An update on biodiversity status, trends, and threats and implications for human well-being

1.1 INTRODUCTION

1.1.1 Sri Lanka's exceptional biodiversity: ecosystems, species and genes

Sri Lanka's rich and distinctive biological diversity[7] is defined by the ecosystems, species and genes that occur in the island's diverse array of forests, wetlands, and coastal and marine and agricultural systems, within a mere 6,524,540 ha[8] land area. Despite this small size, Sri Lanka is considered to be the richest per unit land area among countries of the Asian region with regard to average number of mammal, reptile, amphibian, fish and flowering plant species per 10,000 km2, and is second only to Malaysia with regard to the density of bird species (NARESA 1991). Likewise, among Asian countries, Sri Lanka is second only to Taiwan in terms of the number of pteridophyte species per 10,000 km2 (Ranil et al., 2012). The remarkably high percentage of endemic and relict species among the fauna and flora of Sri Lanka represent unique complements of the earth's biodiversity, and is of global significance. The biota in wet zone forests of the country is of particular importance in this regard as shown by the recognition of several wet zone forests as World Heritage Sites and Man and Biosphere Reserves. International recognition of the importance of the island's biodiversity, and the considerable threats it faces, have placed Sri Lanka (together with the Western Ghats of India) among the 34 biodiversity hotspots in the world (Myers, et al, 2000). Further, the ever-wet southwest Sri Lanka, with an exceptional number of endemics among the fauna and flora, of which most are considered threatened with extinction (BDS/MoE & DNBG, 2012), is termed a "hot spot within a hot spot" (Pethiyagoda, 2005).

At the national level, the island's biodiversity provides vital supporting, regulating, provisioning, and cultural ecosystem services to promote human wellbeing. It is the source of freshwater for domestic and industrial uses and energy production. Ecosystems and species provide socio-economically vital resources for: timber, agriculture and livestock production; fishery; tourism; the practice of traditional medicine; important manufacturing industries and external trade. Components of biodiversity help continuation of cultural beliefs and practices and the conduct of religious activities that shape the country's national identify. Sri Lanka's biodiversity also has potential meet future global needs for food and improving human health and well-being. Sri Lanka's

7 Biological diversity, or biodiversity as it is commonly known, "includes all plants, animals, microorganisms, the ecosystems of which they are a part, and the diversity within species, between species, and of ecosystems."

8 The land area of Sri Lanka is taken as 6,524,540 ha in this report to coincide with the land area used for mapping of forest cover in 2010.

forests are considered important for mitigating the impacts of global climate change as recognized by the REDD+ programme now in operation in the country. A positive aspect is that the need for conserving Sri Lanka's biodiversity and ecosystems is recognized in national planning, and is reflected in the Mahinda Chintana-the framework for national development (DoNP & MoFP, 2010), the Action Plan for the Haritha (Green) Lanka Programme (NCSD & PS, 2009), and the National Physical Planning Policy and Plan (NPPD & MUDSAD (2006). Despite this trend, and the many national efforts for biodiversity conservation, the island's biodiversity continues to be lost. Since the last reporting period, alien invasive species and climate change have become more pronounced. Some aspects of biodiversity loss are already being felt. This is of concern, as biodiversity loss can have considerable and wide ranging socio-economic and ecological implications on the country with inevitable negative impacts on national food security, rural livelihoods, human nutrition & health, and overall economic development: particularly in the fields of tourism and external trade.

1.1.2 What this report contains

The background data on the island's geo-evolutionary past, and the factors that influence the island's rich and unique biodiversity (i.e. location in the Indian Ocean; marked variations in climate, altitude and soils within the country, and a rich cultural and agricultural heritage shaped by centuries of farming) were provided in detail in the Fourth National Report. Similarly, descriptions of the different types of ecosystems (forests, grasslands, wetlands, coastal and marine systems and agricultural systems) and the characteristic species they contain were also provided in it. Hence this report concentrates on providing: (a) updates on ecosystems and species since the last report; (b) the current importance of species, forests, wetlands, coastal and marine systems and agricultural systems in terms of ecosystem services and optional biodiversity value; (c) threats the island's biodiversity faces; (d) major changes that have taken place in the status and trends of biodiversity in Sri Lanka since the Fourth National Report, (e) the impacts and implications of such changes nationally, and (f) future changes in the island's biodiversity that are most likely.

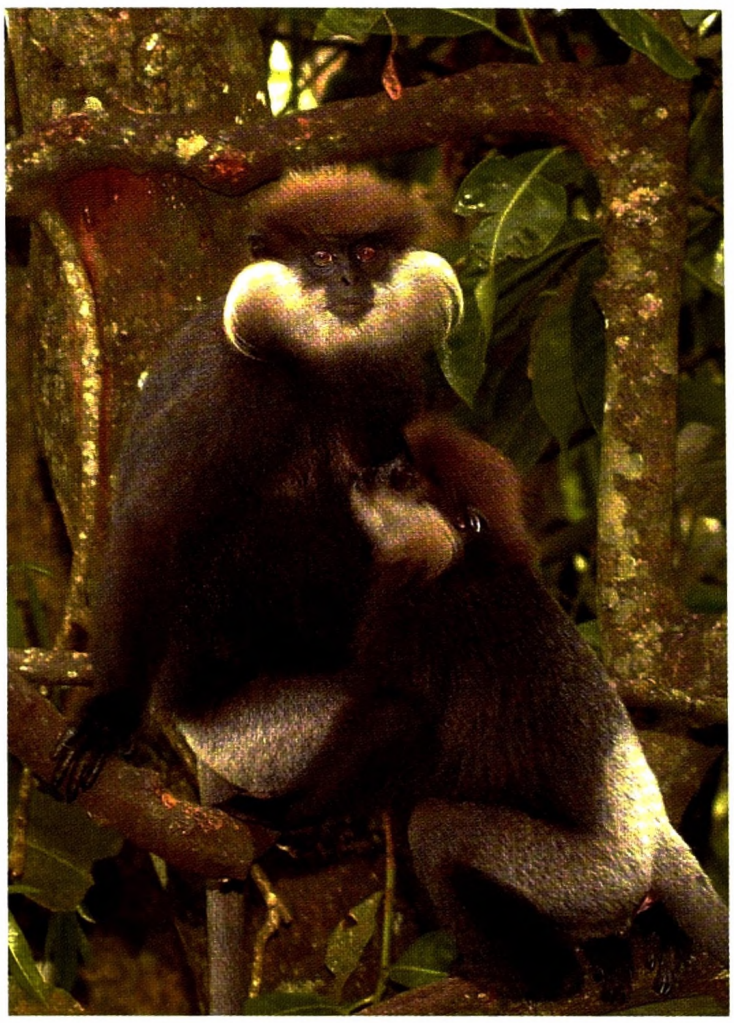
1.2 National and global importance of Sri Lanka's biodiversity

1.2.1 Insight into the earth's evolutionary past

There is evidence of Sri Lanka's long association with the Indian subcontinent among many groups of fauna, such as the island's molluscs, dragonflies, reptiles and mammals despite high levels of endemism in these groups (GoSL, 2008). For example, *Semnopethicus vetulus* (the purple-faced langur) *Macaca sinica* (the toque macaque) and *Paradoxurus aereus* (Golden Palm Civet) are

endemic to Sri Lanka, but show close affinities to sister taxa in India (Groves and Meijaard, 2005). Likewise, Angiosperms show close affinities with India at the Family level, though about 96 genera are non-peninsular (Abeywickrema, 1956).

Even so, Sri Lanka which now occurs within the Indo-Malayan Realm,[9] has many native species that show close affinities with other more distant Realms such as the Palearctic, the Australian and the Afro-tropical due to its past association with various land masses during the earth's geo-evolutionary history (GOSL, 2008). For example, 58 species from the family Dipterocarpaceae (which is pan-tropic), the genera *Hortonia* (Family Monimiaceae), and *Schumacharia* (Family Dilleniaceae) are examples of angiosperm genera with Gondwanic origins (GOSL, 2008). Three members of the Family Ericaceae are of Himalayan lineage and considered to be of Lauracean origin (ibid). Likewise, the rare occurrence of genera such as *Cinnamomum, Litsea, Michelia, Symplocos,* and *Celtis* are thought to suggest Lauracean relationships (Jayasuriya, et al, 1993).



Semnopithecus vetulus the endemic purple faced langur

© Wildlife Conservation Society, Galle

Among the fauna, about 90% of the bee genera in Sri Lanka show close affinities with those of the Afro-tropical (Ethiopian) Region, 18 genera are shared with the Palaearctic Region, 18 are shared with the Australian Region, while only one genera shares affinities with bees of the Indo-Malayan Region (Karunaratne and Edirisinghe, 2006). Sri Lanka's land snail fauna which is distinctively South Asian in composition also have several Gondwana relict taxa (Naggs and Raheem, 2000). Hence Sri Lanka's biodiversity is of global significance in understanding the changes that have taken place in the earth's geo-evolutionary past.

1.2.2 Exceptional diversity, endemism and relict species

Sri Lanka's exceptional biodiversity is possible due to the high ecosystem diversity it supports on land and in the coastal seas (Table 1.1), and the wealth of plant and animal species they harbour (Tables 1.2 and 1.3). This includes many species that are yet to be discovered. Of note is the remarkably high percentage of endemic and geographically relict species that are found in the island's forests and wetlands.

9 Zoogeographic terms follow Udvardy, 1975.

Table 1.1: Ecosystem diversity in Sri Lanka: status and trends

Ecosystems	Previous data (ha)	Present (ha)
Forest and related ecosystems	*(1999 data, FD)*	*(2010 survey, FD)†*
▫ tropical wet lowland evergreen forest (includes lowland and mid elevation rain forests)	124,340.8	123,302
▫ tropical sub-montane forest	65,792.3	28,513
▫ tropical montane forest	3,099.5	44,758
▫ tropical moist monsoon forest	221,977.0	117,885
▫ tropical dry monsoon (mixed evergreen) forest†	1,027,544.1	1,121,392
▫ tropical thorn forest (A	NA	NA
▫ riverine dry forest	18,352.1	2,425
▫ grasslands (wet pathana, dry pathana, savannah, etc)	>75,000	68,043 (savannah only)
Inland wetland ecosystems	(4th NR	NA
▫ flood plains	NA	NA
▫ lentic waters (tanks/reservoirs and ponds)	179,790	*169,941
▫ swamps	NA	NA
▫ wet villu grasslands	NA	*12,500
▫ Overall water bodies	NA	‡ 488,181
Coastal and marine ecosystems	(4th NR)	
▫ mangroves	6,080	†15,669
▫ salt marshes	23,800	NA
▫ sand dunes and beaches	19,394	NA
▫ mud flats	9,754	NA
▫ sea grass beds	NA	NA
▫ lagoons and estuaries	158,017	NA
▫ coral reefs	NA	68,000
Agricultural ecosystems	(4th NR)	
▫ paddy lands	525,000	ˣ845,444.00
▫ fruit cultivations	97,000	‡135,567
▫ small crop holdings or other field crops (pulses, sesame etc)	128,000	‡146,544.69
▫ vegetable cultivations *(excluding root and tuber crops for 2012)*	110,000	‡89,980
▫ crop plantations (major export crops)	772,000	‡703682.8
▫ minor export crops	NA	††106,232
▫ home gardens (cultivated, includes fruit cultivations in home gardens)	367,800	‡1,684,165.60
▫ chena lands (slash and burn cultivation)	NA	‡227,710.28

Source: The data for this table are from the following sources except where specifically mentioned:

*Forest Department 2010 survey data; ‡ AgStats, 2013; ˣ paddy land extent is Asweddumized land area from the DOA for 2012/13; †† Data from Department of Export Agriculture, 2014; *IUCN and CEA, 2006; *MOE, 2010, **MoENR, 2003.*

Note: The discrepancies between areas given for montane and sub-montane forests in the 1999 and 2010 forest assessments are reportedly due to differences in criteria for separation of these forest types. Accordingly, the area under both montane and sub-montane forests has changed from 68,892 ha in 1999 to 73,271 ha in 2010.

The unique endemic and relict lyre-head lizard species *(Lyriocephalus scutatus)* from an endemic genus

While association with Peninsular India and its mega biodiversity for millions of years has resulted in a high species diversity in Sri Lanka (GoSL, 2008), the island's separation in the Miocene about 20 million years ago (Deraniyagala, 1992) has resulted in a remarkable endemism (Bossuyt et al., 2004). This is underscored by the fact that 28% of Sri Lanka's 3,154 species of indigenous angiosperm flora are endemic to the country, including 14 endemic genera distributed in 186 families (BDS/ MoE & DNBG, 2012). For example, all 58 species of Dipterocarps found in Sri Lanka are endemic (ibid). Similarly, the genus Syzygium (Myrtaceae) has 30 indigenous species, of which 25 are endemic, while 26 of the 33 species of Memecylon (Melastomataceae) are endemic (ibid). The lower plant groups are insufficiently identified, but a high biodiversity and endemism is revealed from past studies (GoSL, 2008). Among aquatic plants, the family Araceae harbors the highest number of endemics including 10 species of the genus *Cryptocoryne* and seven species of *Lagenandra* (Yakandawela, 2012).

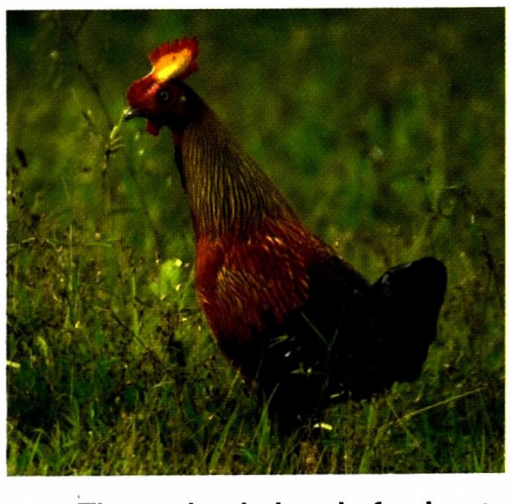
Endemism is also high among the indigenous vertebrates (Table 1.2), which without the migrant birds, is about 42%. Highest endemism in vertebrates is seen among amphibians, freshwater fishes and reptiles (Table 1.2). Most invertebrate groups in the island have been incompletely surveyed, but a high diversity is documented among butterflies, dragonflies, bees, spiders and land snails (Table 1.2).

Table 1.2: Species diversity among selected groups of Sri Lanka's fauna and flora in terrestrial and freshwater habitats

Taxonomic group	Number of species		Number of endemic species and % endemism
	4th NR	Present	Present
Land snails	246	253	205 (81)
Dragonflies	120	118	47 (39.8)
Bees	148	130	NA
Ants	NA	194	33 (17)
Carabid beetles	525	NA	NA
Butterflies	243	245	26 (10.6)
Spiders	501	510	257 (51)
Freshwater crabs	51	51	50 (98)
Freshwater fish	82	91	50 (54.9)
Amphibians	106 +	111	95 (85.6)
Reptiles (terrestrial)	183	193	124 (58.8)
Birds (including migrants)	482 (220 residents)	453, with 240 residents	27 (11.3) definitive and 8 Proposed
Mammals	91	95	21 (22.1)
Angiosperms	3,771	3,154	894 (28.3)
Pteridophytes (Ferns only)	348	336	49 (14.6)
Mosses ‡	560	560	63+
Liverworts*	303	222	NA
Lichens*	661	661	NA

NA= data not available; All data are from BDS/MoE &DNBG (2012) except otherwise mentioned
Data source for present status: BDS/MoE &DNBG, 2012 except IUCN and MoENR, 2007 for mosses and MoENR 2006 for Liverworts and Lichens

The endemic Chirita walkari



The endemic jungle fowl
Galloperdix bicalcarata
© Ruchira Somaweera

Biodiversity is also high among marine species such as corals, echinoderms, molluscs and palargic fishes (Table 1.3). Fringing coral reefs with high biodiversity such as those in the southwest and eastern coasts of Sri Lanka and offshore reefs such as the Bar Reef are of high tourism value, while echinoderms such as sea cucumber, molluscs such as squid and cuttlefish, crustaceans such as lobster, crabs, prawns and shrimps, and a host of marine fishes are of major importance in the food fishery in terms of national nutrition and export value.

Table 1.3: Species diversity among selected groups of fauna in coastal and marine systems

Taxonomic group	Number of species		Source of present data
	4th NR Report	Present	
Hard coral species	183	208	Rajasuriya, 2012
Soft corals	NA	35	Krishnaraja, 2012
Echinoderms	213	NA	---
Echinoderms (Echinoidea)	NA	55	Jayakody, 2012
Echinoderms (Crinoidea, Ophuroidea and Holothuroidea)	NA	135	Fernando, 2012a
Marine mollusks	228	NA	---
Marine shelled bivalves and gastropods	NA	756	Fernando, 2012b
Marine crustaceans	NA	742	Weerakkody, 2012
Sharks	61	64	Dalpathadu, 2012
Skates and Rays	31	33	Dalpathadu, 2012
Marine reptiles	18*	18	---
Marine mammals	28	30	Weerakoon, 2012
Marine and brackish water bony fishes	NA	916	Dalpathadu, 2012

1.2.3 Ecosystems of global importance as World Heritage Sites, Ramsar sites and Biosphere reserves

The global recognition of Sri Lanka's unique biodiversity is demonstrated by the fact that in a land area less than 65,250 sq km., the country has four forests recognized as Natural World Heritage Sites (WHS) because of their exceptional biodiversity value due to high endemism, and four Biosphere Reserves (with Core Zones recognized as making significant contribution to national and global biodiversity) within the UNESCO World Network of Biosphere Reserves. Sri Lanka also has six Ramsar wetlands (namely: Bundala National Park, Annaiwilundawa Tanks Sanctuary, Maduganga, Vankalai Sanctuary, Kumana Wetland Cluster and the Wilpattu Ramsar Wetland Cluster)[10] indicating global importance of the island's wetlands. The Bundala Ramsar site harbours a large number of migrant waterbirds, and four marine turtle species come ashore to its beaches. Thus biodiversity loss in Sri Lanka will contribute significantly to the loss and degradation of the earth's ecosystem services that underlie human well-being in addition to the national impacts of biodiversity loss. Examples of the value of Sri Lanka's biodiversity at the national and global levels are given in BOXES 1.2 and 1.3.

10 http://www.ramsar.org/cda/en/ramsar-pubs-notes-annotated-ramsar-16173/main/ramsar/1-30-168%5E16173_4000_0

1.2.4 Role of biodiversity for provision of ecosystem services

A summary of ecosystem services rendered by forests, wetlands, coastal and marine systems and agricultural systems in Sri Lanka from assessments done during the 2013/14 Periodic Review of the Sinharaja, Kanneliya-Dediyagala-Nakiyadeniya, Hurulu and Bundala Biosphere Reserves (NSF, 2014 a,b,c,d), preparation of the 2012 Red List, and preparation of the National Directory of Wetlands (2006) are presented here, with inputs from expert workshops held for preparation of this report (BOX 1.1). In addition, the examples provided in BOXES 1.2 & 1.3 also demonstrate the many supporting, regulatory, provisioning and cultural services that are offered by various ecosystems in Sri Lanka. Furthermore, contribution of biodiversity and related ecosystem services to human well-being and socio-economic development are also highlighted in this section of the report.

BOX 1.1: Summary of ecosystem services offered by Sri Lanka's forests, wetlands, coastal and marine systems, and agricultural systems

Service Type ***Supporting services*** *(that help maintain the conditions for life on earth and habitats for species):*

- Forests, wetlands, coastal and marine systems provide habitat for Sri Lanka's many indigenous faunal and floral species, including a large number of migrants, marine mammals and five marine turtles. The biologically rich wet zone forests and their rivers and streams are especially important repositories of endemic, relict, rare and/or threatened fauna and flora.
- Grasslands and thorn scrub forests of the dry zone provide the main habitats for large charismatic species such as the elephant, deer, bear and leopard, which are major tourist attractions.
- Wet zone forests form important watersheds for almost all of the island's 103 major rivers which originate from the forests of the lowland wet zone and the central mountains. (See BOXES 1.2 and 1.3 which show how Sri Lanka's Biosphere Reserves and World Heritage Sites play a crucial role in this regard.).
- Cloud forests of the montane zone trap moisture through fog interception. Examples are forests of the Central Highlands World Heritage Site (BOX 1.2).
- Forests in the dry zone provide watersheds for 'reservoir tanks' that are important for irrigated agriculture and have a strong cultural dimension. Good examples are tanks associated with forests of the Kaudulla National Park and the Minneriya National Park. These tanks also provide habitats for aquatic birds and other wetland fauna and flora.
- Mycorhizae and plants that act as biofertilisers, provide nutrients to ecosystems and for tree growth.
- Forests, wetlands and traditional agricultural systems provide habitats for natural enemies of agricultural pests and plants that yield products for pest control *(e.g. Dipterocarpus glandulosus resins),* thus playing a vital role to increase agricultural production.
- Bees, butterflies and birds are important pollinators that promote agricultural production.
- Forests, wetlands, coastal and marine systems and agricultural lands (e.g. crop plantations such as coconut and rubber), and trees in home gardens and urban parks, facilitate nutrient cycling, primary production, seed dispersal, production of O2, and provision of habitats for crops and their wild relatives.
- Myriads of tiny phytoplankton in coastal ecosystems and coastal seas, absorb CO2, and release O2 into the atmosphere helping to make life, as we know, possible on earth.

Service Type *Regulatory services* *(i.e. benefits from regulation of ecosystem processes):*

- Forests, crop plantations (cocoa, coconut and rubber), trees in home gardens and urban parks, wetlands, coastal and marine systems and agricultural lands help air quality maintenance, climate and water regulation, and storm protection.
- Forests and wetlands are important for water retention in the soil, flood and soil erosion control, and water purification. Marshes *(e.g. Bundala, Muthurajawela, Bellanwila-Attidiya)* are particularly useful in absorbing pollutants and purifying ground water.
- Coral reefs, sand dunes and mangroves help control coastal erosion and provide storm protection, thus protecting coastal lands and saving millions of rupees spent for disaster mitigation. For example, the sand dunes of Bundala BR are believed to have acted as a barrier to preclude destruction of the area by the tsunami waves in December 2004. In contrast, coastal lands where the fringing coral reefs had been destroyed for the lime industry suffered badly. This connection is now understood by local people.
- Forests in the dry zone, riparian forests and mangroves in the coastal zone act as barricades for wind currents, and control the impact of storms that would damage adjacent residential areas and cropping lands.
- Sri Lanka's forests block large amounts of C in forest trees, and thereby contribute to mitigate global climate change (due to their C sink capacity). For example, the biomass availability in terms of timber (and carbon storage) in Sri Lanka's forests varies between forest types. The average allowable cut in productive biodiversity rich natural forests of the Wet Zone is around 40 cubic m/ha in a 30 year felling cycle whiles the less diverse Dry Zone forests in terms of tree species have an estimated volume increment of 0.45-0.5 cubic m /ha/annum (FAO and FD, 2009). As such, the carbon sequestration in Hurulu Biosphere Reserve in the dry zone is at the rate of 1 t-C yr-1 ha-1, while carbon sequestration in the lowland tropical rainforest Kanneliya-Dediyagala-Nakiyadeniya Complex is at the rate of 2.9 t C yr-1 ha-1 (NSF, 2014 b & c). Coconut, rubber, and mangroves (as well as other perennial woody species) also help in C sequestration.
- Coastal ecosystems surrounding the island and coastal seas contain myriads of tiny phytoplankton which play a critical role in absorption of CO_2 to mitigate the effect of global warming and help maintain the O_2 in the atmosphere to make life possible on earth.

Service Type *Provisioning services*

- Forests and wetlands provide water for human consumption and other domestic uses necessary for human well-being. Many rural communities continue to use water from forest streams-often piped privately to their homes, as well as irrigation tanks and canals. The most important forest product used by villagers near wet zone forests is water for domestic use.
- Forests and wetlands (e.g. waterfalls in forests and man-made large reservoirs) provide freshwater for hydro-electricity which is a major source of clean and cheap energy in the country. An example are the forests surrounding the Labugama-Kalatuwawa Reservoir that supplies piped water to a large segment of the population in the Western Province of Sri Lanka.
- Many wet zone forests are also the sites of micro- and mini-hydropower plants which provide electricity for people (see BOX 1.3). For examples, the KDN-forest complex supports 3 mini hydro-electric power projects, while the Gin Ganga and Nilwala Ganga irrigation projects (i.e. these rivers originate from the KDN) provide water for 3300 ha and 12,000 ha respectively (NSF, 2014b). The Sinharaja BR supports 5 mini-hydroelectricity plants in the TZ, while the SBR supports the upper watersheds of the Gin Ganga and the Kalu Ganga which provide piped water to a large segment of the country's population (NSF, 2014 a). *[note: proliferation of mini-hydropower plants also have some environmental impacts)*

- Forests and wetlands also provide water and electricity for many industries including the textile and garment industry that are main foreign exchange earners.
- Rivers, tanks and canals are used for transportation of goods and for recreational purposes.
- Rainfed agriculture is lucrative in the fertile lands near forests which help maintain the water balance in the soil in the adjacent lands by controlling run-off.
- Forests and wetlands provide a large number of natural resources such as mineral resources (e.g. sand, clay, gravel, limestone, metal quarrying and quartz). *However, their removal should be sustainable with minimum damage to the environment.*
- Forests and wetlands are reservoirs of crop germplasm and wild relatives of crops. For example, the KDN Biosphere Reserve and the adjacent Sinharaja World Heritage Site and Biosphere Reserve contain germplasm of cardomum, wild pepper spp., several cinnamon species *(Cinnamomum spp.)* and wild banana *(Musa acuminata)*.
- Forests, wetlands, coral reefs and mangrove ecosystems contain a large number of products for subsistence and commercial use, such as:
  - Ornamental plants (e.g. orchids, pitcher plants, aquatic ornamental plants such as *Cryptocryne* spp, *Aponogeton* sp. etc.) and animals such as the black ruby barb (*Pethia nigrofasciata*), cherry barb (*Puntius titteya*) and Bandula barb (*Pethia bandula*) with export value.
  - Food items (e.g. kitul products [jaggery, treacle, local beverages], carbohydrates [flour from *Caryota urens* (kitul), and beraliya (*Doona venulosa*) fruits, fruits of Goraka (*Garcinia* sp.), wild relatives of cinnamon, cardamom and pepper; many species of yams, leafy vegetables and edible mushrooms; crustaceans and fish from lagoons, estuaries and coastal and marine systems and inland wetlands).
  - Medicinal plants and products for various minor ailments and osteopathic medication. Though most rural people rely more on western medication now, traditional medication still plays an important role in some rural areas such as the Hurulu Biosphere Reserve. Many rural traditional medicine practitioners continue to obtain raw material from adjacent forests, grasslands and wetland marshes (e.g. of medicinal plants from wetlands: Lunuwarana [*Crateva adansonii*] and *Neeramulliya* [*Hygrophila schulli*]).
  - Oils and resins for lighting (e.g. *Dipterocarpus glandulosus* resins).
  - Insect repellent plant products and plants.
  - Roof thatching for wattle and daub huts - although this use has declined greatly with development and socio-economic advancement of local people in rural areas near forests resulting in permanent housing.
  - Raw materials for traditional craft based industries. For example, Divi Kaduru (*Paginatha dichotoma* - wood is used to produce traditional masks for sale and use in ritualistic cures, Pandanus leaves are used for mats, etc. However, some traditional craft based industries, such as the rattan and bamboo industry, have declined during the past decades due to diminution of the raw material within forests from over-exploitation in the past.
- Coastal and marine ecosystems such as coral reefs, sea grass beds and mangroves are vital to maintain the traditional as well as commercial fishery which provides fish and crustaceans for consumption. While enhancing the national economy, this supports local livelihood and nutrition to the nation as much of the protein requirements of the country are met with from fish.
- Lagoons are used for salt production which supplies the entire nation. (*These salterns are also home to many water-birds that have adapted to this environment. For example, the two lagoons in the Bundala National Park used for salt production provide habitats for many wetland bird species*).

- Traditional agricultural systems provide habitats for a range of traditional varieties and locally adapted land races of crops and wild relatives of crops with desirable genetic traits for crop enhancement. They are now being investigated for beneficial traits to be used when breeding improved high yielding varieties of rice, vegetables, fruits, spices, and other field crops.
- Traditional farming systems contain locally adapted livestock that are being used to breed locally adapted high yielding varieties.

Service Type Cultural services *(i.e. non-resource benefits obtained from ecosystems)*

- Forests, wetlands, coastal and marine systems provide a valuable base for tourism which has been identified by the government as a major foreign exchange earner in the future and for increasing livelihoods of local people in popular tourist areas. As yet the potential for ecotourism has not been followed-up fully (see next section). The potential for agro-tourism in traditional agricultural lands is now being explored. The aesthetic value of biodiversity is central to expand nature based tourism in the country.

The elephants at Minneriya National Park are a major tourist attraction

- Some stretches of coastal waters are used for adventure tourism, while tanks, artificial lakes and rivers and waterfalls are used for boating and recreation (e.g. Lake Gregory is used for sea plane landings, white-water rafting is popular at Kitulgala, and bird watching is popular in the Bundala wetlands).
- Local people have indigenous knowledge on the use of various Non-Timber Forest Products (NTFPS) from forests, wetlands and coastal and marine systems. This is part of the cultural heritage of the country.
- Some crop wild species are used for cultural purposes. For example wild Piper spp. (thippili, mala bulath and rata bulath) are sometimes cultivated by rural people for use in ceremonial functions.
- Forests such as the Peak Wilderness Protected Area (Part of the Central Highlands WHS) are of paramount religious importance-especially for Buddhists, and many forests in the country have Buddhist monasteries and hermitages that are regularly visited by a large number of people to provide alms.
- Many forests also harbour sites of archeological importance. Examples are: the grasslands of the Horton Plains National Park which contains prehistoric evidence of the earliest agriculture in South Asia, and the Bundala Biosphere Reserve may contain the oldest pre-historic human remains in Sri Lanka.
- Wetlands provide popular flowers (e.g. from *Nelumbo nucifera* or lotus, *Nymphaea nouchali* or water lily and *Nymphaea pubescens* or Egyptian lotus) for Buddhist religious ceremonies.
- The aesthetic value of biodiversity plays a key role in the pursuit of peace and tranquility that is required for religious retreats and meditation.

BOX 1.2: Case study: The Central Highlands World Heritage Site

The Central Highlands World Heritage site (CHWHS) consists of the Knuckles Conservation Forest (KCF), the Peak Wilderness Protected Area (PWPA) and the Horton Plains National Park (HPNP). The vegetation types in the CHWHS are varied. The HPNP consists of gently undulating wet pathana grasslands and patches of cloud forest. The KCF has wet montane grasslands, montane rainforest, and patches of very low stature montane forest with stunted trees ranging in height from "pygmy" to "elfin" forest. The PWPA contains the largest block of sub-montane and montane rainforest in Sri Lanka. Overall, these forests show exceptional endemism among the flora. The PWPA contains 555 woody plant species, of which about 50% are endemic. The KCF harbours 1033 species of flowering plants of which 160 are endemic. About 50% of the woody plant species at the HPNP are endemic.

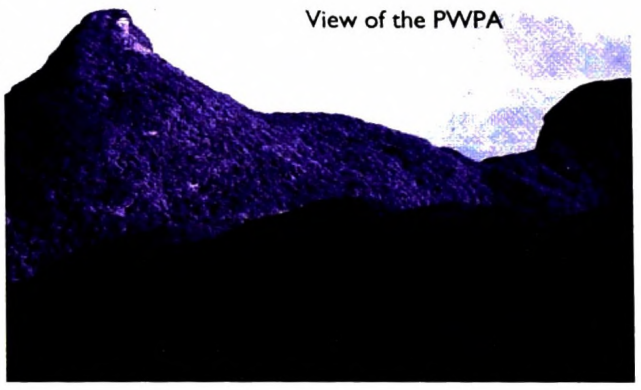

View of the PWPA

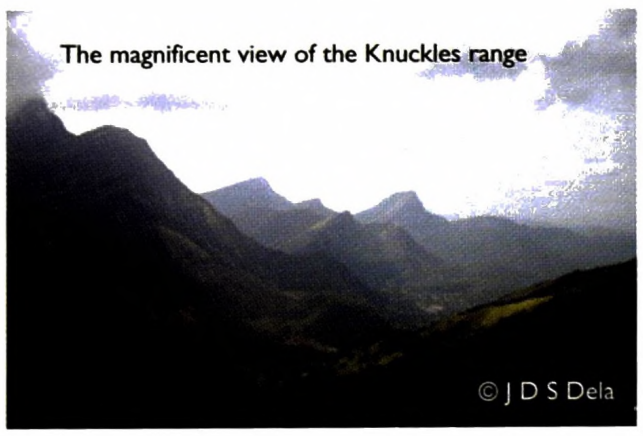
Photo: S Balasubramanium © UoP Department of Botany


Cloud forest at HPNP

© Samantha Mirandu

These wet montane forests of the Sri Lanka's central highlands also contain unique faunal elements. Examples of relict endemic species in the CHWHS are *Ceratophora tennentii* (from an endemic genus) - confined to the higher elevations of the KCF - while close relatives are found in the central massif which contains the PWPA and HPNP, and in the Rakwana hills. The HPNP provides the main refuge for the characteristic and endemic bear monkey *(Semnopithecus vetulus monticola)* and the very rare Horton Plains slender loris *(Loris tardigradus nycticeboides)*. The endemic *Cerotopora stoddarti*, *Calotes nigrilabris* and *Cophotis ceylonica* are 'mountaintop isolates' (Bahir and Surasinghe, 2005), for which the CHWHS provides critically important habitats. Overall, the three forests provide habitats for 48% of the country's endemic vertebrate species. They are also well known for point endemics found no where else. Examples are *Stemenoporus affinis,* an extremely rare species of dipterocarp, which is limited only to the KCF (Green and Jayasuriya, 1996); fish species such as *Garra phillipsi*, *Dawkinsia srilankensis* and *Systomus martenstyni*, amphibians such as *Nannophrys marmorata* from an endemic genus, and the skink *Chalcidoceps thwaitesii* from an endemic monotypic genus, are found only in the Knuckles forests.

The CHWHS is also of cultural importance. The PWPA is of religious and cultural significance to all major religious in the island, and contains a world famous Buddhist Shrine, containing the sacred foot print of Lord Buddha, which is visited by about two million pilgrims annually. The HPNP has valuable palaeo-ecological evidence of global importance as the site where first agriculture emerged in South Asia between 17,000-16,000 years BP. The HPNP and KCF are also currently popular tourist destinations as they offer prime scenic sites such as the famous Baker's Falls at HPNP, and spectacular landscapes in the KCF featuring several magnificent peaks.


The magnificent view of the Knuckles range

© J D S Dela

Another very significant feature is that the PWPA covers the headwaters of the Kelani and Kalu Ganga (rivers), the Walawe Ganga arises from the HPNP, and the entire drainage system of the KCF belongs to the Mahaweli Ganga system. These forests thus serve the critical ecosystem function of protecting the headwaters of major rivers, controlling floods, controlling soil erosion and enabling fog interception.

Source: GoSL, 2008

BOX 1.3: Case study of the four UNESCO MAB Reserves in Sri Lanka

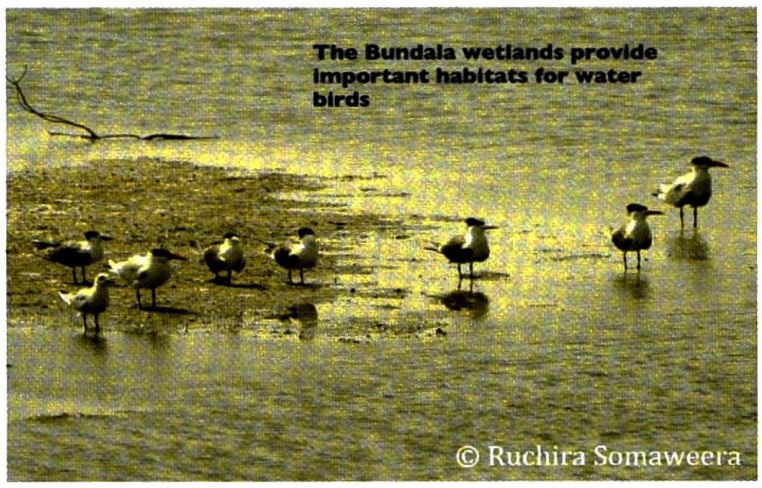
Sri Lanka has four Biosphere Reserves within the UNESCO World Network of Biosphere Reserves. They occur in three different climatic zones, so that the biodiversity within their Core Zones are representative of the lowland wet zone and sub-montane rainforests, dry mixed evergreen forests, and coastal/wetland/dry thorn forests.

The Sinharaja Forest occurs within a Biosphere Reserve and is a World Heritage Site. It is one of the last viable remnants of the mid-Miocene tropical rainforests of Sri Lanka (Dela, 2003). Its lowland and sub-montane rainforests contain exceptionally high levels of biodiversity and endemism. It is one of the richest forests for woody plant species in Sri Lanka, and the second richest for faunal species (IUCN/WCMC/FAO 1997). It supports about 359 species of vertebrates including 46 species of fish, 52 amphibians, 95 species of terrestrial reptiles, 125 birds, 41 species of mammals, at least 119 species of butterflies, and 331 species of Angiosperm flora of which over 50% are endemic (NSF, 2014a). Many Sinharaja species, particularly the flora, show affinities to the flora of Gondwanaland and the Deccan Plate comprising India and Sri Lanka (Ashton and Gunatilleke, 1987).

The Kanneliya-Dediyagala-Nakiyadeniya Biosphere Reserve complex is representative of the lowland rainforest biome within the biologically rich southwest of Sri Lanka. The three forests have 238, 188, 234 species of woody plants respectively (IUCN/WCMC/FAO 1997) of which 155 (65%), 124 (66%), and 132 (56%) are endemic. Likewise 60, 47 and 62 species of fauna are found respectively in these forests of which 25 (42%), 17 (36%) and 31(50%) are endemic (IUCN/WCMC/FAO, 1997). The Sinharaja and KDN BRs are part of eight units of contiguous forests in which at least 79% of the island's woody plant diversity are represented (IUCN/WCMC/FAO, 1997). The rainforests of the SBR and KDN are also of great value as watersheds for some major rivers, and are important sources of water for local people while supporting several min-hydropower plants that generate electricity.

The Hurulu Biosphere Reserve represents Tropical Dry Mixed Evergreen Forests characterized by evergreen, deciduous and semi deciduous tree species. The reserve also has open forests, grasslands, villu grasslands (i.e. seasonally flooded grasslands), riverine forests, scrublands and forest plantations. As this region is in the dry zone and receives rains mainly during October to February, agriculture depends on irrigation from waters stored and released from ancient tanks. Several irrigation tanks in the reserve provide habitats for birds, crocodiles and fish species, while the villu grasslands provide prime habitats for many large charismatic mammals such as elephants, deer, bear, sambur and leopard. Among the evergreen, deciduous and semi-deciduous species in the forest, there are valuable and rare timber species such as *Chloroxylon swietenia* (satinwood), and *Diospyros ebenum* (ebony).

The Bundala Biosphere Reserve and Ramsar site has very diverse vegetation types that show natural succession from low, creeping plants that colonize the beach and sand dunes to climax forest, referred to variously as Thorn, Dry Semi-Evergreen and Dry-Mixed Evergreen Forest in the least disturbed areas. In addition there are riverine forest, anomalous mesquite scrublands and six wetland types: salt marsh, mangrove, brackish water lagoons, sandy and rocky sea shore, seasonal water holes and tanks, and saltern (Bambaradeniya et al, 2001). Notably it has a 20 km stretch of beach where 4 species of marine turtles come ashore to nest. These diverse habitats contain 185 species of woody plants, 52 species of brackish-water and freshwater fish, 230 species of birds, and 31 species of mammals including the elephant. It is an extremely important habitat for migrant water-birds and is a premier bird watching site in Sri Lanka as it is located at the southern tip of the flyway from Northern Europe, Russia and China (NSF, 2014d).



All four biosphere reserves are popular tourist destinations due mainly to their natural values and are potential premier ecotourism sites. The BBR also contains a number of extremely valuable pre-historic archaeological sites.

Source: NSF a, b, c, & d (2014)

1.2.4.1 Examples of economically important ecosystem services:

□ Contribution to the tourism sector

Tourism has grown steadily since the cessation of the war in 2009. Sri Lanka reached a record 1,005,605 tourists in 2012, with foreign exchange earnings from tourism increasing substantially from US$ 838.9 million in 2011 to US$ 1038.3 million in 2012. As such tourism became the 5th largest foreign exchange earner in 2012 and contributed 5.2% to the total country foreign exchange earnings while generating employment (direct 67,862 and indirect 95,007) for 162,869 people (SLTDA, 2012).

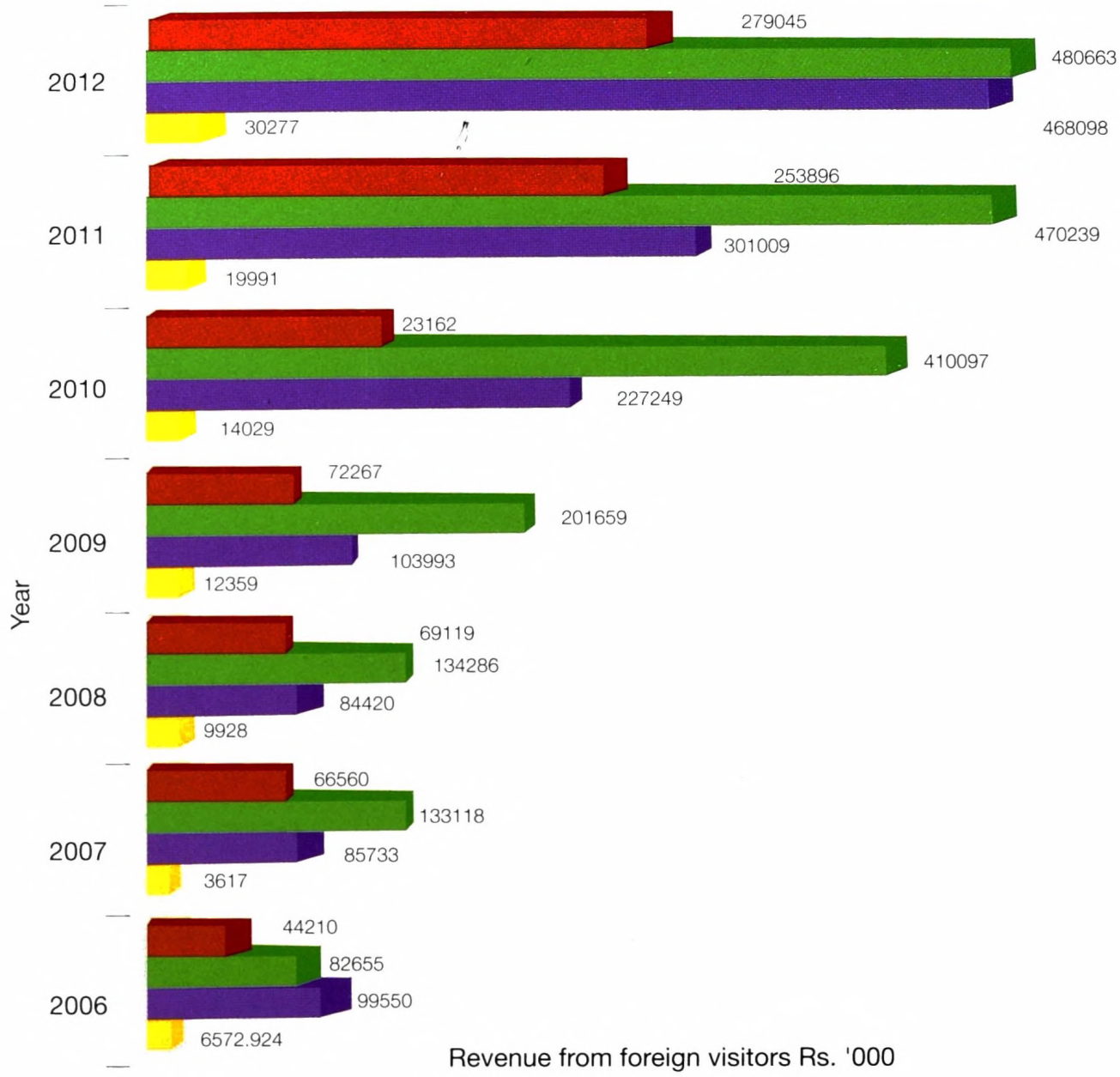


Figure 1.1 Revenue from foreign visitors to Forest Reserves, Wildlife Reserves, National Botanic Gardens and the National Zoological Gardens

(Source : FD unpublished data, 20140 and others SLTDA 2012)

Wildlife tourism has experienced a dramatic and rapid growth in recent years worldwide. Sri Lanka's exceptional biodiversity (**Tables 1.2 and 1.3**) in forests, wetlands and coastal and marine areas and a number of globally important natural sites such as four Biosphere Reserves, two natural World Heritage Sites and six Ramsar sites offer significant attractions to foreign nature tourists. Notably, 74% of tourists visited Sri Lanka for pleasure in 2012 (SLTDA, 2012), of which more than 24% had visited one or more of the 18 National Parks in Sri Lanka or the Elephant Transit Home at Udawalawe operated by the Department of Wildlife Conservation (ibid). **Figure 1.1** shows the increasing foreign visitor revenue from nature related tourism in the country between 2006 and 2012. This indicates the potential for biodiversity centred eco-tourism in the country to help reach the *Mahinda Chintana* target of 2.5 million high spending tourists by 2016 (DoNP and MoF&P, 2010).

Contribution to the agriculture sector

Sri Lanka's traditional farming systems have developed over hundreds of years due to farmers managing production systems to suit local conditions. The 46 agro-ecological regions that are identified in Sri Lanka, based on variations in soil, annual rainfall and altitude (SDoSL, 2007), support a wide range of crops and their wild relatives in a multitude of agricultural systems ranging from traditional rice fields to crop plantations (**Table 1.1**). Sri Lanka has a high diversity of traditional varieties of rice, vegetables and cash crops that are clearly resistant to diseases and insect pests, and are well suited for varied conditions of soil and climate in the island. Sri Lanka also has many wild relatives of rice and other crops in farmer's holdings, forests and wetlands amounting to 410 species (Fonseka and Fonseka, 2010). Of these 289 species are indigenous and 77 are endemic to the island (ibid). This provides a diverse gene pool that can be used in crop breeding programmes to enhance crop production and food security for the nation. A high crop genetic diversity is especially useful to adapt to climate change that is even now being felt in the agricultural sector. Some important examples of the use of biodiversity in the agricultural sector are given below.

– Rice, fruit and vegetable production:

Sri Lanka has now reached self sufficiency in terms of rice production, which is the staple food of the people of Sri Lanka, thus saving considerable foreign exchange for rice imports. This has been made possible partly by the use and popularization of New Improved Varieties (NIV) bred with high yielding properties. However, they lack many of the desirable traits of low yielding traditional rice varieties that are better in taste, nutrition and resilience to pests and disease (BOX 1.4). Characterization of wild rice by the Department of Agriculture (DoA) has also revealed beneficial characters that can be used in future rice breeding efforts. Beneficial traits of traditional rice varieties are already used by the Rice Research and Development Institute (RRDI) to develop new varietal lines, such as LD 183 which is expected to be resistant to drought, and LD 183-187 which is resistant to high salinity; some NIVs such as At 353 and At 354 also have been bred to have high salinity tolerance and BW 361, 363 and 364 are resistant to iron toxicity.[11]

BOX 1.4: Importance of traditional and wild varieties for rice breeding

Currently Sri Lanka has a large number of traditional varieties of rice, and five species of wild rice with characteristics that are important for varietal improvement. For example, *Oryza nivara, Podiwee, Murungakayan* and *O. eichingeri* are resistant to blast; *Dahanala* and *Kalubalawee* are resistant to thrips; *Rathuheeneti, O. eichingeri, Suduhanditan, Balamawee, Sudurusamba, Mawee* and *Hondarawalu* are resistant to the brown plant hopper (BHP); *O. granulata* is resistant to drought, and *O. rufipogon* shows high salinity tolerance.

Sources: Data from the PGRC, 2010 and 2014

Similarly research is done at the Horticultural Research and Development Institute (HORDI) of the DoA to infuse desirable traits from traditional varieties of vegetables and fruit into the breeding stock. This is important because Sri Lanka produced around 783,564 MT of fruit in 2012, while fresh fruit exports amounted to about US$ 8806 (DoA, 2013).[12] There is also a concerted move by the DoA to encourage organic home garden vegetable cultivation using traditional varieties that do not require chemical fertilizer or pesticides. An example is the distribution of the "Saba Sri Lanka rasaya" seed pack consisting of traditional vegetable varieties.[13]

11 Amitha Benthota, Rice Research institute Batalagoda, Department of Agriculture, pers com, 2010.
12 Equivalent to Rs ('000) 1,109,803
13 Information Provided by HORDI in 2014.

– Major and minor export agriculture:

Sri Lanka is fortunate to have variety of Minor Export Agricultural crops by way of beverage crops (coffee, vanilla, cocoa), spices (cinnamon, pepper, cloves and clove stems, cardamom, nutmeg and mace), stimulants (betel leaves and arecanut) and essential oils of spices (oils from cinnamon leaf and bark, oils from clove, pepper, cardamom, citronella, nutmeg, lemongrass, mace and vanilla), ginger, ginger oil, and turmeric that are increasingly assuming importance in terms of export earnings.[14]

BOX 1.5: Economic use of genetic diversity among Cinnamon and Piper species

Sri Lanka, with one indigenous species of cinnamon of commerce and seven endemic species of wild cinnamon, is the only supplier of oil from cinnamon leaf and bark. Various wild relatives of Cinnaman are being used to extract essential oils for industry. Among the wild species used are *Cinnamomum dubium, C. capparu-coronde, C. rivulorum, C. sinharajense, C. citridorum* and *C. litseaefolium*. *Likewise Piper nigrum* (black pepper) has high genetic diversity and 12 local selections are recommended for commercial cultivation (Seneviratne, et al, 2012). Also, 12 wild pepper species have been identified and characterized, of which 10 are conserved by the DoEA.

Source: Department of Export Agriculture, 2014

Over the years, there has been a remarkable increase in export earnings from minor export agricultural crops. For example, the value of Export Agricultural Crops has increased from Rs. 2,035.9 million in 1992 to Rs. 35,321.5 million in 2012 (DoEA data, 2014). This is partly due to the efforts of continual crop breeding programmes and varietal improvement by the Department of Export Agriculture (DoEA), using the genetic diversity of minor export crops that are available in the country (BOX 1.5). Some wild relatives of crops are conserved with a view for crop improvement by the Department of Export Agriculture.

Similarly, the principle export crops tea, rubber, coconut that contributed 1%, 0.3% and 0.9% to GDP in 2013[15] are subject to research and varietal improvement by the respective Tea, Rubber and Coconut Research Institutions and through selection by growers. This has resulted in considerable diversification of cash crops from the originally introduced germplasm to produce high-yielding varieties that are resistant to pests and disease and show resilience to adverse climatic conditions.

– Floriculture:

This industry has shown perceptible growth world-wide over the past decades and Sri Lanka expects to become one of the best centres for floriculture in the world. At present, the required technology has been developed nationally using both local and exotic species for varietal improvement and value addition. Floriculture shows immense potential as a foreign exchange earner for Sri Lanka in the future (Table 1.4), due to the wealth of flowering plants (3,145 species) that are available in different ecosystems in the country. For example, orchids are popular in the floriculture industry, and Sri Lanka has 189 species of indigenous orchids with 55 endemic species (Fernando, 2012) offering much potential for value addition. During the period 2009-2010, the National Botanic Gardens has propagated 63,152 orchid plants for display and sale.[16]

14 Information provided by the Department of Export Agriculture in 2014
15 http://www.statistics.gov.lk/national_accounts/Press%20Release/2013%20 ANNUAL.pdf
16 Data from the Department of Botanic Gardens provided in 2014

Table 1.4: Summary of floriculture exports for Sri Lanka by product category from 2009-2013

Product	Value of Floriculture Exports for Sri Lanka in USD $ Million				
	2009	2010	2011	2012	2013
Flowers	40	110	76	30	20
Leaves	510	540	791	505	767
Plants	590	570	753	505	629
TOTAL	1140	1220	1620	1040	1416

Source: Department of National Botanic Gardens, 2014

Some local orchids like *Phaius wallichi* (star orchid), *Dendrobium maccarthiae* (vesak orchid), *Rhynchostylis retusa* (foxtail orchid) and *Vanda tessellata* with showy flowers are already important in the floriculture industry (Fernando, 2012), while many others, including indigenous and endemic species such *Exacum spp*. (binara), and *Osbeckia octandra* (heen bowitiya) are believed to have floriculture potential by breeding genetic mutations and through ploidy manipulation.[17]

Trends in consumption within the island for cut flowers and foliage plants have already shown a tremendous growth in the past years. Recognizing the potential for floriculture in generating employment and livelihood opportunities and hence for poverty reduction, the Department of National Botanic Gardens has commenced the 'Suwahas Mal' programme country-wide to develop the floriculture sector through empowerment of lower and middle level nurserymen/growers and to facilitate market linkages. There are also plans to establish 1,500 floriculture villages in the Western, North Western and Central Provinces of the country, which is expected to provide 30,000 jobs in rural and semi-urban areas.[18]

Vanda tessellata
very rare colour form

– The livestock sector:

The livestock sub-sector is increasingly gaining importance with its contribution to the GDP reaching 0.8% in 2012 (DAPH, 2012). Small scale dairy farming has also increased in importance as a means of providing financial stability to farmers, and for enhancing rural nutrition and social security to thousands of rural dwellers in the country (DAPH, 2012). Further, domestic biogass units associated with cattle or pig farming is a successful source of alternate energy for rural people. Sri Lanka has already reached self sufficiency in poultry products, and is trying to reach self sufficiency in milk products, due to the high cost of milk imports which reached Rs million 39,023 in 2012 (CB, 2013).

Although imported high yielding livestock breeds are being used to increase milk yield, the development of the livestock sub-sector is now based on cross-breeding cattle, goat, swine and poultry using local breeds of livestock and imported germplasm of high yielding breeds. The indigenous breeds in the country presently are: Lanka cattle (*batu harak*), white cattle, Lanka buffalo, indigenous goat, the locally produced crossbred *Kottukachchiya* goat, indigenous pigs, Jaffna local sheep, local chicken, and the locally cross-bred *Karandagolla* chicken. Notably, eggs of the latter breed are more resistant to salmonella poisoning than imported high yielding breeds that are highly susceptible. Local livestock breeds are more resistant to pests and disease than imported breeds, are well adapted to local conditions, and have low nutritional requirements. In comparison, imported breeds are more costly in terms of feed and maintenance (MoL&RCD and DAPH, 2010; DAPH, 2012 ;). Also imported breeds are prone to heat stress and have high water requirements (ibid), so that maintaining the biodiversity of indigenous livestock breeds in traditional

17 Discussions with HORDI/DoA, 22014
18 Data from the Department of Botanic Gardens provided in 2014

farming systems and backyard poultry can also help meet the challenges posed by climate change, through genetic improvement programmes of the Department of Animal Production and Health and the Veterinary Research Institute.[19]

Contribution to the fisheries sector

The food fishery sector contributed 1.8% to GDP in 2012 and 55%[20] to the total animal protein intake among the people of Sri Lanka in 2011 (MFARD, 2013). This sector also contributed 2.2% to Sri Lanka's export earnings in 2012 recording US$ 206 million foreign exchange from a growing export market. Fish production is targeted to reach 878,360 MT by 2016 to improve nutritional status and food security for the nation (MFARD, 2013).

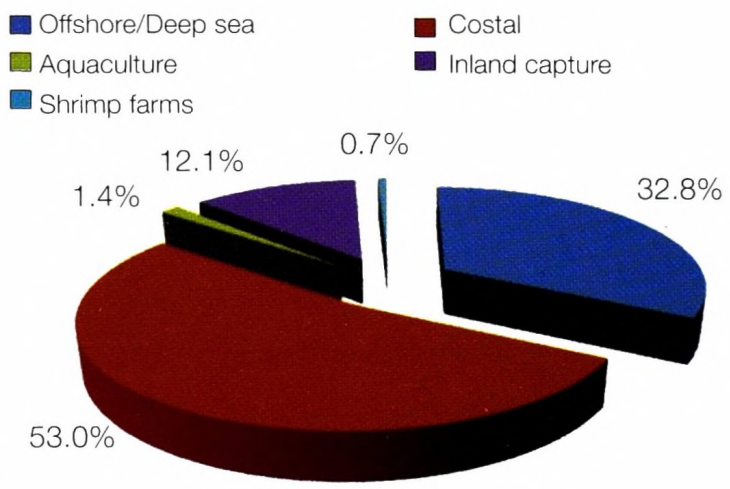


Figure 1.2 : Sri Lanka's fish production in 2012

Sri Lanka has about 1800 species of palargic fish (MoENR, 2002) enabling the harvest of a range of food fish in the marine fishery (Figure 1.3) including seer, carangids, several species of tuna, sharks, skates and mullet. In addition Sri Lanka has 25 species of sea cucumber of which 11 are predominant in the commercial fish catch and sold in the dried form as beche de mer which is exported to Singapore, Taiwan and China (Dassanayake, 2010). This is a particularly lucrative industry as its annual export value is about US$ 7481882.[21] In addition Sri Lanka has a rich diversity of molluscs including squid and cuttlefish that are caught in the fishery. The inland fish catch is dominated by about eight species, including the exotic and naturalized Tilapia, freshwater prawns and cultured shrimps.

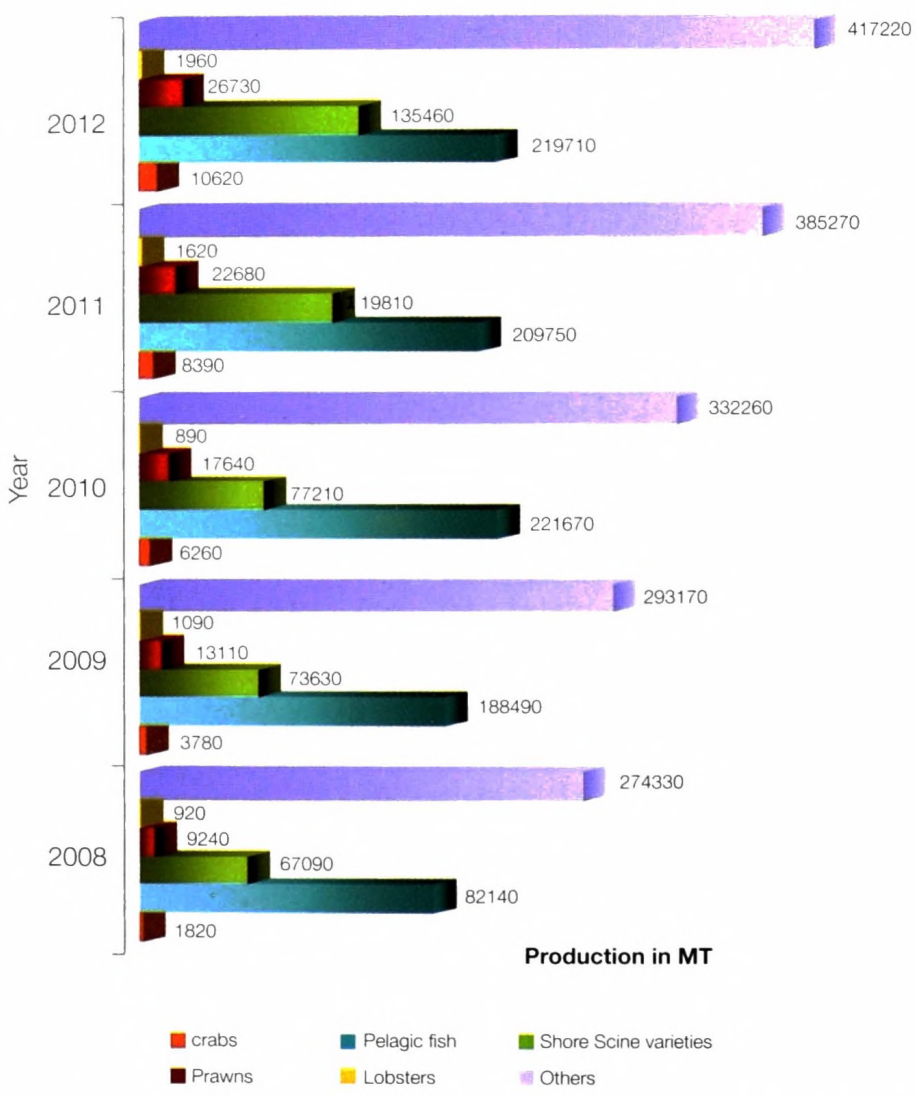


Figure 1.3: Sri Lanka's marine sector fish catch by major commercial groups 2008-2012

Source : MFARD, 2013

Sri Lanka also exports many species of marine and freshwater ornamental fish amounting to an export value of US$ 17540022. In addition sea horses, sea sponges, sea anemones, ornamental crabs and other marine products as well as freshwater aquatic plants are exported as part of the aquarium industry.[21]

19 Discussions with the DAPH and VRI, 2014

20 The Fishery Sector Development Strategy of MFARD states that the fisheries sector contributed 1.3% to the GDP in 2012 and 65-70% of animal protein to people in 2011 (unpublished information provided at the workshop to finalise this report).

21 Unpublished data and information from the Department of Customs for 01/05/2013-30/04/2014

The fishery sector not only earns valuable foreign exchange through the export of marine and aquaculture products, it also provides direct employment for over 262,530 active fishers, contributes 6.5% to the labour force, and fishing and related livelihoods sustain over 2.5 million people (MFARD, 2013). As such, the fishery sector has received much attention in the national development agenda with due recognition in the Mahinda Chintana 10 Year Horizon Development Framework (DoNP & MoFP, 2010) and the Action Plan for the Haritha Lanka Programme (NCSD & Presidential Secretariat, 2009).

However, the fishery industry in Sri Lanka is greatly dependent on biodiversity in coastal and marine systems (Figure 1.2), which is determined by the productivity of feeding and breeding grounds of fish and other species targeted in the food and ornamental fishery such as coral reefs, mangroves, and seagrass beds. The inland fishery is also dependant on pollution free inland waters of wetlands. Thus, reaching the desired fishery targets and sustaining it in the long-term will depend on sustainable fishery management which does not unduly deplete the resource or degrade the coastal and inland ecosystems that provide valuable habitats for resources harvested in the fishery industry.

Contribution to the Energy Sector

In 2012 the largest share of the total primary energy supply was met with by petroleum (45.3%), biomass (43.5%), major hydro-power (5.7%), coal (4.0%), and New Renewable Energy (1.6%) comprising mini-hydro (with individual total installed capacity limited to ≤10 MW), biomass, solar and wind powered plants. Much of the biomass for primary energy comprises fuelwood from forests, plantations and home gardens. The waters for major hydro-power generation depend on ecosystem services of wetlands and forests. Thus components of biodiversity play a major role in energy generation in the country.

The power sub-sector (within the energy sector), is critically important for national development and its expansion to provide electricity for all is a major objective of the government as articulated in the National Physical Planning Policy & Plan (NPPD & MUDSAD, 2006) as well as the Mahinda Chintana (DoNP & MoFP (2010)). As yet electricity has been provided to 85.3% of households in the country (CB, 2013), with 94% grid electrification at the end of 2012 (SLSEA, 2012). The power sub-sector is also critically important for the success of many industries including the textile and garment industry which earned Rs. 508.6 billion in 2012 for the country (CB, 2013).

At present hydro-electricity from 17 major power stations plays an important role in power generation. Sri Lanka's two major hydro-power complexes centre around the waters of the Kelani river (from five power stations of the Laxapana complex) and the Mahaweli river (from eight power stations of the Mahaweli complex). The efficiency of these systems are dependent on a good flow of clear clean water which needs the protection afforded to the head waters and tributaries of these rivers by forests of the central highlands (BOX 1.2).

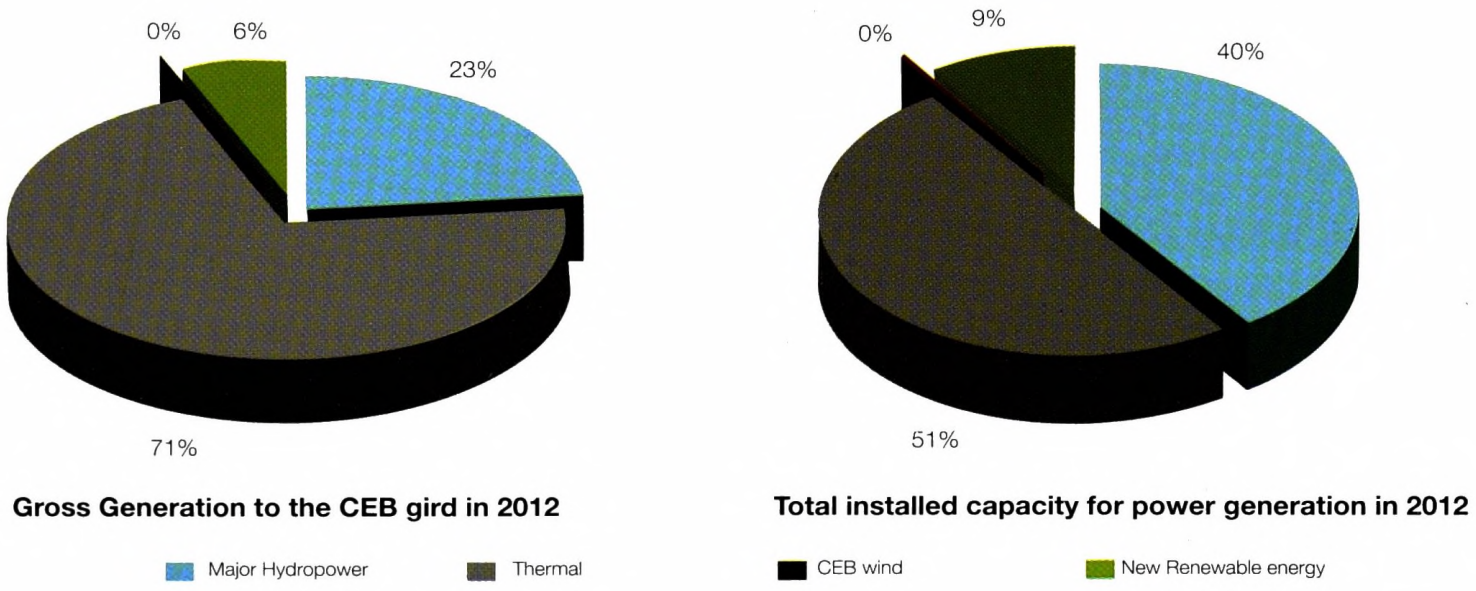


Figure 1.4: Percentage contribution of major hydropower to power generation and installed capacity

Source : SLSEA, 2012

Currently 17 major hydro-electricity plants have a total installed capacity of 1,357.4 MW and generate 2726.7 GWh of electricity. There are privately owned mini-hydro power plants or small power producing plants with a totaled installed capacity of 227.3 MW, adding 564.7 GWh of hydro-power (SLSEA, 2012). Most of these mini-hydropower plants are located in or near forests, and require a permit from the Forest Department after an EIA process.

In the past, Sri Lanka relied mainly on the economically feasible and environment friendly hydro-power for the requirements of the power sector until major-hydropower reached saturation level around 1996. Currently, the installed capacity of major-hydropower is 40% of installed power generation capacity, while thermal power producers comprise >50%. However, actual contribution from major hydro-power to gross power generation is only 23% (SLSEA, 2012). The shortfall is increasingly met by thermal power which now exceeds 70% of power generation (Figure 1.4). Maintaining the contribution from hydro-power at full capacity is thus important to limit the reliance on the more expensive and polluting coal-fired power. However, the major hydro-power reservoirs in the Luxapana and Mahaweli systems used for power generation are located in the montane and sub-montane wet zone where poor land use and soil erosion have led to heavy siltation of reserviours used for hydro-power generation, reducing their power generation capacity (MoENR, 2002). Further, mini-hydro-power plants which are now increasingly important to increase the share of hydro-power (SLSEA, 2012) are directly dependant on good quality forests and wetlands to maintain the required water flows.

Contribution to the water sector

Sri Lanka's range of natural inland wetlands comprise numerous rivers and streams, riverine floodplains/villus, small isolated freshwater bodies, freshwater springs, seasonal ponds, freshwater marshes (permanent and seasonal) and swamps.. In addition there are man-made wetlands such as tanks and reservoirs. They provide water for humans and inland animals alike.

Sri Lanka's inland waters are the only source of water for drinking and other domestic requirements, irrigated agriculture and industrial use for a population of over 20 million. Currently around 88.7% Sri Lanka's population has access to safe drinking water, as opposed to 84.8% in 2006/2007.[22] Even so, a large majority of the rural populations continue to rely heavily on sources of water such as unprotected wells, tanks and reservoirs, and water from forests for their drinking, culinary, washing, bathing and/or laundering purposes. In the dry and intermediate zones, the water collected in numerous tanks and reservoirs is vital for paddy cultivation and domestic use. Water is an important resource for industry - particularly in the textile industry which, together with the garment industry, is Sri Lanka's second foreign exchange earner (SLTDA, 2012). Thus forests which act as watersheds for rivers and reservoirs, together with other natural and manmade inland wetlands, play a pivotal role in providing surface water for the nation. For example, one of the most important uses of forests for rural populations near Wet Zone forests is the provision of domestic water (NSF, 2014 a and b).

Contribution to the health sector

Traditional medicinal systems in Sri Lanka such as *Ayurveda, Unani, Siddha* and *Desheeya chikitsa* use plants or plant products from over 1,400 species of medicinal plants, out of which *Ayurveda* uses about 387 plant species and Unani uses 234 (Department of Ayurveda, 1979). About 50 species are heavily used in preparation of drugs (Sugathadasa et al., 2008). Of all plant species used in Sri Lanka for medicine, about 15% have common and widespread uses in traditional healthcare systems (De Silva, 1998). Although access to hospitals with western medication has reduced the reliance on traditional medication even among rural populations, most communities living around medicinal plant rich areas throughout

BOX 1.6: Practice of Ayurveda in Sri Lanka

The indigenous system of medicine termed Ayurveda is currently practised by a large number of licensed private practitioners for their livelihood, and some of them have a degree from an Ayurveda University. This number, registered with the Department of Ayurveda has grown to 20,441, among which 1,968 are degree holders, 5,005 are diploma holders and 5,296 are practitioners through generational experience. A further 8,172 are specialized in some form of traditional medication such as snake bites, fractures, dislocations, eye diseases, etc.

Source: Department of Ayurveda, 2014

22 The 2012/2013 Household Income and Expenditure Survey by the Central Bank of Sri Lanka

the country make use of more than 620 plant species through the oral tradition (Sugathadasa and Jeewandara, 2012).

One area of indigenous medical practice which continues to be very popular in recent years is traditional orthopedics. A large number of such practitioners still operate around places such as Ritigala, where the necessary herbal material is still available in forests. Traditional medicine is also proving to be popular with foreign tourists and a few hotels are committed entirely to provide ayurvedic health care, indicating potential for expansion of Medical Tourism in the future.

Apart from the advanced system of Ayurvedic health care dispended by traditional village physicians, rural communities also practise a parallel curative system based on supernatural beliefs and superstitions. These cures include traditional exorcising ceremonies and rituals to appease demons, gods and lesser spirits. There are also simple village practices to ward off the "evil eye" and "evil mouth" that are attributed to be the cause of many ailments. Charms (mantara) and simple curative practices (kem) are also popular among village people to ward off various illnesses, and to protect crops and livestock from pests and disease.[23] Many of these practices require plant material from forests and home gardens.

☐ Potential for bio-prospecting, natural product development and bio-mimicry

Due to exceptional species diversity with remarkable endemism in Sri Lanka, there is immense potential for bio-prospecting and natural value added product development locally. Surprisingly, however, the optional value of biodiversity from bio-prospecting has not been explored adequately by developing the local pharmaceutical and cosmetic industry in the country despite high potential for discovering bioactive compounds for cosmetic and medicinal purposes. For example, the resin rich wood of *Gyrinops walla* has high commercial value in the cosmetic industry, and one kilogram of solidified resin (raw material) within the stem fetches about Rs 75,00,000/- while the softer resin is priced at Rs 3.5 million per 300-400 g. The raw material is exported in bulk, but local industries have not explored the immense potential for producing the value added products which will bring in a much higher revenue. Further, coral reef ecosystems with their high biodiversity are believed to be rich in chemical compounds due to the presence of chemicals used for defence by sessile organisms (Meliane, 2004). Sri Lanka though an island with a rich coastal and marine biodiversity tends to export sea anemones, sponges and nudibranchs in bulk form for the aquarium industry, but has high potential for bio-prospecting and natural product development in the future.[24]

There are many local herbal medicines reported to have antimicrobial, hepatoprotective, antioxidant, anticancer, anti-diabetic properties and traditional medicine practitioners use herbal remedies to cure or control diseases such as rheumatism, diarrhea, diabetic, blood pressure, dysentery, fever, etc (Department of Ayurveda, 2014). It is also known that some of the traditional varieties of rice and other crops that have medicinal value, making the relevant genes a valuable bio-resource. Examples of other species with potential in the pharmaceutical industry are *Coscinium fenestratum* (weniwel geta) and *Munronia pinnata* (bin-kohomba). Other species such as *Kokoona zeylanica* (Kokun) and *Hortonia floribunda* (from an endemic genus) hold potential for exploration in the local cosmetic industry. While value added product development using modern by local industries can immensely benefit the Sri Lankan economy, this vast potential is still to be explored. Conversely, local species such as *Salacia reticulate* (kotala himbutu) and *Garcina zeylanica* are used in value added medicinal and diet products for which patents are held elsewhere, often with little benefit to Sri Lanka.

Coscinium fenestratum – a commonly used medicinal plant found in wet zone rainforests of Sri Lanka

The knowledge of the uses of plant material as indigenous cures in folklore or traditional systems of medicine in Sri Lanka can prove invaluable to find the curative agents in plants for use in modern medicines to support development of the local pharmaceutical industry. Sri Lanka's rich

23 Discussions with communities during the periodic reviews of Sinharaja and Bundala Biosphere Reserves by the National Science Foundation

24 Data provided by the Department of Customs in 2014 and Mr Samantha Gunasekera, Pers. Com. 2014.

species diversity also holds immense optional value for the development of nano-technology. Thus Sri Lanka is well placed to use modern technology to produce value added crops as well as natural products for medicinal and cosmetic uses, by establishing centres for genomic studies of biodiversity to identify, isolate and patent the relevant genes. To pursue this approach, biosafety measures are necessary to ensure that products and derivatives are safe, and this is now being put into place in Sri Lanka. There is also potential to set up bio-villages that can more effectively use the natural products that reside in Sri Lanka's biodiversity.

1.3 Current status, major changes and trends of biodiversity in Sri Lanka

Indicators used to gauge major national changes and trends in:

- Coverage of protected areas
- Closed canopy natural forest cover
- Conservation status of threatened species
- Impacts of pollution and alien invasive species in different ecosystems
- Pressures on forests, wetlands, coral reefs and other coastal systems
- Management and harvesting of coastal and marine resources sustainably
- Reducing impacts of unsustainable fishery on threatened ecosystems and species
- Management of agricultural systems to become more environment friendly
- Trends for conservation and use of indigenous genetic diversity in agriculture and livestock production

1.3.1 Trends in Protected Areas (PAs)

The areas managed and protected by the Forest Department and the Department of Wildlife Conservation have increased from 2008 to present (**Table 1.5**). The moratorium on logging in all natural forests which came into force in 1990 is continuing. Hence, commercial timber extraction is prohibited from all natural forests in Sri Lanka. The extent of Conservation Forests set aside for strict conservation has increased over the years with more valuable wet zone forests being added to the Protected Area Network based on the biodiversity assessments made through the National Conservation Review (NCR).[25] Fifteen mangrove sites have also been protected by the Forest Department along the southwest and north-west coast. There has also been a perceptible increase in the Protected Area extent under the Department of Wildlife Conservation. However, management of all Protected Areas do not always meet the required standards, particularly the forest reserves that are not set aside for strict conservation and the wildlife sanctuaries, due to limitations of staff and other resources in the agencies responsible for conservation of these areas. This is compounded in recent years by poor coordination between agencies concerned directly with development and conservation. Eight (08) Environmental Protection Areas have been gazetted by the CEA under the National Environmental Act. They are Gregory's Lake, Thalangama Lake, Bolgoda, Walauwatte–Wathurana, Muthurajawela (buffer zone), private lands within the Knuckles Conservation Forest boundary, Hantane and Maragala. Although they do not have strict legal protection, only identified development activities are allowed in them by the CEA as specified in the National Environmental Act. The CEA, however, does not have adequate mandate to monitor these areas to see that developers adhere to the conditions that need to be followed during development.

25 This assessment of natural forests >200 ha (1992 – 1996) occurred in all parts of the country except in areas inaccessible due to the war prevailing at that time (IUCN/WCMC/FAO (1997).

Table 1.5: Number and extent of protected areas administered by the Forest Department and the Department of Wildlife Conservation

Protected Area category	Area under each category (ha)	
Forests under the Forest Department (FD)*	4th NR (ha)	2010 (ha)
National Heritage Wilderness Area (also a World Heritage Area) [N=1]	11,187	11,427
Conservation Forests* [2008 = 33, now N=75]	76,227	118,758.7
Other Reserved Forests [now N=371]	NA	1,044,008.5
Forest Plantations	72,350 (in 2001)	75,556.7 (in 2014)
Mangroves (now N=15)	2,163	1153.1
Forests under the Department of Wildlife Conservation (DWLC)*		
National Parks (2008=14, now = 22)	495,984	535,182
Nature Reserves (2008=4, now = 5)	32,581	64,585
Sanctuaries (2008=63, now =65)	262,156	376,943
Strict Natural Reserves (3)	31,573	31,574
Jungle Corridors (Kaudulla- Minneriya) (1)	10,360	8,777

*Data source: FD and DWLC unpublished data * Some areas are declared under both FD and DWLC, all areas under the DWLC are not forests as sanctuaries contain private non- forest lands*

The extent (proposed and implemented) as Biosphere Reserves has increased (Table 1.6) with the identification of Transition Zones for the Sinharaja and Hurulu Biosphere Reserves where people live and lead normal lives and demonstrate sustainable livelihoods that do not degrade the adjacent biodiversity rich Core Zones.

Table 1.6: Changes in international Protected Areas and Ramsar Sites

International Protected Area Category	Number of PAs and area covered in 2008	Number of PAs and area covered in 2014
Natural World Heritage Sits (IUCN category X PA)	**N=1, 8864 ha** The Sinharaja World Heritage site	**N=2, 118,884** New: The Central Highlands Serial World Heritage Site with 3 forests
Biosphere Reserves Recognised by UNESCO (IUCN category IX PA)	**N=4, Extent 81363.7 ha** Sinharaja, Kanneliya-Dediyagala-Nakiyadeniya, Hurulu and Bundala BRs	**N=4, extent 143106.3** Same reserves, increased area
Ramsar sites	**N-3; 8,377 ha**	**N=6, 198,027 ha**

The Knuckles Conservation Forest, Horton Plains National Park and the Peak Wilderness Protected Area were accepted by UNESCO as a serial Natural World Heritage Site termed the Central Highlands World Heritage Site in 2010. This brought the total area under this category to 118,884 ha together with the Sinharaja World Heritage Site declared earlier (**Table 1.6).**

1.3.2 Trends in forest systems

1.3.2.1 Natural forests:

The main forest types in the country are the lowland, sub-montane and montane tropical rainforests (the latter are also called cloud forests) of the wet zone; moist monsoon forests of the intermediate zone; and the dry zone monsoon (mixed evergreen) forests, tropical thorn forests and dry riverine forests in the dry zone.

Overall, the total natural forest cover in the country has decreased from 31.2 % of the island in 1999 to 29.6% in 2010 (when savannah grasslands are considered this rises to 29.7%). The total forest loss is estimated as 48,900 ha from 1999-2010 which is approximately a loss of 0.23% of forest area, or 4,445 ha of forest loss, annually.[26] This is a positive trend when compared with 40,000 ha of natural forest loss annually between 1956 and 1992 (MALF, 1995), and the predictions made in 1995 for a reduction of the 23.9% closed canopy natural forest cover in 1992 to about 17% in 2020 under a 'business' as usual scenario (MALF, 1995).

Table 1.7: Comparison of forest cover in Sri Lanka in 1992, 1999 and 2010

Forest category	Total forest area (ha) 1992 *	Total forest area (ha) 1999†	Total forest area (ha) 2010††
Total extent of "closed canopy" dense forest	1,582,757	1,470,636.2	1,438,275
Open canopy sparse forest	463,842	471,583.2	429,485
Total natural forest cover *(Including mangroves and savannah)*	**2,046,599**	**1,942,219.5**	**1,951,473**

Source: Legg and Jewell (1995) and Forest Department Forest cover data for 1999† and 2010††;*

Table 1.1 shows that there are 227,710 ha of chena (slash and burn) lands in the country at present, located within previously forested areas. While the traditional slash and burn cultivation where farmers clear new areas of forest each year has now been largely halted by better management of forests and wildlife parks, the continued use of the same chena plots prevent forest regeneration, making them permanent agricultural lands (DOA, 2014).[27] However, there is a trend for the reduction of extractive forest use especially from wet zone forests (BOX 1.7).

26 Source: Forest Department data provided for this report.
27 Source: Discussions with the Department of Agriculture Extension Division during report preparation.

BOX 1.7: Trends in extractive use of forest resources in the Sinharaja Biosphere Reserve

A survey around the Sinharaja forest during 2007 found that many people collected forest products, although 90% stated that forest use had declined (de Mel, 2008). In contrast, a survey in 2013 showed that only 15% of households got some income from forest products, but did not depended on this for their main income. Several forest extractions continued on a small scale, mainly for domestic use. This included hunting (mostly as crop pests in agricultural holdings); obtaining timber, poles, sticks, medicinal plants such as weniwel *(Coscinium fenestratum)*, bee honey, reeds, rattan, wild cardamom, gum, bamboo, dorana oil *(Dipterocarpus glandulosus)*, and *beraliya (Doona venulosa)* fruit as a food item. Tapping kitul *(Caryota urens)* for sap to produce treacle and a candy like sweeter termed jaggery, and collection of food items (except for *beraliya*), firewood, arecanut, and walle patte ranged from small to middle scale.; Though food items and firewood involved sale, they were mainly for domestic use. Hunting and collection of sticks were solely for domestic use. *Dorana* oil, walle-patta and arecanut fruits were collected only for sale. However, all forest collections had decreased during the past 10 years, except collection of arecanut fruit which was increasing. Walle-patta tree trunks being cut on a small scale by outsiders is of recent origin due to an emerging market. The drop in forest use is mainly due to people moving towards cultivating cash crops and the resultant socio-economic advancement. This trend is widely prevalent near other forests of the wet zone.

Some of the main drivers of deforestation and forest degradation in forest systems are slash and burn cultivation, illegal encroachments - which in the wet zone is mainly for tea and cash crops and has reduced significantly; illegal felling of timber – which also has reduced considerably; forest fires that are often human induced; over-grazing by cattle causing damage to forest vegetation;[28] and development activities without adequate coordination between agencies responsible for development and forest conservation (FD/GoSL, 2012). Conflicts arise as state land for development is limited, and the option of using other lands is similarly limited (ibid).

Table 1.8: Threats identified for major forest types during the 2012 Red listing exercise

Threats	Dry Zone forests / grasslands	Lowland rain forests	Montane forests	Threats	Dry Zone forests / grasslands	Low land rain forests	Montane forests
Habitat destruction	☐	☐	☐	Chena cultivation	☐		
Forest fragmentation	☐	☐		Encroachments		☐	
Forest degradation	☐			Vegetable gardens			☐
Conversion to other uses	☐			Over exploitation of resources	☐	☐	
Firewood collection			☐	Selective timber logging	☐		
Cutting /clearing undergrowth				Invasive spp.	☐		☐
Forest fires in grasslands	☐			Clearing for development	☐		
Cattle grazing	☐			Gem mining			☐
Die-back	☐		☐				

Source: Perera, 2012; Wijesundara, 2012; Kathriaaaarachchi, 2012.

28 Edirisinghe, EAPN (2014). Presentation on Forest Cover of Sri Lanka, Forest Department, March 20114.

The assessment of the status of lowland wet zone forests, montane forests and dry zone forests during Species Red listing in 2012 **(Table 1.8)** indicate that despite many advances in the conservation of the country's forests and wildlife, there are many threats that need to be addressed in the future to conserve forest quality to ensure uninterrupted ecosystem services and to provide habitats for forest living fauna.

Positive trends

Stemming the rate of national forest loss is and degradation (BOX 1.8) is attributed to a significant effort for better forest management which includes enforcing the ban on logging in all natural forests of the country since 1990, boundary marking of most forest and wildlife reserves to halt encroachments, halting logging of natural forests, preparation and implementation of management plans for forest and wildlife reserves (which became legal requirements under the Forest Ordinance Amendment Act No. 65 of 2009 and the Fauna and Flora Ordinance Amendment Act No 22 of 2009), and the trend to encourage community participation in forest and protected area management by both the Forest Department and the Department of Wildlife Conservation. The Forest Department has also started many programmes to engage local people in community forestry to reduce the threat of encroachment for growing cash crops and tea in the wet zone and for slash and burn (chena) cultivation in the dry zone (FD/GOSL, 2012). Further, the demand for wood and wood products are mainly met from non-forest lands and private woodlots, encouraged by programmes of the Forest Department to reduce pressure on natural forests for timber. As such, positive changes in forest quality have been observed in several previously logged rainforests as well as some dry zone forests (BOX 1.8 and Jayasuriya & Abayawardana, 2008).

1.3.2.2 Forest Plantations:

With the shift in emphasis of forest policy from production to protection, and the moratorium on logging in natural forests for timber, forest plantations have become particularly important for timber and wood products and to relieve pressure on natural forests. There are 75,556.7 ha of forest plantations at present. The trend to move away from the past practice of planting exotic species such as teak, *Pinus* and *Eucalyptus* and the move towards indigenous species is beneficial. Further, 80% of forest plantations are set aside for environmental protection and habitat management, especially in water catchments and environmentally sensitive areas, while some are declared as wildlife sanctuaries (FAO and FD, 2009). Notably, about 2,000 ha of *Eucalyptus* plantations at high altitudes are reserved for environmental protection, adding to the permanent carbon stocks in natural forests (FD/GOSL, 2012).

1.3.2.3 Grasslands:

Sri Lanka has many different types of grasslands in the various major climatic zones. With the exception of savannah forests, the specific extents of other grasslands types (dry *pathana* of the intermediate montane zone, wet *pathana* grasslands of the montane zone, and the *talawa* and damana grasslands of the wet and dry lowlands respectively) are not known. However, most of these grasslands are under threat with regard to loss of extent and habitat quality. For example, the savannah woodlands of Nilgala, which are rich in medicinal plant species, are being reduced, while the damana grasslands of Ampara are lost to establish human settlements (Perera, 2012). However, some areas where forest plantations have been harvested and abandoned have converted to grasslands. This can be seen in the Hurulu Biosphere Reserve which now provides better grassland habitats for elephants (NSF, 2014c).

1.3.3 Trends in non-forest tree resources

In addition to forests, a wide range of non-forest tree resources are available in home gardens and tea (shade trees), rubber and coconut plantations that yield timber and fuelwood (CB, 2011). Trees from such non-forest areas reduce the pressure on natural forests to provide timber, fuelwood and Non Timber Forest Products (NTFP). Increasing tree cover in home gardens is, therefore, of major interest as exemplified by the massive national tree planting campaign *(Deyata Sevena)* currently underway, as well as a number of programmes implemented by the Forest Department. In terms of carbon potential, the FAO (FAO/FRA, 2006) estimated the wood supply from non-forest timber resources in Sri Lanka to be 1.5 million m^3 in 2005, with a projected rise to 1.6 million m^3 by 2010. Home gardens have considerable carbon potential, with average stocking density of trees in home

gardens varying from 54-419 stems/ha (FAO and FD, 2009), in addition to providing a range of economically valuable tree species for food and timber. However, the rising human populations and the resultant escalating demand for land has led increasingly to fragmenting and degrading of home gardens and plantations for conversion for commercial housing, division between family members for housing, and resultant felling of large trees (Dela, et al, 2012, and information from HORDI, 2014)

1.3.4 Trends in wetlands

The broad wetland types in Sri Lanka are given in Table 1.1. No recent surveys have been carried out to determine the extent, but water bodies cover around 488,181.25 ha or 7.5% of the island's land area (DoA, 2013). Several positive features have occurred for conservation of wetlands in the past few years, but wetlands continue to be lost and degraded, and their resource are exploited beyond sustainable levels. The most serious problems in wetlands are summarized in BOX 1.8. Wetlands in Sri Lanka face compound threats that are mainly of anthropogenic origin. Consequently most aquatic ecosystems have deteriorated over the past few years.

In addition to the threats that have been prevalent for many years, new threats, such as dumping of e-waste into wetlands and dredging to clean-up wetlands and building up the banks without environmental considerations have emerged. The latter creates problems for some sensitive wetland flora.[29] Many water bodies are being used for water sports, boating and sea plane landing but no charge is made for the use of wetlands to enable addressing problems that may arise as a result. Further inland sand mining has a major impact on wetlands, but the license can be provided by the Geological Survey and Mines Bureau without the concurrence of the Central Environmental Authority (CEA) in charge of wetland conservation. In addition, the eight gazetted EPAs under the NEA (among which are several wetlands) are not supported by regulations to ensure their protection (MoE, 2010b).

BOX 1.8: Analysis of threats to wetlands

Wetland deterioration from siltation due to poor land use in areas adjacent to wetlands, reclamation, clearing of wetland vegetation, water pollution (with agrochemicals, industrial wastes, sewage and solid waste), dams that regulate water flow in rivers that lead to gradual disappearance of lowland wetlands, poorly planned irrigation structures, and illegal sand and gem mining in rivers have been identified as major issues that cause loss of wetland biodiversity. Water pollution affects fauna that are dependent on wetlands for survival (e.g. indigenous fish and amphibians which include a large number of endemics, piscivorous birds, and wetland associated aquatic mammals, etc). Wetlands are also threatened due to over exploitation of ornamental plants and ornamental fish with export potential.

Another major threat faced by wetlands is the spread of invasive plants and animals. There are more than 10 species of invasive plants and 12 species of invasive flora spreading in wetlands of Sri Lanka. Among these are four species of fauna and two species of flora (water hyacinth and giant mimosa) that are listed among the 100 worst invasive plants in the world. Some invasive species such as the apple snail have affected wetlands such as rice fields. In addition to these anthropogenic threats, wetlands are also affected by natural phenomena such as prolonged drought which severely affects these natural ecosystems and the species found in irrigation tanks, large reservoirs and lagoons.

Source: IUCN and CEA, 2006 and MoE, 2010b

□ Positive trends

Some progress has been made in terms of managing wetlands in the country. Among these is the establishment of a special Wetland Unit in the Natural Resources Division of the CEA to oversee the interests of wetlands and to implement the National Wetlands Policy of 2006 (which is now due for revision). However, this unit is severely hampered as it lacks formal authority or mandate to enforce conservation action in wetlands as per the Wetlands Policy. Management plans have been prepared for the Bolgoda Wetlands and are pending for the Thalangama Wetlands, and awareness activities on wetlands are carried out by the CEA. Other positive actions have been the ban on converting rice fields into other uses in the Western Province which is overseen by the Department of Agrarian Services.

29 Discussions with the Natural Resource Management division of the CEA, 2014

1.3.5 Trends in coastal and marine systems

Table 1.1 indicates the main types of coastal and marine ecosystems that are present in Sri Lanka. The extent of each of these ecosystems is now being mapped. While no major changes are expected in areas covered by these systems, loss of quality in most coastal systems has continued since the last reporting period.

1.3.5.1 Coral reefs:

At present the most extensive coral growth is seen in the Gulf of Mannar and fringing coral reefs found in the northern, eastern, and southern coastal waters (Rajasuriya, 2012), and offshore patches of coral between Chillaw and Colombo, located at 10-20 km from the shoreline and at an average depth of about 20 m (ibid). Sri Lanka has a rich coral fauna with 208 species from 71 genera **(Table 1.3)**. Of these, two species of hard coral (*Podabacea sp.* and *Echinopora robusta*) have not been reported from elsewhere to date, while the rare *Blastomussa merleti* has only been collected at Unawatuna (Rajasuriya, 2012). Coral reefs have been affected mostly due to climate change, commencing with the major bleaching event in 1998. The recovery has been variable between reefs, as well as within a single reef, as seen in the Bar Reef (Rajasuriya 2005, 2008). Coral bleaching has since been seen regularly in recent years, especially in reefs of the north and east (Rajasuriya, 2012). The 2004 Tsunami has caused extensive damage to coral reefs, particularly in the eastern and southern coasts. In addition, destructive fishing methods such as use of moxy nets to capture ornamental fish living in coral reefs and blast fishing (for the food fishery) are widely prevalent, invasive species such as the Crown of Thorns Star Fish are proliferating in some locations (e.g. Pigeon island), and there is a recent trend for development of hotels on the coast with inappropriate designs (e.g. water bungalows) that can affect coral reefs and other coastal systems.[30] While some coral reefs are recovering from the bleaching event and the tsunami, coral composition has changed, with the replacement of staghorn coral by plate coral, and some reefs, such as Weligama and Polhena, have not recovered at all.

□ Positive trends

A positive feature is that coral mining for lime production has stopped after the 2004 tsunami as people realized the value of coral reefs to minimize coastal damage from events such as tsunamis and sea erosion. This, coupled with the government ban on using lime based paint for government buildings and the strict enforcement of the Coast Conservation Act, particularly with regard to transportation of coral to lime kilns, has halted the rampant coral mining that exited in the past (CCD, 2004). For example during 2007 there have been only 5 offences for coral extraction, one in 2008 and none thereafter.[31] However, blast fishing using dynamite and walking on coral by tourists continue to be of concern in some areas.

1.3.5.2 Mangroves and salt marshes:

There are about five kinds of mangroves of which the riverine and fringing mangroves are the most common (Jayatissa, 2012). The large scale clearing of mangroves for aquaculture has stopped due to the white spot disease that affected most prawn farms, but clearing of mangroves and salt marshes for establishment of tourism facilities and salterns is occurring in some parts of the coast. At the same time, people are more aware of the importance of mangroves after the 2004 tsunami and mangrove vegetation is making a good recovery in the southern and eastern coastal areas.

1.3.5.3. Seagrass beds:

Sea grass beds continue to be affected due to the use of push nets and dragnets, pollution, and sedimentation from land based activities and clearing of mangroves. For example, the seagrass beds of the Puttalam and Negombo lagoons were severely damaged due to the use of push nets and drag nets, which perceptibly affected the shrimp fishery in these lagoons.[32] The fishers in these areas now understand the importance of seagrass beds as the shrimp are emerging where the seagrass is recovering. However complete recovery and regeneration of these ecosystems is expected to take about 2-4 years.

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30 Discussions with the Coast Conservation Department, 2014
31 CCD, unpublished data provided in 2014.
32 Discussions with NARA, 2014

1.3.5.4 Lagoons and estuaries:

These systems continue to be under threat from pollution, sedimentation from land based activities, sand mining, and in some cases such as the Malala and Embilikala lagoons (at Bundala) due to lowering of salinity caused by the release of irrigation waters. In these two lagoons the shrimp fishery has collapsed completely and is now sustained by the exotic tilapia which is thriving due to lowered salinity. However, water birds that prey on crustaceans are believed to have been affected due to the disruption of the food chain.

1.3.5.5 Sustainability of the coastal and marine biodiversity:

□ Sustainability of the food fishery

Despite the knowledge gained on obtaining catch and effort data and a better understanding of the fishery resource through the Coastal Resources Management Project, the marine and inland fishery are yet not fully sustainable. For example, the use of multi-gear fishing implements that target several species, the use of moxy nets to catch ornamental fish, the use of synthetic gill nets that are death traps for turtles and dolphins, and the use of push nets and dragnets that are detrimental to many coastal ecosystems and organisms continue with negative long-term impacts on the fishery. The coastal fishery has been over exploited, while the offshore fishery is not fully exploited as yet by local fishermen.

□ Sustainability of the marine ornamental fishery:

Moxy nets used to harvest ornamental fish from coral reefs damage the habitat of the fishery resource making it unsustainable in the long-term. Some species are also over harvested. Examples being herbivorous reef fish, the Humphead wrasse *(Cheilinus undulatus)* that feeds on juvenile Crown of Thorns Starfish, and other species that are important for the maintenance of the ecological balance of coral reefs (Ranajasuriya, 2012).

□ Positive action taken to conserve coastal and marine biodiversity[33]

- Several positive actions have been taken since the last reporting period. Chiefly, the enactment of the Coast Conservation Amendment Act No 49 of 2011 which has increased the coastal zone to cover 100 m of riparian land on either side of the 2 km water source perpendicular to a river mouth in the coastal zone. This area is also meant to be a no build zone for new projects.
- The Coast conservation Act (CCA) amendment No 49 of 2011 also paves the way for more positive coastal zone management. It vests powers in the Coast Conservation Department to veto or stop any damaging development activity that occurs in the coastal zone to declare: (a) affected areas in the coast in which no development, dumping of waste or damaging activity can be carried out, (b) beach parks for preservation of scenic beauty and biodiversity, and (c) conservation areas for the protection of the coastal and aquatic eco-systems, where no development activity will be permitted (i.e. permitted activities will only be research and study). Further, all mining activities in the Coastal Zone will need the concurrence of the CCD.
- The revised Coastal Zone and Coastal Resources Management Plan is currently being prepared in accordance with the requirements of the CCA.
- The Coastal Zone Management Plan (CZMP) of 2004 identified a total of 57 sites as needing special area management; of these 26 sites were beset by multiple resource use conflicts and were proposed as Special Area Management (SAM) sites. A further 23 sites which are geographically smaller and had lesser user conflicts, were identified as potential APC (Areas of Particular Concern) sites, while the SAM process was ongoing at a further 8 sites. As management of these sites did not take place, the revised CZMP will address the problem of SAM site management. The CCD will have ownership of the sites, but could delegate the planning and implementation of the SAM process to other agencies - in the state or private sector. All work at each site will be overseen by a Special Area Management Committee which will be co-chaired by the CCD and the implementing agency.

33 Discussions with the Coast Conservation Department, 2014

- Pollution of coastal waters is of concern, and this has resulted in the monitoring of waters at 5 coastal sites: Mt Lavinia, Hikkaduwa, Unawatuna, Polhena, Nilaweli and Arugambay. The CEA is setting standards for bathing in coastal waters. As sewage pollution is a problem, collaboration with the Local authorities is being sought to address it.
- Coastal erosion has been stemmed due to establishment of coast protection structures along vulnerable areas of the coastline.
- Illegal sand mining on the southwest coast has been regulated to a great extent, but recently this has increased on the eastern coast.
- Four marine protected areas are managed by the Department of Wildlife Conservation (Hikkaduwa National Park, Marine sanctuaries at Rumassala, Pigeon island, and Bar Reef). Likewise, there are two fisheries management areas at Great and Little Bases and Polhena set up under the Fisheries and Aquatic Resources Act (FARA) to regulate the fishery in them.

1.3.6 Trends in agricultural systems and livestock breeding

1.3.6.1 Agricultural systems

The agricultural landscape of the country consists mainly of rice paddies, plantation crops (tea, rubber, coconut and sugarcane, and about 25 minor export crops); fruit crops; vegetables, root and tuber crops; other field crops consisting of about 100 species used as food such as chilli, onion, cereals, grain legumes, condiments and oilseeds, and home gardens.

At present agriculture contributes 11.1% to the country's GDP and 33% to the labour force (CB, 2013). In addition, livestock rearing is a major employment opportunity for the rural poor and often serves to cushion them against crop failure while enabling a market based income. Hence, biodiversity among agricultural crops is a positive factor to increase production in this sector.

Due to a long history of agriculture, Sri Lanka has a wide range of cultivated species. The 46 agro-ecological regions in Sri Lanka are based on variations in soil, annual rainfall and altitude (SDoSL, 2007) and they support a wide range of land races or traditional varieties that are well suited for local climatic conditions. The traditional rice varieties and wild relatives of rice show resistant to diseases and insect pests (BOX 1.4). It is now known that among the vegetables and fruits there are about 10 species of wild Vigna-out of 16 species present in the country (Liyanage, 2010); 12 species of wild okra, 16 wild relatives of cucurbits, seven wild relatives of orange and related crops, and seven wild species of *Passiflora* and parent species of the cultivated banana *(M. acuminata and M. balbisiana)*.

□ Positive trends

In recent years there has been a more definite positive trend to conserve and use the germplasm of indigenous crops and their wild relatives for varietal improvement of rice, vegetables, other field crops and minor export crops. **Table 1.9** shows that collections of crop germplasm are increasing at the Plant Genetic Resources Centre (PGRC) of the Department of Agriculture (DoA).

All crop research and development institutes under the Department of Agriculture (e.g. the Horticultural Crops Research and Development Institute (HORDI); the Rice Research and Development Institute (RRDI), and the Field Crop Research and Development Institute (FCRDI) and the PGRC are engaged in research to characterize and investigate the properties of traditional crop varieties and wild relatives of crops for varietal improvement.[34] For example, the PGRC is engaged in gene tagging in the wild relative of Okra with regard to the trait for resistance to the yellow vein mosaic virus.[35] Likewise the Department of Export Agriculture is engaged in crop enhancement using genetic diversity of minor export crops. As such these institutions maintain working collections of crops (including traditional varieties) and their wild relatives.

The PRGC and other research institutions of the DoA also give out seeds of traditional varieties to farmers for on-field propagation. As a result, there are many farmers in the island who are now cultivating traditional rice varieties as this fetches a higher price in the market due to their better

34 Discussions with the research institutions of the DOA, 2014
35 Discussions with the PGRC, 2014.

taste and nutritional value than the new improved varieties. The DoA is also seeking to popularize the use of organic fertilizer with traditional varieties of vegetables for home garden growers. Concurrently, the DoA has also banned several pesticides in Sri Lanka from 2012, namely Carbaril, Chlorophyriphos, Carbofuran and Propanil and the weedicide Glyphosate, due to their propensity to contaminate soil and water and toxicity when applied in large quantities. Four other pesticides were banned since 2010. These measures are expected to improve ecosystem services of agricultural systems.[36]

Table 1.9: Trends in germplasm collection status by crop group at the PGRC

Crop Group	Number of accessions at the PGRC in the 4th National Report	In 2014
Rice and related species	4467	4584
Other cereals and related species	1534	1674
Grain legumes	1,904	2095
Vegetables (legumes, cucurbits, brassics, allium, leafy vegetables etc)	2488	2824
Solanacious vegetables and condiments	1150	1254
Fruit crops	163	161
Root and tuber crops*	150	179
Oil crops	401	434
Medicinal plants	27	27
Fibre crops	63	66
Mustard and related spices	124	128

*Source of 2014 data: unpublished data provided by the PGRC in April 2014. *Root and tuber crops are not maintained in-vitro.*

The means of conserving wild relatives of crops - mainly *Oryza* spp. and *Vigna* spp. have been addressed through a project for conservation of crop wild relatives, and 22 locations have been identified for *in-situ* conservation of crop wild relatives in addition to the protected areas where they occur. The most important areas outside PAs in this regard are the Manikdena Archaeological Reserve and arboretum, Waulpane Forest, and Thumbathanna Forest (Liyanage, 2010).

Among the export crops, the research institutes for plantation crops (i.e. tea, rubber, coconut and sugarcane) maintain live field collections of varieties, cultivars and clones within their purview. The Department of Export Agriculture (DEA) maintains germplasm of species relevant for crop enhancement as per their mandate, while research institutions for minor export crops are also engaged in breeding new varieties with higher yield and beneficial traits. Among the spices, several wild relatives of *Cinnamomum* and 12 wild species of Piper have been characterized. CRS 40 *(Sri Gemunu)* and CRS 317 *(Sri Wijaya)* have been bred by the Cinnamon Research Station.[37] Best performing local selections of black pepper have been selected for commercial cultivation (Seneviratne, et al., 2012), and other types of crops are being investigated for beneficial traits and for products such as essential oils, oleoresins and piperine of commercial value.

1.3.6.2 Livestock sector

Livestock is an important component of the agricultural sector today as seen from the increasing population of livestock in the country over the years. At present there are about 1,265,039 cattle, 473,911 buffalos, 408,787 goats,[38] 88,789 pigs and 15.72 million chickens country wide (DAPH, 2012). Most of the livestock comprise high yielding breeds imported to increase livestock production.[39] However, Sri Lanka also has several local breeds that are well adapted to the local environment and harsh conditions, need less intensive management but are relatively low yielding.

36 Discussions with the Registrar of Pesticides, 2014
37 Information from the Department of Export Agriculture, 2014
38 Unpublished data from the Department of Animal Production and Health, for 2013 provided in 2014
39 Cattle (Friesian, Ayrshire, Jersey of European origin and Sahiwal, Zebu or Bos indicus), buffaloes (Murrah, Nili-Ravi), sheep (Red Madras Bannur), goats (Saanen, Jamnapari) and swine (Landrance, Large white, Duroc) have been imported from time to time.

They are now used for cross-breeding with imported varieties to improve yields and maintain adaptability to local conditions.

□ Positive actions

The Department of Animal Production and Health (DAPH), and its research centre the Veterinary Research Institute (VRI) do not have organized programmes for livestock germplasm conservation, but are using germplasm of indigenous and local breeds in their breeding programmes. Cattle breeding programmes are made available to cattle farmers island-wide to upgrade local breeds through artificial insemination programmes, whereby local cattle are provided imported high yielding germplasm. This has served to propagate the beneficial traits of locally adapted breeds that need less intensive care and are resistant to disease, while increasing milk production. While this affords some degree of conservation for local livestock breeds, there is some concern that indiscriminate cross-breeding may serve to lose the original germplasm which is only found in small pockets of the country. However, these problems have been identified in the Livestock Breeding Policy of 2010 which deals with the in-situ and ex-situ conservation of indigenous livestock including characterization, inventorying and monitoring (MoL&RCD and DAPH, 2010). Other positive actions are measures to conserve traditional knowledge associated with agriculture and livestock rearing, and this is increasingly important for developing the agriculture sector in the face of climate change.

1.4 Major threats to biodiversity in the country

Table 1.10 provides the result of an analysis of major threats to biodiversity in Sri Lanka using assessments carried out during preparation of various national documents since 2012.

One of the main problems is that there is no proper understanding of long-term ecosystem services of biodiversity outside the conservation agencies, so that only short and medium term financial benefits from bio-resources are considered.[40] This could be due to the absence of any local initiative to carry out valuation of biodiversity taking into consideration the important ecosystem services of forests, wetlands, coastal and marine systems and agricultural systems in a holistic manner as recommended in the BCAP of 1999.

40 Inputs from the Experts' workshop to validate this report

Table 1.10: Summary of main threats to biodiversity in Sri Lanka

Threats /direct drivers of threats	Overall main causes of biodiversity loss in Sri Lanka
Encroachment into forests for agriculture: □ Cash crops in the Wet Zone (WZ): tea and vegetables □ Slash-and-burn - cultivation in the Dry Zone and Intermediate Zone (DZ/IZ) □ Cash crop cultivation in the Dry Zone and Intermediate Zone (DZ/IZ) **Illicit felling of timber** (all zones) Logging is banned in natural forests. **Other localized encroachments into forests, wetlands, coastal and marine systems (all zones)** □ For housing, tourism facilities, village expansion/new villages, urbanization □ For provision of amenities – e.g. electricity □ For development of commercial facilities and access roads □ For prawn farming/aquaculture and salt production involving clearing of coastal ecosystems (mangroves, salt marshes, etc) □ For tourist facilities by an irresponsible segment of the tourist sector – often small scale but affecting very sensitive forest and coastal areas. This includes establishing inappropriate tourist infrastructure that adversely affects the environment **Forest degradation** □ Firewood collection and damage to undergrowth □ Cattle grazing □ Die -back of forest species (natural) □ Over-extraction of minerals **Changes in water regimes and sedimentation due to:** □ Dam construction □ Major and mini-hydro projects that alter water regimes □ Large reservoir projects □ Poorly planned irrigation structures and release of irrigation waters □ Encroachments into river reservations □ Proliferation of agro-wells **Lack of strategic use of land during development resulting in loss of critical forests and important wildlife habitats, and wetlands:** □ Development projects (for transportation networks, service facilities and other infrastructure for urban development). □ Expansion and development of existing settlements, and new settlements. □ Large scale agricultural expansion for commercial purposes. (applicable to all zones, but mainly DZ for new settlements and agricultural expansion)	□ **Habitat loss and fragmentation:** resulting in loss of ecosystem services and habitats for species. □ **Ecosystem degradation: resulting in loss of** ecosystem services and habitats for species

Threats /direct drivers of threats	Overall main causes of biodiversity loss in Sri Lanka
Invasive species (IS). □ Unintentional introduction □ Intentional introduction of IAS □ Proliferation of indigenous IS due to ecosystem changes, climate change, and /or reduced population of species in food chains (all zones in forests, wetlands, coastal and marine systems, agricultural systems)	□ **Spread of Invasive Alien Species (IAS):** increased threat status of species, and degradation of natural and agricultural systems and the resources they provide
Over exploitation of species □ Some NWFPs from forests □ Ornamental fish and ornamental plants □ Other commercially important plants and animals	□ **Over exploitation:** of biological resources: loss and increased threat status of species
Destructive practices during resources extraction □ Destructive removal of minerals and rocks from forests □ Sand mining and removal from rivers and beaches □ Illegal gem mining in forests and wetlands □ Destructive impacts of land based activities that cause sedimentation in coastal ecosystems resulting in loss and degradation of coastal ecosystems and resources (e.g. coral reefs and seagrass beds) □ Poor land use in private lands and stream reservations (all zones) □ Destructive fishing practices - e.g. blast fishing damages coral reefs, use of moxy nets to catch reef fish damages coral reefs, dragnets and push nets damage sea grass beds, nylon gill nets spell death to dolphins and turtles as by-catch	□ **Destructive practices during land use and resource extraction:** resulting in loss of ecosystem services and habitats for species, increased threat status of species and loss of long-term fishery and agricultural productivity
Pollution □ Pollution from agrochemicals (chemical fertilizer, weedicides, pesticides and insecticides) □ Eutrophication in inland waterways due to excess fertilizer □ Pollution from detergents such as soaps and shampoos in inland waters used for bathing □ Pollution of coastal waters with oil from ships and boats and ballast water □ Sewage pollution	□ **Pollution:** resulting in loss of ecosystem services and habitats for species, increased threat status of species, and potential loss of biological resources used by people for commercial and subsistence uses
Increasing human populations and contacts with wildlife □ Human - elephant conflict □ Human – primate conflict: mainly with toque macaques and to a lesser degree with the grey langur and the purple-faced langur.	□ **Human population increase:** greater pressure on land and other natural resources. □ **Human - wildlife conflicts:** increased threat status of targeted species, socio-economic loss to people affected.
Climate change and natural disasters □ Human induced global climate change □ Tsunamis □ Floods □ Droughts □ Coastal erosion □ Natural outbreaks of parasites and pests	• **Climate change and other major natural disasters:** These can result in loss of ecosystem services and habitats for species, increased threat status of species (especially already threatened species), and potential loss of biological resources and coastal lands used by people for commercial and subsistence purposes.

Note: These threats and drivers have been validated at a stakeholder workshop in 2014 for preparation of this report.

Table 1.11 shows changes in threat status of major faunal and floral groups between 2007 and 2012 assessments for Red Listing of indigenous plants and animals.

It is of concern that about 44% of all flowering plants in Sri Lanka and 46% of vertebrate species are threatened with extinction. There has been no reduction of threats to the relevant species groups since the last reporting period, which is explained by the many threats to biodiversity as set out in Table 1.11. While the list of threatened species has grown from 2007 to 2012, this is also partly due to increased number of species in some groups based on new findings and revised taxonomic groupings resulting in splitting of species, particularly among the fishes and herpetofauna. Further spiders were very incompletely assessed in 2007, but are now better known.

Table 1.11: Changing threat status of indigenous fauna, flowering plants and pteridophytes in Sri Lanka

Group	Species in the 2007 Red List of Threatened Fauna and Flora of Sri Lanka		Species in the 2012 Red List of Threatened Fauna and Flora of Sri Lanka	
	Number Assessed (no. of endemics in parenthesis)	Number threatened (no. of endemics in parenthesis)	Number Assessed (no. of endemics in parenthesis)	Number threatened (no. of endemics in parenthesis)
Land snails	246 (204)	33 (32)	253 (205)	179 (162)
Freshwater crabs	51 (51)	37 (37)	51 (50)	46 (45)
Dragonflies	120 (57)	20 (20)	118 (47)	61 (40)
Ants	NA	NA	194 (33)	59 (8)
Bees	NA	NA	130	106
Butterflies	243 (20)	66 (13)	245 (26)	99 (22)
Spiders	7(5)	1 (1)	501 (257)	62 (24)
Freshwater fishes	82 (44)	28 (20)	91 (50)	45 (39)
Amphibians	106 (90)	52 (51)	111 (95)	73 (71)
Reptiles	171 (101)	56 (37)	211 (124)	107 (87)
Birds (residents only)	227 (33)	46 (16)	240 (27)	67 (18)
Mammals	91(16)	41(14)	95 (21)	53 (18)
Total vertebrates	677 (284)	223 (138)	748 (317)	345 (233)
Flowering plants	1099 (553)	675 (412)	3156 (894)	1,385 (594)
Pteridophytes	NA	NA	336 (49)	200 (33)

Source: MoENR and IUCN (2007) and MoE (2012).

1.4.1 Threats to terrestrial wild species

The threat assessment of faunal groups, pteridophytes and flowering plants during preparation of the 2012 National Red List reveal that:

- Among the vertebrates, the percentage of threatened species is highest for amphibians (66%) and mammals (56%). Further, 19 species of amphibians from Sri Lanka are among the amphibian species that became extinct during the past 500 years (Manamendra-Arachchi and Meegaskumbura, 2012).
- Among the terrestrial invertebrate fauna, the highest number of threatened species is among the bees (82%), while 40% of butterflies are also threatened. Both are important pollinators of crops.

- Among freshwater faunal groups such as the freshwater crabs and fishes (with very high endemism), 90% and 50% respectively are threatened with extinction. This appears to be a direct result of the threats to inland aquatic systems and over-harvesting in the ornamental fishery.
- Most of the threatened terrestrial vertebrates and fishes are located within the Wet Zone with a high human population density (IUCN MoENR, 2007).
- Among the 3,156 indigenous angiosperm species assessed, 1,385 species (44%) were found to be threatened, of which 65% are endemic.
- Among the pteridophytes, 60% of known species are threatened with extinction.
- Analysis of the causes of threat have shown that:
  - The most widely felt threats across the faunal groups, pteridophytes and orchids are the loss, fragmentation and/or degradation of natural habitats and the impacts of pollution and alien invasive species (van der Pooten and Coniff, 2012; Dias, et al, 2012; Karunaratene and Edirisinghe, 2012; van der Pooten, 2012; Benjamin, et al, 2012; Bahir and Gabadage, 2012; Ranaawana and Priyadarshana, 2012; Goonatilleke, 2012; Manamendra-Arachchi and Meegaskumbura 2012; Wickramasinghe, 2012; Weerakoon and Gunawardena, 2012; Weerakoon, 2012a &b; Ranil and Pushpakumar, 2012; Fernando, 2012).
- Deforestation, fragmentation and degradation of forest habitats were the most serious threats which affected almost all groups [(i.e. dragonflies (van der Pooten and Coniff, 2012), bees (Dias, et al, 2012); butterflies (van der Pooten, 2012); freshwater crabs (Bahir and Gabadage, 2012), land snails (Ranaawana and Priyadarshana, 2012), freshwater fish (Goonatilleke, 2012);
- amphibians (Manamendra-Arachchi and Meegaskumbura, 2012); reptiles (Wickramasinghe, 2012), birds (Weerakoon and Gunawardena, 2012) and pterodophytes (Ranil and Pushpakumar, 2012).
- Freshwater fish, pterodophytes, orchids and aquatic ornamental plants were the most affected groups by over-exploitation.
- Angiosperms in general were most affected by habitat loss and loss of pollinators (Wijesundara et al, 2012).
- Freshwater fishes were particularly affected by changes in water regimes, including mini-hydro projects, reservoir projects; erosion and sedimentation exacerbated by gem mining; and destructive fishing methods (Goonatilleke, 2012).

1.4.2 Threats to wild relatives of crops

- Most populations are not found in Protected Areas (PAs) and are therefore vulnerable to deforestation, urbanization, expansion of agricultural lands, and land clearing.
- Many species are vulnerable to climate change and landslides.
- Some species are over-extracted as food.

1.5 Impacts of change in biodiversity for ecosystem services supporting socio-economic development and cultural aspects

Section 1.2.4.1 indicated the value of biodiversity for enabling ecosystem services, particularly those of economic value, all of which will be affected by loss of biodiversity in Sri Lanka. This section reiterates some of the negative ramifications of biodiversity loss for ecosystem services that support socio-economic development and cultural aspects at the national left.

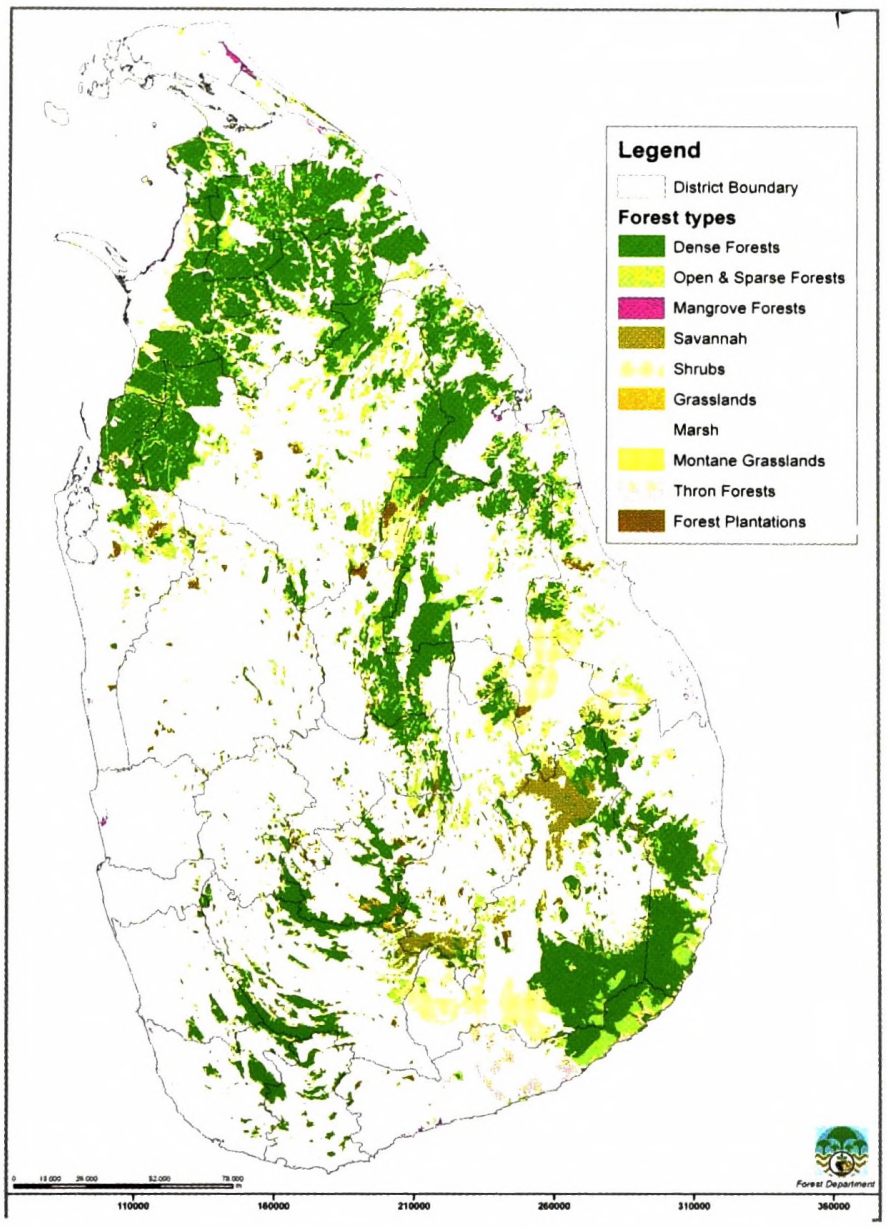

FIGURE 1.5: Forest cover in Sri Lanka in 2010 – by Forest Type

1.5.1 Impacts of habitat loss, fragmentation and degradation

This is a widespread threat felt across all ecosystems in Sri Lanka (BDS/MoERE and DNBG, 2012), and is the most serious factor driving species loss in the island.

With regard to forests, a positive factor is that through judicious management, the rate of deforestation has been significantly reduced (though not eliminated), and the Mahinda Chintana policy framework has set a target of increasing the forest cover to 35% of the island's land area by 2020. Table 1.12 provides the strategy proposed by the Forest Department to reach this target. As loss and degradation of forests is a key threat to many species (BDS/MOE & DNBG, 2012), increasing the island's forest cover to 35% can be expected to have a beneficial impact on Sri Lanka's biodiversity and forest ecosystem services if this target is reached. However, unless forest degradation is also stemmed, there would be continued negative impacts on many species that are dependent on forests for survival (BDS/MOE &DNBG, 2012).

Table 1.12: Projected forest cover in different categories of forests by 2020

Land use	Strategy	Target area (ha)	Percentage of total land area
Forests	Conservation	1,951,472	29.74 %
Shrubs and grasslands	Restoration	100,000	1.52%
Forest plantations	Convert to mixed species plantations	40,000	0.61 %
Home gardens	Improve cover with multi-purpose trees	210,000	3.20 %
Total		2,301,472	35.07 %

Source: Edirisinghe, EAPN, Forest Department, 2014

Wetlands have received much less attention than forests since the last reporting period. Continued reclamation and degradation, despite support from policies and laws, have had many adverse impacts on wetland ecosystem functions. These include loss of habitats for wetland species, and reduced species richness and carrying capacity of wetlands (Weerakoon and Gunawardena, 2012). This has affected many wetland species of socio-economic importance, particularly in the ornamental and food fishery. Systomus martenstyni is an example of a rare endemic species of

freshwater fish with a limited range (i.e. found only in the Knuckles forests) that is endangered due to wetland degradation and loss (Goonetillele, 2012). Notably, 41% of the island's aquatic flora are nationally threatened (Yakandawala, 2012).

Wetland reclamation has also increased the flood hazard in both urban and rural areas. Already, flood damage entails heavy expenditure by the government in terms of flood relief and compensation (MoE, 2010c). The negative impacts of flooding have already been felt in several urban areas of Sri Lanka where wetlands have been reclaimed and converted to other uses, due to loss of flood retention capacity. Large scale irrigation schemes and hydropower reservoirs which are dependant on a good water flow for multiple uses are affected when reservoir capacity is reduced due to siltation. This has also reduced the capacity for hydro-power which is a source of cheap and clean energy. Conversely, the proliferation of mini-hydropower plants that have not adhered to environmental safeguards may lead to the loss of habitat for some rare and endangered aquatic species. Examples of affected species are aquatic plants of the family Podostemaceae (Yakandalwela, 2012) and the endemic Asoka Barb *Systomus asoka*. In some areas there are conflicts of interest due to perceived impacts of mini-hydro-power plants on tourism related activities (e.g. white water rafting) and related local livelihoods. This underlines the need for sound environmental considerations when managing such enterprises and good communication between all stakeholders.

Coastal and marine systems have been affected due to loss and degradation of habitats, pollution, destructive fishing practices, and over-exploitation of resources. For example, the drop in the shrimp fishery in Negombo, which was linked to the loss of seagrass beds from destructive fishery practices, led to loss of livelihood for fishermen and reduced fishery productivity. As destructive fishing practices continue in other locations this can be expected to negatively affect both the food fishery and the ornamental fishery. The biodiversity of some coastal lagoons (e.g. lagoons within the Bundala National Park) have been seriously affected by hydrology and salinity changes, which have affected the fish and crustacean fauna, and consequently the fishery. This has also affected the composition of water birds that feed on crustaceans, reducing the attraction of the BNP to bird watching tourists (NSF, 2014 d).

1.5.2 Impacts of pollution

Pollution is widespread (BD/MOE &DNBG, 2012), and has resulted in loss or degradation of ecosystem services and species in wetlands, coastal and agricultural systems. Pollution occurs due to contamination with fertilizers, pesticides, weed killers, sewage, chemical compounds from shrimp farms in coastal areas, and unsafe dumping of untreated industrial wastes, e-wastes, and solid waste. Pollution has already prevented supporting ecosystem services in many aquatic system by rendering such habitats unusable to freshwater species, such as dragonflies, freshwater crabs, land snails, freshwater fish, amphibians and aquatic plants that need clean clear water (BD/MOE &DNBG, 2012). As such, several species that are important as food fish, ornamental fish and plants have been affected by pollution, affecting rural livelihoods and the gain of foreign exchange (BD/MOE &DNBG, 2012). Likewise, agro-chemical pollution has adversely affected bees and butterflies which are much needed pollinators in agricultural systems, which can affect agricultural production and livelihoods of farming communities. This is denoted by the high percentage of threatened species among bees and butterflies. Pollution of inland and coastal waters with sewage and agrochemicals has also significantly increased the incidence of disease among rural people, due to direct contact with polluted water or consumption of contaminated fishery and other wetland products. Reduced water quality for bathing and drinking has also affected human health as many rural people still rely on wells (ground water) and surface waters in rivers and irrigation tanks for domestic water needs.

1.5.3 Impact of over exploitation of biological resources and adverse resource extraction practices

Some pteridophytes and freshwater ornamental plants (e.g. ornamental ferns and aquatic plants such as Cryptocoryne, Aponogeton and Lagenandra) are the most affected due to over-exploitation (BD/MOE &DNBG, 2012) leading to their increased threat status (ibid). In wetlands,

freshwater ornamental fish, including many endemics, are at risk from over exploitation of wild stocks for the export industry. This is detrimental for the sustainability of the ornamental fish industry which earned export earnings of US$ 175,400 in 2013/14.[41] Other examples are the over exploitation of rattan species in the wet zone forests in the past which has led to non-availability of raw material and the total collapse of the rattan based traditional cottage industry in rural areas near wet zone forests. In recent years, a high demand and market price for walle-patta *(Gyrinops walla)* is causing damage to many wet zone forests when these trees are cut indiscriminately for extraction of the resin (found only in some stems) due to its high market price when exported for value added use in the cosmetic industry elsewhere. Over harvesting of herbivorous reef fish (e.g. the Humphead wrasse *(Cheilinus undulatus)* that feed on juvenile Crown of Thorns Starfish) is altering the ecological balance of coral reefs with detrimental impacts. Likewise, coastal waters are over–exploited in the food fishery.

1.5.4 Impact of the spread of Invasive Alien Species (IAS)

This has increased threat status of several species, and has caused degradation of natural and agricultural systems and the resources they provide. The accidental and intentional introduction of IAS has caused serious environmental and economic problems by reducing functional area of wetlands (e.g. infestations with Salvinia and Water hyacinth), creating reduced surface waters for human use, causing problems in irrigation tanks and hydro-power reservoirs, and leading to loss of habitat for native freshwater dependant species. Some introduced fish species such as tilapia are believed to imperil local indigenous fish species. Intentional and accidental introduction of invasive alien fish species such as *Chitala chitala* (Clown knife fish) and *Hypostomus plecostomus* (Suckermouth catfish) are threatening the existence of native fresh water fishes (Gunawardane, 2012). Several national parks now have major problems due to the spread of IAS (Perera, 2012). Examples are *Lantana camara* in the Udawalwe National Park and *Prosopis juliflora* in the Bundala National Park. Such vegetation reduces the grazing area for large herbivores. Apart from the impact on wildlife, this reduces the food for charismatic grazing animals and their prey that are major tourist attractions. Agricultural systems too have been periodically challenged by IAS, requiring remedial measures at high cost and considerable effort.

1.5.5 Escalation of human-wildlife conflict

Human-wildlife conflict in Sri Lanka has increased in recent years, resulting in increased threat to target species and socio-economic loss to affected people. The most predominant problem is the human-elephant conflict due to forest clearing for development, human settlements, and irrigated agriculture, as it has reduced habitat for elephants and disrupted their migration routes. *Chena* (slash and burn) cultivation in the Dry Zone forests with crops that attract elephants have also brought elephants into closer contact with humans. This has led to increased vulnerability of elephants to poaching and has intensified problems for humans. This conflict resulted in 68 human deaths and 203 elephant deaths in 2013 in addition to large scale damage to crops and human habitations.[42] Likewise, the human-monkey problem has increased in the past few years. The large number of hotels and human habitations that have been established in close proximity to forests in the dry zone, poor garbage disposal, and lack of adequate food in forests year round are factors that have compounded this problem with the endemic toque macaque. Likewise, the rapid fragmentation of home gardens and resultant loss of food trees have led to an increase of human-monkey conflict in the wet zone due to increased competition between humans and monkeys for fruit crops. In addition, many wet zone forest reserves that could serve as 'monkey refuges' are too small, degraded and isolated to provide this service adequately.

41 Data from the Department of Customs, 2014
42 Data from DWLC in 2014

1.5.6 Reduced potential for crop enhancement, bio-prospecting and natural product development

Section 1.2.5.1 provides information on the potential for bio-prospecting, crop enhancement and natural product development in the country. Already some species such as Exacum spp. (Binara), which are rare wild plants found in Sri Lanka with floriculture prospects in future, are now facing severe genetic erosion due to anthropogenic threats to habitats. Many of the orchids in the country are also threatened with extinction. Sri Lanka has been identified as a country with a gene pool for global edible insects, numbering about 20 species which are currently not used by local people.[43] Thus the loss of species and genetic diversity due to the threats listed above, especially due to disruption of ecosystem services caused by habitat loss/degradation, pollution, and spread of invasive species will reduce Sri Lanka's potential for bio-prospecting and natural product development with a view to increasing foreign exchange earnings for the country.

1.6 Possible future changes in biodiversity and their impacts

Threats to biodiversity if not addressed adequately in a timely manner will have many socio-economic implications in the future. For example it will affect resources available for tourism, agriculture and livestock production, fishery (ornamental and food fishery), energy generation, provision of water for multiple uses, and traditional systems of health care. Forest loss will also reduce adaptability to climate change in the future and increase the impacts of potential water scarcity predicted due to climate change (MoE, 2010c). Apart from the impacts already presented in section 1.5 that would be increased in intensity, climate change has been identified as a key factor that could seriously affect biodiversity for ecosystem services in the future. While the impacts are yet not certain, some are very probable. Sri Lanka being an island is vulnerable to the possible impacts of sea level rise and coastal flooding based on global models of sea level rise. Low lying agricultural systems in coastal areas would be affected by saline intrusion, and coastal areas would be affected by frequent storm surges and coastal erosion, with the loss or severe degradation of beaches, mangroves, coral reefs, seagrass beds, and the organisms they contain.

The changes wrought in coastal and marine systems in terms of species diversity and abundance, and ecosystem services, due to sea level rise, global warming and ocean acidification, can be expected to cause significant changes in fish stocks. This will directly affect the coastal and marine fishery, livelihoods of a large number of local fishers and others connected with the fishery, and ultimately affect the national economy and nutritional status.

Sri Lanka's abundant inland freshwater that is dependant on rainfall could also be jeopardized in the future due to increased rainfall variability and changes in rainfall regimes. This can be expected to have negative impacts on the health of forests and wetlands, and accordingly on forest and aquatic species, and the use of freshwater for human well-being and economic development (MoE, 2010c).

Figure 1.5 shows a composite map prepared by the superimposition of the distribution of threatened amphibians, dipterocarps and orchids[44] during preparation of the Climate Change Adaptation Strategy for Sri Lanka (MoE, 2010b). Amphibians and orchids are considered very sensitive to climate change, show high endemicity, and are mainly found in the island's rainforests. All Dipterocarp species in Sri Lanka are endemic, and occur in the country's biodiversity rich rain forests. Together the location of these three groups was expected to indicate areas of rich biodiversity and endemism. The map thus provides an insight into how climate change could adversely impact Sri Lanka's unique endemic species in the biodiversity rich wet zone. Further, it shows that forest ecosystems and species in fringe areas between the major climatic zones are expected to be the most likely to be impacted by climate change. These areas contain some of the most biodiversity rich forests of the wet zone. More work is necessary, however, to make definite predictions in this regard.

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43 Data from Dr M N Goonetilleke, Colombo National Museum provided by Sampath Goonetilleke, 2014 at the final workshop to validate this document

44 Using maps prepared under the PAM&WC project/Portfolio of Strategic Conservation Sites/Protected Area Gap Analysis in Sri Lanka (2006]

Climate change can also be expected to change flowering/fruiting and flushing in forest species and crops and to disrupt the breeding and reproduction of wild fauna and livestock. It is also expected to result in greater spread of invasive species. This will inevitably lead to an increase in the number of threatened indigenous species, leading to species extinctions (MoE, 2010b).

Changes in rainfall regimes due to climate change could lead to pronounced water scarcity, droughts and unpredicted heavy rains that will disrupt cropping cycles and cause socio-economic upheavals among farming communities, affect human well-being and impede national development (MoE, 2010a, 2010b, 2010c, and 2010d).

Due to the influence of climate change on phenology of forest and crop species, it can have adverse impacts on forest structure and species composition, and affect agriculture and livestock production. There can also be the increase of pest and disease, and increase invasions by IAS. This will affect the national food supply, nutrition, and human health and wellbeing.

Climate change impacts on biodiversity of ecosystems (including beaches and protected areas) that are attractive to tourists could impede Sri Lanka's drive to make tourism one of the highest foreign exchange earners for the country in the future.

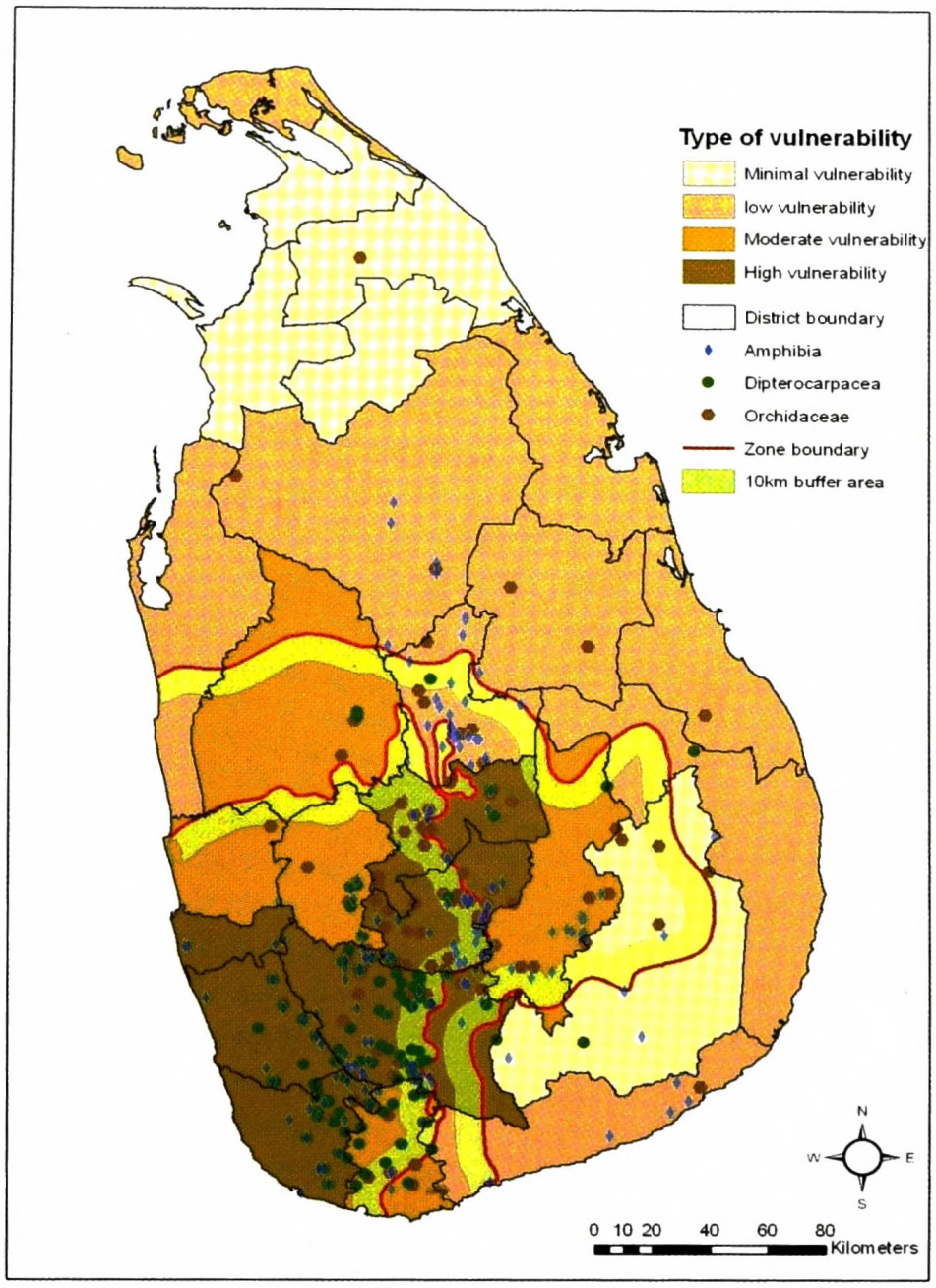
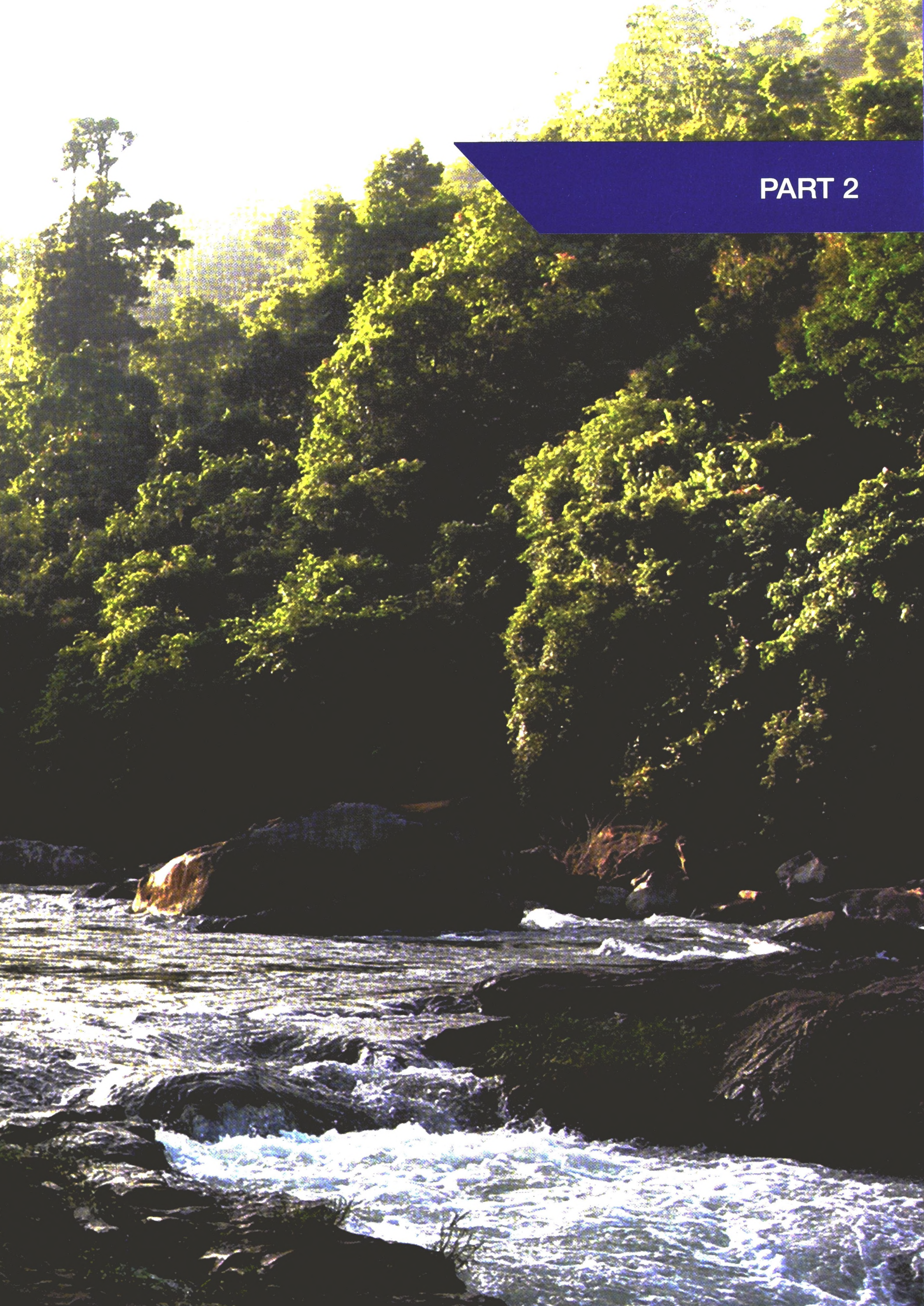


FIGURE 1.6: The potential vulnerability of Sri Lanka's biodiversity rich areas and sites of high endemism to climate change, by Divisional Secretary Division.

Source of distribution of threatened amphibians, orchids and dipterocarps is MoENR, 2006

Kithulgala



PART 2