Feature Article

Native Floral Species for Watershed Restoration and Enrichment in Sri Lanka

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Abstract

Sri Lanka faces frequent floods and land degradation almost frequently which is aggravated by high rainfall intensities and poor land management practices. This problem is common in most areas because about 90% of the total landmass of Sri Lanka comes within river watersheds. Though Sri Lanka is one of the richest countries in floral diversity, the recognition of native tree and plant species which are suitable for restoration of degraded lands in all three climate zones has not been done before. Therefore this study was conducted to fill that gap which is essential for land managers in both private and public sectors. With literature survey, field observations and expert interviews this study identified and developed a database of suitable native tree and plant species for restoration of watersheds and their conservation status, growth parameters, and the uses of each species.

Keywords: watershed planting, tree selection, enrichment, site degradation

1. Introduction

Since ancient times, humans have settled in flood plains due to factors such as superior agricultural productivity and ease of transport, which facilitated economic growth (Douben, 2006). Areas vulnerable to floods share certain common characteristics: they tend to occur in high rainfall areas of low elevations and close to streams, reservoirs or the sea. However, presence of any or all of these characteristics does not necessarily make an area flood prone, and their absence also does not make an area flood free (Disaster Management Center, 2004).

Human communities have used different methods for flood risk management historically. Broadly they can be catagorised as: hard engineering, soft nature-based and non-structural. Though hard engineering methods such as dams, and levees, are conventionally used and viewed to be more predictable, they can have lasting negative impacts on the hydrology and environment of a watershed. Further, construction of such structures are not socially and economical appropriate in many locations. Therefore the use of soft nature-based methods such watershed conservation or riparian zone restoration, are now increasingly drawing the attention in minimising the risk of floods.

Trees and forests play a vital role in managing flow water through a watershed and removing or filtering contaminants that would otherwise be transported to and through waterways. Thus, degraded land with reduced vegetation cover and biodiversity can increase the downstream flood risks, erosion, siltation and pollution related health hazards. Restoration of vegetation (growing and maintaining trees and plants) in degraded sites in watersheds can substantially minimise these risks.

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Land owners, especially large scale plantation managers have started to pay a considerable amount of attention to the enrichment of watersheds, especially the stream and river buffers and degraded sties, primarily as a mandate but also to enhance the biodiversity, aesthetic value and water course protection. However, a proper system is not available in Sri Lanka to identify tree and plant species which are most suited for these diverse objectives and to match them with different climatic and geographical requirements. Therefore this study was conducted with the objectives of identifying the key requirements to be fulfilled with watershed restoration and enrichment; develop the criteria for selecting species for watershed restoration and enrichment and developing the database for identification of most suitable native or endemic tree and plant species for different regions in Sri Lanka. For this purpose the suitable species were identified based on literary texts and formal and informal interviews with experts. The taxonomy status and characteristics were identified from various sources available in literature.

2. Watershed

A watershed is a topographically delineated area that is drained by a stream system. It is the total area above some point on a stream or river that drains past that point (Wang et al., 2016). It can also be defined as an area of land that drains water, sediment and dissolved materials to a common receiving body or outlet. The term is not restricted to surface water runoff and includes interactions with subsurface water as well. A watershed is also a hydrological response unit, a biophysical unit, and a holistic ecosystem in terms of the materials, energy, and information that flow through it. Therefore, as well as being a useful unit for physical analyses, it can also be a suitable socioeconomic-political unit for management planning and implementation. Watersheds can vary in size from thousands of square kilometres to a small area drained by a freshet (Wang et al., 2016). They vary from the largest river basins to just acres or less in size. Watersheds are classified depending on their size (Jaisval, 2016) as illustrated in the Table 1.

Table 1: Watershed classification based on the size.

Size of watershed (ha)	Category
1,000-10,000	Macro watershed
100-1,000	Micro watershed:
10-100	Mini watershed
1-10	Mille watershed

3. Flood

A flood is an overflow or inundation with water flowing from a river or other body of water causing severe damages (US Geology Survey, 2016). It is defined as the covering of normally dry land by water that has escaped or been released from the normal confines of any lake, river, creek or other natural watercourse, whether or not altered or modified; or any reservoir, canal, or dam.

On a global scale, river flood plains and coastal areas are the most susceptible to flooding. However, flooding can also occur in other areas, particularly those receiving unusually long periods of heavy rainfall. Bangladesh is the most flood prone area in the world, because it is a low-lying riverine country located between the foothills of the Himalayas and the Indian Ocean. It is vulnerable due to a long monsoon season which causes heavy rainfall (Farooq, 2008).

There are multiple and various factors which contribute to the global increase in flooding. These include meteorological factors such as rainfall, storms and changing temperatures, hydrological factors such as soil moisture and ground water levels, and societal factors such as changes in land use and occupation of flood plains. Even floods in urban areas are an increasing concern as cities and towns expand rapidly, many along coastal lines, where sea level rise and sinking land (or subsidence) compound risk (Flood Green Guide, 2016).

The most common cause of flooding is the incapability of watercourses to drain away water during an unusually heavy rainfall. Floods, however, are not always caused by heavy rainfall. They can result from other natural or man-made phenomena (Farooq, 2008). When rainfall is received on a catchment, the amount of rainwater that reaches the waterways depends on the characteristics of the catchment, particularly its size, shape and land use. Some precipitated water is captured by soil and vegetation, and the remaining water enters waterways as flow. River characteristics such as size and shape, the vegetation in and around the river, and the presence of structures in and adjacent to the waterway all affect the level of water in the waterway (Panel and Garrett, 2011). Watershed changes that increase the size of floods and frequency of flooding, such as deforestation, agriculture and urbanisation, are major contributors of stream bank erosion (Georgia Soil and Water Conservation Commission, 2000).

4. Impacts of Floods in Sri Lanka

Floods are of more common occurrence in Sri Lanka than the other natural disasters because many of the rivers in the country are prone to causing floods. Sri Lanka's hydrological resources consist of a network of river basins with varying degrees of water availability. There are 103 distinct river basins which cover about 58,550 km^2, which is 90% of the total land mass. The increase in population and subsequent need for land have forced more and more people to live and work in these vulnerable areas, thereby intensifying the risk to life and property in the event of major floods.

The wet zone in Sri Lanka is likely to receive more rainfall due to the effects of climate change, which is proved by the erratic rainfall patterns during the southwest monsoon in the recent years (Dissanayake et al., 2018). Over the past 20 years, recurring floods in the country have had an impact on almost all districts of the country. Districts of Kegalle, Ratnapura, Kalutara, Colombo, Gampaha and Galle are subject to floods on account of Southwest monsoon rains, while Ampara, Trincomalee, Badulla, Polonnaruwa, Batticaloa, Matale and Monaragala suffer from the Northeast monsoon rains (Ghatak et al., 2012). A marked increase in the number of floods that affected people can be noted in 2008, 2011, 2014 and 2017 as several flood events were recorded within the same year. While loss of life remains significant, a reduction in related numbers has been evidenced throughout the period.

Floods in Sri Lanka can be classified in different ways. The following is one of the more common and useful ways of classifying floods, based on the source and the nature of flooding (Disaster Management Center, 2004).

i. Riverine floods
ii. Flash floods
iii. Localized floods
iv. Floods created by reservoir operation

4.1 Main reasons of flood occurrence in Sri Lanka

In Sri Lanka, the occurrence of recent floods is related to the heavy rainfall and concentration of sediment in marshy and other lowlands. Rainfall in Sri Lanka has multiple origins. Monsoonal, convectional and depressional rain accounts for a major share of the annual rainfall. The mean annual rainfall varies from under 900 mm in the driest parts (southeastern and northwestern) to over 5,000 mm in the wettest parts; western slopes of the central highlands of the country (Department of Meteorology, 2018).

Deforestation, improper land use and the absence of scientific soil conservation practices are identified as the major factors contributing to floods in Sri Lanka. Together with global phenomena such as climate change which has increased rainfall intensities, urbanisation accompanied by insufficient infrastructural facilities such as drainage systems trigger urban floods (Dissanayake et al., 2018).

Unplanned land reclamation for housing schemes, industries and agriculture has also been responsible for recent floods in the coastal lowlands during the heavy showers. Sediments from landslides and soil erosion also supply fine materials to the lowlands and are responsible for floods. Such concentrations of sediments are a direct result of deforestation, encroachment of forest reservation and gem mining in the basins (Katupotha, 1989).

5. Integrated Watershed Management to Reduce Flood Risk

Watershed management is the process of organising and guiding land, water, and other natural resources used in a watershed to provide the appropriate goods and services while mitigating the impact on the soil and watershed resources (Wang et al., 2016). It involves socioeconomic, human-institutional, and biophysical inter-relationships among soil, water, and land use and the connection between upland and downstream areas (Ffolliott et al. 2002).

Integrated flood management combines land and water resource development in a river basin within the context of integrated water resource management with a view of maximising efficient use of floodplains and minimising loss of life and property (Flood Green Guide, 2016). However, in order for better assessment of flood related risk and options available to manage that risk, it is important to know the location of the area of interest within the watershed. Multiple and varied factors within a watershed affect the potential for flood risk and the options for putting together a flood management strategy (Flood Green Guide, 2016).

Integrated flood management embraces principles embedded in water resource management and those of risk management. This integration embraces land and water resources development in a river basin, use of floodplains and the reduction of loss of life due to flooding. There is a combination of policies and regulatory, financial and physical measures in trying to cope with floods, and at the same time recognise that floods cannot be fully controlled (Water Meteorological Organization and Global Water Partnership, 2004).

5.1 Use of bioengineering methods for flood risk management

Bioengineering integrates living plants and structural and manufactured materials together in mutually reinforcing complimentary roles (Allen and Leech, 1997). Such techniques used in combination with civil and social engineering measures can considerably reduce the overall cost of landslide mitigation (Singh, 2010). In terms of flash flood mitigation, it refers to the combination of biological, mechanical, and ecological concepts to reduce or control erosion, protect soil, and stabilize slopes using vegetation or a combination of vegetation and construction materials.

Bamboo fencing, brush mattresses, live crib walls, live fascines, wattle fences, live stacking, coir mats, coir nettings, coir rolls, turf reinforcement mat and pre-vegetated blanket are the most common and popular methods used under bioengineering methods. This technology integrates sound engineering practices with ecological principles. It uses living plant material in combination with non-living structural elements and manufactured products. Therefore, it brings biological, ecological, and engineering concepts together to produce living, functioning systems for erosion and flood control, habitat, and aesthetic enhancement, water quality improvement.

5.2 Advantages of soil bioengineering methods

There are several benefits and advantages of soil bioengineering methods. These methods usually require less heavy equipment excavation which yields less cost and less negative impacts. In addition, limiting crews to one entrance and exit route will cause less soil disturbance to the site and adjoining areas. Erosion areas often begin small and eventually expand to a size requiring costly traditional engineering solutions. Installing soil bioengineered systems while the site problem is small will provide economic savings and minimise potential impacts to the road and adjoining resources. Use of native plant materials and seeds may provide additional savings. Costs will be limited to labor for harvesting, handling, and transport to the project site. Soil bioengineering is often useful on sensitive or steep sites where use of heavy machinery is not feasible.

These systems are initially strong and grow stronger as vegetation becomes established. Even if the plants die, roots and surface organic litter continues to play an important role during reestablishment of other plants. Once plants are established, root systems reinforce the soil mantel and remove excess moisture from the soil profile. This is often the key to long-term soil stability. Soil bioengineering provides improved landscape and habitat values (Hartwig, 2015).

6. Riparian Vegetation

A riparian area is an ecosystem situated between aquatic and upland environments that is at least periodically influenced by flooding. It is the relatively narrow strip of land along the bank of a river and differs from a flood-plain in that the latter is a more extensive valley floor subject to inundation during floods. Further, riparian systems function to reduce flood peaks, recharge groundwater, transport and trap sediments and nutrients, control water temperatures, and stabilize surrounding ecosystems (Debano and Schmidt, 1990). Riparian habitats are streamside or riverside communities (biological) continually disturbed by floods, erosion, deposition etc. (Wikramaratne and Chandrakanthi, 2005). Protection and rehabilitation of riparian vegetation is a main requirement because damages to the banks of water causes can cause severe problems that affect the environment and nearby communities.

6.1 Benefits of riparian vegetation

Healthy riparian areas have the ability to reduce sedimentation of waterways by filtering pollutants from adjacent upland areas and reducing the rate of soil loss from banks and upland areas. Riparian areas provide valuable benefits to streams such as shading, reducing stream temperatures and organic matter inputs that serve as a food source for many aquatic macro-invertebrates. Moreover, healthy riparian areas provide significant aesthetic value to residents and tourists who experience thousands of miles of riverine systems while driving transportation corridors throughout Colorado (Pusey and Arthington, 2003). Riparian areas also act as a sponge by absorbing floodwaters. The water is then slowly released over a period of time which minimizes flood damage and sustains higher base flows during late summer (Binford and Buchenau, 1993).

Properly functioning riparian areas play key roles in providing fish and wildlife habitat, preserving water quality and water supply, and providing recreational opportunities. A comprehensive assessment of criteria useful in judging riparian area condition and attributes that constitute a proper functioning condition for lotic areas should usually be developed and refined by an interagency team (Prichard and Clemmer, 1996).

7. Species Selection to Restore Watersheds and Flood Prone Areas

Establishment of degraded site restoration depends on proper selection of species, plant material procurement and handling, planting location, and establishment techniques (Hoag, 1993). It also depends on an understanding of the location of the site on the landscape, because landscape position influences the availability of soil moisture and sunlight. Site type is a reflection of landscape position, which is a combination of the direction that a slope faces and topography. Aspect, slope steepness, and location on the slope are the primary factors to consider when selecting tree species for planting (Davis et al, 2012).

7.1 Criteria used for the selection of species

Only native species were selected for this purpose to enhance the diversification of the floral species. The considerations made in species selection for this study are given below.

i. Conservation status
ii. Size at maturity
iii. Growth parameters
iv. Suitable climate
v. Suitable elevation
vi. Suitable location
vii. Use

Table 2: Identified suitable tree species with their key characteristics.

Family	Botanical name	Common name	Conservation status	Tree size	Height (m)	Diameter (cm)	Climate	Elevation (m)	Suitable location	Engineering benefits	Growth rate	Use
Achariaceae	*Hydnocarpus venenata*	Makulu	Endemic	Large			Wet	600	Home gardens, Forest	Soil stabilisation/ Control surface runoff	Slow	Medicine/ Wood
Anacardiaceae	*Campnosperma zeylanicum*	Aridda	Endemic/ VU	Medium to Large		Up to 200		Up to 400		Stream/river bank stabilisation	Medium	
Anacardiaceae	*Semecarpus walkeri*	Badulla	Endemic/ VU	Small to Medium						Stream/river bank stabilisation	Medium	Medicine
Anacardiaceae	*Nothopegia beddomei*	Bala	Native	Small to Medium	Up to 12			Up to 1,100			Slow	Medicine
Anacardiaceae	*Anacardium occidentale*	Kaju	Introduced	Small to Medium	Up to 14		Wet and Dry	Up to 1,000	Home gardens	Bank stabilisation	Fast	Food/ Medicine/ Source of various commodities
Anacardiaceae	*Lannea coromandelica*	Hik	Native/ LC	Medium	05 to 20	Up to 45	Dry	100-1,800	Home gardens, Forest, Cultivation		Medium	Food/Medicine
Anacardiaceae	*Mangifera indica*	Amba	Native/ DD	Medium to Large	08 to 30	100 to 120	Wet and Dry	Up to 800	Home gardens, Forest, Cultivation		Fast	Food/ Medicine/ Wood
Anacardiaceae	*Mangifera zeylanica.*	Etamba/ Wal amba	Endemic/ VU	Large	30	Up to 90	Wet and Dry	Up to 801	Forest	Soil stabilization, Surface runoff control	Slow	Food/ Medicine/ Source of various commodities
Anisophyllaceae	*Anisophyllea cinnamomoides*	Welipenna/ Weli piyana	Endemic/ VU								Slow	
Annonaceae	*Annona muricata*	Katu-Anoda	LC	Small	04 to 10	Up to 15	Wet	Up to 1,000	Home gardens, Forest, Cultivation		Fast	Food/ Medicine/ Pesticides
Annonaceae	*Cananga odorata*	Rata-Sapu/ Wana sapu	Naturalized Exotic/ LC		03 to 30	Up to 30	Wet	Up to 1,200	Home gardens, Forest, Cultivation	Used for rainforest regeneration in Australia	Fast	Food/ Medicine
Annonaceae	*Xylopia championii*	Dathketiya	Endemic/ LC	Small to Medium	Up to 12						Slow	Medicine
Annonaceae	*Xylopia parvifolia*	Netawu/ Athu ketiya	Native/ LC	Medium to Large	Up to 25		Wet		Forest		Slow	Medicne/ Wood/ As a masticatory, chewed with betel nut
Apocynaceae	*Cerbera odollam*	Diya Kaduru	Native/ LC	Small to Medium	05 to 17	20 to 90	Wet	Up to 300	Forest	Stream/river bank stabilisation	Medium	Medicne/ Wood/ Fiber and Oil Source
Apocynaceae	*Cerbera manghas* L.	Goda kaduru	Native/ LC	Small to Medium	05 to 17	Up to 70	Wet		Forest	Stream/river bank stabilisation	Medium	Medicne/ Wood/ Fiber and Oil Source
Apocynaceae	*Hunteria zeylanica*	Mediya	Native/ LC	Small	Up to 15	Up to 30	Wet	Up to 350	Home gardens, Forest		Slow	Food/ Medicine/ Wood/ Latex
Apocynaceae	*Pagiantha dichotoma*	Divi kaduru	Native/ LC	Small			Wet	Up to 1,200	Forest	Stream/river bank stabilisation	Medium	Medicne/ Wood for dancing masks

Family	Botanical name	Common name	Conservation status	Tree size	Height (m)	Diameter (cm)	Climate	Elevation (m)	Suitable location	Engineering benefits	Growth rate	Use
Araceae	*Phoenix pusilla*	Wal indi	Native/ LC	Small	2.6 to 07		Dry	Up to 700	Home gardens, Forest		Slow	Food/ Medicine/ The leaves are used locally for making baskets, mats etc.
Araceae	*Areca concinna*	Lenteri puwak, Lenatheriya	Endemic/ EN				Wet		Home gardens, Forest	Bank stabilisation	Fast	Food (mainly used for chewing with betel leaf)/ Medicine
Araceae	*Caryota urens*	Kithul	Native/ LC	Small to Medium	12 to 20	Up to 30	Wet	Up to 2,000	Home gardens, Forest		Medium	Food/ Medicine/ Wood for ropesand rafts
Araceae	*Areca catechu*	Puwak	Native/ LC	Small to Medium	13 to 26	20 to 40	Wet	Up to 1,000	Home gardens, Forest, Cultivation	Bank stabilisation	Fast	Food/ Medicine
Burseraceae	*Canarium zeylanicum*	Dik Kekuna	Endemic/ VU	Large	25 to 30				Forest, Cultivation		Slow	Food/ Wood
Calophyllaceae	*Calophyllum bracteatum*	Walu Kina	Endemic/ VU	Large	20 to 30	Up to 113	Wet	50 to 915	Forest		Slow	Wood
Calophyllaceae	*Calophyllum inophyllum*	Domba	Native/ LC	Medium	Up to 25	Up to 50	Wet	Up to 200	Home gardens, Forest	Wind break	Medium	Food/ Medicine/ Source of materials
Calophyllaceae	*Calophyllum calaba*	Gurukina	Endemic/ LC	Small	Up to 10	Up to 158	Dry	Up to 620	Forest		Slow	Wood
Cannabaceae	*Trema orientalis*	Gadumba	Native/ LC	Medium	Up to 18	Up to 60	Wet	Up to 2,500	Home gardens, Forest, Cultivation	Shade for other crops (coffee), Stabilisation of flood-damaged riverbanks, Improve soil quality, Construction	Fast	Food/ Medicine/ other commodities like ropes, paper etc.
Celastraceae	*Kokoona zeylanica*	Kokun	Endemic/ EN	Very Large	20 to 35		Wet	Up to 1,200	Forest		Slow	Medicine/ Wood/ Oil
Clusiaceae	*Garcinia mangostana*	Mangus	Introduced	Small to Medium	Up to 20		Wet	Up to 610	Home gardens, Cultivation		Fast	Food/ Medicine
Clusiaceae	*Garcinia morella*	Goraka/ Gokatu/ Kokatiya	Native/ NT	Small to Medium	Up to 20		Wet	Up to 1,200	Forest, Cultivation	Stream/river bank stabilisation	Medium	Food/ Medicine
Clusiaceae	*Garcinia quaesita Pierre*	Rath goraka	Endemic/ LC	Small to Medium	Up to 20	Up to 60	Wet	Up to 2,000	Home gardens, Forest, Cultivation	Stream/river bank stabilisation , Control soil erosion	Medium	Food/ Medicine
Clusiaceae	*Mesua ferrea*	Na	Native/ LC	Medium to Large	30 to 40	Up to 95	Wet	60-1,500	Home gardens, Forest	Shade provider	Slow	Medicine/ Wood
Clusiaceae	*Mesua thwaitesii*	Diya na	Endemic/ LC	Medium to Large	Up to 30	7.5 to 11.5	Wet	Up to 1,100	Home gardens, Forest		Slow	
Dilleniaceae	*Dillenia indica*	Hondapara/ Wampara	Native/ LC	Medium to Large	Up to 30		Wet	Up to 1,000	Forest	Stream/river bank stabilization	Fast	Medicine

Family	Botanical name	Common name	Conservation status	Tree size	Height (m)	Diameter (cm)	Climate	Elevation (m)	Suitable location	Engineering benefits	Growth rate	Use
Dilleniaceae	*Dillenia retusa*	Godapara	Endemic/ LC	Small to Medium	Up to 20		Wet	Up to 500	Forest	Stream/river bank stabilization	Fast	Medicine
Dilleniaceae	*Dillenia triquetra*	Diya para		Small to Medium	Up to 20		Wet	Up to 1,000	Forest	Stream/river bank stabilization	Fast	Medicine
Dipterocacarpaceae	*Dipterocarpus zeylanicus*	Hora	Endemic/ EN	Large	Up to 40		Wet	Up to 900	Home gardens, Forest	Construction	Medium	Medicine/ Wood
Dipterocacarpaceae	*Dipterocarpus hispidus*	Bu hora	Endemic/ CR	Very Large			Wet		Forest		Slow	Wood/ Resin
Dipterocacarpaceae	*Shorea dyeri*	Yakahalu	Endemic/ EN	Very Large					Forest		Slow	Wood
Dipterocacarpaceae	*Vateria copallifera*	Hal	Endemic/ EN	Very Large	Up to 40			Up to 700	Forest		Slow	
Ebenaceae	*Diospyros insignis*	Porawa mara, Wal mediriya		Very Large							Slow	Wood
Euphorbiaceae	*Chaetocarpus castanocarpus*	Hedawaka	Endemic/ LC		Up to 45	Up to 78			Forest		Slow	Wood
Euphorbiaceae	*Macaranga peltata*	Kenda/ Path kenda	Native/	Small	Up to 15			Up to 1,000	Home gardens, Forest	Soil improver	Fast	Medicine/ Wood
Euphorbiaceae	*Mallotus tetracoccus*	Bu-kenda			Up to 20			Up to 350	Forest	Soil improver	Fast	
Euphorbiaceae	*Aleurites moluccana*	Thel kekuna/ Rata kekuna	Naturalized Exotic/ LC		Up to 20	Up to 70	Wet and Dry	Up to 300	Home gardens, Forest, Cultivation	Used in reforestation projects	Medium	Food/ Medicine
Euphorbiaceae	*Aporusa lanceolata*	Heen kebella/ Veli mediya	Endemic/ VU		Up to 08			Up to 900			Slow	
Euphorbiaceae	*Elaeocarpus serratus L.*	Weralu	Native / LC		Up to 18			Up to 900	Home gardens, Forest, Cultivation		Slow	Food/ Medicine
Euphorbiaceae	*Macaranga digyna*	Gal ota/ Ota	Endemic/ NT	Small						Stream/river bank stabilization	Medium	
Euphorbiaceae	*Margaritaria cyanospermus*	Geri atta/ Sudu liyan	Endemic/								Medium	
Euphorbiaceae	*Phyllanthus stellatus/ Glochidion stellatum* (Syn.)	Kirilla/Olu peliya	Endemic/								Medium	
Euphorbiaceae	*Mallotus fuscescens*	Diyathora	Endemic/ VU				Wet	Up to 500	Forest		Fast	
Fabaceae	*Saraca asoca*	Ashoka/ Diya rathambala	Native/ VU	Small	Up to 10	Up to 10	Wet	Up to 750	Home gardens, Forest, Cultivation		Medium	Medicine

Family	Botanical name	Common name	Conservation status	Tree size	Height (m)	Diameter (cm)	Climate	Elevation (m)	Suitable location	Engineering benefits	Growth rate	Use
Fabaceae	*Adenanthera pavonina*	Madatiya	Native/ LC	Large	06 to 20	Up to 45		Up to 400	Home gardens, Forest, Cultivation	Land reclamation, Re-establish forests	Fast	Food/ Medicine/ Wood
Fabaceae	*Pericopsis mooniana*	Nadun	Native/ VU	Medium to Large	Up to 40	80 to 100		Up to 350	Home gardens, Forest, Cultivation	Construction	Slow	Medicine/ Wood
Fabaceae	*Cynometra zeylanica*	Gal mandora	Endemic/ NT		Up to 25						Medium	Medicine
Lauraceae	*Litsea longifolia*	Rat-Keliya	Endemic/ VU					Up to 1,300			Slow	Medicine
Lauraceae	*Cryptocarya wightiana*	Gulu-mora	Native/ VU		Up to 18						Medium	
Lauraceae	*Persea macrantha*	Ululu	Native		Up to 30						Slow	Medicine
Lecythidaceae	*Barringtonia racemosa*	Goda Midella	Native/ LC	Small	Up to 20		Wet	Up to 600	Forest		Slow	Medicine/ Wood
Lythraceae	*Lagerstroemia speciosa*	Murutha			Up to 21		Wet	Up to 300	Forest	Construction	Slow	Medicine
Malvaceae	*Cullenia ceylanica / Durio ceylanicus* (Syn.)	Katuboda	Endemic/ VU	Large	Up to 40			Up to 1,500	Forest		Slow	Wood
Meliaceae	*Melia azedarach*	Lunumidella/ Kiri-kohomba	Native/	Large	Up to 45		Wet/ Dry	Up to 1,800	Home gardens, Forest, Cultivation	Forest establishment	Fast	Food/ Medicine/ Wood
Moraceae	*Ficus hispida*	Kota dimbula	Native/ LC		Up to 17	Up to 25	Wet	500 to 1,100	Forest		Slow	Food/ Medicine
Moraceae	*Ficus callosa*	Gonna	Native/		25 to 45	25 to 35		600 to 800	Forest		Slow	Food/ Wood
Moraceae	*Ficus tinctoria*	Gas netol/ Wal ehetu/ Gas-aguna	Native/ LC	Large	Up to 25	Up to 300		Up to 500	Forest		Slow	Food/ Medicine/ Wood/ Dye
Moraceae	*Ficus exasperata*	Sevan mediya/ Bu thediya	Native/ LC	Small to Medium	Up to 25	Up to 50			Home gardens, Forest	Shade for other crops (coffee, cocoa)	Slow	Food/ Medicine
Moraceae	*Artocarpus nobilis*	Bedi del/ Wal del	Endemic/ VU		Up to 25				Home gardens, Forest	Runoff control	Slow	
Moraceae	*Artocarpus heterophyllus*	Kos	Native/		Up to 25	Up to 200		450 to 1,200	Home gardens, Forest, Cultivation	Construction	Medium	Food/ Medicine/ Wood
Moraceae	*Artocarpus incisus*	Del/ Rata del	Native/						Home gardens, Forest, Cultivation	Runoff control	Fast	Food/ Medicine
Moraceae	*Ficus racemosa*	Attikka	Native/ LC		Up to 30	36 to 90	Wet	100 to 1,700	Home gardens, Forest, Cultivation	Shade for other crop s (coffee), Slope/gully/ river bank stabilization	Slow	Food/ Medicine/ Wood/ Latex

Family	Botanical name	Common name	Conservation status	Tree size	Height (m)	Diameter (cm)	Climate	Elevation (m)	Suitable location	Engineering benefits	Growth rate	Use
Myristicaceae	*Horsfieldia irya*	Irya	Native/ LC		Up to 47	Up to 112	Wet	Up to 450	Home gardens, Forest	Bank stabilization	Slow	Food/ Wood
Myristicaceae	*Horsfieldia iryaghedhi*	Ruk/ Thalan	Endemic/ CR		5 to 25	Up to 50	Wet	Up to 500	Home gardens, Forest	Bank stabilization	Slow	Wood/ Essental oil
Myrtaceae	*Syzygium nervosum*/ *Cleistocalyx operculatus* (Syn.)	Bata-damba	Endemic/ LC							Bank stabilization	Slow	Wood
Myrtaceae	*Syzygium gardneri*	Damba, Panu pera	Native/		Up to 30						Slow	
Myrtaceae	*Syzygium makul*	Alu-bo	Native/ VU	Large					Forest		Slow	
Myrtaceae	*Syzygium rubicundum*	Maha Kuretiye/ Pini baru/ Karaw	Native/	Large	Up to 40	Up to 200					Slow	
Phyllanthaceae	*Aporosa cardiosperma*	Maput-Kebella			Up to 18			Up to 600	Forest		Slow	
Phyllanthaceae	*Bridelia moonii*	Pat-Kela	Endemic/ VU		Up to 15		Wet	Up to 700	Forest	Construction	Medium	Wood
Rhizophoraceae	*Carallia brachiata*	Dawata	Native/ NT		Up to 50			Up to 1,500	Home gardens, Forest	Used in reforestation and reclamation schemes on degraded and heavily polluted land	Fast	Food/ Medicine/ Wood
Rubiaceae	*Nauclea orientalis*	Bak mee	Native/ LC	Medium	Up to 30	Up to 100	Wet/ Dry	Up to 500	Home gardens, Forest	Control soil erosion, Shade tree, Bank stabilisation	Slow	Food/ Medicine/ Wood
Rubiaceae	*Psydrax dicoccos*	Panduru/ Maha seru/ Gal karanda	Native/ VU		Up to 15		Wet	100 to 600	Forest		Medium	Wood
Rubiaceae	*Mitragyna tubulosa*	Helamba	Native/	Small			Wet		Forest	Control soil erosion	Slow	Medicine
Rubiaceae	*Acronychia pedunculata*	Ankenda	Native/ LC	Small	Up to 28			Up to 900	Home gardens, Forest	Soil erosion control	Slow	Food/ Medicine/ Wood/ Cosmetic
Rubiaceae	*Melicope lunu-ankenda*	Lunu-Ankenda	Native/ LC	Small	Up to 30			Up to 2,200	Forest	Soil erosion control	Slow	Food/ Medicine/ Wood
Rubiaceae	*Wendlandia bicuspidata*	Rawan idala/ Agana/ Rawana idala	Endemic/								Slow	Medicine

Family	Botanical name	Common name	Conservation status	Tree size	Height (m)	Diameter (cm)	Climate	Elevation (m)	Suitable location	Engineering benefits	Growth rate	Use
Sapindaceae	*Dimocarpus longan*	Mora/ Rasa mora/ Peni mora	Native/ NT	Medium to Large	Up to 30	Up to 100			Home gardens, Forest, Cultivation		Slow	Food/ Medicine/ Wood
Sapindaceae	*Pometia pinnata*	Naimbul/ Bulumora/ Gal mora	Native/ LC	Large	Up to 40	100 to 140		Up to 500	Home gardens, Forest, Cultivation		Slow	Food/ Medicine/ Wood/ Gum
Sapotaceae	*Madhuca longifolia*	Mee	Native		Up to 20				Home gardens, Forest	Soil erosion control	Slow	Food/ Medicine/ Wood/ Oil
Sapotaceae	*Mimusops elengi*	Munamal	Native/ LC	Large	Up to 40	Up to 100	Wet	Up to 800	Home gardens, Forest, Cultivation		Slow	Food/ Medicine/ Wood/ Oil
Simaroubacea	*Quassia indica*	Samadara	Native	Small	5 to 12		Wet				Slow	
Symplocaceae	*Symplocos cochinchinensis*	Bobu	Native	Small	Up to 12	Up to 50			Home gardens, Forest		Slow	
Verbenaceae	*Vitex altissima*	Milla/ Kaha milla/ Niyan milla/ Sapu milla	Native	large	Up to 33	up to 170		Up to 1,200	Home gardens, Forest, Cultivation	Construction	Medium	Medicine/ Wood

Table 3: Identified suitable shrub species with their key characteristics.

Family	Botanical name	Common name	Taxonomic status	Tree size	Height (m)	Diameter (cm)	Climate	Elevation (m)	Suitable location	Engineering benefits	Growth rate	Use
Apocynaceae	*Tabernaemontana divaricata*	Wathusudda	Only under cultivation						Home gardens		Fast	Medicine
Aristolochiaceae	*Thottea siliquosa*	Thapasara Bulath	Native								Fast	Medicine
Asteraceae	*Tithonia diversifolia*	Naththasuriya/ Wal suriyakantha/ Titta/ Padimella			02 to 03		Wet/ Dry		Home gardens, Cultivation		Slow	Medicine
Connaraceae	*Connarus semidecandrus*/ *Connarus monocarpus* (Syn.)	Radaliya	Native/ LC		Up to 05						Medium	Medicine
Dilleniaceae	*Schumacheria castaneaefolia*	Kekiri-Wara	Endemic/ LC	Large	Up to 08		Wet	Up to 750	Home gardens, Forest	Bank stabilisation	Fast	
Euphorbiaceae	*Agrostistachys indica*	Dat-Wenna/Leaf litter plant	Native							Soil improvement	Medium	
Euphorbiaceae	*Antidesma bunius*	Kebella/ Karawala kebella	Native/ LC		Up to 08	Up to 100	Wet	Up to1,200	Home gardens, Forest, Cultivation	Forest gap succession	Medium	Food/ Medicine/ Wood
Euphorbiaceae	*Aporosa fusiformis*	Embilla	Native/ CR	Small	Up to 18						Medium	
Euphorbiaceae	*Blachia umbellata*	Kosatta	Native/ LC		02 to 05						Medium	
Fabaceae	*Flemingia strobilifera*	Hampinna/ Hampilla	Native/ LC	Small	01 to 04			200 to 1,600	Home gardens, Forest		Medium	Food/ Medicine
Fabaceae	*Senna occidentalis*/ *Cassia occidentalis* (Syn.)	Peni-Tora	Native/ LC		Up to 02			Up to 1,200	Home gardens, Forest		Fast	Food/ Medicine
Lamiaceae	*Clerodendrum cordatum*/ *Clerodendrum infortunatum* (Syn.)	Pinna/ Gas pinna	Native/ LC	Small	01 to 05				Home gardens, Forest		Fast	Food/ Medicine
Lamiaceae	*Mesosphaerum suaveolen*/ *Hyptis suaveolens* (Syn.)	Ali thala	Naturalized Exotic		Up to 2.5				Home gardens, Forest		Medium	Medicine/ Essential Oil
Lauraceae	*Cinnamomum cassia*	Dawul-Kurundu/ Kudu dawula	Native/ LC	Large	Up to 20		Wet	Up to 500	Home gardens, Forest	Erosion control, Bank stabilisation	Slow	Medicine/ Essential Oil
Lauraceae	*Cinnamomum dubium*	Wal kurundu/ Sewel kurundu	Endemic/ LC	Small					Home gardens, Forest	Erosion control, Bank stabilization	Medium	Medicine/ Essential Oil

Family	Botanical name	Common name	Taxonomic status	Tree size	Height (m)	Diameter (cm)	Climate	Elevation (m)	Suitable location	Engineering benefits	Growth rate	Use
Lauraceae	*Cinnamomum verum*	Kurundu	Native/ VU	Moderate to Large	Up to 15				Home gardens, Forest, Cultivation	Erosion control, Bank stabilization	Fast	Food/ Medicine/ Wood/ Essential Oil
Malvaceae	*Microcos paniculata*	Kohu-kirilla	Native/ LC	Moderate to Large	Up to 20	Up to 50			Forest	Erosion control, Bank stabilization	Slow	Food/ Medicine/ Wood/ Source of fibre
Malvaceae	*Grewia carpinifolia*	Wel-mediya/ Wel keliya	Native/ LC		1.5 to 03						Medium	Food/ Medicine
Melastomataceae	*Memecylon umbellatum*	Kora-Kaha	Native	Small	Up to15		Dry		Home gardens, Forest		Medium	Food/ Medicine/ Wood/ Source of material
Melastomataceae	*Osbeckia aspera*	Bowitiya	Native						Home gardens, Forest	Erosion control, Bank stabilization	Fast	
Melastomataceae	*Osbeckia octandra*	Heen-bovitiya	Endemic	Small	Up to 05				Home gardens, Forest	Erosion control, Bank stabilization	Fast	Medicine
Myristicaceae	*Ardisia missionis*	Gambi	Native					Up to ,1200			Medium	
Myrtaceae	*Syzygium caryophyllatum*	Dan/ Heen dan	Native/ EN	Small	03 to 05		Wet	Up to 700	Home gardens, Forest	Erosion control, Bank stabilization	Slow	Food/ Medicine
Ochnaceae	*Gomphia serrata*	Go-kera/ Bo kera/ Kera	Native/ LC	Small	Up to 10			Up to 1,500	Home gardens, Forest		Slow	Food/ Medicine/ Wood
Ochnaceae	*Olax imbricata*/ *Olax zeylanica* (Syn)	Mella/ Malla	Native	Small			Wet		Forest	Erosion control, Bank stabilization	Medium	Food/ Medicine/ Wood
Pandanaceae	*Benstonea thwaitesii*/ *Pandanus thwaitesii*(Syn.)	Dunukeiya/ Dumukeiya	Native	Small	01 to 1.8					Hedge establishment	Slow	Food/ Fiber
Phyllanthaceae	*Glochidion zeylanicum*	Hunukirilla	Native/ LC		Up to 08				Forest		Slow	Medicine/ Wood
Phyllanthaceae	*Breynia androgyna*/ *Sauropus androgynous* (Syn.)	Japan batu/ Mella dumkola/ Singappuru kola	Native	Small	Up to 03			Up to 400	Home gardens, Forest, Cultivation	Hedge establishment	Fast	Food/ Medicine
Phyllanthaceae	*Breynia vitis-idaea*	Gas kaila	Native/ LC	Small	Up to 05			Up to 800	Forest		Medium	Medicine
Poaceae	*Davidsea attenuata*/ *Bambusa attenuata* (Syn.)	Thuththiri bata									Fast	
Poaceae	*Ochlandra stridula*	Bata	Endemic		Up to 05	Up to 100			Forest	Bank protection, Hedge establishment	Fast	Medicine
Rhamnaceae	*Zizyphus rugosa*	Maha-Eraminia	Native	Large	Up to 06			Up to 1,400	Forest		Medium	Food/ Medicine/ Wood

Family	Botanical name	Common name	Taxonomic status	Tree size	Height (m)	Diameter (cm)	Climate	Elevation (m)	Suitable location	Engineering benefits	Growth rate	Use
Rubiaceae	*Ixora chinensis*/ *Ixora coccinea* (Syn.)	Rathmal/ Rathambala		Small	Up to 03			Up to 600	Home gardens, Forest	Hedge establishment	Fast	Medicine
Rubiaceae	*Pavetta indica*	Pavatta	Native/ LC	Small	Up to 04			Up to 1,200	Home gardens, Forest		Fast	Food/ Medicine
Rubiaceae	*Mussaenda frondosa*	Wel-Butsarana/ Mussanda/ Mus wenna	Native		Up to 03			Up to 1,200	Home gardens, Forest		Fast	Food/ Medicine
Rubiaceae	*Gaertnera vaginans*	Pera tambala	Native/ LC		Up to 15			Up to 1,000	Home gardens, Forest		Medium	None
Sapindaceae	*Allophylus cobbe*	Kobbe/ Bu kobbe	Native/	Small	Up to 25	Up to 04	Wet	Up to 1,500	Forest		Medium	Food/ Medicine
Simaroubacea	*Brucea javanica*	Titta-Kohomba/ Kaputu gedi	Native/ LC	Small	Up to 10			Up to 900	Forest		Medium	Medicine/ Insecticide
Vitaceae	*Leea indica*	Gurulla / Burulla	Native/ LC	Small	Up to 10	Up to 19		Up to 1,200	Home gardens, Forest, cultivation		Medium	Food/ Medicine
Zingiberaceae	*Alpinia nigra*	Alu-gas/ Kelaniya/ Alan	LC		Up to 03				Home gardens, Forest		Slow	Food/ Medicine

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