

# Socio-economic and environmental change of Sri Lanka's Central Highlands<sup>1</sup>

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Sri Lanka's Central Highlands occupy a unique position among the main geographical zones of the country. It is an area elevated 300 m above the mean sea level and occupies about 17% of the country's land area. Though small in extent, the landlocked area features great climatic diversity. The Central Highlands are also the watershed for 103 main rivers and more than 1,000 feeder streams. This area is the heart of the entire country because of its important ecological characteristics and as provider of economic functions for the whole country. It is an important source of various ecosystem services and one of the hotspots of biodiversity on a global scale. This has been recognized by the UNESCO who inscribed three areas in the list of UNESCO World Natural Heritage Sites. The cultural importance of the Sri Lankan Highlands is extremely high; it was the core area of the last independent kingdom before colonization. The area hosts three UNESCO World Cultural Heritage Sites. On the other hand, the management of the sensitive ecosystems of the Sri Lankan Highlands was and is extremely weak and destructive. This started with deforestation during the colonial period and is still on-going despite all the government efforts since independence. The highlands host Sri Lanka's most important development project, the Mahaweli Project. Climatic changes and the destruction of natural assets have a negative impact on the whole country. A strategy for sustainable utilization, together with the preservation of natural assets, must be developed and implemented to secure the value of this unique tropical highland.

The objective of this study is to identify the strengths, weaknesses, opportunities and threats that impact on this area and to identify the impacts of global social, political and environmental changes on Sri Lanka's Central Highlands.

**Keywords:** Sri Lanka, ecosystem, biodiversity, world heritage site, Mahaweli project, global change

## Sozioökonomischer und Umweltwandel in Sri Lankas zentralem Hochland

Sri Lankas Zentralhochland nimmt eine wichtige Position unter den geographischen Teilräumen des Landes ein. Das Gebiet über 300 Höhenmeter gelegen, nimmt 17 % der Landesfläche ein. Obwohl gering in der Ausdehnung, mitten im Land gelegen, hat das Gebiet eine große klimatische Diversität. Das Hochland ist auch die Wasserscheide für 103 wichtige Flüsse und mehr als 1 000 kleine Wasserläufe und Bäche. Das Hochland ist wegen seiner ökologischen und als Träger wichtiger ökonomischer Funktionen das Kerngebiet des Landes. Es ist Träger verschiedener wichtiger Ökosystem-Dienstleistungen und ist eines der Kerngebiete der Biodiversität weltweit. Dies ist dadurch anerkannt worden, dass es durch die UNESCO zum „World Heritage Natural Site“ erklärt wurde. Die kulturelle Bedeutung des Sri Lanka Hochlands ist sehr hoch und erklärt sich auch dadurch, dass es das Kerngebiet des letzten nicht kolonial abhängigen Königreiches war. Das Gebiet beherbergt drei UNESCO „World Heritage Sites“. Andererseits war und ist das Management der sensiblen Ökosysteme des Sri Lanka Hochlandes extrem mangelhaft und zerstörerisch. Dies begann mit der Entwaldung während der Kolonialzeit und ist immer noch nicht beendet neben allen Erfolgen der Regierung nach der Unabhängigkeit. Im Hochland ist Sri Lankas wichtigstes Entwicklungsprojekt, das Mahaweli Projekt, lokalisiert. Klimaverände-

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rungen und die Zerstörung des Naturpotenzials beeinflussen das gesamte Land negativ. Eine Strategie für nachhaltige Nutzung, verbunden mit dem Schutz des Naturpotenzials muss entwickelt und angewandt werden, um die Werte dieses einmaligen tropischen Hochlandes zu bewahren.

Das Ziel dieser Studie ist es, die Stärken, Schwächen, Möglichkeiten und Bedrohungen zu identifizieren, die Einfluss auf das Gebiet haben. Außerdem soll der Einfluss der globalen sozialen, politischen und Umweltveränderungen auf das Sri Lanka Hochland dargestellt werden.

### **Cambios socioeconómicos y ambientales en las tierras centrales altas de Sri Lanka**

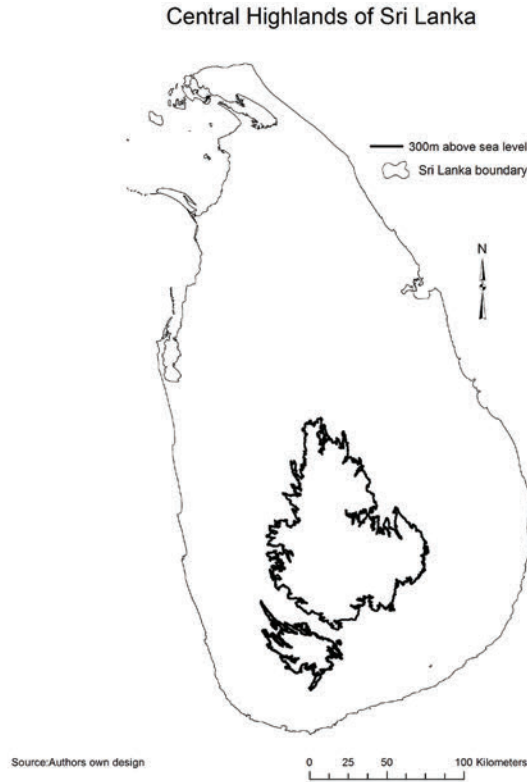
Las tierras altas centrales de Sri Lanka ocupan una posición única entre las regiones geográficas del país. Esta es una zona que se eleva 300 metros sobre el nivel del mar, ocupando cerca de un 17% de la superficie del país. A pesar de esta pequeña extensión, por su localización en el centro del país, cuenta con una gran variabilidad climática. La zona de las tierras altas centrales es también el lugar de origen de 103 ríos principales y más de 1000 afluentes que conectan estos ríos principales. Esta zona es el corazón del país debido a sus características ecológicas y es un impulsor de las funciones económicas. La zona posee algunas características específicas como proveedora de servicios ambientales y es un centro de biodiversidad a nivel mundial. Esto ha sido reconocido por la UNESCO, quien declaró 3 zonas como patrimonio natural de la humanidad. La importancia cultural de las tierras altas centrales de Sri Lanka es muy alta; fue el núcleo del último reino independiente antes de la colonización. El área posee tres sitios culturales patrimonio de la humanidad. Por otro lado, el manejo de los frágiles ecosistemas de las tierras altas centrales de Sri Lanka fue y es todavía, extremadamente débil y destructivo. Esta situación empezó con la deforestación durante el periodo colonial y todavía no se detiene, a pesar de los esfuerzos del gobierno después de la independencia. En esta zona se encuentra el proyecto de desarrollo más importante de Sri Lanka, el proyecto Mahaweli. Los cambios climáticos y la destrucción del potencial natural tienen una influencia negativa en todo el país. Una estrategia de uso sustentable junto a la preservación del potencial natural debe ser desarrollada e implementada para asegurar el valor de estas tierras tropicales.

El objetivo de este estudio es identificar tanto las fortalezas, debilidades, oportunidades y amenazas que juegan un rol en este tema, como también los efectos de los cambios sociales, políticos y ambientales en las tierras altas centrales de Sri Lanka.

## **1 Introduction**

Sri Lanka's Central Highlands occupy a unique position among the main geographical zones of the country. The area is elevated 300 m above the mean sea level and occupies about 17% of the country's land area (Wickramagamage 1990). Though small in land extent, being located within the country, this zone has a diverse blend of most of the world's climatic features. The Central Highlands are the watershed for 103 main rivers (Madduma Bandara 2000) and for more than 1,000 feeder streams joining the main rivers. The area is the heart of the entire country because of its important ecological conditions and as driver of economic functions for the whole country (Fig. 1).

The objective of this study is to identify the strengths, weaknesses, opportunities, and threats having an impact on this area and to identify the impacts of global social, political, and environmental changes on Sri Lanka's Central Highlands (Fig. 2). The main features of both national and global value in this area are as follows:



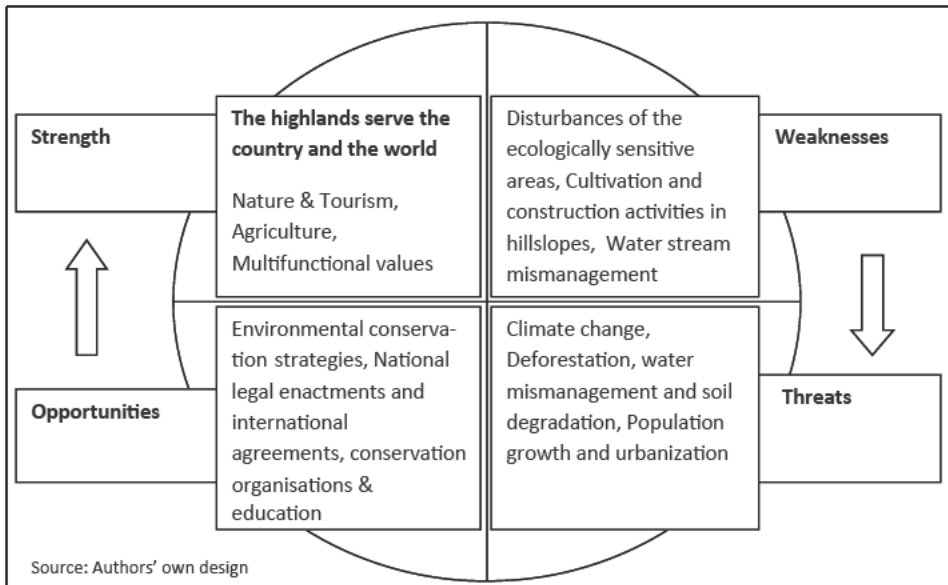
*Fig. 1: Location of the Central Highlands of Sri Lanka*

1. Sri Lanka's Central Highlands are blessed with unique sceneries of international importance and with an extraordinary biodiversity.
2. The area contributes to the national and global economy through agricultural production and tourism.
3. The area contributes to hydro-electricity generation, irrigation, subsistence farming, and agricultural settlements planning.

## 2 Strengths

### 2.1 Nature and Tourism

Sri Lanka's Central Highlands can be seen as one of the most beautiful tropical highland areas in the world and it is Sri Lanka's most visited region. The Central Highlands are the latest World Heritage Site in Sri Lanka. On 31 July 2010, the World Heritage Committee, holding its 34<sup>th</sup> session in Brasília, inscribed the Central Highlands of Sri Lanka. The site comprises the Peak Wilderness Protected Area,



*Fig. 2: Perspectives on Sri Lankan Central Highlands*

the Horton Plains National Park and the Knuckles Conservation Forest. These are rain forests at an elevation of 2,500 m (8,200 ft) above sea level. More than half of Sri Lanka's endemic vertebrates, half of the country's endemic flowering plants and more than 34% of its endemic trees, shrubs, and herbs are restricted to these diverse mountain rain forests and adjoining grassland areas (UNESCO 2012).

The Sri Lankan Highlands are richly endowed with biological resources manifested in a wide range of ecosystems, such as montane forest, evergreen forest (in the lower parts of the highlands), inland wetlands, savanna grasslands and riparian ecosystems (Gunatillake et al. 2008; MENR 2007). By the environment activist group Conservation International (CI), Sri Lanka has been identified as one of 25 biodiversity hotspots in the world. In Sri Lanka, diversity, richness, and endemism across all taxa are much higher in the wet (including the montane) zone than in the dry zone. Indeed, the wet zone, which accounts for only a quarter of Sri Lanka's territory, contains 88% of the flowering plants occurring in the island, and 95% of its angiosperm endemics. There are more than 450 known bird species from the hotspot, of which about 35 are endemic. More than 20 species are endemic to Sri Lanka, mostly from the lowland rainforests and montane forests of the island's southwestern region. Both the Western Ghats and the island of Sri Lanka are considered as Endemic Bird Areas by Birdlife International ([CI] Conservation International 2012).

Kandy is the second largest city in Sri Lanka and its history extends far beyond the colonial period. Most of the British governors preferred Kandy's cool climate for their local residences. The British governor Sir Edward Barnes (1824–1831) is known as the person who encouraged human settlement in Sri Lanka's Central Highlands: Nu-

wara Eliya *Barnes Hall*, for example, which today is an exclusive hotel, was originally built as recreation and hunting post. The British Governor William Gregory further developed the outpost Nuwara Eliya town in Sri Lanka's Central Highlands by adding several attractions and landscaping from 1872 to 1877. To reach the highlands, several roads and road networks were built in the British colonial time (e.g. Colombo – Kandy road from Peradeniya via Ramboda Colombo – Avissawella road passing Ginigathena Hatton, Thalawakale and via Nanuoya Badulla – Bandarawella road via Walimada to Hakgala, from Colombo – Kandy road passing, Hgurankeetha, Rikillagaskada, Padiyapalella, Ragala via Kadapola). Within this road network, settlements were developed as urban centers in Sri Lanka's Central Highlands (GoldenSriLanka.com 2011). Both national and international tourism profits from this and from former tea plantation bungalows and hotels. Tourism is one of the most important drivers of growth and development in the Sri Lankan economy and is a key focus in the governmental development strategy (Ranasinghe & Deshyapriya 2010).

## 2.2 From subsistence agriculture to commercial tea production

Agriculture in Sri Lanka can be categorized into two groups on the basis of its economic value: subsistence agriculture (for domestic consumption) and commercial agriculture. Archaeological studies in the Horton plains and neighboring areas provide evidence of a history of subsistence agriculture in Sri Lanka's Central Highlands which can be traced back 15,000 yr (Deraniyagala 1992). In recent history, subsistence agriculture is assumed to have started again during the Kandy Kingdom. Since then, with an increasing population, the area cultivated both under paddy and highland crops is assumed to have increased. The Portuguese colonial period in the 16<sup>th</sup> century, development activities, migration from low land and settlement expansion processes, and the Chena cultivation can be considered as some considerable human interference with nature. However, land use patterns were environmentally friendly and the old terraced paddy fields and the Kandyan forest garden systems have prevailed up to the present. Although forests were cleared for Chena farming (shifting cultivation), the land was allowed to regenerate by allowing natural vegetation to grow in such locations without disturbance for a long period of time and the impact level was minimal (Wickramagamage 1990). During the Dutch colonial period, cinnamon was popular in the lower lying areas of the highlands but the large scale commercial agriculture was started by the British when coffee plantations were established. During the period, coffee from Sri Lanka enjoyed premium prices on the world market. By the yr 1869, the number of coffee crop owners was approximately 1,700, but the production dipped rapidly as a disease set in and every effort to revive coffee production failed. Coffee had to be replaced by tea plantations and the British had early access to vast extents of land while tea fetched high prices. The climatic conditions were very favorable, cheap labor was imported from southern India and tea production reached a maximum level. Tea production was started in 1873 and it



*Fig. 3: Mackwood's tea plantation Labokeli (photograph by J. Breuste 2010)*

already amounted to 81.3 tons in 1880. In 1890, it reached 22,899 tons and in 1927 it increased up to 10,000 tons (Holsinger 2002).

Although soil fertility in the tea lands is decreasing at present, Sri Lanka is the fourth largest tea producer in the world and a massive labor force is involved in this industry (Fig. 3).

### **2.3 Vegetable production and dairy farming**

Except for tea, Sri Lanka's Central Highlands, at an elevation over 600 m, are exploited mainly for potato and vegetable production. The land extent under potato and vegetable cultivation is around 60,000 ha, which is comparatively low compared to the area under tea cultivation (188,966.4 ha) (Perera & Jayasuriya 2008; Holsinger 2002). Therefore, potato and vegetables are cultivated in the region on an intensive and commercial scale. Potato, carrots, capsicum and other vegetables have become common in the highlands during the last two to three decades. The Sri Lankan Highlands also contribute more than 25% of the livestock sector. The livestock sector contributes around 1.2% to the national GDP and livestock primarily provides a crucial source of high quality protein by producing milk, meat, and eggs. In addition, cattle and buffalo are the primary source of renewable and draught power for a variety of agricultural operations and transport (Perera & Jayasuriya 2008) (Fig.4).





*Fig. 4: Vegetable production near Nuwara Eliya (photograph by J. Breuste 2010)*

## 2.4 Mahaweli Development Program

The Mahaweli River, Sri Lanka's largest river (325 km) with an annual discharge of 7,650 million m<sup>3</sup> also has by far the largest catchment area (10,327 km<sup>2</sup>) covering one sixth of the country (NSF 2000). Due to the geographical configuration with a rain-fed central hill zone, the upper catchment of all the major rivers of Sri Lanka are situated in Sri Lanka's Central Highlands and the area enjoys a high hydropower potential. In 1968, to get the best benefits from such a massive water resource, a major, multi-purpose development plan named Mahaweli Development Program (MDP) (Fig. 5) was initiated with the help of UNDP and FAO funding and was expected to cover a period of 30 yr (Peiris 2006). The Mahaweli River Development Program is the largest integrated rural development multi-purpose program ever undertaken in Sri Lanka and was based on the water resources of Mahaweli and six allied river basins. The main objectives were to increase agricultural production, hydropower generation, employment opportunities, settlement of landless poor, and flood control. The program, originally planned for the implementation over a 30-yr period, was brought to acceleration in 1979, with incorporation of Mahaweli Authority (IEG 2012). At present, the country gains benefit from this project and major hydropower potential will be fully developed in the Upper Mahaweli Catchment (UMC) mainly to generate hydropower, which contributes to about 40–50% of the total hydropower production in the country and also sustains 90% paddy and other crops cultivation in the low land of Sri Lanka (Tolisano 1993).

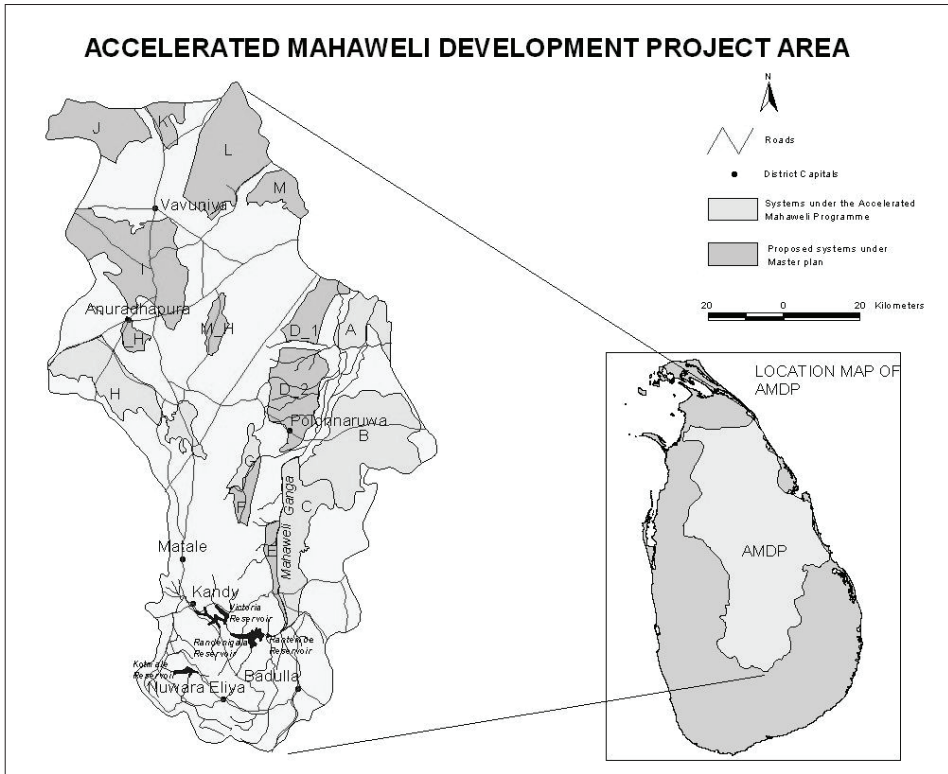


Fig. 5: The Mahaweli Project (Source: Department of Geography, 2010. Accelerated Mahaweli Development project Area. GIS Lab, University of Peradeniya, Sri Lanka)

### 3 Weaknesses

Although Sri Lanka's Central Highlands have extraordinarily attractive scenery with a very high value of biodiversity, nature conservation receives hardly any attention and is often disappointing (Tolisano et al. 1993; IEG 2012). Due to encroachment on the environmentally sensitive areas, biodiversity is at risk. Cultivation and construction activities along hill slopes are risky and in people's attitudes environmental values are relatively unimportant (Gunatillake 2008; Wickramagamage 1990).

#### 3.1 Disturbances of the ecologically sensitive areas in Sri Lanka's Central Highlands

Encroaching or exploiting the environmentally sensitive locations has a history going back about 15,000 yr. However, during the early stages, when land was used for food production and residential purposes, these disturbances were relatively low.



The upper catchment areas of the major rivers situated in Sri Lanka's Central Highlands were stripped of the natural vegetation to make way for the plantation agriculture during the British colonial period. The plantation area grew from 19 km<sup>2</sup> to 2,500 km<sup>2</sup> within less than a century without concerning the natural equilibrium of the watershed (Wickramagamage 1990). The land value of forested land per acre was significantly lower (13–65 pounds) compared to the value of areas cleared for cultivation (100–500 pounds). The consequences were immediately visible in the form of landslides, heavy soil losses, soil fertility decline and reduction in crop yields siltation of low lying areas, frequent flooding, drying out of streams, etc. During the British colonial period Sri Lanka's Central Highlands were also used to provide infrastructure for the plantations and roads, railway tracks, and holiday homes were constructed. There was not enough concern about the ecological role of forests for water balance, soil fertility, erosion prevention, and as habitat. British hunters killed exceedingly large numbers of wild animals, which led to the endangerment of several species, e. g. the Sri Lankan elephant. A single hunter reported that he alone had killed more than 6,000 wild elephants (Baker 1853).

The third stage of invading the environmentally sensitive Central Highlands started after Sri Lanka's independence in 1948. The multipurpose *Mahaweli Development program* was part of this stage. The attention to ecosystem and biodiversity conservation in the submerged areas and to the impact on dried up areas was inadequate. According to the report *An Environmental Evaluation of the Accelerated Mahaweli Development Program*, the current data on wildlife population characteristics, migration and dispersal patterns, and habitat requirements are not sufficient to guide management decision making. Habitat conditions in many of the designated protected areas were degraded over time, and restoration or enrichment measures were insufficient to support the existing wildlife populations. In addition to that some environmental and cultural values are in a despairing state. (Tolisano et al. 1993; IEG 2012; Bulankulama 1992). Before the Mahaweli project there were 257 bird species, 50 mammalian species, and more than 20 reptile species in addition to amphibians and some others. Most of them are extinct now due to the destruction of lower lying areas of the evergreen forest and riparian ecosystems (Tolisano et al. 1993). The inhabitants of the Mahaweli project area were sheltered in newly developed areas, and given a fixed extent of land where, during heavy rain periods, they were exposed to diseases spread by mosquitoes. Increased population pressure lead to the exploitation of remaining forest areas for shifting cultivation or for attaining firewood (IEG 2012) and the day to day problems they faced created substantial tension and stress (Tolisano et al. 1993; Furset 1994) (Fig. 6).

### 3.2 Cultivation and construction activities along hill slopes

The process of soil erosion in Sri Lanka began in the 19<sup>th</sup> century with the expansion of human settlements and the cultivation of upland rain fed crops. It was aggravated



*Fig. 6: Utilization of the sensitive hill slopes (photograph by J. Breuste 2010)*

by the changes in land use patterns during the British administration, when the upper catchments of major rivers located in Sri Lanka's Central Highlands were stripped of natural vegetation to make way for plantation agriculture such as coffee and tea. Land clearing continued even after independence primarily for the establishment of human settlements and for agriculture. During the past five decades, land under human settlements has doubled, while the land brought under crops other than tea, rubber, coconuts, and paddy has increased by 250%. On the other hand, total land under forests and wildlife and nature reserves has declined by 40%, while land taken up by tea plantations and rubber has fallen by 35% and 25% respectively (Hewawasam 2010; Yogaratnam 2010). In this situation on-site soil loss rates, particularly in the upper catchment, continue to be greater than soil replacement rates. Other causes are depletion of soil nutrients, damage to physical and chemical properties of the soil, and the reduction in the soils' capacity to retain moisture. Cropping patterns are often inappropriate for soil and microclimatic conditions of the site, resulting in reduced productivity and increased reliance on environmentally inappropriate agricultural practices. Due to all these causes, massive landslides occur during the rainy seasons. According to the records of the Road Development Authority (Yogaratnam 2010), the total cost of maintaining 1 km of A and B class roads in Nuwara-Eliya District of Sri Lanka's Central Highlands has increased by almost 350% during the past five yr (Yogaratnam 2010). According to studies conducted by Senanayakeon factors associated with the occurrence of landslides in Sri Lanka, human activities in the cultivation of tea, rubber, coconut, paddy, and vegetables contribute to 35, 20, 10, 13, and 8% respectively (Senanayake 1993; cited by Hewawasam 2010) (Table 1).

*Table 1: Extent of different land use types and estimated soil erosion rates in the UMC (Upper Mahaweli Catchment). Source: Hewawasam 2010*

Land use type	Area (km <sup>2</sup> )	Soil loss (t km <sup>-2</sup> y <sup>-1</sup> )	Bedrock erosion rate <sup>1</sup> (mm ky <sup>-1</sup> )
Dense forest	356.6	100	37
Degraded forest and scrubs	435.7	2,500	925
Degraded grasslands	141.9	3,000	1,110
Poorly managed seedling tea	3,454.8	5,200	1,924
Seedling tea with some conservation	252.7	1,500	555
Vegetative-propagated tea	114.9	200	74
Paddy	285.7	300	111
Home gardens	537.7	100	37
Shifting cultivation and tobacco	484.6	7,000	2,590
Market gardens	163.6	2,500	925

<sup>1</sup> Converted into corresponding bedrock erosion considering density as 2.7 g/cm<sup>3</sup>.

### 3.3 Water stream mismanagement

Many rivers and streams journey through catchments that are densely populated regions in Sri Lanka's Central Highlands and are generally negatively impacted by urbanization. The most consistent and pervasive effects are channeling due to settlements, solid waste mismanagement, stream pollution, and an increase in water discharge. In Akurana at Pinga Oya River, the stream being channelized nearly 3 km without proper planning and solid waste issues create massive risks (Dissanayake 2000a, 2010b unpublished; Mahees 2009). In Geli Oya at Mahaweli River, similar effects as in Pinga Oya and in Meda Ela have been registered (Dayawansa 2008), where the effects of urbanisation described above brought about changes to the stream channel width, the water quality and the stream load. Also, the river banks were smoothened by the construction of concrete walls. The reduction of the channel width has reduced the channel capacity; the floral coverage and diversity in the stream corridors shows a decreasing pattern towards the town resulting in an increased risk of flooding. Meda Ela and Akurana experienced unprecedented floods in the recent past as a direct result of the stream channel encroachment for the construction of residential and commercial buildings. Recent severe floods caused damage to the properties of Akurana. The river flows into the stagnant water body of the Polgolla barrage resulting in the aggradations of the lower reaches. Increased garbage and environmental pollution are major issues in the urban environments of the Sri Lankan Highlands. Kandy, Matale and Nuwara Eliya are some of the municipalities which are suffering from increased garbage pollution owing to a lack of proper dumping or recycling methods. As of today, infrastructure for garbage collection is lacking in most municipal areas. This has increased uncontrolled scattering and

dumping of garbage everywhere in the urban and suburban areas in the highlands, as there is a high potential of water pollution threats due to garbage accumulation. For example, solid wastes getting into water ways at the higher watershed areas lead to serious situations like overflow floods and reduction of water storage capacity of reservoirs associated with hydro power generation. Also, the occurrence of water born and water associated diseases is increasing and reports of dengue epidemics in the central region points out the emerging challenges.

The increased garbage quantity also causes slower waterflow in many drainage channels in the Sri Lankan Highlands and provides breeding places for disease vectors such as rats and mosquitoes. Pinga Oya, Nanu Oya, Geli Oya, Kandy and especially Meda-Ela are the best examples of polluted streams due to solid waste. Most of the solid waste transfer points are located close to the most sensitive locations such as water ways, road sides, schools, and so on, which poses several health risks (Dissanayake, unpublished data). Open dumping sites (e. g. Gohagoda in Kandy) cause pollution of ground and surface-water sources (Fig. 7). Open burning of waste without any government regulation is widespread in the country and causes bad smell and air pollution in neighborhoods. It contributes to atmospheric pollution and may cause serious health problems. The river water is also contaminated with fertilizer and pesticides, sewerage, and other types of waste from the residential and commercial establishments located on either side of the channel. This causes the spreading of water borne diseases (Dissanayake 2009; Piyasiri 2009). Although Sri Lanka has adequate rules and regulations with regard to environment conservation the implementation mechanism has weaknesses that prevent a proper implementation.



*Fig. 7: Mismanagement of solid waste tributary in Mahaweli River (photograph by L. Dissanayake 2012)*

## 4 Opportunities

### 4.1 Environmental conservation

Environmental degradation is the major issue in Sri Lanka's Central Highlands, therefore individuals, organizations, and government programs are trying to introduce several conservation methods such as planting vegetation, contour plowing, maintaining the soil pH, soil organisms, crop rotation, watering the soil, salinity management, terracing, bordering from indigenous crops, no-tilling farming methods and also to home gardens. A home garden is a piece of land around the dwelling with clear boundaries and it has a functional relationship with its occupants related to economic, biophysical, and social aspects (Weerakoon 2011). Kandyan home gardens can be identified in Sri Lanka's Central Highlands as a valuable, diversified, and sustainable ecosystem; it exhibits the geometric relationships of trees, light attenuation in canopy layers, multiple functions and interactions that occur in limited areas outside natural forest with human relations. The canopy stratification minimizes rain drop impact and soil erosion is reported to be negligible. This special forest management practice, primarily inherited as family resource, and its knowledge transfer of ownership from parents to children, means that management has retained continuity (Halladay & Gilmour 1995). The history of cultivating trees and crops in home gardens, social tree planting, protecting and managing forests, appreciating wildlife, and sustaining the beauties of nature, especially in the Central Highlands, go back more than 25 centuries (Nianthi 2010). Today, the traditional knowledge of agroforestry is being developed and expanded with the objective of improving living standards, especially among the rural communities not only in the central highlands but also all over the country.

### 4.2 National legal enactments and international agreement

Sri Lanka's Central Highlands host the latest World Heritage Site in Sri Lanka. On 31 July 2010, the World Heritage Committee inscribed Sri Lanka's Central Highlands. In spite of negative impacts exerted on the socio-economic and political processes within Sri Lanka's Central Highlands, it is fortunate that its environmental values remain to some extent. Having recognized its value to make it sustainable, UNESCO has identified Sri Lanka's Central Highlands as a world heritage zone in three major component parts: Peak Wilderness Protected Area, Horton Plains National Park, and Knuckles Conservation Forest. The Peak Wilderness Sanctuary is unique among Sri Lanka's forests in having a range of altitudinally graded, structurally and physiognomic distinct, and biologically diverse forest formations that include tropical lowland, submontane and upper-montane rain forests, and natural grasslands (UNESCO 2012).



*Table 2: Central Highland Protection – Related Regulation and Legal Enactments in Sri Lanka; Copyright: CEA 2012, Jayakody 2012*

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1.	National Environmental Act No. 47 of 1980. (Amendment) No 56 of 1988/ No. 53 of 2000
2.	National Environmental (Upper Kotmale Hydro-Power Project- Monitoring) Regulation No. 1 of 2003. Gazette Notification Number 1283/19 dated 10th April 2003
3.	Regulation for Prohibition of use of Equipment for exploration, mining and extraction of Sand & Gem. Gazette Notification Number 1454/4 dated 17th July 2006.
4.	Regulation for Prohibition of use of Cultivation of annual crops in high gradient area. Gazette Notification Number 1456/35 dated 4th August 2006.
5.	Order under Sections 24(C) and 24(D) to declare Gregory Lake as an Environmental Protection Area. Gazette Notification Number 1487/10 dated 5th March 2007.
6.	Order under Section 24(C) and 24(D) to declare Knuckles Environment Protection Area. No.1507/9 dated 23rd July 2007.
7.	Land Ownership Act of 1840 ( by British Rulers)
8.	Crown Land Encroachment Ordinance of 1840 ( by British Rulers)
9.	Irrigation Ordinance of 1856 (by British Rulers)
10.	Forest Ordinance of 1907 (by British Rulers)
11.	Land Development Ordinance of 1935 ( by British Rulers)
12.	Soil Conservation Acts No. 25 and 29 of 1951 (General Regulations) and 1953 (Special Regulations)
13.	Agrarian Services Act of 1959
14.	Water Resources Act of 1964
15.	State Land Ordinance
16.	National Water Supply and Drainage Board Act of 1974
17.	Land Grant Act of 1979
18.	Mahaweli Authority of Sri Lanka Act No. 23 of 1979
19.	National Environment Act of 1980 amended in 1988
20.	Irrigation Ordinance of 1990
21.	Soil Conservation (amended) Act No 24 of 1996
22.	Scheduled waste (hazardous waste) management regulations 2008 – Gazette Notification No. 1534/18 dated 01.02.2008.
23.	Regulation for Prohibition of manufacture of polythene or any product of 20micron or below thickness. Gazette Notification Number 1466/5 dated 10 <sup>th</sup> October 2006

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The Horton Plains National Park and the Knuckles Forest are important in terms of rare species of woody plants and animals, some of which are unique to this site. In addition, this forest contains 14 of the 23 endemic bird species; more than 50% of the endemic fish, of which nine are endangered, and three are restricted to the forest; and a large number of butterflies and reptiles. The City of Kandy was identified as a sacred Buddhist site that has a long history reaching back more than 2,500 yr. This allows a global cooperation in conserving this area. Except for that, a substantial number of legal enactments and international agreements are available as authorities

related to the environment have made efforts to protect the diversity of Sri Lanka's Central Highlands (Table 2).

The substantial number of legal enactments to dispel all undesirable aspects due to political interferences, implementation of imposed legal enactments had been delayed or not done at all. If the legal enactments were enforced, the present problems related to environmental, social, cultural, and economic aspects could be avoided.

### **4.3 Environment conservation organizations**

Sri Lanka has an adequate network of government and non-governmental organizations focusing on environment conservation. According to the Sri Lanka Environmental Journalist Forum (SLEJF), there are 7,000 non-governmental organizations with an interest in environmentally friendly activities. Government institutions directly contributing to environmental protection are the Wild Life Environment and Forest Conservation Department, the Central Environment Authority, the Geological Survey and Mines Bureau, the Wildlife Trust of Sri Lanka and the Mahaweli Authority; they protect the highland environmental resources and values (SLEJF 2004).

Other government authorities and 700 other non-governmental organizations additionally provide services related to influencing, encouraging, and promoting sustainable development. They communicate environmental issues and build awareness among the public not only in Sri Lanka's Central Highlands but also in the whole country.

### **4.4 Environmental education**

In the recent past, there has been an increasing awareness of environmental education from school to university degree level both in Sri Lanka and in the larger regional setting of South Asia. Also governmental and non-governmental organizations are trying to provide informal environmental education, especially for farmers and households. To reach the global environmental targets, Sri Lanka faces big challenges but also huge opportunities. Managing Sri Lanka's Central Highlands ecologically will be an important contribution to both global and national environmental targets.

## **5 Threats**

### **5.1 Climate Change**

According to current predictions for Sri Lanka, the effects of climate change by 2050 will be marginal, reaching only +0.50°C temperature increase and +5% evaporation / rainfall (wet season only) in the high scenario (Yogarathnam 2010). The Central

Highlands studies also revealed that the amount of rainfall on the eastern and western slope of the area increases with the altitude to a maximum at a height of about 1,000 m; further up it decreases (Nianthi 2005). These trends show that within the average, the intensity of dry weather and rainfall may increase. Therefore, climate change could have increasingly significant effects in the scenario for the yr 2070. Studies on weather patterns and crop yields for the past yr (Ratnasiri et al. 2008; Yogaratnam 2010) have shown that drought affects tea by reducing the yields. Direct impacts will result from increased carbon dioxide levels, which affect photosynthesis and rising temperatures which, in turn, cause heat stress and increased evapotranspiration in crops. Indirect impacts will result from changes in moisture levels, an increased incidence of pests and growing spoilage of agro-products as a result of enhanced microbial activity. These effects could result in reduced yields and shifts in productivity. On the other side, irregular patterns of rainfall and high seasonal concentrations in Sri Lanka's Central Highlands, with attendant increases in run-off ratios, could result in soil erosion, land degradation and the loss of productivity of plantation crops. Hydropower generation in Sri Lanka in June 2012 has dropped to 14.8% 323 GWH due to receding water levels of hydropower reservoirs due to less rainfall (Abeywicrama 2012). Therefore, these issues may need to be addressed more through laws and regulations, while at the same time taking into account developmental needs. In that context, balancing enforcement measures with awareness and training through assistance programs appears to be a big challenge for the relevant authorities (Ministry of Environment 2010).

## 5.2 Deforestation

Sri Lanka has a striking variety of forest types brought about by spatial variations in rainfall, altitude, and soil. The forests have been categorized; wet sub-montane forests (at elevations between 1,000–1,500 m in the wet zone); wet montane forests (at elevations of 1,500–2,500 m); with reverence vegetation along river banks; the wet lowland forests transform into sub-montane and montane forests (UNESCO 2012).

The present natural forest cover of Sri Lanka is a little less than 25% of the total land area (Ministry of Forestry and Environment 1999). In the 1880s, after the British had spent fifty yr clearing jungle for plantations, the forest cover was estimated to be around 80%. However, during the colonial period, mostly tropical montane forest and tropical moist evergreen forest cover rapidly decreased. By the time the British left the island in 1948, the forest cover was down to about 54% to 50%. In fact this trend has accelerated after independence; largely tropical lowland wet evergreen, tropical dry mixed evergreen and riverine forest was continually reduced from about 44% to 24% from 1956 to 1992 due to resettlement programs. Considerable areas of the forest were also submerged by the hydropower reservoirs that were constructed during the past three decades under the Accelerated Mahaweli Project (Ministry of Forestry and Environment 1999). The average rate of deforestation between



Fig. 8: Recent settlement extensions near Newara Eliya (photograph by J. Breuste 2010)

1956 and 1992 was approximately one km<sup>2</sup> per day (Hewawasam 2010). After 1992, large parts of the forest patches in the Central Highlands were cleared to expand towns and villages and to develop infrastructure facilities (Fig. 8; Table 3).

### 5.3 Water mismanagement and soil degradation

Water management schemes have changed the natural flow regimes of the major rivers, resulting in sometimes higher flood flows, lower dry-season flows, and the degradation of riparian and wetland habitats in the lower catchment. Downstream water quality in the lower catchment area is being degraded as a result of nutrient loading and pesticides from farm runoff. Sediments and agrochemicals in runoff water lead to eutrophication of the reservoirs. Chemical inputs to the agricultural systems in the upper and lower catchment areas are degrading local surface and ground water quality. The increase in the cultivation of annual crops in contrast to perennials in hilly regions also causes damage to roads through increased erosion and rainfall run-off ratios (Piyasiri 2009). The loss of multipurpose reservoir capacity as a result of sedimentation is a major off-site effect. This loss has a major adverse impact on power generation and on the irrigation of agricultural land in the dry zone outside Sri Lanka's Central Highlands.

Table 3: Forest cover in Sri Lanka;  
Source: Wicramagamage 1990;  
MF&E 1999; Ratnayake et al. 2011

Year	Percentage
1881	84
1900	70
1956	44
1983	27
1992	24

*Table. 4: Original capacity, surveyed capacity and percentage of loss of original capacity due to siltation of hydropower reservoirs impounded in the UMC. Source: Wallingford 1995*

Name of the reservoir	Year of the impoundment	Original capacity (Million m <sup>3</sup> )	Year of the hydrographic survey	Surveyed capacity (Million m <sup>3</sup> )	The loss of original capacity due to siltation
Kotmale	1985	176,770	1990	184,640	–
Polgolla	1976	5,271	1993	2,794	44%
Victoria	1985	717,530	1993	713,080	1%
Rantembe	1991	10,950	1994	7,900	28%

The land degradation has been recognized as the most serious environmental problem especially in the highlands of the country. A high population density, presently over 300 per km, and a lack of off-farm livelihood opportunities has led to excessive highland exploitation (Ministry of Environment 2010). In the higher elevations in Sri Lanka's Central Highlands, particularly due to the cultivation of tobacco, potato, and vegetable crops and the construction of roads and highways, soil erosion has been taking place to a considerable extent. The degrees of soil erosion extend up to massive land sides. When the same land is planted continuously with the same crop, soil fertility tends to gradually decrease while the application of fertilizers and agro-chemicals further challenge the soil. Due to tillage and pulverizing soil clods, due to sudden heavy rains, soil erosion, landslides, and the deposition of clay and silt, the reservoirs designed to supply water to hydropower in the region are under great risk. According to the H.R. Wallinford Limited completed hydrographic survey (Hewawasam 2010), sedimentation rates in small reservoirs of the Upper Mahaweli catchment for the period from 1985 to 1993 the Polgolla barrage has reduced its storage capacity to 56% over a 17 yr period. Rantambe reservoir has reduced its storage capacity to 72% during a three yr period after impoundment (Table 4).

#### 5.4 Population growth and urbanization

Sri Lanka's Central Highland mainly covers four administrative districts: Kandy, Nuwara Eliya, Matale, and Badulla. The total population of these four main districts is 3,203,949 and its population density is around 395 per km<sup>2</sup>, (Population survey 2001). The high population density and sustained efforts to improve living standards have exerted tremendous pressure on the natural environment of the highlands. Unplanned urban population growth has exerted pressure on the central highlands and water resources in the cities as well as peripherals with impacts on sewage disposal, waste management and environmentally related health problems. The high proportion of the poor and the growing population, combined with an unequal distribution of benefits from natural resources, make a sustainable development in the Sri Lankan Highlands a quite challenging task. According to the independent evalua-



tion group study on the Mahaweli Development Program, a substantial rudiment of the population, who disliked leaving their original villages, migrated to the higher elevation areas. This worsened the living standard there as they only have access to miniscule land holdings prone to environmental risks.

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We donate this paper to our friend and colleague Christoph Stadel. Together with me (Jürgen Breuste), he organized a very successful excursion to Ecuador for the University of Salzburg, Austria, in 2003. I profited from his extraordinary knowledge of the country and especially of its cultural landscape, land use and people of the mountains. We were a very well cooperating team, I with my contributions on ecosystems and he with his on land use, human systems and mostly all regional aspects. It is still a unique remembrance.

I could invite Christoph Stadel to my excursion to Sri Lanka in 2010 and spent great days with him, especially in the Sri Lankan Highlands. Here we could again profit from his unique experiences in mountain areas and knowledge of socio-economic conditions. Not having been to Sri Lanka before, he could easily recognize the relations between natural conditions and the utilization by the people and give very valuable contributions to the excursion, especially by various comparisons to other tropical mountain areas. We surely profited from his expertise.

Christoph persistently ignored all travel problems (heat, rain, long tours with the bus, foot walks in the forests, insects, late to come to sleep), was in a good mood every day and enjoyed the new experiences. He was, and still is, in many ways as young and encouraged as the students 50 years younger than he. You can't find such an excursion participant and good comrade everywhere (Fig. 9).



*Fig. 9: Christoph Stadel 2010 experiencing the tropical montane forest of Ritigalla in the Sri Lankan Highlands together with students from Salzburg University (photograph by J. Breuste 2010)*

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