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Sector Vulnerability Profile:
Biodiversity and Ecosystem Services

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Sector Vulnerability Profile on Biodiversity and Ecosystem Services

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Biodiversity and Ecosystem Services

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."[a] Biodiversity gives us life, and underlies the goods and services that are crucial for human survival and wellbeing due to a host of vital supporting, regulating, provisioning and cultural ecosystem services.[b] Biodiversity is determined by many factors, including mean climate and climate variability, as well as disturbance regimes caused by changes of tectonic, climatic, biological, anthropogenic and other origin.[i] It is now generally accepted that global biodiversity will be significantly affected by climate change, although its precise impacts are still nebulous. This is of concern to us as Sri Lanka's exceptionally rich biological diversity is central to its national identify and for maintenance of numerous ecosystem services essential for the country's 20 million people and future national development. Components of biodiversity provide us with freshwater for domestic and industrial uses, and underpin the socio-economically vital areas of agriculture and livestock production, fishery, forestry, tourism, traditional medicine and several important manufacturing industries. Not surprisingly, the value of conserving the country's biodiversity is recognized in national planning, as reflected in the Mahinda Chintana, the Action Plan for the *Haritha* (Green) Lanka Programme and the National Physical Planning Policy and Plan. While the current and probable future impacts of climate change on agro-biodiversity are being addressed, the possible impacts of climate change on wild biodiversity are mostly speculative. Nonetheless, the socio-economic and ecological implications of biodiversity loss in Sri Lanka will be considerable and wide ranging, because of probable changes in forests and other terrestrial systems, inland wetlands and coastal and marine systems and the species they contain. These changes will have inevitable impacts on national food security; rural livelihoods, nutrition and health; and overall economic development, particularly in the fields of tourism and external trade. Although all impacts of climate change on biodiversity may not be preventable, it is recognized that genetically diverse populations of species, and species rich ecosystems, have much greater potential to adapt to climate change. Conservation of biodiversity and maintenance of ecosystem structure and function may, therefore, be one of the most practical climate change adaptation strategies that Sri Lanka can adopt to conserve the country's natural heritage, and to ensure an uninterrupted flow of ecosystem services[b] and bio-resources that are essential for national development.

1.0 Introduction

A unique natural heritage

Sri Lanka's rich and unique biodiversity forms the basis for the country's natural heritage, and is a core feature of its cultural heritage and economic advancement. Despite a relatively small size of 65,625 sq km[ii] the island exhibits an exceptional array of terrestrial and freshwater ecosystems that support a remarkable diversity of species.[3] Due to the isolation of the island for the greater part of the past 20 million years, Sri Lanka's biodiversity is also characterized by an outstanding degree of endemism (i.e. species not found anywhere else in the world) among the wild flora and fauna. [3] Being an island, Sri Lanka has a rich marine and coastal biodiversity along its 1620 km coastline[4] and the Exclusive Economic Zone which comprises the sea bed and water column over an area of 517,000 km^2.[c] Due to a long history of agriculture that stems from a unique hydraulic civilization, Sri Lanka also has a rich agro-biodiversity, resulting from selection by farmers and adaptation of crops and livestock to varied ecological conditions that prevail in the country.[3]

"Climate change has emerged as a key concern for Sri Lanka and its people in the 21st century. Sea level rise, warming temperatures, uncertain effects on forest and agricultural systems, and increased variability and volatility in weather patterns are expected to have a significant impact in the developing world, where people remain most susceptible to the potential damages and uncertainties inherent in a changing climate."

Source: National Physical Planning Policy and Plan. Sri Lanka 2006-2030 (final draft).[5]

Provision of goods and services

Sri Lanka's biodiversity provides a wide range of ecosystem services,[b] which include providing fresh water, ameliorating the climate, containing soil erosion, regulating surface runoff and providing bio-resources for subsistence use as well as domestic and export oriented markets. These resources include food, fuel, fibre, wood products (including timber), medicines and biomedical materials, ornamental species of commercial value, raw materials for industry, and areas for recreation and aesthetic enjoyment. Many components of biodiversity are vital to meet the consumptive and economic needs of the country.

[a] This is a contraction of the definition given in The Convention on Biological Diversity, and is provided by the Secretariat of the Convention on Biological Diversity.

[b] Ecosystems provide many goods and services essential for human wellbeing. Ecosystem services are classified in many ways which are given in BOX 2 as defined by the Millennium Ecosystem Assessment.[1]

[c] Sri Lanka can gain an additional seabed area of 1,000,000 sq km through the claim submitted under the UN Convention on the Law of the Sea (UNCLOS) – see SVP on Agriculture and Fisheries (Part II).

The country's thriving fishery industry, which sustains 2.5 million people and helps meet the protein requirements of a growing population, is based on the abundance and diversity of edible species in the offshore, near-shore and inland waters. Agriculture, carried out in various agro-ecological regions and using diverse crops, has continued to exert an important influence on Sri Lanka's economy, food security and culture from time immemorial. Likewise, the export of ornamental plants and fish earn significant export earnings. Sri Lanka's potential for nature tourism, which is now a key avenue for economic advancement, is almost wholly dependant on the high quality of relevant components of biodiversity—comprising a wide range of natural habitats and species—that the country has to offer. Furthermore, valuable genetic resources offer considerable economic potential, particularly for enhancement of agriculture and pharmaceutical industries, underlining the optional use value of the island's biodiversity.

The cost of climate change

The distribution of Sri Lanka's rich biota depends largely on the spatial variation of rainfall and temperature in the island, as well as topographic variation and the spatial distribution and diversity of soils. While much of the possible impacts of climate change on wild species and ecosystems are speculative, major impacts on the island's biodiversity—in both natural and human modified environments—are highly probable in view of trends observed for rainfall and temperature in the country during the past few decades, the already observed impacts of climate change in other countries and regions, and the earth's evolutionary past.[1] Such impacts of climate change can create profound and long-term changes in the island's biodiversity—which is already under pressure from a host of anthropogenic impacts (BOX 1). The resultant changes in Sri Lanka's biodiversity and ecosystem services can jeopardize sustainable economic development and national initiatives for future food security.

BOX 1: THE MAIN FACTORS THAT CURRENTLY AFFECT SRI LANKA's BIODIVERSITY (*OTHER THAN CLIMATE CHANGE*)

- Habitat loss and fragmentation
- Habitat degradation
- Loss of genetic potential from a large number of traditional crop varieties and livestock breeds due to increased reliance on fewer high yielding varieties and breeds
- Over-exploitation of biological resources, exceeding the recuperative capacities of ecosystems and species, and destructive harvesting practices
- Pollution, particularly in freshwater and coastal habitats
- Human-wildlife conflicts, due to expansion of agriculture and settlements into wildlife habitats and travel routes, particularly with regard to elephants and primates
- Spread of invasive alien species (IAS) into wetlands, forests, coral reefs, wetlands and agricultural systems
- Increasing human population densities and resultant human needs that increase pressure on natural ecosystems and species

From the 4th Country Report from Sri Lanka to the United Nations Convention on Biological Diversity.[6]

Experiences at the global level have already shown that some adaptation measures to address climate change, such as establishing monoculture energy plantations can also have adverse impacts on biodiversity.[1] Conversely, biodiversity, through the ecosystem services it supports (BOX 2), could make an important contribution to both climate-change mitigation and adaptation.[1] The impacts of climate change on biodiversity are, however, varied and often unpredictable, as natural systems and wild species tend to react in different ways and impacts are influenced by local conditions and anthropogenic influences. However, there is considerable evidence that "**functionally diverse communities tend to adapt to climate change and climatic variability better than impoverished one**s;"[1] and g**enetically diverse species appear to have more potential for long-term persistence**.[1] Consequently, conserving and sustainably managing biodiversity is of critical importance to reduce the negative impacts of climate change on Sri Lanka's biodiversity, ecosystem services, and economic advancement. Options for adaptation should, therefore, prioritize monitoring and identification of the probable impacts of climate change on the most vulnerable and/or important components of biodiversity in the country and promote their conservation, using methods based on both scientific principles and traditional knowledge.[1] The 'Ecosystem Approach' promoted by the Convention on Biological Diversity (CBD) offers excellent opportunity to meet this goal.[1]

"Climate change impacts would be most severe on islands where natural exposure to such events is heightened by growing urbanization, proliferation of squatter settlements, degradation of coastal ecosystems, and rapidly expanding coastal infrastructure."

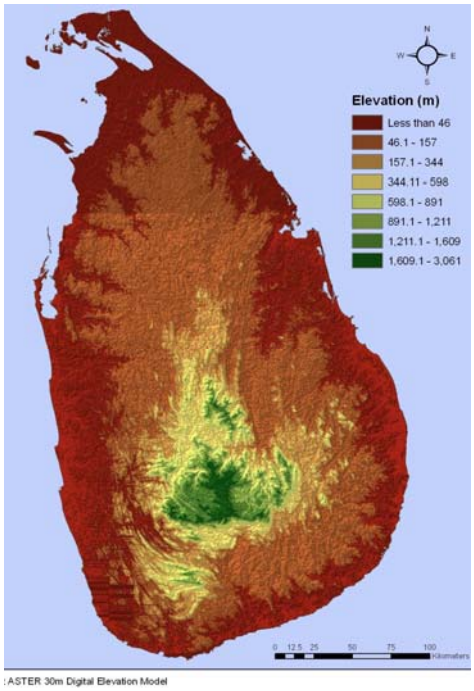
Source: Ceasar, H. (2004) Paying the Price of Climate Change in World Conservation, *Volume 35, No 1. pp 28-29*[7]

1.1 Key factors influencing Sri Lanka's biodiversity

- *Environmental factors*

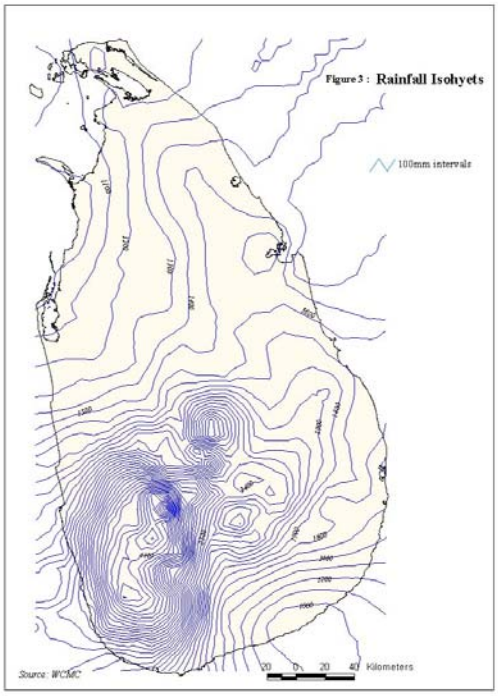
"The rich biota of Sri Lanka has evolved due to climatic factors and geo-evolutionary processes which caused "geological upheavals and geographic movements"[8] resulting in a distinct altitudinal gradation in the central

part of the island (FIGURE 1). Consequently, the general topography of the island displays a "staircase pattern" of about 11 planation surfaces,[9] with the south-central mountains rising to 2500 m from the surrounding broad lowland plains that occur at a height of 0 – 150 m above MSL.[2] Sri Lanka's tropical climate is influenced by its geographic location in the Indian Ocean and its proximity to the Indian sub-continent. The island's climate shows a marked seasonality of rainfall, influenced by two distinct monsoons and convectional and cyclonic effects. The rainshadow effect caused by the central mountains (FIGURE 1) has given rise to two



Source: Generated by the ADB TA 7326 for this report using raw data from ASTER 30m Digital Elevation Model

FIGURE 1: Altidudinal variation in Sri Lanka



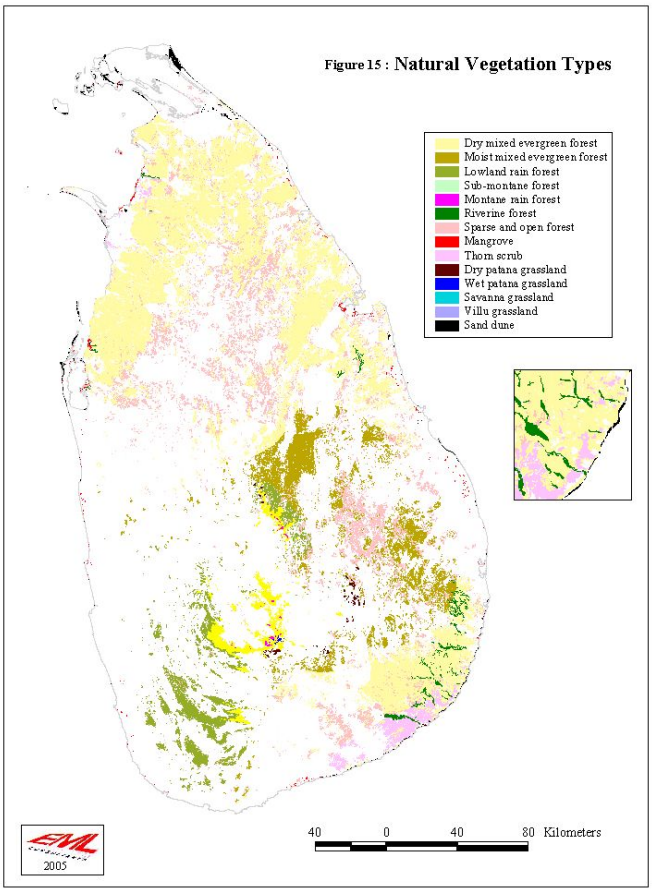
Sourse: MoENR, 2006[10]

FIGURE 2: Spatial distribution of rainfall in Sri Lanka

pronounced climatic zones termed the Wet and Dry Zones[d] that are separated by the 2000 m isoheyt (FIGURE 2). Climate plays a prominent role in the distribution of biodiversity in Sri Lanka, resulting in very specific vegetation types occurring in different climatic zones (FIGURE 3). Altogether a total of 15 distinct floristic regions have been recognised in the island by Ashton and Gunatilleke (1987**).**[11]

The Wet Zone with a perhumid, ever-wet climate and an annual rainfall of 2500 mm – over 5000 mm is located in the south-west quarter of the island, where a high rainfall is maintained throughout the year by the receipt of rain from both south-west and the north-east monsoons, as well as from inter-monsoonal rains during March-April and October to November.[2] The first inter-monsoonal rains are often accompanied by warm conditions and thunderstorm type rains; the second is also characterized by thunderstorm type rains and depressions and cyclones that originates in the Bay of Bengal[2]—although Sri Lanka lies outside the main cyclone belt. The Dry Zone, which is spread over much of the lowlands plains, has a mean annual rainfall of 1250 mm – 1750 mm,,[2] and is subjected to several months of drought as it receives rain only from the north-west monsoon, As such, more than 70% of the rains in the Dry Zone occur between October and December, resulting in a considerable seasonal variation in the rainfall of this region.[12] The less extensive Intermediate Zone, with a mean annual rainfall between 1750 and 2500 mm, lies between the Wet and Dry Zones.[2] The Wet Zone is further divided into Low, Mid and Montane Zones due to altitudinal variation, which has resulted in a progressive drop in temperature with the increase of altitude. Consequently the average annual temperature of the Wet Zone ranges from 27.5^{0}C in the lowlands to around 15.9^{0}C in the montane areas, where ground frost occurs in the coldest months,.[2] The Montane Zone has cloud forests important for fog interception and the maintenance of hydrological cycles.[13] Each major climatic zone has characteristic vegetation and faunal species, with most of the endemics being concentrated in the Wet Zone. The temperature and altitudinal differences in the Wet Zone have in turn contributed to the presence of very distinct forest formations that contain species characteristic of the Low, Mid and Montane Zones. The Montane Zone spans three distinct and separated mountain ranges that have similar climatic conditions and altitude but have closely related species that are characteristic to each, due to their being isolated from each other for many thousands of years.[13]

[d] The arid zone is not mentioned here as agreed at the Sector Working Group Meeting to discuss the Agriculture Sector Vulnerability Profile (SVP).



Sourse: MoENR, 2006[10]

FIGURE 3: Natural vegetation types in Sri Lanka

Inland systems

Apart from climate and altitude, the rich diversity of soils in the island, which amount to fourteen of the Great Soil Groups[14] and the multitude of rivers and irrigation reservoirs in the island (FIGURES 4 and 5) have also influenced inland biodiversity, including those of agricultural systems. The freshwater resources in the island are extremely vulnerable to the impacts of climate change,[e] making the issues related to conservation of watersheds and wetland biodiversity of crucial importance when adapting to climate change.

Coastal and marine Systems

Sri Lanka as a continental island has a considerably wide continental shelf around most parts of the country, and the coastline supports a range of reef and shoreline types, including bays inlets and lagoons.[4] These features have resulted in a rich array of ecosystems and species that are vulnerable to the impact of climate change, particularly to sea level rise and increased storm surges.

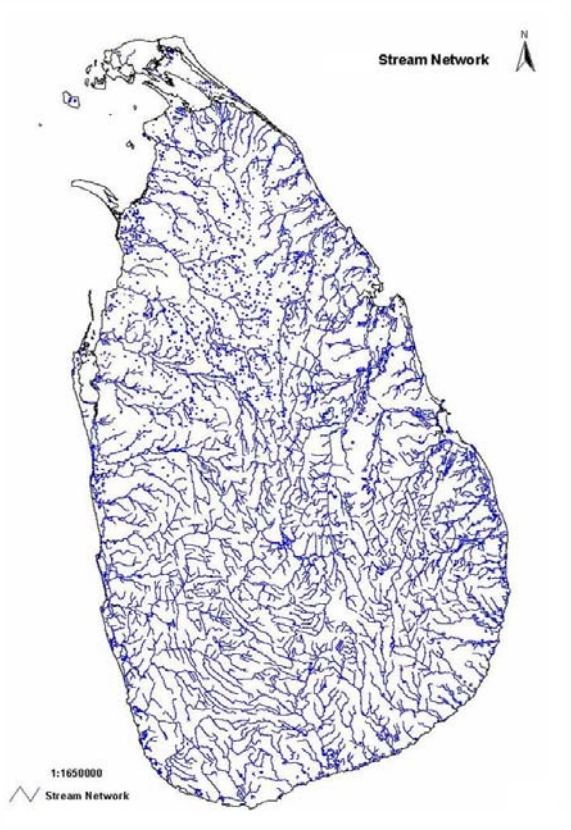
Due to the critical influence of rainfall, humidity and temperature on the evolution of Sri Lanka's rich biota, and the considerable coastal areas that the country supports, climate change impacts of sea level rise, the already increased variability of rainfall intensity and regimes, increased frequency of storms and increasing mean ambient temperature, can be expected to have definite impacts on the country's biodiversity and the ecosystem services and bio-resources they provide.

- *Cultural factors*

"Traditional practices and wisdom have been ignored for too long with negative consequences"
The CBD and the UNFCCC stress the need to draw on traditional knowledge to meet the challenges of biodiversity loss and climate change impacts.

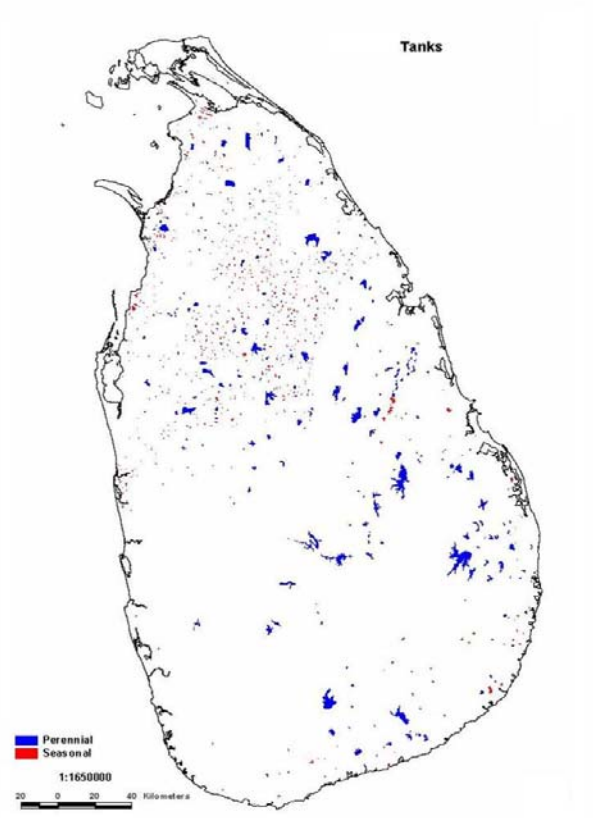
Human impacts and cultural features too have served to fashion and maintain the island's unique biodiversity. The conservation of forests, watersheds and fauna were deeply ingrained in the culture of ancient Sri Lanka due to the influence of Buddhism, which promotes respect for all forms of life.[3] Not surprisingly, wildlife `sanctuaries' had been set up for the protection of fauna and flora in Sri Lanka as far back as the third century BC, and stone edicts of the twelfth century AD show the prevalence of concepts akin to 'urban nature reserves.[3,6] These values are less evident today due to modernization, but with localised exceptions, they continue to be upheld to a fair extent, resulting in considerable species diversity residing outside protected areas.[6,10]

[e] Note: With regard to water, the impacts of climate change on inland surface waters, both natural and man-made, with the focus on irrigation and water for domestic use, have been addressed in detail in the SVP for the Water Sector. This document focuses only on impacts of climate change on ecosystem functions and services, species and bio-resources in inland surface waters.



Sourse: MoENR, 2006[10]

FIGURE 4: Sri Lanka's stream network



Sourse: MoENR, 2006[10]

FIGURE 5: Sri Lanka's irrigation tanks and hydropower reservoirs

Agriculture practiced for centuries in Sri Lanka has also influenced the county's cultural base, influenced by a unique hydraulic civilization.[15] This in turn has contributed to a rich agro-biodiversity through farmer selection and the evolution of land races. Numerous religious beliefs, traditional agricultural and livestock rearing practices that include pest control, veterinary care, and ensuring a good harvest sans artificial fertilizer and pesticides, have also persisted through the ages in some rural areas. Ritualistic and medicinal uses of biodiversity have continued to be important in rural areas from time immemorial, though their importance has waned with modernization and greater reliance on western medicine. Many of the traditional practices used in agriculture and traditional medicine that are now in danger of being lost could, however, be of considerable value to meet the challenges of climate change. Conversely, as seen in other parts of the world, climate change may affect traditional cultural practices at the local level due to the loss of species that are critical for their continuation.[1]

At the global level: IPCC findings on climate change have alerted that "Traditional[f] people or local people will feel the effects of climate change before the general impacts of climate change are felt, as climate and land-use changes lead to loss of biodiversity for subsistence use and livelihoods.[16] Climate change has already affected the traditional practices of indigenous communities in some parts of the world. More impacts are expected worldwide on the lifestyles of traditional peoples due to:

- shifts in timing and ranges of wildlife;
- health impacts due to changes in biodiversity at ecosystem and species levels, including changes in disease vectors and loss of medicinal species;
- loss of food sources and revenue from fishing or tourism;
- changes in water flow; and
- the trend to cultivate monocultures as 'carbon sinks' that would compete with traditional land use practices of local people.

Source: SCBD, 2003[1]

1.2 Overview of Sri Lanka's biodiversity

Ecosystem diversity

Sri Lanka's ecosystem diversity lies in the multitude of terrestrial, inland wetland[g], coastal and marine, and agricultural ecosystems that occur in the country **(Table 1).** They include many different types of forests, inland wetlands associated with the rivers that originate from the central mountains, and over 10,000 irrigation tanks and reservoirs. Being an island, Sri Lanka's marine and coastal ecosystems feature several distinct types of reefs, estuaries and lagoons, wide sandy beaches, mangrove habitats and coastal marshes.[4] Considerable biodiversity also exists in human modified habitats such as plantations, other agricultural lands, home gardens and even built-up areas such as roadsides and urban environments.[6]

TABLE 1: Ecosystem diversity in Sri Lanka with provisional extents of ecosystem types

Ecosystems	Provisional extent (ha)
Forest and related ecosystems	
• tropical wet lowland evergreen forest (includes lowland and mid elevation rain forests)[†]	124,340.8
• tropical sub-montane forest[†]	65,792.3
• tropical montane forest[†]	3,099.5
• tropical moist monsoon forest[†]	221,977.0
• tropical dry monsoon (mixed evergreen) forest[†]	1,027,544.1
• tropical thorn forest (Arid Zone)	NA
• riverine dry forest[†]	18,352.1
• grasslands (wet *pathana*, dry *pathana*, savannah, etc)[17]	>75,000.0
Inland wetland ecosystems	
• flood plains	NA
• swamps	NA
• lentic waters (tanks/reservoirs and ponds)[17]	169,941
• river basins[18]	5,924,500
• wet villu grasslands[19]	12,500
Coastal and marine ecosystems	
• mangroves[4]	6,080
• salt marshes[4]	23,819
• sand dunes and beaches[20]	19,394
• mud flats[20]	9,754
• sea grass beds	NA
• lagoons and estuaries[4]	129,075
• coral reefs[21]	68,000
Agricultural ecosystems	
• paddy lands[x]	977,561
• fruit cultivations[x]	85,066
• small crop holdings or other field crops (pulses, sesame etc)[x]	130,297
• vegetables (including, root and tuber crops)[x]	85, 663
• crop plantations (major export crops)[+]	716,320
• minor export crops[††]	119,862
• home gardens (cultivated)[††]	76,483.2
• *chena* lands (slash and burn cultivation)	NA

Sources: CCD (2006)[4] ; MENR, 2009[17]; Manchanayake and Madduma Bandara (1999)[18]; IUCN and CEA (2006)[19]; MOENR (2003)[20]; Rajasuriya, (2007) [21]; Forest Department unpublished data for 1999[†]; Department of Agriculture unpublished data provided for this report [x]; Composite of data from Central Bank, Sri Lanka, (2010)[+] ; Data from the Department of Census and Statistics (2010).[††]

[f] SCBD (2003)[1] follows IPCC (2002) [16] where references to traditional peoples mean local populations who practise traditional lifestyles that are often rural, and may or may not be indigenous to the location.

[g] The impacts of climate change on inland surface waters, both natural and man-made, with the focus on irrigation and water for domestic use, have been addressed in detail under the SVP for the Water Sector. This document focuses only on impacts of climate change on ecosystem functions, species and bio-resources in inland surface waters.

BOX 2: ECOSYSTEM SERVICES

The most crucial ecosystem services are:

- *Supporting services (that help maintain the conditions for life on earth)*: Soil formation and retention; nutrient cycling; primary production; pollination; seed disposal; production of O_2; provision of habitats.
- *Regulatory services (i.e. benefits from regulation of ecosystem processes)*: Air quality maintenance; climate and water regulation; flood and erosion control; water purification; waste treatment; detoxification; human disease control; biological control of agricultural and livestock pests and disease; storm protection.
- *Provisioning processes (i.e. products obtained from ecosystems)*: Food; wood fuel; fiber; biochemicals; pharmaceuticals and natural medicines; genetic resources; ornamental resources; freshwater; minerals, sand and other non-living resources.
- *Cultural services (i.e. non-material benefits obtained from ecosystems):* Cultural diversity and identify; spiritual and religious values; knowledge systems; educational and aesthetic values; social relations; sense of place; cultural heritage; recreation and ecotourism; communal; symbolic.

Source: Millenium Ecosystem Assessment 2003 Report "People and Ecosystems: A framework for assessment" cited in SCBD, 2003[1]

Example ecosystem services:
At the global level, terrestrial and oceanic ecosystems with their component species have absorbed at least half the carbon that is currently emitted to the atmosphere from human activities, therefore slowing the rate of global climate change.
Source: SCBD, 2003[1]

In addition to their environmental value, Sri Lanka's varied ecosystems provide many services that are of significant economic value. Despite the fact that all ecosystem services (BOX 2) are not marketable, and many pass unrecognized, they play a crucial role in providing goods and services to meet local and national needs.

The subsequent sections featuring specific aspects of biodiversity in forests, freshwater wetlands, coastal and marine systems and agricultural systems, provide greater detail on the ecosystem services and bio-resources they offer, and the specific pressures that jeopardize the provision of these services and render such ecosystems more vulnerable to adverse impacts of climate change.

Species diversity

As could be expected, the high ecosystem diversity in the island has given rise to a large number of indigenous species, including a remarkably high percentage of endemics among both fauna and flora (**Table 2**). Not surprisingly, Sri Lanka is considered to be the richest per unit area in the Asian region with regard to mammals, reptiles, amphibians, fish and flowering plants,[22] and is only second to Malaysia with regard to the density of bird species per unit area.[22]

Sri Lanka is notably one of the richest countries for amphibian diversity with 3.9 species per 1000 sq km (Goonewardena, et al, 2006),[23] and is far ahead of Costa Rica which scores second with regard to amphibian diversity per unit area (Manamendra-Arachchi and Pethiyagoda, 2005).[24] While the number of amphibian species in Sri Lanka may increase further with the description of several newly discovered species (ibid), there have been extinction of 21 amphibians during the past two centuries, the reasons for which are not yet clear.

In addition to the 670[h] species of indigenous vertebrate species (excluding marine forms) in the country, there are 272 species of migrant birds that visit the island annually (**Table 2**). Endemism (284) among indigenous vertebrates (sans the migrant birds) is about 42%, with highest endemism among amphibians, freshwater fishes and reptiles that are poor dispersers. 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 2**).

Snails are generally considered very sensitive to climate change. Sri Lanka's land snail fauna are unique due to the presence of more Gondwana relict species compared with India (Naggs and Raheem, 2000).[25] They include a total of 14 species from five endemic genera that are considered geographically restricted relict species.[26]

The molluscs of Sri Lanka are considered the most distinctive in the South Asian Region, with exceptional endemism and diversity displayed by land snails.[25,26] Among the other invertebrate groups that have been studied to some extent (**Table 2**), endemism is notable among freshwater crabs (98%) and dragonflies (48%). Similarly the island contains a rich diversity of about 3,771[i] indigenous flowering plants of which a quarter are endemic.[27] While the lower plants are less well known, a high diversity among them is suspected from the limited studies that

[h] This is by taking the number of residents as 220 as per Table 2. IUCN and MoENR (2007) gives this number as 677,with 227 residents

[i] Figures vary slightly. Out of 4,143 species listed in Senaratna (2000)[28], only 75% are stated as indigenous. Of these, 27.53% (854) are endemic.

have been carried out. Many of these groups are highly susceptible to environmental changes, such as pteridophytes (Dr D S A Wijesundara, pers.com 2009).

Much of the endemic species of Sri Lanka are concentrated in the rainforests of Sri Lanka's Wet Zone,[3,6] which are heavily dependant on rainfall and humidity to maintain their structure and function. A unique feature is that Sri Lanka has many endemic rainforest species among both plants and animals that are 'point endemics': restricted to extremely small areas within a single forest.[13] Further, the various geo-evolutionary and geological processes in Sri Lanka, coupled with spatial variations in climate and topography, have also promoted isolation of species resulting in a large number of 'geographically relict species'.[13] Several endemic relict genera are recorded among the land snails[13,26] and herpetofauna.[13,29] A significant complement of geographically relict endemic species occur in the high elevation cloud forests of the island.[13] Species diversity is also high in coastal and marine systems that are important to sustain the food and ornamental fishery. Among these are 27 cetaceans, the dugong and five species of turtles,[4] many of which are globally threatened. Due to a long history of agriculture, Sri Lanka has a wide range of cultivated species. In addition, there are also many wild relatives of crops that occur in forests and other wild habitats that can contribute positively to national and global food security in the face of climate change.

TABLE 2*:* Species diversity among selected groups of Sri Lanka's fauna and flora in terrestrial and freshwater wetlands[j]

Taxonomic group	Number of species	Number of endemic species and % endemism
Land snails	246	204 (83%)
Dragonflies	120	57 (48%)
Bees	148	21 (14%)
Butterflies	243	20 (8%)
Spiders	501	NA
Freshwater crabs	51	50 (98%)
Freshwater fish	82	44 (54%)
Amphibians	106 +	90+ (85%)
Reptiles (terrestrial)	171	101 (59%)
Birds (including migrants)	492 (220 residents)	26 definitive* and 7 proposed *(i.e. 5% of all species and 12% of residents)*
Mammals	91	16 (18%)
Angiosperms	3,771	926 (25%)
Pteridophytes (Ferns only)	348	48+
Mosses	566	63+
Liverworts	222	NA
Lichens	661	NA

NA= data not available

Source: IUCN and MoENR, 2007[27] except for freshwater crabs (Beenaerts, et al*, 2010)[30] and birds (Kotagama and Ratnaweera, 2010).*[31]

About 38 species of fauna and 20 species of flora (some of which are now domesticated) have already reached, or have high probability of reaching, invasive proportions in the country.[20] IAS pose serous threats to

[j] The total number of species in groups provided in **Table 2** is from the 2007 Red List of Threatened Fauna and Flora of Sri Lanka reference 27), except for birds and the number of endemics among freshwater crabs. As some of the figures in the 2007 Red List vary from the papers presented in *The Fauna of Sri Lanka: status of taxonomy, research and conservation* published by IUCN and the Government of Sri Lanka in 2006, it was understood that the preparers of the 2007 Red List had since updated figures for some of the faunal groups using the most recent publications. As the scope of this report is to provide justification to understand the importance and richness of Sri Lanka's biodiversity rather than to provide an inventory of the country's species diversity, it was decided to use the figures in the 2007 Red List which forms the most up-to-date published compilation of Sri Lanka's fauna, with the exception of freshwater crabs[30] and birds[31] for which authors provided the preparers of this document with the most recent published figures. For more information the reader is referred to IUCN and GOSL (2006) for a comprehensive account of Sri Lanka's faunal biodiversity as presented by experts working on respective taxonomic groups.

indigenous species and ecosystems,[27] and it is suspected that some freshwater fish fauna are already affected by exotic fish species.[32]

Genetic diversity

Genetic diversity is relatively well known among agricultural crops which show a range of varieties and land races, particularly among grains, cereals, vegetables and root and tuber crops. Some of them show marked adaptations to various climatic conditions. Several local crop varieties are also resistant to pests and disease, and in the case of some traditional varieties of rice, to adverse climatic conditions such as droughts, high soil salinity, and submergence. There are also some indigenous breeds of livestock that are resistant to pests and disease and have low nutritional requirements.[33] These indigenous varieties and breeds[k] are believed to offer a valuable pool of germplasm for genetic improvement of crop and livestock species in the face of climate change.

"The degree of genetic variability within species can be important for maintaining ecosystem performance and for allowing continued adaptation to changing conditions.[1]

Chemical weapons with potential for bioprospecting in the biological gold rush . . .

Even though bio-prospecting marine resources for medicinal use is considered time-consuming and economically risky, many are used in technology and industry . . . "So far, relatively few marine plants, animals and microbes are responsible for an impressive yield of more than 12,000 new chemicals. . . . Most bioprospecting experiments have been carried out in the tropical seas. Coral reef ecosystems are first choice targets because they are characterized by high biodiversity and intense competition for space, leading to a chemical warfare among sessile organisms . . . Soft bodied sessile invertebrates in particular, such as sponges, soft corals, sea-fans and sea-squirts, are renowned for their refined chemical arsenals of bioactive compounds because they lack the means for mechanical defence. They are among the least studied marine organisms, with new species discovered almost daily."

Source: Meliane, I. (2004). A Biological gold rush. World Conservation, *Volume 35, No 1. p 20.*[35]

Genetic diversity among wild species in Sri Lanka is less well known than for crops. However, a substantial genetic diversity is inferred among both wild flora and fauna from the variations in morphological features that are seen, particularly among mammals.[3,6] For example, some groups, such as the primates, show clear morphological variation in different climatic zones regions,[34] suggesting adaptation to specific environmental conditions. Genetic diversity thus offers much scope for future investigation in Sri Lanka in the face of adaptation to climate change, especially in view of the increasing global interest in bioprospecting. While conservation of genetic diversity in wild species has not been prominent in Sri Lanka's previous conservation programmes, some measures have now been initiated to conserve genetic diversity of selected species by the National Botanic Gardens (Dr S Wijesundara, pers. com, 2010) and the National Zoological Gardens.

- *Forests*

Status

Natural forests: Sri Lanka's forest cover according to the most recent estimate is 29.6% of the land area, with closed canopy natural forest amounting to 22.4% of the island (**Table 3**)[l]. The influence of climate on forest formations is shown by the characteristic variations between forests of different climatic zones. Each forest type, even in the lowland and montane forests of the Wet Zone, has a complement of fauna and flora and forest formations that are distinct from the others.[13]

Diversity of forests in Sri Lanka

"For a relatively small country, Sri Lanka shows a marked diversity of forest types due to differences in spatial distribution of rainfall, altitude and soil. Within the Wet Zone, forests grade from lowland, sub-montane and montane rainforests with increasing altitude. Sri Lanka's dipterocarp-dominated lowland rainforests have a characteristic dense canopy of trees with straight boles reaching 30-40 m in height, with emergents rising through the canopy to about 45 m. These forests, as do other rainforests, also have an abundance of woody lianas. The canopy height of Wet Zone forests show a progressive decline, as wet lowland and midland forests that occur between 0-1000 m transform into sub-montane and montane forests at elevations of above 1000 m. Patches of unique pygmy forests occur in some montane areas above 2000 m. The lowland Intermediate Zone contains yet another distinct group of vegetation termed tropical moist monsoon (evergreen) forest. Tropical dry monsoon (mixed evergreen) forests, with an overall canopy height of less than 20 m are found in the Dry Zone. Due to historical factors, the Dry Zone forests are secondary, although climax vegetation can be found in isolated hills such as Ritigala. These forests change into the characteristic thorny scrub forest in the driest areas of the north-western and south-eastern coastal regions. The level of endemism in Wet Zone forests ranges from 37 - 64 % for woody plants and 14 - 52 % for animals, compared with 10-16% for species in the Dry Zone forests."

Source: MoENR, 2009[6]

Dry monsoon forests (FIGURE 6) that cover the lowlands of the northern, north-central and eastern areas of the country are the most widespread, amounting to about 1,027,544.1 ha (**Table 1**). The Wet Zone covers about 12,205 km^2 in the southwest region of the island,[18] where rainforests provide habitats for about 90% of the country's woody endemic flora,

[k] See more details and examples under agricultural systems.

[l] This percentage is based on a land area of 6,562,500 ha for Sri Lanka as per the National Atlas, 2007.[2] Based on 6,616,628 ha of land area as in Legg and Jewell (1995) [36] it is 29.4% and 22.2% respectively.

about 75 per cent of the endemic fauna, and all the endemic genera.[3] The rainforests of the southern wet lowland hills and plains are also believed to be the richest species wise in South Asia.[11] However, these biologically valuable rainforests are severely fragmented, and the highly diverse wet lowland forests amount to only around 124,340.8 ha, while sub-montane and montane forests are even more scarce (FIGURE 6). As such, lowland rain forests amount to less than 2 % of the island's total land area, while wet sub-montane and montane forests add only a further 1 % and 0.05% respectively. The Dry Zone forests through less diverse than rainforests, are nevertheless important as the charismatic large ungulates, carnivores and primates show their highest species diversity in the Dry Zone. For example, the floodplains of the Mahaweli river in the Dry Zone form the most important habitat in the country in respect of wildlife biomass.[3] These forests are therefore of great value to the tourist industry.

TABLE 3: Comparison of Forest Cover in Sri Lanka in 1992 and 1999

Forest category	Total forest area (ha) 1992 *	Total forest area (ha) 1999 †
• Total extent of "closed canopy" forest	1,582,757	1,470,636.2
• Open Canopy Sparse Forest	463,842	471,583.2
• **Total natural forest cover**	**2,046,599**	**1,942,219.5**

*Source: *Legg and Jewell (1995)* [36] *and †Forest Department 1999 data provided for the 4th Country Report to the Convention on Biological Diversity*[6]

The National Conservation Review (NCR) enabled identification of eight forest complexes that contain over 79% of woody plant diversity and at least 83% of faunal diversity in the country, of which six are in the Wet Zone, and two are in the Intermediate and Dry Zones.[37]

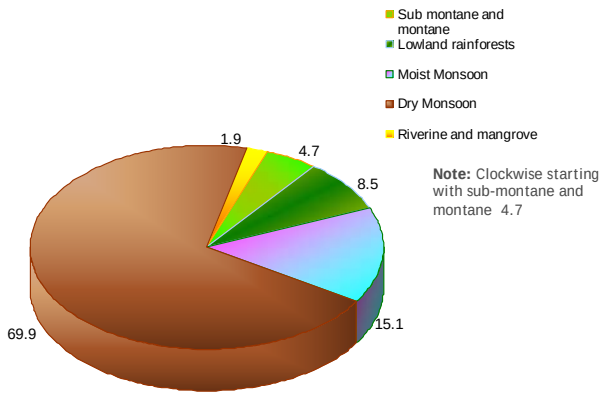


FIGURE 6: The percent composition of Sri Lanka's main natural forest categories in 1999.
Source: 4th Country Report to the Convention on Biological Diversity, 2009[6]

"The National Conservation Review (NCR) carried out by the Forest Department in the mid 1990s, comprised a major biodiversity assessment of all the island's natural forests over 200 ha. This survey identified the wet lowland rainforests as the richest among Sri Lanka's forests in terms of biodiversity and endemism, as well as of prime importance for soil and water conservation.[37] *These extremely fragmented wet lowland forests are also the last remnants of the once widespread mid-Miocene tropical rain forests of Sri Lanka. In terms of evolutionary importance among endemic species, the even more fragmented forests of the Montane Zone are the main habitats for the most conservative (ancient) faunal elements in the island, due to 'mountain top isolation' and least disturbance by faunal invasions from south India during the intermittent land bridges formed during the Pleistocene."*

Source: 4th Country Report to the Convention on Biological Diversity[6]

Sri Lanka's forests are also associated with several different types of grasslands,[17] comprising savannas that are important for medicinal plants, dry *pathanas* of the Uva basin, wet *pathanas* that occur in association with cloud forests at elevations around 2000 m, *damana* grasslands of the Dry Zone, *talawa* grasslands of the lowland Wet Zone and wet *villu* grasslands in the flood plains of rivers flowing through the Dry Zone.[6] The latter are particularly rich in biodiversity among the large grazing and browsing herbivores such as deer and elephant.[3]

Forest plantations: With the shift in emphasis of forest policy from production to protection, and the moratorium on logging natural forests for timber, forest plantations have became particularly important in

terms of timber production and wood products and to relieve pressure on natural forests. The total area of forest plantations maintained by the Forest Department currently is around 95,037 ha[m] (compared with 72,340 ha in 1992).[36] In the past**,** exotic species such as teak (*Tectona grandis*), *Pinus* and *Eucalyptus* comprised much of the total forest plantations, but planting *Pinus* has been discontinued after 1989.[n] Other exotic species used for forest plantations on a lower scale include *Swietenia macrophylla* (broad-leaf mahogany). Jak (*Artocarpus heterophyllus*) an indigenous species is also now increasingly used in forest plantations. **Table 4** indicates the extents of forest plantations under selected timber species in 1999 and 2009.

TABLE 4: Species planted in forest plantations by extent in 1999 and 2009

Species	Planted area in 1999 (ha)	Planted area in 2009 (ha)[↑]
Teak	31,700	30,436
Pinus sp.	16,500	15,776
Eucalyptus (up country)	9,175 (mainly *E. microcorys* and *E. grandis*)	18,256
Jak (*Artocarpus heterophyllus*) and Mahogany (*Swetenia macrophylla*)	2.800	5,002
Eucalyptus and *Accasia*	19,100 *E. camaldulensis, E. tereticornis, Acacia mangium* – mainly fuelwood species, in the Dry Zone	19,280 (Dry Zone)
Mixed and other species	12,225	6,287

[↑]Note: enrichment planting of natural forests with mahogany is not included here.
Source: Forest Department data for 1999 and 2009 provided for updating the 4th National Report to the CBD.

Forestation programmes continue to be carried out in degraded or barren lands, clear felled areas, and degraded forests and catchment areas. In keeping with the importance for increasing national tree cover in the current forest policy, many forestation activities are carried out in non-forested areas such as home gardens, roadsides, stream reservations and canal banks, school forest gardens and public places. Home gardens and other non-forest sources have contributed considerably to the tree cover of the country and to meet the national timber requirements. For example, Kandyan home gardens located in small plots, constitute a traditional system of perennial cropping that helps maintain canopy cover and a range of economically valuable tree species such as jak (*Artocarpus heterophyllus*), arecanut (*Areca catechu*) and coconut (*Cocos nucifera*). In addition, rubber and coconut plantations contribute to the country's timber and fuelwood needs, as do shade trees planted in tea plantations. Trees grown for shade, or as windbreaks, along roadsides and farm boundaries also provide timber and fuelwood. Trees from such non-forest areas have reduced the pressure on natural forests as sources of timber, fuelwood and other small wood requirements.

Ecosystem services

Forests in Sri Lanka also play a pivotal role in providing supporting and regulating ecosystem services. Among these are soil conservation, reducing flood hazards, watershed functions and trapping moisture through fog interception. Forests also continue to provide a range of essential goods and services and support livelihoods of people, especially in the rural areas of the Dry and Intermediate Zones. Forest dependency as a means of livelihood has dropped perceptibly in villages near Wet Zone forests during the past few decades, due to a shift towards cultivation of cash crops, though many villagers continue to obtain firewood, medicinal plants, food items and small wood requirements from adjacent forests.[38,39,40] Furthermore, rural villagers near Wet Zone forests depend heavily on freshwater from forests for their daily domestic requirements.[39,40] Hence loss or degradation of forests, resulting in reduced irregular water flows and drying up of natural springs and base flow of streams, will affect rural communities in the Wet Zone. Traditional activities such as crafts based on rattan and bamboo products, that were once major forest based sources of income in the Wet Zone, have declined during the last decades due to diminution of the raw materials within forests by over-exploitation. [38]

Issues

Forests and grassland related issues: Deforestation has resulted in the island loosing approximately 50% of its forest cover within about 50 years during the last century due to expansion of irrigation, human settlements, agricultural development, and other non-forest

[m] Forest Department unpublished data for 2009 provided for updating the 4th National Report to the CBD.
[n] Information provided by the Forest Department, 2009 for preparation of the 4th NR to the CBD

development activities such as hydro-power generation, resulting in the area under closed-canopy dense natural forests declining from 44% (2.9 million ha) in 1956, to 26.6% (1.76 million ha) and 23.9% (1.58 million ha) of the land area respectively in 1983 and 1992;[36] and to 22.4% in 1999[o] as per Forest Department data for 1999. The rate of deforestation was high from 1956 to 1992, but it is believed to have dropped perceptibly since then due to the adoption of various conservation measures that include better forest management and law enforcement to prevent logging and encroachment by local people. At present encroachment into Wet Zone forests by local people for tea cultivation has been largely stemmed due to boundary marking of reserves through the Forest Resources Management Project. Clearing for plantation agriculture during colonial rule and forest encroachments for cash crops in the Wet Zone until recently have, however, already reduced many of the valuable Wet Zone forests to small fragmented patches of forests. Further, although the rate of annual deforestation has decreased, this could increase due to forest clearing and conversion for various development purposes in the future.[p]

Among the key issues[q] that currently affect forests are:

- The degradation of both Dry Zone and Wet Zone forests over a long time period has had considerable impacts on forest biodiversity.

- Although there are laws and regulations in place to address illegal deforestation which has decreased in recent years, relevant enforcement agencies are not always adequately consulted during initiatives to convert forest land for development purposes.

- Unplanned forest clearing to establish reservoirs for hydro-electric generation, human settlements and agriculture in the Dry Zone—often with crops that attract elephants—during the last century has resulted in drastic loss of habitats, food sources and migration routes for the elephant. This has led to increased vulnerability of elephants to poaching and intensified the human-elephant conflict.

- Many small Wet Zone reserves that could serve as faunal refuges are too small, degraded and isolated to provide this service. This is also leading to increased human-wildlife conflicts in the wet zone – especially with regard to primates[r] that are now increasingly invading home gardens adjoining such forests.

- The above issue is further exacerbated by further loss of connectivity between Wet Zone forests due to the recent trend for loss of connective canopy cover in surrounding non-forest areas, due to: (a) spread of urbanization into rural areas and increasing human population density that results in loss, fragmentation and degradation of tree cover in home gardens, and (b) loss of crop plantations (e.g. rubber and coconut) for housing and development activities. This loss of canopy cover also affects biodiversity outside natural forests due to isolation and pocketing of faunal populations and loss or severe degradation of existing modified habitats and habitat connectivity.

- The past practice of reforestation and afforestation with exotic species has compounded forest degradation in the Wet Zone. These species are not used for food by local faunal species and some of these exotic species are suspected to have affected the water table in adjacent human settlements.

- Many forest species that yield bio-resources have been listed as threatened during preparation of successive lists of nationally threatened species due to over–exploitation in the past.

- Invasive alien species (IAS) have reached threat proportions in several natural forests in both the Wet and Dry Zones. Examples are *Lantana* spp. at Uda Walawe National Park; *Ulex europeus* at Horton Plains National Park and *Prosopis juliflora* at the Bundala National Park.

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[o] This percentage is based on a land area of 6,562,500 ha for Sri Lanka as per the National Atlas, 2007.[2] Based on 6,616,628 ha of land area used as in Legg and Jewell (1995)[34] it is 22.4%.

[p] Input from the workshop to discuss the Biodiversity and Ecosystem Services SVP.

[q] Issues identified through workshops and discussions when preparing the 4th National Report on Biodiversity for the CBD by MoE, validated and added to at the workshop to discuss the SVP on Biodiversity and Ecosystem Services, and through individual consultations. Some issues are from published references which are cited.

[r] One of these primates (*Semnopithecus vetulus nestor*) is critically endangered and highly arboreal. The more terrestrial macaque is increasingly viewed as a serious pest by wet zone villagers (Dela, unpublished data).

- Accidental and intentional firing of grasslands and forest fires in biologically diverse forests such as Horton Plains and Knuckles forest affect biodiversity. Much of the firing is intentional – attributed to pyromania rather than for forest use.

- Forest die back has been observed in many forests with high biodiversity value (e.g. Knuckles Conservation Forest and Horton Plains National Park) for which the cause is still undetermined. This is further compounded by tree species specific die-back (among dominant species) in both Wet and Dry Zone forests. The latter could be due to climate change impacts on tree species which could lead to major changes in forest composition.

- *Eucalyptus* spp. grown for timber value to decrease pressure on natural forests for timber have been recently affected by *Leptocybe invasa* – an alien species of wasp common in India. This could increase the pressure on forests for national timber requirements.[s]

- There is poor knowledge as yet on the impact of climate change on natural forests or its adverse impacts on species they contain (e.g. the plasticity of forest species with regard to climate change responses is not known). Impacts on forests in fringe areas between climatic zones and in the Intermediate Zone are also unknown.

- River reservations that could act as forest linkages and refuges for wildlife outside natural forests are degraded or lost as there are no legal provisions for the Forest Department to manage them. The Land Commissioner can issue permits and lease out such land on an annual basis. This issue is exacerbated by overlapping legal and institutional arrangements for protection of river reservations.

Terrestrial species related issues: The percentage of species that are threatened among the faunal groups and flowering plants assessed during the preparation of the 2007 National Red List are given in **Table 5**.[27]

- Among the vertebrates, the percentage of threatened species is highest for amphibians and mammals. This is reflected by the fact that 21 species of amphibians have become extinct during the past 100 years.[27]

- Among the terrestrial invertebrate fauna, the highest number of threatened species is among the butterflies—amounting to 27% of butterfly species assessed.

- Significant local extinctions have occurred among several mammal and bird species in the Wet Zone due mainly to loss or disturbance of tree cover in natural as well as terrestrial modified areas, and the loss and degradation of wetland habitats.[27]

- Most of the threatened terrestrial vertebrates and fishes are located within the Wet Zone with a high human population density.[27]

- Among the 1099 indigenous angiosperm

TABLE 5: Nationally threatened fauna and flora of Sri Lanka from selected taxonomic group

Group	Species in the 2007 Red List of Threatened fauna and flora of Sri Lanka	
	Number Assessed for threat *(no. of endemics in parenthesis)*	Number threatened *(no. of endemics in parenthesis)*
Land snails	246 (204)	33 (32)
Freshwater crabs	51 (51)[t]	37 (37)
Dragonflies	120 (57)	20 (20)
Butterflies	243 (20)	66 (13)
Therapsid spiders	7(5)	1 (1)
Freshwater fishes	82 (44)	28 (20)
Amphibians	106 (90)	52 (51)
Reptiles	171 (101)	56 (37)
Birds (residents only)	227 (33)[u]	46 (16)
Mammals	91(16)	41(14)
Evaluated vertebrates	677 (284)	223 (138)
Evaluated Flowering plants	1099 (553)	675 (412)

Source: IUCN and MOENR, 2007[27]

[s] Currently there is a moratorium on logging in natural forests, and the island's timber needs are met from forest plantations.
[t] The number of endemic crabs have since been reduced to 50.[30]
[u] The number of species and endemics are listed here as given in IUCN and MENR, 2007[27] – so that some figures are not the same as in Table 2.

species assessed, 675 species were found to be threatened, of which 412 (61%) are endemics, and 23% are Critically Endangered; a further 72 species (6.6%) out of the total number assessed had already become extinct (including one species that was extinct in the wild).[27]

- There is a perceived decline in the population of bees and wasps that are important pollinators, which could affect agriculture and natural biodiversity.

- The dipterocarps with a remarkable endemicity in Sri Lanka comprised 6.2% of the threatened plants in the list, with 42 species threatened out of 58 assessed (of which all were endemic). Most of the threatened dipterocarps are confined to the Wet Zone. [27]

- Loss, modification, fragmentation and degradation of natural habitats are the prime threats for many of Sri Lanka's terrestrial and freshwater species now being pushed towards the brink of extinction.[27]

- Forest loss, fragmentation and isolation have caused several species to undergo local extinctions. Among those most affected are arboreal endemic mammals (e.g. the purple-faced langur (*Semnopithecus vetulus*), the golden palm civet (*Paradoxurus zeylonensis*) and the red slender loris (*Loris tardigradus*).[27] Some plant species are also showing signs of future genetic isolation due to extreme fragmentation of habitats and hence populations.[v]

- Over exploitation of forest species of resource value has already depleted many such resources, and affected those who depended on those raw materials (from forests) for their livelihood.[38] This has led to loss of many traditional occupations and the related crafts and knowledge. Ornamental plants and fish species of commercial value are similarly affected due to over collection from the wild.[6]

- Hunting and poaching has aggravated the threat status of many vertebrate species, such as the leopard, which is shot and speared for skins and also prone to be killed by snares set for other species such as wild boar and deer hunted for meat.[27]

- A population decline has been observed for orchids and pteridophytes, believed to be due to climate change.[w]

- The nature and extent of forest resource use varies according to location and socio-economic level of the local communities. However, depletion of non-timber forest resources has occurred in all climatic zones due to over exploitation of species of commercial or subsistence value.

- Pollution and siltation caused by improper land use has adversely affected aquatic fauna and flora and some of the lower plants. For example, several mosses and liverworts and the fern *Schizaea digitata* have disappeared from around the city of Colombo, which is attributed to pollution. Similarly, there is evidence that forest dieback in the montane rainforests of Horton Plains National Park may be due to air pollution and acid rain in far off urban areas.

- Species specific die back observed for some dominant species in forests could be due to climate change.[v] If so, other species could show similar responses in the future with increasing ambient temperatures. This could lead to major changes in forest composition.

- Agrochemicals such as fertilizers and pesticides have adverse impacts on air, water and soil, and on terrestrial species.

- Sand and gem mining in forests and rivers have had adverse impacts on forest and wetland fauna and flora.

[v] Prof. I A U N Gunatilleke, personal communication during preparation of this report.
[w] Dr D S A Wijesundara, Personal Communication during preparation of this report.

- *Inland wetlands*

The Convention on Wetlands of International Importance especially as Waterfowl Habitat (also called the RAMSAR Convention) defines wetlands as "areas of marsh, fen, peatland or water, whether natural or temporary, with water that is static, flowing, fresh, brackish or salt, including areas of marine water, the depth of which at low tide does not exceed 6 m." In more simple terms, wetlands are habitats with permanent or temporary accumulation of water with associated floral and faunal communities

Source: IUCN SL & CEA, 2006.[19]

"Wetlands, both natural and man-made, were the centres of Sri Lanka's ancient hydraulic civilization that thrived for over a thousand years and formed the hub of its [Sri Lanka's] cultural, economic and social evolution. Due to the system of land use adopted in ancient times, catchment areas and other important wetlands in the uplands were preserved under forest cover, while the Dry Zone lowlands were irrigated using water from thousands of rainfed tanks dotted throughout this region. This system of land use served to conserve the biodiversity of natural wetlands. There is also evidence that the conservation of biodiversity in man-made tanks was given consideration in Royal Decrees as early as the twelfth century A.D."

Source: MOFE, 1999.[3]

Sri Lanka has a range of natural inland wetlands, comprising rivers and streams, riverine floodplains/*villus,* small isolated freshwater bodies, freshwater springs, seasonal ponds, and freshwater marshes (permanent and seasonal) and swamps.[3,19]

The main component among wetlands is the network of 103 major rivers that constitute a total collective length of about 4,560 km; forming 103 river basins **that** cover an area of 59,245 km^2,[18] which is about 90% of the island's land area. These river and stream basins vary in size from about 9 km^2 to more than 10,000 km^2.[18] All major rivers originate in the central highlands of the Wet Zone and radiate across the lowland plains into the sea, forming a large number of scenic waterfalls when streams and rivers flow sharply down from high and mid altitudes. The headwaters of major rivers, including the *Mahaweli, Kal*u and *Kelani,* are located in the forests of the central highlands in the Wet Zone.[19] The rivers flowing with their entire course in the Wet Zone are mainly perennial, and account for about 49% of the total mean annual yield of all the rivers in Sri Lanka,[18] and some have a propensity for flooding during high intensity rainfall. Many rivers that originate and flow mainly through the Dry Zone are seasonal;[18] some rivers and their tributaries in the Dry Zone supply water to the floodplains and to numerous irrigation reservoirs.

Sri Lanka's riverine floodplains contain saucer-like depressions (villus) that become inundated with the overflow from rivers during the rainy seasons and contract during drought conditions. The cyclic variation in habitat conditions due to fluctuations in salinity and the depth of water is an important ecological feature that fashions the biodiversity and productivity of villus.[3]

Source: MOFE, 1999.[3]

The extensive marshes and swamps associated with rivers form important wildlife habitats.[3] The *villu* wetlands cover about 12,500 ha and are formed by the cut off of river bends.[19] Many of the larger *villus* are located in the *Mahaweli* floodplains.[19] Other freshwater marshes include: shallow depressions that receive water from a river, surface water run-off, or groundwater seepage, and are characterized by water logged sticky soil (e.g. such as the Muthurjawela Marsh)[19] as well as swamp forests with trees that are adapted to grow in shallow stagnant water and are seasonally inundated (e.g. the Walauwatte Wathurana swamp forest).[19] There are also inland salt water *villus* that are seen as shallow water bodies of the Wilpattu National Park and form a unique wetland ecosystem.[19]

Man made wetlands

Sri Lanka does not have natural inland lakes, but this gap is bridged by several large multi-purpose and hydropower reservoirs and a network of manmade irrigation tanks that number over 10,000, with their associated canals (FIGURE 5) and rice paddies.[3] Other man-made wetlands comprise aquaculture ponds. The total area under paddy cultivation is currently 977,561 ha **(Table 1),** which is about 15% of the land area of the country. Rice fields have standing water for long periods of time, and when flooded form agronomically managed marshes that provide seasonal aquatic habitats for wildlife.[19]

Wetland species

Natural and man-made wetlands provide habitats for a unique freshwater fauna and flora that contain a large complement of endemic species. Endemism is high among freshwater fish, crabs (**Table 2**) and other aquatic invertebrates such as ostracods, freshwater prawns and mayflies.[3] The structural diversity of the wetland vegetation and the availability of water and open spaces create ideal habitats for other wildlife, especially for the grazing mammals, avifauna that include many migratory species, and a number of reptiles and amphibians, of which many are endemic. The importance of wetland habitats are shown by the fact that 30% of inland vertebrate species are ecologically dependant on wetlands; about 32% of nationally threatened vertebrate species and more than 50% of all migrant birds also depend on wetland ecosystems.[19] Tanks and reservoirs of

the Dry Zone, as well as natural wetlands in the region provide refuges for many aquatic birds. Urban freshwater marshes, such as the Bellanwila-Attidiya sanctuary, provide habitats for birds,[19] and are important for flood retention. The *Mahaweli* Ganga and its tributaries alone are associated with about 10,000 ha of freshwater riverine marshes, which are highly productive and rich in biodiversity and are the habitat of large mammals like the elephant, deer and leopard.[3]

Different niche requirements of wetland plants

"Different types of wetlands have characteristic species associated with them. Among the flora, species composition may vary in a single river at different points. In the uplands where the rivers originate, there is fast-flowing water, and these streams and rivulets contain simple aquatic plant communities and species that are segregated based on their degree of tolerance of the speed of water flow. In the lowland streams and rivers, and in shallow tanks and ponds, there are various rooted aquatics with floating or submerged leaves as well as submergent macrophytes. The deeper reservoirs contain floating plants, fresh water algae and several species of diatoms. The shallow village tanks often support phytoplankton, while the shallow submerged areas contain grasses, sedges and several other herbaceous species. The tank margins have sedges, rushes and emergent vegetation. Shrubs and other small trees may occur in the adjacent high ground. Riverbanks support gallery forests. The riverine vegetation gradually merges into the natural forest typical of a given area."

Source: MoENR 2002[41] adapted from MOFE, 1999[3]

The species composition and biodiversity of a freshwater wetland depends on the climatic zone in which it is located. The rivers and streams that originate in the rainforests of the Wet Zone provide the main habitats for indigenous freshwater fish, including almost all the endemic species. The wet *pathanas* in the montane region (typically at Horton Plains) are unique in their characteristic wetland flora. The irrigation tanks in the Dry Zone are the home of some species of fish found only in this region.

Ecosystem services

The scale and technology used for ancient irrigation tanks and rice fields in Sri Lanka stand testimony to a rich cultural heritage associated with wetlands.[18,19] Even today, **w**etlands provide many functions that make them invaluable to the people of Sri Lanka. Chief among such wetland functions are their importance as a source of: freshwater for domestic use, irrigation and agricultural production; medicinal herbs; raw material for handicrafts and mats; food fish and crustaceans; ornamental plants and fish; material for religious and ritualistic uses; hydro-electricity generation; and recreation and tourism.[3,19] In addition, wetlands provide essential habitats for wildlife—particularly for fish and water birds; marshes, tanks and rice fields help mitigate floods; and marshes serve to purify water, remove toxic compounds and act as carbon sinks.

Issues

Despite their importance, most wetlands in Sri Lanka face compound threats that are mainly of anthropogenic origin. Consequently most aquatic ecosystems have deteriorated. The main issues in wetlands are[x]:

- Habitat deterioration/degradation is caused by reclamation, landfills and clearing of vegetation in urban wetlands for housing and commercial and industrial development.[3,19] Urban marshes that function as flood retention areas during extreme rainfall events, and also provide habitats for urban wetland biodiversity, have been severely affected.

- Loss of wetlands have led to local extinction and drastic reduction of species associated with these ecosystems.[3,19]

- Resilience of wetlands systems are decreased by:
  - siltation caused by poor land use in lands adjacent to or away from wetlands, which results in the loss of wetland area and species that need clear water.
  - garbage disposal and pollution from agro-chemical run-off, sewage and industrial effluents that degrade wetlands and cause loss of species and eutrophication. Such actions are also harmful to humans in the area.
  - sand mining and illegal gem mining in rivers, which has caused degradation and loss of habitats and species.

- Badly planned irrigation structures can change water quality of wetlands and hydrological alterations due to regulation of water flow by dams have led to loss of downstream wetlands.[19] Especially affected are

[x] Issues identified through workshops and discussions when preparing the 4th National Report on Biodiversity for the CBD by MoE validated and added to at the workshop to discuss the SVP on Biodiversity and Ecosystem Services, and through individual consultations. Some issues are from published references which are cited.

coastal *villus* in the Dry Zone.

- Natural phenomena such as prolonged droughts cause seasonal drying up of several tanks, streams, salt marshes and lagoons, causing the death of wetland faunal species periodically. Such phenomena may become more frequent with climate change.

- Exploitation by over-harvesting ornamental fish and plant for trade has caused direct loss of wetland species; excessive poaching for consumption of some wetland species has reduced resilience of wetland ecosystems.

- Changes in fishing habits have led to exploitation of inland wetlands that were not used before, adversely affecting the breeding grounds of fish and causing a chain reaction in the affected wetland systems.

- The spread of invasive alien species in wetland systems is already threatening some aspects of native aquatic species.

- Vast scale conversion of lowland marshes to other uses have already caused local extinction of species such as the threatened fishing cat (*Prionailurus viverrinus*) and the otter (*Lutra lutra*).[27]

The spread of Invasive Alien Species (IAS) is proving to be a real threat to native wetland species. During the past five years 10 species of IA fauna and 12 species of IA flora have been recorded in wetland ecosystems of Sri Lanka. Among them are 4 species of fish and two species of flora that are listed among the world's worst 100 IAS.

Source: IUCN and CEA, 2006[19]

- Climate change impacts such as variability of rainfall and changes in hydrological cycles, salt water intrusion and changes in salinity of coastal freshwater wetlands will have adverse impacts on biodiversity.

- *Agricultural systems*

At present agriculture contributes 12% to the country's GDP,[42] and about 32.7% of the labour force is engaged in agriculture, fishing and forestry.[43] About 250,000 farmers were cultivating cash crops such as chilli, onion and potato by the end of the last century,[44] about 75,000 families are currently involved in the poultry industry.[y] The Sri Lankan agricultural scene is dominated by small-holders, who cultivate small holdings, often less than 1 ha.[3] The agricultural landscape of the country consists mainly of rice paddies, plantation crops (tea, rubber, coconut and sugarcane) and minor export crops (such as coffee, cocoa, cinnamon, nutmeg, mace, cardamom, pepper, clove, cashew, arecanut, betel leaves, essential oils such as citronella, and un-manufactured tobacco); fruit crops; vegetables, root and tuber crops; and other field crops consisting of about 100 species used as food such as chilli, onion, cereals, grain legumes, condiments and oilseeds. Home gardens too contribute significantly to the agricultural landscape. Overall, over more than 2,000,000 ha of land are under some form of cultivation (*Data from Ministry of Agriculture provided for this report*).

Crops

Sri Lanka's traditional farming systems have developed over hundreds of years, with farmers managing production systems to best suit their local conditions. Rice fields, crop plantations, vegetable plots, *chena* plots and home gardens constitute the main habitat for crops. In view of the forty six agro-ecological regions that are identified in Sri Lanka, based on variations in soil, annual rainfall and altitude,[2] it is not surprising that the country supports a wide range of

Farming systems

- *Sri Lanka's traditional paddy fields are both rainfed and irrigated. Paddies in the Dry Zone are rain-fed from the north-east monsoon during the* Maha *season and irrigated in the non-rainy period or* Yala *season. Paddy fields in the Wet Zone are rainfed, forming open systems in flat lowland areas, and terraced systems in hilly areas, to maximize land use to suit the local terrain and rainfall.*
- *Chena, or slash and burn cultivation, though environmentally destructive, provides a high diversity of cereals and vegetables that have been subject to selection by farmers over time. Fallow chena lands provide food for invertebrates such as butterflies, and large mammals such as elephants and deer. In the past, chena cultivation was a traditional activity with associated cultural practices, and involved long fallow-periods to permit recuperation of the forest ecosystem. However, chena cultivation in recent times is a major cause of forest degradation in the Dry Zone.*
- *Home gardens constitute a traditional system of perennial cropping for a wide range of valuable crops, and are known to be particularly important for maintaining the high species and genetic diversity of fruit and vegetables.*[3] *These lands make a substantial contribution to agricultural production in the country, and also play a perceptible role in maintaining canopy cover, ameliorating the local climate, and providing timber and wood products.*[44] *Forest analogue home-gardens, or the typical 'Kandyan home gardens' that demonstrate diverse agricultural systems, are also repositories of indigenous traditional knowledge on agricultural practices that could be of great value when addressing adaptation measures for climate change. Home gardens in the Wet Zone are, however, increasingly fragmented, due to decreasing land-man ratio in the region, resulting in considerable localized loss of canopy cover and erosion of indigenous horticultural crop diversity.*

[y] Data received during preparation of this report.

landraces or traditional varieties. Some of these are clearly resistant to diseases and insect pests, and are suited for varied conditions of soil and climate in the island.[3] Most land races have been subjected through the ages to farmer selection and introduction to new areas and climatic conditions, and are consequently well adapted to their new environments, but are also still close genetically to their wild relatives.

Sri Lanka has many traditional varieties of rice that exhibit a wide range of genetic characteristics with potential for varietal improvement. Among these are traditional upland varieties well known for their drought tolerance; varieties grown in the coastal areas and floodplains of rivers that possess tolerance of submergence and flash floods; a few rice varieties cultivated at higher elevations (over 1000 m) and grow at low temperatures; and several varieties that show broad-based resistance to serious pests, high salinity and other adverse soil conditions.[3] *For example, the traditional rice varieties* Murungakayan *and* Podiwee *are resistant to blast,* Dahanala *and* Kalubala wee *are resistant to thrips, while* Rathuheeneti, Sudhuru samba, Suduhanditan, Balamawee, Mawee, Hondarawalu *and are resistant to the brown plant hopper (BHP).*[†] *The traditional rice variety* Pokkali *has natural resistance to high salinity, through a characteristic water absorption system and ability to oust sodium, but is low yielding.*[↑] *This variety is used by the DoA as a foundation to produce new varieties that could meet the impacts of climate change by introducing favourable characteristics to high yielding rice varieties.*[↑]

(Sources: MoFE, 1999[i]; PGRC/DoA unpublished data provided for preparation of this report[†]; DoA unpublished data provided for preparation of the 4th National Report on Biodiversity to the CBD in 2009)[*]

The long history of paddy cultivation and the wide range of eco-edaphic conditions present in the country have resulted in a wide varietal diversity of *Oryza sativa.* Similarly there are a range of cereals that have been cultivated through the ages. Finger millet is grown in almost all the *chena* holdings of the Dry Zone and maize is widely cultivated in the Dry Zone for human consumption and animal feed. There are a range of grain legumes in cultivation, such as cowpea, green gram, black gram, winged bean, and soya bean, all of which constitute an important source of protein for most Sri Lankans, particularly in rural areas. Genetic diversity is also high among indigenous vegetables, particularly among cucurbits, tomato and eggplant; local root and tuber crops such as *cassava, dioscorea* and *innala*; and horticultural crops such as banana (*Musa* spp.), citrus, mango, avocado, jak durian, pomegranate, *rambutan*, guava and papaw, which are found mainly in home gardens. Fruit crops such as wood apple and velvet tamarind provide a source of income for the Dry Zone farmers who harvest them from forests for sale. This is destructive as it involves chopping down large fruit bearing branches to facilitate collection. There are also many indigenous spices for which Sri Lanka is world renowned. Cinnamon has been cultivated for commercial purposes in the south-western coastal region since the fifteenth century; cardamom, pepper, and betel leaf are widely cultivated in the lowland wet and intermediate zones of Sri Lanka; arecanut or betel nut is common in home gardens of the Wet Zone; and clove is cultivated in home gardens of the Wet Zone, mainly in the Kandy and Matale districts. Sri Lanka also has three species of nutmeg, two species of chilli, and one species each of ginger and turmeric.

Source: MoFE, 1999.[3]

Sri Lanka's Biodiversity Conservation Action Plan of 1999 recognizes that maintaining a high biodiversity in agricultural lands and livestock, especially in traditional farming systems, is essential to increase future national agricultural and livestock productivity, and to meet the challenges posed by climate change, through genetic improvement, and this is reiterated in the recent Addendum to the BCAP.

Plantation agriculture plays an important role in Sri Lanka's economy. The Plantation Sector comprises tea, rubber, coconut and sugarcane, which together with other minor export crops such as coffee, cocoa, spices (including cloves, cinnamon, nutmeg, mace, pepper, cardamom, etc.), cashew, arecanut, betel leaves, essential oils and un-manufactured tobacco are important in terms of export earnings. Research carried out at the respective Tea, Rubber and Coconut Research Institutions[z,3] and the Department of Export Agriculture, as well as selection by growers, has resulted in considerable diversification of cash crops from the originally introduced germplasm. This has served to produce high-yielding varieties that are also resistant to pests and disease and adverse climatic conditions.

Crop wild relatives

Sri Lanka also has 410 species of food crop wild relatives from 47 families and 122 genera, most of which from the central province; 289 species are indigenous and 77 are endemic to Sri Lanka.[45] Among these wild relatives of various crops are the two parent species of the cultivated banana (*M. acuminata* and *M. balbisiana);* five species of wild rice and one species of weedy rice; one species of wild arecanut (endemic to Sri Lanka, and listed as endangered) and two wild relatives of jak.[46] Among the wild relatives of vegetables and fruits there are about 10 species of wild *Vigna,* 12 species of wild okra, 16 wild relatives of cucurbits, seven wild relatives of orange and related crops and seven wild species of *Passiflora*.[46] Among the wild relatives of species there are five species

Sri Lanka has five species of wild rice with many characteristics that are important for varietal improvement of rice. For example, Oryza nivara *is resistant to grassy stunt and blast;* O. eichingeri *is resistant to blast and the brown plant hopper,* O. rufipogon *shows high salinity tolerance and* Oryza rhizomatis *has a rhyzome and is perennial.*

Source: information from the PGRC/DoA provided in 2009 for preparation of the 4th National Report to the CBD and in 2010 for preparation of this report.

[z] Information provided by the CRI and TRI during preparation of the SVP on Agriculture.

of wild pepper; eight species of wild Cinnamon that occur in the natural forests of the Wet Zone. and 13, 7 and 4 wild relatives of ginger, cardamom and nutmeg.[46] In addition, there are a number of wild relatives of non-food crop species among medicinal plants, ornamental plants and timber species. The wild relatives of crop plants that occur only in the Dry Zone are vulnerable to the threat of climate change;[47] all as well as to urbanization, forest clearing, expansion of agricultural grounds and firing.[46]

Livestock

With regard to livestock, local varieties of cattle that show high resistance to disease and tolerance of internal parasites still exist, as do some local breeds of poultry that are resistant to tropical diseases.[3] However, their use is limited due to low productivity and the greater popularity of imported high yielding breeds. For example, 90% of chicken in the country are imported breeds, with indigenous breeds used only by subsistence farmers.[33] Among the extant indigenous breeds are a type of locally adapted native cattle (*Bos indicus* var *ceylonicus*) or "*Batu Harak*" and the white cattle of Thamankaduwa that are reared for draught and milk, hardy indigenous goats including the locally adapted breed Kottukachchiya; and village chicken that are poor egg producers but are highly adapted to a harsh environment.[48][aa] Among the wild species there are several that have potential in the livestock industry. Examples are the wild boar (*Sus oristatus*), wild buffalo, jungle fowl (*Gallus lafayetti*) and the Sri Lanka Spur fowl (*Galloperdix bicalcarata*), the common Moorhen (*Gallinula chloropus*), the purple swamp hen (*Porphyrio porphyrio)*, the wild hare (*Lepus nigricollis*), wild ponies ("Delft ponies"), and two types of wild donkeys.[48]

Significantly, none of the genetic characteristics of the endemic jungle fowl, a progenitor species, has been reported in the imported and improved breeds in the country, highlighting the uniqueness of germplasm from this species. Among the swine population, gene flow appears to be taking place between the wild and village types, but imported breeds are dominating the industry with no efforts being made to increase diversity of populations through breeding programmes. Sri Lankan indigenous buffaloes are believed to form a unique genetic group in the Indian subcontinent, which unlike the other native buffaloes in the region, represent swamp characteristics while resembling the river type genotypically.

Source: Marambe et al., *2006*[33]

The problems in the agricultural sector are:[bb]

Issues and threats

- While it has been necessary to introduce and use new improved varieties of rice to increase rice production, this has perceptibly narrowed the rice gene pool in the country.[cc]

By the early 1980s, more than 90% of the paddy lands had switched to the NIVs, so that Old Improved Varieties (OIV) and traditional varieties together had declined to less than 10% of the cultivated area .[44]

- A drop in the cultivation of traditional varieties of crops will cause the inevitable loss of knowledge about their cultivation requirements and associated cultural practices over time.
- The high nutritional needs of high yielding rice varieties require high application of external fertilizer. Excess use of such agrochemicals by farmers pollute soil and water, causes eutrophication in water bodies, and has a deleterious effect on many indigenous terrestrial and freshwater species in wetlands and paddy fields.
- Many high yielding varieties and breeds of crops and livestock are from uniform genetic stock, and therefore, more vulnerable to pests and disease than traditional varieties, and thereby increase farmers' reliance on agrochemicals to maintain high yields.
- Insecure land tenure in agricultural holdings, and their small size, have resulted in farmers not spending time consuming but environment friendly soil conservation practices, but remedying poor soils by overuse of chemical fertilisers and pesticides. A result has been the loss of diversity among soil microorganisms, causing reduced natural biodiversity associated with farming systems and impoverished agro-biodiversity.

[aa] Dr Pradeepa de Silva, personal communication. See more details on characteristics of local breeds in the SVP on Agriculture and Livestock.

[bb] Issues identified through workshops and discussions when preparing the 4th National Report on Biodiversity for the CBD by MoE validated and added to at the workshop to discuss the SVP on Biodiversity and Ecosystem Services, and through individual consultations. Some issues are from published references which are cited.

[cc] However, studies carried out on the distribution of traditional varieties of crops in the country show that several such varieties are even now cultivated, but in very small holdings scattered across the country (Dr D K N G Pushpakumara pers. com. June 2010). The PGRC has also commenced *in-vitro* conservation of traditional varieties of rice, and are thus able to provide limited seed to farmers for propagation.

Home garden fragmentation

Studies of home garden vegetation in the 1980s revealed as much as 101 species including coconut, rubber, fruit and timber, comprising over 2817 individuals and a stem density of over 400 trees/ha in a single 7 ha patch of semi-urban home gardens in the Western Province. Jak trees (Artocarpus heterophyllus), providing food and timber to local people, amounted to over 51 trees/ha in the same patch of home gardens.[49] *These home gardens of the Western Province are also the main refuge of the critically endangered western purple-faced langur, considered as one of the 25 most endangered primate taxa in the world. However, the same area is now severely degraded due to fragmentation of home gardens for sale of land, housing and felling of timber trees.*[34] *There is a marked loss of mature jak trees which is the main food of the langur, and increased food conflicts with humans. Such changes in home gardens are increasingly common in other parts of the Western Province and could lead to a severe depletion of canopy cover outside fragmented forest patches in other parts of the Western Province.*

Source: Dela, 1998[49] *and 2004*[34] *as adapted from the 4th National Report to the CBD*

- Home gardens in most of the highly populous areas of the Wet Zone have suffered considerable degradation in the past two decades due to urbanisation and fragmentation, with consequent loss of habitat and habitat corridors for biodiversity outside and between forests.

- Crop wild relatives (CWR) in the Dry Zone are vulnerable to increased temperatures; many others are under threat due to anthropogenic actions. CWR that are C3 plants are also in danger from climate change as the existing ambient temperature is at, or very near, the upper margin of the optimum temperature range for these crops.

- Many local strains of livestock that are resistant to pests and disease and harsh environments are disappearing due to a strong preference for imported breeds that are more productive, but are also genetically more uniform and more vulnerable to pests and disease. Among the factors contributing to this diminishing trend is the lack of proper valuation of local breeds.

- The reduced use of local breeds could serve to lose the genetic diversity of livestock required for livestock improvement in the face of climate change, especially as there are no organised programmes or institutions for conservation of livestock germplasm similar to what exists for crops at the PGRC. Some facilities that do exist in centres like the AgBiotec Centre are underused due to lack of coordination.

- Agricultural lands are affected by Invasive Alien Species; climate change that could lead to their accelerated spread and destruction of agriculture.

- There is a marked lack of information on ecosystem services in agricultural lands that are dependent on particular species (e.g. pollination by bees), and on indigenous livestock breeds.

- *Coastal and marine systems*

TABLE 6. Species diversity among selected groups of fauna in coastal and marine systems

Taxonomic group	Number of species
Hard coral species	208
Echinoderms	213
Marine mollusks	228
Sharks	61
Rays	31
Marine reptiles	18
Marine mammals	28
Pelagic fishes	1800

Source: IUCN and MoENR, 2007 except for hard coral species,[21] and Pelagic fishes (CCD, 2006).[4]

Sri Lanka has a variety of coastal and marine habitats that include large expanses of beaches (including barrier beaches, spits and dunes); estuaries and lagoons, mangroves, salt marshes, sea grass beds, and several types of reefs including coral reefs.[4] These systems support a rich array of species **(Table 6)**.

Reefs

Distinctly different reefs comprising coral, sandstone, and rocky reefs have been identified around the island, occurring separately or mixed together.[4] Once famed for their spectacular beauty, coral reefs are still among Sri Lanka's most valuable shallow water marine ecosystems in terms of biodiversity and ecosystem services though now considerably degraded due to coral bleaching. Fringing coral reefs are found along 2% of the coastline.[4] The most extensive coral reefs in Sri Lankan waters are the patchy coral reefs in the north-western coastal and offshore waters, occurring within the Gulf of Mannar and west of the Kalpitiya Peninsula.[4] There are about 208 hard coral species from 71 genera and 9 families[21] and at least 300 species of reef fishes are associated with these reefs,[21] many of which are important in the ornamental and food fishery.[4]

Sea grass beds

Sr[illegible]oastal waters have extensive seagrass beds[4] as sub-tidal w[illegible]ow a 6m depth.[19] They often occur in association with co[illegible]osystems or within estuaries and lagoons.[4] Seagrasses are m[illegible] in the basin estuaries and lagoons of Puttalam, Negombo, Mawella, Koggala, Kokilai. They are also found in the Dutch Bay (in Kalpitiya), to the western end of the Jaffna Peninsula, and from Mannar to the northwest across the Palk Bay and to Rameswaram Island on the Indian coast,[4] and also along the south and south-western coasts including Rumassala and Hikkaduwa.[19] Sri Lanka's seagrass beds are of particular interest as they are believed to be the main habitat of the endangered dugong (*Dugong dugong*) and are valuable habitats for the globally threatened sea turtles that come ashore in the island.[4]

Barrier beaches, spits and dunes

[illegible]de and sandy beaches that are famous for their scenic beauty and tourism potential support a [illegible] fauna and flora. The barrier beaches isolate lagoons and swamps from the sea. Spits are most [illegible] the western and eastern coasts of the country and are in association with estuaries (e.g. *Kalu Ganga* estuaries).

Dunes are of three types: the low, flat to slightly undulating isolated platforms of sand less than 1m in height; the transverse primary dunes, consisting of ridges of undulating sand masses associated with stable beaches and exceeding 5 m in height; and the secondary transgressive dunes; usually exceeding 3 m in height.[4] The most prominent sand dunes are found along the northeastern, northwestern and southeastern coasts of Sri Lanka. The dunes in the southeast coast that extend from Ambalantota (Godawaya) in the Hambantota district to Sangamankande Point in the Ampara district form the longest stretch of dunes in the world close to the equator.[4] Many animal species are associated with sand dunes; including the wild donkeys of Kalpitiya and Mannar. It is believed that areas on the southern beaches with extensive dunes, such as the Bundala National Park, were relatively little damaged from the tsunami of 2004.

Lagoons & estuaries

Sri Lanka's coastline has many picturesque and economically important estuaries and lagoons. These complex systems contain a rich diversity of species and a variety of coastal habitats including, mangroves, salt marshes, seagrass beds and mud flats. Overall, there are 45 estuaries, of which 28 are of the riverine type and 17 of the basin type.[4] Coastal mapping in 2002 revealed a total area of 90,965 ha for basin estuaries, and about 2,110 ha for riverine estuaries.

Sri Lanka's lagoons are salt or brackish water coastal wetlands separated from the sea by a low sand bank with one or more relatively narrow permanent or seasonal outlets into the sea. They are defined in the Coastal Zone Management Plan of 2006 as coastal bodies of water that may be brackish, fresh or hypersaline, and are separated from the sea over a very long period of time by any of several types of barriers that restrict water circulation. They can also contain one or more coastal wetland types such as mangroves, mud flats and sea grass beds.

Estuaries occur in places where the rivers enter the sea, and hence generally have a free connection to the sea though some remain clearly closed to the sea during a part of the year. The daily tidal fluctuation and the intermediate salinity between salt and freshwater (brackish water) are main characteristics of this ecosystem.

Source: CCD, 2006[4]

Sri Lanka has about 89 lagoons, which range from 3 ha to 7,589 ha in extent, with only eight exceeding 1,000 ha each.[4] Collectively they comprise 36,000 ha. These extremely productive ecosystems contain many edible species of fish and economically important invertebrates, including 5 annelids, 28 species of edible molluscs, over 25 species of shrimps, mud crabs and swimming crabs.[3,4]

Mangroves

swamps in Sri Lanka are naturally fragmented and amount to only 6,080 ha.[4] Due to a low tidal y exceeding 75 cm, these mangroves occur as a narrow belt in inter-tidal areas of lagoons, sociated islands and river mouths where there is low wave action.[4] They rarely extend beyond 1 [4] Even so, the mangal vegetation in Sri Lanka comprises around 40 different species of trees, and vines, of which about 25 are true mangroves.[4] Occurring within the mangrove habitats are many species of fish, birds and reptiles.[4] The Kala Oya estuary is the largest stretch of mangroves recorded so far in Sri Lanka and extends upstream about 2 km from the river mouth.[19]

Salt marshes

According to a Coastal Habitat Survey of 2002, there are around 23,800 ha of salt marshes in the country.[4] rally found close to the landward margin of the inter-tidal zone where there is relatively high Extensive salt marshes occur along the coast from Mantai to Vankalai, where tidal flats contain es of marsh vegetation. Patchy salt marshes occur mainly in sedimented lagoon/estuarine areas antota, Puttalam, Kalpitiya and Mundel.[4] These ecosystems are important habitats for salt ion, brine shrimps (such as *Artemia marina),* wading and migratory birds, and milk fish fry (*Chanos chanos*) for which these areas form the nursery grounds [4]

Ecosystem services

The interplay between the different elements in coastal ecosystems enable them to perform many services as life support systems and to provide goods and services essential for humans and habitats for wildlife. Coastal ovide food fish, crustaceans and other fishery products, ornamental fish and salt, and have high ial. Sri Lanka's wide sandy beaches are particularly famous tourist attractions.

so serve a protective function as they protect the coast from storms and coastal erosion, retention of sediments, and together with coral reefs and sea grass beds are breeding grounds for fish and other marine organisms, many of which are important in the food and ornamental fishery.

Once Sri Lanka had many healthy reefs remote from human settlements, such as the Bar Reef. Marine surveys in 1999 and the early 2000s showed, however, that live coral cover in shallow reef habitats of about 3m depth was almost non existent in the Bar Reef Marine Sanctuary; only 7% at Hikkaduwa Marine Sanctuary; and down to 28% at Weligama and 20% at the Rumassala reefs.† These systems are now regenerating, but the disturbance has caused many changes in reef structure and compositions, and have rendered them open to invasions by other species, such as Halimeda *which has taken over the reef at Weligama.††*

Source: CCD, 2006 † and Rajasuriya, A (2005)††

Issues and Threats

Coastal and marine systems face many threats that can be expected to make them more potentially vulnerable to climate change. [dd]

ied in the CZMP of 2004, through workshops and discussions when preparing the 4th National Report on Biodiversity for the CBD by MoE validated and added to at the workshop to discuss the SVP on Biodiversity and Ecosystem Services, and through individual consultations.

Ecosystem related issues:

- The CRMP coastal habitat survey of 2002 revealed degradation of most of Sri Lanka's coastal habitats to varying degrees when compared with the previous five decades, including a reduction in the extent of coral reefs, estuaries and lagoons, mangroves, seagrass beds, salt marshes, and barrier beaches, spits and dunes.[4]

- Coral mining for the lime industry in the south and southwest coasts had caused extensive damage to coral reefs during the 1980s and 1990s.[4]

- There is continued damage to coral reefs due to blasting of coral reefs for fishing, anchorage of boats near coral reefs and dragging of nets and purse seine nets.

- The 'El Nino' effect in 1998 led to mass scale coral bleaching and death, and there is a bleaching event taking place on the east coast at present. The tsunami of 2004 has also resulted in serious damage to coral reefs in Sri Lanka.[50]

> *At the global level, coral reefs are particularly affected by climate change, and often bleach in response to thermal stress combined with other factors. During 1998, 75% of the world's coral reefs were affected and 16% suffered subsequent mortality.*
>
> *Source: Ceasar, H. (2004). Paying the Price of Climate Change in* World Conservation, *Volume 35, and No. 1. pp 28-29.*[39]

- The regeneration process at Bar reef and at Hikkaduwa after the coral bleaching is showing considerable changes in coral reef species composition and structure. This will also affect the other organisms associated with coral reefs.

- Reefs disturbed by the coral bleaching are affected by invasive organisms such as Halimeda (e.g. Weligama reef is now totally invaded by *Halimeda).*

- Seagrass beds in lagoons and coral reefs have been seriously damaged or degraded by the use of destructive fishing practices, polychaete harvesting, and land based adverse practices that increase siltation of coastal waters. Large scale commercial trawling, drift netting and beach seining in certain sections of the coastline have also been detrimental to some seagrass beds.

- Estuaries and lagoons are affected by pollution and siltation from land-based activities, garbage dumping; changes in hydrology due to freshwater flows from inland irrigation schemes; sediment from soil disturbed by inland agriculture, deforestation, mining and construction; and sandbar formation either through natural or anthropogenic causes.

- The functional area of lagoons are reduced due to unauthorised encroachment and reclamation, particularly so in the Bolgoda and Negombo estuaries and the Mawella and Lunawa lagoons.

- The naturally fragmented mangrove swamps of the island have further shrunk or disappeared due to unplanned establishment of shrimp farms, lowland agriculture and housing. Encroachments are largely responsible for the reduction of large extents of mangrove cover between 1986 and 2002.[4]

- The existing mangrove areas are degraded due to the extraction of mangrove poles and fuelwood for domestic use and twigs for the brushpile fishery beyond sustainable levels, as well as due to water pollution and siltation.

- Salt marsh areas have been reduced through reclamation, and conversion for salt production and aquaculture (e.g. nearly 2,960 ha was lost between 1986 and 2002 in the Puttalam district).[4]

- Natural phenomena such as prolonged droughts have caused the drying up of salt marshes and lagoons, causing the death of several wetland animal species; the December 2004 tsunami also resulted in the degradation of coastal wetlands such as mangroves, lagoons and estuaries.

- Coastal waters are polluted by the release of domestic wastewater, sewage, and untreated or partially treated wastewater and toxic substances from industries, tourist resorts and shrimp farms; solid waste

dumping; pollutants conveyed from rivers, estuaries and lagoons, and the receipt of waste oil and tar from fishing boats, ships, coastal service stations and oil spills.

- Sand dunes, barrier beaches and spits have been affected by encroachment for construction of dwellings, unplanned growth of tourist hotels, and conversion to agricultural lands.

- Exotic plant species such as *Prosopis juliflora*, introduced for dune stabilization in some areas have become invasive.

- The conversion of coastal habitats to other uses, unregulated fishing effort, pollution from ships, and adverse inland activities have had negative impacts on coastal habitats.

- The use of trammel nets, purse seines, explosives (blast fishing), bottom-set nets, and trawlers that use long drift nets, have served to destroy marine habitats and biodiversity.

- Threats to coastal habitats are exacerbated by the high human population density in Sri Lanka's Coastal Zone due to human-induced disruption of coastal processes and the corresponding degradation of coastal habitats.

- Past haphazard construction and expansion of piers and fish landing points in lagoons have interfered with water flow, leading to siltation of coastal waters and degradation of coastal habitats. Some coast protection structures constructed in the past have already altered the pattern of sand movement along the coast with a negative impact on coastal stability and biodiversity.

- The use of some climate change adaptation measures could threaten coastal biodiversity. e.g. Structures to protect against sea level rise can have adverse impacts on coastal biodiversity;

- Intensive agriculture along some areas of the coast has affected coastal ecosystems in such areas.

- Lack of adequate management of the coastal systems by the responsible state institutions despite adequate laws and polices, partly due to ambiguity of responsibility for conservation of the coastal and marine environment, has led to over-exploitation and degradation of coastal resources.

- Large scale development projects on the coast may also change current patterns in the ocean, resulting in adverse impacts on fish production.

Species related issues:

- The five species of turtles that come ashore for nesting are affected by degradation of coastal habitats due to indiscriminate allocation of beach land for construction of hotels and other tourist facilities.

- Bycatch in the fishery due to use of nylon gill nets has increased threats to the already threatened marine turtles and small marine mammals.

- Over-fishing in coastal waters has led to the exhaustion of the near-shore fish resource, while promotion of the use of large multi-day motorised crafts with insulated fish holds to overcome this problem has led to unsustainable fishing effort in the offshore deep sea fishery.

- The indiscriminate harvesting of gravid female lobsters, and over collection of food and ornamental fish from reefs, over fishing of edible sea cucumbers, illegal slaughter of dolphins and the rare dugong for meat in the food fishery, have increased threats to these species.

- The unsustainable collection of species important in the ornamental fishery has led to a population decline among some species, largely due to poor management of coastal resources.

- **Ex-situ** *conservation facilities*

TABLE 7: Germplasm Collection Status by Crop Group at the PGRC

Crop Group	Number of accessions at the PGRC in 2009
Rice and related species	4,507
Other cereals and related species	1,617
Grain legumes	1,948
Vegetables (legumes (cucubits, brassics, allium, leafy vegetables, other vegetables)	2,579
Solanacious vegetables and condiments	1,193
Fruit crops	163
Root and tuber crops	209
Oil crops	414
Medicinal plants	27
Fibre crops	66
Mustard and related spices	124
Wild relatives of crop species	308*

*Source: Source: unpublished data provided by the PGRC for this report in June 2010, and March 2009**

Sri Lanka has several institutions that can engage in captive breeding or propagation, and can aid *ex-situ* conservation of wild species. Among them are the National Botanic Gardens (NBG), the National Zoological Gardens (NZG), the National Aquatic Resources Research and Development Authority (NARA) and the Plant Genetic Resources Centre.

The Plant Genetic Resources Centre (PGRC) established in 1988 is mandated to plan and conduct plant exploration, collection, introduction, evaluation, documentation, and conservation of genetic diversity of food crops and their wild relatives. The PGRC has in storage over 12,847 accessions from 375 crop species and 308 accessions of crop wild relatives. The later includes the five species of wild rice. Seeds of orthodox species are kept in storage modules, while recalcitrant seeds and species that can be grown from cuttings are maintained *in-vitro*. In the past, plant characterization at the PCRC was based on morphological features, but now characterization based on molecular features has commenced.

Source: Unpublished data provided by the PGRC for preparation of the 4th National Report to the CBD in 2009 and for this report in 2010.

Under the Department of Botanic gardens, *ex-situ* conservation facilities for plants are present in five Botanic Gardens (RBG) located in the low, mid and upcountry regions of the wet zone and the Dry Zone. The role of the National Zoological Gardens for *ex-situ* conservation is limited as yet, due to the paucity of scientifically managed captive breeding programmes for threatened fauna, though captive breeding has been initiated and successful with some species. This is due to be further expanded with the opening of the new zoological gardens at Pinnawela. The National Aquatic Resources Development Agency (NARA) has had several small scale programmes to breed indigenous and endemic freshwater ornamental fish species that are exploited from the wild, but facilities are lacking to upscale such efforts to be important as a tool for *ex-situ* conservation. Developing this activity further is important to provide greater inputs to become a viable enterprise that will reduce the need for exporters to collect ornamental fish from the wild.

All crop research and development institutes under the Department of Agriculture (e.g. the Horticultural Crops Research and Development Institute [HORDI] for fruit and vegetable species and root and tuber crops; the Rice Research and Development Institute [RRDI] for rice genes, and the Field Crop Research and Development Institute [FCRDI] for coarse grains, grain legumes and condiments and the research institutes for plantation crops (i.e. tea, rubber, coconut and sugarcane) maintain live field collections of varieties, cultivars and clones of crops within their purview. The Department of Export Agriculture (DEA) maintains germplasm of coffee, cocoa, cardamom and clove and other export crops. The Department of Animal Production and Health (DAPH), and its research centre—the Veterinary Research Institute (VRI) do not have similar organized programmes and facilities for livestock germplasm conservation, although the DAPH is mandated to enhance livestock productivity and the use of domesticated animals such as cattle, pigs and poultry. Some facilities that do exist in centres like the AgBiotech Centre (AgBC), University of Peradeniya and at the Veterinary Research Institute, Gannoruwa are underused. The Agbiotech Centre (affiliated with the University of Peradeniya) has facilities for biotechnology and *ex-situ* conservation of both plant and animal germplasm, but these facilities are under-utilized.[5]

There are several field gene banks for medicinal plant species at Nawinna, Haldemulla, Pattipola, Girandurikotte and Ganewatte. The Ayurvedic garden in Nawinna harbours around 200 species of medicinal plants, with more than 1500 individual plants.

Issues

The issues with regard to *ex-situ* conservation facilities are:[ee]

- The lack of detailed genetic information on both captive and wild populations is a serious handicap to maximize potential for *ex-situ* conservation of the most relevant elements of wild biodiversity.

- Captive breeding should be supported by successful reintroduction of species into the wild, carried out with specific expertise with regard to re-introduction programmes and a knowledge of the species that is being re-introduced. Such expertise is not present in the relevant institutions, so that most institutions deal with *ex- situ* storage for preservation rather than conservation of wild species.[51]

- Trained staff are insufficient to handle the wide needs of *ex-situ* conservation of wild faunal species (breeding technology and transfer to relevant sectors, reintroduction, etc.) in most institutions mandated with *ex-situ* conservation.[51]

- There is a serious dearth of funding for infrastructure and research relating to *ex-situ* conservation.

- There is no facility for *ex-situ* conservation of threatened marine species, which is a complicated process that needs a long-term plan with adequate resources, skilled staff and infrastructure. [51]

- There is insufficient funding for adequate field assessments to cover large areas and habitats for collection of material for *ex-situ* conservation.

- There are gaps in Sri Lanka's coverage of important species, particularly those from threatened and endangered habitats, species with recalcitrant seeds, wild species, and livestock. [51]

- The facilities at the PGRC need to be enhanced and upgraded for long-term storage to be in par with international standards and to be environment-friendly. The long-term integrity of the currently stored germplasm should be resolved. More funds should be allocated for describing the germplasm present in the banks, which is a high priority for making the germplasm useful to plant breeders.[51]

- The focus of the PGRC is still limited to food crops, and about 99% of the accessions conserved in the gene bank are in this category. Hence, the scope of the PGRC should be widened and should assume the role of a central or nodal agency for all PGR activities in Sri Lanka. [51]

- Efforts by the Department of Animal Production and Health and the Veterinary Research Institute (VRI) to conserve the indigenous animal species of economic value have been constrained by insufficient funds and infrastructure. This compounded by the absence of a coordinated international effort for conserving the genetic resources of livestock.

[ee] Issues identified through workshops and discussions when preparing the 4th National Report on Biodiversity for the CBD by MoE validated and added to at the workshop to discuss the SVP on Biodiversity and Ecosystem Services, and through individual consultations. Some issues are from published references which are cited.

BOX 3: FACTORS IDENTIFIED AS NECESSARY TO ENHANCE *EX-SITU* CONSERVATION OF WILD AND AGRO-BIODIVERSITY IN SRI LANKA

- Identifying *ex-situ* conservation as a part of an overall integrated programme
- Reviewing the information provided to develop an investment proposal for strengthening identified centres such as a gene bank for indigenous animals
- Monitoring the efforts of private sector organizations to propagate commercially important, indigenous, threatened species using biotechnology
- Compiling a directory of all privately and institutionally held species collections
- Identifying critical species and developing conservation strategies by NSCAG and overseeing their implementation.
- Formulating a national policy for germplasm conservation
- Strengthening the capacity and scope of the PGRC and other relevant *ex-situ* conservation facilities for crops and livestock
- Strengthening the geographical distribution and facilities of the botanic gardens to expand their *ex-situ* conservation activities
- Improving the facilities available at the National Zoological Gardens to enable it to serve as a repository of genetic material for all indigenous wild animal species and be able to participate in *ex-situ* conservation activities

Source: Adapted from Wijesundara, et al.*, 2006*[51]

- ***Traditional knowledge and practices associated with conservation and sustainable use of biodiversity***

Rural people depend considerably on diverse bio-resources for their many goods and services such as food, medicines and water from forests, freshwater wetlands, and coastal and marine ecosystems. As such these segments of the population will feel the impacts before the general impacts of climate change are felt by others. Climate change will also affect traditional practices and cultural and religious sites that are affected by increased severity of natural hazards due to climate change. The Intergovernmental Panel on Climate Change has also identified traditional and local knowledge as an important missing element in its previous assessments and a focus for its work during the next assessment process. When referring to traditional knowledge, the focus is not on outdated knowledge, but on existing knowledge that is currently relevant. For instance, many indigenous groups recognize that environmental and climate related changes are not in themselves new phenomena, and they historically have extensive experience of responding to and successfully negotiating such changes. It is clear that 'Indigenous Peoples' are already responding to climate change in creative ways, drawing on their traditional knowledge of the natural resource base and combining critical knowledge that is used by them in their everyday lives.
Source: SCBD, 2003[1]

Issues

Sri Lanka with a recorded history of over 2500 years and a prehistory of several millennia, has a vast store of accumulated wisdom for using, managing and conserving a rich biodiversity. This knowledge base has been gradually eroded due to colonial rule extending over 500 years. Despite this, the people of Sri Lanka—and particularly those in the rural interior—continue to retain a reasonable stock of traditional knowledge related to biodiversity. For example many rural people are still dependant on traditional medicine for various ailments to some degree, for which the medications require an array of plant material from the wild. Use of traditional knowledge to promote sustainable use of biodiversity and to combat the problems of climate change is required by the CBD as well as by the UNFCCC**.**

In the Biodiversity Conservation in Sri Lanka: Framework for Action (BCAP), section 6.9 makes reference to the need for preservation of indigenous knowledge particularly in relation to agriculture and traditional medicine. It recommends the launching of a programme for the collection and archiving of related data and institutionalizing the process, while regulating and controlling access to such data.[3]

The wealth of traditional knowledge that exists in Sri Lanka had hardly been recognized or harnessed in the past for development (e.g. agriculture) or biodiversity conservation. It is now increasingly recognized that for sustainable development and the conservation of nature and its riches, traditional wisdom and the lifestyles of people with minimal demands on natural resources, could perform a vital role. This aspect is of particular importance in the areas of agriculture, control of pests and plant diseases, and curative purposes for humans and livestock, especially to face the exigencies of climate change.

Ayurvedic physicians who dispense oils (thel), pastes (pattu) and decoctions (kasaya) for curative purposes in the buffer zone areas of forests are usually elderly people with an inherent love and respect for the forest and its resources, and they dispense medicines and medication for humanitarian rather than commercial purposes. Few among the younger generation in the villages seem willing to take up this occupation due to low financial returns, so that the knowledge associated with these practicse could gradually die out.

Source: Dela, J D S (2003). The Sinharaja MAB Reserve Periodic Review for UNESCO.[39]

1.3 Socio-economic importance of biodiversity

- *Provision of water for domestic use*

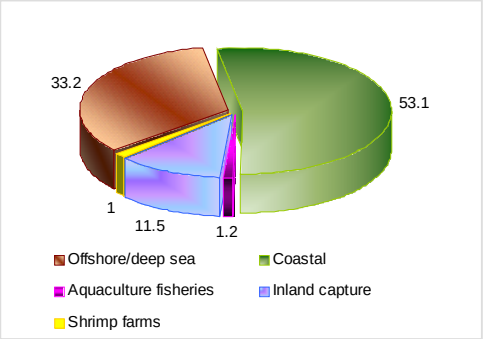
Sri Lanka's inland waters are the only source of water for drinking, irrigated agriculture and other domestic requirements for a population of 20 million. The 2006/2007 Household Income and Expenditure Survey by the Central Bank of Sri Lanka showed that around 84.8% of Sri Lanka's population had access to safe drinking water, but only 35.5% per cent of households and commercial establishments had access to pipe borne water.[42] As such, a large majority of the rural population continue to rely heavily on other sources of water such as wells, tanks and reservoirs and water from forests for their drinking, culinary, washing, bathing and laundering purposes. In the Dry and Intermediate Zones, the water collected in numerous tanks and reservoirs is vital for paddy cultivation and domestic use. One of the most important uses of forests as perceived by for rural populations living near Wet Zone forests is the forest as a source of domestic water.[39,40]

Forests together with rivers and other inland wetlands, play a pivotal role in provision of surface water for the nation. Conservation of these forest and wetland ecosystems to enable an uninterrupted provision of ecosystem services is vital to meet the freshwater requirements of the country. The past practice of planting exotic species such as *Pinus* and *Eucalyptus* that are heavy on water use to enhance tree cover may also have adversely affected ground water availability in areas where they are extensively cultivated. Likewise, water pollution and the prolific growth of aquatic weeds such as water hyacinth have reduced surface waters for public use.

- *Fishery industry*

The fishery industry is entirely dependant on the biodiversity of coastal and marine waters and inland surface waters. Degradation of the coastal and marine ecosystems and inland wetlands due to anthropogenic activities will increase its vulnerability to climate change. Maintaining the biodiversity of coastal and marine ecosystems and inland wetlands is therefore a vital requirement for sustenance of the fishery industry and for its expansion.

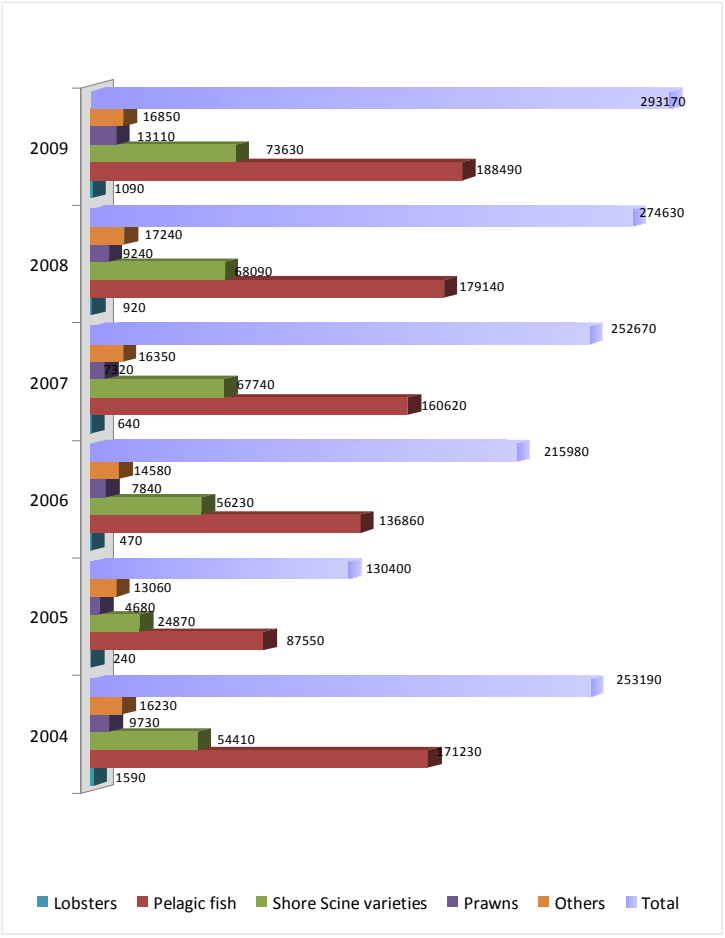
The total fish production in Sri Lanka for 2009 was 339,730 t, of which the coastal and marine fishery contributed over 86% (FIGURE 7). **Pelagic fish contributed the most to the fishery** (FIGURE 8)**.** The fishing industry is also a dynamic export sector in the island's economy (FIGURE 9). The fishery sector earns valuable foreign exchange through the export of marine and aquaculture products, and provides direct employment to over 475,000 people, while fishing and related livelihoods sustain over 2.5 million people.[52]



Source: MFAR, 2009[52]

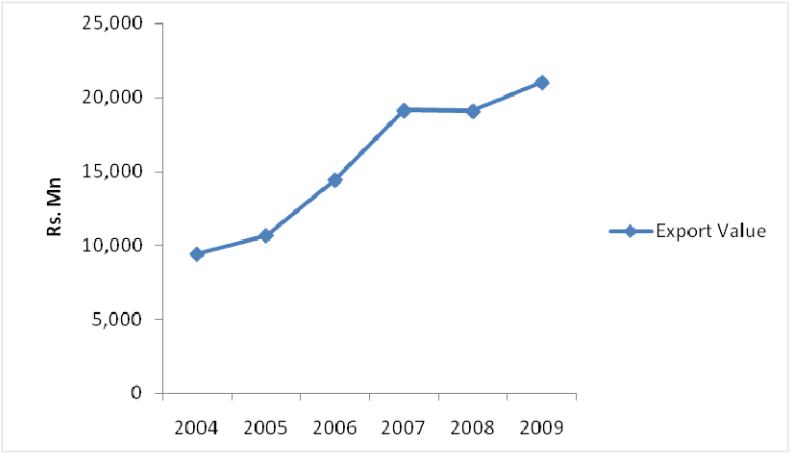
FIGURE 7: Sri Lanka's fish production in 2009 (as a % of total production)

Fishery is the major economic activity in the coastal region, which contains 25% of the island's population.[4] The inland fishery accounts for about 11.5% of Sri Lanka's total fish production,[52] and provides food and income for rural people. 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*[53] and the Action Plan for the *Haritha Lanka* Programme.[54]



Source: MFAR 2007[56] and 2009[52]

FIGURE 8 Fish production by commercial groups in metric tonnes



MFAR 2007[55] and 2009[52]

FIGURE 9 Value of total export earnings from fishery products 2004-2009

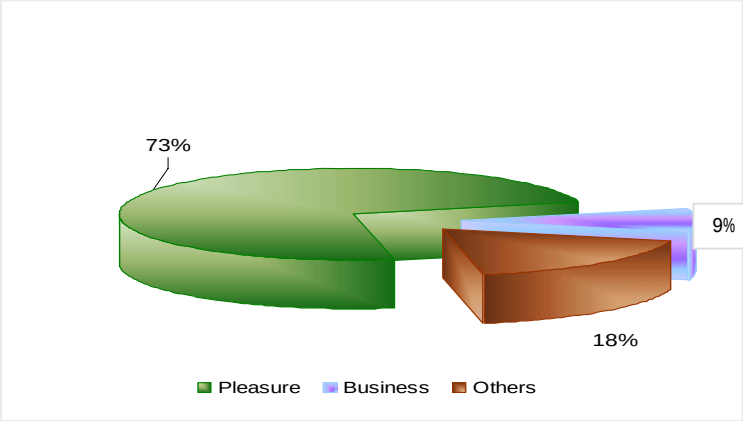
- *Tourism industry*

The tourism industry is greatly influenced by Sri Lanka's natural attractions—beaches, wildlife, waterfalls and scenic beauty— which are components of biodiversity. Sri Lanka is famous for wide sandy beaches, which are part of coastal biodiversity, and the different types of forests that support many species of interest and scenic beauty. Waterfalls and other wetlands are also of much interest to tourists. A high quality of these tourist attractions would be vital to attract the serious high spending ecotourist.

Tourism has been recognized as a high priority area capable of effectively driving the country's economic development in the *Mahinda Chintana vision for the future*, with the vision of making Sri Lanka the most sought after tourist destination in South Asia. Accordingly there is a target of 2 million tourists to be achieved in 2016**,** with tourism becoming a major foreign exchange earner for the country.[53] The *Randora* Infrastructure Development Programme identifies an investment of Rs 24,917 million between 2006-2016 for development of the Tourist Sector[56] to make Sri Lanka a regional tourist hub.

Analysis of tourism arrivals in 2008 for the country shows that most tourists arrive for pleasure (FIGURE 10).[57] The country's high biodiversity offers very high potential for tourism development as promoted by the current tourism development policies and plans. However, maintaining biodiversity also becomes key to maintaining these tourist attractions in the long-term and to optimize investments made in the tourism industry. This would involve identifying the components of biodiversity that are already under threat from all factors, including climate change, and taking timely measures to alleviate or minimize these threats.

Beaches are still a main attraction to tourists as indicated by the concentration of 41% of hotel and guest house rooms in the coastal region[ff]. However, wildlife, forests and other natural sites inland are also becoming popular tourist attractions. FIGURES 11 a & b provide the numbers visiting various Forest Reserves managed by the Forest Department and revenue gained from the same in 2008. FIGURES 12 a & b provides the number of visitors to the existing three Botanic Gardens and annual income derived from the same between 2006 and 2009.

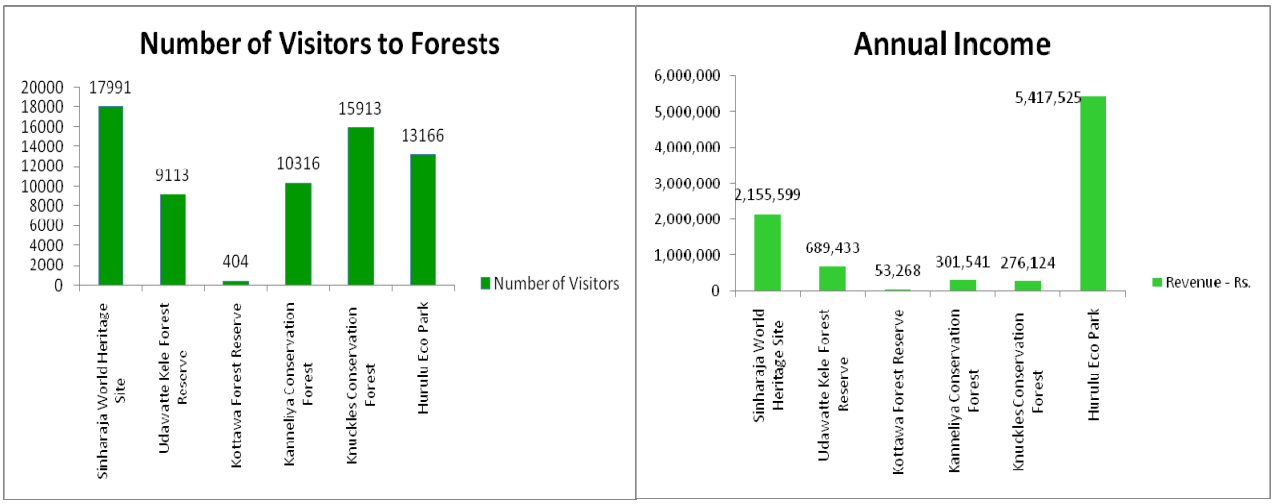


Source: Sri Lanka Tourism Development Authority. Annual Statistical Report, 2008.[57]

FIGURE 10: Tourist Arrivals by Purpose of Visit in 2008

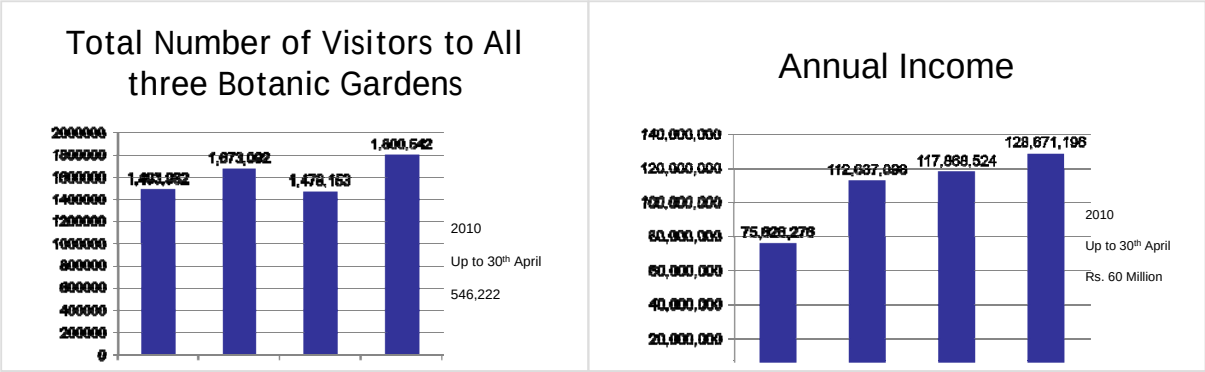
It is a known fact in the tourist industry that nature tourists are very sensitive to adverse changes in the environment. Areas that are degraded due to unplanned tourism development in many places of the world are now sans the very attractions that drew tourists to them in the first place. High spending genuine ecotourists are especially sensitive to environmental degradation and adverse impacts on wildlife, and they are more interested in the environment than in the tourism facilities that are on offer.

[ff] Data generated through the GIS mapping exercise carried out under this project.



Source: Data provided in the Forest Department Annual Report, 2008

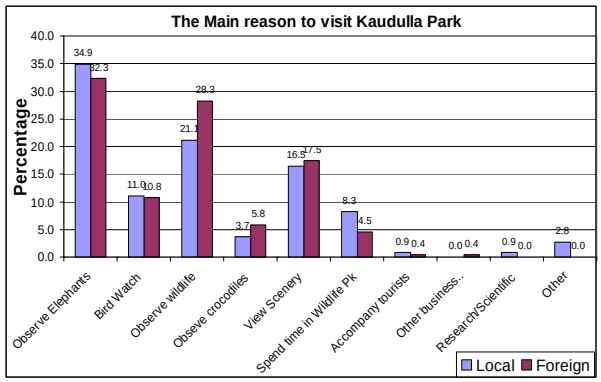
FIGURE 11: (a) Total number of visitors to forest reserves and (b) revenue in 2008

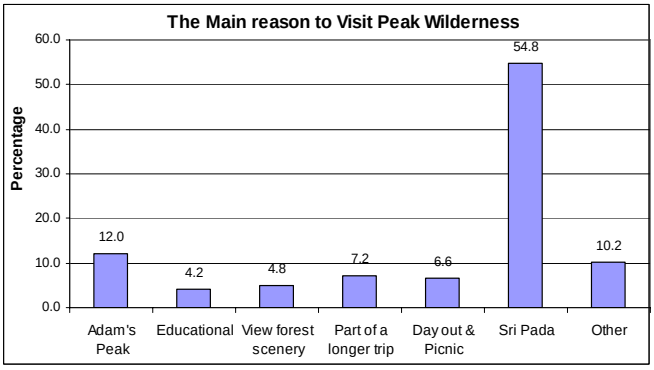


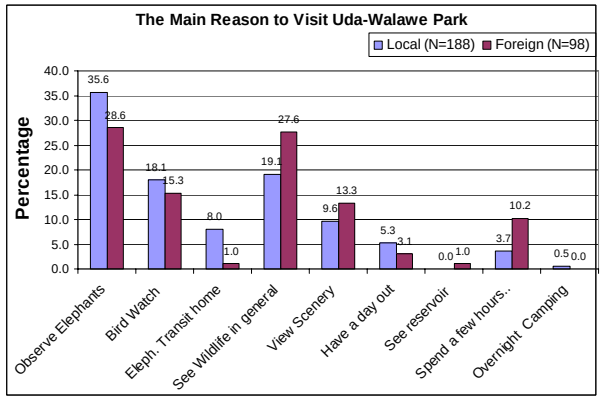
Source: Graphs provided by the Department of Botanic Gardens in 2010 for updating the 4th National Report to the Convention on Biological Diversity for publication

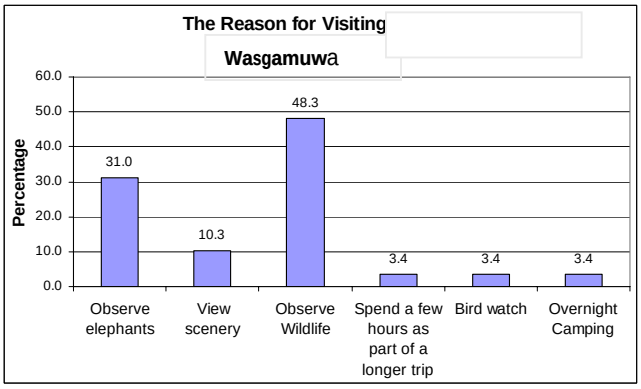
FIGURE 12: (a) Total Number of Visitors to the Botanic Gardens at Peradeniya, Gampaha and Hakgala between 2006 – 2009 and (b) annual income from such visitors.

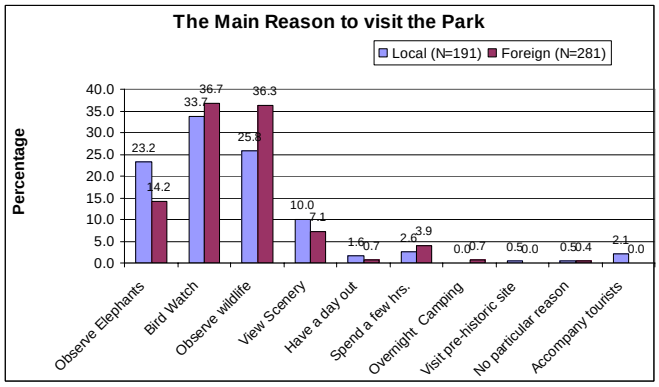
FIGURE 13 shows the main reasons picked by tourists visiting six wildlife reserves managed by the Department of Wildlife Conservation. The diverse and different attractions that these sites offer to tourists indicate the value of biodiversity for nature tourism.

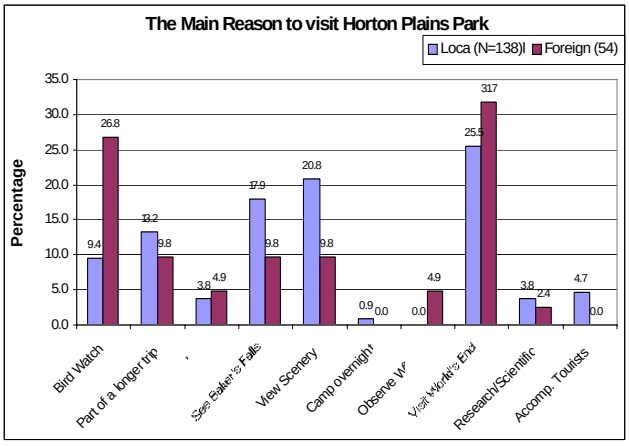












Source: Final Report of the Visitor Survey under the PAM&WC Project.[58]

FIGURE 13: Results of the survey of main reasons for local and foreign tourists visiting six wildlife reserves in Sri Lanka *(as a % of visitors surveyed at each site)*

• *Agriculture and livestock sector*

Meeting the nutritional requirements of the country in the face of increasing human needs is prioritized through government policy. Recognizing the importance of agriculture for national development, the government developmental policies envisage an agricultural renaissance, with special attention on the paddy farmer. These policies aim at achieving self sufficiency in food crops and enhancing local milk production for the people, and also to generate agricultural crops for the export market. About 70% of the population still lives in rural areas where farming is widely practiced. Agriculture, which depends on agro-biodiversity, is thus very much part and parcel of the lives of most Sri Lankans.

"Changing weather patterns due to climate change during the past few years is threatening Sri Lanka's hard achieved self-sufficiency in rice as out of the total area used for paddy cultivation, 30% of the rice fields are rainfed. Over the years the Rice Research and Development Institute (RRDI) of Sri Lanka has worked on varietal improvement to produce rice that is resistant to salinity, drought, pests, and bacterial leaf blight."

Source: MoENR, 2009[6] using information from Waterless rice? The Nation. March 8th 2009

Food is very much a product of biodiversity, and biodiversity can play a major role in the development of national agriculture and livestock in the future, especially in the face of climate change, by using the rich genetic diversity of indigenous crops and livestock breeds that offer much potential for genetic improvement. Traditional varieties of crops that are acclimatized to varied climatic conditions, wild relatives of crops, and indigenous livestock breeds offer potential to address challenges that may arise for agriculture in the future. Conserving ago-biodiversity and the systems they occur, as well as conserving traditional knowledge associated with agriculture and livestock rearing, are increasingly important for developing the agriculture sector in the face of climate change.

The earnings from floriculture as an export industry in the early 1980s reached one million SLRs and has since then shown an impressive growth of foreign exchange earnings over the past two decades. Foliage production forms the core of the floriculture industry in Sri Lanka, and contributes nearly 90% of all floriculture exports. The floriculture industry in Sri Lanka consists of both export and domestic trade. Cut flowers, cut foliage, live plants, planting material (i.e. seeds, bulbs, corms and tubers) are the main items of export interest, while domestic trade is primarily comprised of cut flowers and ornamental indoor/out door plants for interior decoration as well as landscaping.[59] The floriculture export value from 2004-2008 by Product Category is provided in Table 8.

TABLE 8: Summary of Floriculture Exports for Sri Lanka by Product Category from 2004-2008

Product	Value of Floriculture Exports for Sri Lanka in USD $ Million				
	2004	2005	2006	2007	2008
Cut Foliage	3.98	4.60	5.54	6.32	6.60
Live Plants (Potted)	3.84	4.10	4.90	4.87	6.80
Cut Flowers (fresh and dried)	1.22	1.60	0.66	0.80	0.81
Flower seeds; bulbs, corms, tubers, etc.	1.43	0.70	0.37	0.27	0.31
TOTAL	10.47	11.00	11.47	12.26	14.52

Source: Sri Lanka Customs Statistics cited in Krishnarajah, S. A., Dhanasekera, D. M. U. B., Wijesundara, D. S. A. [59]

• *Health sector*

It is estimated that there are 1414 plants used in traditional medicine, while 50 are heavily used and 208 are commonly used.[33] Many medicinal plants in the country are directly harvested from forests.[8] The fact that some of these species are becoming rare due to over extraction[33,38] will therefore have a negative impact on the health of rural populations.

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 Ayurvedic Commissioner, has grown steadily to 19,529 by 2009.[42] They practise healing through the use of herbal medicines. Despite the popularity of western medication, traditional medication is still quite popular among a large segment of the population. This has resulted in commercial scale collection of medicinal plants. Often commercial scale collectors over-extract from the

wild.[38] In contrast, collections from the wild by rural traditional medicine practitioners near forests are often sustainable.[39]

The use of plant species for herbal medicines is well known throughout the history of Sri Lanka as reflected in the ruins of hospital complexes at Ritigala, Mihintale, Polonnaruwa and Anuradhapura. One area of the indigenous medical practice which has continued to be popular in recent years is traditional orthopaedics, and a large number of practitioners still operate around places such as Ritigala, where the necessary herbal material is still available in the wild. The use of *Beheth Oruwa* or medicinal trough had been widespread in ancient times, but the remaining stone troughs defy any proper understanding of its ancient use. These structures have, however, given the medicinal bath a lucrative place in the current hotel industry. The local and overseas market for herbal products has also increased tremendously in the recent past as reflected in numerous products. A total of 170 medicinal plants quoted in the "Sarartha Sangrahaya" have now been identified, and comprise: 51species of cereals, 61 species of herbs, 10 species of shrubs, 20 species of climbers, 20 species of trees, 7 species of tubers, and 01 species of mushrooms. (*Madduma- Bandara, et al, 2006)*. [60]

While there are very few communities in Sri Lanka that are totally dependant on ecosystem goods and services for their daily needs (including medicines), many rural communities continue to depend to some extent on forests and other ecosystems for part of their medicinal needs. 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. Many of these practices require plant material from forests and home gardens (*Source: IUCN, 1995*). [38]

2.0 Climate Change Related Issues and Vulnerability

According to the IPCC, *vulnerability* is the degree to which a system is susceptible to, or unable to cope with adverse effects of climate change. Vulnerability is a function of the character, magnitude and rate of climate variation and its effects to which a system is exposed, its sensitivity, and its adaptive capacity. *Exposure* means the nature and degree to which a system is exposed to significant climatic variations. *Sensitivity* is the degree to which a system is affected either adversely or beneficially by climate related stimuli. *Adaptive capacity* is the ability of the system to adjust to climate change (including climate vulnerability and extremes) to moderate potential damages, to take advantage of new opportunities or to cope with the consequences.

The potential impact of climate change is of considerable concern worldwide and has been given due consideration by both the Convention on Biological Diversity (CBD) and the United Nations Framework Convention on Climate Change (UNFCCC). There is an obligation for Parties of the CBD to identify and address related threats, while the ultimate aims of the UNFCCC includes the stabilization of green-house gas concentrations within a timeframe sufficient to allow ecosystems to adapt to climate change.[1] The findings of the IPCC and the attention given to this subject by the Conference of Parties to the CBD suggest that there are potentially serious threats to biodiversity as well as potential for adapting to climate change while also enhancing the conservation of biodiversity.[1] Although the impacts of climate change on Sri Lanka's biodiversity are not well known, a precautionary approach has been taken during the preparation of this report, taking into consideration lessons from the global level as well as experiences of national experts who have been dealing with biodiversity at the local level.

BOX 4: DETERMINANTS OF VULNERABILITY OF BIODIVERSITY AT THE GLOBAL LEVEL

Among the many determinants of biodiversity in a give area at a given time are " the mean climate and its variability", and "disturbance regimes and occurrence of perturbations of . . . climatic . . . origin". The dynamics of evolutionary and ecological processes induces a background rate of change in the earth's biodiversity, and human induced global warming and other climate change impacts are a new perturbation that will impact on biodiversity either directly or in synergy with the other determinants of biodiversity change.

Many of the Earth's species are already at risk of extinction due to pressures from natural processes or human activities. Climate change will add to these pressures, while for a few species the pressures will be alleviated by climate change.

While there are regional variations in the impacts of climate change on biodiversity, a few common findings of the IPCC are:

- Species with limited climatic ranges and/or restricted habitat requirements are typically the most vulnerable to climate change. Species in mountain areas are more at threat as they cannot move further upward in elevation.
- Species in islands are more at risk as they cannot migrate easily.
- Biota with particular physiological (e.g. species with temperature dependant sex determination, amphibians with permeable skin and eggs) or phenological (flushing, fruiting and flowering) traits that are sensitive to climate change are especially vulnerable.
- Species already at risk due to low population numbers, restricted or patchy habitats, limited climatic ranges, or occurrence on low lying islands vulnerable to sea level rise or on top of mountain ranges are more at risk.
- Geographically restricted ecosystems, especially where there is added pressures from human activities are potentially vulnerable to climate change. E.g. coral reefs, mangrove areas, coastal wetlands.

Source: SCBD (2003) Interlinks between biodiversity and climate change for advise on the integration of biodiversity considerations into the implementation of the UNFCCC, CBD Technical Series No 10.[1]

At the global level . . .

Global past [Pleistocene] climate change resulted in marked reorganizations of biological communities, landscapes, and biomes, and major shifts in species geographical ranges. Projected rate and magnitude of changes in climate during the 21st century are, however, unprecedented compared to those in the last 1.8 million years [Pleistocene]. The present ability of species to adjust given present human-dominated landscapes is also questionable as many species exist in fragmented, weed and pest infested localities, are confined to small areas within their previous ranges, and/or reduced to small populations with reduced genetic diversity. They are therefore constrained in adapting to climate change through migration or genetic potential. There is therefore no reliable model in the recent past of what to expect in terms of current impacts on biodiversity due to sustained greenhouse driven global climate change. Warming beyond the Pleistocene temperature range can be expected to lead to large biotic turnover and extinctions, besides the expected substitution of present biotic communities by non-analogues communities.

Source: SCBD (2003) Interlinks between biodiversity and climate change for advise on the integration of biodiversity considerations into the implementation of the UNFCCC, CBD Technical Series No 10.[1]

"Implementation of climate change adaptation activities will depend on the expected climate change impacts in the country concerned: for example, sea level rise, increased risk of flooding and occurrence of extreme weather events."
(Korne et al. in SCBD 2003)[1]

As an island nation, Sri Lanka is vulnerable to the risk of sea level rise and increased frequency of storms that can bring major impacts on coastal biodiversity. Analysis of climate data for Sri Lanka clearly indicate a change in rainfall regimes, and a trend for increasing air temperature, which can also have impacts on the country's biodiversity (BOX 5).

The impact of climate change on biodiversity and possible areas for adaptation are still speculative. As such the perceived key climate change-related issues and risks related to Sri Lanka's biodiversity have been collated from discussions with a wide range of stakeholders.

2.1 Climate Change Induced Threats[gg]

- *Possible impacts of sea level rise, coastal flooding, rising temperature and elevated CO_2 concentrations*

- Salinization of low lying areas due to sea level rise, storm surges and salt water intrusion.
- Loss of coastal land due to sea level rise and increased coastal erosion due to more frequent and intense storm surges.
- Net loss of wetland area if coastal wetlands are unable to migrate to keep pace with sea level rise.
- Adverse impacts of sea level rise and storm surges on mangroves, coral reefs and seagrass beds could affect marine organisms for which they form important breeding grounds.
- Disturbed coastal dynamics and habitats that could cause altered species composition and distribution, communities, and ecosystem services.
- Landward migration of coastal wetlands, resulting in the loss of freshwater and brackish habitats.
- Changes in salinity of lagoons and estuaries could affect ecosystem services and the species they contain, including the abundance of fish and crustaceans important for the food fishery.
- Changes in current patterns due to climate change may affect the commercial fishery.
- Changes in coastal and marine systems, species and ecosystem services due to global warming and ocean acidification that will have major impacts on

BOX 5: IMPACTS OF CLIMATE CHANGE ON THE WEATHER IN SRI LANKA

Increasing temperature

- Air temperature in Sri Lanka has increased by 0.64 ^{0}C over the past 40 years and 0.97^{0}C over the last 72 years, which revealed a trend for an increase of 0.14 ^{0}C per decade. However, the assessment of a more recent time band of 22 years has shown a 0.45^{0}C increase over the last 22 years, suggesting a rate of 0.2^{0}C increase per decade.
- Consecutive dry days are increasing in the Dry and Intermediate Zones.
- Ambient temperature (both minimum and maximum) has increased.
- The number of warm days and warm nights have both increased, while the number of cold days and cold nights have both decreased.
- The general warming trend is expected to increase the frequency of extreme hot days.

Rainfall variability

- The precipitation patterns have changed, but conclusive trends are difficult to establish.
- A trend for rainfall decrease has been observed historically over the past 30-40 years, but this is not statistically significant.
- There is a trend for the increase of one day heavy rainfall events.
- An increase in the frequency of extreme rainfall events is anticipated, which would lead to more floods.

Drought

- An increased frequency of dry periods and droughts are expected.

Source: Department of Meteorology, Sri Lanka, provided for preparation of this report in 2010 *[bring in from water)*

Predicted impacts of sea level rise

The forecasts for global sea level rise in this century vary considerably, but the Inter-governmental Panel on Climate Change (IPCC) has provided a central estimate of 0.2 m and 0.5 m rise by the years 2050 and 2100 respectively. The forecasted sea level rise for 2050 is expected to cause a general shoreline retreat of 10 m along all sandy coasts assuming a mean slope of 1:50 for a typical coastal profile. Over a 50 year period this will correspond to 0.2 m of shoreline retreat per year. By 2100 a general shoreline retreat of 25 m is expected, corresponding to an average retreat of 0.25 m per year. These values are valid for sandy coasts with relatively no erosion.

Source: CCD, 2006[4]

[gg] Responses received or validated during the workshop to discuss this SVP and during individual consultations with stakeholders.

coral reefs, other shell forming organisms and associated species and fish stocks *(see details of impact of temperature rise on fish stocks in the SVP on Agriculture and Fisheries (Part II)*.

- Rising ocean temperatures and El Nino events that will systematically bleach and impoverish coral reef systems, including reef dwelling species of commercial and environmental value.
- Increased spread of marine invasive species in areas affected by climate change (E.g. Coral reefs affected by EL Nino at Weligama have been invaded by *Halimeda* – a red algae).

Examples at the global level on potential climate change impacts of sea level rise and global warming on coastal and marine systems:

- Most coastal wetlands could be affected by storm surges that cause physical damage and salt water intrusion so that globally 20% of coastal wetlands could be lost by 2080 due to sea level rise, but with significant regional variations.
- Mangroves and coastal lagoons are expected to undergo rapid change and be perhaps lost when relocation to withstand adverse conditions is precluded by infrastructure and geographic features.
- Sea level rise and coastal development (coastal squeeze) could affect inter-tidal areas, leading to loss of feeding habitats and population decline of wintering shore birds.
- Frequent storms could cause further erosion of beaches and barrier beaches; while the ability of fringing and barrier reefs to reduce impacts of storms can be adversely impacted by sea level rise.
- Increased seasonal and annual temperature can increase incidence of disease and coastal water toxicity.
- There could be changes in fish populations related to large scale climate oscillations.
- The changes in marine plankton due to climate change could affect marine productivity and hence, commercial fish yields.
- Range shifts in marine species as a result of climate change could have impacts on marine predator and prey populations, and hence on the entire marine ecosystem.
- Impacts of climate change on marine food chains would impact on marine mammals.

Source: SCBD, 2003[1]

Fisheries production is but one of the many ecosystem services that disappear when a reef dies. Many people depend directly on the reefs for their daily subsistence and/or income. In the central Indian Ocean, bleaching has been shown to have direct impacts on 90% of the traditional artisanal fishing communities. Initial studies estimate that dead, crumbling reefs could lose 50% of their fisheries value. The coral bleaching episode in 1998 was estimated to cost as much as US$8 billion in the Indian Ocean in terms of fisheries, tourism loss and reduced coastal protection.

Source: Ceasar, H. (2004) Paying the Price of Climate Change. In *World Conservation*, Volume 35, No 1. pp 28-29[7]

- *Impacts of rising temperature and elevated CO_2 concentrations and change in rainfall regimes*

Possible impacts on forests and terrestrial species:

Examples at the global level on potential climate change impacts of global warming on forests and terrestrial biodiversity:

- The relationship between elevated CO_2 and plant growth and forest functions are presently not clear. More knowledge is needed to calibrate models to predict changes in forest structure and biodiversity.
- Tree growth rates, litter-fall, and fine root increment *may* increase; and total net productivity *may* increase with higher CO_2 levels; but this can make the plants more vulnerable to pests and disease.
- Increased dominance of lianas has been observed under higher CO_2 situations in the Amazon. This could degrade the forest structure with increased liana biomass pulling down trees.
- Impacts of elevated CO_2 differ for C3 and C4 plants - with positive impacts on C4 plants being more than for C3 plants. [i.e. This could lead to geographic changes of C3 and C4 plants due to migration of C3 plants and greater spread of some C4 plants].

Source: SCBD, 2003[1]

- Climate change is expected to cause changes in onset of flowering/fruiting and flushing in terrestrial plants and breeding and reproduction in animals. This can have major impacts on species survival, and the ecosystems they are a part of.
- Forest ecosystems and species in fringe areas between the major climatic zones are expected to be most liable to impacts of climate change.
- Changes in forest structure due to impacts of elevated CO_2 levels on lianas (see above) and timber in forest plantations.
- Loss of species and structural and compositional changes in habitats & deterioration of ecosystem services.

Possible impacts on wetlands:

Examples at the global level on potential climate change impacts of changes in rainfall regimes on inland wetland biodiversity:

- Changes in water cycles & hydrology of catchments as most are intricately dependant on the hydrology of the catchments. This will affect biodiversity and cause temporal changes of wetlands.
- Changes in rainfall and flooding patterns across large areas of land can affect aquatic species, especially aquatic birds.

(Source: SCBD, 2003) [1]

- Water scarcity (quality and quantity) due to changes in rainfall regimes and deterioration of regional water quality from impacts of climate change (*More details of loss of water quality due to water scarcity are given in the SVP on water)*.
- Variability of rainfall regimes that cause changes in hydrological cycles will affect wetlands and the species they contain; some regions will be affected most.
- Degraded watersheds due to degradation of Wet Zone forests in the past will be more vulnerable to climate change

Degradation of watersheds due to degradation of Wet Zone forests in the past will compound water scarcity, while loss of flood retention areas in urban areas will render people more vulnerable to the impacts of extreme rainfall events.

Possible impacts on agricultural systems:

Examples at the global level on potential climate change impacts of changes in rainfall regimes on agricultural lands:

- About 40% of agricultural land worldwide has been strongly degraded in the past 50 years. Climate change will provide additional pressure on these ecosystems and the goods and services they provide.
- Agriculture in some regions will benefit – due to the receipt of more rainfall and longer growing seasons; farmlands in some regions may become further impoverished.
- Many natural populations of Crop Wild Relatives are increasingly at risk due to loss of habitats.

Source: SCBD, 2003[1]

- Saline intrusion into coastal agricultural lands.
- Changes in flowering/fruiting and flushing in crops, and breeding and reproduction in livestock.
- Adverse impacts on productivity of crops and livestock due to elevated $C0_2$ levels; increasing temperature; and changes in rainfall regimes that can lead to water scarcity, droughts and unpredicted heavy rains that will disrupt cropping cycles, cause landslides and floods. *(see more details of climate change on crops and livestock in the SVP on Agriculture and Fisheries [Part 1])*.
- Increase of pest and disease populations due to climate change and resultant productivity loss in crops and livestock.
- Beneficial climate change impacts on IAS which may spread faster than before and adversely affect crops and livestock.
- Impact of rising temperature on CWR, traditional crop varieties that could be used for crop improvement to overcome lowered productivity due to climate change.

2.2 Vulnerability enhancing factors for biodiversity

- *The main anthropogenic factors that currently threaten biodiversity and would reduce resilience of ecosystems and species to withstand impacts of climate change*[hh]

- **Habitat loss and fragmentation:** This is the most serious threat to wild inland biodiversity in Sri Lanka, the most acute problems being: (a) the fragmented Wet Zone forests where loss of forest connectivity has led to restricted natural dispersal of species and increased vulnerability to genetic erosion, edge effects, local extinction and climate change; (b) *ad hoc* reclamation of wetlands and landfills in urban wetlands, which also make adjoining areas more prone to flooding—despite laws and policies that preclude such activities; and (c) loss of coastal lands due to unplanned development.

[hh] Outcome at consultative meeting to validate and /or update information in the 4th Country Report from Sri Lanka to the United Nations Convention on Biological Diversity and re-validated at the workshop to discuss this SVP.

- **Ecosystem degradation:** Harmful effects are mostly in freshwater wetlands due to pollution and siltation from unsustainable land use practices including deforestation, agricultural run-off, over-extraction of water for irrigation, illegal sand mining; the spread of monocultures around 500 years ago in steep lands which caused the onset of large scale soil erosion in the country and subsequent inappropriate land alienation in hill slopes; state logging in the already fragmented Wet Zone forests in the 1970s that severely degraded them (i.e. although the larger forests have regenerated well the smaller forest patches are isolated and badly degraded); salinity intrusion into coastal areas; degradation of coastal ecosystems such as mangroves, lagoons and estuaries due to unsustainable fishing practices, over-exploitation of resources, pollution, unauthorized encroachment and land reclamation, coral mining and coral death due to bleaching from El Nino effects.

During the Pleistocene, species' adaptation to climate change appear to have been by evolutionary changes— the chances of which are enhanced by high genetic diversity in a species, by sheltering in patches of conducive refugia, or by migration to conducive areas–causing major range shifts in species. Species that could not adapt to changing conditions became extinct.

Climate change related issues and adaption related to biodiversity and ecosystem services have been identified by the IPCC and CBS secretariat. Chief among these are that climate change is expected to have an impact on all the earth's major ecosystems-especially:

- *Geographically restricted ecosystems*
- *Coral reefs*
- *Mangrove forests and other coastal wetlands*
- *High mountain ecosystems (2000-3000m)*
- *Remnant native grasslands*
- *Ecosystems over-laying permafrost and ice edge ecosystems*
- *Ecosystems with added threat from human activities*
- *Ecosystems dominated by long-lived species (i.e. long-lived trees) will be slow to show evidence of CC but the effects will be more long lasting*
- *Ecosystems affected by climate change that cannot relocate*

The species that are most expected to be vulnerable to climate change are:

- *Populations and habitats that are already fragmented as this precludes migration as an adaptation mechanism*
- *Populations that are already small and with reduced genetic diversity as this reduces species' options for adaptation*
- *Species with competition from alien invasive species, pests and weeds as this decreases resilience*
- *Species living in climate change affected regions/ecosystems*
- *Species greatly affected by temperature and rainfall regime changes*
- *Already threatened species due to prior human action and other changes*

Source: SCBD (2003) Interlinks between biodiversity and climate change for advise on the integration of biodiversity considerations into the implementation of the UNFCCC, CBD Technical Series No 10.[1]

- **Over exploitation of biological resources:** This, as well as destructive harvesting practices have particularly affected populations of coastal food fish and lobsters, marine and freshwater ornamental fish, medicinal plants of commercial value, valuable timber species, and other species providing raw materials for cottage industries (such as rattan) and/or have subsistence value as food items or wood for posts, poles and fuelwood.

- **Loss of traditional crop and livestock varieties and breeds:** Due to the need for increased food production in the face of rapid population growth in the country, and the consequent commercialization of agriculture, indigenous varieties of rice and other food crops that are relatively low yielding, but show resistance to pests, and biotic and abiotic stresses under varied agro-ecological conditions, have been largely replaced in farming systems by fewer new high yielding varieties that are greatly reliant on fertilizer and pesticides. This is particularly apparent in rice fields. These new varieties are genetically uniform and more liable to pests and disease. The replacement of traditional varieties has also brought about the loss of associated traditional knowledge developed through the ages on how to cultivate and use them to best advantage for human wellbeing. Among livestock the indigenous breeds are hardly used due to high reliance on imported varieties that are high yielding but sensitive to disease and climatic conditions. Conservation of the local livestock germplasm is not sufficiently addressed in the country as yet, although conservation of crop germplasm is being addressed.

- **Pollution:** Pollution of inland freshwater and coastal wetlands and associated marshes due to contamination with fertilizers, pesticides, weed killers, sewage, chemical compounds from shrimp farms in coastal areas, and dumping of untreated industrial wastes and solid waste due to the paucity of land for safe disposal. The release of ballast water and waste oil and tar from ships may add to coastal pollution. Pollution has already made many aquatic habitats unusable to freshwater species, threatening several aquatic endemics that need clean clear water.

- **Human - wildlife conflicts:** The disruption of travel patterns of wildlife, particularly elephants, has led to serious human-wildlife conflicts by the break up of continuous stretches of forest, particularly in the Dry Zone, for establishment of human settlements, irrigated agriculture and *chena* cultivation.[ii] The human–elephant conflict has consequently become acute. There are also signs that proximity of human habitations and hotels to forest areas has increased garbage and crop raiding and harassment of people by the endemic toque macaque. Likewise, the severe fragmentation of Wet Zone forests due to plantation agriculture in the past has led to co-occurrence of monkeys in home gardens and crop plantations through the ages. However, these areas too are now undergoing rapid change due and loss of canopy, giving rise to escalating human-monkey conflict due to crop raiding and roof damage.

- **Spread of Invasive Alien Species (IAS):** The accidental and intentional introduction of IAS has caused serious environmental and economic problems by reducing functional area of wetlands, problems in irrigation tanks, and loss of native freshwater dependant species. Several national parks have major problems due to the spread of IAS and agricultural systems have been periodically challenged by IAS. This has required remedial measures at high cost and considerable effort for removal and monitoring to prevent re-establishment.

Examples at the global level on potential climate change impacts on the spread of IAS:

- The increased spread and establishment of IAS could seriously affect natural and agricultural systems and their biodiversity.
- Threats from IAS on native biodiversity may become worse with climate change as new areas become hospitable to AIS.
- Increased spread of disease, pests and weeds in previously unaffected areas are predicted due to climate change.

Source: CBD, 2003[1]

Example of the impact of alien invasive species in Sri Lanka

Climate change is expected to increase the worldwide range of many alien invasive species. Sri Lanka as an island is highly vulnerable to alien species invasions and the severe repercussions they could have on all ecosystems: particularly on marine and inland wetland systems and the fishery, on agriculture, and hence the national economy. Sri Lanka's indigenous freshwater species are believed to be threatened due to the introduction of IAS that have also brought in new diseases into freshwater systems. Some introduced species have out-competed or consumed indigenous species leading to their local extinction. It is believed that currently there are about 22 species of introduced food fish in the inland freshwaters. Some species, such as Tilapia*, are believed to be the direct cause of population decline among indigenous aquatic fauna.*[32] *Other species such as trout, common carp and rohu are also now spawning in the wild. Some brackish water indigenous species introduced to freshwaters could also become invasive in the future in the face of climate change, and may pose a severe threat to the indigenous freshwater fishery. The red calcareous algae* Caulerpa *has already become invasive in coral reefs, the reason for which is not clear* **(Arjan Rajasuriya personal communication, 2010).**

The role of climate change in promoting invasions

"Recent decades have seen another factor emerge with regard to invasive species spread. Whereas the natural range expansions of organisms can occur in response to changing environmental conditions, there is evidence that climate change and global warming can significantly accelerate the process. For example, the arrival of exotic species from the tropical Atlantic through the Gibraltar Strait into the Mediterranean Sea has become a relatively common occurrence in recent decades. Scientists believe this reflects an expansion of their natural distribution due to the warming of seawater."

Source: Meliane, I and Hewitt, C. (2004) Confronting invasives. *World Conservation*, Volume 35, No 1. p 22 [61]

[ii] With regard to the human elephant conflict the clearing of high forest and establishment of grasslands and chena has increased conducive habitats for the elephant causing the elephant population to rise from 2500 in 1972 to over 6000 at present. Coupled with loss of natural habitats and migration routes this has inevitably escalated human-elephant conflict in the Dry Zone (Prof. S.W Kotagama pers. com. during preparation of this report in 2010).

- **Increasing human population density:** Sri Lanka has a total human population of over 20 million, which causes pressure on natural ecosystems and species, especially in the species rich Wet Zone where forests and wetlands are surrounded by human settlements, increasing the risk of forest encroachment, land fills and poaching. The rising demand for land has also led to loss of canopy cover in human settlements due to fragmentation of home gardens that are important repositories of horticultural biodiversity and are important habitats for birds, butterflies, small mammals and primates, in addition to their ability to ameliorate local climate.

- *Socio-economic issues that would arise due to impacts of climate change on biodiversity*

Examples at the global level on potential impacts on traditional communities[1]

- Effects of CC will be felt early by indigenous and local peoples – in terms of impacts on their subsistence and livelihood.
- Sea level rise and other climate change impacts may affect unique cultural and spiritual sites and the people that reside in them.
- Shifts in the timing or ranges of wildlife due to climate change can impact on the cultural, religious and agricultural beliefs and practices of indigenous people.

- Impacts on coastal communities due to loss of livelihood from fishery related activities.
- Loss or severe reduction of species of subsistence or commercial importance due to the impact of climate change.
- Impact of climate change on agriculture and livestock based livelihoods and incomes.
- Impacts of water scarcity on communities that depend on forests and wetlands for at least part of their water requirements.

2.3 Mapping climate change vulnerability

A vulnerability mapping exercise, using GIS, was undertaken in order to better understand climate change vulnerability in key sectors in Sri Lanka, building on the IPCC definitions of exposure, sensitivity, and adaptive capacity as defined in section 2.0 above.[jj] The analysis is intended for use as a macro level planning tool, to illustrate where sector-specific vulnerability is high, in relative terms, across the nation, and to guide decisions on prioritization and targeting of potential climate change adaptation responses.

General methods

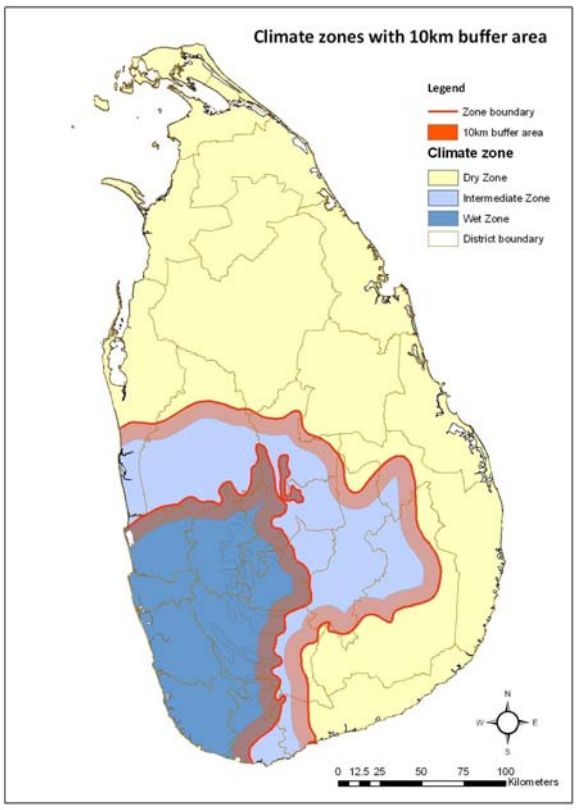
The basic methodology involved in the GIS mapping exercise (used in general for all SVPs) was to develop indices for exposure, sensitivity and adaptive capacity as relevant to each given sector. These three indices were then combined to create a composite sector-specific climate change vulnerability index. The analysis for this document was slightly different in that it is largely based on available data sources from the 2001 National Census (for socio-economic data); the Portfolio of Strategic Conservation Sites/Protected Area Gap Analysis in Sri Lanka (2006) for the forest cover map and distribution of threatened amphibians, orchids and diptrerocarps;[10] the 2007 Red List of Threatened Fauna and Flora of Sri Lanka for district level forest area (ha), numbers of threatened species from selected groups (i.e. butterflies, vertebrates and flowering plants) and human population density on a district basis,[27] and the map of major climatic zones from the National Atlas of Sri Lanka (2007).[2]

It must be noted that the causal relationship between exposure events due to impacts of climate change (i.e. temperature rise, sea level rise, changing rainfall patterns, etc.) and components of biodiversity and ecosystem services are not clearly quantified and are as yet speculative at best. Therefore, the impacts depicted in the maps are based on probable future scenarios, and vulnerability was assessed based on sensitivity and adaptive capacity indices only . The sensitivity and adaptive capacity indices used here are unique to this SVP and have been computed (given below) based on consultations held with a number of species experts working at field level. It must also be noted that the mapping exercise itself is preliminary and limited in scope, and should be refined on an on-going basis, based on detailed data which may become available in the future.

[jj] IWMI's Climate Change Vulnerability Index as in Eriyagama *et. al.*, 2010[62] was used as a starting point and substantially refined for finer grain and sector specific analysis.

What the vulnerability maps foretell

- *Possible shift in climatic zones*



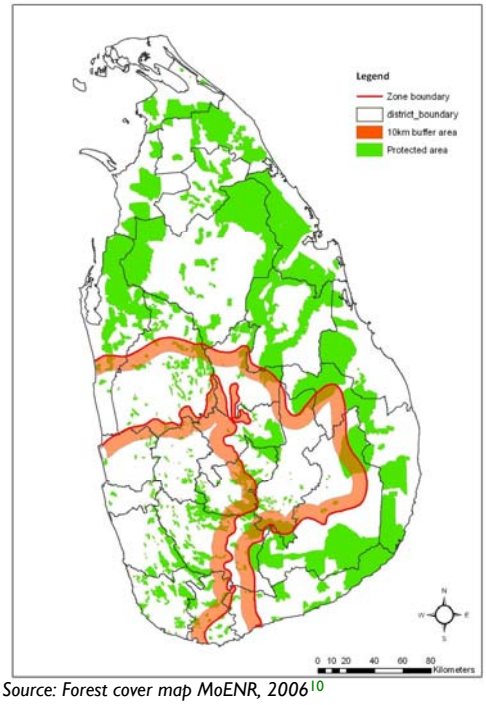
Source of climate zones map: National Atlas, 2007[2]

FIGURE 14: Possible shifts in major climate zones due to climate change

FIGURE 14 depicts a possible shift in the boundaries of major climate zones due to climate change, on the premise that the Dry Zone will spread into the Intermediate Zone, and the latter will spread into the Wet Zone. The area of spread is depicted subjectively as a 10 m band (i.e. pink colour band) within the respective Intermediate and Wet Zone boundaries, where they could become more water scarce and drier. The original boundaries of the Dry, Intermediate and Wet Zones as depicted by the red line are from the National Atlas (2007).[2]

FIGURE 15: Shows an overlay of forest cover in the island with the 10 m bands which shows where there could be a possible shift in major climate zones, namely in the Intermediate and Wet zones. This map suggests that valuable montane wet zone forests such as Horton Plains National Park and the Peak Wilderness Protected Area (which are now serial sites in a Natural World Heritage Site), and several lowland forests could be affected. In addition wildlife reserves, including National Parks in the Intermediate Zone, could also be affected.

On the basis of FIGURE 15, the forest area within the intermediate zone/dry zone 10 km band is 1248 km^2, while the forest area within the intermediate zone/wet zone 10 km band is 544 km^2. While the width of the selected band is subjective and this analysis is speculative, it is possible that these forests and the species they contain could be affected by shifts of the Dry Zone and Intermediate Zone boundaries due to climate change.



Source: Forest cover map MoENR, 2006[10]

FIGURE 15: Possible Forests affected by a shift in major climate zones due to climate change

- *Vulnerability of inland biodiversity to climate change (based on existing threats and low adaptive capacity)*

FIGURE 17 illustrates the geographic distribution (at district level) of vulnerability of Sri Lanka's biodiversity to climate change. The indicators considered in developing the sensitivity and adaptive capacity indices are given below.

The sensitivity index	The adaptive capacity
A composite of data (at DSD level) on: • number of threatened butterfly species per district (IUCN and MOENR, 2007)[27] • number of threatened vertebrate species per district [27] (IUCN and MOENR, 2007) • number of threatened flowering plants per district (IUCN and MOENR, 2007)[27] (these three groups have been taken as representative groups that could be expected to be affected by climate change)	A composite of data (at DSD level) on: • Forest cover (ha) per district (2007 census data) • Human population density per district (2007 census data) • Home garden size per district (calculated using the 1: 50,000 land use map to obtain home garden area per district, and the number of housing units per district from the 2001 Census)

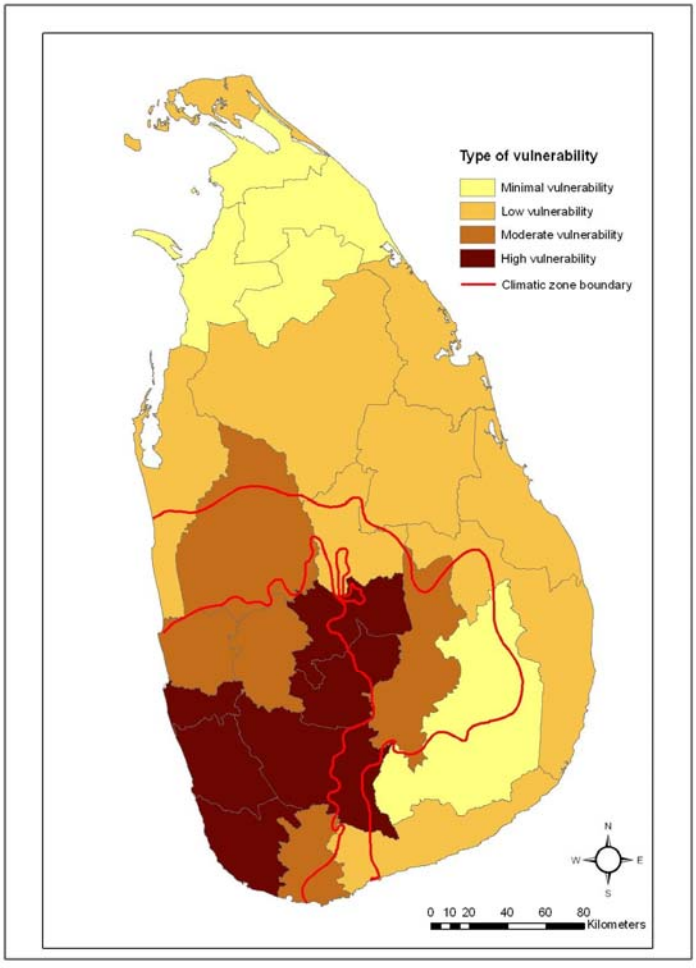


FIGURE 16: The potential vulnerability of biodiversity by District

Notably:

- 6 Districts appear to be highly vulnerable in terms of biodiversity. These Districts are Galle, Kalutara, Colombo, Ratnapura, Nuwara Eliya and Matale. They have:
  - a total human population of 7,827,000, of whom nearly 15.3% are below the poverty line.
  - 183,378 ha of forests.
  - 1,583 (57.8% of all currently listed nationally threatened species.[27]
  - about 593,740 people engaged in jobs related to agriculture.
  - an average home garden size of 52.6 perches per household unit.
  - Most of the biodiversity rich lowland and montane wet zone forests
- Historically, Ratnapura, Kalutara, Galle, Colombo districts are also highly vulnerable to floods and Nuwara Eliya and Rathnapura Districts are highly vulnerable to landslides.
- A further 4 Districts (Matara, Badulla, Gampaha and Kurunegala are in the moderately vulnerable category. They have:
  - a total population of 4,605,000.
  - a total forest cover of 90,269 ha
  - 494 (18.03%) of all currently listed nationally threatened species.[27]

FIGURE 17 shows a composite map prepared by the superimposition of the distribution of threatened amphibians, dipterocarps and orchids [(as per maps prepared under the PAM&WC project/Portfolio of Strategic Conservation Sites/Protected Area Gap Analysis in Sri Lanka (2006)][10] on the map depicting district wise vulnerability (FIGURE 16). Amphibians and Orchids were selected because they are considered very sensitive to climate change, show high endemicity and are mainly found in the island's natural forests. Dipterocarps were selected due to their high endemicity and occurrence in country's biodiversity rich rain forests. *Together the location of these three groups were expected to indicate areas of rich biodiversity and endemism.*

Notably the composite map shows that the three groups were mainly found in the DS Divisions that fall within the Districts found to be highly vulnerable category in terms of climate change.

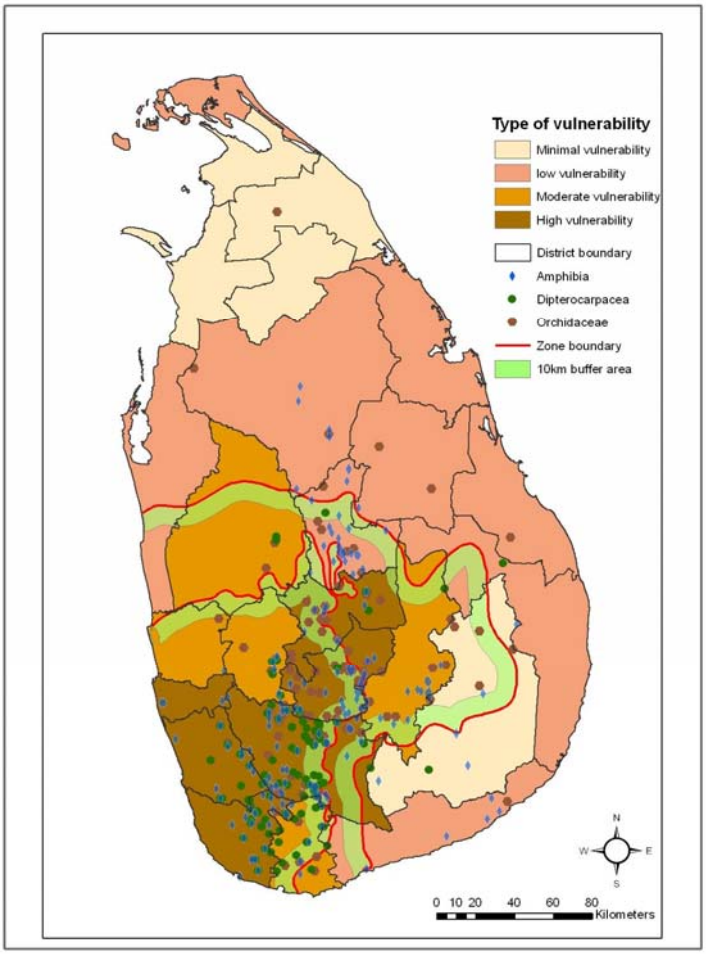


FIGURE 17: The potential vulnerability of Sri Lanka's biodiversity rich areas and sites of high endemism to climate change, by DSD

Source of distribution of threatened amphibians, orchids and dipterocarps: MoENR, 2006 [10]

Actions identified as necessary for adapting to climate change with regard to conservation of biodiversity and enabling uninterrupted ecosystem services are given in APPENDIX A.

3.0 Institutional and Policy Framework

3.1 Institutional set up

More than 30 state institutions are involved with some aspect of management and protection of the environment and natural resources in Sri Lanka. The key stakeholders involved in biodiversity conservation are in **Table 9**. Those with greatest responsibility for biodiversity conservation are the Ministry of Environment, which is the Focal point for the Convention on Biological Diversity, and its line agencies the Forest Department (FD), the Central Environmental Authority (CEA), and the Marine Environment Protection Authority (MEPA), the Department of Wildlife Conservation (DWLC) located under the Ministry for Economic Development, and the Coast Conservation Department (CCD) located under the Ministry of Ports and Aviation.

TABLE 9: Key institutions for conservation of biodiversity

Ministries with a role to play in biodiversity conservation	Key agencies	Other agencies/groups that could support biodiversity conservation
Key ministries • Ministry of Environment • Ministry of Economic Development (dealing with wildlife and tourism) • Ministry of Agriculture • Ministry of Lands and Land Development • Ministry of Livestock and Rural Community Development • Ministry of Fisheries and Aquatic Resources Development • Ministry of Ports and Aviation • Ministry of Indigenous Medicine • Ministry of External Affairs • Ministry of Construction, Engineering Services, Housing and Common Amenities *Other ministries that need to support biodiversity conservation* • Ministry of Finance and Planning • Ministry of Irrigation and Water Resources Management • Ministry of Plantation Industries • Ministry of Industry and Commerce • Ministry of Co-operatives and Internal Trade • Ministry of Technology and Research • Ministry of Power & Energy • Ministry of Education (and relevant institutions under it) • Ministry of Defence • Ministry of Water Supply and Drainage • Ministry of Disaster Management • Ministry of Resettlements	• Forest Department (FD) • Department of Wildlife Conservation (DWLC) • Department of National Zoological Gardens (DNZG) • Department of National Botanic Gardens (DNBG), • Central Environmental Authority (CEA), • Department of Agriculture (DOA) and associated research institutions plus other divisions under it including: The Seed Certification and Plant Protection Centre (SCPPC), Natural Resources Management Centre (NRMC), Field Crops Research and Development Institute (FCRDI), Horticultural Crops Research and Development Institute (HORDI), Rice Research and Development Institute (RRDI) • Plant Genetic Resources Centre (PGRC) which is also under the DoA but has a special role for *ex-situ* conservation of crops • Department of Agrarian Development • Department of Export Agriculture (DEA) • Department of Animal Production & Health (DAPH) • Coast Conservation Department (CCD) • Department of Fisheries & Aquatic Resources (DFAR) • Marine Environmental Protection Authority (MEPA) • Department of Land Use Policy Planning • Urban Development Authority (UDA) • Sri Lanka Customs *Research institutions* • National Aquatic Resources Research and Development Agency (NARA) • Coconut Research Institute (CRI) • Tea Research Institute (TRI) • Rubber Research Institute (RRI) • Sugarcane Research Institute (SRI). • Veterinary Research Institute (VRI) • Universities	• The National Science Foundation (NSF) • Sri Lanka Land Reclamation Development Authority (SLRDA) • Aquaculture Development Agency (NAQDA) • Mahaweli Authority of Sri Lanka (MASL) • Department of National Museums (DNM) • Department of Ayurveda • Export Development Board • Bandaranaike Memorial Research Institute • Department of Meteorology • Attorney General's Department • Legal Draftsman's Department • Department of National Planning • The Police Department • Sri Lanka Standards Institute (SLSI) • Department of Censes & Statistics • Sri Lanka Ports Authority (SLPA) • Registrar of Patents and Trademarks • Registrar of Pesticides • Institutions under the ministry dealing with education and higher education • Sri Lanka Tourism Promotion Bureau • Sri Lanka Tourism Development Authority • Disaster Management Centre (DMC) • Land Reform Commission (LRC) • Presidential Secretariat *Other Relevant groups* • Community Based Organisations (CBOs) adjacent to forests • Media institutions -(press, T.V, radio) • Journalists' for a • Civil Society represented by various organizations • NGOs focusing on environmental conservation

Ministries with a role to play in biodiversity conservation	Key agencies	Other agencies/groups that could support biodiversity conservation
	Regional/local level institutions: • Provincial Councils (PCs) • District/Divisional Secretariats • Local Authorities (LAs) • Provincial Environmental Authority of the North-western Province • Provincial Environmental ministries	*Private sector* • Industries/business sector institutions • The Chambers of Commerce • Agri-business companies

Source: Adapted from the *4th Country Report from Sri Lanka to the United Nations Convention on Biological Diversity in 2009, and validated in 2010 at the Consultative meeting to update chapters 3 and 4 of this report, as well as at the workshop to discuss the SVP on Biodiversity and Ecosystem Services.*

A summary of the key institutions that are mandated to implement conservation of the environment are given in APPENDIX B.

State institutions such as the Department of Small Industries, the Geological Survey and Mines Bureau (GSMB), the State Timber Cooperation (STC), and the institutions dealing with the transport and energy sector may sometimes negatively impact on biodiversity through their respective activities. It is recognized that biodiversity concerns should also be mainstreamed into their sectoral policies, plans and programmes.[63]

Inter-sectoral co-ordination in Sri Lanka with regard to addressing climate change impacts on biodiversity and adaptation mechanisms

Coordination could occur: through the Climate Change Secretariat of the MoENR and the Biodiversity Division of the Ministry of Environment (MoE) And through the National Disaster Management Center

Regional /local coordination

The decentralization system includes District Secretariats, Divisional Secretariats and *Grama Niladharis*, the *Pradeshiya Sabhas*, Local Authorities and the Provincial Councils. The absence of a strong coordinating mechanism to mainstream biodiversity into these decentralized institutions and into development sectors and the cross-sectoral plans and programmes is considered a major setback for implementing the biodiversity conservation action plan holistically and for sectoral and cross-sectoral integration of biodiversity concerns. [63] This gap can jeopardize biodiversity related adaptation mechanisms for climate change (i.e. those actions that are mainly to step-up conservation of biodiversity) so that a viable coordination mechanism should be given due consideration. A setting up a network of individuals in different institutions to meet this gap could be considered and incentives provided to create a vibrant professional network through local training (on an annual basis) and overseas study tours. This network could also be used to strengthen capacity to address climate change impacts in the respective sectoral plans and programmes of these institutions through capacity building. [63]

3.2 The main policies and laws that govern biodiversity conservation

Table 10 gives the main legislation, polices and plans that influence conservation and management of biodiversity in Sri Lanka.

TABLE 10: Key legislation, policy and plans governing biodiversity conservation

Main legislation governing biodiversity conservation	Other legislation having impact on biodiversity	Key policies/plans/strategies governing biodiversity conservation
• The Forest Ordinance No. 16 of 1907, and its subsequent amendments, including Act No. 23 of 1995 and Act No. 65 of 2009 • The Fauna and Flora Protection Ordinance No. 2 of 1937, and subsequent amendments including Act No. 49 of 1993 and Act No. 22 of 2009 • The National Environmental Act No. 47 of 1980 and the amendments: Act No. 56 of 1988 and Act No 53 of 2000	• The Soil Conservation Act No. 25 of 1951 as amended in 1996. • Felling of Trees Control Act No. 9 of 1951 • Water hyacinth Ordinance No 9 of 1909 • Urban Development Authority Law No 37 of 1978, as amended by	*Key policies* • The National Environmental Policy of 2003 • The National Wildlife Policy of 2000 • The National Forest Policy of 1995 • The National Wetlands Policy and Strategy of 2006 • The National Watershed Management

Main legislation governing biodiversity conservation	Other legislation having impact on biodiversity	Key policies/plans/strategies governing biodiversity conservation
• The National Heritage Wilderness Area Act No. 3 of 1988 • The Coast Conservation Act No. 57 of 1981 as amended by Act No.64 of 1988 • Plant Protection Act No. 35 of 1999 (replacing Plant Protection Ordinance No.10 of 1924). Legislation is being drafted to implement the Protocol on Biosafety • The National Zoological Gardens Act No.14 of 1982. • The Botanic Gardens Ordinance No. 31 of 1928. *(This Act is being amended)* • Fisheries Ordinance No. 24 of 1940 and amendments: The Fisheries and Aquatic Resources Act No. 2 of 1996 and Act No. 4 of 2001 • The Marine Pollution Prevention Act No.59 of 1981 as amended by Act No.35 of 2008 • The Northwestern Environmental statue No 12 of 1990	subsequent Acts, the recent ones being Act No. 44 of 1984 and Act No. 4 of 1992 • Agrarian Development Act No. 46 of 2000 • Town and Country Planning Act No. 49 of 2000.	Policy of 2004 • The National Policy on Agriculture of 2007 (deals with conservation of traditional varieties of crops).[kk] • The National Fisheries and aquaculture Policy of 2006[o] (which deals with environmentally friendly management of the fishery). • The National Land Use Policy of 2009 *Plans* • The National Biodiversity Conservation Action Plan of 1999 (Biodiversity Conservation in Sri Lanka: a framework for action) termed the BCAP and the Addendum to be BCAP of 2007. • The National Environmental Action Plan of 1991 and its subsequent revisions (the current being Caring for the Environment, path to sustainable, 2008) which has a chapter on biodiversity conservation, forests and wildlife. • The Forestry Sector Master Plan of 1995 which has an entire chapter on biodiversity conservation needs. • The Coastal Zone Management Plan (CZMP) which is updated periodically (1991, 1997 and 2006). The latest has a chapter on coastal habitats and their conservation, which includes the BCAP recommendations for coastal biodiversity. • The National Action Plan for Protection of the Marine and Coastal Environment from Land based activities of 1999 • The National Oil Contingency Plan (NOSCOP) • National fishery development plans • National agriculture development plans • The Solid Waste Management Strategy of 2000 • National Strategy for Sri Lanka Tourism (This deals with incorporating nature, culture and adventure tourism to develop the tourist industry)

* Legislation is being developed for a Biosafety Act.

[kk] Dealt with in detail in the SVP for Agriculture and fisheries

4.0 Current policies/plans/strategies and actions that support adaptation

Adaptation **is the adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities.**

"When animal populations face sudden environmental change, they must adapt, migrate, or die out. Human Populations face the same choice. Barring a miraculous turn of events, adaptation and relocation are our only acceptable options. Both are extremely expensive, technically. demanding and politically, controversial "

The impacts of climate change on biodiversity are complex and often based on findings of past impacts during the Pleistocene, changes occurring now on Earth, projected changes based on ecosystem and species characteristics, projected sea level rise and observed changes in rainfall regimes and ambient temperature. To help countries meet the challenges of climate change, the Convention on Biological Diversity has provided Country Parties several broad suggestions on how to address mitigation and adaptation to climate change.[1] The suggestions for adaptation are summarized in BOX 6.

Adaptation to climate change is not merely to address projected changes, but to address already manifested impacts that are affecting many ecosystems and species. Conservation of biodiversity and maintenance of ecosystem structure and function are important climate change adaptation strategies because genetically diverse populations and species rich ecosystems have greater potential to adapt to climate change. For example, increasing the health of coral reefs may allow them to be more resilient to increased water temperature and to reduce their susceptibility to bleaching events.
(SCBD, 2003)[1]

Although all climate change impacts on biodiversity may not be preventable, guidelines provided by the Secretariat to the Convention on Biological Diversity[1] strongly suggest that timely identification of threats, concerted conservation action to increase and maintain the resilience of species and ecosystems, availability of connected and safe protected areas and conducive refugia for affected species, and the use of an integrated ecosystem approach (that should be based on adequate research, monitoring, information from varied sources, and stakeholder participation at all levels, through multiple strategic thrusts and cross-cutting interventions) are practical and effective climate change adaptation strategies.

BOX 6: ADAPTATION OPTIONS SUGGESTED BY THE IPCC AS RESPONSES TO CLIMATE CHANGE IMPACTS WITH REGARD TO BIODIVERSITY CONSERVATION:

- Conserving and restoring native ecosystems, managing habitats for rare, threatened and endangered species, and protecting and enhancing ecosystem services.
- Reduction of other pressures on biodiversity arising from habitat conversion, over-harvesting, pollution, and invasion by alien species. *(Since mitigation of climate change impacts will be a long-term endeavor, reduction of other pressures would be the more practical option).*
- Countering habitat fragmentation, through the establishment of biological corridors between protected areas, particularly between forests, and the establishment of a mosaic of interconnected terrestrial, freshwater and marine multiple-use reserves and protected areas designed to take into consideration climate change impacts.
- Increasing resilience of existing protected areas while recognizing that some change is inevitable due to the response of species to climate change.
- Creating networks of reserves with connecting corridors or habitat matrices to provide for dispersal and migration routes for plants and animals, by using corridors to link fragmented reserves through the landscape. [corridors may be habitat areas sufficiently close to each other (meaning functionally linked), with adequate understanding of the appropriate width and structure of the corridor, management of corridor edges, optimal pattern of habitat patches in the matrix and surrounding lands].
- Using transition zones between ecosystem types (ecotones) within and among reserves to serve as repositories for genetic diversity that can be used to restore degraded adjacent regions.
- Backing up *in-situ* measures as above with *ex-situ* conservation, as captive breeding of animals and *ex-situ* conservation of plants and relevant translocation programmes can be used to augment and re-establish some threatened or sensitive species.

Source: SCBD, 2003[1]

BOX 7: ENVIRONMENTAL CONSIDERATIONS IN OVERARCHING POLICIES AND PLANS THAT INFLUENCE NATIONAL DEVELOPMENT

- ***Mahinda Chintana*: A vision for a new Sri Lanka**

The *Mahinda Chintana* 10 Year Horizon Development Framework 2006-2016[64] is the overarching vision for the country's development programme, the concepts of which are reflected in the National Physical Planning Policy & Plan and the *Randora* Infrastructure Development Programme. The framework considered actions for forests and wildlife, water and water sheds and biodiversity conservation. The *Mahinda Chintana*: Vision for the future (2010)[53] envisages establishment of green villages (under the *Gama Naguma* Programme), waste management (through the *Pilisaru* project), addressing the human–elephant conflict (through the *Gaja-mithuro* project), and the conservation of threatened species and promotion of environmental conservation (the latter projects are to be initiated from 2010).

- **The National Physical Planning Policy and Plan (NPPP&P) [5]**

The NPPP&P was approved by the National Physical Planning Council chaired by H.E. the President, and formally adopted on 3rd July, 2007 as a requirement under section 3(1) of the Town and Country Planning Amendment Act No. 49 of 2000. Guided by the NPPP&P, provincial level Regional Physical Plans are being prepared, some of which are now complete. The NPPP&P gives vision and direction for structural physical development in Sri Lanka up to 2030. It targets maximizing national economic development while taking into consideration the global economy. Being an integrated plan that takes into account all sectors of the country, it is significant that the underlying theme of the NPPP&P is to preserve equilibrium between conservation and production. For example, it encourages urban centre development while protecting environmentally sensitive areas such as forests, wildlife habitats, archaeological sites and areas prone to natural disasters. It acknowledges the need for Sri Lanka to carefully manage development activities and to avert (and in some cases reverse) the over-burdening of the island's natural systems with rapid and unplanned development.

The Principles and Strategies of the National Physical Planning Policy and Plan provide the tools to achieve its Vision. The Principles and Strategies guide the government planning process and decision making. In addition Regional, District and Local Plans have to be consistent with the Principles and Strategies which are an integrated holistic set. They are organised under the following headings, with no intended priority:

- protecting the environment;
- reducing vulnerability to natural disasters;
- human settlement development;
- infrastructure facilities;
- water development; and
- economic development.

- **The *Randora* National Infrastructure Development Programme**[56]

The *Randora* Programme complements the *Mahinda Chintana* and articulates in greater detail the plan and financing requirements for all major infrastructure investment across the country between 2006 and 2016. A summary of planned investments under the key infrastructure sub-sectors of economic infrastructure (i.e. roads, electricity, water supply and sanitation, ports and aviation, transport and rural infrastructure development); irrigation, education and health, industries (i.e. industrial development, tourism, science and technology, environment **and biodiversity**) and urban development and townships are outlined in the Randora Programme.

- ***The Action Plan for the Haritha Lanka* Programme**[54]

This programme has been developed through an interactive process involving all key ministries. Its mission is to focus on addressing critical issues which, if left unattended, would jeopardize the nation's economic development programme. Actions to address key issues that would enable sustainable development are embodied in the strategies and proposed actions set out under the ten missions of the *Haritha Lanka* Programme. The implementation of the programme is overseen by the Ministry dealing with plan implementation, while the secretariat for the programme is located within the Ministry if Environment. The 10 missions of the Action Plan are as follows: 1. Clean air – everywhere, 2. Saving the fauna, flora and ecosystems, 3. Meeting the challenges of climate change, 4. Wise use of the coastal belt and the sea around, 5. Responsible use of the land resource, 6. Doing away with dumps, 7. Water for all and always, 8. Green cities for health and prosperity, 9. Greening the industries, and 10. Knowledge for right choices. The funds for implementing the programme have to be generated by the implementing agencies, which has slowed down the process. A strong coordinating and monitoring mechanism and funds for implementation of the various programmes are a priority.

The Ecosystem Approach promoted by the Convention on Biological Diversity provides a flexible management framework to address climate change mitigation and adaptation activities in a broad perspective. This holistic framework considers multiple temporal and spatial scales and can help to balance ecological, economic, and social considerations in projects, programmes, and policies related to climate change mitigation and adaptation. "Adaptive management", which allows for the re-evaluation of results through time and alterations in management strategies and regulations to achieve goals, is an integral part of the ecosystem approach.

Source: SCBD, 2003 [1]

4.1 Measures taken that will help conservation of biodiversity by adaptation to climate change

Goal 7 of the 2010 Biodiversity Targets deals specifically with addressing the impacts of climate change. The global and national targets under this are given below:

Goal 7. Address challenges to biodiversity from climate change and pollution
Global targets: 7.1: Maintain and enhance resilience of the components of biodiversity to adapt to climate change. 7.2: Reduce pollution and its impacts on biodiversity.
National target: • Research on impacts of climate change on selected major ecosystems and indicator species. • Reduce pollution of air, water and land. *Source: 4th Country Report from Sri Lanka to the United Nations Convention on Biological Diversity* [6]

While the impact of climate change on Sri Lanka's wild biodiversity has not yet been subject to wide investigation, the government has taken certain landmark actions to address climate change in general at the national level, which also serve as a base to adaptation (BOX 8).

In addition, there has been:

- Systematic gathering of atmospheric data by a large number of state departments, although networking to share this data is deficient.
- Introduction of new technologies for adaptation by the Departments of Agriculture, several other research Institutes.
- National strategies for carbon trading under the CDM, preparation of a draft CDM Policy and establishment of two CDM centres.
- Projects to improve the quality of the environment through air quality management, solid waste management and promoting technologies for renewable energy through wind, solar and dendrothermal power.

Further, based on the understanding that ensuring biodiversity conservation is one of the most practical adaptations to climate change, many of the prerequisites have also already been met by Sri Lanka.

- *Sectoral legal and policy framework that supports climate change adaptation*

Overall, there are about 80 laws to conserve Sri Lanka's environment, many of which are of direct relevance for conservation and sustainable use of

BOX 8: LANDMARK ACTIONS TAKEN BY SRI LANKA IN RESPONSE TO CLIMATE CHANGE

- Ratification of the United Nations Framework Convention on Climate Change (1992) on 23 .11.1993 followed by the Montreal Protocol (on substances that deplete the ozone layer) and acceded to the Kyoto Protocol (which commits countries--i.e. mainly Annex I parties— to reduce their collective emissions of greenhouse gases).
- Establishment of a Climate Change Secretariat (CCS) within the Ministry dealing with the Environment to facilitate, formulate and implement projects and programmes at the national level with regard to climate change.
- Preparation of an inventory of green house gases (2000) followed by an update which is on-going.
- Establishment of a separate Climate Change Division within the Ministry dealing with the Environment.
- Establishment of a Centre for Climate Change Studies (CCCS) under the Department of Meteorology in 2000 to conduct research, monitor climate change, and provide the general public with current information on climate change and allied issues.
- Preparation of the Initial National Communication on Climate Change under the UNFCCC in 2000 by the Ministry of Environment (MOE), which indicated the sectors most vulnerable to climate change and subsequent impacts, the sectors that most contribute to climate change, the required mitigation options and adaptation responses and research and development.
- Initiation of the second National Communication on Climate Change under the UNFCCC by the MOE which is on-going.
- Addressing national capacity needs to implement the UNFCCC through the National Capacity Needs Self Assessment Project (NCSA) and preparation of the NCSA Action Plan based on a thematic assessment of existing capacity to address climate change by the Ministry of Environment and Natural Resources.

biological diversity, and hence to provide an important framework to support maintaining ecosystem resilience to climate change. The main enactments in this regard are given in **Table 10.** Of particular significance are the Flora and Fauna Protection Ordinance and the Forest Ordinance, The National Environmental Act, the Coast Conservation Act, and the Marine Environment Protection Act. These are periodically revised to provide adequate protection of wild biodiversity. The introduction of alien invasive species and biosafety are not felt to be adequately covered by the existing laws. While there are no special laws concerning access to genetic resources, the existing legal framework provided by the Flora and Fauna Protection Ordinance and the Forest Ordinance are perceived as adequate to the granting or denial of a legitimate application made to the Government of Sri Lanka for Transfer/Access of Genetic Resources by another Country Party to the CBD, as well as natural and legal persons from these countries.[63] The main policies and plans that would support biodiversity conservation are also given in **Table 10** and BOX 7**.** The most important polices and strategies that would support adaptation to climate change with regard to biodiversity conservation are given below.

The 2003 National Environmental Policy of Sri Lanka [65]

This policy aims to ensure sound environmental management within a framework of sustainable development in the country. It presents the course of action to be taken by Sri Lanka for safeguarding the environment and ensuring that economic development is sustainable. The policy addresses environmental dimensions under conservation and management of four basic groupings of natural resources, namely: land, water, atmosphere and biological diversity. It addresses restoration and conservation of ecosystems; conservation of threatened species; conservation of forest and agro biodiversity and the threat from invasive species. It also underscores the need for valuation of biodiversity in national accounting, research on conservation and sustainable use of biodiversity, protection of traditional knowledge on biodiversity and measures to limit access to genetic resources by external parties unless equitable benefits to the country are assured.

The National Forest Policy of 1995 [66]

This policy addresses biodiversity conservation and participatory management of forests with local people.
The current National Forest Policy of 1995 identifies biodiversity conservation as a key objective of forest and wildlife conservation. It advocates reorientation of the traditional approach to forest and protected area management by enabling greater involvement of local people in planning and managing Protected Areas. The main objective of the current Forest Policy of 1995 is to conserve forests for posterity "with particular regard to policy on biodiversity, soil, water, and historical, cultural, religious and aesthetic values", and promotes the adoption of the Protected Area work Programme in Sri Lanka. This policy decrees that all state forests will be brought under suitable management for continued existence of important ecosystems and the flow of forest products and services, while recognising traditional rights of local people and their beliefs; it promotes management and protection of forests by adopting partnerships with local people, rural communities and other relevant stakeholders with the use of appropriate tenural arrangements; and supports nature based tourism in so far as it does not damage ecosystems and will benefit local people. This policy also emphasises the importance of retaining the present natural forest cover and increasing overall tree cover as a whole, including in non-forested areas. It also reiterates that the State will observe international forest-related conventions and principles that have been agreed upon by Sri Lanka. In pursuance of this policy, the functions of the Forest Department have become 'greener' and shifted from one of production to conservation of the nation's forest biodiversity.

The National Wildlife Policy of 2000 [67]

The current National Policy on Wildlife Conservation addresses policy needs that respond to the evolving needs of Sri Lankan society and the mandate conferred as obligations under the Convention on Biological Diversity. The National Wildlife Policy of 2000 recognizes the need for appropriate and effective management of PAs, taking into consideration the needs of local communities and for providing support to wildlife resource managers by way of reorientation, strengthening and decentralization of their institutions. This policy renews state commitment to conserve wildlife resources for the benefit of present and future generations. It also recognizes the need to link activities, interests and perspectives of the people who use and benefit from wildlife resources with those of professional wildlife managers and scientists. The policy has taken into account the needs for promoting conservation of wildlife through study, education, sustainable use and participatory management; maintenance of ecological processes; conservation of genetic diversity useful for agriculture and livestock production; sharing of benefits from providing access to bio-resources, and preservation of indigenous and endemic species.

The Forestry Sector Master Plan of 1995 [66]

The Forestry Sector Master Plan (FSMP) of 1995 was prepared to take forward the National Forest Policy of 1995 during the period 1995 to 2020. This plan was developed with special emphasis on the conservation of biodiversity in the forest and wildlife sub-sectors. While the management of PAs under the Department of Wildlife Conservation does not follow the FSMP, the Forest Department follows the strategy outlined in the FSMP for management of its reserves. Accordingly, forests under the jurisdiction of the Forest Department will be reclassified, rehabilitated and placed under four management systems for: (a) strict conservation; (b) non-extractive use such as research and tourism with controlled collection of non-wood resources; (c) management of multiple use forests for sustainable production of wood, and (d) management of forests with community participation to meet the needs of local people. A significant feature of the FSMP is that it advocates a re-orientation of the traditional approach of both Forest and Wildlife Conservation Departments promoting the involvement of local communities in Protected Area Management. This plan has a chapter dedicated to biodiversity conservation in the forestry and wildlife sector and addresses in detail the needs, issues and options for management of forest areas to conserve indigenous terrestrial biological resources, with involvement of local people in the planning and management of Protected Areas. These concerns and needs were integrated into the National Biodiversity Conservation Action Plan and its Addendum.

The National Wetlands Policy and Strategy of 2006 [68]

This deals with conservation of wetlands. Accordingly all wetlands are to be zoned and classified according to the level of ecological, utilitarian, and international, national and local significance; the legal ownership of wetlands are to be ascertained – with legal reforms where needed and managed sustainably with appropriate management mechanisms and relevant restoration where necessary and with the participation of civil society. Several strategies are proposed to meet the aims of the policy. They are: strategies to support institutional arrangements; strategies to support inter-institutional linkages; strategies to support management of wetlands; strategies for research and development, training and capacity building.

The National Agricultural Policy of 2007 [69]

This policy promotes production and utilization of organic and bio-fertilizers to gradually reduce the use of chemical fertilizers through Integrated Plant Nutrition Systems (IPNS); minimizing the use of synthetic pesticides through promoting bio-pesticides and Integrated Pest Management (IPM); conservation of water resources, efficient water management and soil moisture retention techniques; prevention of water pollution from agriculture; adhering to the National Land Use Policy when allocating land for cultivation purposes; land conservation within watershed areas; enforcing the provisions of the Soil Conservation Act; conservation of traditional agricultural crops and methodologies relating to organic farming, pest control; promoting preservation and processing of food for nutritional and medicinal purposes; facilitating exchange of such knowledge among the farming community; and promoting home gardening and urban agriculture to enhance household nutrition and income.

The National Fisheries and Aquatic Resources Policy of 2006 [70]

The policy places responsibility of implementation of the national fisheries and aquatic resources with the ministry in charge of the subject of fisheries and aquatic resources and adopts a precautionary approach for management of the resources. This policy also promotes responsible fisheries, and prioritizes surveys on fisheries and aquatic resources and stock assessments; use of appropriate harvest technology and resource friendly fishing gear; and management of coastal fisheries to conserve the resource. It also seeks to protect the rights of the traditional coastal fishers and to regulate the use of fishing gear that will harm the fishery or other marine species in accordance with international obligations. It also seeks to enable participation of all stakeholders in developing inland fisheries and to protect the right of inland fishers to fish in irrigation reservoirs.

The National Livestock Development Policy [71]

The livestock development policy deals with developing the Dairy sub-sector, the Poultry Sub-Sector, and Animal feed resources. The Dairy sector is regarded as the priority sector for public sector investment in livestock development. There is no direct government involvement or support in the meat sub-sector, but private sector activity is permitted and the government takes responsibility for ensuring public health safeguards and quality standards in the meat industry. The policy goals and targets are: the achievement of sustainable and equitable economic and social benefits to livestock farmers; increasing the supplies of

domestic livestock produce at competitive prices to the consumers; achieving increased self-reliance, of at least 50 % in domestic milk by 2015; doubling the current domestic production of poultry products by 2015; making domestic livestock products competitive with the imported livestock products.

- *Key cross-sectoral environmental plans and strategies that support adaptation*

Caring for the Environment: Path to sustainable development (i.e. the National Environmental Action Plan [NEAP] 2008-2012) [72]

This NEAP has a chapter on Biological Diversity, Forests and Wildlife sector which deals with *in-situ* conservation, *ex-situ* conservation, access to genetic resources, and biosafety. The major environmental issues related to biodiversity, forests and wildlife are identified—in terms of habitat loss and fragmentation, loss of wetlands, global climate change and pollution. Gaps in major programme areas of biodiversity are identified under *in-situ* and *ex-situ* conservation, access to genetic resources, traditional knowledge, impacts on biodiversity, and legal and institutional aspects. It also deals with the vision for biodiversity, forests and wildlife sector; a sectoral analysis. The CFE /NEAP devotes separate chapters to climate change, coastal and marine resources, land resources, waste management water resources. The CFE contains the national environmental policy and strategies, and mechanisms for implementation and monitoring.

The Coastal Zone Management Plan (CZMP) of 2004[4]

This has nine chapters. Including an introductory chapter, followed by chapters dealing with Managing Coastal Erosion, Conserving Coastal Habitats, Controlling Coastal Water Pollution, Integrating Coastal Fisheries and Aquaculture with Coastal Zone Management, Special Area Management (SAM), Managing Sites of Special Significance and Public access along with the archaeological sites, monuments and cultural and religions sites. All chapter provides the required policies, strategies and actions to address the goals set out in each Chapter 8 on Enforcing Regulations and describes the strategies formulated and implemented by the CCD to regulate development in the Coastal Zone in accordance with the Coast Conservation Act No. 57 of 1981 and its Amendments and chapter 9 on Implementation of the CZMP Policies, Strategies and Actions summarizes the policies and outputs set out in each chapter.

- *Environmental related projects that support adaptation*

A large number of projects have served to build national capacity to conserve biodiversity to varying degrees. The main projects that have built capacity for biodiversity conservation are given below; some of which (key projects) are described further in APPENDIX C. Some of the important projects that could be expected to provide the base for adaptation measures for biodiversity conservation are:

- **The Environmental Action 1 Project** (commenced in 1997 for five years) enhanced institutional capacity for environmental conservation and regulatory aspects. Amongst many other activities, this provided training for CEA staff on biodiversity conservation and management.

- **The National Biosafety Framework Development Project** (May 2003-2005) (APPENDIX C)

- **The Crop Wild Relatives Project for "** *In-situ* conservation of crop wild relatives through information management and field application implement by the DoA through HORDI with support from the MoE and other partners (2004-2009). (APPENDIX C)

- **The Protected Areas Management Project c**arried out by the Department of Wildlife Conservation (DWLC) as an investment programme implemented with funds from the Global Environmental Facility (1992-1998) with the aim of strengthening capacity and capability of the DWLC and for preparation of resource inventory based viable management plans for protected areas.

- **The Forestry Sector Development Project** (FSDP) which strengthened capacity to establish forest plantations to supply timber without exploiting the island's natural forests.

- **The Community Forestry Project** (1982-1990) and the Participatory Forestry Project (1992-2000) which led to understanding of the role of local people in forest conservation through raising timber plantations and raising fuelwood plantations for local communities respectively.

- The GEF/UNDP funded Southwest Rainforest Conservation Project of the Forest Department (2000-2006) was instrumental for pilot testing and creating a model for participatory forest conservation in the wet zone with the help of local people.

- **The Forest Resources Management Project** (FRMP) (APPENDIX C)

- **Sri Lanka Australia Natural Resources Management Project (SLANRMP**) for poverty reduction through improved natural resource management in selected areas of the Intermediate and Dry Zone with the participation of local people. (APPENDIX C)

- **The Protected Area Management and Wildlife Conservation (PAM&WC) Project** 2001-2008. (APPENDIX C)

- **The Wetland Conservation Project (WCP)** Phase I was carried out by the CEA in 1991, which heralded significant measures for the conservation of wetlands in the island, and was instrumental in prioritizing wetlands for conservation and management.

- **The Integrated Resource Management Project (IRMP)** followed t**he WCP and focused on two selected wetlands (Muthurajawela Marsh and the Negombo Lagoon) for preparation of pilot scale implementation of Management Plans.**

- **The Coastal Resources Management Project (CRMP)** from 2000-2006 with funds from the ADB and the Government of the Netherlands to strengthen capacity for coastal resources and habitat conservation within the institutions under the Ministry dealing with Fisheries (including the Department of Coast Conservation). (APPENDIX C)

- **The GEF-UNDP funded National Capacity Needs Self Assessment (NCSA)** carried out by the Ministry of Environment to assess priority capacity needs of the country to implement the three Rio Conventions, namely, the Convention on Biological Diversity (CBD), the United Nations Framework Convention on Climate Change (UNFCCC) and the United Nations Convention to Combat Desertification (UNCCD). This involved preparation of a detailed thematic assessment on biodiversity to identify the most relevant capacity needs to implement the CBD through a wide stakeholder consultation process and the identification of actions and projects to build the required capacity.[63] Under this project, stakeholders were made aware of the principles of the Ecosystem Approach, and national capacity needs were assessed to implement this approach for *in-situ* and *ex-situ* conservation of biodiversity.

The 12 Principles of the Ecosystem approach

1. Objectives of management of resources a matter of societal choice
2. Management decentralized to lowest appropriate level
3. Consider effects on adjacent ecosystems
4. Recognize potential economic gains
5. Ecosystem structure and functioning is maintained
6. Managed within the limits of their functioning
7. Appropriate spatial and temporal scales
8. Recognize spatial scales and lag effects
9. Recognize that change is inevitable
10. Strike a balance between conservation and use
11. Consider all forms of relevant information – scientific, local, innovations, practices
12. Involve all relevant sectors of society and scientific disciplines

Source: UNESCO (2000)[73]

- The National Information sharing mechanism (NIM) for Plant Genetic Resources for Food and Agriculture (PGRFA) from 2007-2010, for state of the Plant Genetic Resources (Sri Lanka country status).

- Agro-biodiversity and climate change project to mainstream biodiversity conservation and sustainable use for improved human nutrition and well-being (single country project UNDP/GEF/Bioversity project executed by the MoE and implemented by the DoA.

- *Relevant Institutional programmes*

- **The National Red listing exercise:** Sri Lanka has been engaged in the preparation of nationally threatened species lists since 1989. They have influenced policy and legislation for conservation of species biodiversity in the country. This is in accord with the Convention on Biological Diversity, ratified by Sri Lanka in 1994, that requires Contracting Parties to identify important components of biological diversity for conservation and sustainable use

- **The Forest Department participatory forest programmes to increase tree cover through community participation:** An amendment has been brought to the Forest Ordinance in 2009 empowering the Conservator General of Forests to enter into agreements with stakeholders to carry out community participatory programmes for the development of forests. Accordingly, home garden development, canal bank planting, tank catchment rehabilitation and rehabilitation of degraded mangrove forest have been carried out in Ampara, Trincomalee and Batticaloa districts. In addition, reforestation of 877 hectares was completed in 2009.

- The **preparation and publication of a National Wetlands Directory** by the Central Environmental Authority (CEA) in collaboration with the International Water Management Institute (IWMI) and IUCN Sri Lanka. This has data sheets on 62 wetland sites in the island, and covers both inland and coastal wetland sites. This directory was published in 2006. *The information from this currently being entered into a database which will be continually updated by the Wetland Unit of the CEA.*

- The wetland Unit of the CEA is consulted by the Sri Lanka Reclamation Development Corporation prior to filling of paddy land and prior to approval for any development activity to be carried out in wetlands. EIAs are required for planning committee approval for clearing or filling of wetlands more than 4 ha, and for clearing any wetland that fall within the schedule 3 sensitive area category irrespective of size.

- Gazetting of 8 Environmental Protection Areas by the CEA under the National Environmental Act, including Gregory's Lake, Thalangama Lake, Bolgoda, Walauwatte–Waturana, Muthurajawela (buffer zone), and Private lands within the Knuckles Conservation Forest boundary, Hantane, and Maragala.

- There is a UNDP funded Integrated Strategic Environmental Assessment of the Northern Province by the CEA to prepare zoning plans for development of the region. This has been completed for Hambantota and Trincomalee Districts.

- MEPA has commenced a programme of work to implement the Marine Pollution Prevention Act and for surveillance and regulation of activities within its area of authority.

- Setting up *ex-situ* conservation facilities by the Department of Botanic Gardens in different climatic zones.

- *Facilitating the Man and the Biosphere Reserve (MAB) Concept*

Sri Lanka is well placed to adopt the MAB concept for management and conservation of biodiversity, which offers an excellent platform to promote principles that are inherent in implementing climate change adaptation measures for conservation of national biodiversity. MAB activities that are consonant with the MAB programme of UNESCO are promoted at the national level by the National MAB Committee of the National Science Foundation.

Biosphere Reserves are internationally designated Protected Areas belonging to Category IX under the IUCN system of classification. They are established to promote and demonstrate a balanced relationship between humans and the biosphere, and thereby take a people-centred approach. They offer solutions to conserving the environment to ensure sustainable development for people through reconciling the objectives of *conserving biological resources* with *sustainable use* of the environment and its resources. Biosphere reserves have three main functions: a Conservation function for conservation of landscapes, ecosystems, species and genetic variation; a Development function to foster sustainable economic and human development at the local level that is socially and culturally acceptable; and a Logistic support function to support demonstration projects, research and monitoring related to local, national and global issues of conservation and sustainable development, and promote environmental education and related information exchange. Biosphere reserves offer excellent opportunities to implement the 'Ecosystem Approach' for management and conservation of protected areas with the full participation of all stakeholders and *to apply adaptation measures to combat climate change*. The concepts of Biosphere Reserves are promoted in the country since the 1980s by Sri Lanka's National Man and the Biosphere Committee convened by the National Science Foundation. Currently four International MAB reserves have been declared in Sri Lanka, the Sinharaja World Heritage site, Kannleliya – Dediyagala – Nakiyadeniya Conservation Forest, Bundala National Park and the Hurulu Forest Reserve. Under the National Capacity Needs Self Assessment Project (NCSA) carried out by the Ministry of Environment in 2006, the National MAB Committee joined the MoE in promoting awareness on the Ecosystem Approach to relevant stakeholders, assessing national needs to: apply this approach for *in-situ* and *ex-situ* conservation, integrate biodiversity concerns into sectoral and cross-sectoral plans and programmes, and enhance national capacity for conservation of biodiversity in the country.
Source: Information Provided by the National MAB Committee of the National Science Foundation

- *Maintaining protected areas*

TABLE 11*:* Extent of protected areas administered by the Forest Department and the Department of Wildlife Conservation

National Designation of Reserves	No. of reserves	Area under each category (ha)
Reserves under the Forest Department†		
National Heritage Wilderness Area (also a world Heritage area)	1	11,127
International Biosphere Reserves	3	42,768
Conservation Forests* including the 20 mangrove areas	53	91,859
Reserved Forests		612,396
Reserves under the Wildlife Department		
Jungle Corridors (Kaudulla-Minneriya)	1	8,777
National Parks	20	526,156
Nature Reserves	5	57,056
Sanctuaries	61	349,105
Strict Natural Reserves	3	31,575
Total areas under the DWLC		**941,094**

Source: Forest Department data for 1999 and Department of Wildlife Conservation data for 2010

* The total number of Conservation Forests sans mangroves is 33. Some are pending gazetting, but all are currently managed as Conservation Forests

† Note: The reserve categories under this section are not mutually exclusive.

Over 28% of the total land area of Sri Lanka is reserved and administered by either the Forest Department (estimated at 15.1% - 16.1 %) or the Department of Wildlife Conservation (12.4%); and more then 60% of closed canopy natural forest, or 55% of all natural forests, lie within the reserves of these two departments.[37] A new category of protected areas are administered by the Central Environmental authority termed Environmental Protection Areas gazetted under the provisions of the National Environmental Act. There are currently 8 EPAs of which 5 are wetlands. Another two: Bentota Estuary and Dedigamuwa Kanda are proposed.

While about 9,462 km ^{2} of natural forest and scrubland amounting to around 15% of the island lie within the PAs system, a major gap is that only about 18% of this system falls within the biologically rich Wet Zone.[3] Further, whilst the Forest and Wildlife Departments and the CEA are responsible for managing the island's PAs, identifying areas for protection is not carried out jointly through a coordinated exercise although all three institutions are kept informed of intentions for declaring areas for protection.[63]

4.2 Relevant measures in place to address natural hazards

The main national initiatives for addressing natural disasters have been addressed by the SVPs on Urban Development, Human Settlements and Economic Infrastructure; Agriculture and Fisheries, and Water

Among the many initiatives to provide early warning on natural hazards and to map sea level rise, a selected few that are considered critically important to counter climate change impacts and related natural hazards on biodiversity are given below. Forest Department maintains Meteorological records at its field stations, For example, Meteorological records for the Sinharaja forest have been maintained since the mid 1980s at the Field Research Station

- *Collection of meteorological information*

The Forest Department maintains meteorological records at its field stations. For example, Meteorological records for the Sinharaja forest have been maintained since the mid 1980s at the Field Research Station at Sinharaja, and the annual, seasonal and monthly variations of temperature, rainfall and dry days from 1984-2000 have been analysed in the light of *El Nino* and *La Nina* events and climate change.[74]

- *The Landslide Hazard Mapping Project initiated in 1990*

The Landslide Hazard Mapping Project which commenced in 1990 was carried out by the NBRO. This project provided vital information on the location of landslide prone areas in the districts of Badulla and Nuwara Eliya, Ratnapura and Kegalle[+] to regulate the development of housing and infrastructure on a sustainable basis. The landslide prone areas were mapped and identified through the project, and important information was obtained for prevention and mitigation of danger from earth slips and landslides and to enable relocation of people away from such vulnerable areas. This information could benefit planning for biodiversity conservation.

- *The Risk Profile of Sri Lanka*

The Disaster Management Centre is playing the lead role in this process in collaboration with the UNDP and will provide inter-agency coordination and monitoring. The disaster risk profile of Sri Lanka would provide decision makers and planners to identify location, frequency and impact of main hazards affecting the country, as well as the elements at risk. With this knowledge, polices and strategies can be formulated for mitigation, preparedness and preparation of contingency plans. This would enable risk reduction strategies to be incorporated into development projects (as well as biodiversity conservation).

- *Assessing sea level rise*

Vulnerability can be assessed by advanced methods incorporating LIDAR (light detection and ranging) surveys or less expensive methods such as Aerial Video Assisted Vulnerability Analysis. In the aftermath of the Indian Ocean Tsunami, LIDAR Surveys supported with satellite images were carried out on the west, south and eastern coasts of Sri Lanka. The project, which was funded by the Italian Government, provided a valuable database covering a distance from the coastline up to 2 to 2.5 km inland. This database provides valuable information for the preparation of a vulnerability database. However, this requires ground based measurements. The availability of LIDAR Surveys would be a considerable advantage for both vulnerability analysis and modeling of hazards.

BOX 9: IMPACTS OF NATURAL HAZARDS THAT AFFECT SRI LANKA

"Natural hazards occur due to natural phenomena that have a human element, and result in a large number of fatalities and/or large scale damage to property." (MENR, 2002)

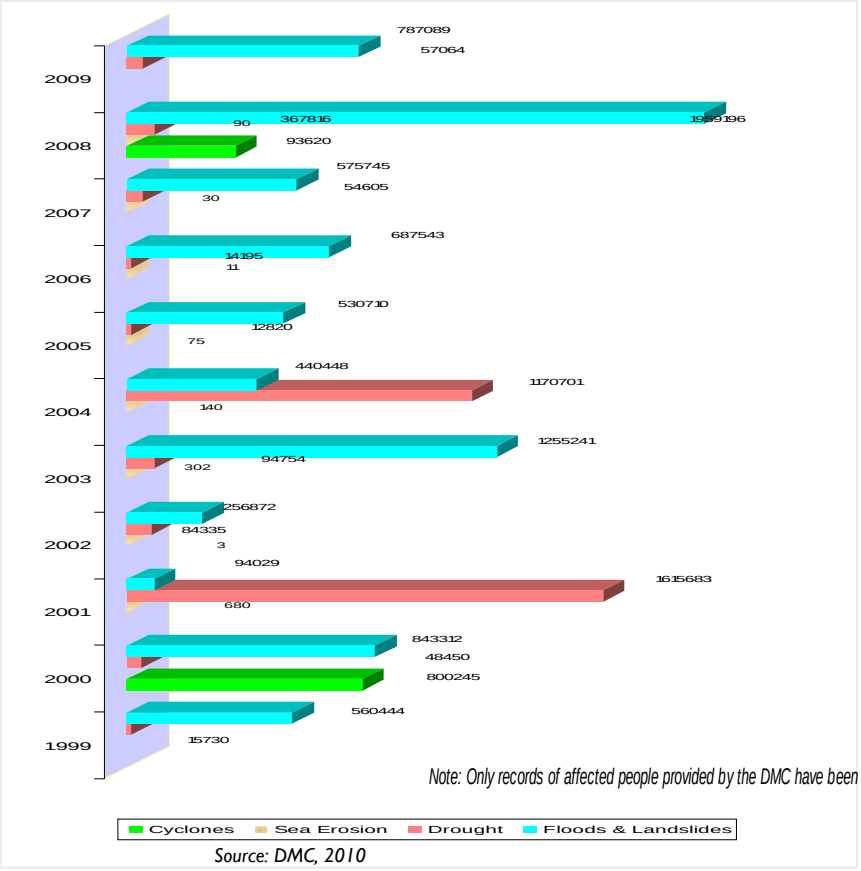
Coastal erosion affects Sri Lanka's beaches and adjacent coastal lands that are constantly subject to erosion, by winds, waves and currents that pound the coast. Available records indicate an average rate of coastal erosion of about 0.5 m/year and an accretion rate of about 0.2 m/year (CCD 2006[4]).

Landslides have been a frequent problem in Sri Lanka for many decades, and they generally follow heavy rains exceeding a threshold of 125 within 24 hours (NBRO data provided for preparation of this report, 2010).

Floods are associated with extreme rainfall conditions, and occur in almost all river basins in Sri Lanka. Serious flooding frequently occurs in the Kelani, Kalu and Mahweli river basins. Floods occur mainly in the Wet Zone, in areas having high rainfall, though flooding may sometimes occur in the Dry Zone as well (Manchanayake and Madduma Bandara, 1999;[18] NARESA, 1991).[22]

Drought is the major natural hazard experienced in Sri Lanka, which, despite the lack of a heavy toll on life, has very serious negative impacts on the economic and social life of the country due to considerable expenditure by the government for compensation of crop failure due to drought (Manchanayake and Madduma Bandara, 1999**).**[18]

Cyclones are less felt in the island than the Indian subcontinent as Sri Lanka is situated outside the cyclone belt. However, several serious cyclones have been felt periodically, with most damage occurring in the northern and eastern parts of the island, and to a lesser degree in some areas of the North Central Province. (*Note: This situation can vary in the future with climate change, and although the frequency of cyclones has remained the same, there is increasing cyclone intensity during the past few decades.*



Number of people affected by Natural Disasters

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Appendices

Appendix A
Actions identified as necessary for adapting to climate change with regard to conservation of biodiversity and enabling uninterrupted ecosystem services

Enhance climate change resilience of terrestrial ecosystems and their services

Link/restore/conserve, forests and other habitat refugia to increase resilience of ecosystems and species

- It is necessary to enhance the resilience of forests and other key terrestrial habitats and the species they contain by establishing and effectively managing PAs and other viable wildlife refugia in all climatic zones. The ecosystem approach provides an effective framework for integrated management of PAs, other habitat refuges, and their buffer zones with the participation of all key stakeholders. Special attention should be given to areas with already threatened and or endemic, charismatic, relict and/or possible keystone species with high potential to be affected by climate change and the fragmented wet zone forest patches that could be linked via forest plantations, home gardens and crop plantations through participatory approaches based on public sector/local community/private sector partnerships.

Convert monoculture forest plantations into mixed species plantations

- There can be adverse impacts of climate change on productivity and resilience of monoculture forest plantations. This can be addressed by converting them into mixed species forest plantations that are also better able to support wildlife, have less pest issues, and cause less land degradation and soil water loss. This should be supported by research on plantation species and site species matching.

Promote land use planning for biodiversity conservation and limit inappropriate vegetation conversion

- There is a need to minimise inappropriate vegetation conversion and land alienation (especially in hill slopes and paddy lands) and to adopt proper landscape level planning to promote conservation of terrestrial biodiversity based on the present land use policy. This can be achieved by use of the ecosystem approach promoted by the CBD that allows for wide stakeholder participation, zoning of land use, and the integrated management of forests, associated inland wetlands and/or coastal and agricultural ecosystems, and restoration of forests and canopy cover outside forests with appropriate tree species.

Establish and/or effectively manage Protected Areas and other important wildlife refuges in all climatic zones

- It is necessary to enhance the resilience of forests and grasslands and the species they contain by establishing and effectively managing PAs and other viable wildlife refugia in all climatic zones. The ecosystem approach promoted by the CBD provides an effective framework for integrated management of PAs and other refuges and their buffer zones. Special attention should be given to management of degraded forest fragments in the highly populated wet zone which require enrichment and linkages across forest plantations, home gardens and crop plantations through participatory multi-stakeholder approaches.

Research, monitor, and train to address climate change threats to terrestrial biodiversity and ecosystem services

- Research on, and monitoring of, the impacts of climate change on terrestrial biodiversity is needed to better understand impacts of climate change and where adaptation interventions are most needed. Establishing phenological studies on forest tree species, monitoring critical habitats and fauna most liable to be affected (e.g. dragonflies, amphibians, freshwater species, butterflies, arboreal primates, freshwater crabs and mammals with large home ranges and other species that are indicators of climate change), examining climate change impacts on different types of forest flora (e.g. orchids, pteridophytes and selected large tree species, lianas, species showing die-back throughout their ranges, etc.) are vitally important. Capacity should be built among biodiversity managers for monitoring climate change impacts through training programmes on species identification, biodiversity monitoring, behavioural ecology, principles of conservation biology, phenological sampling and maintenance of accurate data sets on rainfall and ambient temperature.

Enhance the resilience of coastal and marine ecosystems and associated vulnerable species

Promote integrated coastal resource management, particularly at SAM sites

- All development activities carried out along the coast should be coordinated and approved by the Coast Conservation Department to ensure that they adhere to the National Land Use Policy (NLUP), requirements of the Coastal Zone Management Plan (CZMP) and EIA procedures. It is also necessary to prepare and implement new Special Area Management (SAM) Plans and implement existing plans. Integrated coastal zone management should be encouraged at SAM sites in consultation with all stakeholders. Implementation of the CZMP and EIA procedures should be strengthened to reduce inappropriate coastal zone development and habitat degradation through capacity building of technical and planning personals in the CCD and other relevant institutions, and by strengthening institutional coordination across relevant agencies active in the coastal zone.

Restore and rehabilitate degraded coastal ecosystems and depleted coastal species

- **Many coastal ecosystems are degraded due to poor land use, conversion to other uses, coastal erosion and pollution. Likewise commercially important species are over harvested. Programmes should be developed with stakeholder participation for sustainable use of coastal resources, including introduction of breeding programmes and pilot testing of sustainable harvest levels for commercially important organisms.**

Research, monitor, and address climate change threats to coastal biodiversity and ecosystem services

- Research and monitoring is required continually to identify threats to coastal biodiversity that would be exacerbated by climate change, and to understand where adaptation interventions are best needed. Monitoring changes in coastal water quality parameters – i.e. acidity, temperature, salinity, etc. is essential. Monitoring of salinity intrusion into surface water is particularly important to enable fishermen to adapt accordingly by selecting appropriate species for aquaculture, and to adapt to changed distribution of species in fishing grounds. Likewise research and dissemination of results are necessary to enable fishermen to change fishing methods and areas, seasons, fishing depths and catch species accordingly.

Enhance climate change resilience of natural inland wetlands and associated species

Protect marshes/flood retention areas in urban areas and limit land conversion.

- The protection of marshes and flood retention areas is particularly important in urban areas as urban flooding is already a serious concern due to reclamation of wetlands, and is expected to increase with climate change. Protection of urban wetlands will also enhance and conserve urban biodiversity, thereby enhancing wetland ecosystems and species' resilience to climate change, and enable provision of vital environmental services for human wellbeing. Marshes and flood retention areas should be protected by restricting development projects in them by declaring them PAs and/or EPAs, or by promoting alternate development (e.g. as recreational sites or urban agriculture) that will enable uninterrupted ecosystem services.

Prevent the discharge of industrial effluents, solid waste and other pollutants into inland wetlands

- It is required to prevent the discharge of industrial effluents, solid waste and other pollutants into inland wetlands by promoting compliance of regulations guiding industrial pollution, solid waste management and wetland conservation, by providing incentives for CSR, and strengthening the wetland monitoring system to be effective and regular.

Control and manage salt water intrusion into coastal freshwater wetlands

- It is necessary to prevent degradation of coastal freshwater wetlands (both natural and modified) and biodiversity due to salt water intrusion by continual monitoring of coastal surface and ground water, and by regulating environmental flows, controlling ground water over-extraction, and river sand mining that exacerbates this problem.

Strengthen coordination and streamline management of wetlands across relevant agencies

- Streamline management of wetlands across relevant agencies, and strengthen coordination mechanisms to enable compliance with the national wetland policy, the National Environmental Act and other relevant policies, plans and laws.

Research, continual monitoring and addressing climate change threats to freshwater biodiversity and ecosystem services

- More research is required on the impacts of climate change on freshwater biodiversity and ecosystem services to understand precise adaptation interventions. Monitoring freshwater bodies and threatened aquatic species should be encouraged to minimise negative impacts on biodiversity and ecosystem services. Periodic monitoring of ecosystem health in all climatic zones is also vital for early identification of climate change impacts on freshwater species and ecosystems.

Address socio-economic concerns resulting from climate change impacts on biodiversity

Identify impacts of climate change on biodiversity that could affect local communities

- It is necessary to identify impacts of climate change on livelihoods, cultural aspects, and lifestyles of local communities that are heavily dependent on biodiversity followed by efforts to conserve such biodiversity. The possible increase of human-wildlife conflict due to changes in geographic ranges or migration routes of wildlife due to impact of climate change on their current habitats and availability of food and water also needs to be identified and addressed.

Help communities adapt to changes in livelihoods or to relocate when necessary

- It is necessary to engage vulnerable communities to strategize options to address climate change where livelihood options are at risk. They should also be engaged in plans for relocation (where necessary) in order to adapt to climate change and to shift to other livelihoods if necessary. .

Research and use traditional knowledge on potential climate change for adaptation mechanisms

- Collate, record and use traditional knowledge on climate change adaptation mechanisms (particularly with regard to agrobiodiversity) that can be used by relevant state agencies that deal with adaptation to climate change.

Monitoring and Preventing/Minimizing entry, establishment and spread of IAS into terrestrial and aquatic systems

Prevent or minimize entry, establishment and spread of IAS

• There is need to step up preventive measures to preclude entry of new IAS; monitor natural and modified ecosystems to detect establishment of new IAS and the further spread of existing IAS; promote and inculcate skills for monitoring of natural and modified ecosystems to detect climate change impacts in forests (e.g. forest or species specific die-back that can promote spread of invasive species), coastal areas (e.g. coral bleaching leading to *Halimedia i*nvasions, etc), and wetlands that may promote spread of IAS, with the support of universities and researchers with appropriate skills and experience.
Capacity building to address IAS problems better
• It is also necessary to promote research to expand understanding of behaviour and physiology of selected IAS, and to enhance skills for adaptive management of IAS within institutions responsible for *in-situ* and *ex-situ* conservation of national biodiversity.

Appendix B
Key State Agencies Mandated with Some Aspects of Biodiversity Conservation

- **The Forest Department (FD)**

The FD is responsible for the implementation of the Forest Ordinance (FO) which has been subject to many revisions to make provision for the protection of state forests from unlawful felling, clearing, encroachment, removal of produce, etc; the declaration of forests as Reserve Forests: the control of felling and other forms of exploitation in forests and the transportation of timber. The 1995 amendment created Conservation Forests. While encroachment and illicit felling of timber from Wet Zone forests has been largely controlled. The Forest Ordinance amendment act of 2009 empowers the Conservator General of Forests to enter into agreements with stakeholders to carry out community participatory programmes for the development of forests. The FD is also responsible for implementing the National Heritage Wilderness Area Act No. 3 of 1988.

- **The Department of Wildlife Conservation (DWLC)**

The DWLC is primarily responsible for the implementation of the FFPO which recognises six categories of wildlife reserves. This law, besides protecting animal and plant life within the national wildlife reserves, has provision to protect certain categories of animals and plants wherever they are found, and lists penalties for violation of the law. The amendment Act of 1993 of the Fauna and Flora Protection Ordinance provides negative listing of species for several faunal groups, including all vertebrate groups, to ensure better coverage of species to be protected by law. This Act also requires a permit for the export of any wild plant or animal or their body parts from the DWLC, and this is enforced by the Customs Department at ports of exit from the country.

- **The Central Environmental Authority (CEA)**

The CEA was originally established under the National Environmental Act (NEA) of 1980 as a policy formulation and co-ordinating body for environmental management. Subsequently, it received adequate authority and legal provision under the 1988 revision of the NEA to control environmental pollution and to mitigate the adverse impacts of development activities through legally binding EPL and EIA procedures respectively. The CEA is also empowered with monitoring industrial discharge of effluents into waterways, air emissions and noise pollution. The issue of licenses for 15 types of low polluting industries have, however, been delegated to Local Authorities since 1994. Similarly, checking mobile source emissions is delegated to the traffic police. The CEA is also the regulatory authority for standard setting (e.g. in respect of ambient water standards, ambient air quality standards, mobile source emission standards, industrial emission standards and interim stationery sound emission standards). Under the NEA, the CEA can declare environmentally sensitive areas as Environmental Protection Areas where development activities are regulated.

The activities of the CEA are decentralised via eight regional offices that have authority to award EPLs, carry out the CEA's monitoring functions, and where relevant to carry out EIA procedures of prescribed projects with less complexity and magnitude such as small housing projects, small scale land clearing, etc. The CEA has also Divisional Environmental Offices (DEOs) placed in the Divisional Secretariat Offices to help address environmental matters at the local levels. These officers are expected to advise the Divisional Secretaries on environmental matters, such as awarding permits for sand mining and awarding of minor permits within the Coastal Zone on behalf of the Coast Conservation Department, and to carry out environmental awareness at the local level. The Wayamba Environmental Authority has been setup under the North Western Provincial Administration.

- **The Urban Development Authority**

The Urban Development Authority Law No 37 of 1978 served to establish the Urban Development Authority (UDA) to promote the integrated planning and implementation of social, economic and physical development of areas declared as "Urban development areas". The special provisions of the amendment act of 1984 provides for the development of environmental standards and schemes for environmental improvement in areas identified as UDA areas.[II] The Urban Development Authority (UDA) is mandated to promote the integrated planning and implementation of social, economic and physical development of areas declared as "Urban Development Areas" under the UDA Act with the overall vision of guidance, facilitation, and regulation of urban development through innovative and integrated physical planning. The UDA urban areas include 1 km inland from the coast in all areas of the coastal zone. The planning committee of the UDA looks into all environmental aspects of urban development within their jurisdiction. Already 42 Urban Development Plans have been gazetted. There are monitoring and coordination committees for each major project undertaken by the UDA. However this does not always happen in practice.

[II] 18 Municipal areas, 42 Urban Council Areas, and a further 154 areas termed Urban Development Areas come under this category based on national importance and population density.

- **The Coast Conservation Department (CCD)**

This department is now located under the Ministry dealing with Ports and Aviation (formerly under the Ministry dealing with fisheries), and is the prime agency responsible for coastal issues in Sri Lanka. Its mandate provides it with a key role to play in conserving and managing coastal and marine biodiversity according to the periodically revised Coastal Zone Management Plan. The Director of the Coast Conservation Department is responsible for administration and implementation of the provisions of the Coast Conservation Act, including the survey and inventorization of coastal resources.

The CCD is also responsible for the conservation and management of natural coastal habitats and areas of cultural and recreational value in the coastal zone. Programmes carried out so far by the CCD cover mitigating coastal erosion, policy development and coastal resources management. The functions of the CCD also include issuing of permits for coastal development and revision of the Coastal Zone Management Plans periodically to regulate and control development activities in the coastal zone. More information can be obtained at http://www.coastal.gov.lk/

- **The Department of Agriculture (DOA)**

This department was established in 1912 as the premier institution concerned with research and development for the food crop sector in the country. It is mandated to deal with rice and other field crops, horticultural crops, root and tuber crops, ornamental plants and plants of medicinal values. It also deals with formulation/reform of policy/law/and regulations pertaining to the agricultural sector; setting up institutional coordination; research at ecosystem, species and genetic levels; survey and documentation of anthropological and cultural values of agro-biodiversity; sustainable use of agrobiodiversity; taxonomic studies for food crops; survey, inventory and monitoring and setting up *ex-situ* conservation centres (including seed banks); *ex-situ* management of species and artificial propagation of endangered species - including tissue culture); and information management and database development for food crops.

There are several divisions, centres and research institutes under the DOA that play a vital role in enhancing agricultural productivity. Chief among these are the: Horticultural Research and Development Institute (HORDI), Rice Research and Development Institute (RRDI), Field Crops Research and Development Institute (FCRDI), Seed Certification and Plant Protection Centre (SCPPC), The Plant Genetic Resources Centre (PGRC), The Natural Resource Management Centre, Extension and Education Division and the Seed and Planting Materials Division.

The DOA has several Regional Agricultural Research and Development Centres (RARDCs) and a further network of research sub-stations island-wide. The Rice Research and Development Institute (RRDI) has one regional station; the Field Crops Research and Development Institute (FCRDI) located at Maha Illuppalama has a regional centre at Bandarawela headed by a Deputy Director. The Horticultural Crops Research and Development Institute (HORDI) has six regional centres. More information can be obtained at http://www.agridept.gov.lk/

- **The Natural Resource Management Centre**

This functions under the DOA and is mandated by the amendment Act of 1996 of the Soil Conservation Act, No. 25 of 1951. This agency deals with formulation and reform of agricultural policy/laws and regulations for the DOA. It is also responsible for promoting and implementing the Soil Conservation Act and for supporting and implementing laws and policies with respect to the agricultural sector.

- **Horticultural Research and Development Institute (HORDI)**

This is the main national institute mandated to undertake *ex-situ* conservation of horticultural crops and for information management and dissemination for horticultural crops. It is also mandated for demand driven research on vegetables, fruit, root and tuber crops in a manner that is productive, eco-friendly and sustainable. HORDI carries out extension services at the central and regional levels through 6 regional centres focusing on farmers and general public to promote horticultural crop development in the country.

- **Seed Certification and Plant Protection Centre (SCPPC)**

This institution addresses plant quarantine and seed health. The National Plant Quarantine Service at Katunayake, the Office of the Registrar of Pesticides, the Plant Protection Service at Gannoruwa, the Seed Certification Service at Gannoruwa and the Plant Genetic Resources Centre (PGRC) at Gannoruwa function under the SCPPC. There are also Plant Quarantine Offices at Gannoruwa, the sea port (in Colombo) and the airport (at Katunayake). The SCPPC is responsible for the implementation of the Plant Protection Act No. 35 of 1999, The Seed Act of 2002 and the Control of Pesticides Act No. 33 of 1980 as amended by Act No. 6 of 1994. All exports of plant materials have to be given a phytosanitory certificate through the SCPPC, and all imports of plant material (including food items and horticultural plants or plant parts) should have permits from the SCPPC for importation and release into the country. There are customised agreements drawn up by the SCPPC with specific instructions issued for each importation permit, on a case by case basis.

- **The Plant Genetic Resources Centre (PGRC)**

The Plant Genetic Resource Centre (PGRC) set up in 1988 functions under the DOA and is well equipped to conserve indigenous plant germplasm of crops and their wild relatives. This agency functions under the Seed Certification and Plant Protection Centre (SCPPC) of the DOA, and is the main repository of crop germplasm in the country, including wild and traditional varieties. Accordingly its functions include exploration, evaluation, seed conservation, biotechnology and data management. The activities of the PGRC are important for conservation of plant genetic diversity for future use in the face of climate change. Over 12,000 accessions are held at the PGRC at present.

- **The Department of Animal Production and Health**

The DAPH is responsible for implementing the Animals Act No. 46 of 1988 and the Animal Disease Act No. 33 of 1992. It has several divisions to deal with Animal Breeding, Animal Health, Planning and Economics, Finance, and Human Resource Development. There is also an institute of continuing education (ICE) in Animal Production and Health with good residential training facilities. Training is offered to the private sector on request. Its activities are decentralized through Provincial Departments of Animals Production and Health, which are funded by the respective Provincial Councils. Most of these provincial agencies are under the provincial ministries dealing with agriculture, but the Provincial Directors function under the all island service of the DAPH, and are monitored by the Central Service. There are also several regional Animal Quarantine Centres, including one branch office at the airport, and several farmer training Centres at the Provincial level.

- **The Veterinary Research Institute (VRI)**

This agency functions under the DAPH with a mission "to be the centre of excellence in research and development in the livestock industry". Research in the livestock sector is mainly the responsibility of the VRI, which is mandated to carry out veterinary research as well as other research on all aspects of animal breeding and genetic improvement, disease control and regulatory functions, animal feeds, farming systems and production of vaccines and human resource development (research and training) to meet the objectives of the DAPH. Conservation of economically important indigenous animal species and the use of traditional varieties of domestic cattle and poultry for livestock breeding is the responsibility of both the DAPH and the VRI. Veterinary surgeons of the VRI function under the provincial administration as well as under the central service. Efforts by the Department of Animal Production and Health and the Veterinary Research Institute (VRI) to conserve indigenous animal species of economic value have been constrained by insufficient funds and infrastructure.

- **The AgBiotech Centre**

This is linked to the Agricultural Faculty of the University of Peradeniya) and has up-to-date facilities for preservation of both plant and animal germplasm and for biotechnology using genetic resources. These facilities are, however, underutilized at present.

- **The Department of National Botanic Gardens (NBG)**

Under the Department of National Botanic Gardens (NBG) there are the Royal Botanic Gardens (RBG) at Peradeniya, the botanic gardens as Hakgala and Gampaha (Henerathgoda); and the Illukkowita (Awissawella) and Mirijjawila (Hambantota District) botanic gardens that are nearing completion. These Botanic Gardens provide coverage of all major climatic zones. *Ex-situ* conservation facilities for plants are present in 5 Botanic Gardens which are located in the low, mid and upcountry regions of the Wet and Dry Zone. Due to their location in different climatic zones, the botanic gardens offer insight into variation in plant responses to environmental conditions and has potential to examine climate-driven changes in plants. The RBG at Peradeniya, is located on 147 acres and contains over 4000 species under cultivation. It is mandated for *ex-situ* conservation. Among its other objectives are public education on plants, development of technologies related to exploitation of lesser known and under-utilised plants, and development of ornamental and amenity horticulture. The NBG pioneered floriculture in Sri Lanka. In the 1960s the horticultural aspect of botanic gardens became important as it was under Department of Agriculture. This trend has been reversed somewhat in recent times, with more local species being incorporated and more emphasis given to research and *ex-situ* conservation functions of the botanic gardens.

- **The National Zoological Gardens (NZG)**

The NZG at Dehiwala houses about 3500 animals from over 350 species of mammals, birds, reptiles, fish, amphibians, butterflies and marine invertebrates in a space of about 10 ha. While most of the animals are non-indigenous, the zoo has initiated support for biodiversity conservation by breeding some rare and endangered species, with special emphasis on elephants, endemic ornamental fish, tortoises, crocodiles, the fishing cat and leopard. There are on going programmes to breed several other indigenous carnivores and birds. The NZG also promotes *ex-situ* conservation of indigenous species in the walk-in aviary for birds, the small cats zone and the butterfly garden. The role of the National Zoological Gardens for *ex-situ* conservation is limited as yet, due to few scientifically managed captive breeding programmes for threatened fauna, though captive breeding has been successful with some species. This aspect will be promoted with the setting up of the Sri Lankan section of the new zoological gardens being set up at in the Kegalle District.

- **The Ministry of Fisheries and Aquatic Resources (MFAR)**

The Ministry of Fisheries and Aquatic Resources (MFAR) and its line agencies have a key role to play in management of the fishery industry. According to the Fisheries Act of 1996, the Minister responsible for fisheries can declare fisheries reserves when and where necessary. There are currently nine Fisheries Management Areas, but no fisheries reserves have been declared as yet, although the Minister could do so under this Act. **-** http://www.fisheries.gov.lk/

- **The Department of Fisheries and Aquatic Resources (DFAR)**

The Department of Fisheries and Aquatic Resources (DFAR) is mandated with conservation and sustainable use of fish species through the Fisheries Act No 2 of 1996. The DFAR is currently under the Ministry of Fisheries Aquatic Resources. It is mandated to formulate/reform conservation policy/laws/regulations in the fisheries sector and to promote or implement relevant laws and policies. The divisions of this department include Administration, Fisheries Management, Fisheries Industry, Quality control, Monitoring control and Surveillance. The DFAR has Regional District Fisheries Offices in Batticaloa, Chilaw, Colombo, Galle, Jaffna, Kalmunai, Kalutara, and Kilinochchi, Mannar, Matara, Mulaitivu, Negombo, Puttalam and Tangalle. More information at http://www.fisheriesdept.gov.lk/

- **National Aquaculture Development Authority (NAQDA)**

NAQDA was established in 1999 under the provisions made available by the National Aquaculture Development Authority Act No. 53 of 1998. It is the main state sponsored organization mandated for the task of development of the aquaculture and inland fisheries sector in Sri Lanka. Presently, it comes under the purview of the Ministry of Fisheries and Aquatic Resources with a mandate to:

- develop aquaculture and aquaculture operations, with a view of increasing fish production and consumption in the country;
- promote the creation of employment opportunities through the development of fresh water, brackish water and coastal aquaculture and mariculture;
- promote the farming of high value species including ornamental fish for export;
- promote the optimum utilization of aquatic resources through environmentally friendly aquaculture programmes;
- promote and develop small, medium and large scale private sector investment in aquaculture;
- manage, conserve and develop aquatic resources used for aquaculture and aquaculture operations;
- prepare and implement and assist in preparing and implementing plans and programmes for the management, conservation and development of aquaculture and aquaculture operations.

More information at http://www.naqda.gov.lk/

- **National Aquatic Research and Development Agency (NARA)**

The National Aquatic Resources Research and Development Agency (NARA) is the apex national institute vested with the responsibility of carrying out and coordinating research, development and management activities on the subject of aquatic resources in Sri Lanka. NARA is a statutory body duly established by NARA Act of No. 54 of 1981, during its past 27 years conducted numerous scientific researches in the field of fisheries and aquatic resources. NARA also provides services for development and sustainable utilisation of living and non-living aquatic resources. NARA as the premier research institution dealing with aquatic systems is engaged in gathering data relevant for conservation and development of the fishery industry (e.g. fisheries data), from which assumptions on coastal resource and habitat conservation and sustainable use should be made. More information at http://www.nara.ac.lk/

- **The Marine Environment Protection Authority (MEPA)**

The Marine Pollution Prevention Act of 1981 enabled the establishment of the Marine Pollution Prevention Authority (MPPA) and provided for the prevention, reduction and control of pollution in Sri Lankan waters, and for giving effect to international conventions that Sri Lanka is a signatory to for the prevention of pollution of the sea. The 2009 revision of this Act has strengthened the MPPA and renamed it as the Marine Environment Protection Agency. MEPA is responsible for warning and promoting prompt remedial action in the event of a major oil spill in Sri Lankan waters, or in adjacent waters that may affect the country's marine environment. MEPA is the focal point for UNCLOS (United Nations Convention on the Law of the Sea), the MARPOL Convention (for the prevention of pollution from ships**)** and several other international conventions, and is responsible for some functions under the Basel Convention (for control of transboundary movements of hazardous wastes and their disposal)**.**

The MPPA has a regional office in Galle which is not fully functional, attributed to the fact that the MPPA Head Office does not have sufficient cadre to make the regional office more functional. MPPA will delegate various functions at the time of an oil spill contingency to various agencies (*i.e.* Sri Lanka Ports Authority, Ceylon Petroleum Corporation, Sri Lanka Navy, Sri Lanka Air Force, Sri Lanka Army, Sri Lanka Police, Department of Meteorology, Coast Conservation Department, Local Authorities) to work at both on-shore and offshore levels.

Appendix C
Major Projects that Facilitate Adopting Adaptation Mechanisms

- **The Forestry Sector Development Project (FSDP)**

This landmark project strengthened forest management and promoted establishment of forest plantations to supply timber without exploiting natural forests. It also resulted in the development of an Environmental Component to the FSDP. Under these projects several landmark activities were carried out, amongst which are the Accelerated Conservation Review (ACR) of 31 lowland rain forests followed by the National Conservation Review (NCR) for biodiversity assessment of natural forests greater than 200 ha in the country; setting up a database on forest biodiversity (the Environmental Information Management system-EIMS) and a comprehensive survey of traditional uses of forests by local communities and their impact on forest biodiversity.

- **The ADB funded Forest Resources Management Project (FRMP)**

Under this project, there was capacity building of the Forest Department (FD) (as the main beneficiary), targeted awareness and extension, agroforestry, rehabilitation of degraded forests, buffer zone development through participatory community programmes, and boundary demarcation of natural forests and forest plantations. Skills training included technical assistance (TA) provided to the FD in the form of expatriate and local senior level expertise in the fields of forestry education, forest management and the revision and improvement of the curricula at the Sri Lanka Forestry Training Institute (SLFTI). Assistance was specifically provided for integrated management planning and biometrics, planning and project implementation, data collection and collation, database development and management via technology development (for GIS databases); public awareness and extension, developing technology for research, ecosystem and biodiversity management, participatory forestry and institutional capacity building, and improving the database established through the NCR. Overall, about 500 FD staff has received special training and skills development through this project. The project also had a training programme for capacity building on an annual basis, through both local and overseas training.

The FRMP also provided equipment and other facilities in-kind, including computers and equipment for field survey, inventory and communication. Financial assistance was provided to the FD to enhance nature based tourism at Sinharaja, Knuckles and Kanneliya forest reserves with the involvement of local people.

- **Asian Development Bank (ADB) the Global Environmental Facility (GEF) and the Netherlands Government funded Protected Area Management and Wildlife Conservation (PAM&WLC) Project 2001- 2008**

The main beneficiary from this project was the Department of Wildlife Conservation (DWLC). The key objectives of the project were: (a) enhancing institutional capacity in the DWLC for wildlife management, (b) promoting participatory adaptive management, (c) facilitating collaborative conservation planning, and (d) sustainable financing for community partnership building. Institutional strengthening and human resource development for PA management has been achieved at the DWLC by updating staff knowledge, providing staff training, building technical and managerial competence in the DWLC, and development of institutional potential. Adaptive management was pilot tested at the Peak Wilderness Nature Reserve, Horton Plains National Park, Ritigala Strict Nature Reserve, Bundala National Park, Wasgamuwa National Park, Minneriya - Kaudulla National Park complex, and the Udawalawe National Park for habitat enrichment, including management of alien invasive species and pilot research on invasive species eradication, grassland establishment and enhancing water and fodder for animals. The project enhanced community participation in PA conservation, and facilitated buffer zone community development. The project also developed visitor service plans for the pilot PAs, and enhanced visitor facilities by establishing visitor centres with interpretive material at several PPAs. Under the project, the DWLC has been assisted to carry out detailed biodiversity assessments and habitat mapping in seven PPAs to pilot test systematic monitoring of biodiversity and to enable PA zoning**.** The gap analysis carried out under this project also helped to assemble a strategic portfolio of conservation sites for Sri Lanka.

- **The Coastal Resources Management Project (CRMP) from 2000-2006 with funds from the ADB and the Government of the Netherlands**

The Coastal Resource Management Project (CRMP) was a major initiative of the then Ministry of Fisheries and Ocean Resources. Component B of the CRMP for Institutional Strengthening covered several aspects that are relevant for managing coastal resources. This component has dealt with enhancing institutional arrangements within key agencies of the Ministry dealing with fisheries, which included Institutional strengthening of the Coast Conservation Department (CCD) by setting up a GIS unit in the CCD with the required facilities and a database to assist the department's functions, capacity enhancement for Integrated Special Area Management Planning in the coastal areas; assistance for conservation and mapping of coastal habitats and sites of archaeological, historical and scenic value; assistance for erosion management, controlling coastal water pollution, and identification of coastal land use patterns and sites for future development. Under this project an IT programme and a data gathering network was developed within the ministry, and was piloted for 18 months to gather catch and effort fishery data as a first step towards interpreting and managing the biological state of the fishery. It also dealt with building capacity for identification of coastal land use patterns, and identification of setback standards for infrastructure development within the Coastal Zone as relevant at the time.

- **The GEF/UNDP funded Southwest Rainforest Conservation Project of the Forest Department (2000-2006)**

This project pilot tested the development of a viable participatory management model for forests in Sri Lanka, and was functional in buffer zone villages along the southern perimeter of the Sinharaja Forest Reserve and the perimeter of the Kanneliya Forest—two forests within Sri Lanka's PA system. The project built capacity in the Forest Department for community mobilisation and formal registration of existing CBOs involved with the project in villages where its was in operation. The model took into account the conservation status of the relevant forests, the level and type of forest dependency among local people, and the national forest policy. As such, the model developed was one in which the overall control of forest resources remains vested in the Forest Department, while the communities had a recognisable role in planning and managing the pilot forest reserves so that they remained committed stakeholders in the process. The CBOs assisted the Forest Department to work out appropriate systems for delivery of assistance (for each village) as deemed required for social upliftment and to reduce forest dependency (including encroachment) by improving local livelihoods. The CBOs were helped to become self-reliant in the long-term after the project ended through establishment of Community Trust Funds (CTFs) for which seed money were initially provided via the Forest Department. The CBOs were registered so that they can operate the CTFs and a bank account. The CTFs provided soft loans at very low interest rates for CBO members to engage in activities that would enhance cash incomes and reduce forest dependency – mainly to alleviate the need to expand tea small holdings into the reserves and to wean away local people from some damaging forest extractions for commercial purposes. The CBO members were trained through the project to write proposals for seeking funds, and office bearers were trained to keep accounts and carry out the CBO activities.

The CBO members were also assisted in developing technical and entrepreneurial skills by the Forest Department for enhance their cash incomes, thereby reducing the need to encroach into the reserve to expand tea holdings. The required training programmes and the members to receive training were selected by the CBOs. As a result of this project, communities have become more aware of the value of the forests due to effective social mobilization, and a dialogue developed between the community and the Forest Department. This has generated greater local commitment towards conservation of the reserves. The project also provides tangible benefits for CBO members, thereby promoting continued support for forest conservation. The Forest Department which initially facilitated the formation of these voluntary CBOs has now moved into an advisory and monitoring role; the CBOs are run entirely by community members.

- **The Aus-Aid funded Sri Lanka Australia Natural Resources Management Project (SLANRMP) for poverty reduction through improved natural resource management SLANRMP: Sri Lanka – Australia Natural Resources Management Project.**

This project was active in two Dry Zone areas in the Kurunegala and Matale districts since February 2003 - 2008 to support communities improve the management of natural resources through a participatory and holistic approach. The project aimed for institutional capacity enhancement and human resources development in this sphere in the forestry sub-sector. The project also aimed to pilot the handing over the management of degraded forest patches to communities in adjacent villagers who would benefit from enhanced household incomes due to improved land use and integration of forestry and agriculture. The project specially targeted communities that were dependant to varying degrees on the adjacent forests for their livelihood, and were thus willing to accept responsibility for community management of forests in exchange for forest user rights. Women and disadvantaged members were given special attention.

This project acted as a pilot research project to test an appropriate development processes that the Forest Department could implement through its institutional programmes on a routine basis. A Training of Trainers course was developed to disseminate the results nationally. The ultimate goal of the project was to contribute to poverty reduction through improved natural resource management in Sri Lanka.

- **The National Biosafety Framework Development Project (May 2003-2005)**

This Project sought to ensure that the risks due to modern biotechnology and its products would be minimized and biodiversity, human health and environment will be protected in a maximum way; the transboundary movements of GMOs would be regulated through formulation of relevant policies, regulations, technical guidelines and establishment of management bodies and supervisory mechanisms. This resulted in a comprehensive National Biosafety Framework of 2003, a database (that is to be made available on the web, and a national policy on biosafety.

- **The Wetland Conservation Project (WCP)**

Phase I of this project initiated by the CEA in 1991 heralded significant measures for the conservation of wetlands in the island, and was instrumental in prioritizing wetlands for conservation and management. This involved identification of 41 key wetland sites; carrying out site surveys and preparing site reports for 26 wetlands of which ten are also management plans. These plans envisage a sustained yield of multiple benefits with minimum resource use conflicts within a framework of preserving the ecological, cultural and social values of the wetlands. The project also created public awareness on wetlands and their values, developed methodologies for wetland conservation, set up a digital database on wetlands, developed a wetland evaluation system, and formulated criteria for selection of wetlands for total conservation.

- **The Integrated Resource Management Project (IRMP)**

This project followed the WCP and focused on two selected wetlands (Muthurajawela Marsh and the Negombo Lagoon) for preparation and of pilot scale implementation of Management Plans. Some Special Area Management (SAM) sites identified by the CCD were also selected under this project as wetland sites requiring special conservation measures.

Appendix D
Country Profile in Brief

Population status
Sri Lanka is a multi-ethnic, multi-religious secular state, with a total population of over 20.4 million and a population density of 326 persons per km^2. The Wet Zone, with a very high biological diversity, and more favourable climate and better socio-economic considerations than the water scarce Dry Zone, contains about two thirds of the country's population despite its coverage of less than a third of the island. The population in Sri Lanka is still predominantly rural as only about 20% of the population live in urban areas.

Healthcare and life expectancy
Sri Lanka has achieved remarkable progress in health and social welfare relative to other low income countries and its neighbouring South Asian counterparts as shown by a Human Development Index (HDI) of 0.759 in 2007. This is due to a large share of public expenditure being redistributed to households perceived to be in need in the form of free education and health services, as well as food subsidies and subsidized credit to improve living standards.

Sri Lanka has relatively high standards of health care, and the national health indicators are comparable with those of developed countries. The Government of Sri Lanka provides free health care services through a network of western and traditional health care institutions including hospitals, dispensaries and health units located in all parts of the country. There is also significant enhancement of health services for women and children through pre- and post-natal care nutritional programmes. Sri Lanka's consistent decline in maternal mortality for over 5 decades is attributed to a wide network of maternal services which is integrated with childcare. The life expectancy at birth for males and females is respectively 70.3 and 77.9 years. Infant mortality rates are low at 10 (per 000), while under five mortality at 14 (per 1,000) live births is the lowest for the WHO South East Asian region.

Education
The net enrolment ratio in primary education exceeds 98%, and the country has an island wide network of schools which include public, private and religious education centers. Education was made compulsory for all children between the ages of 5-14 in 1997 and is free of charge to all students in state schools since 1945. Hence, Sri Lanka has a high adult literacy rate of 92.5%. Sri Lanka has 15 universities, six postgraduate institutions and about seven institutions affiliated to the universities which offer Bachelor's Degree courses in specialised fields. University education is a public sector monopoly as yet and free of charge, except for the Open University which is open to students of any age and with varying basic educational backgrounds.

Status of women
Men and women are granted equal status and rights under the Constitution of Sri Lanka and Sri Lankan women - including women in the rural areas - have a comparatively better status than their counterparts in many developing countries. Gender wise the literacy rate is 94.5% for males and 90.6% for females. Sri Lanka has achieved gender equality in primary and secondary education in the generations that had access to free education. Overall there has been a perceptible upward social mobility in the status of women since gaining independence in 1948, mainly due to increased access to free education, economic opportunities for employment in the industrial sector and migrant domestic employment overseas. Sri Lanka's Gender Development Index (GDI) in 2007 was 0.756 but the Gender Empowerment Measure (GEM) was only 0.389.

Housing and lifestyles
Lifestyles are changing in Sri Lanka with increased household income, and household consumption is shifting from food (as in the past) to communication, education, recreation, housing and utilities. The average household size is at present 4.1 persons. About 79% of households now own a radio or TV and 36% own a refrigerator. Household access to motorized transport and telephone facilities stand at 22% and 25% of households respectively. The demand for houses and urban infrastructure is increasing. About 75% of the population outside the north and east live in houses with more than three rooms, and over 72% of houses throughout the island comprise modern building and roofing materials such as bricks and cement for walls and tiles or asbestos for roofing; about 77% of households have sanitary and toilet facilities, 86% have electricity and 84.8% of households have access to safe water – although only about 35.5% have access to pipe borne

water. Consequently much of the rural population still depend mainly on well water, water from forest streams, reservoirs, canals and streams which become contaminated with faecal matter and other pollutants.

Economic trends and poverty

Per capita income in Sri Lanka exceeded US$2000 in 2009, but very high regional disparities remain. According to government figures, 15 percent of Sri Lankans live below the official poverty line of Rs. 3,087 a month. The country's commitment to alleviating poverty is reflected in Sri Lanka's macroeconomic policies which are pro-growth and pro-poor while continuing to uphold market based economic policies. The economic policies of the country also encourage foreign investments by providing foreign exchange and employment opportunities to catalyze the development process. Overall, the country's monetary and fiscal policies are geared towards improving macroeconomic stability by enhancing development, increasing investment and poverty reduction. The country's economic growth and poverty alleviation programmes focus on regionally balanced growth with rural and small and medium private sector development with the medium-term objective of macroeconomic stability and a regionally balanced economic growth rate of about 6-8 percent**.** Being an open economy, open market operations prevail with considerable individual freedom. This has to some degree had a positive impact on the environment.

Importance of bio-resources for economic development

Sri Lanka's diverse bio resources serve to maintain a range of economic activities within the island. Foremost among these are agriculture, the marine and brackish water fishery and tourism. Agriculture, forestry, fisheries and water had contributed only about 12% of the GDP. The fisheries sector provides direct employment to about 208,731 people, and sustenance to at least 2.5 million. Fish also constitutes the top source of animal protein for Sri Lankans. Sri Lanka's rich biodiversity offers ample potential to support the government's current tourism related policy aimed at maximizing potential for nature-based tourism and cultural tourism.

Industrial growth

Sri Lanka has been gradually changing from an agricultural based economy to an industrial based one over the last few decades and presently follows a liberalized industrial policy. At present industry comprises 28.6% of the GDP. Sri Lanka has been promoting the development of private sector-led, export-oriented industries with sufficient diversification in relation to both products and geographical location. However, relatively little attention has been paid in the past to ensure environmentally sustainable economic growth.

Source: Central Bank (2010). Annual Report of 2009. Central Bank of Sri Lanka; Human Development Report 2009, UNDP; Household Income and Expenditure Survey, 2005. Department of Census and Statistics; Population and Housing Census, 2001. Department of Census and Statistics

Appendix E
List of Persons/Institutes Consulted

The Consulting team has attempted to consult a broad range of stakeholders throughout the SVP preparation process through working group discussions and individual consultations. All consulted across sectors are given below.

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