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Czech University of Life Sciences Prague
**Faculty of Tropical
AgriSciences**

Bachelor thesis

Local plant species sold on rural markets
in Sri Lanka

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Declaration

I hereby declare that the present bachelor thesis called „Local plant species sold on chosen rural markets in Sri Lanka“ is my own work and all the sources have been quoted and acknowledged by means of complete references.

In Prague, 15 April 2016

.....

Ondřej Horák

Acknowledgement

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Abstract

Agricultural markets are important places in rural areas. Eight species of edible plants traded at local markets in Sri Lanka were selected for our study, i.e. *Aegle marmelos* (L.) Corrêa, *Amorphophallus paeoniifolius* (Dennst.) Nicolson, *Centella asiatica* (L.) Urb., *Limonia acidissima* L., *Luffa acutangula* (L.) Roxb., *Murraya koenigii* (L.) Spreng, *Trichosanthes cucumerina* var. *anguina* (L.) Haines, and *Dialium ovoideum* Thwaites. All species were of South Asian origin, contributing significantly to local tradition or cuisine and represented important market article. Thesis used interdisciplinary approach consisting of market survey, ethnobotanical screening and value-chain to identify for what purposes are those species used. Bachelor thesis used data collected in Vavuniya city in the northern part of Sri Lanka by two master students in September 2010. Thesis provides and discusses available scientific literature dealing with selected species, while specific attention is given to *Dialium ovoideum* as the only selected species not cultivated in the farms but collected in the wild. However, value-chain of that species is not yet fully developed and unregulated collection might lead to decreasing population or even extinction of *Dialium ovoideum* in the study area. Own contribution is also in last chapters about promoting value chain and domestication, as one of tools for nature conservation and sustain biodiversity. Additionally, any domestication experiments were not documented. The theme shows a possible changes accompanied already mentioned domestication and it can serve as useful source of information about given tropical plants.

Key words: market survey, local markets, underutilised species, tree domestication, value-chain, Sri Lanka

Abstrakt

Zemědělské trhy jsou důležitá místa ve venkovských oblastech. Pro naši studii bylo vybráno osm jedlých druhů rostlin, jmenovitě: *Aegle marmelos* (L.) Corrêa, *Amorphophallus paeoniifolius* (Dennst.) Nicolson, *Centella asiatica* (L.) Urb., *Limonia acidissima* L., *Luffa acutangula* (L.) Roxb., *Murraya koenigii* (L.) Spreng, *Trichosanthes cucumerina* var. *anguina* (L.) Haines a *Dialium ovoideum* Thwaites, prodáváných na místních trzích na Srí Lance. Všechny druhy pochází z Jižní Asie a hrají důležitou roli v místní kuchyni a tradičním využití místními lidmi. Bakalářská práce využívá data, které posbíraly dvě studentky magisterského studia v září, roku 2010, ve městě Vavuniya, které leží v severní části Srí Lanky. Práce přináší dostupné vědecké informace, týkající se osmi rostlinných druhů, které byly předem stanoveny na základě své jedinečnosti pro místní obyvatele. Pozornost je věnována zejména rostlině *Dialium ovoideum*, která jako jediná není kultivována, ale sbírána pouze z volné přírody, z lesa. Avšak hodnotový řetězec tohoto konkrétního druhu není plně vyvinut a nekontrolovaný sběr může vést k snížení populace nebo dokonce k úplnému vytracení z přirozeného prostředí. Vlastní přínos je taktéž v posledních kapitolách týkajících se podpory hodnotového řetězce a samotné domestikace, kterou zde vyzdvihují jako jeden z možných nástrojů ochrany přírody a udržení biodiverzity. Žádné pokusy o domestikaci dosud nebyly zaznamenány. Toto téma ukazuje možné změny doprovázené již zmíněnou domestikací a taktéž může sloužit jako užitečný zdroj o daných tropických rostlinách.

Klíčová slova: průzkum trhu, místní trhy, nedostatečně využitě druhy, domestikace rostlin, hodnotový řetězec, Srí Lanka

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1. Introduction

Temperature and humidity create great conditions for high biodiversity of tropical nature and make it fascinating by its richness of plant species. Edible plants represent significant source of food, which has increasing importance particularly in developing countries. Those plant species could be gathered in the wild or planted at local farms. Moreover, surpluses of both gathering and farming are commonly sold at local agricultural markets. Very often, collection and gathering of edible plant species represents important income-generating activity of rural households. However, regular supplies are based on efficient market-chains, sustainable consumer demand and reflect biological limits of local agro-ecosystems. Data collected from rural markets in Sri Lanka during September 2010 has been used in this thesis. Generally, agricultural markets represent a good way to look inside of native/local people's culture and habits. According to products which are being sold on the markets a local use of agricultural and/or natural products can be predicted. Based on data collection, eight edible plant species, e.g. *Aegle marmelos* (L.) Corrêa, *Amorphophallus paeoniifolius* (Dennst.) Nicolson, *Centella asiatica* (L.) Urb., *Dialium ovoideum* Thwaites, *Limonia acidissima* L., *Luffa acutangula* (L.) Roxb., *Murraya koenigii* (L.) Spreng and *Trichosanthes cucumerina* var. *anguina* (L.) Haines, were identified as of high priority and thus their potential benefits for human nutrition as well as their natural habitat have been discussed. Furthermore, focus is given also to social and economic aspects of domestication of wild species at local farming systems, particularly home gardens. Thesis represents an inter-disciplinary study, combining market theory, nutrition and natural resource management. As already mentioned, the place of research is Sri Lanka, which is a tropical island that attracts many tourists thanks to its natural beauty. On the other hand, it has been endangered by a civil war between the majority of Sinhalese and the Tamil minority in the northeast, two different ethnic groups with different beliefs and religion. Main reason for creating this thesis was to contribute work of Food and Agriculture Organization (FAO) which currently has two ongoing programmes. First is Achieving sustainable food security and nutrition followed by second one Preservation and rehabilitation of forestry. Both programmes are related to priority areas in the north and east of the country. Sri Lanka is place of great diversity of underutilized plant

species. There has been 227 species of wild plant species identified in Sri Lanka, while the largest group were fruits, represented by 90 species, particularly *Dialium* spp., *Limonia acidissima* and *Aegle marmelos*, and others, such as *Citrus grandis*, *Citrus aurantium*, *Psidium cattleianum* or *Annona reticulata*, followed by vegetables (39 species), cereals (30 species), legumes (17 species), oil seeds (3 species), fibre crops (6 species), root and tubers (16 species), spices and condiments (16 species) and the others (10 species) (Ganashan et al., 1995; Arachchi and Wijeratne, 2008). Many of these species have been gathered in the local forests. Nevertheless, Sri Lanka belongs to the most densely populated countries in Asia. Hence, there has been a lot of pressure to improve living standards by increasing importance of natural wealth of the country, with special emphasis on forests. Forests of Sri Lanka are managed, protected and controlled by state, while other subjects owning forests are negligible (Geekiyanage et al., 2015). According to the FAOSTAT (2012) Sri Lanka's forests cover 1.83 mil. ha (18 300 sq. km) of the land area, which represents 27.89 % of the area of the country. Shifting cultivation, expansion of tea plantations, gem mining, illegal logging and other encroachment are main threats forests are faced with (Geekiyanage et al., 2015). All these activities contribute to deforestation with potential negative impact on rural communities which are dependent on those forests in order to fulfil their requirements for food, medicine and/or additional cash income (Sim et al., 2003).

2. Literature review

2.1 Plant species sold on agricultural rural markets in Sri Lanka

Not all gathered plants are used at household level only as surpluses are usually sold on local market directly by farmers or via middlemen (Alexiades, 1996; Williams et al., 2000). Generally, rural markets are basically places of connection between supply and demand, but they are very valuable source of information on local plant diversity as well. This definition is surely valid, but value of market is bigger. It is not only place for trading things. Local markets support a social role of exchanging traditional knowledge and use of local plants among cultural and social groups at local level. Markets provide place where people meet each other and exchange their knowledge. Because of that market is a rich source of information about food plant species for us. People, accessibility to the market, goods and the public nature of the market offer favourable conditions for fieldwork. Socio-economic role of market is irreplaceable, mainly in developing country. Anyway, market is definitely a place, where people either purchase or sell many kind of food products, among others edible plants from local environment or imported (Bye and Linares, 1983; Alexiades, 1996; You-Kay, 2004). Furthermore, rural markets constitute an important segment of overall economy and create important places for transaction of agricultural commodities. Rural markets, as part of any economy, have significant socio-economic potential for development of rural areas, traditional products trading or local habits conservation, however this potential remained rather untapped (Kotni, 2012).



Figure 1
Typical rural market, Sri Lanka
Source: Hodson (2014)

This because there are many hurdles in rural marketing, e.g. understanding the rural consumer preferences, poor infrastructure or physical distribution of products (Patel, 2012). These markets are the channels for the movements of goods and services as well as to promote cultural integration. Additionally, rural markets are less saturated and crowded compare to urban markets and they play a significant role in the society regardless of decline of agricultural production on overall economic output, particularly in the terms of ensuring food security of rural households (Kotni, 2012).

2.3.1. Edible plants

Particularly edible plants are very important part of rural markets. They reflect local agro-biodiversity as well as wide range of wild products that are commonly used in local cuisine through which they influence nutrition status of local households (Alexiades, 1996; You-Kay, 2004). Table 1 presents some of the most common edible plants obtained from the forests in Sri Lanka and their different parts that are used as a food, e.g. roots, tubers, barks, leaves, flowers, fruits or seeds. All of them are intended

particularly for household consumption. Nevertheless, surpluses are commonly sold at agricultural markets as well. Many households are involved in collection of edible plants, for example 65-70% of households in the intermediate and dry zone forests. Collection rates are much lower in mountainous zone forests, where around 20% of households regularly gather edible plant species (Durst and Bishop, 1994; Sim et al., 2003).

Table 1: Common edible plants gathered from forests of Sri Lanka

Latin name	Vernacular name	Plant part used (main product)	Use
<i>Shorea megistophylla</i>	Beraliya	seed	Dried and used as food item
<i>Shorea disticha</i>	Panamora	seed	Dried and used as food item
<i>Garcinia quaesita</i>	Goraka	fruit	Dried fruit flesh is used as a spice
<i>Vateria copallifera</i>	Hal	seed	Extracted starch from seeds used to prepare various food items
<i>Elettaria cardamomum</i>	Wal enasal	seed	Dried seeds are used as a spice
<i>Cinnamomum multiflorum</i>	Wal kurundu	bark	Dried bark used as a spice
<i>Limonia acidissima</i>	Wood apple	fruit	Edible fruit
<i>Manilkara hexandra</i>	Palu	fruit	Edible fruit
<i>Drypetes sepiaria</i>	Weera	fruit	Edible fruit
<i>Cycas circinalis</i>	Madu	seed	Extracted flour is used to prepare various food items
<i>Dialium ovoideum</i>	Gal siyambala	fruit	Edible fruit
<i>Palaquium granda</i>	Mee	seed	Extract edible oil
<i>Ananas comosus</i>	Gal- annasi	fruit	Edible fruit
<i>Psidium gaujava</i>	Ambul-pera	fruit	Edible fruit
<i>Syzygium cumini</i>	Madan	fruit	Edible fruit
<i>Solanum xanthocarpum</i>	Ela-batu	fruit	Used as a vegetable
<i>Amaranthus</i> sp.	Gona- tampala	leaves	Used as a vegetable
<i>Syzygium assimile</i>	Damba	fruit	Edible fruit
<i>Nephelium</i> sp.	Mora	fruit	Edible fruit
<i>Aerva lanata</i>	Polpala	whole plant	Used to prepare herbal tea

Source: own work, data taken from Sim et al. (2003)

Nowadays, the role of edible plants may not be too much important at the national level, but lot of people are still depending on the forests because of their food needs, particularly in rural areas (Durst and Bishop, 1994). They use forest products to supply household's needs in the time of harvesting shortages, political instabilities, unfavourable climate conditions etc.

2.3.2. Medicinal plants

Besides edible plant species, herbs are also very important as they can contribute to the health status of rural population in the case when conventional medicine is not achievable from any reason (Durst and Bishop, 1994). Medicinal plants are collected for thousands of years and people learnt well their medical properties. Due to many side effects and high cost of drugs of medicals, the traditional medicines are being still used all over the world. There are studies estimating that around 80% of inhabitants living in developing country rely on traditional medicine (Pandavadra and Chanda, 2014). Use of medicinal plants obtained from the forest is ordinary for many centuries, including Sri Lanka, where medicinal plants play an important role in the indigenous medical system and 30-35% of local people are believed to use a traditional system of health care. There were estimations that about 25% of endemic plant species on the island could be in folder medicinal plants and as recorded later on that there is 600 plant species used for healing more than 300 ailments (Ganashan et al., 1995; Sim et al., 2003). Table 2 shows some of the more common medicinal plants obtained from the forests of Sri Lanka. For example herbs are very often collected in the forest together with other non-timber forest products (NTFPs), e.g. savanna forests provide places of the highest family income from the collection of medicinal plants, which contribute by 70% of the total income from collection of NTFPs and over 60% of the villagers are involved in gathering, which significantly higher in comparison to 20-55% documented in other areas (Durst and Bishop, 1994).

Table 2: Common medicinal plants gathered from forests of Sri Lanka

Latin name	Vernacular name
<i>Acronychia pedunculata</i>	Ankenda
<i>Terminalia sp.</i>	Aralu
<i>Hibiscus micranthus</i>	Babila
<i>Munronia pumila</i>	Bimkohomba
<i>Litsea chinensis</i>	Bo-mi
<i>Terminalia bellirica</i>	Bulu
<i>Cissampelos pareira</i>	Diyamitta
<i>Dipterocarpus glandulosus</i>	Derana
<i>Shorea oblongifolia</i>	Dummala
<i>Elettaria cardamomum</i>	Enasal
<i>Hemidesmus indicus</i>	Eramusu
<i>Pterocarpus marsupium</i>	Gammalu
<i>Asparagus falcatus</i>	Hatawariya
<i>Adenia hondala</i>	Hondala
<i>Strychnos potatorum</i>	Ingini
<i>Nardostachys jatamansi</i>	Jatamansa
<i>Croton tiglium</i>	Jayapala
<i>Diospyros melanoxylon</i>	Kadumberiya
<i>Cerbera manghas</i>	Kaduru
<i>Murraya koenigii</i>	Karapincha
<i>Azadirachta indica</i>	Kohomba
<i>Pogostemon heyneanus</i>	Kolon kola
<i>Schleichera oleosa</i>	Kon
<i>Salacia reticulata</i>	Kothalahimbutu
<i>Caesalpinia bonduc</i>	Kumburu wel
<i>Bacopa monnieri</i>	Lumuwila
<i>Mimusops elengi</i>	Munamal
<i>Mesua ferrea</i>	Na
<i>Euphorbia tirucalli</i>	Navahandi
<i>Phyllanthus emblica</i>	Nelli
<i>Vitex negundo</i>	Nika
<i>Aerva lanata</i>	Polpala
<i>Cassia auriculata</i>	Ranawara
<i>Aristolochia indica</i>	Sananda
<i>Coscinium fenestratum</i>	Veniwel

Source: own work, data taken from Sim et al. (2003)

Gathering is however just the first step of the whole value-chain. Collected plant parts are further chopped or sliced, dried in sunlight and finally sold to traders, wholesalers, manufacturers, processors, or directly at local rural markets. Very often they are also exported abroad as medicinal plants from Sri Lanka were also exported from other countries (Sim et al., 2003).

2.2 Promoting value-chain for underutilised plant species

Interesting issue is the cash income that is generated from gathering, processing and selling of plants species either gathered in the wild or produced within farming systems. However, to sell any kind of plant species at local or international market, proper value-chain or market-chain must be well-developed. According to Will (2008) the definition of value chain is described by sequence of activities from producing up to final products for customers. There are three basic components of each value chain: (i) production or gathering, usually done by farmers, (ii) post-harvest management and processing, and, (iii) marketing (Musara et al., 2014). For promotion of any value chain is important to abide these five steps (see Figure 2). At first, select underutilized plant, analyse existed value chain of given plant, assess opportunities, develop an up-grading strategy and the last one, implement, monitor and refine strategy (Will, 2008).

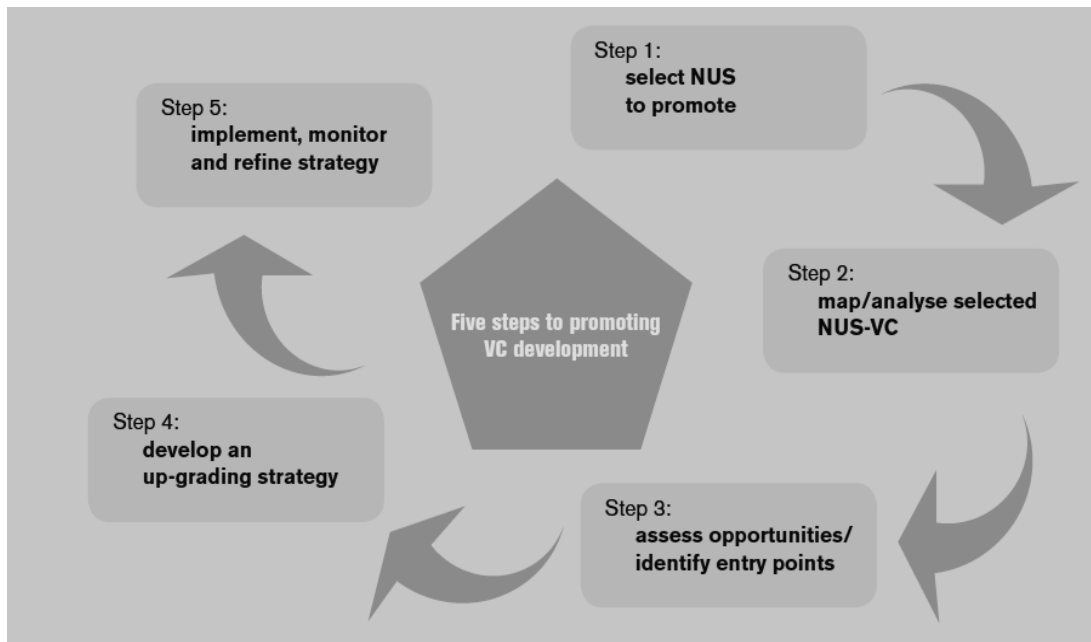


Figure 2
Five steps to promoting value chain development
Source: Will (2008)

Due to value chain is possible to check how the price increases step by step during the process. Without value chain we can only predict the reasons of concrete price on the market offered by sellers. There are three different types of sellers, each of whom deals with commodities in different ways. Producer-sellers, middlemen and long-distance

traders. At the beginning of this chain are growers (small-scale farmers) or gatherers/collectors (individuals or groups) in case of wild species from forests (Will, 2008). Unfortunately, unsustainable collection leads to overexploitation of scarce resources and therefore one of the solutions is domestication.

2.3 Potential for domestication of wild underutilised plant species and its impact on household economy

Any potential transition of useful plant species from wild form to cultivated one represents a big advantage for farmers to supply their needs. Generally, collection of edible plants in the wild can lead to overexploitation, and consequently to deforestation. The role of forest products in household economic strategies shows progress from lower to higher levels of development. Cultivation and intensified forest management are ways how to maintain or increase the supply of valuable products (Ruiz-Pérez, 2004; Polesný et al., 2014). Thus, there are attempts, effort to tree domestication. Purpose of tree domestication is to improve tree features to get higher volume and more valuable products. Tree domestication is a process that includes species selection, production, management and adoption of desirable germplasm, to product marketing. Involvement of farmers in tree domestication will increase efficiency because they are best able to identify tree characteristics that will satisfy their needs and apply indigenous knowledge to guide tree management (Roshetko et al., 2012). Improvement and expansion (understand as domestication) of local plant species directly help to increase the diversity of genetic resources (Arachchi and Wijeratne, 2008). The concept of domestication can be thought of any advances regarding a whole plant, such as higher yield, adapting on specific conditions, larger fruits and so on. Domestication of any kind of plant requires good knowledge about the given plant and helps with sustain biodiversity and nature conservation as well.

3. Objectives of the thesis

The aim of the thesis was to analyse data on eight plant species that were traded on rural markets Vavuniya city, northern Sri Lanka in 2010. Specific attention was given to:

- identify for what purposes selected species were mostly used
- collect available scientific literature on particular species
- analyse their value-chains with specific regard to the place of collection and/or planting
- consider potential constraints of value-chain development with special regard to domestication of suitable species at local farming systems

4. Methodology

4.1 Study sites

Sri Lanka (Democratic Socialist Republic of Sri Lanka, until 1972 known as Ceylon) is an oceanic tropical island. Climate is tropical and warm which is greatly influenced by monsoons. And because of that a year is divided into two parts: rainy season and drought season. Monsoon (that one that blows from the ocean to the mainland) entails rains. It affects vegetation on a whole island. Annual average precipitation is 1840 mm and annual average temperature is 25.3 °C (Weatherbase, 2016). From relations of temperature and precipitation it is a humid region. Results are compared from climadiagrams of five meteorological stations positioned differently on Sri Lanka. This climate is considered to be Aw according to the Köppen climate classification (Klimadiagramme weltweit, 2016; Climate-data, 2012). Map of Sri Lanka with study site highlighted in black is enclosed bellow (see Figure 3). Data were collected in Vavuniya city, which is located in northern part of the country.

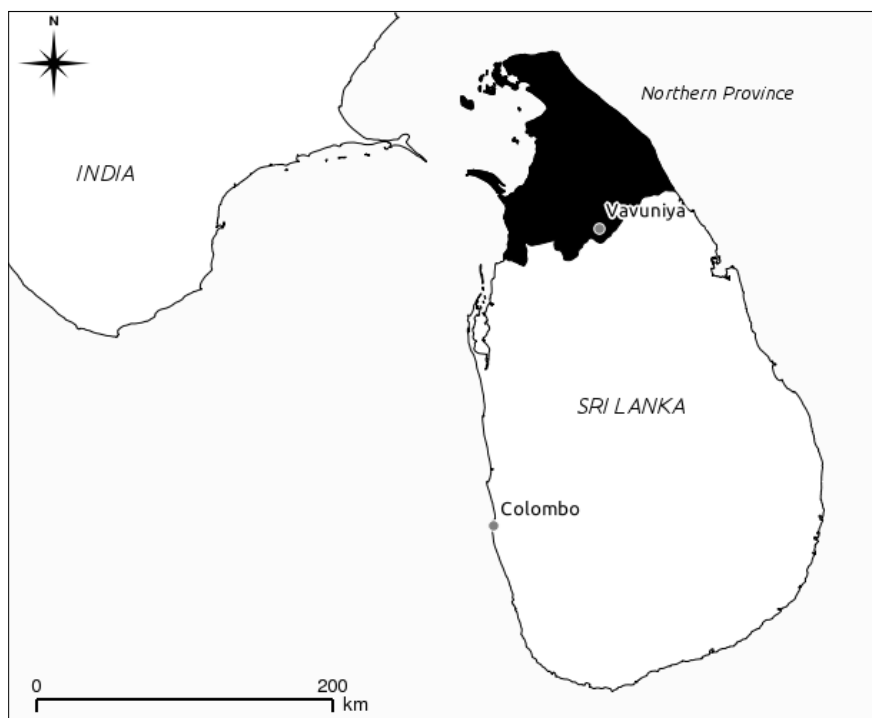


Figure 3
The location of Vavuniya city, Vavuniya district, northern Sri Lanka
Source: Vlková et al. (2010)

Area of Sri Lanka is 65,610 sq. km and on this surface lives 21.2 million inhabitants (BBC, 2015). The principal ethnic majority are the Sinhalese who account for 74% of the population, while the Tamils, who are of Indian origin, account for 18% of the population. Each ethnic group has its own language. Currency is Sri Lankan rupee (current exchange rate: 1 US\$ = 143.9000 LKR, 8 March 2016) (Central Bank of Sri Lanka, 2016). Main economic sector is agriculture together with forestry and fishing. Main agricultural products are rice, coconuts, tea, coffee, sweet potatoes or rubber. However, for export the most crucial are tea, which Sri Lanka is the largest world exporter, rubber and ware from coconuts. Tea, coconuts and rubber are also designated as the main cash crops of Sri Lanka (Palmer, 2000; Nations Encyclopedia, 2011).

4.2 Data collection and analysis

The data were collected in three fruit and vegetable markets in Vavuniya city in northern Sri Lanka during September 2010. The first market (8°45'24.70" N 80°30'03.78" W; 98 m a.s.l.) was uncovered and composed of permanent stalls, while the second (8°45'19.44" N 80°29'59.06" W; 101 m a.s.l.) and the third (8°45'25.14" N 80°30'01.49" W; 102 m a.s.l.) markets were both covered. Furthermore, the third market was characterized by non-permanent stalls. Forty sellers were interviewed through semi-structured interviews on eight pre-selected food plant species. The selection of given species was based on the role which were playing in Tamil and Sinhala ethnic groups' culture, which was based on informal discussion with local older farmers. Interviews with vendors were carried out in Tamil and subsequently translated into English. Gathered information on pre-selected species traded in the stalls of targeted markets includes: (a) vernacular names according to Tamil and Sinhalese vendors according to Sinhala, (b) plant part used and purpose of use, (c) mode of preparation, (d) source area, (e) whether the plant is gathered or cultivated, (f) cultivation requirements, and (g) selling price. Besides products sold, further basic demographic information about the vendors was gathered as well showing us that all of the interviewees were middlemen with an average age of 39.5 years, ranging between 17 and 65 years. Thirty-eight sellers belong to Tamil ethnic group and remaining two to Sinhala ethnic group. Only seven of them were women, while the others were men.

5. Results and discussion

5.1 Overview and ethnobotanical knowledge of pre-selected products sold on chosen local markets in Vavuniya city

The family with the largest number of plant species was Rutaceae with 3 species (representing 37.5% of the total species), followed by Cucurbitaceae with two (25%). The families Apiaceae, Araceae and Fabaceae comprised one species each. Moreover, all of the surveyed species were native to Sri Lanka or to Indian subcontinent. Table 3 documents the prices of given plant species. The standard prices for each plant vary between 40 and 400 LKR (0.3 and 2.8 US\$) per kg, whereas *Centella asiatica* and *Murraya koenigii* were sold by bunch (10 LKR = 0.069 US\$ per bunch each).

Table 3: Prices of species sold on the markets

Species sold	Frequency on the markets*	Minimal price LKR/kg / US\$/kg	Maximal price LKR/kg / US\$/kg	Average price LKR/kg / US\$/kg
<i>Aegle marmelos</i>	2	35 / 0.243	45 / 0.313	40.0 / 0.278
<i>Amorphophallus paeoniifolius</i>	18	60 / 0.417	93 / 0.646	79.8 / 0.555
<i>Centella asiatica</i>	11	8 / 0.056	13 / 0.09	10.3 / 0.072
<i>Dialium ovoideum</i>	2	400 / 2.78	400 / 2.78	400.0 / 2.78
<i>Limonia acidissima</i>	18	115 / 0.799	145 / 1.008	130.4 / 0.906
<i>Luffa acutangula</i>	7	65 / 0.452	87 / 0.605	80.0 / 0.556
<i>Murraya koenigii</i>	5	8 / 0.056	12 / 0.083	10.0 / 0.069
<i>Trichosanthes cucumerina</i> var. <i>anguina</i>	20	44 / 0.306	55 / 0.382	50.4 / 0.35

Note(s): * How many times to sell.

LKR per 1 US\$: 143.9000 / US\$ per 1 LKR: 0.006949 (Central Bank of Sri Lanka, 2016)

The most frequent plant life forms were trees (50%), followed by herbs and climbers (25% each). Fifty percent of surveyed species was available on the market all year round, while *Aegle marmelos* was harvested twice a year, and the collecting season for *Amorphophallus paeoniifolius*, *Dialium ovoideum* and *Limonia acidissima* was only once a year, mostly in the period September-November. From our data, the majority of selected plants (62.5%) were harvested only from the field or home garden, whereas

Murraya koenigii and *Limonia acidissima* can be either collected in the wild or cultivated. *Dialium ovoideum*, meaning jungle tamarind in Sinhala, was the only harvested wild species, in the rainforest or forest. This species was sold by two vendors only which together with the need to be gathering was reflected in the price. Furthermore, the species *Aegle marmelos* was considered as very rare plant. All species are imported to the markets by different middlemen, or the vendors are the intermediaries who buy the species from other people that collect the plants in the wild or cultivate them. Ethnobotanical knowledge of local people shows that the eight selected species were used as food (87.5%), medicine (75.0%), feed, religious item (25.0% each), food additives and dye (12.5% each). Eighty-eight percent of the species have multiple uses. The most frequent habitus were trees (50%), herbs (25%) and climbers (25%). All of the surveyed species were native to Sri Lanka or to Indian subcontinent.

Out of the species primarily used as food or food additive, *Amorphophallus paeoniifolius*, *Luffa acutangula*, *Murraya koenigii* and *Trichosanthes cucumerina* var. *anguina* were used for traditional Sri Lankan „meal, rice & curry”. Regarding the mode of preparation of food, most of the species (*Aegle marmelos*, *Centella asiatica*, *Dialium ovoideum*, *Limonia acidissima* and *Murraya koenigii*) were eaten raw, boiled (*Amorphophallus paeoniifolius*, *Luffa acutangula* and *Trichosanthes cucumerina* var. *anguina*) or fried (*Amorphophallus paeoniifolius*). Additionally, the species *Centella asiatica*, *Limonia acidissima* and *Murraya koenigii* were used for local juice making.

Furthermore, in total nine different medicinal indications were recorded to heal or alleviate a wide range of illnesses and pains. Among the most versatile species were *Amorphophallus paeoniifolius* involved in the five medicinal indications and *Centella asiatica* with four. The highest number of species (*Aegle marmelos*, *Amorphophallus paeoniifolius*, *Limonia acidissima*, *Luffa acutangula*, *Murraya koenigii* and *Trichosanthes cucumerina* var. *anguina*) that represented 75% of total species reported were used to cure digestive system disorders, mainly stomach ailments and pains, diarrhea and dysentery; followed by eye disorders (*Centella asiatica* and *Murraya koenigii*), heart diseases (*Aegle marmelos*) and brain tumor (*Amorphophallus paeoniifolius*).

Table 4: Eight pre-selected food plant species

English name	Latin name	Vernacular name	Family	Source area	Plant part used (main product)	Use
Bael	<i>Aegle marmelos</i>	Be li (Sinhalese), Vilvama (Tamil)	Rutaceae	field	fruit, leaves	lemonade, jam, compote, ritual purposes
Elephant foot yam	<i>Amorphophallus paeoniifolius</i>	Karnakilanku (Tamil)	Araceae	field	tuber crop	food, medicine
Asian pennywort	<i>Centella asiatica</i>	Kotukola (Sinhalese), Vallarai (Tamil)	Apiaceae	paddy field	leaves	medicine (tea, ointment, „for a longer life“), salad
Pebble (Velvet) Tamarind	<i>Dialium ovoideum</i>	Gal-siyambala (Sinhalese), Pattu Puliyampalam (Tamil)	Fabaceae	rainforest, forest, wild	timber, fruit	food, dessert fruit
Wood-apple	<i>Limonia acidissima</i>	Divul (Sinhalese), Vilam Palam (Tamil)	Rutaceae	homegarden, wild	bark, fruit	bark – edible gum, fruit - jam
Chinese okra/ Ridge gourd	<i>Luffa acutangula</i>	Wetakolu (Sinhalese), Peer kangai (Tamil)	Cucurbitaceae	homegarden	young shoots, fruit	young fruits and young shoots – use as vegetables, mature fruit - food
Curry tree	<i>Murraya koenigii</i>	Karapincha (Sinhalese), Kariveppilai (Tamil)	Rutaceae	homegarden, wild	leaves	spice, medicine
Snake gourd	<i>Trichosanthes cucumerina</i> var. <i>anguina</i>	Pathola (Sinhalese), Pudal (Tamil)	Cucurbitaceae	field	young shoots, leaves, fruit	young shoots and leaves – use as vegetables, mature fruit - food

Table 4 is based on collected data (Vlková and Tůmová, 2010) and vernacular names are found out according to Multilingual multiscrypt plant name database (2012). But only Latin name is authoritative and valid name in every publications. It is the main, crucial and universal title. Vernacular name can be different in each ethnic group. As we can see in the same Table 4.

Moreover, *Centella asiatica* was mentioned as medicinal plant which helps to improve the memory and body condition, while *Amorphophallus paeoniifolius* increased the energy flow in human body. 62.5% of surveyed species were used for cooling the human body. From all the selected species only *Dialium ovoideum* had no medicinal uses. Some of these species have previously been recorded in the literature to be used as local remedies, i.e. *Aegle marmelos* (Kala, 2006; Gupta et al., 2008) *Centella asiatica* (Brinkhaus et al., 2000; Zainol, 2003) and *Murraya koenigii* (Ayyanar and Ignacimuthu, 2005; Ayyanar and Ignacimuthu, 2011). However, research on *Amorphophallus paeoniifolius* and *Luffa acutangula* remains neglected in this context. Large use of documented species at local market could be explained through long tradition of the traditional Sri Lankan system of medicine, Ayurveda, which has been practiced for at least three thousand years and about 35% of the population is primarily dependent on it (Russel-Smith, 2006). Surprisingly, only two species *Trichosanthes cucumerina* var. *anguina* and *Murraya koenigii* were mentioned as plants used in ayurvedic treatment. Furthermore, two surveyed species from the family Rutaceae were considered as sacred plants with magic connotations. Both were often planted in the vicinity at majority of Shiva temples and used in religious rituals in Hinduism, such as leaves of *Aegle marmelos* are offered in prayers to please Lord Shiva. The offered trifoliolate leaves symbolize the trident that Shiva holds in his right hand. The importance of this tree in worship of Lord Shiva is mentioned by several authors (Chandrakanth and Romm, 1991; Kala, 2006; Gupta et al., 2008).

5.2 Characteristics of pre-selected plant species from Vavuniya market

Seven of given species can people cultivate on their own home gardens or fields, i.e. *Aegle marmelos* (L.) Corrêa, *Amorphophallus paeoniifolius* (Dennst.) Nicolson, *Centella asiatica* (L.) Urb., *Limonia acidissima* L., *Luffa acutangula* (L.) Roxb., *Murraya koenigii* (L.) Spreng and *Trichosanthes cucumerina* var. *anguina* (L.) Haines. Only one plant can be collected from wild, particularly forests, which is *Dialium ovoideum* Thwaites. Specific information on particular species are listed below. Following chapters includes basic information especially: names (Latin, vernacular, English), inclusion into the family, description of habitus, range, kinds of products and edible and medicinal uses. *Dialium ovoideum*, *Centella asiatica*, *Trichosanthes cucumerina* and *Limonia acidissima* are native species on Sri Lanka (Arachchi and Wijeratne, 2008).

5.2.1 *Aegle marmelos* (L.) Corrêa

Aegle marmelos from family Rutaceae is also known as the bael tree. Sinhalese called it Be li and Tamil called it Vilvama. Is native to the Indo-Malayan region and is currently cultivated in Sri Lanka, India, Pakistan, Bangladesh, Burma and Thailand. The tree is slender, aromatic perennial, 6.0-7.5 m tall. It flowers from May to July and provides 200-250 kg of edible fruits (300-400 pieces). This medicinal plant is used to heal many kinds of ailments. Each part of the plant is used to different ailment, e.g. roots are used for treating diarrhoea and dysentery, leafs could be used against diabetes and asthmatic complaints, and unripe fruit is beneficial for treating diarrhoea, dysentery (same as roots) or tooth ache (Arumugam et al., 2008). Fruit can be consumed raw, made into jams or very refreshing drink (Useful Tropical Plants Database, 2014). According to published study of Arumugam et al. (2008), results showed that leaves and callus can decrease blood sugar level which implies that *Aegle marmelos* can be used for treating diabetes.



Figure 4
Fruit of *Aegle marmelos*
Source: Boose (2014)

5.2.2 *Amorphophallus paeoniifolius* (Dennst.) Nicolson

Belongs to family Araceae and represents a tuber crop also known as Elephant foot yam. This perennial plant is used as tuber vegetable which is in addition good source of proteins and starch. The net economic return is approximately US\$ 700 per ha. Due to high production and great export potential because of deficiency in other parts of the world is classified as cash crop (Singh and Wadhwa, 2013). *Amorphophallus paeoniifolius* occurs in certain areas such as South-east Asia, western Pacific and north Australia. In agroforestry systems, Elephant foot yam can be cultivated with other plantation crops, for instance: betel (*Areca* spp.), coconuts (*Cocos nucifera*), bananas (*Musa* spp.) or coffee (*Coffea* spp.).

The tuber of the wild species is toxic and inedible, the wild plant only being used for medicinal purposes. There are many cultivated forms, some of them have less or no alkaloids (for withdrawal it must be thoroughly boiled or baked). It is a multipurpose plant for treating different human ailments. Besides edible uses there is a wide range of medicinal purposes. For example, the roots are used for dysentery, the stem in the treatment of snakebite and the sap from the petiole is fermented and drunk as a treatment for diarrhoea and dysentery (Useful Tropical Plants Database, 2014). Thanks to reviewed study of (Singh and Wadhwa, 2013), all potential activities of *Amorphophallus paeoniifolius* have been summarized e.g. analgesic activity, antibacterial activity, antioxidant activity, anti-tumour activity. Moreover, insecticidal potentiality was also detected. Products of *Amorphophallus paeoniifolius* such as pickles, dried cubes, and chips are being more popular and bread made from *Amorphophallus paeoniifolius* flour can be used as substitute for wheat flour.



Figure 5
Tuber of *Amorphophallus paeoniifolius*
Source: Aruna (2014)

5.2.3 *Centella asiatica* (L.) Urb.

Centella asiatica, popularly called Gotukola, belongs to family Apiaceae and it is traditional medicine used for wound healing and improving memory (Besung et al., 2014). This perennial and small herbaceous plant with trailing habit occurs in area of Himalayan foot-hills of India and also of Sri Lanka. The plant can be harvested at any time of the year and is used fresh or dried. Its healthy green vegetable is used in preparing gruel called Kanda (Nath, 1999). For medicinal uses are the most important leaves. Fresh leaves are used for making tea or salad. On the contrary, dried leaves are used only for making tea. It has been proved that this revitalizing herb strengthens nervous function, clears our body from toxic compounds, reduces inflammations and fevers, and also improves healing and immunity (Brown, 1995). According to Nath (1999) the demand for Gotukola in the vegetable market increased so the farmers decided to put it under cultivation and met the demand of consumers. Excessive trade of *Centella asiatica* affected negatively local forests, but also its domestication saved the species from overexploitation from its natural habitat.



Figure 6
Leaves of *Centella asiatica*
Source: Acharya (2014)

5.2.4 *Limonia acidissima* L.

Limonia acidissima L. is also known as Wood-apple, Divul (Sinhalese) or Vilam Palam (Tamil). It belongs to family Rutaceae. Pinnate leaves with citrus scent are located at its large tree, up to 9 m tall with spiny and rough bark. The fruit is a berry, 5-9 cm in diameter and it tastes sweet or sour. The unripe fruit is interesting remedy for dysentery, diarrhoea but also for sore throat and diseases of the gums. On the other hand, the ripe fruit contains beta-carotene and in addition it is good source of vitamins e.g. complex of B vitamins and small amount of vitamin C. Nevertheless, different parts of *Limonia acidissima* can be used for treating different illnesses. For example the roots (root juice) were popular as a remedy for snakebites, the seed oil is a purgative and leaves (leaf juice) mixed with honey is a folk remedy for fever. Also bark (decoction from bark) is an interesting in healing malaria (due to the content of tannin and alkaloid) (Banerjee et al., 2011). According to Pandavadra and Chanda (2014) basically the fruits are used for asthma, tumors, wounds, cardiac debility, hepatitis and the leaves are used in the treatment of constipation and vomiting. The leaves contain coumarin, triterpenoids and steroids.



Figure 7
Close-up of the fruit
Source: Garg (2014)



Figure 8
Fruit cut open to reveal flesh and seeds
Source: Garg (2014)

5.2.5 *Luffa acutangula* (L.) Roxb.

Luffa acutangula is from family Cucurbitaceae and is commonly known as Chinese okra or Ridge gourd. Watakolu is vernacular name from Sinhalese and Peerkangai from Tamil ethnic group. It is a widely growing vegetative climber. The fruits of *Luffa acutangula* are baseball club shaped with sweet juiciness and bitter flavour (Singh et al., 2014). The fruit is also source of fibres commonly used for manufacturing cleaners, brushes etc. The seeds of *Luffa acutangula* are purgative and it is possible to eat them to expel intestinal worms. Except various traditional medicinal uses it can be utilized as pesticide (Useful Tropical Plants Database, 2014). Moreover, antidiabetic activity was detected same as in *Aegle marmelos*. Generally, phytomedicines are better than allopathic drugs due to its lower price and not showing side effects (Singh et al., 2014).



Figure 9
Ripening fruit of *Luffa acutangula*
Source: Ganguly (2014)

5.2.6 *Murraya koenigii* (L.) Spreng

Murraya koenigii from family Rutaceae is also known as Curry tree. It is highly valuable plant due to its characteristic aroma and medicinal value. For centuries, *Murraya koenigii* is being used in local cookery and it plays universal role in traditional medicine. Original habitat is in India but it is available in other countries in Asian region (e.g. Bhutan, Laos, Nepal, Pakistan, Sri Lanka, Thailand and Vietnam), South Africa and Réunion Island. It looks like bush or small tree (up to 6 metres high). The tree has slender but strong woody stem covered by dark green bark and branches are covered by dark grey bark. Leaves are glabrous and strongly aromatic. Bark and roots are used for gashes and bites of poisonous animals. Green leaves are eaten raw because of dysentery and diarrhoea (Jain et al., 2012). Sinhalese called it Karapincha and Tamil called it Kariveppilai. Typical fruit is berry which is known by its antioxidant activity. Results from Yogesh et al. (2012) showed that berry is excellent source of phenolic and flavonoid compounds.

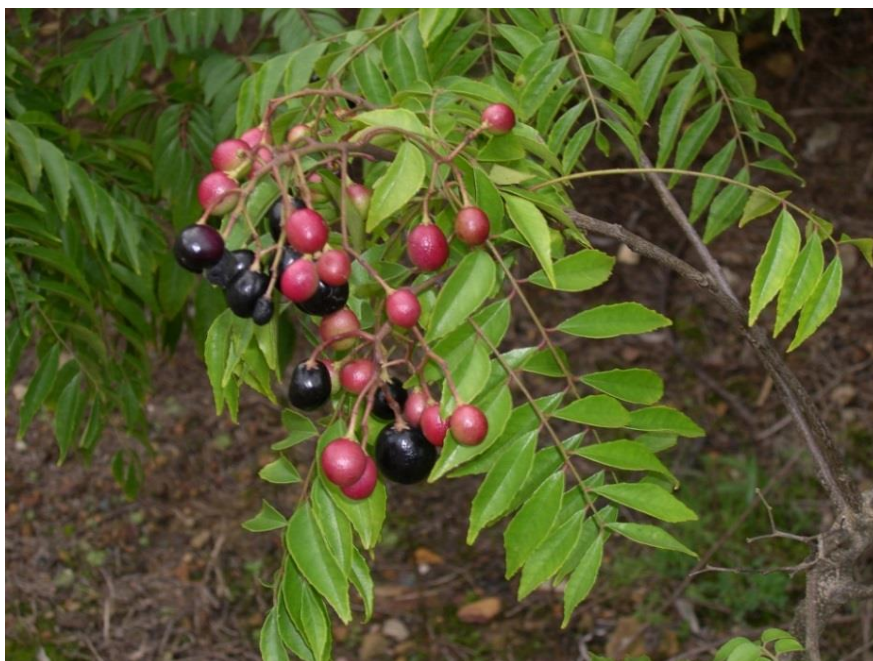


Figure 10
Ripe and unripe fruits of *Murraya koenigii*
Source: Chang (2014)

5.2.7 *Trichosanthes cucumerina* var. *anguina* (L.) Haines

Trichosanthes cucumerina var. *anguina* belongs to family Cucurbitaceae and is also known as Snake gourd, Pathola (Sinhalese) or Pudal (Tamil). It is herbaceous, climbing type plant (vegetable crop) of the moist tropics which is intolerant of drought. *Trichosanthes cucumerina* var. *anguina* occurs in certain areas of Indian subcontinent, Myanmar, Vietnam, Malaysia but also it can be found in Indonesia, Philippines and Australia. Edible *Trichosanthes cucumerina* var. *anguina* evolved from inedible wild species which are nowadays collected from forests for medicinal uses (Useful Tropical Plants Database, 2014). It is important to differ these two forms. Nutritional value of *Trichosanthes cucumerina* var. *anguina* is significant for human's health because it contains considerable amount of protein (0.5 %), fat (0.3 %), minerals (0.5 %), fiber (0.5 %), and carbohydrates (3.3 %). Also, it is also rich in vitamin A (Gopalan et al., 1982).



Figure 11

Fruits for sale in the market

Source: Aruna (2014)

5.2.8 *Dialium ovoideum* Thwaites

Gal-siyambala (vernacular name of *Dialium ovoideum*) belongs to family Fabaceae. It is also known as Pebble Tamarind or Velvet Tamarind because of appearance of fruits. It is a large tree of the moist tropics harvested from the wild for its timber and edible fruit (see Figure 12). Fruits are 1.5 cm long, produced in large clusters and covered by velvet peel. The peel is easily removable from the fruit and it tastes sweet and slightly acid (Dominica Academy of Arts and Sciences, 2004). A mature gal-siyambala tree produces 250-300 kg of fruit. The fruit producing cycle begins in late August and extends until October (Blockhus et al., 2002). So the collecting season is only once a year. Any medical uses of *Dialium ovoideum* have not been detected yet.



Figure 12
Fruits of *Dialium Ovoideum*
Source: Odunayo (2015)

5.5. Value-chain of *Dialium ovoideum*

Dialium ovoideum was the only one plant sold on chosen market in Vavuniya city, which is gathered in the wild and not domesticated. However, as stated in previous chapters, it is classified as a local favourite fruit and together with honey represents one of the major non-timber forest products of Sri Lanka.

Based on our data, price of gal-siyambala was 2.78 US\$ per kg in 2010. However, the price varies with the quality of the fruit. Based on Blockhus et al. (2002), raw and green fruits could be sold for less than US\$ 0.1 per kg, while the best quality fruits, large, ripe and undamaged velvet skin, would be sold even for US\$ 0.21-0.27 per kg. Nevertheless, even if we consider increasing purchasing price for gatherers, the range between the price for which gatherer selling fruit and final price at the market is wide. On the other hand, collecting of *Dialium ovoideum* fruits represents very profitable activity of farmers, which can earn up to US\$ 4 per day and even worth of paying fees for its collecting (Blockhus et al., 2002; Ministry of Environment and Natural Resources, 2009). Based on our data and existing literature, value-chain of *Dialium ovoideum* could be described as follows. During the peak season, harvesters come out of the forest with sacks of fruits and immediately sell their harvest to local traders (middlemen). In our case, all vendors were middlemen who sold goods that had been produced/gathered elsewhere by whomever. First steps are access to source and harvest. When harvesting takes place for commercial trade, there is often large number of people involved, from initial harvest through processing, sale and resale (Cunningham, 2001; Blockhus et al., 2002). As mentioned earlier, sellers are middlemen. So they buy fruits from harvesters. This item is a part of this chain and it is somewhere between production and marketing.

5.6 Domestication potential – advantages and disadvantages

As already mentioned, *Dialium ovoideum* is the only one plant species from eight chosen at local market, which is not domesticated. If collection of this particular species would become unsustainable, there is a possibility of extinction or least reduction of the population of *Dialium ovoideum* in the wild. Propagation is made by seeds which have to be chosen on the basis of appearance and have to be undamaged. For better germination, pericarp of the seeds should be slightly cut open. However, we should be cautious by conducting this step. Seeds may be collected from local sources (trees in the landscape) or purchased from commercial dealers. Local collection has certain advantages; the freshness, degree of maturity and parentage of the seed are usually known by the collector. Seeds can be collected from local sources, trees in the wild. Local collection has certain advantages; the freshness, degree of maturity and parentage of the seed are usually known by the collector (Broschat and Meerow, 2015).

Cultivation of gal-siyambala depends on several factors, mostly on features of soil. It is known that *Dialium ovoideum* has a symbiotic relationship with certain soil bacteria, these bacteria form nodules on the roots and fix atmospheric nitrogen (Huxley et al., 1992). Some of this nitrogen is utilized by the growing plant but some can also be used by other plants growing nearby. Moreover, physical and chemical features of soil can affect nutrition of plants, mainly pH. Microorganisms require pH near 5-6. Other merits can be harmful and in final it can influence plant nutrition. Besides providing edible fruits, almost every other parts of plant found its use. The flowers are a source of nectar for bees. The branches are a source of fuelwood, and the trunks are used for timber (Blockhus et al., 2002). Among farmers there is always problem with adoption of new strategy, who can collect fruit in the wild instead or use their own sources for domestication. Nevertheless, reducing expenses that are very often connected to collection natural products, e.g. in forest (Polesný et al., 2014) is very tempting for them. Possible solution may represent forestry nurseries or agroforestry systems (Roshetko et al., 2006). Suitable agroforestry system can provide diverse production, increased income for smallholders, prevent erosion and protect of natural resources. On the other hand, this is a long-term process which is profitable after certain period of time, usually at least three or five years. Furthermore, it also requires higher household labour input compare to annual crops.

6. Conclusion

This study documented eight edible species which were sold on three markets in Vavuniya town. The most frequent plant life forms were trees (50%), followed by herbs and climbers (25% each). Ethnobotanical knowledge of local people shows that the eight selected species were used as food (87.5%), medicine (75.0%), feed, religious item (25.0% each), food additives and dye (12.5% each). Eighty-eight percent of the species have multiple uses. The most frequent habitus were trees (50%), herbs (25%) and climbers (25%). All of the surveyed species were native to Sri Lanka (i. e. *Dialium ovoideum*, *Centella asiatica*, *Trichosanthes cucumerina* and *Limonia acidissima*) or to Indian subcontinent. Fifty percent of surveyed species was available on the market all year round, while *Aegle marmelos* was harvested twice a year, and the collecting season for *Amorphophallus paeoniifolius*, *Dialium ovoideum* and *Limonia acidissima* was only once a year, mostly in the period September-November. Antidiabetic activity was detected in *Aegle marmelos* but also in *Luffa acutangula*. It is possible to discuss which plant has better influence on decreasing blood sugar level. Extract of *Luffa acutangula* is useful only in combination with another plant *Madhuca longifolia* (this plant was not a subject of this thesis), but on the other hand *Luffa acutangula* is available through all year round compared to *Aegle marmelos*, which is harvested twice a year. Due to that fact, anti-diabetic medicine from *Aegle marmelos* cannot be for example produced in same amount as medicine of *Luffa acutangula*. All species were of south Asian origin, particularly *Dialium ovoideum*, *Centella asiatica*, *Trichosanthes cucumerina* and *Limonia acidissima*, which have their origin directly in Sri Lanka. From our data, the majority of selected plants (62.5 %) were harvested only from the field or home garden, whereas *Murraya koenigii* and *Limonia acidissima* can be either collected in the wild or cultivated. *Dialium ovoideum*, meaning jungle tamarind in Sinhala, was the only wild harvested species, in the rainforest or forest. *Dialium ovoideum* was sold by two vendors only and had the highest price which reflected method of obtaining. *Dialium ovoideum* is important to local people by being important source of food. Analysis of existing value chain shows that gathering of *Dialium ovoideum* fruits is very profitable activity for farmers as they can earn equal income as from gold mining. Nevertheless, documented price at local market was significantly higher than price which collectors

receive, which point out at unfair linkages between the nodes within the value chain. On the other hand, increasing attractiveness of *Dialium ovoideum* collection would lead to extinction of this species or to decrease of its population. Thus, thesis suggests to consider more the basic part of value-chain, which deals with the sustainability of the whole system – access to genetic material. Nevertheless, it is important to say that no reviewed studied has been found to obtain data regarding domestication of *Dialium ovoideum*, as one of tools for sustain biodiversity and nature conservation. Thus, domestication of *Dialium ovoideum* is a suitable step to promote actual value chain and rescues forests of Sri Lanka. Therefore, it is possible to discuss over several topics, such as utilization of this plant in agroforestry, advantages and disadvantages of inclusion into agroforestry systems and outlining options for symbiotic cultivation.

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