Journal of the Department of Wildlife Conservation 2006-1: 149-168

EFFECT OF CLIMATE CHANGE ON FLORA AND FAUNA OF YALA AND BUNDALA NATIONAL PARKS IN SOUTHERN SRI LANKA

S.P. SAMARAKOON*

Department of Botany, University of Ruhuna, Matara, Sri Lanka

ABSTRACT

An attempt was made in 2003 to identify the climate variability and its effects on flora and fauna in Hambantota. The objectives of the study were (1) to extract the patterns of climate variability, (2) to construct a "Climate Trend Diagram (CTD)" and (3) to study the effect of climate change on flora and fauna.

Rainfall and temperature data (1869 - 2002) were collected from Colombo Meteorological Department and analyzed using Statistical Packages to find the cycles of relatively similar patterns and trend lines for each cycle. Information on flora and fauna were collected from desk-top studies, and field visits.

The mean annual rainfall and temperature at Hambantota were 1022.4 mm, and 27.1^{0}C respectively. Generally, the rainfall was declining and temperature was increasing since 1970s.

November showed the highest rainfall of 183.1 mm and the driest months were February, July, and August. The actual rainfall and the mean temperature showed patterns of climatic cycles of 16- years and 6-years respectively. Since 1970s, the CTD showed that the mean annual temperature has been increasing and the rainfall decreasing.

Presumably, the prolonged drought has decreased ground water and increased scrub species. Plants and animals, which have relatively higher demand for water, were the most threatened species. The long-term effects of climate change were reflected by forest die-back, and spread of woody weeds in Bundala and Yala National Parks.

INTRODUCTION

According to the information available throughout the history it is apparent that the climate of different parts of the earth has been changing and such changes are generally referred to as natural climate changes or more precisely climate variability (IPCC, 2001; IPCC, 2004). Usually these changes occur in the atmosphere, but the effects of such changes affect on other environmental components including both biotic and a-biotic parts. United Nations Framework Convention on Climate Change (United Nations, 1992; Orlando, and Smeardon, 1999) defines climate change as "a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods". Atmosphere is an essential part of the physical and chemical environment for life. Changes, anthropogenic or otherwise, to the physical and chemical properties of the atmosphere have the potential of affecting directly the quality of life and even the very existence of life. Climate generally defined as the pattern or cycle of weather conditions such as wind, rain, snowfall, humidity, and clouds, including extreme or occasional ones, over a large area, averaged over many years. During the past century or so with the increased use of mineral oils and emission of green house gases and the destruction of natural environment the man has been identified as the major factor behind the change in natural climatic changes. Sri Lanka as an island country in the tropics, its vulnerability to the effect of global climatic changes such as increased atmospheric temperature becomes serious. This is especially true for Hambantota area (South Eastern corner of the island) compared to other areas of the country because of its inherent dry, high temperature and low rainfall situation despite its ancient historical settlements (Perera, 1965). The present study is aimed to identify the climate variability patterns and the advent of the serious anthropogenic modern climate change and the vulnerability of flora, and fauna of Yala and Bundala National Parks in Hambantota District to the drastic effects of climate changes.

OBJECTIVES

(1) To study the patterns of climate variability since 1869-2002 in Hambantota Area.

Hambantota has weather recordings of rainfall and temperature since the year 1869. Although daily maximum and minimum temperatures appear more serious effects on the vegetation and fauna for most of the period only mean temperature values are available; mean monthly temperature gives only marginal understanding of the effects while annual mean gives still less representation of the real temperature variation.

(2) To identify and extract rainfall and temperature cycles for Hambantota District.

(3) To study the variation of rainfall and temperature trend lines for each of the climate cycle.

(4) To construct a pictorial representation of both monthly rainfall and temperature continuous variability for 134 years from January 1869 to December 2002.

(5) To identify the advent of major climate change in Hambantota.

(6) To study the effect of climate change on flora and fauna of National Parks of Hambantota Area.

MATERIALS AND METHODS

Extraction of climate cycles using mean monthly rainfall and temperature (continuous) in Hambantota

Monthly rainfall and temperature data of Hambantota were collected from Colombo Meteorological Department for the period from 1869 to 2002. These data were analyzed using SPSS Statistical Package and Microsoft Excel to find the patterns of monthly changes, mean individual monthly changes, continuous monthly changes and patterns of annual changes. Periods (cycles) of relatively similar variability patterns for rainfall and temperature were extracted.

Climate cycle trend lines

For each climate cycle the trend lines were drawn using the Excel

Programme to show the climate trends.

Construction of climate trend diagram

Using the extracted rainfall and temperature trend lines a "Climate Trend Diagram" was constructed for Hambantota.

The effect of climate change on flora and fauna of the national parks

Information on flora and fauna of the Yala and Bundala National Parks was collected as follows:

i. Desk-top studies of the previous work:
For the desk-top study information were collected from (a) the Department of Wildlife, and (b) my previous studies of the area and (c) Interviewing the relevant personnel of the park.

ii. Field studies of the different areas of the national Parks

The changes in the botanical and faunal composition during the recent past (!990 - 2002) were noted. Special attention was paid to study the spread of woody weeds, forest die-back and the presence of large herds of domesticated and feral cattle in the park area. Information regarding the vulnerability of flora and fauna to changing climate and potential climate related problems were collected through the historical and field studies of the occurrence of wild fire, spread of woody weeds (*Lantana camara, Prosopis juliflora*), possibility of the spread of giant panic grass (*Panicum maximum*), forest dieback (*Manilkara hexandra, Drypetes sepiaria, Salvadora persica*, and availability of water, changes in the botanical composition, and encroachment of the parks by the feral cattle and buffaloes.

The Climate Trend Diagram was used to identify the human influenced climate change in Hambantota. The points of deviation from the normal patterns of variation in the rainfall and temperature cycles were considered as the points of the commencement of severe human influence on the climate variability.

RESULTS AND DISCUSSION

Analysis of climate data

Descriptive statistics

The central tendencies in terms of the mean and the dispersion in terms of range, minimum and maximum values, standard deviation and variance are shown in the Table 1. With a mean of 183 mm the month of November showed the highest rainfall at Hambantota, followed by December (128 mm) and October (127 mm).

Since 1869 the minimum, maximum and mean values of monthly rainfall at Hambantota in October, November and December were 1, 10, 2 (mm); 564, 472, 486; and 127, 183, and 128 (mm) respectively (Table 1). In all the other months the mean rainfall were less than 100 mm and the lowest rainfall were experienced in the months of February, July and August with less thank 50 mm.

Table 1. Descriptive Statistics for rainfall (mm) data (1869 - 2002) Hambantota

Month	Minimum mm	Maximum mm	Mean mm	Standard Error	Standard Deviation
JANUARY	0	376	83	6	74
FEBRUARY	0	273	44	4	50
MARCH	0	258	63	5	55
APRIL	1	333	92	5	62
MAY	0	512	93	7	85
JUNE	1	235	59	4	49
JULY	0	224	44	4	44
AUGUST	0	214	46	4	42
SEPTEMBER	0	452	64	6	65
OCTOBER	1	564	127	8	92
NOVEMBER	10	472	183	8	95
DECEMBER	2	486	128	7	85
TOTAL	489	2063	1013	21	247

Table 2. Descriptive Statistics for temperature (^{0}C) data (1869 - 2002) Hambantota

Month	Minimum (^{0}C)	Maximum (^{0}C)	Mean (^{0}C)	Standard Deviation
JANUARY	24.7	32.4	26.6	1.8
FEBRUARY	24.0	33.2	27.0	1.8
MARCH	25.8	33.7	27.8	1.8
APRIL	25.7	34.1	28.4	1.7
MAY	25.8	34.5	28.5	1.7
JUNE	25.2	34.4	28.2	1.8
JULY	25.6	34.1	28.3	2.0
AUGUST	25.9	33.8	28.1	1.8
SEPTEMBER	26.2	33.2	27.9	1.7
OCTOBER	25.6	33.1	27.7	1.7
NOVEMBER	25.4	32.5	27.2	1.6
DECEMBER	24.6	31.9	26.6	1.7

Classification of months and years based on rainfall data

(a) Classification of cases (years)

The Dendrogram produced by the hierarchical analysis of the mean annual rainfall and temperature data of Hambantota (1869-1980) did not show meaningful cluster separation.

(b) Classification of variables (months)

The Dendrogram produced by the hierarchical cluster analysis to classify the variables (months) using the mean monthly rainfall data of Hambantota (1869-1980) is shown in the Figure 1.

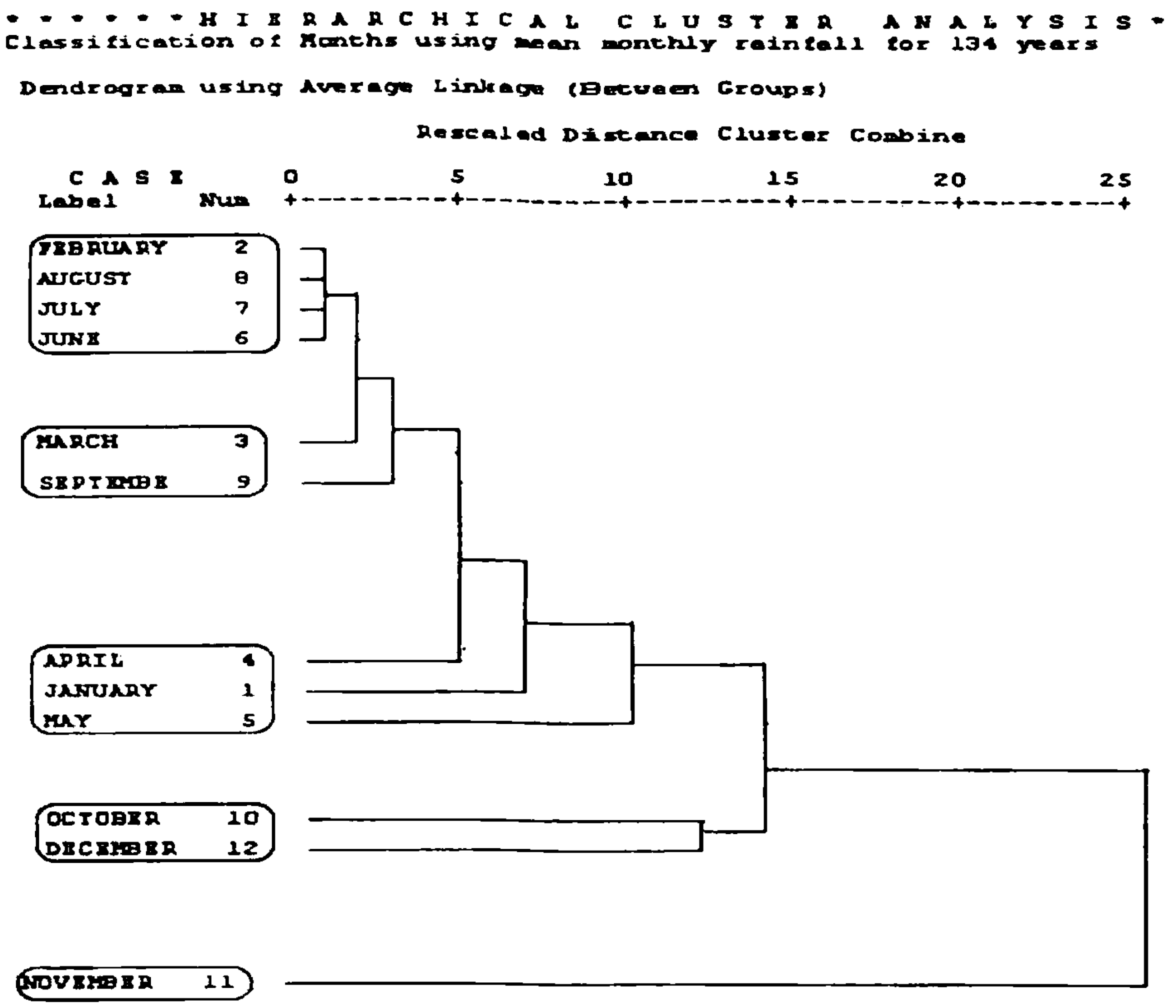

Figure 1. Classification of months based on the rainfall data

Based on mean monthly rainfall the variables (months) can be classified into 4 groups and 7 cycles (spells) as follows:

Group 1: February, March. June, July, August, and September (44-64 mm of rainfall):
Two cycles (spells) of drought,
(a) February and March, and (b) June, July, August, and September

Group 2: January, April, and May (83-93 mm of rainfall): Two cycles (spells) with
Moderate rainfall (a) January, and (b) April and May

Group 3: October and December (127-128 mm of rainfall): Two cycles (spells) with High
rainfall (a) October, and (b) December

Group 4: November (183 mm of rainfall): One cycle with very high rainfall

Classification of months and years based on temperature data

The Dendrogram produced by the hierarchical cluster analysis to classify the variables (months) using the mean monthly temperature data of Hambantota (1869-1980) is shown in the Figure 2.

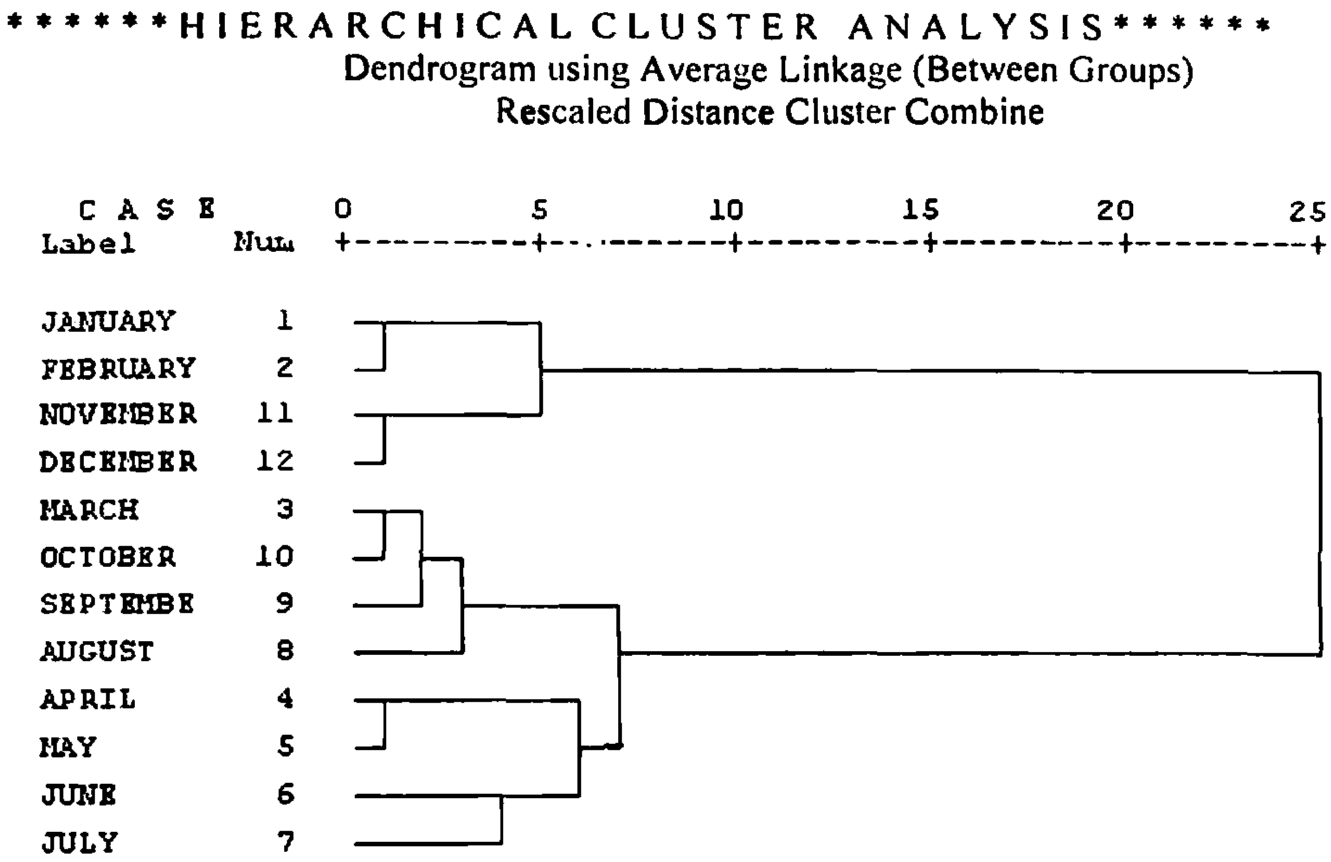

Figure 2. Classification of months based on the mean monthly temperature data

Based on mean monthly temperature the variables (months) can be classified into 3 groups and 7 cycles (spells) as follows:

Group 1: November, December. January, February (26.6-27.2 ^{0}C):
One cycle (spell) of mild temperature

Group 2: March, August, September, October (27.7 – 28.1 ^{0}C): Two cycles (spells) with
moderately high temperature (a) March, and (b) August, September, and October

Group 3: April, May, June, and July (28.1 – 28.5 ^{0}C): One cycle (spell) of high temperature

On the other hand the minimum mean temperatures were recorded for the months of November, December and January and maximum means for May, April, July, June and August (Table 2). As such under the influence of low rainfall and the high temperatures the driest months in Hambantota are June and July followed by August and September.

Rainfall patterns

(a) Mean Annual Rainfall

Except around the 9th Year (1877), generally the graph of mean annual rainfall looked somewhat arc-like (Figure 3). About 85% of the peaks appeared above the 1000 mm rainfall line and one peak has risen above the 2000 mm level. About 5 years (approximately 11% of the years) the rainfall had been very low (the inverted peaks). Generally, the shape of the curve showed that the rainfall had been declining during the last 30 years (from about the year number 100) or so indicating a severe long drought in Hambantota.

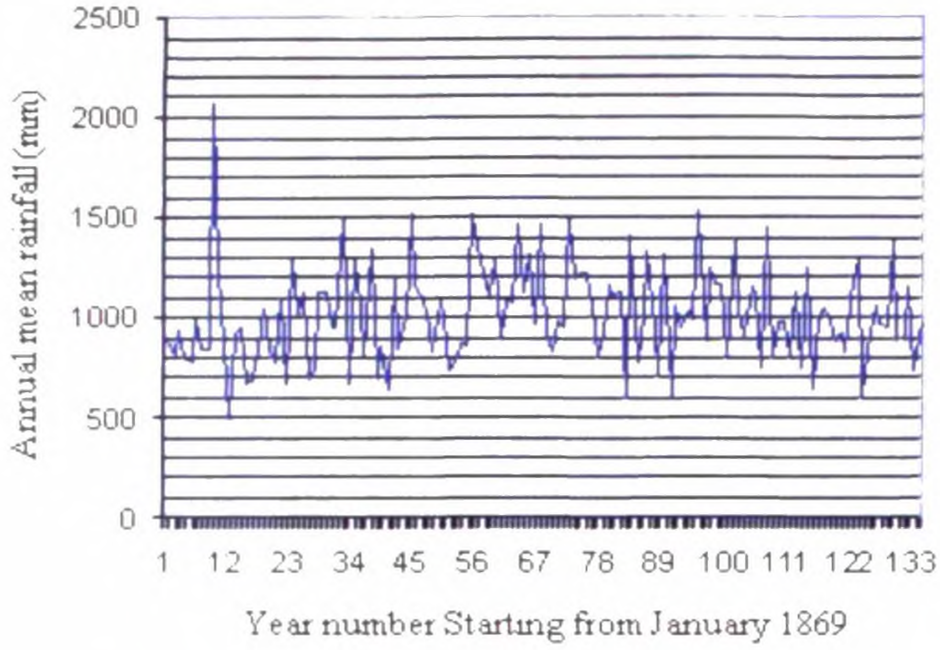

Figure 3. Mean annual rainfall of Hambantota plotted against year.

(b) Mean Continuous Monthly Rainfall (January 1869 to December 2002)

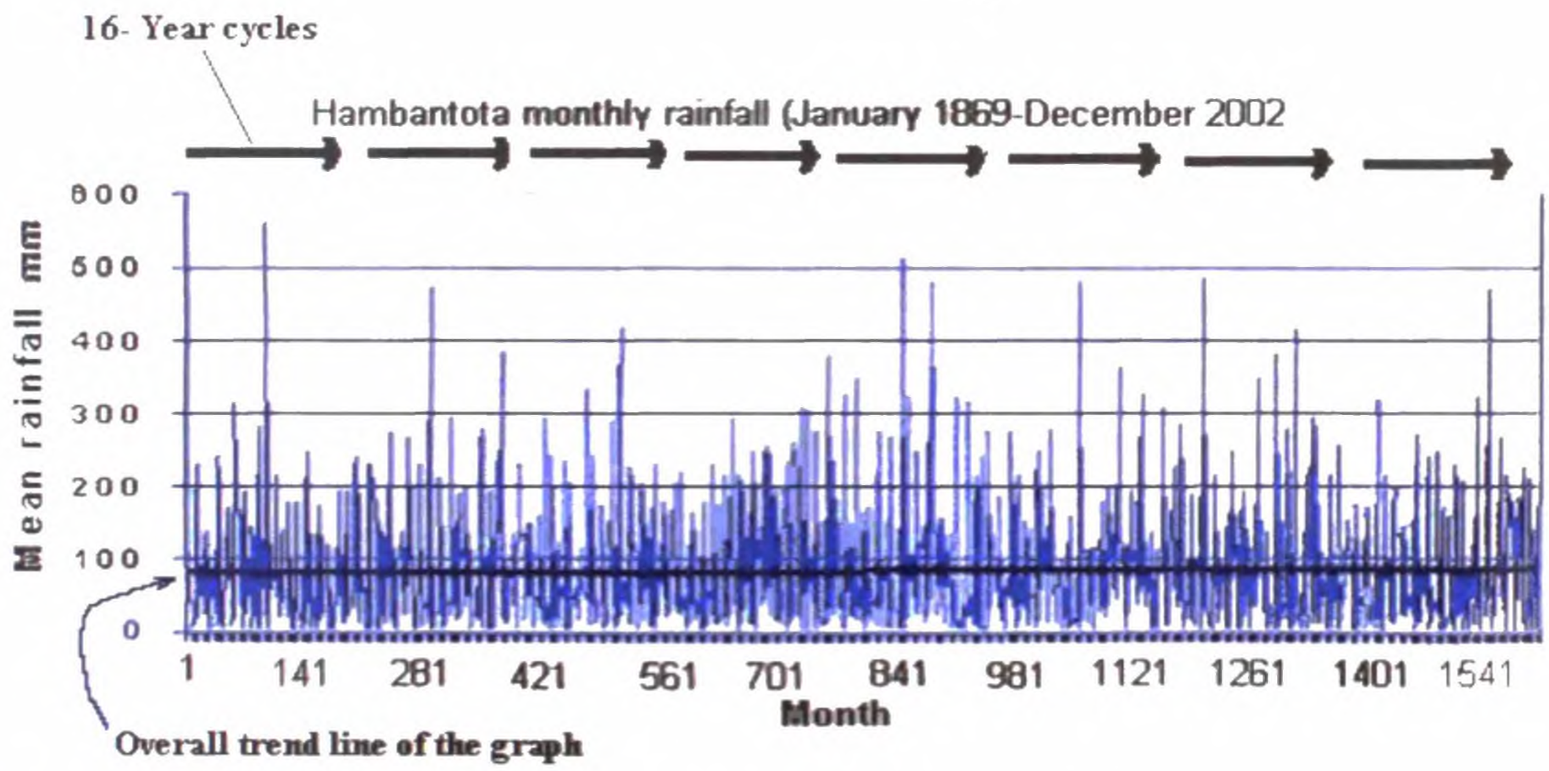

Figure 4. Monthly rainfall of Hambantota (1869-2002) plotted against number of the month

When monthly rainfall was plotted against the number of the month starting from January 1869 and ending at December 2002 some interesting patterns were resulted (Figure 4-11). The month number 69 (1874 November) showed a high peak of more than 300 mm of rainfall. Similarly, the graph showed a general pattern of recurrence of high rainfall over 200 mm, which had a cycle of approximately 25months. The frequency of the rainfalls over 300 mm is approximately 30 years.

An interesting observation of Figures 4-11 is that the overall monthly variation of rainfall has distinct units of periods with consistent duration of 192 months (16 years approximately). The overall trend line of rainfall during the period (monthly values from the year 1869 to 2002) was neither positive nor negative (Figure 4). A long band of rainfall spectrum was used to extract rainfall cycles (⟶) which are shown in the concise diagram.

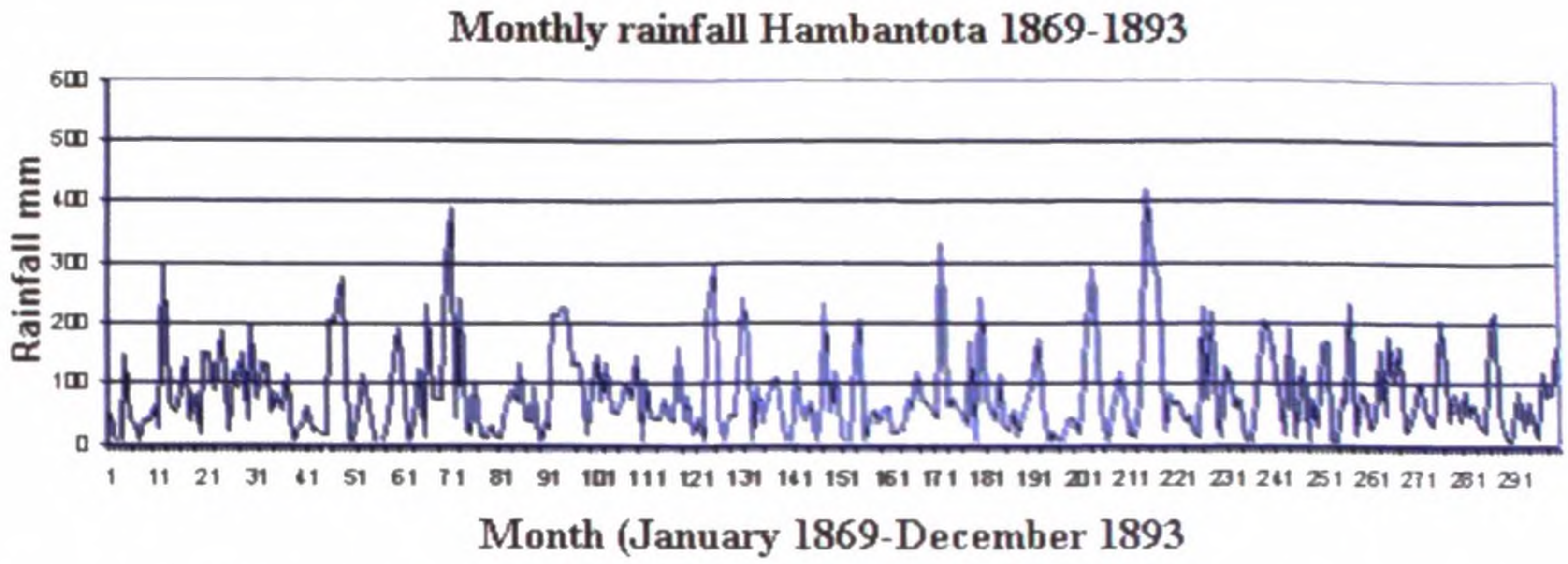

Figure 5. Monthly rainfall of Hambantota (1869-1893) plotted against number of the month

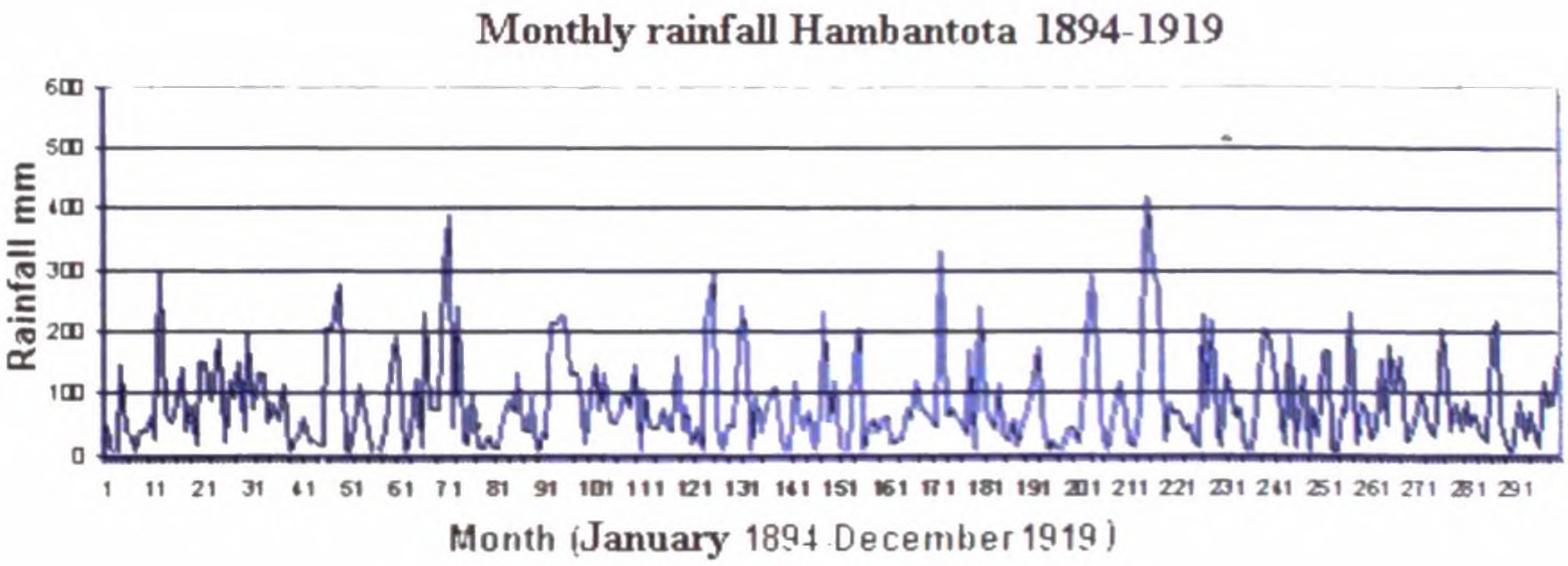

Figure 6. Monthly rainfall of Hambantota (1894-1919) plotted against number of the month

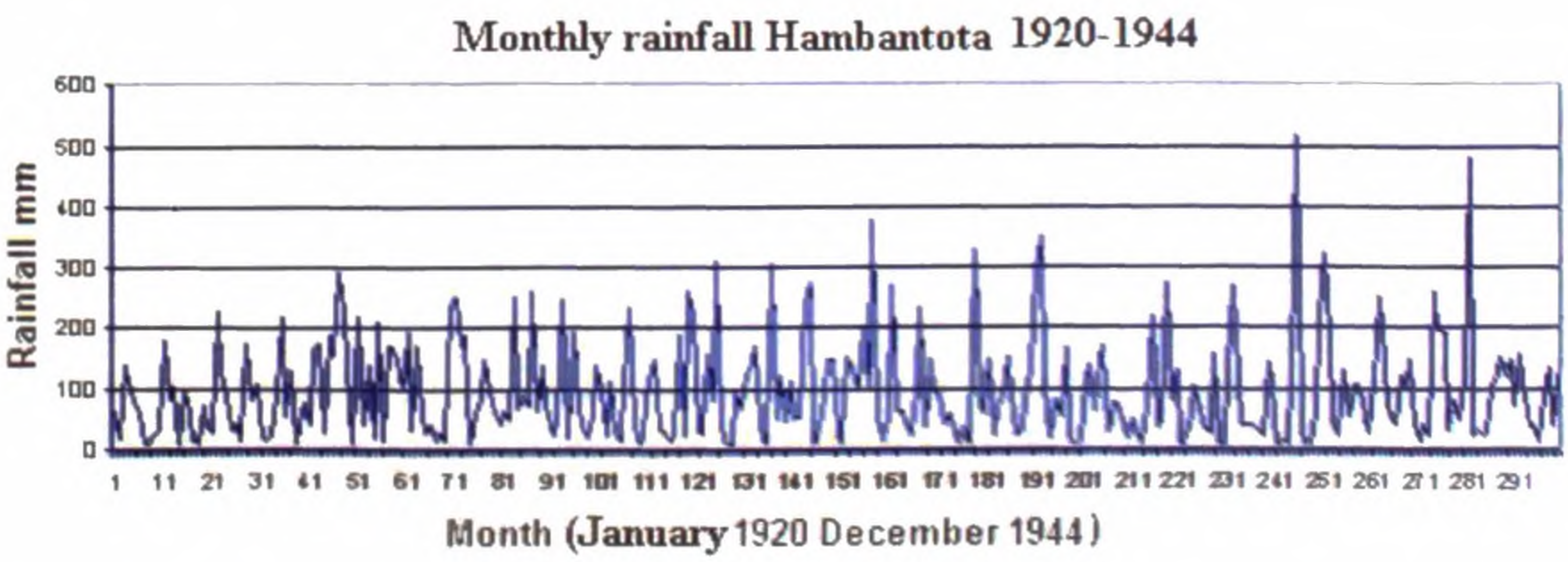

Figure 7. Monthly rainfall of Hambantota (1920-1944) plotted against number of the month

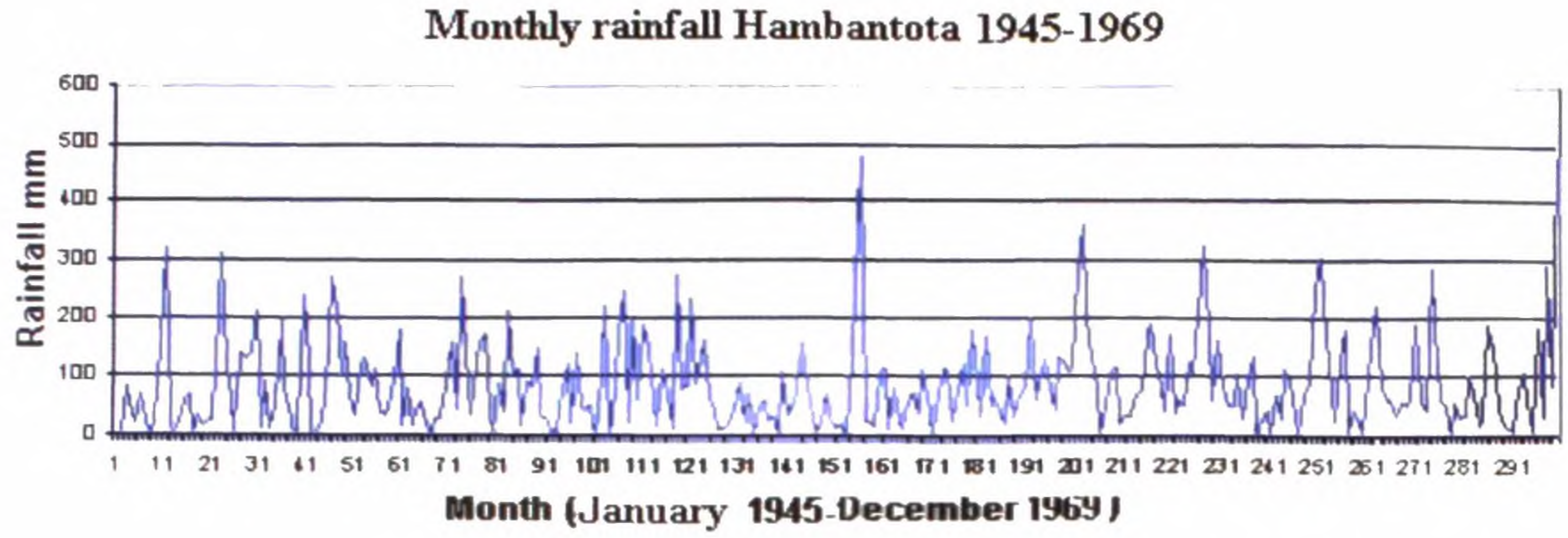

Figure 8. Monthly rainfall of Hambantota (1945-1969) plotted against number of the month

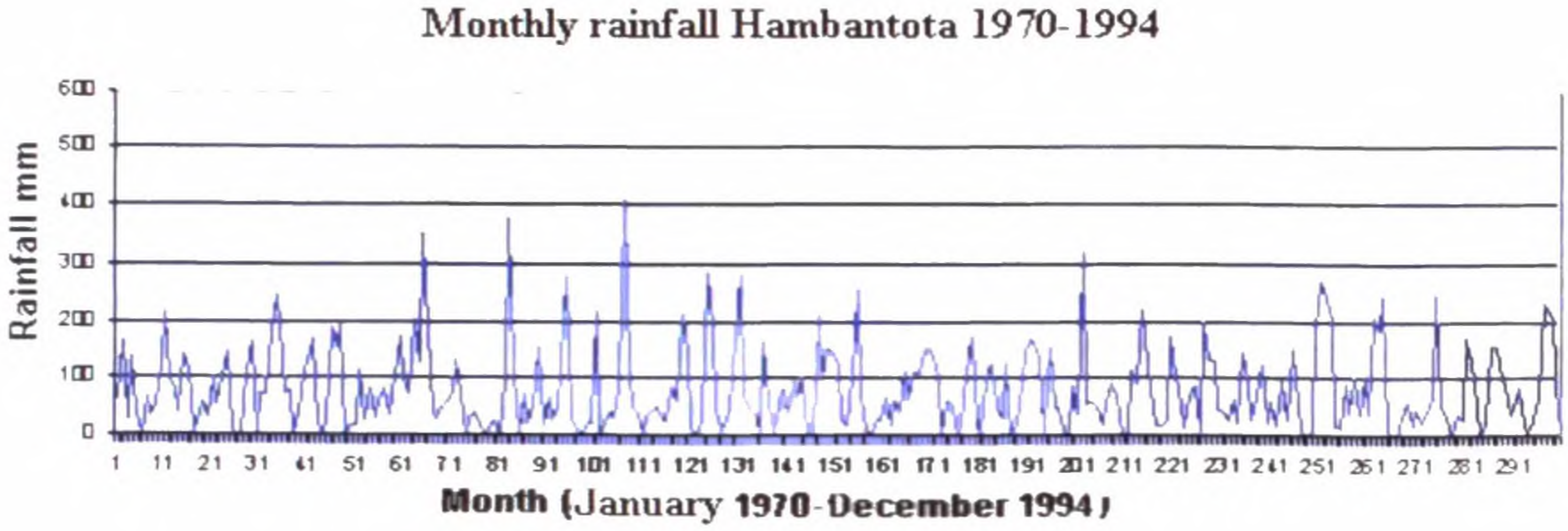

Figure 9. Monthly rainfall of Hambantota (1970-1994)

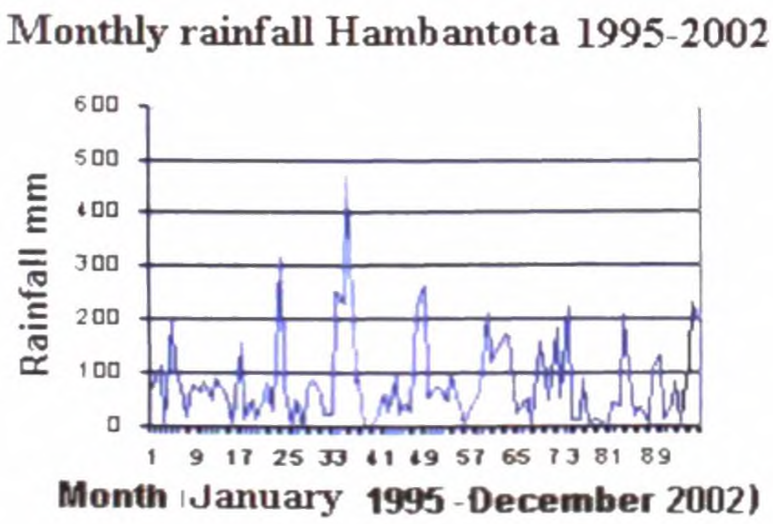

Figure 10. Monthly rainfall of Hambantota (1995-2002)

Temperature patterns

Monthly temperature values were plotted against the number of the month starting from January 1869 and ending at December 2002 and the results are presented in the Figure 3.8. An interesting observation of it is that the overall monthly variation of temperature has distinct units of periods with consistent duration of 75 months (6 years approximately). The overall temperature trend line during the period (monthly values from the year 1869 to 2002) was positive. As for rainfall data a long band of temperature spectrum was used to extract temperature cycles (Figure 3.9). Temperature variation patterns for 25 year periods are shown in figures from 3.9 - 3.14 sequentially. Each temperature cycle has its own inherent features however apparently the duration is the same (6-years).

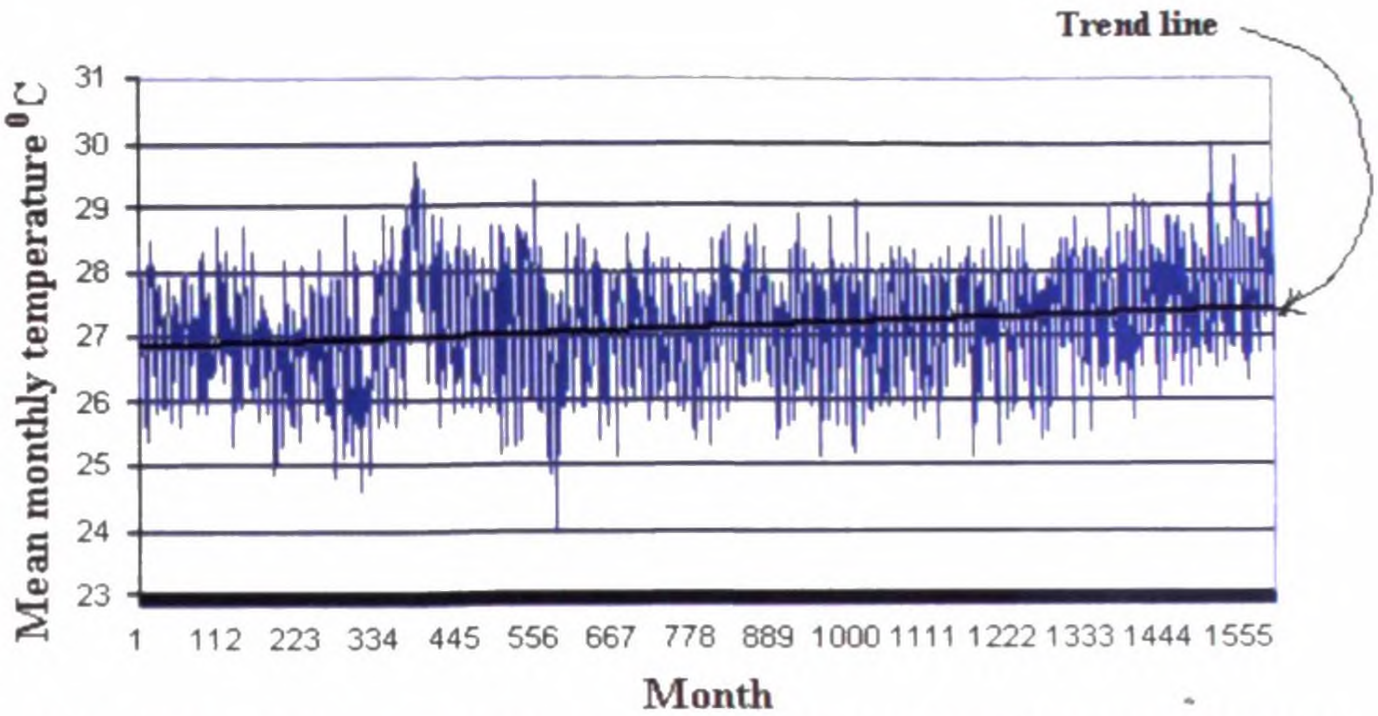

Figure 11. Continuous monthly mean temperature of Hambantota (1969-2002)

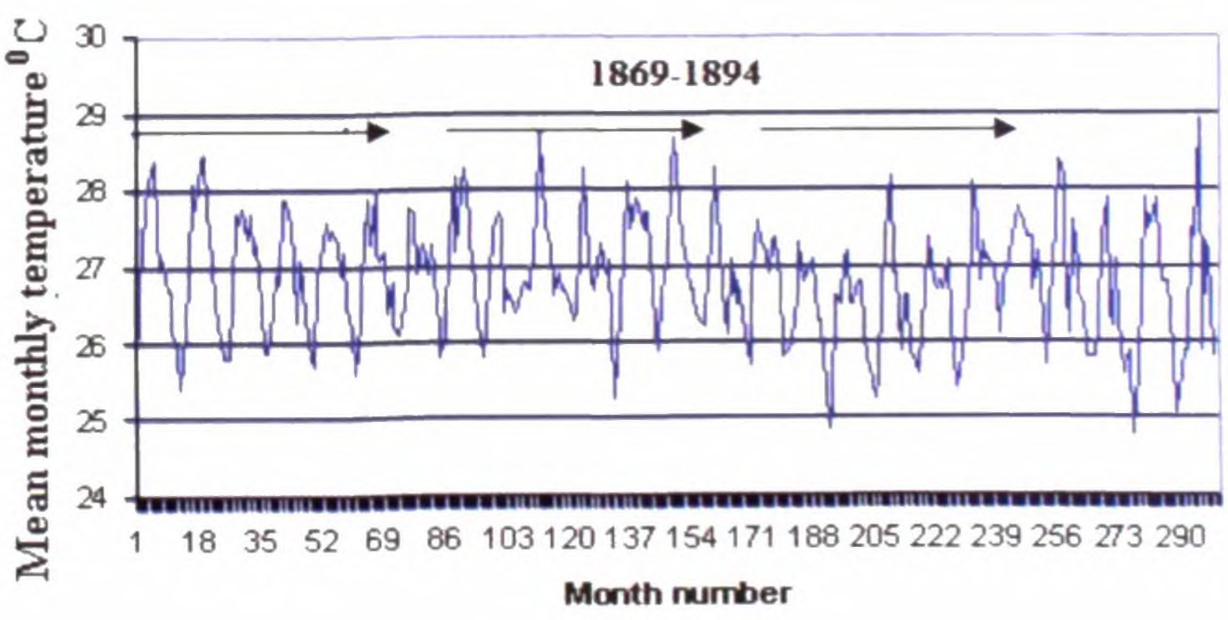

Figure 12. Monthly temperature of Hambantota (1869-1894)

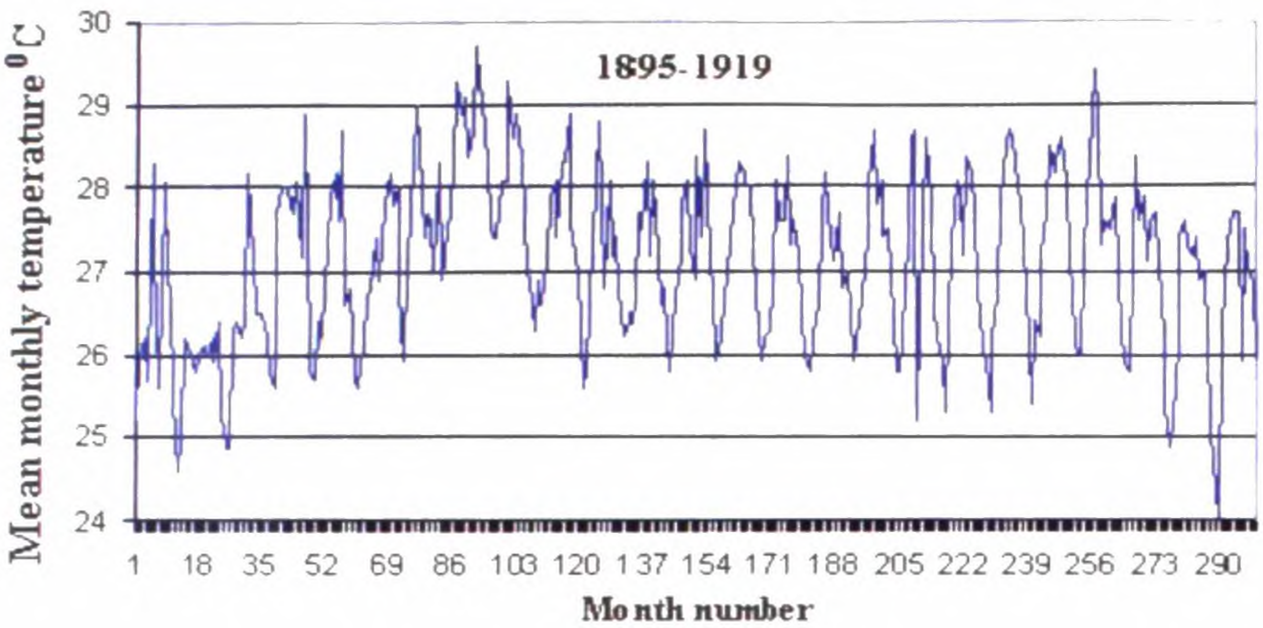

Figure 13. Monthly temperature of Hambantota (1895-1919)

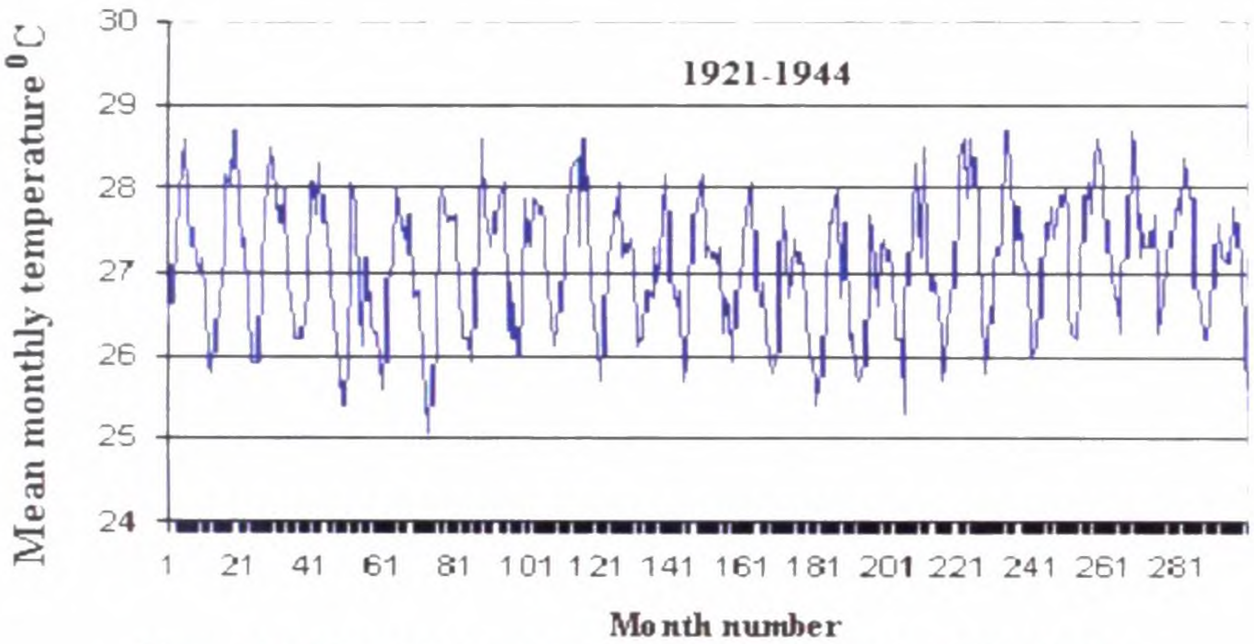

Figure 14. Monthly temperature of Hambantota (1921-1944)

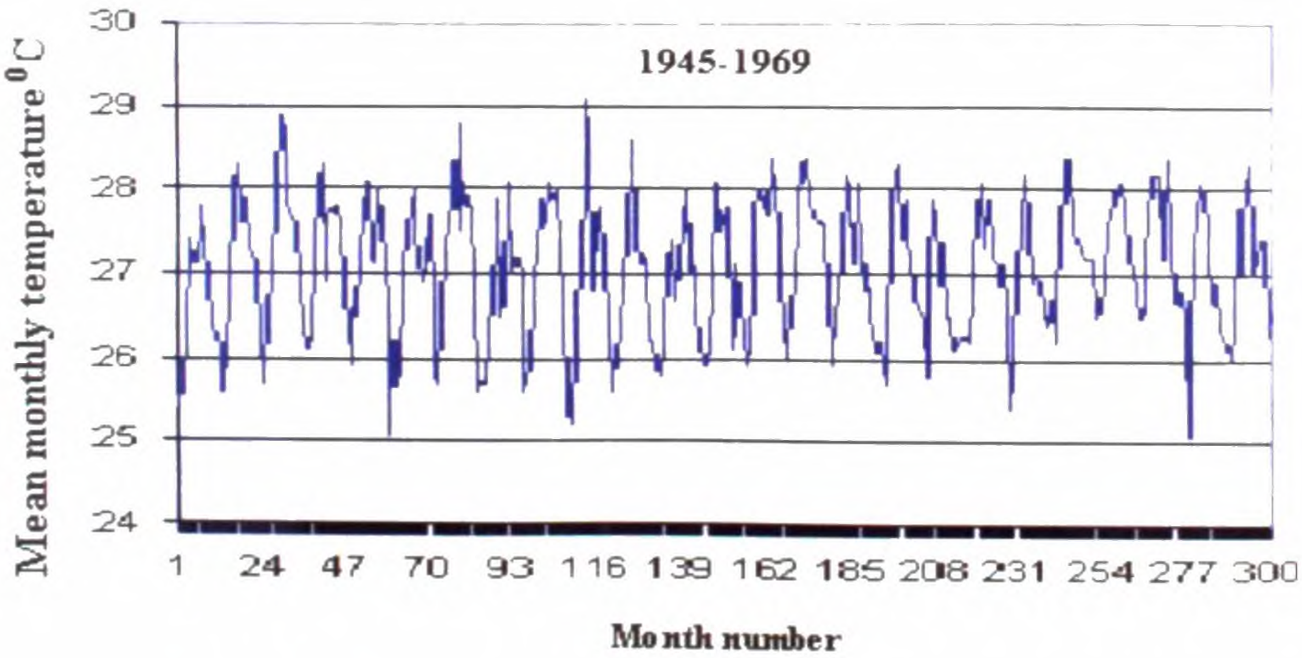

Figure 15. Monthly temperature of Hambantota (1945-1969)

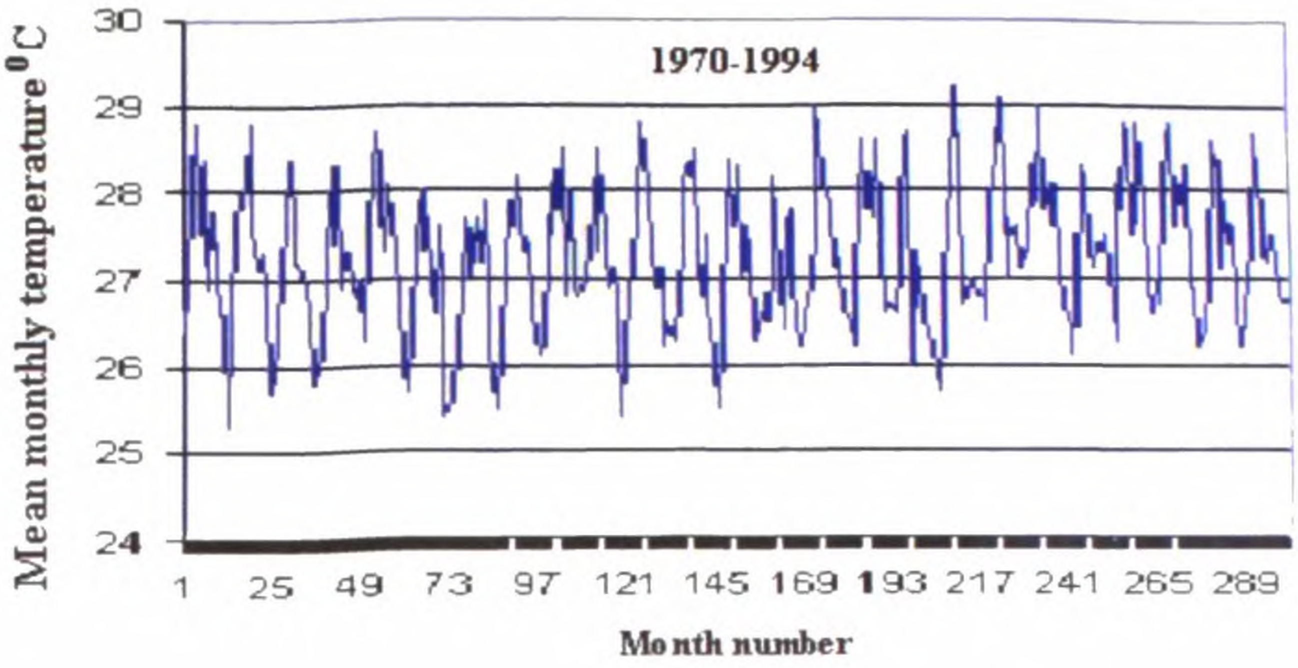

Figure 16. Monthly temperature of Hambantota (1970-1994)

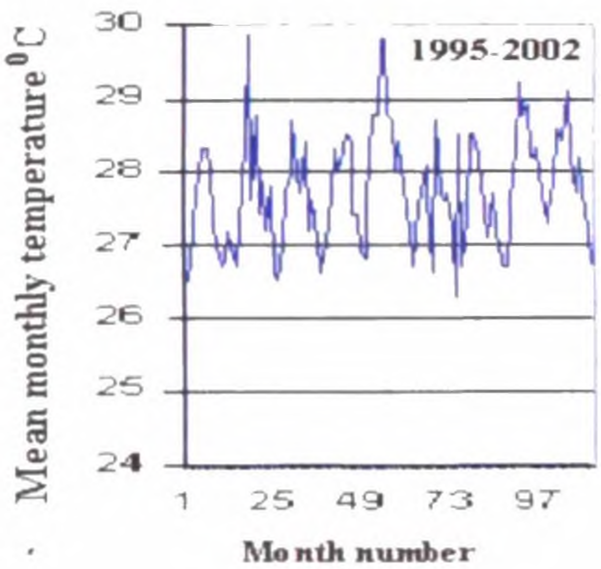

Figure 17. Monthly temperature of Hambantota (1995-2002)

Construction of climate trend diagram (Figure 4)

As noted in the previous sections, after careful observations of the rainfall and temperature graphs it was possible to extract patterns of climatic cycles. It was found that there was a conspicuous rainfall cycle which occurred in 16-year (192 months) periods. Similarly, the continuous monthly temperature curve suggests temperature cycles of approximately 6-year (75 months) duration. Within a cycle, either rainfall or temperature, there was more or less a similar pattern of fluctuations. For each cycle a graph (rainfall in mm verses month, and temperature ^{0}C verses month) was plotted and the trend of each graph (positive, negative, or neutral) was extracted and such trend lines were used to construct the **Climate Trend Diagram (CTD)**. Climate data of all main climate stations were analyzed and a climate diagram for each was constructed in the previous studies of the variability of climate of Sri Lanka (Mueller-Dombois, 1968). However, the use of climate trend lines in the present study appears to be a new approach to obtain more information using monthly data of 133 years.

The main features of the CTD (Figure 4) were as follows:

(1) Left vertical line (Y axis) represents monthly rainfall (2 cm = 100 mm),

(2) Right vertical line (Y axis) represents mean monthly temperature (1 cm = 1 ^{0}C),

(3) Lower horizontal line (X-axis) represents time in months since the year 1869. It is graduated in temperature cycles of approximately 6 years (75 months), and

(4) Upper horizontal line (X-axis) represents time in months since the year 1869. It is graduated in rainfall cycles of approximately 16 years (192 months).

The diagram clearly shows that during the last 30 years the rainfall has been decreasing (the thick trend lines) and the temperature increasing (the thin trend lines) in Hambantota, an indication of severe drought in the area; further the temperature trend line has surpassed the rainfall trend line during the last 10 years. Such a situation may be directly attributable to humanly influenced climate change during that period, rather than natural climatic variations. Although rainfall trend line was horizontal during the last cycle the good news is that the raw data suggests a slightly positive trend since 1997 up to the present days (not shown in the diagrams).

Figure 4 Climate (rainfall and temperature) Trend Diagram (CTD) for Hambantota showing the variation of climate through the last 133 years from 1869 to 2002.

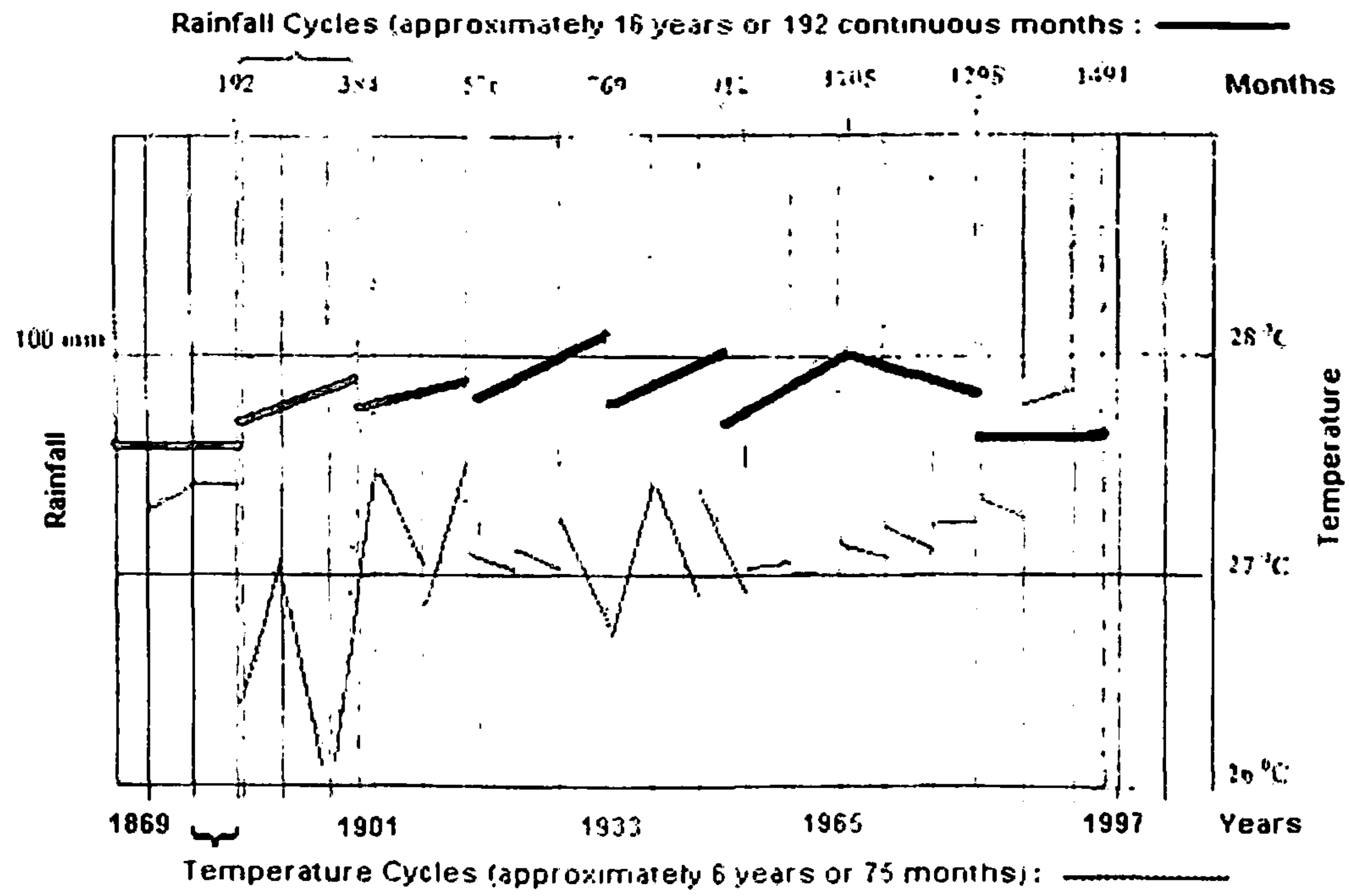

Figure 18. Climate (rainfall and temperature) Trend Diagram (CTD) for Hambantota

Effect of climate change on flora and fauna of Yala and Bundala National Parks

Principal habitats and vegetation in Yala and Bundala of and Hambantota

In Yala and Bundala National Parks the principal habitat types present are (1) dense forests, (2) open forests, (3) scrub forests, (4) grasslands, (5) fresh water tanks, (6) lagoons, and (7) sand dunes (Survey Department, 1988). Grasslands in the area are of two types, viz., *Pitiyas*, which occur usually around the *Wewas* (artificial tanks) and *Pelessas* associated with open forests and mainly located towards the coastal belt in areas such as the Block I and Yala east (Samarakoon, 1997, 1998). Closed canopy dense forests in Yala National Park are generally located in the northern areas (Block IV and V) and along the banks of River *Menik*, and *Kumbukkan Oya* (*Riverine* forests) (Samarakoon, 1998). In Bundala closed canopy dense forests are not found and its forests are either the open canopy type or the scrub type. It was found that certain forests and grasslands habitats in Bundala National Park are changing at a faster rate due to introduction of serious alian weedy species (Mesquite and Lantana) coupled with sea level rise as a result of global climate change. Mesquite has already conquered many low-lying areas replacing the fringe mangroves in lagoons and the natural vegetation in the grassland park country around the lagoons. As a result a large number of previously grassland type and deciduous type scrub forest habitats with a grassland component (*Pelessa*) have been changed into a more or less closed canopy single species thorny forest, which is usually devoid of a grass cover on the ground. Despite the fact that mesquite is a palatable species browsed by the elephants and deer the presence of large thorns gives it a negative value; on the other hand the changed habitat does not produce sufficient feed material for the domesticated buffaloes and neat cattle. It appears the end results are: 1) migration of the domesticated grazing animals into the grasslands in the Yala National Park causing severe problems to wild animals, and 2) human elephant conflict.

Flora of Yala and Bundala National Parks

Within the park a total of about 280 species of flowering plants have been recorded representing large trees, shrubs, and herbs. A list of common trees and shrubs found in the Yala and Bundala National Parks is shown in the Table 3. In the present study a total of 9 tree species and 8 shrubs species were noted as commonly found in the two parks. It was noted that *Lantana camara* has penetrated into the deep forests, almost every part of Yala and Bundala, and has become the dominant thorny shrub particularly in the scrub forest habitats. Its presence and dominance especially in the open forest areas has displaced the natural shrub species which are a major component of the herbage eaten by the large mammals including the elephant. It has, during the last century, changed the botanical composition of the flora and the habitats of the park country.

Table 3. List of common trees and shrubs in Yala and Bundala National Parks
*** Not in Bundala and coastal areas of Yala**

Species	Vernacular name	Species	Vernacular name
Trees		**Shrubs**	
*Chloroxylon swietenia**	Burutha	*Cassia auriculata*	Ranawara
Vitex pinnata	Milla	*Salvadora persica*	Maliththan
Manilkara hexandra	Palu	*Carissa spinarum*	Karamba
Drypetes sepiaria	Weera	*Randia dumetorum*	Kukuruman
Feronia limoponica	Divul	*Gymnema sylvestre*	Mas-bedda
Azardracta indica	Kohomba	*Securiniga leucopyrus*	Katupila
Tamarindus indica	Siyambala	*Lantana camara*	Gandapana (Weed)
*Berrya cordifolia**	Halmilla	*Prosopis juliflora*	Mesquite (Weed)
Terminalia arjuna	Kumbuk		

Fauna of Yala and Bundala National Parks

Animal numbers were obtained from the Yala and Bundala National Parks and the department of Wildlife Conservation in Colombo. Of the large mammals highest number estimated is for the spotted deer (5,205) and the lowest for leopard and sloth bear (Table 4). In the whole of Yala Protected Areas Complex (YPC) the estimated number of elephants is a meager 319. In addition to the large animals the author has observed many cattle (neat type), mostly domesticated, are grazing within the YPC. Lists of other mammals, birds and other animals are given in the Table 5.

Table 4. Large mammals and their numbers in Yala Protected Area Complex
Source: Department of Wildlife Conservation

Scientific name	Vernacular Name	Estimated number in the YPC
Elephas maximus	Elephant	319
Bubalus bubalis	Buffalo	1,749
Cervus unicolor	Sambur	898
Axis axis	Spotted deer	5,205
Sus scropfa	Pig	637
Panthera pardus kotiya	Leopard	124
Melurus ursinus	Sloth Bear	125

Table 5. List of the other mammals, birds (including the migratory ones), and other animals commonly found in Yala and Bundala National Parks.

Scientific name	Vernacular Name	Scientific name	Vernacular Name
Mammals:		**Birds:**	
Loris tardigradus	Una-hapuluwa	*Gallus lafayetti*	Wali-kukula
Canis aurius	Nariya	*Galloperdix*	Haban-kukula
Tragulis meminna	Miminna	*bicalcarata*	
Vivericula indica	Urulawa	*Ephippiorhynchus*	Ali-manawa
Canis aurius	Hiwala	*asiaticus*	
Prebites entellus	Wandura	*Letoptilosjavanicus*	Bahuru-

Paradoxurus	Kalawedda	*Pelecanus*	manawa
zeylonensis		*phillipensis*	Alu-pastuduwa
Manis crassicaudata	Kaballawa	*Phalacrocorax niger*	
Histrix indica		*Mycteria*	Diya-kawa
Lepus negricollis	Ittawa	*leucocephala*	
singhala	Hawa	*Bubulcus ibis*	Latu-wekiya
Other Animals:		*Egretta garzetta*	
Testudo elegance	Taraka-ibba	*Mesophoyx*	Gawa-koka
Calotes versicolor	Gara-katussa	*intermedia*	Kuda-ali-koka
Calotes calotes	Pala-katussa	*Casmerodius albus*	Sudu-medi-
Calotes ceylonensis	Thola-visithuru-	*Ardeola grayii*	koka
	katussa	Migratory Birds:	
Varanus bengalensis	Thala-goya	*Tringa hypoleucos*	Maha-sudu-
Varanus salvator		*Dendronanthus*	koka
Lankascinus fallax	Kabara-goya	*indicus*	Kana-koka
Python molurus	Dumburu-hiraluwa	*Limosa limosa*	
Crocodilus palustris	·Pimbura		Silibilla
Crocodilus porosus	Kimbula	*Pitta brachyura*	Helapenda
Bufo athukoralei	Geta-kimbula	*Pluvialis fulva*	
	Athukoralage-	*Phoenicopterus*	Penda-kalu-
Limnonectes greenii	kurugemba	*ruber*	gohonduwithth
	Lanka-welmediya		a
			Awichchiya
			Ranmaha-
			olevia
			Siyakkaraya

Vulnerability of flora and fauna

Demand for water

A list of major plant and animal species found in the area which demand relatively more water for their sustenance is shown in the Table 6.

Table 6. List of major plant and animal species considered having high demand for water.

Scientific name	Vernacular name	Scientific name	Vernacular name
Plants:		Animals:	
Vitex pinnata	Milla	*Elephas maximus*	Elephant
Manilkara hexandra	Palu	*Bubalus bubalis*	Buffalo
		Cervus unicolor	Sambhur
Drypetes sepiaria	Weera		
Azardracta indica	Kohomba		
Tamarindus indica	Siyambala		
Terminalia arjuna	Kumbuk		

The trees listed are evergreen and relatively use more water for transpiration. *Terminalia arjuna*, usually grows on the riverbanks and benefited by the availability of soil water even during the long droughts; the other species of trees are adapted to grow mainly on hilly mounds where there is more silt in with higher water holding capacity compared to sandy soils in the valleys amongst the hills, where only grass and strongly zerophytic plants (e.g., *Acacia eburnean*) survive. Generally, in some Blocks of Yala and almost all the areas of Bundala the vegetation is a mosaic of forested (or scrub forest) hills and valleys of grassland with scattered thorny trees. Such a system had been surviving in the area for hundreds of years in equilibrium with the climate. However, with the onset of serious climate change in 70s annual drought became more and more severe and the new climate affected the natural vegetation by way of replacing some tree species (e.g., *Manilkara hexandra*, and *Drypetes sepiaria*) which cannot survive during the severe droughts due to lack of sufficient water. Similarly, the animal species listed in the table are large and need more water for the maintenance of transpiration and normal bodily needs. Further such animals prefer to stay in water and muddy habitats at least few hours a day to avoid high temperatures during the day time. Plant and animal species, which have higher demand for water, appear more threatened by the effect of climate change.

Woody weeds

Another consequence of habitat destruction (death of tree species) is the introduction of woody weeds such as *Lantana camara*, mesquit and other thorny shrubs, which demand less water and spread very fast. Further, generally they are not good feed material for the animals such as the elephants; however, I have observed that both species provide food for birds.

The effect of habitat change due to climate on the large animals is immediately visible in many areas of both parks. However, although not easily observable, the effect of climate change on smaller mammals and other vertebrates for example the amphibians and the like is more drastic. Some species require moist and watery places for the completion of their life cycles. With the destruction of their habitats (depletion of water in the streams and ponds for example) such animals become extinct in the area or become imprisoned, isolated and restricted to places where the environmental condition is still remain suitable.

Forest dieback

Forest dieback is a phenomenon occur in certain areas, for example the Horton Plains Montane Forest) of the country, reported since 1960s, 70s, 80s and 90s (Samarakoon, 1994). I have observed the same phenomenon occurring in Hambantota and its surroundings since early 1990s. The death of patches of Maliththan (*Salvadora persica*) and Weera Trees (*Drypetes sepiaria*) was seen in Bundala National Park (Figure 5). The dead or dying patches were noted closer to the water front of the lagoon area. Since 1996 the death of Palu trees (*Manilkara hexandra*) was observed in that area and the death of the mangrove species Kirala (*Sonneratia casiolaris*) was observed in the Menik Ganga estuary at Yala (Figure 6). As at present the Weera trees are very rare in the affected areas and a large number of Palu trees are dead and similar numbers are dying. The apparent reasons behind the death of these species are the increase in the mean sea level with the increase in earth atmospheric temperature and unavailability of sufficient fresh water during the long severe droughts.

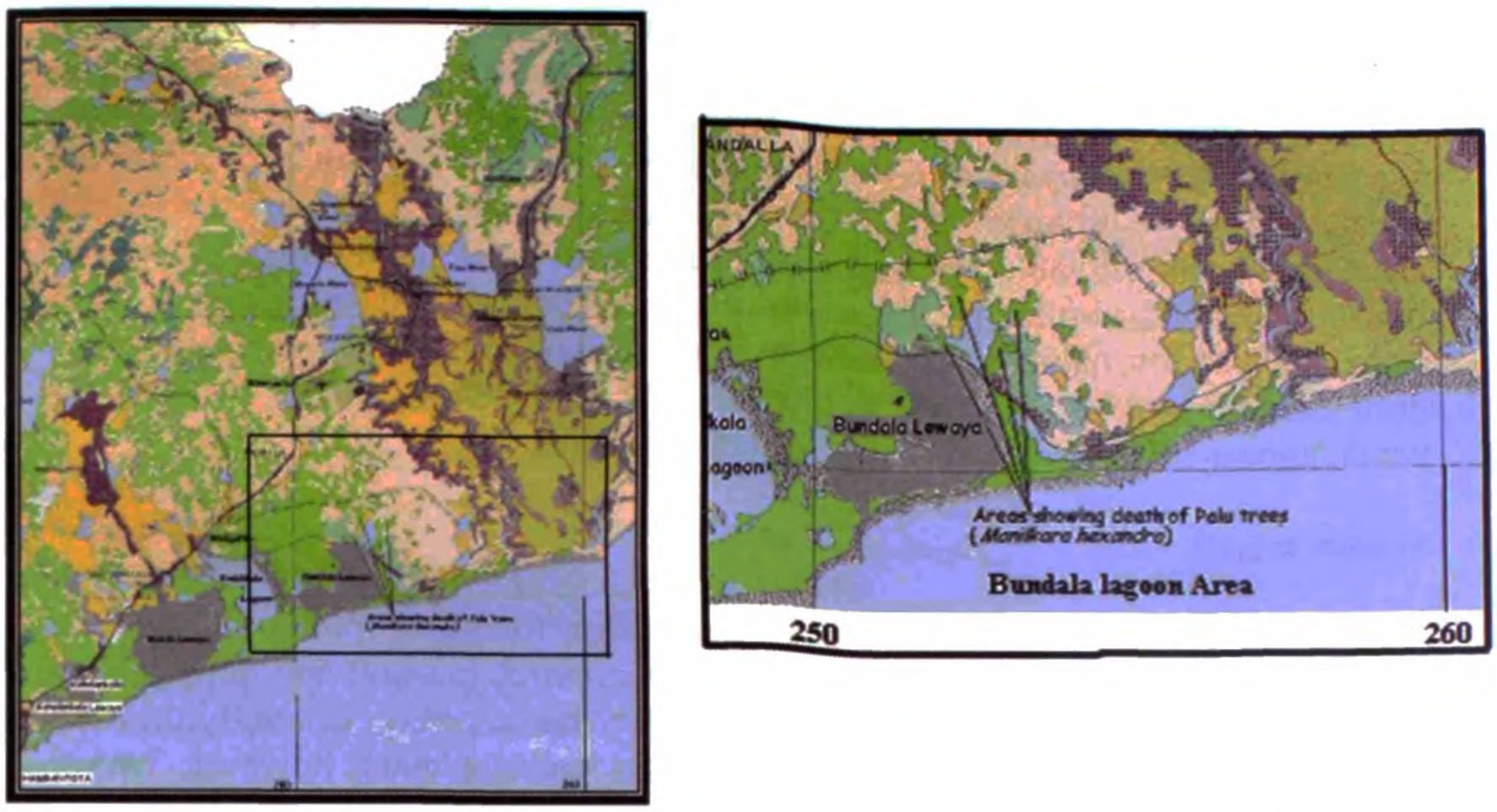

Figure 5. Map showing the die-back areas of Palu (*Manilkara hexandra*) trees in Bundala National Park

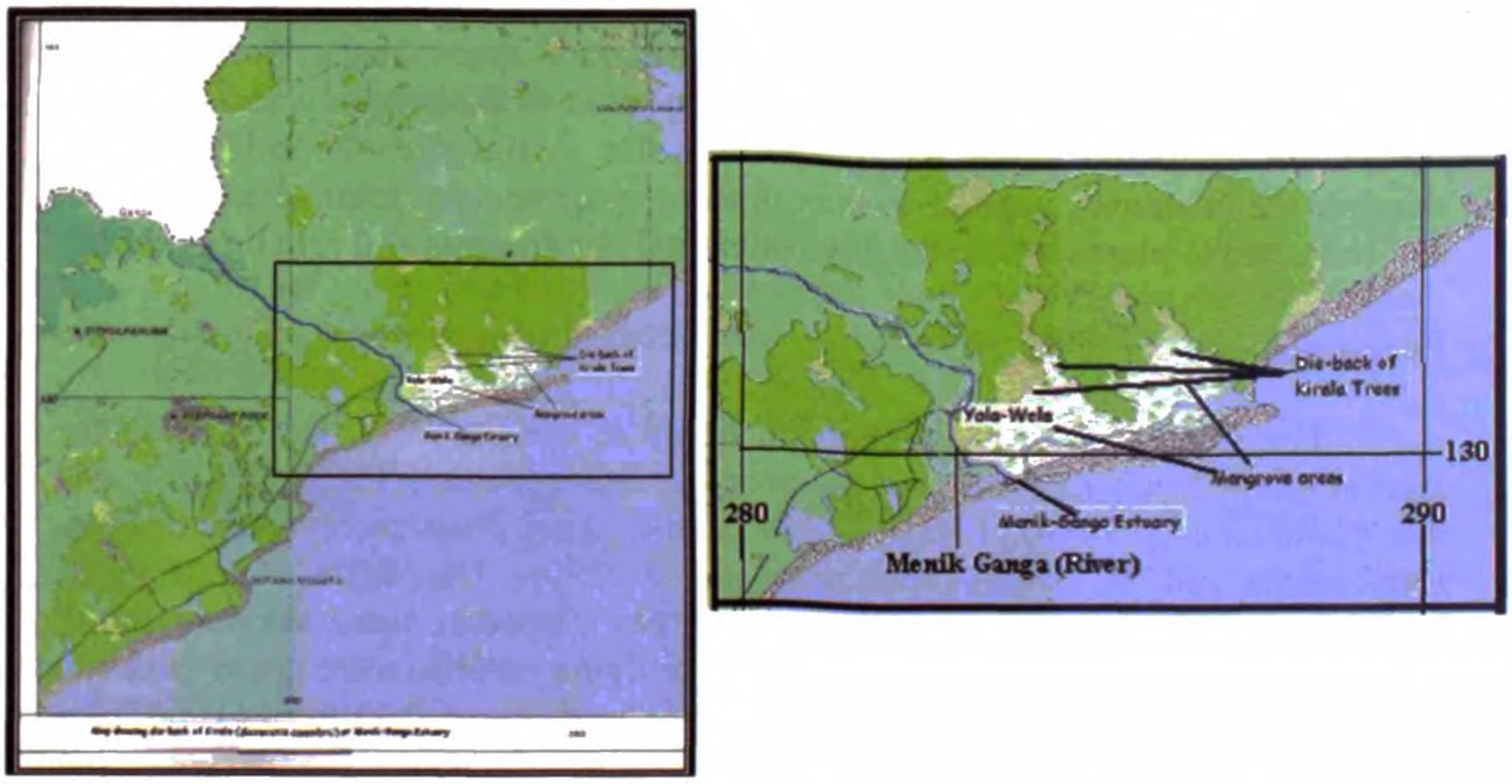

Figure 6. Map showing the die-back areas of Kirala (*Sonneratia caseolaris*) trees in Menik River estuary at Yala

Crop failure

In parallel with the death of forest population water availability for paddy and other cultivations in Hambantota became very low especially during the last 20 years or so. Keep in mind that a sufficient water supply could be provided for the crops government constructed vast irrigation schemes such as the Lunugamwehera and other reservoirs in late 1980s early 1990s. With the declining rainfall and increasing temperatures such reservoirs were never filled even during the rainy season. Thousands of crop fields were devastated. The farmers became poorer and poorer; some changed their way of earnings; to earn their living some secretly cultivate *Cannabis sativa* in the jungles; some others encroached into the national parks and hunted animals and yet others involve in some other practices. Most of these practices created social problems.

CONCLUSIONS

(1) Climate change associated with global temperature increase and rainfall fluctuation causes drastic changes to the habitats of Hambantota area

(2) Throughout the climatic history of 134 years in Hambantota it is possible to identify rainfall cycles of approximately 16 years and temperature cycles of approximately 6 years.

(3) Since 1869 to about the year 1965 the rainfall in Hambantota had been increasing and showed marked positive trends in consecutive cycles.
(4) Since around 1970 the mean rainfall declined and the rainfall trends of the cycles were negative or more or less neutral.

(5) The mean monthly temperatures around the year 1900 were very high and above the level of 28 ^{0}C. The temperature effected drought prevailed for a brief period of about one year.

(6) In general the average temperature trend during the last 20 years or so had been on the increase.

(7) Increase in sea water levels causes sea water intrusion into the lagoons and estuary systems which lead to the destruction and slow change of the existing habitats.

(8) Increased temperature and relatively low rainfall for a long period of about 20 years or so in Hambantota means decrease in ground water levels, decrease in water availability for plants and animals.

(9) As mitigate actions measures such as the following are suggested:
(i) Rehabilitation of the ancient tanks in the area
(ii) Instead of cultivating high water demanding crops to cultivate less water demanding crops
(iii) Instead of practicing animal husbandry using high water demanding animals use less water demanding crops
(iv) Try to make use of the dry situation as a resou.ce of high value (E.g. to produce more salt, dry fish)

ACKNOWLEDGEMENTS

I thank Dr. B.M.S. Batagoda, Project Director and Mr. T.K. Fernando, Consultant of the Climate Change Enabling Activity (Phase II) Project of the

Ministry of Environment and Natural Resources, "Sampathpaya", No. 82, Rajamalwatta Road, Battaramulla for providing the necessary funds for this study.

REFERENCES

IPCC (2001): Climate Change (2001): Synthesis Report. A Contribution of Working Groups I, II, and III to the Third Assessment Report of theIntegovernmental Panel on Climate Change [Watson, R.T. and the Core Writing Team (eds.)]. Cambridge University Press, Cambridge,United Kingdom, and New York, NY, USA, 398 p.

IPCC (2004) IPCC Workshop on Describing Scientific Uncertainties in Climate Change to Support Analysis of Risk and of Options, SWITZERLAND INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE IPCC Secretariat, c/o WMO, 7bis, Avenue de la Paix, C.P. N° 2300, 1211 Geneva 2 Ireland, May 11 – 13, 2004

Mueller-Dombois, D. (1968). Ecogeographic analysis of a climate map of Ceylon with particular reference to vegetation The Ceylon Forester 8 (2-4): 39-58.

Orlando, B.M. and L. Smeardon (eds.) (1999) Report of the Eleventh Global Biodiversity Forum: Exploring Synergy Between the UN Framework Convention on Climate Change and the Convention on Biological Diversity. IUCN—The World Conservation Union, Gland, Switzerland and Cambridge, United Kingdom, 46 p.

Perera, L.S. (1965) Rohana Rajyaya (Kingdom of Rohana), Anuradhapura Period (Vidyankankaaa University Press.

Samaranayake, R. (1983). Hambantota A Profile of a District in Rural Sri Lanka Ministry of Plan Implementation Sri Lanka

Samarakoon, S. P. (1994). Dying of trees in Horton Plains *Bio News* 8:106-109.

Samarakoon, S. P. (1997). A preliminary investigation of the plant communities of Nimalawa sanctuary in southern Sri Lanka Proceedings of the Sri Lanka Association for the Advancement of Science. 249p.

Samarakoon, S. P. (1997). Vegetation types of Lunugamwehera National Park. Proceedings of the Sri Lanka Association for the Advancement of Science. 250p.

Samarakoon, S. P. (1998). Fodder plants of Yala National Park Complex in southern Sri Lanka. Proceedings of the Sri Lanka Association for the Advancement of Science. 128-129.

Samarakoon, S. P. (1998). Herbage production from native grasses and planted pastures under coconut in southern Sri Lanka. Proceedings of the Sri Lanka Association for the Advancement of Science. 130-131.

Samarakoon, S. P. (1998). Some preliminary observations on the ecology of Kirinda sand dune in southern Sri Lanka. Proceedings of the Sri Lanka Association for the Advancement of Science. 198p.

Survey Department, (1988). 1:50,000 Maps compiled and published by the Surveyor General of Sri Lanka.