kidaran (S), Elephant foot yam (T)	Corm
	Colocasia esculenta (L.) Schott		Taro (E), Gahala, kiriala (S)	Root
	Typhonium roxburghii Schott		Panu-ala (S)	Whole plant
	Typhonium trilobatum (L.) Schott		Panu-ala (S)	Whole plant
	Xanthosoma sagittifolium (L.) Schott	Isuru	Desi ala, Kiri ala (S), American taro (E)	Tuber
Cannaceae	*Canna indica* L.	Red buthsarana, white buthsarana	Buthsarana (S), Indian shot, Canna (E), Kalvazhai (T)	Tuber
Dioscoreaceae	*Dioscorea alata* L.	Raja ala, Kakulu ala	Raja ala, Rata ala (S), King yam, Greater yam (E), Urumpirai (T)	Stem-tuber
	Dioscorea bulbifera L.		Udala, Panu-kondol (S), Aerial yam (E), Mothaka (T)	Stem-tuber
	Dioscorea esculenta (Lour.) Burkill.	Suta kukulala	Heen kukulala, Katu kukulala (S), Asiatic yam, Chinese yam (E), Siru valli (T)	Stem-tuber
	Dioscorea koyamae Jayasuriya**		Gonala, Kahata-gonala (S)	Stem-tuber
	Dioscorea oppositifolia L.		Hiritala, Kitala (S)	Stem-tuber
	Dioscorea pentaphylla L.		Katu-ala (S), Allai (T)	Stem-tuber
	Dioscorea spicata Roth		Gonala (S)	Stem-tuber

Family	Botanical name	Known varieties	Common name	Part used
	Dioscorea tomentosa Koenigh ex Spreng.		Uyala (S)	Stem-tuber
	Dioscorea trimenii Prain & Burkill**		Dahiya-ala (S)	Stem-tuber
Lamiaceae	*Coleus rotundifolius* (Poir.) A. Chev. & Perrot		Innala (S), Country potato, Chinese potato (E)	Tuber
Marantaceae	*Goeppertia allouia* (Aubl.) Borchs. & S.Su rez		Guinea arrowroot, sweet corn root (E)	Tuber, inflorescence
	Maranta arundinacea L.		Hulan-kiriya (S), Arrow root (E)	Tuber

Note: (S)=Sinhala; (E) = English; (T)=Tamil

** Species endemic to Sri Lanka

3.4 Collections, conservation, crop improvement, seed systems' issues of underutilized fruit, vegetable and root and tuber crops

3.4.1 Gap analysis - Priority traditional and indigenous vegetables (and fruits) and target regions for collection and identification of partners for future collection and conservation under FRESH.

Although priority setting is an important step to identify species for conservation, collection, crop improvement and to address issues of seed systems, no systematic priority setting exercises have been carried out in Sri Lanka for underutilized species for their sustainable use (MoMD&E, 2016; Pushpakumara et al., 2008; 2011). Among the most important vegetable crops, the DOA has identified priority species for crop improvement programmes to be undertaken at their research stations. Among these are eggplant (brinjal), tomato, bean, potato, capsicum, pumpkin, okra, and yard long bean. The medium priority vegetable crops include cucumber, bitter gourd, luffa, snake gourd and spiny gourd, leafy vegetables, root and tuber crops, mushrooms, ash banana and moringa. Among the lower priority vegetable crops are carrot, beet, leek, cabbage, radish, ash pumpkin, Chinese cabbage, cauliflower, broccoli, and traditional vegetables (Personal Communication, Ms. Theja Nanayakkara, HORDI, Gannoruwa, Peradeniya, Sri Lanka).

Recently, neglected and underutilized fruit species in Sri Lanka were prioritized by Rathnayake et al. (2020) using 26 criteria (Table 5) and a fruit selection index (Table 6). The research also provided information on the potential distribution of these priority species based on environmental factors that influence or limit their distribution under different climate change scenarios. In the case of underutilized vegetable and leafy vegetable species, other than the distribution maps prepared based on herbarium samples deposited at the National Herbarium by Peradeniya by Ranil et al. (2021), there has been no comprehensive study undertaken on priority settings or potential distribution of vegetable species in Sri Lanka. Similarly, for the underutilized root and tuber crops no priority setting process has been carried out.

Table 5: Criteria used to prioritize neglected and underutilized fruit species (NUFS) in Sri Lanka.

No.	Category	Inclusion criteria description
1	*Research & policy framework*	Importance for national food production and food security programmes
		Importance for national and regional agriculture research system
2	*Germplasm & agroecology*	Availability of germplasm
		Current genetic conservation status
		Potential demand for germplasm
		Adaptation to local climate and soil
3	*Acceptability*	Local preferences/consumption
		Rural income generation
4	*Uses*	Nutritional value and health benefits

No.	Category	Inclusion criteria description
		Cultural acceptance and consumer preferences
		Potential diversification for products
		Multiple uses (wood value, medicinal value, etc.)
5	*Production practices*	Wide adaptability
		Cropping systems' suitability
		Satisfies need for crop diversification
		Pest/disease situation
		Production and technology
		Seasonality
		Availability of planting material
		Local Knowledge
6	*Post harvest*	Possibility of storage
		Processing technology
		Products in relation to market
7	*Market and value chain*	Access to market
		Potential value addition
		Potential export processing

Source: Rathnayake *et al.* (2020)

As priority setting is an important element in the conservation and sustainable use of underutilized species, 30 fruit species were prioritized using the fruit selection index defined by Rathnayake et al. (2020) (Table 6) by 35 experts from Government Departments and research stations, academia, non-governmental organizations, and leaders of community-based organizations.

The same 26 statement criteria and methodology used by Rathnayake et al. (2020) were also used to prioritize underutilized vegetable by defining a vegetable selection index (Table 7), a leafy vegetable selection index (Table 8) and a root and tuber crop selection index (Table 9).

Table 6: Ranking of 30 Sri Lankan neglected and underutilized fruit species resulting from the priority setting exercise using the fruit selection index (FSI).

Rank	Scientific Name	Family	Common Name	Local Name	FSI
1	*Limonia acidissima*	Rutaceae	Wood apple	Divul	0.696
2	*Aegle marmelos*	Rutaceae	Bhel, bhal	Beli	0.674
3	*Annona muricata*	Annonaceae	Soursop	Katuannoda	0.648
4	*Phyllanthus emblica*	Phyllanthaceae	Emblic	Amla, Nelli	0.629
5	*Tamarindus indica*	Fabaceae	Tamarind	Siyambala	0.595
6	*Citrus reticulata*	Rutaceae	Mandarine	Dodam	0.564
7	*Psidium guajava*	Myrtaceae	Guava	Pera	0.535
8	*Syzygium aqueum*	Myrtaceae	Water apple	Jambu	0.438
9	*Garcinia quaesita*	Clusiaceae	Brindle berry	Goraka	0.403
10	*Dialium ovoideum*	Fabaceae	Velvet tamarind	Gal siyambala	0.401
11	*Mangifera indica*	Anacardiaceae	Mango	Mee amba	0.399
12	*Citrus grandis*	Rutaceae	Pomelo	Jambola	0.399
13	*Psidium cattleianum*	Myrtaceae	Cherry guava	Cherry pera	0.351
14	*Flacourtia inermis*	Salicaceae	Lovi-lovi/batoko plum	Lovi	0.351
15	*Pouteria campechiana*	Sapotaceae	Canistel	Lavulu	0.341
16	*Elaeocarpus serratus*	Elaeocarpaceae	Ceylon olive	Veralu	0.337
17	*Lansium domesticum*	Meliaceae	Langsat	Gaduguda	0.337
18	*Flacourtia indica*	Salicaceae	Ramontchi, Indian plum	Uguressa	0.326
19	*Manilkara zapota*	Sapotaceae	Sapodilla	Sapodilla	0.309
20	*Ziziphus mauritiana*	Rhamnaceae	Indian Jujube	Masan	0.309
21	*Averrhoa carambola*	Oxalidaceae	Carambola	Kamaranga	0.253
22	*Psidium* spp.	Myrtaceae	Guava	Jam pera	0.233
23	*Syzygium cumini*	Myrtaceae	Malabar plum	Dan	0.222

Rank	Scientific Name	Family	Common Name	Local Name	FSI
24	*Cynometra cauliflora*	Fabaceae	Nam nam	Nam nam	0.201
25	*Carissa spinarum*	Apocynaceae	Conkerberry	Karamba	0.201
26	*Manilkara haxandra*	Sapotaceae	Ceylon iron wood	Palu	0.191
27	*Grewia tiliifolia*	Tiliaceae	Daminiya	Daminiya	0.139
28	*Euphoria longana*	Malvaceae	Longan	Mora	0.128
29	*Schleichera oleosa*	Sapindaceae	Ceylon oak	Kon	0.128
30	*Drypetes sepiaria*	Putranjivaceae	-	Weera	0.128

Source: Rathnayake *et al.* (2020)

Table 7: Ranking of 22 Sri Lankan underutilized vegetable species resulting from the priority setting exercise using the vegetable selection index (VSI).

Rank	Scientific Name	Family	Common Name	Local Name	VSI
1	*Moringa oleifera* Lam.	Moringaceae	Moringa, drumstick tree	Murunga	0.903
2	*Lasia spinosa* (L.) Thw.	Araceae	Lasia	Kohila	0.855
3	*Canavalia gladiata* (Jacq.) DC.	Fabaceae	Sword bean	Awara	0.819
4	*Psophocarpus tetragonolobus* (L.) DC.	Fabaceae	Winged bean	Dambala	0.817
5	*Amaranthus tricolor* L.	Amaranthaceae	Amaranthus	Thampala	0.774
6	*Coccinia grandis* (L.) J. Voigt	Cucurbitaceae	Ivy gourd	Kowakka	0.746
7	*Trichosanthes anguina* L.	Cucurbitaceae	Snake gourd	Pathola	0.742
8	*Mucuna pruriens* (L.) DC.	Fabaceae	Cowage, Velvet bean	Wanduru me	0.732
9	*Osbeckia octandra* (L.) DC.	Melastomataceae	Eight stamen osbeckia	Heen bowitiya	0.720
10	*Momordica charantia* L.	Cucurbitaceae	Bitter gourd	Local karawila	0.712
11	*Cycas circinalis* L.	Cycadaceae	Queen sago	Madu	0.651

Rank	Scientific Name	Family	Common Name	Local Name	VSI
12	*Abelmoschus esculentus* (L.) Moench	Malvaceae	Okra	Athdala bandakka	0.645
13	*Hygrophila schulli* (Buch.-Ham) M.R. & S.N. Almeida	Acanthaceae	Long leaved barleria	Neera mullia	0.633
14	*Trianthema decandra* L.	Aizoaceae	Desert horsepurslane	Maha sarana	0.615
15	*Costus speciosus* (Koenig.) Smith	Costaceae	Crêpe ginger	Thebu	0.613
16	*Benincasa hispida* (Thumb.) Cogn.	Cucurbitaceae	Ash pumpkin	Alupuhul	0.609
17	*Cardiospermum halicacabum* L.	Sapindaceae	Lesser balloon vine, balloon plant	Penela	0.589
18	*Nelumbo nucifera* Gaertn.	Nelumbonaceae	Lotus	Nelum ala	0.563
19	*Portulaca oleracea* L.	Portulaceae	Common purslane	Genda pala	0.554
20	*Aponogeton crispus* Thunb.	Aponogetonaceae	Wavy-edged Aponogeton	Kekatiya	0.548
21	*Luffa cylindrica* (L.) M. Roemer	Cucurbitacea	Sponge gourd	Niyan wetakolu	0.540
22	*Talinum paniculatum* (Jacq.) Gaertn.	Portulacaceae	Fameflower, Jewels-of-Opar	Gas nivithi	0.534

Table 8: Ranking of 19 Sri Lankan underutilized leafy vegetable species resulting from the priority setting exercise using the vegetable selection index (VSI).

Rank	Scientific Name	Family	Common Name	Local Name	VSI
1	*Lasia spinosa* (L.) Thw.	Araceae	Lasia	Kohila	0.855
2	*Sesbania grandiflora* (L.) Poir	Fabaceae	Vegetable hummingbird	Kathurumurunga	0.845

Rank	Scientific Name	Family	Common Name	Local Name	VSI
3	*Wattakaka volubilis* (L.f.) Stapf.	Aslepiadaceae		Anguna kola	0.832
4	*Psophocarpus tetragonolobus* (L.) DC.	Fabaceae	Winged bean	Dambala	0.817
5	*Amaranthus tricolor* L.	Amaranthaceae	Amaranth	Thampala	0.774
6	*Basella alba* L.	Basellaceae	Malabar spinach	Nivithi	0.763
7	*Trachyspermum involucratum* (Roxb.) Maire.	Apiaceae		Asamodagam	0.667
8	*Boerhavia diffusa* L.	Nyctaginaceae	Red spiderling, spreading hogweed	Pitasudu pala	0.662
9	*Cycas circinalis* L.	Cycadaceae	Queen sago	Madu	0.651
10	*Hygrophila schulli* (Buch.-Ham) M.R. & S.N. Almeida	Acanthaceae	Long leaved barleria	Neera mullia	0.633
11	*Trianthema decandra* L.	Aizoaceae		Maha sarana	0.615
12	*Costus speciosus* (Koenig.) Smith	Costaceae	Crêpe ginger	Thebu	0.613
13	*Cardiospermum halicacabum* L.	Sapindaceae	Lesser balloon vine, balloon plant	Penela	0.589
14	*Talinum paniculatum* (Jacq.) Gaertn.	Portulacaceae	Fameflower, Jewels-of-Opar	Gas nivithi	0.534
15	*Olex zeylanica* (L.) R.Br.	Olacaceae		Mella kola	0.520
16	*Physalis micrantha* Link	Solanaceae		Adibatu kola	0.512

Rank	Scientific Name	Family	Common Name	Local Name	VSI
17	*Senna tora* L.	Fabaceae		Tora kola	0.510
18	*Passiflora edulis* Sims	Passifloraceae	Passion fruit	Wel dodam	0.501
19	*Gymnema lactiferum* (L.) R.Br. ex Schult.	Asclepiadaceae	Ceylon cow-tree, Ceylon cow plant	Kurinnam kola	0.498

Table 9: Ranking of 8 Sri Lankan underutilized root and tuber crop species resulting from the priority setting exercise using the vegetable selection index (VSI).

Rank	Scientific Name	Family	Common Name	Local Name	VSI
1	*Dioscorea alata* L.	Dioscoreaceae	Greater yam, King yam	Raja ala	0.780
2	*Goeppertia allouia* (Aubl.) Borchs. & S.Su rez	Marantaceae	Guinea arrowroot, sweet corn root	Artichoke	0.766
3	*Plectranthus rotundifolius* (Poir.) Spreng.	Lamiaceae	Country potato	Innala	0.702
4	*Stachyphrynium spicatum* (Roxb.) K.Schum.	Marantaceae	Arrowroot	Hulankeeriya	0.690
5	*Canna indica* L.	Cannaceae	Indian shot	Buthsarana	0.673
6	*Colocasia esculenta* (L.) Schott	Araceae	Taro	Kiriala	0.649
7	*Xanthosoma sagittifolium* (L.) Schott	Araceae	American taro	Desi ala	0.593
8	*Amorphophallus paeoniifolius* (Dennst.) Nicolson	Araceae	Elephant foot yam	Kidaran	0.552

Source: Rathnayake *et al.* (2020)

3.5 Opportunities and approaches to monitor biodiversity and rescue threatened fruit and vegetable diversity that uses a complementary conservation approach

In Sri Lanka, agricultural genetic resources and their biodiversity have long been recognized as most valuable for agricultural development. Agrobiodiversity provides food and commodities for economic growth along with social and economic benefits. As an important source of income for farmers, agricultural genetic resources are also critical for wealth creation and for food security programmes. Thus, the sustainable management of agricultural genetic resources is essential for agricultural

development, i.e., for increasing food production, poverty alleviation and to promote national economic growth (Pushpakumara and Silva, 2018).

In Sri Lanka, the conservation and sustainable use of fruit and vegetable diversity, along with other crops, are largely formulated and implemented via long-established national institutes that have specific mandates for different crops (Table 10). The conservation of agricultural biodiversity is possible through in situ, ex situ and on-farm conservation approaches. It is understood that genetic resources of crop wild relatives, underutilized species and naturally occurring agriculturally important plants and medicinal plants are effectively and efficiently conserved in their natural ecosystems. In Sri Lanka, this is achieved through an established protected area network. At present, the network covers over 29.2% of the country's total land area (Premakantha et al., submitted) managed by the Forest Department (FD), the Department of Wildlife Conservation (DWC) and the Central Environmental Authority (Table 10). However, detailed research is scanty on the distribution and genetic diversity of underutilized fruit and vegetable species in protected areas.

In general, protected areas in the Dry and Wet zones of Sri Lanka are rich in wild relatives of cereals, vegetables and underutilized fruit and vegetable species. A limited number of eco-geographic studies on crop wild relatives revealed that high genetic diversity of wild species exists in the protected area network but that their distribution is spread out (Liyanage, 2010). No such studies have been conducted for underutilized fruits, vegetables (including leafy vegetables) and root and tuber crops. In addition, genetic resources of underutilized crops and their wild relatives are also located outside existing protected areas. Some of these lands are private and most of them are disturbed by anthropogenic activities, hence the difficulty to set them aside for the conservation of crop wild relatives and/or underutilized species. The literature review revealed that there is a dearth of information on the collection, characterization and evaluation of underutilized fruit, vegetables and root and tuber crops in natural environments. Further, comprehensive assessments of the distribution of underutilized crop species have not been conducted (Dahanayake, 2015; Ranil et al., 2020). Ranil et al. (2020), who studied the samples deposited at the national herbarium and the national red list of 2012, revealed that 28% of indigenous vegetables are categorized as threatened (MoE, 2012).

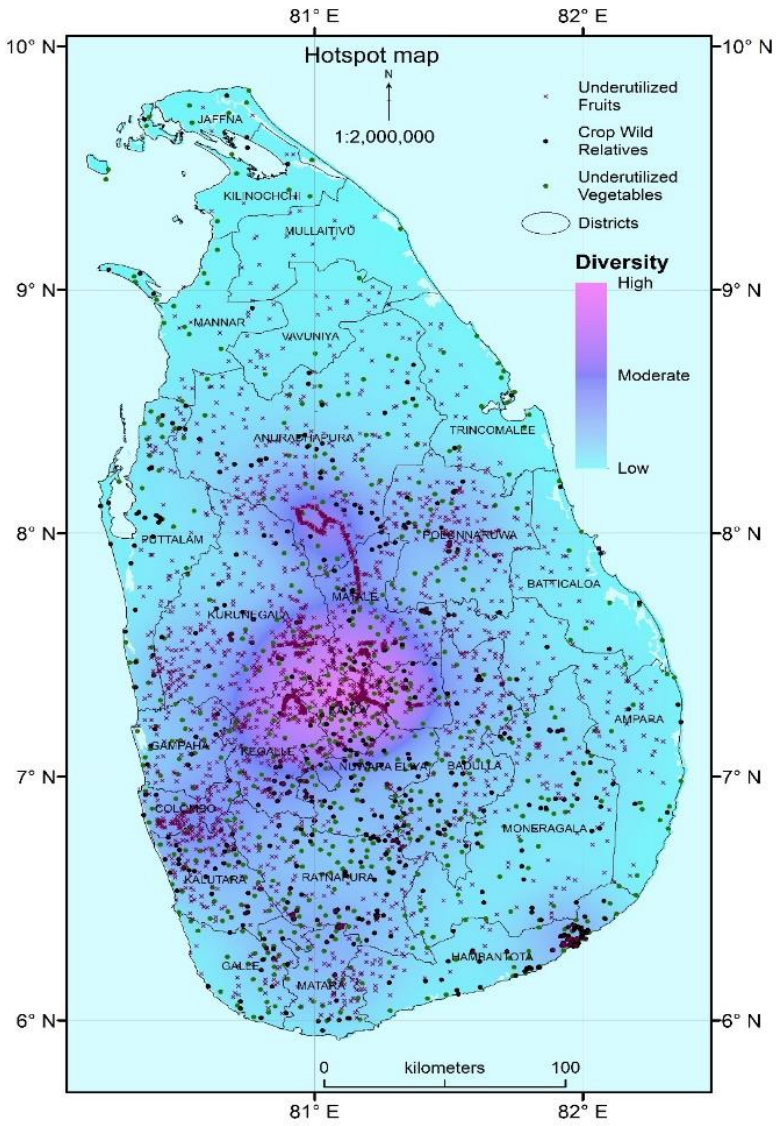
Recently, Rathnayake et al. (2023) reported that neglected and underutilized plant species in Sri Lanka are distributed in various landscapes such as aquatic landscapes, wetlands, forests, owita systems, home gardens, tank cascade systems, plantations and in commercial agricultural systems. Based on past eco-geographic survey data, high-value (hotspots) areas have been mapped (Rathnayake et al., 2023). These hotspots are shown in Figure 3. Species are distributed across the country but converge largely in the central and southern parts of the wet zone areas.

The Department of National Botanical Gardens (DNBG) is the main agency responsible for the ex situ conservation of Sri Lankan plants. The National Herbarium of Peradeniya maintains the national repository of preserved flora. The Royal Botanic Gardens of Peradeniya and its botanic garden network under the DNBG identified developing technologies related to the exploitation of lesser-known and underutilized plant species as one of its objectives. Their plant collection also includes some fruit trees and many herbarium samples of fruit and vegetable species including underutilized species (Table 10).

The Sam Popham's Arboretum, which belongs to the National Institute of Fundamental Studies (NIFS), also supports the ex-situ conservation of plants, especially medicinal plants. The National Herbarium is the main institution responsible for the authentication of Sri Lankan plants. It is actively involved in plant exploration and taxonomic investigations of the flora of Sri Lanka. At present, the total number of specimens at Peradeniya (PDA) is about 160,000 (DNBG, 2022). In addition, the Department of

Ayurveda also contributes to the ex-situ conservation of medicinal plants. Their network includes the Ayurvedic herbal garden, alongside the Haldummulla and herbal gardens of Girandurukotte, Kanneliya, Navinna, Pattipola and Pinnaduwa.

Figure 3: Sri Lanka's hotspots for neglected and underutilized fruit and vegetable species as well as their wild relatives based on spatial distribution of species occurrence data.



Source: Rathnayake *et al.* (2020)

Further, Sri Lanka has a national programme for the ex-situ conservation of agricultural genetic resources that uses deed genebanks, in vitro genebanks, field genebanks, botanical gardens, arboreta, and cryopreservation. The Plant Genetic Resources Centre (PGRC) is the nodal organization for promoting and facilitating the conservation and sustainable use of crop genetic resources. It has national responsibility for conserving all food crops and their wild relatives. The PGRC is responsible for planning and conducting plant exploration, collection, introduction, evaluation, documentation, and conservation of the genetic diversity of food crops and their wild relatives for the benefit of present and future generations (Table 10).

Table 10: National institutional capacity for the conservation and sustainable use of agricultural genetic resources of fruits and vegetable (including underutilized) species in Sri Lanka.

Ministry	Department	Institute/Centre	PGR category	No. of accessions/plants
Ex situ conservation of fruit, vegetable and root and tuber crops (including underutilized species) genetic resources				
Agriculture	Agriculture (1912)	PGRC, Gannoruwa (1988)	All crops	16,882
		RRDI, Bathalagoda (1952)	Rice	
		FCRDI, Mahailuppallama (1994)	Field crops	
		HORDI, Gannoruwa (1967)	Vegetables, Root & tuber crops	
		FRDI, Horana (2013)	Fruits	
		NPQS, Katunayake (1994)	All crops	
		GLORDC, Angunakolapaless (1994)	Grain legumes and oil crops	
		RARDC at Makandura, Bandarawela, Aralaganwila, Bombuwela, Vavunia	Many crops including vegetables and leafy vegetables	
		A-Park, Gannoruwa	Leafy vegetable garden, root and tuber crop demonstration unit	
Tourism & Lands	National Botanic Gardens (2006)	RBG, Peradeniya (1821) National Herbarium	Trees, herbs, shrubs	> 4,000
		BG, Hakgala (1861)	Trees, herbs, shrubs	> 5,000
		BG, Gampaha (1876)	Trees, herbs, shrubs	> 2,000

Ministry	Department	Institute/Centre	PGR category	No. of accessions/plants
		BG, Ganewatta (1951)	Medicinal plants	500
		BG, Mirijjawila (2013)	Trees, herbs, shrubs	> 2,000
		BG, Avissawella (2015)	Trees, herbs, shrubs	
Education	National Institute of Fundamental Studies (1981	Sam Pophem's Arboretum	Trees, herbs, shrubs	> 350 plants species
Health		BMARI, Nawinna, Maharagama (1962).	5 herbal gardens	
Private sector		Belipola Arboretum, Uva	Analog forest	
		One Earth Urban Arboretum, Moratuwa	Trees. Dilmah Conservation	500 trees
		Arboreta of Native Forest Foundation	Underutilized fruit trees	>60
		Field genebanks at various places	Mango and other crops	
NGOs	Community Development Centre (1994)	Field gene banks in Aranayake, Sri Lanka	Indigenous varieties of root and tuber crops	60
	Manawa Sanwardena Padanama	Network of traditional farming fields	Many underutilized crops	
In situ conservation of fruit, vegetable and root and tuber crops (including underutilized species) genetic resources				
Wildlife & Forest Resources Conservation	FD (1887)		Plant/crop genetic resources	
	DWLC (1949)		Plant/crop genetic resources	

Ministry	Department	Institute/Centre	PGR category	No. of accessions/plants
Environment	CEA (1981)		Plant/crop genetic resources	

Notes: PGRC=Plant Genetic Resources Centre; FCRDI=Field Crops Research Development Institute; HORDI=Horticultural Crops Research & Development Institute; FRDI=Fruit Research Development Institute; NPQS=National Plant Quarantine Service; RARDC=Regional Agriculture Research & Development Center; RBG=Royal Botanic Gardens; BG=Botanic Gardens; BMARI=Bandaranayake Memorial Ayurvedic Research Institute; FD=Forest Department; DWLC=Department of Wildlife Conservation; CEA=Central Environmental Authority. The year of establishment of Department or Institute/Centre indicated within brackets.

Source: DNBG, 2022; Jayasuriya and Rajapakse, 2003; Wijesundara et al., 2006; MENR, 2009; Personal Communication

In the Plant Genetic Resources Centre (PGRC), seeds of orthodox species (seeds which will survive drying and/or freezing during ex situ conservation) are conserved in cold storage, whereas vegetatively propagated material and recalcitrant species (seeds that do not survive drying and freezing during ex situ conservation) are conserved in green houses, tissue culture repositories, botanical gardens and field gene banks and arboreta. To facilitate its services, the PGRC has five technical units to support its activities namely the (i) exploration unit; (ii) seed conservation unit/seed gene bank; (iii) in vitro conservation and biotechnology unit; (iv) multiplication, characterization, and evaluation unit and (v) data management unit. At present, a total of 16,882 accessions have been collected and conserved ex situ in the PGRC. This represents a 28% increase compared to its collection in 2012 (Personal Communication, Senior Deputy Director, PGRC, Peradeniya, Sri Lanka). In the case of vegetables, in 2022, the ex-situ collection consisted of 5,606 accessions. The in vitro collection of *Dioscorea* spp. and *Plectranthus rotundifolius* consisted of 229 accessions. The number of accessions of fruit crops is 400. However, except for a few scattered studies on some underutilized fruit and vegetable species, there are no systematic studies on germplasm collection, characterization and evaluation of underutilized fruit and vegetable species for their conservation at the level of PGRC.

Further, other organizations under the Department of Agriculture (DOA) and research institutes maintain field gene banks strengthening the ex-situ conservation of crop genetic resources. The mandate of the Fruit Research and Development Institute (FRDI), established in 2013, is to undertake research and development activities to boost the national fruit crop sector. Among its objectives are the exploration, evaluation, multiplication of genetic resources of major and indigenous underutilized fruit crops for food security and crop diversification. The institute is also responsible for the release of new fruit varieties, the promotion of underutilized fruit crops in home gardens, and the creation of new technologies for pot cultivation and landscape technology linked to fruit trees. Its headquarters are in Horana and the center has well-developed fruit orchards consisting mainly of rambutan, durian, mangosteen, jackfruit, guava, passion fruit, papaya and several underutilized fruit species. FRDI has nine subunits, namely the:

(i) Fruits Crop Research and Development Station, in Peradeniya, which conducts breeding research on banana, papaya, guava, avocado, longan and durian. Evaluation trials on underutilized fruits such as Indian gooseberry (*Phyllanthus emblica*) known locally as aonla, longan (*Dimocarpus longan*) and Malabar plum (*Syzygium cumini*), known locally as madan

are also conducted to identify promising varieties. Agronomic studies are in progress on highly demanded underutilized fruits such as bael (*Aegle marmelos*), Indian jujube (*Ziziphus mauritiana*), longan, Indian gooseberry, soursop and bilimbi (*Averrhoa bilimbi*) (Table 11). In addition, the research station houses a collection of pot plants and field gene banks of several underutilized fruit species;

(ii) Plant Virus Indexing Centre, in Homagama;

(iii) Agriculture Research Station, in Maduraketiya. Its main role is the production of planting material of fruit crops;

(iv) Agriculture Research Station, in Muthukandiya. Its main role is the production of planting material of fruit crops;

(v) Citrus Research Station, in Bibile. The research station contains a collection of sweet orange varieties of bibile sweet, bibile seedless and Maduraketiya and and planting material of fruit crops;

(vi) Rambutan Research Station, in Eraminigolla. The research station houses planting material and germplasm of several fruit species;

(vii) National Fruit Variety Conservation Centre, in Kundasale. Established in 2012, the center conserves 307 fruit accessions in its field gene bank of field and pot plants (Table 11);

(viii) Sustainable Agriculture Research and Development Centre, in Makandura; and

(ix) Agriculture Research Station, in Rahangala. Established in 1978, the research station undertakes temperate fruit crop related research (e.g., on pears, apples etc.) However, except for a few species such as emblic (*Phyllanthus emblica*), bael and Annona spp., there has been no systematic collection and characterization of genetic resources of underutilized species.

Details of the collected underutilized fruit species, their varieties and accessions and number of plants conserved at the National Fruits Variety Conservation Centre (NFVCC), in Kundasale, and the Fruit Crops Research and Development Station (FCRDS), in Gannoruwa, are given in Table 11.

Table 11: Underutilized fruit species collected and conserved at the National Fruits Variety Conservation Centre (NFVCC) and the Fruit Crops Research and Development Station (FCRDS).

Species	Identified varieties	NFVCC		FCRDS	
		Accessions	No. of plants	Accessions	No. of plants
Bael fruit (*Aegle marmelos*)	Supun	2	20	32	72
Wood apple (*Limonia acidissima*)	Rawana	3	10	5	11
Indian plum (*Flacourtia indica*)	Gannorua Uguressa, Thai	2	5	6	24
Pomelo (*Citrus grandis*)	Surath	1	3	27	68

Species	Identified varieties	NFVCC		FCRDS	
		Accessions	No. of plants	Accessions	No. of plants
Longan (*Dimocarpus longan*)	Nirodha, Thai, Cambodia, Burma	6	10	11	41
Indian jujube (*Ziziphus mauritiana*)	Green big, Aralaganvilla	2	5	10	38
Malabar plum (*Syzygium cumini*)	Gannoruwa madan, Gannoruwa eladan Thai	3	5	12	4
Tamarind (*Tamarindus indica*)	Indian	2	10	8	13
Amla/Emblica (*Phyllanthus emblica*)	Gannorua nelli, Thai	2	50	18	54
Bignay (*Antidesma bunius*)	Red bunch	1	8	1	18
Ceylon olive (*Elaeocarpus serratus*)	Horana 7, 9, 5, 13	3	5	14	37
Sapodilla (*Manilkara zapota*)	Horana 1,2 / Gannoruwa	3	6	5	15
Garcinia (*Garcinia quaesita*)	Horana 3, 8, 11 Weerapana	4	8	13	21
Rose apple (*Syzygium jambos*)	Ruby giant, Ruby drop, Lindula green, Thai red, Golden pink	5	15	15	34
Pomegranate (*Punica granatum*)	Daya, Nayana, Kalpitiya, Nimali	4	15	3	10
Lemon (*Citrus × limon*)	Ureka, Local acc.	5	8	2	3
Macadamia (*Macadamia* spp.)	Harha, Lanka	2	3	2	7
Mandarin (*Citrus reticulata*)	Madu, Rahangala, Indu, Ehimi	4	20	9	14
Heen Embilla (*Antidesma alexiteria*)		1	3	2	6
Mulberry (*Morus* alba)		2	5	4	9
Blue olive		1	3	2	5

Species	Identified varieties	NFVCC		FCRDS	
		Accessions	No. of plants	Accessions	No. of plants
(*Elaeocarpus serratus*)					
Ceylon gooseberry (*Dovyalis hebecarpa*)		1	5	2	5
Red santol (*Sandoricum koetjape*)		1	2	2	3
Brazilian cherry *(Eugenia uniflora)*		1	3	3	7
Gaduguda, Rambi (*Lansium domesticum*)		1	5	2	2
Himbutu (*Salacia reticulata*)		2	5	4	8
Velvet tamarind (*Dialium ovoideum*)		1	1	3	11
Jabuticaba (*Plinia cauliflora*)		2	2	2	7
Maha karamba (*Carissa carandas*)		2	3	2	6
Star apple (*Chrysophyllum cainito*)		1	2	3	7
Daminiya (*Grewia tiliifolia*)		1	3	2	2
Miracle berry (*Synsepalum dulcificum*)		1	3	1	6
Loquat (*Eriobotrya japonica*)		1	5	2	3
Abiu (*Pouteria caimito*)		1	3	2	2
Wild sweetsop/Rollinia (*Rollinia mucosa*)		1	5	2	5
Yaki naran (*Atalantia ceylanica*)		1	10	1	1
Malay apple (*Syzygium malaccense*)		1	2	2	6

Species	Identified varieties	NFVCC		FCRDS	
		Accessions	No. of plants	Accessions	No. of plants
Weera (*Drypetes sepiaria*)		1	1	2	2
Palu *(Manilkara hexandra)*		1	2	1	6
Bastard oleaster (*Elaeagnus latifolia*)		-	-	1	1
Rose apple (*Syzygium jambos*)		1	2	2	4
Kumquat (*Citrus japonica*)		-	-	1	2
Patabambara (*Uvaria sphenocarpa*)		1	2	1	4
Corky debbar tree/Kalati (*Polyalthia suberosa*)		-	-	1	3
Shoebutton ardisia/Baludan (*Ardisia elliptica*)		1	10	1	1
Bullock's heart (*Annona reticulata*)		1	3	2	5
Koholla lawalu (*Donella lanceolata*)		-	-	1	2
Sweet sop (*Annona squamosa*)		1	2	2	4
Nam nam (*Cynometra cauliflora*)		1	1	4	8
Damson (*Carissa grandiflora*)		1	1	1	6
Chinese guava (*Psidium cattleianum*)		1	50	4	14
Ceylon boxwood (*Psydrax dicoccos*)		-	-	1	5
Star gooseberry (*Sauropus androgynus*)		1	5	1	4
Soursop		1	50	23	49

Species	Identified varieties	NFVCC		FCRDS	
		Accessions	No. of plants	Accessions	No. of plants
(Annona muricata)					
Bilimbi (*Averrhoa bilimbi*)		1	2	1	4
Sour guava (*Psidium guineense*)		1	20	1	1
Malabar ebony (*Diospyros malabarica*)		-	-	1	1
Yellow sapote, Lavalu (*Pouteria campechiana*)		1	2	6	6
Christ's thorn jujube (*Ziziphus spina-christi*)		-	-	1	1
Mangosteen (*Garcinia mangostana*)		-	-	1	6
Malabar plum/Madan (*Syzygium cumini*)		1	2	3	10
Lovi-lovi/Sapida (*Flacourtia inermis*)		1	1	2	3
Ceylon oak (*Schleichera oleosa*)		1	1	1	2
Kolikuttu Lawalu (*Pouteria campechiana*)		1	1	1	1
Total		96	434	303	740

Source: Personal Communication, Mrs. A.V.C. Abayagunasekara, Deputy Director (Research), Fruit Crop Research & Development Station, Gannoruwa, Sri Lanka

At present, except for a few programmes, there are no well- defined coordinated on-farm conservation programmes to conserve agricultural genetic resources nor does a database exist with this information. In 2013, the DOA has initiated the collection of local and traditional varieties of several vegetable species and revealed that genetic resources such as traditional varieties/landraces are still being conserved by farmers. Eleven traditional vegetables and 10 minor varieties have been collected through this program although continuity did not exist with the program (Personal Communication, Dr. Hemal Fonseka, Former Director, HORDI; Director, Onesh Agriculture Private Limited, Colombo). Recently, the private sector and non– governmental organizations (NGOs) are undertaking ex situ conservation of agricultural genetic resources by establishing field gene banks, seed banks and maintaining traditional farms.

Although the ex situ conservation of plant and animals by the private sector and communities are not mainstreamed in Sri Lanka, there are a few privately-owned arboreta, which are maintained by NGOs. While it has not been adequately documented, members of civil society, Community Based Organizations (CBOs) voluntarily conserve indigenous varieties of seeds, yams, vegetables, spices, all of which can be considered vital components of Sri Lanka's agrobiodiversity. For example, several NGOs and individuals maintain and conserve germplasm of various plant categories. The Community Development Centre (CDC) in Aranayake has supported the conservation and utilization of 60 accessions of root and tuber crops at the local level. Here, women-led self-help groups (300 families in total) demonstrate local technologies used to produce vanishing root and tuber crops on their land parcels. These self-help groups operate as cooperatives and are divided into federations of 5-6 groups that use revolving funds for livelihood development and conservation. CDC also established model crop gardens at a pilot site to demonstrate the variety of local root and tuber crops available. Not only have they increased the production of roots and tubers but also documented and developed value-added products from these crops. Among CDC's activities is the provision of planting material to farmers and other organizations upon request. Although scattered germplasm characterization has been undertaken, detailed characterization of accessions has not been conducted so far (Godamulla, 2018; Personal Communication, Damayanthi Godamulla, Director, Community Development Centre, Aranayake). Community Seeds Banks (CSBs) to store seeds of traditional underutilized crops have also been established in several locations (for example during the Biodiversity for Adaptation to Climate Change [BACC] project), though their sustainability and long-term survival is uncertain.

At present, seed production and the distribution of selected underutilized species is limited and is conducted by a small number of individuals. For example, the Native Forest Foundation located in Gampaha, in the wet zone of Sri Lanka and owned by Mr. Damitha Rajapaksha, has conserved over 60 native fruit tree species. Mr. Rajapaksha, who is propagating the species among local communities and raising awareness of their importance, including among school children, is expecting to increase his collection to 100 species. In addition, Facebook groups such as Global Youth Biodiversity Network Sri Lanka are promoting traditional crops and associated agricultural practices and knowledge. Private sector organizations, such as the Landmark Agro Seeds Pvt Ltd in Dankotuwa have initiated seed production and selling of selected underutilized vegetable species (Personal Communication, Mr. M.C.J. Premarathne, 47/B, Katanawatta Road, Dankotuwa). Several others have also collected and conserved genetic resources of underutilized fruit, vegetable and root and tuber crop species.

The use of underutilized traditional varieties of fruit and vegetable crops is common in Sri Lankan traditional farming systems. This is where the most effective examples of on farm conservation and sustainable use of agricultural genetic resources exists. Homegardens, particularly Kandyan homegardens (Pushpakumara et al., 2012), are one of the systems that currently operate in a stable fashion for the cultivation of local varieties of yams, leafy and other vegetables, and fruits. Yet, these farming systems are offered no legal protection from land encroachment and residential development driven by the rapid urbanization and increased population growth in the country. Although many state that important germplasm of fruits, vegetables and root and tuber crops is conserved by custodian farmers in different farming systems, information on such custodian farmers are limited or not available with respect to underutilized crop species.

Further, national schools, universities and many other institutes have also established small gardens of medicinal plants and other crop species although their sustainable maintenance and documentation is a problem.

3.6 Barriers and constraints facing the promotion of underutilized fruits and vegetable species for markets and consumption

Despite increasing awareness of underutilized fruit, vegetable and root and tuber crops and their benefits as healthy foods, there are multiple constraints to mainstreaming the promotion of underutilized species for improved human nutrition and wellbeing (Hunter et al., 2020). These barriers consist of the growing commercialization of agriculture production systems leading to the narrowing down of the number of food species and varieties available on the market. In this arena underutilized crops are unable to compete with commercial commodities due to several socio-economic and technical challenges. Sri Lanka's rapid urbanization, the population's changing food and dietary habits and trade globalization have influenced the popularity of underutilized crop species as communities become less dependent on local resources (Rathnayake et al., 2023). Most of these underutilized species can only be found in the wild or grown in homegardens, and except for a few species such as Spiny gourd (*Momordica dioica*) known locally as 'thumba karawila', there is no organized cultivation of these crop species (Pushpakumara, 2011).

The limited availability of scientific evidence such as food composition data and agronomic and horticultural research information, and the low investment priority on varietal improvement and technology development are major challenges for the promotion of underutilized crop species in local and international markets. Other contributing factors that limit their availability in markets are the:

i. lack of a coordinated strategy for research and development,
ii. lack of a coordinated strategy for production and marketing
iii. scarcity of quality planting material
iv. inadequate financial and non-financial incentives to create a conducive growing environment
v. lack of systematic data on cultivation and production
vi. lack of guidelines for seed collection and production
vii. consideration of indigenous fruits and vegetables as inferior, mainly due to limited awareness of consumers, lack of awareness of recipes and culinary practices

(Bandula et al., 2016; Chamara et al., 2021; Malkanthi et al., 2014; Rathnayake et al., 2023).

Chamara et al. (2021) further argue that there is a research gap between modern, improved varieties of crops and traditional crop species with most of the research funds provided to expand research on major crops, particularly rice, starting from the Green Revolution. Malkanthi et al. (2014) reasoned that the availability of land, labour and knowledge owned by traditional farmers should be considered major strengths for the future promotion of traditional underutilized fruit and vegetable species. However, farmers' knowledge is mostly limited to agronomic and management practices, which does not address the large knowledge gaps linked to processing, conservation, and value addition. Several key challenges have been reported in relation to mainstreaming and making better use of underutilized crop species in Sri Lanka. These are summarized in Table 12.

Table 12: The key barriers/constraints and major challenges limiting the mainstreaming and use of underutilized crop species in Sri Lanka.

Constraint	Description
Lack of coordinated and enabling policies	Disconnect between the Agriculture, Nutrition, Health, Education, Conservation and Trade sectors. Lack of attention from policy makers
Lack of institutional capacity and human resources skills.	Lack of institutional capacity and human resources' skills to undertake plant breeding and germplasm collection, characterization, and utilization using advanced and social models
Lack of knowledge on agronomy and crop improvement	Limited characterization of underutilized species and their varieties, and limited breeding and selection efforts and quality planting material production. Lack of sufficient seed and planting material.
Environmental changes	Changing land use patterns, climate change, pollution and biodiversity loss impacting species' distribution
Socio-economic changes	Increasing poverty and illness in communities, changing food habits, poor attitudes, loss of traditional knowledge of underutilized species. Competition from commercialized crops and advertisements.
Lack of research, extension, data and information	Limited and scattered research and data. Poor links with nutritional outcomes and biodiversity. Negative perceptions and attitudes towards these crops and their products. Lack of capacity and quality extension services
Weak promotion and awareness	Lack of scientific evidence on the species' nutritional and medicinal qualities. Weak outreach activities and uncoordinated awareness campaigns. Lack of credit facilities and loan schemes for farmers and enterprenures. Lack of national recognition of the importance of fruit and vegetables compared to major crops
Disorganized marketing	Inefficient processing and value adding, and disorganized or non-existent value chains

Source: Modified from Rathnayake et al. (2023); Bandula et al. (2016); Chamara et al. (2021); Malkanthi et al. (2014); Singh & Bhatnagar (2019).

3.7 The current policy environment for traditional and indigenous vegetables and fruits and opportunities for future cross cutting action

Several studies have proven that viable opportunities exist to promote the use of underutilized fruit and vegetable species as a sustainable food industry (Table 13). Yet, several important challenges exist in Sri Lanka linked to farmers' perceptions around exploiting these crops. These include access to quality seed and planting material and reversing the prevailing negative perceptions associated with the quality of this material (Malkanthi et al. 2014). Thus, governing bodies and authorities play a vital role when it comes to obtaining, conserving, and disseminating improved, safe planting material for traditional crop varieties.

Further, training should be provided to traditional farmers who largely lack capacity in value addition and processing of underutilized crops, ultimately limiting potential additional income. Given the land availability, underutilized fruits and vegetables could be planted in kitchen gardens and home gardens. According to the Land Use Policy Planning Department of Sri Lanka, there are more than 4.5 million homegardens scattered across the island, covering a total land area more than 84,000 ha with much of it being underutilized. Moreover, a significant majority of these home gardens are endowed with a permanent water source, or a well, pipe borne water and other natural water sources. The land survey report concludes that 51% of home gardens In Sri Lanka have available space for the introduction of new trees/species (LUPPD, 2020). This is a golden opportunity to expand and promote the use of underutilized crop species, given the limited space available for commercial level cultivation.

Table 13: Characteristics of underutilized fruits and vegetables that could be used for greater promotion.

Qualities to promote underutilized species	References
Additional income source for households	Bandula et al. (2016), Sahoo et al. (2021) and Thakur (2014)
Nutrient rich raw and processed products	Sarananda et al. (2017) and Singh & Bhatnagar (2019)
Traditional knowledge on cultivation and processing	Bandula et al. (2016) and Chamara et al. (2021); Malkanthi et al. (2014)
Space and land availability for expansion in different farming systems	Sarananda et al. (2017); Malkanthi et al. (2014)
Possession of medicinal and therapeutic values	Sarananda et al. (2017); Singh & Bhatnagar (2019); Sugathadasa et al. (2008)

Most of the studies conducted on promoting, optimizing, and expanding the production and consumption of underutilized crop species see these nutrient-rich plant-based foods as playing an important role in household diets and improving food and nutrition security. Given the nutritional significance and health-giving properties of these foods when they are processed for consumption, they can contribute to household dietary requirements as part of a sustainable diet (Bandula et al., 2016; Chapman, 2022; Fonseka et al., 2007; Kumar et al., 2018; Pathirana et al., 2020; Ratnayake & Kumar, 2020; Sahoo et al., 2021; Thakur, 2014).

Using Sri Lanka as a case study, Rathnayake et al. (2020) studied the impacts of projected climate change scenarios on the distribution of neglected and underutilized fruit species (NUFS). Research reveals that climate change particularly increases the vulnerability of NUFS and significantly shrinks their suitable cultivation areas. The work also suggests that under future climate, tropical species will shift from dry and intermediate zones to cooler, high altitude areas. Further, some species, such as *Tamarindus indica*, are predicted to be at higher risk than others. For preparedness, the authors suggest the implementation of information-based climate change mitigation and adaption strategies that target specific areas and species as well as greater awareness promoted among researchers, policymakers, and decision-makers. Additional recommendations include the development of climate resilient NUFS varieties that can adapt to adverse climate challenges in vulnerable areas.

4. Discussion and recommendations

Sri Lanka is endowed with many underutilized species of fruit, vegetable, leafy vegetable and root and tuber crops. Most of these underutilized species, which occur naturally in protected areas, are threatened with habitat destruction although no systematic threat assessment has been made. Except for a handful of root and tuber crops, ex situ collections of most underutilized species are scattered, and conservation is uncoordinated and disorganized. Coordinated and concerted efforts should be made for the collection, evaluation, conservation, and utilization of underutilized fruits and vegetables as well as gathering of data to identify, use and protect their intellectual property rights. Collection and conservation efforts should be monitored based on the characterization and evaluation of species for their utilization. Compared to major crop species, underutilized species are rarely used in national agricultural crop selection and breeding programmes. Occasionally, some species have been taken into consideration but there has been no effort put into their full exploitation.

Essential remedial actions for the conservation and use of underutilized species include upgrading facilities at the PGRC for the maintenance, evaluation, and phenotypic and molecular characterization of genetic resources of underutilized species. This includes expanding PGRC's capacity for long-term storage and improving its cryopreservation facilities to accommodate underutilized species.

Also it is vital to increase FRDI and HORDI's capacity to document and evaluate their established germplasm collections. A computer-based national database on underutilized plant genetic resources maintained in situ and ex situ should be developed and made available to researchers, plant breeders, and policy makers to facilitate their conservation and use. The database is expected to encourage national and provincial institutes to maintain, evaluate and update their collections, and strengthen the National Herbarium with specimen collections of underutilized species. In addition, A-Park with demonstration blocks of fruits and vegetables can be used not only for exhibition and popularization of fruit and vegetables but also can be used as planting material production units to dissimite them among visitors.

The literature review, accompanied by stakeholder consultations, revealed limited capacity of PGRC staff, as well as that of regional research centers, other stakeholders, and community groups to maintain and use genetic resources of underutilized species. Training and investments should be provided in crop breeding. Since the use of conventional breeding programmes to develop commercial cultivars of underutilized species can be expensive and time-consuming, it is recommended that efforts are made to use available molecular-assisted breeding and selection techniques to enhance the efficiency of breeding methodologies and to develop new and improved varieties not only for pest and disease resistance but also for tolerance to extreme temperatures and climates, tolerance to salinity, drought resistance, and improved nutritional quality. Facilities for molecular techniques should be made available. These targets can be achieved through the implementation of prioritized, nationally coordinated breeding programmes to provide a national grid for breeding in collaboration with centers of excellence elsewhere.

To reverse the negative perceptions of underutilized crop species, recommendations include using mass media to deliver a well-coordinated public awareness campaign highlighting the value and importance of prioritized underutilized fruit, vegetable, leafy vegetable and root and tuber crops for food, nutrition and environmental security of individuals, families, communities, districts, provinces, and the country. It is also recommended that this knowledge be institutionalized by inclusion of these messages in school, diploma, and undergraduate curricula. These messages can also be shared

through farmer participatory extension and training programmes and disseminated to pregnant and lactating women.

The lack of understanding on the genetic variation existing in underutilized species and their genetic base is a problem. This should be addressed through the latest molecular biology tools for selecting varieties with important nutrient categories.

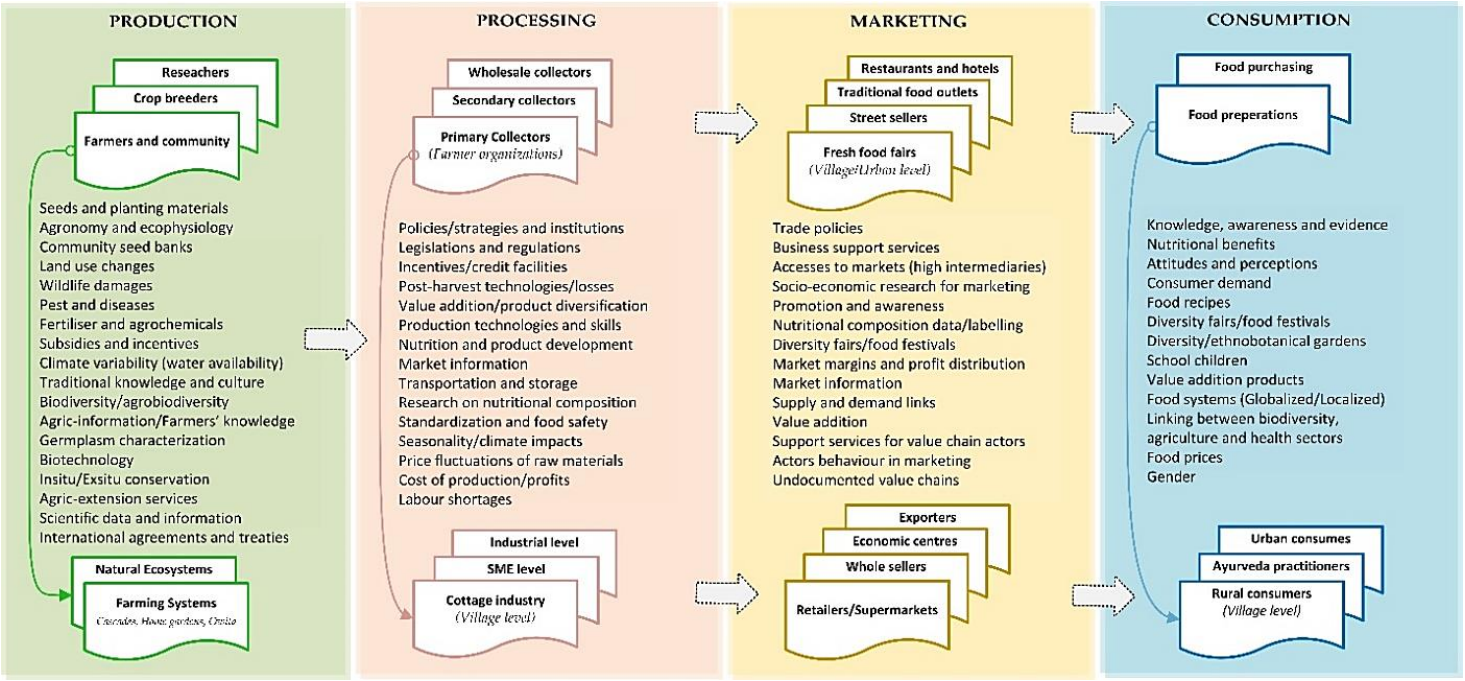
Although in situ conservation is the ideal method to conserve genetic resources of prioritized underutilized fruit, vegetable, leafy vegetable and root and tuber crops in their natural environments, at present no database exists on the occurrences and dynamics of such species in the protected area network of Sri Lanka. Hence, no decision can be made targeting the effective conservation of genetic resources of prioritized underutilized species. Under ex situ conservation, not many accessions exist in PGRC. The status of genetic resources available in different field gene banks and parks, in live collections in botanic gardens, collections through NGOs and CBOs needs to be fully documented. While mechanisms to conserve genetic resources of prioritized underutilized fruit, vegetable, leafy vegetable and root and tuber crops via in situ and ex situ are vital, it is equally essential to protect these resources by promoting them via their sustainable use in identified in small, medium, and large-scale farming systems.

Lack of institutional support through coordinated programmes for underutilized fruit, vegetable, leafy vegetable and root and tuber crop categories and individual species and funding limitations are the additional challenges that need to be addressed in the Sri Lanka of today. However, exploiting the potential of these genetic resources requires the capacity to use plant breeding to improve varieties and to establish multi-stakeholder partnerships and networks that include farmers, researchers, academia and educators, gene bank managers, CBOs and communities, policy makers and administrators.

It is also essential to undertake the economic valuation of these underutilized plant genetic resources. It is expected that this will highlight the “hidden” biodiversity values of underutilized fruit, vegetable, leafy vegetable and root and tuber crops for improving both use (instrumental) and non-use (intrinsic) values. This would contribute to better decision-making by policy makers and administrators about their potential contribution to household and national economy and to make their conservation and utilization endeavors financially sustainable.

Although much attention has been given to underutilized crops globally due to nutrition and health concerns, the value chain development (VCD) of underutilized crops in Sri Lanka is scanty. Limited studies have been conducted (Bandula et al., 2016; Bandula and Nath, 2020). Current value chains for these crops are very basic maintaining a typical traditional supply chain. Very rarely are they linked to supply and demand-driven strategies (Rathnayake et al., 2023). Most of the underutilized crops in Sri Lanka are seasonal and thus cannot respond to market changes (Wimalaweera and Samarasinghe, 2013). Careful investigation of opportunities, constraints, and innovations along the value chains for these crops is encouraged (Rathnayake et al., 2023; Wimalaweera and Samarasinghe, 2013). Rathnayake et al. (2023) comprehensively reviewed potential actors and drivers identified in the value chains of Sri Lankan underutilized fruits and vegetables. These are listed in Figure 4. However, the production, processing, marketing, and consumption of prioritized species needs to link with conservation to make it holistic and innovative. For it to be viable, the approach should promote livelihood benefits for more vulnerable groups and communities where these resources are intimately connected with local food systems and culture.

Figure 4: Potential actors and drivers identified in future value chain development for neglected and underutilized fruits and vegetables in Sri Lanka.



Source: Adapted from Rathnayake et al. (2023).

The success of the Spiny Gourd (*Momordica dioica* ex Roxb.Willd)

The case of spiny gourd (*Momordica dioica*) – a once neglected and underutilized species - is a notable success story. Normally consumed as a processed vegetable crop in Sri Lankan cuisine, the spiny gourd, is a member of the bitter gourd family. However, unlike bitter gourd, it tastes sweet when cooked as a curry, making it popular and palatable (DOA, 2023). Considered a healthy vegetable, it is recommended for diabetics and people suffering from stomach ailments. The Department of Agriculture (DOA) has taken the leadership in exploiting this as a cash crop by introducing several varieties including a hybrid. It is a dioecious species where Thumbika, Golika, Wisal, Kesara and Chandu are the female varieties and Parakum and Wishma are the male varieties. The combination of Chandu and Wishma results in the hybrid variety of spiny gourd. The crop is considered highly successful in the low country dry zone areas. The plant's seed requirement, preparation of planting material, spacing, cultivation time, pest and disease management and, harvesting have all been well documented. One female vine can produce 6-8 kg of spiny gourd/year under ideal conditions. Currently, individual farmers are also managing germplasm for production purposes.

Photo by: Danny Hunter / Bioversity International

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