Spices and their Essential Oils

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Spices are a whole variety of dried plant products that exhibit a pronounced aroma and flavour. Spices are derived from aromatic vegetable substances from which none of the flavouring matter has been removed nor any artificial flavour or colouring matter has been added. Spices are derived from almost every part of one plant or another which falls into the group of aromatic spice plants. For instance, cinnamon and cassia consist of the bark, ginger and turmeric are underground stems, cloves are flower buds, pepper are berries, nutmegs are seeds. Entire fruits such as cardamom, coriander, cumin, fennel, caraway and dill make up some of the most important spices, while the herb spices such as mint, sage, thyme, bay and rosemary consist of the leaf and green shoot of a number of aromatic plants.

The history of spices and man's exploitation of them is a fascinating one and goes back to the era of pyramids. Ancient Egyptians have used spices for making their perfumes and cosmetics. In the days before refrigeration, oriental spices added flavour and piquancy to European food and helped to mask any unpleasant odour in them. Spices became so indispensable that they were regarded as a symbol of political and economic prestige. Nations gambled lives and fortunes away in their explorations. They waged many wars over their possession. Indeed, on account of spices many parts of the world came to be discovered. Spices became a sort of 'curreney' of the medieval age and maintained this unique position for a long time afterwards.

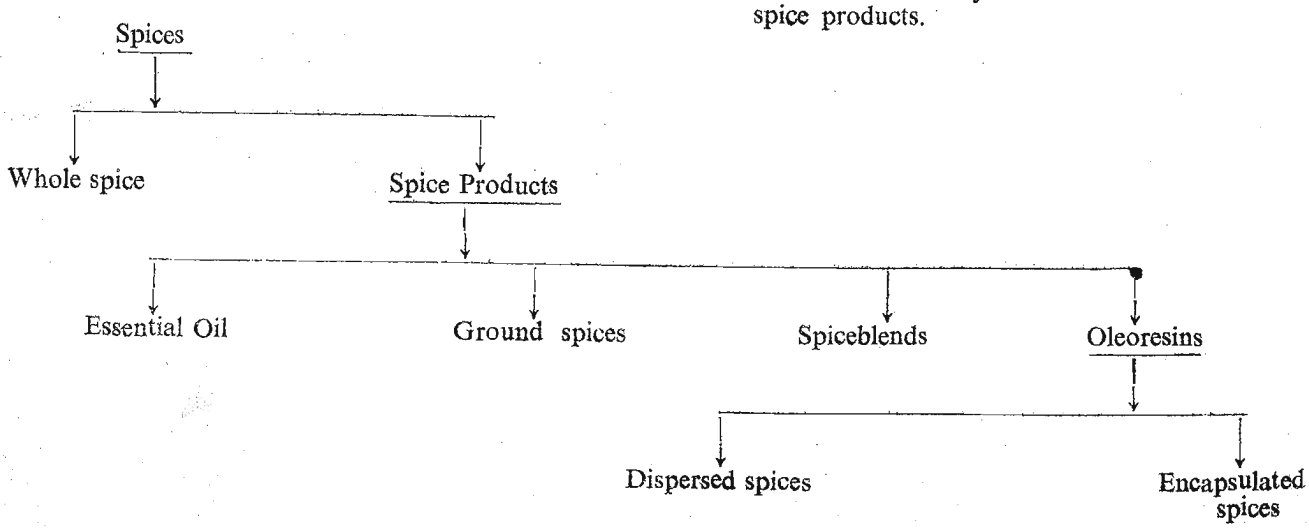
Spices are perhaps Sri Lanka's oldest export commodity of a trade which began after the Portuguese landed and made a monopoly of the cinnamon trade. It was the Dutch who really organised the spice trade of ancient Ceylon and brought in many other spices.

The spices available in Sri Lanka can be put into two groups, In the first are those spices which are produced in this country and in the second group are those spices which are important for our food preparations but are imported from abroad.

Group I :	Cardamom
	Cinnamon
	Cloves
	Nutmeg
	Pepper
	Ginger
	Turmeric
	Capsicum/Chillie
	Mustard
Group II :	Coriander
	Cumin
	Fennel
	Fenugreek
	Garlic

Among the herbs which are commonly used for culinary purposes locally are karapincha, rampe, celery and mint.

Among the first group, cinnamon is the most important spice in this country. We produce over fifty percent of the world's cinnamon of the Ceylon type. This product is far superior in quality and flavour to the Chinese cinnamon or cassia which is produced in the Far East and China. Although India is by far the largest producer of cardamom, the product from Sri Lanka has a ready market mainly in the Middle East and this is expanding gradually. Cardamom is the most expensive spice produced in this country. Of the other spices produced locally only clove bud, pepper and nutmeg are exported in small quantities. Ginger and turmeric are of rather poor quality and are not exported and these and many others are all consumed internally in domestic use and for obtaining spice products.



A Survey of the Economic Plants of Sri Lanka

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Sri Lanka, because of its geographical position and its physical features, has a relatively wide range of climatic regions and a correspondingly rich and varied flora. This flora remained more or less undisturbed by man up to about 500 B.C. From then onwards various crop plants e.g. rice, millets, sugar-cane and sesamum, along with mango, tamarind, jak and certain other trees, and settled agriculture were introduced to the island from the Indian sub-continent.
Further, from very early times Sri Lanka served as a trading centre between the East and the West and traders from different countries seem to have brought here a number of plants. More recently, during the last three or four centuries, several hundred plant species— many of them from the New World — have been introduced to the island. A large number of these alien plants have now become naturalised in Sri Lanka and are among the commonest plants seen along roadsides, waste ground and as weeds of cultivated land.
In this paper, I shall not deal with the latter group of plants and shall confine attention to the indigenous species and some of the very early introductions.

Even though our vegetation has been much disturbed for almost 2500 years and the original forests are now restricted to a very few small areas, we still have a rich flora with nearly 3000 indigenous species of which about 850 are endemic to the island. No complete survey has yet been made of the useful products that could be obtained from these plants. What we now know about them, comes mainly from the accumulated traditional knowledge which again is based on empirical observations. According to the information available, about 780 of the indigenous flowering plants and nearly 70 of the early introductions could be used as sources of food or of phytochemicals of economic importance. A list of these plants are given at the end of this paper.

FOOD PLANTS

The number of indigenous plants that could be used in various ways as sources of food is about 200. Over half of them are used as vegetables or pot-herbs. The parts used range from roots and tender shoots to flowers and young fruits. They are mostly collected from wild or semi-wild plants. A very few are cultivated on a small scale. Among these are **Alternanthera sessilis** (Mukunuwenna), **Basella rubra** (Niviti), **Centella asiatica** (Gotukola), **Ipomoea aquatica** (Kan-kun), and **Lasia spinosa** (Kohila). Some of these local vegetables are said to be good sources of nitrogen, minerals and vitamins. According to Pirie (1971), leaves of **Ipomoea aquatica** have 4.6 to 5.8 per cent nitrogen in the dry matter and the annual yield could be as high as 80,000 kg/ha.

Very few of the local legumes are edible and even these are of little importance except as gene reservoirs for breeding purposes. Over 80 species produce fruits or seeds that could be eaten in the fresh condition or after roasting. A few of them, e.g. **Feronia limonia** (Divul), **Flacourtia indica** (Uguressa), **Elaeocarpus serratus** (Veralu), **Carissa carandas** (Karanda), **Zizyphus mauritiana** (Maha-debara), and **Aberia gardneri** (Ketambilla, Ceylon Gooseberry) are sometimes cultivated in home gardens. In most species, however, the fruits are collected from wild or semi-wild plants. Some of the fruits are suitable for preparation of fruit-drinks, jams and jellies. It is also said that good quality wines could be produced from some of them.

The starch-producing plants number about 30. They are mainly grasses, palms, aroids and Dioscorea yams. Flour could also be extracted from some of the larger seeds like those of **Cycas** and **Vateria copallifera** (Hal). Our starch-producing plants are of relatively little importance. Tubers of many wild aroids, some of which are plentiful along waterways, are never used locally because of the irritant action of the raphides present in them. If satisfactory methods to remove them are devised it should be possible to use these tubers at least as animal feed.

The local sugar producing plants are **Madhuca longifolia** (Mi) and certain palms. **Madhuca** flowers are said to contain 50 to 70 per cent of their dry weight as sugars. These do not seem to be used now in Sri Lanka, but in India many thousands of tons are used annually in the fermentation industry. Locally sugar is extracted from **Borassus flabellifer** (Palmyrah), **Caryota urens** (Kitul), and **Cocos nucifera** (Coconut). A few years ago some attempts were made to tap **Nypa fruticans** (Gin-pol) in Sri Lanka. Nypa is considered to be one of the cheapest sources of sugar — one acre producing up to 1-1/2 tons sugar without any cultivation (MacMillan, 1943).

Non-drying oils could be obtained from over 20 local species but very few of them are suitable for use as food. Oil from coconut and from **Sesamum** (Gingelly) are the only ones now used as food in the country. **Madhuca** (Mi) oil was used in the past. This is still an important item of food in India.

Before the introduction of tea to the island, infusions of the dried flowers of **Cassia auriculata** (Ranawara), and **Aegle marmelos** (Beli) were much used as beverages and are still used to some extent. According to Brown (1950), infusions of the leaves of **Streblus asper** (Moraceae) and those of **Carmona microphylla** (Boraginaceae) are used as tea in some countries. Sap from palm inflorescences, either fresh or after fermentation, is also much used as a beverage.

SPICES and FLAVOURINGS

Sri Lanka has been well known for its spices from time immemorial and a considerable number of local plants are used as spices. The most important of these are cardamom and cinnamon. In addition to these and the other better known ones, leaves of **Premna serratifolia, P. latifolia,** and **P. procumbens** (Verbenaceae) are sometimes used as flavourings.

MASTICATORIES

The most widely used masticatories, **Piper betle** (Betel) and **Areca catechu** (Arecanut) are both very early introductions to the island. Among others used locally are the seeds of the endemic palms, **Areca concinna** (Lenateri) and **Loxococcus repicola** (Dotalu) and the seeds of the Zingiberaceous plant **Amomum masticatorium** which is also endemic to Sri Lanka. In some parts of the island, **Callicarpa tomentosa** is said to be used for chewing.

MEDICINAL PLANTS

Nearly 700 indigenous plant species are used in medicine either here or in some of our neighbouring countries. Out of our native plants which are common to Sri Lanka and India, about 30 per cent are considered to be of medicinal use. As against this, only about 3 or 4 per cent of the endemics are so considered. We still seem to be using the same plants as in India with only a very few additions from the local flora even though the ayurvedic system of medicine has been used here for well over 2000 years.

Some of our local drug plants are reputed to have bactericidal properties. In studies carried out in India, many of these have been found to be ineffective or only partially effective but **Glycosmis pentaphylla** (Rutaceae), **Hiptage benghalensis** (Malphigiaceae), and **Phyla (Lippia) nodiflora** (Verbenaceae) are reported to have inhibited completely the growth of nine different types of bacteria for which tests were carried out.

POISONS, INSECTICIDES and INSECT REPELLANTS

About 47 species are recorded as being poisonous; nearly 30 species are used as fish poisons and 19 are reputed to be active as insecticides or insect repellants.

NETTLES and SKIN IRRITANTS

Of the plants listed under this group those belonging to the Urticaceae and **Tragia involucrata** (Euphorbiaceae) are true nettles with stinging hairs. One of them, **Laportea crenulata** (Maussa, devil nettle or fever nettle) stings severely producing distressing effects which may last for several days. The ripe fruits of **Caryota urens** (Kitul) and the tissues of certain aroids, if rubbed against the skin, cause irritations due to the presence of raphides in them.

ESSENTIAL OILS and PERFUMES

The species producing essential oils and perfumes number about 30, but of them only **Cymbopogon** spp. (Citronellas and Lemon grass), **Cinnamomum zeylanicum** (Cinnamon), and **Elettaria** (Cardamoms) are cultivated for commercial purposes. Many of the plants producing essential oils are the same as those used as spices.

DYES and TANNINS

Before the synthetic dyes became freely available, vegetable dyes were much in use in the country. Some of these were considered to be "softer" and more permanent than the synthetics, but this industry died down as it could not compete with the cheaper imports. With the present expansion of various industries, local vegetable dyes should have a ready market if a regular supply of quality products could be made available. Tannin extraction still continues but with the deforestation that is now going on the numbers of the tannin producing trees are rapidly dwindling.

GUMS, RESINS, etc.

Good grade gums, resins etc., are produced by many of our local trees especially the Dipterocarps. **Donna zeylanica** (Dun), for example, produces a good grade gum resin; **Shorea oblongifolia** (Dumala) gives a clear resin suitable for varnish; and **Vateria copallifera** (Hal) gives a clear yellowish resin said to be equal to the best dammars. All three of these are endemic to the island.

GENERAL OBSERVATIONS

Out of the several hundred indigenous plants listed, coconut is the only major crop plant and this is now grown over an area of about a million acres. Cinnamon, citronella and cardamom are minor export crops and they cover about 36,000 acres, 15,000 acres, and 9,500 acres respectively. None of the others are grown on any large scale. A few of the food plants and some of the medicinal plants are grown in small plots or in home gardens. Attempts are now being made to grow certain medicinal plants on a larger scale. From the vast majority of the species listed however the various products are collected from wild or semi-wild plants growing on waste ground or in forests, and with the progressive clearing up of the forests these plants are becoming less and less available for exploitation.

Except for the research on coconut and, perhaps, also on citronella, little or no work has been done on the selection and the improvement of any of the indigenous economic plants. In fact as far as some of them are concerned, selection may be working against improvement due to the fact that plants or parts of plants with any desirable characteristics are often uprooted or removed for use by man leaving only those with the less desirable characteristics to mature and reproduce.

Cultivation and selection would undoubtedly improve many of our economic plants. In some of them various strains are recognised and some are regarded as superior to others. In these selection for quality

and high yields is desirable. In cinnamon, for example, such selection and vegetative propagation of clonal material could ensure uniform and high quality products.

Untapped phytochemical products may still remain hidden in some of our local species, especially the endemic ones. A full and comprehensive survey of these is urgently needed but at the rate exploitation of forests and deforestation is now going on, many endemics may become extinct long before any such survey is complete. Early action should therefore be taken to protect and even cultivate any endangered species and to preserve representative samples of vegetation types as Strict Natural Reserves so as to protect the flora for studies and use even at a later date.

LIST OF VASCULAR PLANTS OF SRI LANKA WHICH ARE OF ECONOMIC IMPORTANCE AS FOOD, DRUGS, ETC.

This list has been prepared after a preliminary survey of the literature on the useful plants of Sri Lanka and some of the neighbouring countries. A full list of the literature consulted is given at the end. Only plants indigenous to the island and those considered to have been introduced to Sri Lanka at a very early date are given in this list. The names of those introduced are underlined. Names of plants brought here during the last few centuries from the New World and elsewhere have not been included. Further only plants used as food, drugs, etc. or as sources of useful chemical products are listed. Those providing timber, fibres, etc. are not included.

The plant names are arranged under families in the same order as in the author's Check List of the Flowering Plants of Ceylon (Abeywickrama 1959). References to descriptions of the plants may be obtained from this work. Against each name the nature of the use or the product is indicated by a figure. These figures are arranged in two columns. Those under column A refer to uses as food, etc. and those under column B to drugs, etc. as follows:—

Column A

1 Starch
2 Sugar
3 Non-drying oils
4 Vegetables and Pot herbs
5 Legumes
6 Edible fruits and seeds
7 Beverages
8 Spices and flavourings
9 Masticatories

Column B

1 Medicinal drugs
2 Poisons
3 Fish poisons
4 Nettles and skin irritants
5 Pesticides and Insect repellants
6 Perfumes and essential oils
7 Dyes and tannins
8 Gums and mucilages
9 Cements and Resins

For example,

	A	B
Areca catechu L.	9	1 7
and Cinnamomum zeylanicum Bl.	8	1 6

mean that the first named plant is an introduced one, as the name is underlined, and that it provides a masticatory (A9), medicinal drug (Bl) and also a dye or tannin (B7), and that the second is an indigenous plant used as a spice or flavouring (A8), and provides a medicinal drug (Bl) and an essential oil (B6).

I wish to record here my sincere thanks to Professor R.N. de Fonseka and to Miss L. H. Chang for assistance in checking references.

	A	B
Pteridophytes		
Lycopodiaceae		
Lycopodium phlegmaria L.		1
Pteridaceae		
Acrostichum aureum L.	4	1
Parkeriaceae		
Ceratioteris thalictroides (L) Brongn	4	1
Aspidiaceae		
Diplazium esculentum (Retz.) Sw.	4	1
Polypodiaceae		
Drynaria quercifolia (L.) J.Sm.	4	1
Gymnosperms		
Cycadaceae		
Cycas circinalis L.	1 4 6	1 2
Monocotyledons		
Typhaceae		
Typha angustifolia L	1	
Pandanaceae		
Pandanus tectorius Soland. ex Park.	6	1 6
Aponogetonaceae		
Aponogeton natans (L.) Engl. & Krause	1 4	
A. crispus Thumb.	1 4	
Hydrocharitaceae		
Enhalus acoroides (L.f.) Rich. ex Steud.	6	
Ottelia alismoides (L.) Pers.	4 6	1
Gramineae		
Lophatherum gracile Brongn.		1
Phalaris arundinacea L.		2
Eleusine indica (L.) Gaertn.		1 2
E. coracana (L.) Gaertn.	1	1
Dactyloctenium aegyptium (L.) Beauv.		1 2
Cynodon dactylon (L.) Pers.		1 2
Oryza sativa L.	1	1
Hygroryza aristata (Retz.) Nees		1
Panicum repens L.		1
P. miliaceum L.	1	1
P. psilopodium Trin.		1
P. miliare Lam.	1	1
P. antidotale Retz.		1 2
Echinochloa colonum (L.) Link	1 4	
E. frumentacea Link	1	1 2
E. crus-galli (L.) Beauv.	1 4	1
E. sragnina (Retz.) Beauv.		1
Paspalum scrobiculatum L.	1	1 2
Setaria Plicata (Lam.) Cooke		1
S. italica (L.) Beauv.	1	1
Pennisetum glaucum (L.) R.Br.	1	1
Imperata cylindrica var. major (Nees) C. E. Hubb		1
Saccharum spontaneum L.		1
S. officinarum L	2	1
Hackelochloa granularis (L.) Kuntze		1
Sorghum halepense (L.) Pers.		1 2
S. bicolor (L.) Moanch.	1	
Vetiveria zizanioides (L.) Nash		1 6
Chrysopogon aciculatus (Retz.) Trin.		

Cymbopogon winteranus Jowitt		1 6
C. nardus (L.) Rendle		1 6
C. citratus (DC) Stapf	8	1 6
Themeda triandra Forsk.		1 2
Heteropogon contortus (L.) Beauv.		1
Chionachne koenigii (Spreng.) Thw.		1
Coix gigantea Koen.	1	
C. Lachryma-jobi L.	1	1
Bambusa bambos (L.) Druce	4 6	1
B. vulgaris Schrad.	4	1
Cyperaceae		
Cyperus iria L.		1
C. diffusus Vahl		4
C. rotundus L.		1 5 6
C. stoloniferus Retz.		1
C. platyphyllus Roem. & Schult.		1
C. triceps (Rottb.) Endl.		1
C. brevifolius (Rottb.) Endl.		1
Scirpus articulatus L.		1
S. grossus L. f.		1
Remirea maritima Aubl.		1
Scleria pergracilis (Nees) Kunth		5
Palmae		
Areca catechu L.	9	1 7
A. concinna Thw.	9	1
Loxococcus rupicola (Thw.) Wendl. & Drude	9	
Caryota urens L.	1 2 7	1 4
Nypa fruticans Wurmb.	2 6 7	
Phoenix zeylanica Trim.	6	
P. pusilla Gaertn.	1	1
Corypha umbraculifera L.	1	3
Calamus rotang L.		1
Borassus flabellifer L.	1 2 6 7	1
Cocos nucifera L.	2 3 6 7	1 6
Araceae		
Pothos scandens L.	6	1
Acorus calamus L.	8	1 5 6 7
Rhaphidophora laciniata(Burm.f.)Merr		1
Lasia spinosa (L.) Thw.	4	1
Amorphophallus campanulatus (Roxb.) Bl.	1 4	1
A. sylvaticus (Roxb.) Schott Kunth.		1
Remusatia vivipara (Roxb.) Schott		1
Colocasia esculenta (L.) Schott	1 4	1
Alocasia cucullata (Lour.) Schott	1	
A. macrorrhiza (L.) Schott	1	1 4
A. indica (Roxb.) Schott	1	1
Typhonium triolbatum (L.) Schott		1
Arisaema leschenaultii Bl.		1
Lagenandra lancifolia (Schott) Thw.		1
L. ovata (L.) Thw.		1 2
Cryptocoryne spiralis (Retz.) Fischer		1
Pistia stratiotes L.		1 4
Flagellariaceae		
Flagellaria indica L.		1
Xyridaceae		
Xyris indica L.		1
Eriocaulaceae		
Eriocaulon sexangulare L.		1
Commelinaceae		
Cyanotis tuberosa Schultes f.		1
C. axillaris (L.) J.A.& J.H.Schult.		1
Murdannia spirata (L.) Brueckn.	4	
M. nudiflora (L.) Brenan	4	1
Floscopa scandens Lour.		1
Commelina benghalensis L.	4	1
C. clavata C.B.Clarke	4	
Pontederaceae		
Monochoria hastata (L.) Solms	4	1
M. vaginalis (Purm.f.) Kunth	4	1
Liliaceae		
Gloriosa superba L.		1 2
Aloe barbadensis Mill.		1 8
Sansevieria zeylanica (L.) Willd.		1
Asparagus recemosus Willd.		1
A. falcatus L.	4	
A. gonoclados Baker		1
Smilacaceae		
Smilax aspara L.		1
Amaryllidaceae		
Allium cepa L.	4 8	1
Crinum asiaticum L.		1
C. defixum Ker-Cawl.		1
C. latifolium L.		1
C. zeylanicum L.		1
Hypoxidaceae		
Curculigo orchioides Gaertn.		1
Dioscoreaceae		
Dioscorea esculenta (Lour.) Burkill	1	1
D. pentaphylla L.	1 4	1
D. bulbifera L.	1 4	1 2
D. oppositifolia L.	1	1
D. alata L.	1 4	1
Musaceae		
Musa acuminata Colla	4 6	1
M. balbisiana Colla	4 6	1
M. x paradisiaca L. cvs	4 6	1
Zingiberaceae		
Kaempferia rotunda L.		1
K. galanga L.	8 9	1
Boesenbergia pandurata (Roxb.)Schlecht		1
Curcuma aromatica Salisb.		1 6
C. zedoaria (Berg.) Roscoe	1 8	1 6 7
C. domestica Valeton	8	1 5 7
Z. zerumbet (L.) Sm.		1
Z. officinale Roscoe	1 8	1 6
Amomum masticatorium Thw.	9	
Elettaria repens (Sonner.) Baill.	8 9	1 6
E. ensal (Gaertn.) Abeywick.	8 9	1 6
Languas chinensis Koen.		1
L. galanga (L.) Stuntz		1 7
Costus speciosus (Koen.) Sm.	1 4	1
Cannaceae		
Canna indica L.	1	1 7
Orchidaceae		
Dendrobium macraei Lindl.		1
D. crumenatum Sw.		1
Eulophia epidendraea (Retz.) C.E.C.Fischer		1
E. nuda Lindl.		1
Cymbidium aloifolium (L.) Sw.		1
Rhynchostylis retusa (L.) Bl.		1
Luisia tenuifolia (L.) Bl.		1
Vanda tessellata (Roxb.) Lod.		1
V. spathulata (L.) Spreng.		1
Acampe praemorsa Blatter & McCann		1
Anoectochilus regalis Bl.		1
Zeuxine strateumatica (L.) Schlecht.		1

Dicotyledons

Piperaceae
- **Piper longum L.** 1
- **P. betle L.** 9 1
- P. thwaitesii C.DC 8
- **P. nigrum** L. 8 1
- P. umbellatum L. 8

Chloranthaceae
- Chloranthus glaber (Thunb.) Makino 1

Jlmaceae
- Holoptelea integrifolia (Roxb.) Planch. 1
- Celtis cinnamonea Lindl. 1
- Trema orientale (L.) Bl. 1 7

Moraceae
- Streblus asper (Retz.) Lour. 7 1
- Artocarpus nobilis Thw. 1 6 7
- A. lakoocha Roxb. 6 1 7
- **A. heterophyllus Lam.** 1 6 1 7
- Antiaris toxicaria (Pers.) Leschen. 1 2
- Ficus parasitica Koen. 1
- F. benghalensis L. 1
- F. mysorensis Heyme ex Roth 1
- F. altissima Var. fergusonii King 1
- F. trimenii King 1
- F. nervesa Heyne ex Roth 1
- F. arnottiana (Miq.) Miq. **1**
- **F. religiosa** L. 1
- F. tsjakela Burm. f. 1
- F. tsiela Roxb. 1
- F. virens Ait. 1
- F. callosa Willd. 1
- F. heterophylla L. f. 1
- F. asperrima Roxb. 1
- F. hispida L.f. 1
- F. racemosa L. 6 1

Urticaceae
- Laportea terminalis Wight 4
- L. crenulata (Roxb.) Gaudich. ex Wedd. 1 2 4
- Fleurya interrupta (L.) Wight 1 4
- Girardinia zeylanica Decne. 1 4
- Pouzolzia zeylanica (L.) Benn. 1

Olacaceae
- Ximenia americana L. 6 1
- Olax scandens Roxb. 1
- O. zeylanica L. 4 1

Opiliaceae
- Cansjera rheedii Gemlin 2

Loranthaceae
- Dendrophthoe falcata (L.f.) Danser 1
- Viscum orientale Willd. 1
- V. monoicum Roxb. 1 2

Aristolochiaceae
- Apama siliquosa Lam. 1 3
- Aristolochia bracteolata Lam. 1
- A. indica L. 1

Polygonaceae
- Polygonum glabrum Willd. 1
- P. barbatum L. 1
- P. chinense L. 1
- P. plebejum R. Br. 1

Chenopodiaceae
- Atriplex repens Roth 4
- Arthrocnemum indicum (Willd.) Moq. 1
- Salicornia brachiata Roxb. 1
- Suaeda monoica Forsk. ex J.F. Gmel. 1

Amaranthaceae
- Celosia argentea L. 4 1
- Allmania nodiflora (L.) R.Br. 4
- Amaranthus spinosus L. 4 1
- A. tricolor L. 4 1
- A. viridis L. 4 1
- Digera muricata (L.) Mart. 1
- Cyathula prostrata (L.) Bl. 1
- Aerva lanata (L.) Juss. 4 1
- Achyranthes aspera L. 4 1
- A. bidentata Bl. 1
- Alternanthera sessilis (L.) R.Br. 4 1

Nyctaginaceae
- Boerhaavia diffusa L. 4 1
- Pisonia aculeata L. 1
- **P. grandis** R. Br. 4 1

Aizoaceae
- Cisekia pharnacioides L. 4 1
- Clinus lotoides L. 1
- G. oppositifolius (L.) A.DC. 4 1
- Mollugo pentaphylla L. 4 1
- M. cerviana (L.) Ser. 1
- M. nudicaulis Lam. 1
- Sesuvium portulacastrum (L.) L. 4
- Trianthema portulacastrum L. 4 1
- T. triquetra Rottl. 4
- T. decandra L. 1

Portulacaceae
- Portulaca cleracea L. 4 1
- P. quadrifida L. 4 1
- P. tuberosa Roxb. 1

Basellaceae
- Basella alba L. 4 1 7

Caryophyllaceae
- Polycarpaea corymbosa (L.) Lam. 1

Nymphaeaceae
- Nelumbo nucifera Gaertn. 1 4 6 1
- Nymphaea lotus L. 1 4 6 1
- N. stellaya Willd. 1 4 6 1

Ceratophyllaceae
- Ceratophyllum demersum L. 1

Ranunculaceae
- Clematis smilacifolia Wall. 1
- C. gouriana Roxb. 1 2

Berberidaceae
- Berberis tinctoria Leschen. 1 7
- B. wightiana Schneider 1 7
- B. ceylanica Schneider 1 7

Menispermaceae
- Tiliacora acuminata (Lam.) Miers 1
- Anamirta cocculus (L) Wight & Annr. 1 2 3
- Coscinium fenestratum (Gaertn.) Colebr. 1 7
- Tinospora malabarica (Lam.) Miers 1
- T. glabra (Burm. f.) Merr. 1
- T. cordifolia (Willd.) Miers 1
- Hyserpa nitida Miers 1
- Diploclisia glaucescens (Bl.) Diels 1
- Cocculus hirsutus (L.) Diels 1
- Pachygone ovata (Poir.) Miers 3

Stephania japonica (Thunb.) Miers		1
Cissampelos pareira L.		1
Cyclea burmanni (DC) Miers		1
Magnoliaceae		
Michella champaca L.		1 6 7
Annonaceae		
Uvaria narum (Dunal.) Wall.		1
Polyalthia longifolia (Sonner.) Thw.		1
Lauraceae		
Cinnamomum zeylanicum Bl.	8	1 6
C. iners Reinw.	8	1
Machilus macrantha Nees		1
Neolitsea cassia (L.) Kosterm.		**8**
Litsea glutinosa (Lour.) C.B.Rob		1 8
Cryptocarya wightiana Thw.		1
Cassytha filoformis L.		1 5
Hernandiaceae		
Hernandia ovigera L.		1
Capparidaceae		
Crataeva religiosa Forst. P.		1
Capparis zeylanica L.	6	1
C. horrida L.P.	6	1
Cadaba trifoliata (Roxb.) Wight & Arn.		1
Maerua arenaria (DC) Hook.f.& Thomas.		1
Cleome monophylla L.		1
C. chelidonii L. f.		1
C. viscosa L.		1
Gynandropsis gynandra (L.) Briq.	4	1
Cruciferae		
Brassica junacea (L.) Coss	3 8	1
Moringaceae		
Moringa oleifera Lam.	3 4 8	1
Nepenthaceae		
Nepenthes distillatoria L.		1
Droseraceae		
Drosera burmanni Vahl		1
D. indica L.		1
D. peltata J. E. Sm.		1
Crassulaceae		
Kalanchoe laciniata (L.) Pers.		1
Rosaceae		
Rubus ellipticus Sm.	6	
R. niveus Thunb.	6	
Connaraceae		
Connarus moncarpos L.		1
Leguminosae		
Crotalaria prostrata Rottl. ex Willd.		1
C. albida Heyne ex Roth		1
C. retusa L.		1
C. verrucosa L.		1
C. juncea L.		1 2
C. medicaginea Lam		1
C. mucronata Desv.		2
C. laburnifolia L.		1
Indigofera linifolia (L.f.) Retz.		1
I. enneaphylla L.		1
I. aspalathoides Vahl		1
I. glabra L.		1
I. trita L. f.		1
I. oblongifolia Forsk.		1
I. tinctoria L.		1 7
I. galegoides DC.		2
Psoralea corylifolia L.		1
Mundules sericea (Willd.) A. Chev.		1 2 3
Tephrosia spinosa (L.) Pers.		1
T. purpurea (L.) Pers.		1 3 7
T. villosa (L.) Pers.		1
Sesbania sesban (L.) Merr.		1 8
S. grandiflora (L.) Pers.	4	
Zornia diphylla (L.) Pers.		1
Smithia sensitiva Ait.		1
S. conferta Sm.		1
Pseudarthria viscida (L.) Wight & Arn.		1
Uraria picta (Jacq.) DC.		1
Alyssicaropus vaginalis (L.) DC.		1
A. longifolius (Rottl.) Wright & Arn.		1
Desmodium pulchellum (L.) Benth.		1
D. triquetrum (L.) DC.		1
D. heterocarpum (L.) DC.		7
D. triflorum (L.) DC.		1
D. heterophyllum (Willd.) DC.		1
D. gyroides DC.		1 2
Abrus precatorius L.		
Glycine javanica L.	5	
Teramnus labialis (L.f.) Spreng.		1
Mucuna monosperma DC.		1
M. gigantea (Willd.) DC.		1 2
M. prurita Hook.		1
Erythrina variegata L.	4	1 7
Butea monosperma Taub.		1 5 7 8
Canavalia gladiata (Jacq.) DC.	5	
Phaseolus adenanthus C.F.W.Mey.		1
P. trilobus L.	5	1
P. aconitifolius Jacq.	5	1
P. aureus Roxb.	5	1
P. mungo L.	4 5	1
P. radiatus L.		1
P. calcaratus Roxb.	4 5	
Clitoria ternatea L.	4	1 7
Lablab niger Medic.	5	1 2
Dolichos biflorus L.		1
D. uniflorus Lam.	5	
D. falcatus Klein.		1
Rhynchosia minima (L.) DC.		1
Moghania strobilifera (L.) J.St.Hil.		1
M. macrophylla (Willd.) Kuntze		1
Dalbergia lanceolaria L.f.		1
Pterocarpus marsupium Roxb.		1 8
Pongamia pinnata (L.) Pierre	3	1 3 5
Derris scandens (Roxb.) Benth.		3
D. uliginosa (Willd.) Benth.		1 3
D. benthamii (Thw.) Thw.		3
Sophora tomentosa L.		1 2
Caesalpinia bonduc (L.) Roxb.		1
C. crista L.		1
C. digyna Rottl.		1
C. sappan L.		1 7
Cassia fistula L.		1 7
C. occidentalis L.	4	1
C. sophera L.		1
C. tora L.	4	1 7
C. auriculata L.	7	1 7
C. italica (Mill.) Lam.		1
C. siamea Lam.		2
C. absus L.		1
C. mimosoides L.		1
Cynometra ramiflora L.		1
Dialium ovoideum Thw.	6	
Saraca indica L.		1
Tamarindus indica L.	1 3 4 6 8	1 7 9
Bauhinia tomentosa L.	4	1

B. racemosa Lam. 1
Neptunia oleracea Lour. 1
Entada phaseoloides (L.) Merr. 1 2 3
Adenanthera pavonina L. 1 7 8 9
Dichrostachys cinerea (L.) Wight & Arn. 1
Acacia nilotica var. adansonii (Guill. & Perr.) Kuntze.
A. leucophloea (Roxb.) Willd. 7 8
A. ferruginea DC. 1 7 8
A. concinna (Willd.) DC. 1
A. pennata (L.) Willd. 1 5 7
Albizia lebbeck (L.) Benth. 1 3 7
A. odoratissima (L.f.) Benth. 1 7
A. chinensis (Osb.) Merr. 1
A. amara (Roxb.) Boiv. 1
Geraniaceae 1
Geranium nepalense Sweet
Oxalidaceae 1
Oxalis corniculata L.
Linaceae 4 1
Hugonia mystax L.
Erythroxylaceae 1
Erythroxylum monogynum Roxb.
Zygophyllaceae 1
Tribulus terrestris L.
utaceae 1
REuodia lunu-ankenda (Gaertn.) Merr. 1
Ruta graveolens L. 1
Chloroxylon swietenia DC. 1
Toddalia asiatica (L.) Lam. 8 1 2
Acronychia pedunculata (L.) Miq. 4 1 3
Glycosmis pentaphylla (Retz.) Corr. 1 8
Murrava paniculata (L.) Jacq. 8 1 6 8
M. koenigii (L.) Spreng. 8 1
Clausena dentata (Willd.) M. Roem. 6
Atalantia monophylla DC. 6 1
Paramignya monophylla Wight. 1
Citrus aurantifolia (Christ.) Swingle 6 8 1
C. sinensis (L.) Osb. 6 1
C. reticulata Blanco 6 1
Aegle marmelos (L.) Corr. 6 1 6 7 8 9
Feronia limonia (L.) Swingle 6 1 8
Simaroubaceae
Samadera indica Gaerthn 1
Burseraceae
Canarium zeylanicum (Retz.) Pl. 6 3 8
Meliaceae
Chukrassia tabularis A. Juss. 1 7
Xylocarpus granum Koen. 1
X. moluccensis (Lam.) M. Roem. 1
Melia dubia Cav. 1
Azadiracta indica A. Juss. 3 1 5 6
Walsura piscidia Roxb. 6 1 3
Amoora rohituka (Roxb.) Wight & Arn. 3 1
Aglaia roxburghiana(Wight.& Arn.)Miq. 6 1
Malphigiaceae
Hiptage benghalensis (L.) Kurz 1 5
Polygalaceae
Polygala chinensis L. 1
P. sibirica var.macrolophos(Hassk.)Benn. 1
P. telephoides Willd. 1
Euphorbiaceae
Aporosa cardiosperma (Gaertn.) Merr. 6
A. lindleyana (Wight) Baill. 4 6 1
A. lanceolata (Thw.) Thw. 6
Antidesma ghassembilla Gaertn. 4 6 1
A. alexiteria L. 1
A. bunius (L.) Spreng. 4 6 1 2
Glochidion zeylanicum (Gaertn.) A.Juss. 1
Putranjiva roxburghii Wall. 1
Securinega leucopyros (Willd.) Muell.Arg. 1 3
Phyllanthus reticulatus Poir. 1 7 8
P. emblica L. 6 1
P. urinaria L. 1
P. maderaspatensis L. 1
P. debilis Klein ex Willd. 1
Drypetes sepiaria (Wight & Arn.) Pax & Hoffm. 6
Cleistanthus collinus (Roxb.) Hook.f. 1 2 3
Bridelia retusa (L.) Spreng. 1
Croton oblongifolius Roxb. 1
C. aromaticus L. 1 9
Chrozophora rottleri (Geisel.)A.Juss. 1 2
Aleurites moluccana (L.) Willd. 3 1 6 7
Trewia nudiflora L. 1
Mallotus philippensis (Lam.)Muell.Arg. 1 7
Macaranga indica Wight 1 8
M. peltata (Roxb.) Muell.Arg. 1 8
Acalypha fruticosa Forsk. 1
A. indica L. 4 1
Tragia involucrata L. 1 4
Homonia riparia Lour. 1
Ricinus communis L. 3 1
Dalechampia indica Wight 4
Jatropha glandulifera Roxb. 1 7
J. curcas L. 1 3
Sebastiana chamaelea (L.) Muell.Arg. 1
Excoecaria agallocha L. 1 2 7
Sapium indicum Willd. 2 3
S. insigne (Royle) Trim. 1
Euphorbia antiquorum L. 1
E. tirucalli LL. 1 2 7
E. atoto Forest. f. 1
E. rosea Retz. 1
E. hirta L. 1
E. thymifolia L. 1
E. rothiana Spreng. 1
Anacardiaceae
Mangifera zeylanica (Bl.) Hook.f. 6 1 6 7
M. indica L. 6 7 8
Lannea coromandelica (Houtt.) Merr. 6
Semecarpus marginata Thw. 9
S. gardneri Thw. 1
Spondias pinnata (L.) Kurz 6
Celastraceae
Cekastrus paniculatus Willd. 1
Kurrimia ceylanica Arn. 6
Kokoona zeylanica Thw. 1
Elaeodendron glaucum (Rottb.) Pers. 1 7
Hippocrateaceae
Hippocratea indica Willd. 1
Salacia prinoides (Willd.) DC. 1
S. reticulata Wight 1
S. oblonga Wall. 6 1
Salvadoraceae
Azima tetracantha Lam. 1
Salvadora persica L. 1
Sapindaceae
Cardiospermum halicacabum L. 1
Allophyllus cobbe (L.) Bl. 6 1
Sapindus trifoliatus L. 1 3

S. emarginatus Vahl	3	
Schleichera oleosa (Lour.) Oken.	3 6	1
Euphoria longana Lam.	6	1
Dodonaea viscosa Jacq.		1 3
Harpullia arborea Blanco. Radlk.		1 3
Balsminaceae		
Impatiens balsamina L.		1
Rhamnaceae		
Rhamnus wightii Wight & Arn.		1
Colubrina asiatica (L.) Brongn.		1 3
Zizyphus mauritiana Lam.	6	1 7
Z. oenoplia (L.) Mill.		1
Z. rugosa Lam.		1
Ventilago maderaspatana Gaertn.		1 7
Vitaceae		
Cissus setosa Roxbi.		1
C. quadrangularis L.		1
C. pallida (Wight & Arn.) Planch.		1
Cayratia trifolia (L.) Domin.		1
C. pedata (Lam.) Juss.		1
Leeaceae		
Leea indica (Burm.f.) Merr.		1
Elaeocarpaceae		
Elaeocarpus serratus L.	6	1
Tiliaceae		
Grewia asiatica L.	6	1
G. tiliifolia Vahl	6	1
G. hirsuta Vahl		1
G. microcos L.	6	1
G. tenax (Forsk.) Fiori	6	1
Triumfetta rhomboidea Jacq.		1
Corchorus capsularis L.		1
C. olitorius L.	4	1
C. fascicularis Lam.		1
C. aestuans L.		1
Malvaceae		
Sida veronicifolia Lam.		1
S. acuta Burm. f.		1
S. rhombifolia L.		1
S. cordifolia L.		1
Abutilon asiaticum (L.) G. Don		1
A. indicum (L.) G. Don		1
A. hirtum (Lam.) Sweett		1
Urena lobata L.		1
Pavonia zeylanica Cav.		1
P. odorata Willd.		1
Hibiscus surattensis L.	8	1
H. furcatus Willd.		1
H. micranthus L.f.		1
H. vitifolius L.		1
H. abelmoschus L.		1 6
H. tiliaceus L.		1
H. esculentus L.	4	1
H. rosa-sinensis L.		1 7
Thespesia lampas (Cav.) Dalz. & Gibbs.		1 7
T. populnea (L.) Soland.		1
Gossypium arboreum L.	3	1
Bombacaceae		
Adansonia digitata L.	4 6 7 8	1 5
Salmalia malabarica (DC.) Schott & Endl.	3	1 7 8
Ceiba pentandra (L.) Gaertn.	3	1
Sterculiaceae		
Sterculia foetida L.	6	1
S. urens Roxb.		1
S. balanghas L.		1
Helicteres isora L.		1

Pentapetes phoenicea L.		1
Melochiz corchorifolia L.		1
Waltheria indica L.		1
Dilleniaceae		
Dillenia indica L.	6	1
Ochnaceae		
Ochna squarrosa L.		1
Theaceae		
Ternstroemia japenica (Thunb.) Thunb.	9	1
Guttiferae		
Hypericum japonicum Thunb.		1
Mesua ferrea L.	6	1 6
Calophyllum inophyllum L.	3	1
C. tomentosum Wight	3	1
Garcinia cambogia (Gaertn.) Desr.	6	1 9
G. morella Desri.	3	1 7
G. echinocarpa Thw.	3	
G. spicata (Wight & Arn.) Hook.f.		7
Dipterocarpaceae		
Dipterocarpus hispidus Thw.		9
D. zeylanicus Thw.		9
D. glandulosus Thw.		6
Doona zeylanica Thw.		6
D. trapezifolia Thw.	1	9
D. cordifolia Thw.	6	9
D. ovalifolia Thw.		9
D. macrophylla Thw.		9
Vatica obscura Trim.		9
Vateria copallifera (Retz.) Alst.	1	7 9
Shorea oblongifolia Thw.		9
Tamaricaceae		
Tamarix gallica L.		1
Cochlospermaceae		
Cochlospermum religiosum (L.) Alst.		1 6 8
Violaosaegens Hall.		
Hybanthus enneaspermus (L.) F.Muell.		1
Viola serpens Wall.		1
Flacourtiaceae		
Hydnocarpus venenata Gaertn.		1 3
H. octandra Thw.		1
Trichadenia zeylanica Thw.		1
Flacourtia indica (Burm.f.) Merr.	6	1
Dovylis hebecarpa (Gardn.) Warb.	6	
Passifloraceae		
Adenia Wightiana (Wall.) Engl.		2
A. palmata (Lam.) Engl.		1 2
Thymelaeaceae		
Gnidia eriocephala Heisn.		1 3
Lythraceae		
Ammania baccifera L.		1
Woodfordia fruiticosa (L.) Kurz		1 7 8
Lawsonia inermis L.		1 6 7
Lagerstroemis speciosa (L.) Pers.		1 7
Sonneratiaceae		
Sonneratia caseolaris (L.) Engl.	6	1
Lecythidaceae		
Barrigntonia asiatica (L.) Kurz		1 3
B. racemosa (L.) Bl.		1
B. ceylanica (Miers) Gardn.		1
B. acutangula (L.) Gaertn.		1 3 7
Careya arborea Roxb.		1
Rhizophoraceae		
Rhizophora mucronata Lam.		1 7
R. apiculata Bl.		7
Ceriops tagal (Perr.) C.B. Rob.		1 7
Bruguiera gymnorhiza (L.) Lam.		7

B. sexangula (Lour.) Poir. 7
B. cylindrica (L.) Bl. 7
Carallia brachiata (Lour.) Merr. 1

Alangiaceae
Alangium salviifolium (L.f.) Wangerin 1

Combretaceae
Terminalia bellirica (Gaertn.) Roxb. 6 1 7
T. chebula Retz. 1 7
T. arjuna (Roxb.) Wight & Arn. 1
Anogeissus latifolia (Roxb.) Wall. 1 7 8
Lumnitzera racemosa Willd. 1

Myrtaceae
Syzygium aqueum (Burm.f.) Alst. 6
S. jambos (L.) Alston 6 1
S. hemisphericum (Wight) Alst. 1
S. zeylanicum (L.) DC. 1
S. operculatum (Roxb.) Nied 6 1
S. cuminia (L.) Skeels 6 1 7
S. makul Gaertn. 6

Melastomataceae
Osbeckia cupularis D. Don 1
Melastoma malabathrica L. 4 6 1
Memecylon grande Retz. 4
M. umbellatum Burm.f. 1 7
M. capitellatum L. 7
M. angustifolium Wight 1

Trapaceae
Trapa bispinosa Roxb. 6 1

Umbelliferae
Hydrocotyle javanica Thunb. 4 1 3
H. sibthorpicides Lam. 4
Centella asiatica (L.) Urb. 4 1
Pimpinella heyneana Wall. 1

Cornaceae
Mastizia tetrandra (Wight) C.B.Clarke 9

Ericaceae
Gaultheria rudis Stapf 1 5 6

Myrsinaceae
Aegiceras corniculatum (L.) Blanco 3
Ardisia humilis Vahl. 1
Embelia ribes Burm.f. 4 1

Plumbaginaceae
Plumbage Zeylanica L. 1

Sapotaceae
Chrysophyllum roxburghlii G.Don 6
Madhuca longifolia (L.) J.F.NcBr. 2 3 6 1 5 6 7
Palaquium grande (Thw.) Engl. 3
Mimusops elengi L. 3 6 1 6 7
Manilkara hexandra (Roxb.) Dubard. 6

Ebenaceae
Maba buxifolia (Rottb.) Pers. 6
Diospyros montana Roxb. 1 2 3
D. malabarica (Lam.) Kostel. 1 5 7 8
D. atrata (Thw.) Alst. 7
D. albiflora Alst. 7
D. ebenum Koen. 1 3
D. melanaxylon Roxb. 1 7

Symplocaceae
Symplocos loha Buch-Ham. 1 7

Oleaceae
Jasminum angustifolium (L) Willd. 1
J. suriculatum Vahl 1
J. humile L. 1
Olea glandulifera Desf. 1

Loganiaceae
Strychnos colubrina L. 1
S. cinnamomifolia Thw. 1 2
S. nux-vomica L. 1 2
S. potatorum L.f. 1

Gentianaceae
Exacum pedunculatum L. 1
Canscora diffusa (Vahl) R.Br. 1
Enicostema verticillare (Retz.) Baill. 1
Nymphoids indicum (L.) Kuntze 1

Apocynaceae
Carissa carandas L. 6 1 7
C. spinarum L. 6 1
Rauvolfia serpentina (L.) Benth. 1
Petchia ceylanica (Wight) Livera 2
Cerbera manghas L. 1 2 3
Catharanthus pusillus (Murr.) GDon 1 2
C. roseus (L.) G. Don 1
Holarrhena mitis (Vahl) R.Br. 1
Rejouva dichotoma (Roxb.) Gamble 1 2
Ervatamia divaricata (L.) Burkill 1
Alstonia scholaris (L.) R.Br. 1
Vallaris solancea (Vahl) Kuntze 1
Wrightia tomentosa Roem. & Schult. 1 7
W. antidysenterica (L.) R.Br. 1
Ichnocarpus frutescens (L.) Ait.f. 1
Nerium oleander L. 1 2

Aselepiadaceae
Hemidesmus indicus (L.) Ait.f. 1
Cryptolepis buchananii Roem. & Schult. 1
Secamone emetica (Retz.) R.Br. 1
Oxystelma esculentum (L.f.) R.Br. 1
Calotropis gigantea (L.) Aft.f. 1 5 7
Pentatropis microphylla (Heyne) Wight & Arn. 1
Pergularia daemia (Fersk.) Choiv. 1
Holostemma annulare (Roth) K.Schum. 1
Sarcostemma brunonianum Wight & Arn. 1
Gymnemma sylvestre (Retz.) R.Br. 1
Marsdenia tenacissima (Roxb.) Moon 1
Tylophora fasciculata Buch-Ham. 1 2
T. indica (L.) Merr. 1
Cosmostigma racemosun Wight 1
Dregea volubilis (L.f.) Hook.f. 4 1
Leptadenia reticulata (Retz.) Wight & Arm. 1

Convolvulaceae
Cuscuta reflexa Roxb. 1
C. chinensis Lam. 1 7
Cressa cretica L. 1
Evolvulus alsinoides (L.) L. 1
Ericybe paniculata Rexb. 1
Rivea ornata (Roxb.) Choisy 4 1
Merremia tridentata (Ll) Hallier f. 1
M. emarginata (Burm.f.) Hallier f. 1
M. umbellata (L.) Hallier f. 1
M. vitifolia (Burm.f.) Hallier f. 1
Operculina turpethum (L.) Mansoc 1
Ipomoea mauritiana Jacq. 1
I. muricata (L.) Jacq. 4 1
I. pes-tigridis L. 1
I. eriocarpa R.Br. 1
I. obscura (L.) Ker. Gawl. 1
I. pes-caprae (L.) R.Br. 1
I. aguatica Forsk. 4
Argyreia populifolia Choisy 4

Momordica charantia L.	4	8	1
M. dioica Roxb.		4	1
Cucumis melo var. agrestis Naud.	4	6	1
C. sativus L.		4	1
Luffa aegyptiaca Mill		4	1
L. acutangula (L.) Roxb.		4	1
Colecynthis vulgaris Schrad.		4	1
C. citrullus (L.) Kuntze		6	1
Bryonopsis laciniosa (L.) Naud.			1
Melothria maderaspatena (L.) Cogn.			1
M. perpusilla (Bl.) Cogn.			1
M. heterophylla (Lour) Cogn.			1
Kedrostis rostrata (Rottl.) Cogn.			1
Corallocarpus epigaeus (Rottl.) C.B.Clarke			1
Ctenolepis garcini (L.) C.B.Clarke			1
Benincasa hispida (Thunb.) Cogn.			1
Zanonia indica L.	4		1
Campanulaceae			1
Lobelia nicotianifolia Heyne			1
Godeniaceae			1
Scaevola sericea Vahl			1
Compositae			1
Vernonia cinerea (L.) Less.			1
V. anthelmintica (L.) Willd.	4		1
V. zeylanica (L.) Less.			1
Elephantopus scaber L.			1
Adenostemma lavenia (L.) Kuntze			1
Grangea maderaspatana (L.) Poir.			1
Erigeron asteroides Roxb.			1
Laggera alata (D.Don) Schultz-Bip.			1
Epaltes divarieata (L.) Cass.			1
Sphaeranthus indicus L.			1
S. africanus L.			1
Xanthium strumarium L.			1
Siegesbeckia orientalis L.			1
Eclipta prostrata (L.) L.			1
Wedelia chinensis (Osb.) Merr.			1
W. biflora (L.) DC.			1
Spilanthes paniculata Wall.			1
Centipeda minima (L.) A.Br. & Aschers.			1
Emilia sonchifolia (L.) DC.			1
Notonia grandiflora DC.	4		1
Lactuca runcinata DC.			1
Launaes sarmentosa (L.) Alston			1

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Groundwater Resources in Sri Lanka

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The main source input of water resources in Sri Lanka is direct rainfall which mainly showers down during the Maha season between October and January. With an average annual rainfall of 75 inches over the country of 25,330 sq. mile area, the total annual run off of drainage rivers and streams is only 41.6 million acre feet. In the dry zone, the run off in the streams, varies between 10% to 50% of the precipitation and in the wet zone it is about 65%. Allowing a small percentage for the evapo-transpiration losses, the balance amount of water percolates into the ground and exists as groundwater.

The relevant systematic and scientific investigations for an exploration of groundwater in the country are being carried out for the past 15 years by the Government Institutions such as the Irrigation Department and Water Resources Board and valuable information is available with them.

The availability of groundwater varies greatly in different parts of the island because of the diversity of geologic, topographic and climatic conditions. On the basis of hydrogeology, the zones of occurrence of groundwater may be classified broadly into the following groups :

1. Belt of sedimentary rocks consisting predominantly of miocene karst limestone, existing within the north and north-western coastal belt of Sri Lanka encompassing the whole of Jaffna Peninsula and the Islands.

2. The coastal sand deposits occurring in most parts of the coastline and the thin alluvial deposits within the river outfalls overlying the precambrian basement and the sedimentary rocks.

3. Crystalline hardrock area which occupies nearly 90% of the country and thinly covered by a mantle of residual soils and the valley alluvium.

The groundwater potential in the Zone 1, the sedimentary rocks, has been found to be the highest and is partly exploited. Deep seated groundwater aquifers have been found to exist in areas such as Vanathavillu, Madurankuli, Mannar, Silavathurai, Mulankavil, Paranthan and Mullaitivu. Most of these basins were observed to be overlain by impermeable and semi-permeable formations creating flowing conditions in some limited localities. In the Jaffna Peninsula, where the overburden is very thin, groundwater has been the main source of water for all purposes. Investigations are being carried out to study the extent of fresh water availability and safe limits of exploitation to prevent the floating thin freshwater lens from dangerous damages of lateral intrusion and upconing of sea water. The yield of groundwater from the shallow to moderately deep tube wells in these areas ranges from 6,000 to 24,000 gallons per hour.

In Zone 2, the coastal sands, and alluvial deposits in river-mouth areas, groundwater potential is substantial. The available good quality water in this zone is limited by the recharge input from rainwater and the danger of sea water intrusion. The shallow tube wells in the major river deltaic areas and the littoral sands yield ranging from 2000 to 6000 gallons per hour.

In the rest of the country, where the hard basement rock exists, the occurrence of groundwater is limited and confined to fissured, fractured and sheared zones essentially. Moreover, the inter-mountain valley regions with thick overburden store substantial groundwater which can be exploited. The yield from wells in this zone ranges from 200 to about 5,000 gallons per hour, most commonly averaging to about 1,000 gallons per hour. It is important to keep in mind that the yield from a well depends on the location of the well in relation to the geomorphology and the geological structure, storage of groundwater, the transmissivity of the formation, the design and construction of the well.

Forest Resources

Sri Bharet

Deputy Conservator of Forest

The tropical forest, possibly the oldest biome on earth, is a complex of symbioses and of subtle processes of co-operation of which we know very little. Technology and the vastly increasing human population have been the main causes for the destruction of the climax forest types which covered the greater part of the earth's surface in historical times. The great tropical ecologist Paul Richards, the author of 'The Tropical Rainforest', sees the tropical forests disappearing within another generation.

However, modern man as a matter of struggle for existence and of his own survival is now once again looking on his ancestral home, the forest, as one of the greatest natural resources and as having some function of guardianship of plants and animals, including man himself.

That the forests play a protective, productive and aesthetic role is well illustrated in a declaration of the Seventh World Forestry Congress which states that 'Forests counter erosion, protect agriculture, reduce floods, assures clean water, provide amenity and recreation, shelter wildlife, reduce pollution generally constituting a defence against environmental deterioration, provide timber, wood based industrial products which enter into every sphere of man's activities and also provide employment. In short, forests make a decisive contribution to the environmental, social and economic progress of mankind'.

Forests play a very vital role in moderating the effects of climate and in reducing the impact of pollution in the atmosphere. Forests help in ameliorating the effects of rain and wind, in checking soil erosion and controlling the water regime of the soil. Thus, it is not surprising that at present the protective function of the forests is given precedence over that of production. The productive role of the forest can be quantified easily. However, the protective role of forests cannot be quantified as easily. This difficulty precludes the direct assessment of the importance of the forest within the national economic framework.

Sri Lanka has a land area of 25,332 square miles or about 16 million acres. Of this land area, 7 million acres i.e. 45% of the land area was under forest in 1956. Between 1956 and 1980, there has been a substantial reduction in the forest areas and at present there are only about 4 million acres or 25% of the land area under forest.

There are 3 main rainfall regions in Sri Lanka, namely the Wet, the Intermediate and the Dry Zones. Each of these regions has its own distinctive type of forest differing from the forests of the other regions in species composition. Certain species grow only in the wet zone, while the growth of others is restricted to the dry zone. Both the Dry Zone species and the West Zone species grow side by side in the Intermediate Zone.

Within each of these 3 climatically defined zones, the distribution of quality classes (timber yield) and the individual species is determined by the combination of local factors, among which the availability of moisture, the texture, depth, permeability and nutrient content of the soil, the slope of the land and the degree of interference by man figure prominently.

The evergreen rain forest in the South West region of the Island (Wet Zone) consists of a total area of 152,000 ha. which includes 40,000 ha. of montane forests which is of an inferior type in timber production to the typical wet evergreen forests and excludes the 81,000 ha. of the intermediate zone forest. The wet zone and intermediate zone forests at present adds up to 8% of the total forest area. Most of these forests are located in the mountainous and therefore inaccessible terrain.

Although the untapped timber resources of the country are concentrated in the wet zone, their location in critical watershed areas imposes an additional problem on the management of these forests. The more important tree species found in these forests are as follows: the Duns, Horas, Na (*Mesua ferrea*) Kataboda (*Cullenia* spp.), Malaboda (*Myristica dactyloides*) Pelen (*Kurrimia ceylanica*) and Gurukina (*Callophyllum calaba*).

The dry zone type of forest covers abut 1.7 million ha, or about 82% of the forest area. These forests are of little economic importance with regard to timber production due to low stocking and low annual yield per unit area. Further, utilizable species are few and widely scattered. Among the main tree species are Wira, Mora, Welang, Milla, Satin, Halmilla and Kon.

Table I lists the extents of natural forests in Sri Lanka as at 31.12.1978.

1978 — Administration Report
Conservator of Forests

TABLE I

Natural forest (Forest Reserves) in acres as at 31.12.78.

Territorial Unit		Area of Unit	Area of Reserve	%of Area
Southern Division				
Southern Province	...	1,373,440	132,994	9.68
Up-Country Division				
Uva Province	...	2,019,200	21,657	1.07

Kandy & Nuwara Eliya Districts in Central Province	879,360	104,722	11.91
Northern Division			
Northern Province ...	2,152,320	428,728	19.92
North Central Division			
North Central Province ...	2,561,280	433,474	16.92
Trincomalee District in Eastern Province ...	745,600	169,127	22.10
Eastern Division			
Batticaloa & Amparai Districts in Eastern Province...	1,837,440	522,606	28.44
North Western Division			
North Western Province	1,918,080	329,715	17.19
Matale District in C.P. ...	592,000	36,105	6.10
Sabaragamuwa Province (Part) ...	282,880	6,994	2.45
Western Province (Part) ...	140,800	4,430	3.15
Western Division			
Western Province (Part) ...	775,680	56,366	7.27
Sabaragamuwa Province (Part) ...	933,760	116,871	12.52
Total : ...	16,211,846	2,363,762	14.58

TABLE II

Natural Forests and Wildlife Reserves in Sri Lanka

Category	Area in hectares 1975	1976	1977
Proclaimed Reserves ...	470,774	470,955	470,183
Proposed Reserves ...	482,826	482,799	482,825
Other State Forests ...	1,762,753	809,717	809,717
National Parks ...	304,557	304,557	304,570
Intermediate Zones ...	36,092	36,092	36,092
Natural Reserves ...	55,517	44,841	63,914
Jungle Corridors ...	10,517	10,517	10,364
Sanctuaries ...	199,928	199,928	205,222

The heavy exploitation of the natural forests which took place in the past has resulted in rapid deforestation and it has come to a stage when we cannot afford to continue this practise. (The present extents of natural forests including the wildlife reserves are given in Table II). This situation shifted the responsibility of timber supply from the natural forest to the 'manmade' or plantation forests.

These manmade forests began as a mere 20 ha. of teak in 1880. The extent of plantation forests risen rapidly due to the efforts of the Forest Department and in 1976 stood at 101,348 ha. of various species mainly teak (*Tectona grandis.*) This value is expected to rise to 300,000 ha. (0.75 million acres) or 4.6% of total land area by 2000 A.D. at the present rate of reforestation of around 8000 ha. (20,000) acres per year.
The main species used in afforestation in the Dry Zone are teak and eucalyptus. In the Intermediate Zone, the species used is mainly mahogany. In the West Montane zones, species like Pinus and eucalyptus are planted on a large scale. Ipil-Ipil is another species introduced lately in the Dry Zone. These species mentioned are all exotics and are fast growing. The indigenous species which are far slower growing than these exotics are also grown to a limited extent.

TABLE III

Record of Plantations

Species	Area on 31.12.78 (Acres)
Teak	161,386
Eucalyptus	30,897
Jak/Mahogany	11,910
Jak	10
Mahogany — Line Planting	45,802
Nedun — Line Planting	102
Light Hardwood	4,777
Bamboo	2,756
Pinus	27,758
Cypress/Pinus	1,981
Tamarind	49
Araucaria cunninghamii	29
Alstonia	45
Casuarina	505
Hulanhik	84
Nedun	200
Milla	9
Kumbuk	49
Et-Demata	295
Mahogany/Halmilla	10
Acacia mollisima	3
Gravillea robusta	3
Kudumberiya	14
Bamboo/Eucalyptus	888
Toona — Line Planting	35
Callitris	5
Margosa	422
Halmilla	37
Mixed species	307

Table III gives a record of the manmade forests in terms of acres of each species.

The plantation forests of Sri Lanka yield standardized premier timber as reflected in the high value component of the total turn over of the State Timber Corporation of a total turnover of 54 million during 1976, yield of plantation timber amounted to Rs. 13 million. This contribution is likely to rise steadily with the progressive maturing of the plantation forests.

Of the species planted Teak gives the highest socio-economic gain. The enormous capital value of Teak plantations can be gauged from the fact that at a rotation age of about 50 years it is worth around Rs. 100,000/ha at a very modest assessment.

The Mahaweli Development Scheme by virtue of its sheer magnitude and scope is the largest development scheme undertaken in Sri Lanka. For the first time in the history of an irrigation cum hydro-power scheme, the total value of forestry as a necessary input to maximise and maintain gains from this scheme has been accepted. The Mahaweli Scheme envisages the conversion of 650,000

acres of mainly forest land to irrigated agriculture, the generation of 500 M.W. of hydroelectric power, the setting up of agrobased industries and the settlement of 500,000 families.

TABLE IV

Mahaweli Ganga Basin Forest Resources as at 1956

	Forest	Total
Wet Zone ...	138,180	736,540
Intermediate Zone ...	111,550	551,200
Dry Zone ...	881,460	1,286,970
Total : ...	1,131,190	2,574,710

The intrinsic value of the forests in the upper catchment of the Mahaweli is in no doubt regarding the the regulation of the stream flow, in increasing deep storag of water in the ground, in drastically reducing floods and erosion and in increasing the purity of water. Therefore, the strict maintenance of river and stream bank and their reservations in undisturbed vegetative growth whether natural or planted, all along the course of the Mahaweli is of great importance.

Even though the macroclimate is uninfluenced by the forest, the microclimate is influenced by the forest to a great extent. Thus the removal of vast extents of forests in the lower Mahaweli would affect the plant and animal life adversely. Therefore the multiple use of land on a rational, long term basis incorporating the forestry sector is of utmost importance.

Harnessing and Utilization of Our Mineral Resources

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Minerals today, are vital for a developing country like ours and are indispensible for modern industry. Modern structures, roads and machines, are all built of materials obtained from minerals. Military strength provided by arms and ammunition is largely of mineral origin. Soil fertility is maintained by mineral fertilizers and water. Modern scientific and technological achievements, such as space travel have also been possible because of minerals. It is therefore of the utmost importance that we harness and utilize our mineral resources to the best advantage to the nation.

In the highly industrialised countries, both the total and per capita consumption of every mineral is very high. The mineral consumption of nations with predominantly agrarian economies on the other hand is low. These countries call themselves underdeveloped and very often strive to industrialise. Sri Lanka belongs to this latter group of countries. However, it has to be pointed out that we in Sri Lanka have only twenty-five thousand square miles to provide us with all the minerals we need. But a country like the Soviet Union for instance, which extends almost half way round the globe can probably name any mineral they want and find it within their territory. It is therefore all the more important that we carefully harness the scarce mineral resources we possess and conserve and use them to the best advantage.

From the time of the Sinhalese Kings, Sri Lanka was considered essentially an agricultural country. In colonial times, the major part of her revenue was derived from the agricultural industries, tea, rubber, coconut and rice. Consequently all development work was geared to the development of these industries and our mineral resources were neglected. We had to import all our cement, ceramics and a major portion of our brick and tile from abroad. The only mining industry prevalent at that time was graphite, and this too was done to cater to the needs of our colonial masters who exported the graphite to provide them with raw materials needed for industries in their home country. This situation continued for quite a long time, until during World War Two, due to the restriction of imports, several pilot scale factories were started in Sri Lanka for the production of ceramic ware, brick and tiles using locally available raw materials. With the cessation of hostilities, a concentrated effort was made to find out what mineral raw materials were available in the country which could be utilized for industry. Such a survey was found all the more necessary at that time, as we did not have a proper inventory of our mineral resources and therefore were unable to assess the mineral potential and industrial potential of Sri Lanka. Further, because of the falling prices of our main products, tea, rubber and coconut and the increased cost of production of these commodities due to increases in fuel, fertilizer and machinery, we had to look for other sources of income. Minerals and products derived from them therefore constituted important alternatives as sources of revenue and employment.

A full-scale systematic mineral exploration programme in Sri Lanka was first started in the late thirties by the Department of Mineralogy, (now the Geological Survey Department) and a large part of the effort in the early stages was devoted to traverses across the length and breadth of the country looking for minerals of economic value at or near the surface. Substantial progress was made during that time and with the limited resources available, it was possible to identify some of the potential economic minerals, such as the superficial limonitic iron-ores of the South Western Sector of the Island, the china clay deposits, the beach mineral deposits and the Muthurajawela peat deposits. However, these techniques could not be applied for hidden or buried mineral deposits. These underground deposits could only be explored by adopting the more modern scientific prospecting techniques. These are geophysical, geochemical and radiometric, and are based on a more methodical search for ore bodies on a knowledge of the mineralogy, structure, and geological history of an area and factors favouring mineralisation. By the use of these techniques together with aerial photographs and diamond drilling techniques, the Geological Survey Department was able to harness interesting new findings of minerals which could be economically exploited.

The various surveys and programmes conducted by the Geological Survey Department over the years led to the discovery of an ever increasing number of economic important minerals both in hard rock and in the alluvial deposits derived from the weathering of rock which are as follows :—

Iron Ores
Limonite, geothite and magnetite.

Limestone minerals
Sedimentary, coral, shell and crystalline.

Radioactive minerals
Monazite, thorianite, allanite.

Magnesium minerals
Dolomite, magnesite.

Titanium minerals
Ilmenite, rutile.

Zirconium minerals
Zircon, baddelyite.

Silicate minerals
Vein quartz, silica sands, zircon sands, feldspar, serpentinite garnet sands, cordierite, sillimanite.

Copper minerals
Chalcopyrite.

Phosphorous minerals
Apatite.

Mica minerals
Phlogopite, muscovite and biotite.

Carbon minerals
Graphite, peat.

Clay minerals
China clay, ball clay, pipe, brick and tile clay and clay suitable for cement.

Gemstones
Several varieties of which the most important are :—

Sapphire, ruby, alexandrite, catseye, emerald, aquamarine, topaz, tourmaline, garnet, spinel, zircon, moonstone, iolite and quartz.

There are a host of other minerals which have been discovered during the mineral exploration programme, but the quantities so far discovered are small and are therefore not economically feasible at present. However, with further work it will be possible to discover the sources of origin of these minerals and discover more of them which could eventually be used in industry.

Having discovered a large variety of minerals which could be used as raw material for various industries, let us now consider how these have been harnessed and put into use for the best advantage to the nation. One of the earliest industries to be established (as a direct result of the discovery of valuable limestone deposits in the Jaffna Peninsula and clay deposits in Mannar), was a factory for the manufacture of cement at Kankesanturai in the late forties. Again after the discovery of a further 20 million tons of high grade limestone and adequate clay resources at Puttalam, a second cement factory was established there. The manufacture of cement is now in charge of the Cement Corporation. The Corporation has further expanded its output of cement by setting up a grinding plant at Galle and hopes to put up a factory in the South using the limestone available there.

Consequent to the discovery of economically valuable deposits of kaolin, fire clay, ball clay, quartz, feldspar and dolomite, all the raw materials required for the establishment of an ever expanding ceramic industry are now available locally, with the result that four factories have been established for the manufacture of ceramic ware, wall tiles, electro ceramics, and miscellaneous ornamental and fancy ware in various parts of the island. Two factories have been set up for refining kaolin. These supply the refined kaolin to the various ceramic factories and also to the local paint, paper and rubber industries.

As a direct result of a systematic study of the clay deposits of the island, a variety of products using clay are being manufactured throughout the country, which, until recently were imported. The cottage industry manufactures about 350 to 400 million bricks per annum, unglazed tiles of the Mangalore pattern type are produced in abou fifty modern factories resulting in a total production of over fifty million tiles per annum.

Earthenware pipes and floor tiles are also produced in Sri Lanka. With the establishment of a refractories factory at Hanwela, we will be in a position to use our zircon sillimanite and dolomite as raw materials for this factory and will be self-sufficient with respect to furnace linings needed for the ceramic and steel factories. Up to now, the crystalline limestone — the dolomitic variety, although found in large quantities has had only a limited use, chiefly in the ceramic industry and in agriculture for correcting magnesium deficiency in soils. However, this kind of limestone can be used to manufacture magnesia. The raw materials needed, namely sea water and dolomite are available in Sri Lanka and the possibility of producing magnesia here is very promising. The British Peridore Company produces magnesia by this method.

With proved reserves of iron-ore, both of the limonitic and magnetic variety of about 12 million tons, it will not be long before Sri Lanka will establish a smelting plant to utilize iron ore. The Steel Corporation has already established a plant at Oruwela with Soviet aid for this purpose. The proposal is to operate it in three stages. The first stage is to use imported iron ingots, the second to use scrap iron and finally our own iron-ore. The first two stages have already begun and plans are ahead with the last stage to use our iron-ore. The Seruwila deposit is by far the most promising as it contains apart from magnetite, apatite and copper minerals. Once this deposit is exploited it will be possible to recover apatite and copper as well as a by-product.

The beach sands of Sri Lanka contain valuable minerals like ilmenite, rutile, zircon, monazite, sillimanite and garnet. These are scattered round the coast of Sri Lanka but concentrated at various points along the beach, particularly at Pulmoddai. The Mineral Sands Corporation has been entrusted to exploit and develop these sands. In their factory at Pulmoddai, the Corporation is geared to produce 90,000 tons of refined ilmenite, 12,000 tons of rutile, 8,000 tons of zircon, 500 tons of monazite and 200 tons of sillimanite. All the minerals they produce at present are exported in bulk, without processing to developed countries like Japan.

The gem and graphite industries are two of the oldest industries in Sri Lanka. Until recently these industries were in the private sector, but now they have been handed over to state sponsored Corporations. After the take-over, the State Gem Corporation was established in 1971 to develop the gem industry of the island. Gem mining is however, carried out by the private sector. All gem exports from Sri Lanka have to be channelled through the Corporation. The Corporation has made a significant contribution towards establishing a sound gem industry. The known figure for the value of gem exports in 1971 was two million rupees. The export figure for 1977 was over 200 million rupees. The revenue from the

export of gems is increasing daily and before long will be one of our chief foreign exchange earners. Graphite mining is at present carried out by the State Graphite Corporation. Graphite mined in Sri Lanka has a very high carbon content and is in great demand all the world over. Grades over 99 percent carbon are common. The bulk of the graphite mined is exported. The local consumption is negligible, except for some used in the manufacture of graphite crucibles and pencils. The State Graphite Corporation has also undertaken the development of the mica industry which has been neglected over the years. Mica occurs at a number of points. Systematic surveys are now being conducted to locate commercially valuable deposits and to establish this industry, too, on a firm footing.

Sri Lanka is rich in silica deposits. Vein quartz of extreme purity (over 99% silica) is found as scattered deposits. Pure quartzites occur in the central high lands and they can be traced for miles. Both these forms find use in the ceramic industry. High grade silica sands are found in various parts of the island particularly at Nattandiya, Madampe, Chilaw, Jaffna and Trincomalee. These sands are ideally suited as raw material for glass manufacture. A factory is now being set up with Chinese aid to produce sheet glass using these silica sands as raw materials. When this factory comes into production we should be able not only to produce our requirements of sheet glass but also to cater for an export market.

Thus with the discovery of these mineral resources of Sri Lanka which we were hitherto unaware of, it is now clear that our country is fairly well provided with resources of certain minerals, specially of the industrial type. Based on these deposits, a number of factories have been set up. However, a deeper analysis shows that some of these minerals are under-utilized or not utilized at all. Since minerals are a non-renewable commodity it is absolutely essential that we secure their optimum utilization by processing and developing them. Therefore, if the industries already established or about to be established are to prosper, a comprehensive programme of work will have to be undertaken both on the minerals, the processed material and by-products. Such a programme has become all the more necessary today as some minerals are not processed for want of appropriate technology to process them. The beach mineral industry for instance has been in existence for the last fifteen years and produces valuable minerals like rutile, ilmenite, zircon, monazite and sillimanite, all of which are exported to other countries without processing them here. The ilmenite is sold at 18 US dollars per ton. If however, we can convert this to titanium slag or synthetic rutile it would fetch 175 to 200 US dollars a ton. If this can be processed further to titanium dioxide pigments it would fetch 1000 US dollars a ton. Again, monazite, a thorium-rich rare earth phosphate is a valuable source for making compounds of thorium, rare-earths and phosphorus. The tremendous potential for thorium in nuclear reactors, and the rare-earth chlorides as catalysts in petroleum refining makes monazite an important mineral for the future. Countries like India and Brazil, which also produce monazite, have completely prohibited by law the export of this mineral in the unprocessed form. It is therefore opportune that Sri Lanka, too, follow the example of these countries and if necessary stockpile this mineral, till it is possible to establish a technology to process it. The same should apply to other radioactive minerals like thorianite and allanite found in Sri Lanka. Again, if we examine other mineral industries like graphite which have been mined and exported from this country for over a century, not a single graphite based industry of any significance has been established here. However, there is a great demand for our graphite from developed countries because of its high quality and suitability for making crucibles, electrodes, carbon rods and lubricants.

Two important mineral discoveries of great significance to Sri Lanka have been made by the Geological Survey Department in recent years. These are :-

(1) the apatite deposits at Eppawela and
(2) the copper magnetite deposit at Seruwila.

With the discovery of the apatite deposits the possibility of starting a phosphate industry in Sri Lanka has now almost become a reality. The deposit is estimated at 50 million tons with an average P_2O_5 content of 30 per cent. However, the Eppawala apatite is characterised by its low solubility, which is about 40 per cent less than that of Tunisian phosphate and 20 per cent less than the minimum value recommended for direct application. Any attempt to use this apatite as a direct application fertilizer, amounts to a wasteful expenditure of money and depletion of a valuable resource. From a study of its chemistry and mineralogy, it is recognised as a fluo-carbonate apatite. Beneficiation and treatment with sulphuric acid to convert it into super or triple superphosphate or conversion to fused magnesium phosphate by fusion with magnesium silicate are possible alternatives. High quality (magnesium silicate) serpentinite found to occur in the Uda Walawe area could be used for this purpose and experiments carried out in this direction have given encouraging results. Considering the price increases of phosphate fertilizers and the complex character of our apatite, further studies are obviously necessary both on the laboratory and pilot scale, followed by field trials to develop this apatite as a potential source of fertilizer and use, using a process that would be most advantageous to Sri Lanka. The copper-magnetite deposit at Seruwila is the first base-metal found in Sri Lanka. From investigations made so far only one fifth of the total mineralised area, it is estimated that 68,500 tons of metallic copper and 6.6 million tons of magnetite are available. Much more exploration work is required to cover the entire prospect to obtain a correct estimate of the grade and quantities of copper and magnetite (iron). Detailed studies will have to be made on the beneficiation and processing of the ore before commencing any extractive metallurgy. In addition to the iron and copper, apatite too, has been found in this deposit, which could be recovered once this deposit is exploited.

With a view to accelerating this exploration work, the Government has entered into an agreement

with a foreign firm for an expanded programme of exploration and before long it will be possible to know the total copper, magnetite, apatite and other minerals in this deposit and process these to the best advantage of the nation.

From the foregoing it is clear that Sri Lanka, although small in size, when compared to other Asian countries, has sufficient minerals, especially of the industrial type to start industries of its own. Based on these deposits, a number of industries have already been started, whilst some of them will be established once the initial exploration work is over and the feasibility studies are completed.

Mineral deposits are considered an exhaustible resource and it is now known that the richer mineral deposits of the world have been or are being exhausted and future need for metals and minerals must be met from larger deposits of progressively lower grade. In such a context, optimum utilization of our mineral resources becomes all the more important. As pointed out earlier, processing adds greatly to the value of mineral products. A further advantage, as is well known, would be to set up possible local industries based on the processed mineral raw materials and their by-products.

The mining and mineral industry has a tremendous future in Sri Lanka. The total value of our mineral commodities is now over 400 million rupees per annum. If however, we take the potential mineral deposits still unexplored, the value is almost double this amount. We have the resources and the man-power. What Sri Lanka lacks at present are trained mineral technologists, metallurgical chemists and the chemical engineers to handle the many problems that await the development of our minerals. For this purpose, the Government should consider the establishment of a single organisation, as in other developed countries, to undertake research and development of our mineral resources and work in close liaison with Corporations and other institutions engaged in the use of mineral raw materials. Such an establishment will not only help in the training of mineral technologists and chemists but also in the development of technology to process the minerals which are at present exported in the raw state.

In Sri Lanka as in other countries, the search for new mineral deposits is being continued. It is however left to the industrialists to intelligently and economically exploit these deposits. No industry based on local raw material can prosper, unless reserves and potentialities of the raw materials used are fully understood and the problems associated with their behaviour and use are solved. It is only then, that can we develop and build up the mineral industry in Sri Lanka into a major progressive and stable one for the future.