Chapter - I

Introduction

1.1 Introduction

Climate is a dynamic component of the environment, which has direct/indirect influence on man and his activities. Most commonly, climate is known as the long-term average weather conditions prevailing over an area. Climate is dynamic in many respects, for example, it varies in time and space, and changes occur over sufficiently long period of time.

"Climate Change" is the long-term changes in characteristics of climate of a region due to astrophysical, geophysical or human-induced parametric variations. Such changes of climate at global or regional level have significant influences on life processes on earth, especially man and his living environment. One characteristic of climate, under normal circumstances is its stability and predictability which govern not only human activities like given agricultural practices, but even other living beings, say for example timely flowering of plants, regulating the reproductive behaviour of animals and so on. With climate change, the predictability of climate is destroyed; and that creates a lots of problems to cope with by both the living world in general, but human beings, in specific. Throughout earth's history, climate has never been same over time and space. With climate change, corresponding changes occur in the human activities, particularly in the
agriculture that invites attention of the scientists to probe into the problem associated with such changes.

Most scientists agree that the global climate is changing, especially during the past century, which in turn may drastically affect the biophysical environment of man and the society. On the other hand, the local climate may change due to global climate change (its impact on a regional scale) that has given rise to regional variations or reasons specific to local factors. Such impacts could be varied over countries, depending on the scale of regional impacts as well as the economic and technical ability of the specific countries in tackling these impacts. No nation can remain immune to the direct or indirect effects of climate change, and Sri Lanka is no exception to it. The inevitability of the climate change is quite visible in recent years, and a series of technical -country reports of the Inter-governmental Panel on Climate Change (IPCC), a UN body is testimony to this process and resultant concerns.

Climate change in Sri Lanka is mainly characterised by the temporal and spatial variations of temperature as well as rainfall conditions, two vital parameters of climate. Sri Lanka is (a) a tropical country close to the Equator and (b) is an Island nation with the surrounding sea, the nature of which is providing more uniform ambient conditions as opposed to land masses. Other climatic parameters are, perhaps relatively less important in the instant case. Moreover, these two parameters are the most influential factors affecting agriculture, which is going to be one of the main thrust areas of the present study.
Agriculture is the most dominant and important sector of Sri Lanka’s economy that plays a vital role in the overall economic development of the country. This sector is heavily weather dependent world over, more so in the tropical monsoon type of climate. Agricultural crops are extremely susceptible to fluctuations in climatic factors such as rainfall and temperature conditions, especially their seasonality and (un)-predictability. Climate change has significant economic effects on agriculture including changes in farm productivity, cropping pattern, profitability, price, supply, and trade. The variability of climate poses major challenge for the large peasantry and small farmers of the country.

Agricultural productivity is sensitive to global climatic changes in the country and therefore, its impacts needs to be evaluated. As climate affects many aspects of plant and animal biology, the effects of climatic elements and their extremes will significantly alter the productivity in agriculture. The disturbance to ‘eco-systemic balance’ may generate negative impacts on the socio economic conditions of many societies, specially for the developing countries like Sri Lanka, where agriculture contributes little more than a quarter of the country’s Gross Domestic Product (GDP).

1.2 Statement of the Problem

Climate change may adversely affect the water balance leading to serious water scarcity and management problems, thus shrinking agricultural land use and the potential effects on agricultural production in Sri Lanka. In 1996 Sri Lanka experienced a decline in the real growth rate of Gross National Products (GNP) from 6 per cent in 1995 to 3.1 per cent (real GDP growth declined from 5.5 per cent in 1995 to 3.8 per cent in 1996).
The depressed conditions at the beginning of 1996 were due to unfavourable weather conditions resulting from the severe droughts and accompanying power cuts. Due to its strong dependence on hydropower, Sri Lanka's electricity generation declines during the drought periods, and it directly affects some of the plantation industries and other sectors related to agriculture in the country.

Agriculture is one of the predominant sectors of Sri Lanka's economy, which accounts for over 25 per cent of the GDP (Central Bank, 1994). This sector supplies nearly half of the total employment and export earnings and about 40 per cent of government revenues. Over 90 per cent of the rural population directly or indirectly depends on agriculture as a major source of income and livelihood. In recent years, Sri Lanka's agriculture has suffered serious setbacks from abnormal weather conditions. Climate change and its variability could be the main reasons for the sustained yield fluctuations and almost every crop sub-sector has experienced sluggish growth due to it, especially due to rainfall decline. Positive growth in one year has been followed by decline in the succeeding year. Consequently, major crop production declined drastically that resulted in a sudden decrease in export-earnings, deficiency in food supply, and a massive increase in import of foodstuffs. However, it is to be recognised that other factors like price response to commercial crops like tea, coconut and rubber, input prices and governmental policies do affect agricultural output. Therefore, it may be necessary to study the partial contribution of climate change on agricultural production and coverage of crops etc.
Sri Lanka experienced severe shortages in agricultural production, aggravated by climatic fluctuations during the last three decades. The contribution of the agriculture sector to the national economy has declined drastically, from 46 per cent of GDP in 1950 to the about the current level of twenty percent. The rate of growth of agricultural output has slowed in recent years from 4.5 per cent in 1999 to 1.8 per cent in 2000. This resulted in a decline in the sectors' contribution to Gross Domestic Products (GDP) from 21.3 per cent in 1999 to 20 per cent in 2001. Besides the contribution to GDP, the agriculture sector provided 19 per cent of export earnings in the year 2001 (Ministry of Plantation Industries, 2003).

The agriculture sector consists of two sub-sectors, the non-plantation or domestic food crop sector ('subsistence farming' sector) and the plantation sector. The non-plantation sector, which mainly consists of paddy, other food grains like, maize, soybean, vegetables, perennial crops etc. accounts for 76 per cent of the total cultivable land, whereas the plantation sector accounts for the balance 24 per cent.

Rice is the staple food crop in Sri Lanka, which account for about 37 per cent of per capita calories and 30 per cent of the per capita protein on the average, in Sri Lankan diet (Statistical Abstract, 1991). Climate change research in Asia (Sri Lanka Country Report, 1994) reveals the possibility of some adverse future impacts on agriculture of the country. Coarse grains and legumes will be subject to severe fluctuations in annual production. Rice cultivation too, will be similarly affected. According to the statistics, the paddy production has stagnated over the last few decades. Analysis of impacts on rice using a crop model developed by Seshu and Cady (1983) shows that rice cultivation will
drop by about 6 per cent with a temperature increase of 0.5°C in the year 2010. This will reduce the Gross National Products (GNP) at current prices, by 0.2 per cent. Moreover, Mahaweli Development Project (MDP), which diverted water from the Wet Zone to Dry Zone for agricultural purposes has not fulfilled its primary objective mainly due to less of rainfall and consequent reduced discharge of the river. Frequent abnormal weather conditions witnessed in recent times are the main causes for the reduction of water flow in River Mahaweli. It seriously affects, and has resulted in the reduction of rice production in the Dry zone of Sri Lanka.

Plantation sector plays a major role in the Sri Lankan economy and climate change can affect plantation crops, too. This sector comprises tea, rubber and coconut that are the highest net foreign exchange earner of the country (SRs. 71 billion per annum). Plantation sector provides employment for about 380,000 workers in the plantation districts and it is equal to 20 per cent of employment in the economy as a whole. The plantation crop-yields show the widest fluctuations in the period of 1982-1990 (Central Bank, 1991). The GDP value addition of the plantation crops has declined by 6.4 percent in year 2001. This was mainly attributed to the failure of both the Northeast and Southwest monsoons. The production of all major plantation crops declined during the year 2001 mainly due to the adverse weather conditions (Ministry of Plantation Industries, 2003).

Sri Lanka is one of the major players in the global tea industry, accounting for 10 per cent of world tea production and 21 per cent of tea exports. Sri Lanka’s tea industry is the country’s highest net foreign exchange earner, which accounts SRs. 59.32 billion or
US dollar 663 million in 2001. It provides direct employment for about 600,000 people, out of which 380,000 belong to large plantations or estates, and the rest to smallholdings. The last completed tea survey in 1994/95 recorded the total tea area in the country as 189,000 hectares contributing 42 per cent in low country, 30 per cent in mid country and 28 per cent in up-country. Total tea area in the country has declined to 181,172 hectares in the year 2001. The steady upward trend experienced in tea production since 1993 reversed in 2001. The output, which exceeded 300 million Kg. in 2000, declined by 3.3 percent to 295 million Kg. in 2001. The decline was mainly the outcome of the unfavourable weather conditions that prevailed throughout the year, compounded by the failure of Southwest Monsoon, especially during the later part of the year. Past production records of tea industry in the Central High Lands clearly show the year-to-year fluctuation of tea production, attributed to the bad weather conditions during recent years. The breakdown of the hydropower generation of the country, which resulted in power cuts during the second half of the year (2001), aggravated the situation by directly affecting the tea production.

Rubber is the second largest plantation (export) crop in Sri Lanka. It is an important raw material used for local and foreign manufacturing industries. The total land area under rubber presently covers only 157,000 hectares (continuous shrinkage of 19 per cent during past ten years). The rubber sector has shown variation in production during the past years. The total rubber production of 96584 metric tons in 1999 declined to 87,636 metric tons in 2000, and has further declined to 86230 metric tons in 2001.
Coconut continues to be an important plantation crop, which contributes about 2.6 per cent of the GDP and 3.4 per cent to the foreign exchange earnings annually. It provides livelihood for about 5 per cent of the total workforce, which signifies the socio-cultural importance of coconut. The most important contribution of the coconut crop is as source of food, providing on an average 22 per cent of the per capita calorie intake in the daily diet, thus ensuring nutrition security of a large segment of the population of the country. The total area of coconut cultivation is 442,000 hectares. It is estimated that 150,000 persons are directly employed, and around 750,000 families are dependent on the coconut industry as a whole. Generally 70 per cent of the coconut production is consumed locally, the balance 30 per cent is absorbed by the processing industries. The total coconut production from 1995 to 2001 were 2755, 2546, 2632, 2561, 2822, 3000 and 2700 million nuts, respectively. This scenario has changed in 2001 with the decline in production. Coconut production continued to drop due to the lagged effect of the drought in 2001. Coconut production declined by 10 per cent during the first half of the year 2002. Apart from the other economic reasons, one of the main reasons for this declined was cumulative affects of adverse weather conditions mainly the low rainfall in main growing areas during the period 2000-2001 (Ministry of Plantation Industries, 2003).

Coastal-marine fisheries contribute 85 per cent of all fish production in the Island and provides about 65 per cent of animal protein, 13 per cent of the total protein consumed in Sri Lanka. It is a vocation that provides full or part time employment to about 100,000 persons. The fishery industry is affected by climate change in many ways.
As a consequence of the rise of global air temperature, there could be increase in ocean water temperature leading to thermal expansion of oceanic water. It would lead to change of the weather systems in the ocean. Changing pattern of the weather extremes can have adverse effects on the country’s fishery productivity, farming, income and nutritional availability of the country, thus jeopardizing the food security of the country. Further, a temperature rise of about 2 °C can have substantial impacts on the distribution, growth and reproduction of fish stocks, due to the resulting changes in distribution patterns of spawning areas. Further, as the coastal region contains about 21 per cent of all paddy land and most of the coconut land of the country, the changing pattern of the climate, can be expected to significantly lower national agricultural output, especially as coastal agriculture constitute about one-sixth of the total agricultural GDP.

The production patterns of agricultural crops are uneven and the yields low due to uncertain weather conditions over the major Agro Climatic Zones in Sri Lanka. This marked disparity of agricultural production influences the economic conditions across regions in Sri Lanka. Sri Lanka has three major Agro Climatic Zones depending on the differences in altitudes, climatic and soil factors. However, seasonal changes and inter-seasonal variations of rainfall and temperature conditions within the climatic zones are very crucial to fresh-water regimes and the agricultural economy that remain relatively less investigated. Hence, it is a timely need to understand spatial and temporal changes of rainfall and temperature conditions in the major climatic zones in order to undertake appropriate policy responses to mitigate the possible negative impacts of the changing climate and its impact on agriculture. Therefore, the present study will examine the
spatial and temporal changes of rainfall and temperature conditions with concern to the major agricultural crops in selected districts over the major Agro Climatic Zones in Sri Lanka. Although there have been some studies on fluctuations of the rainfall in different rainfall stations in Sri Lanka, detailed and specific regional studies have not been carried out in main Agro-Climatic Zones from the view point of spatial and temporal changes, seasonality in rainfall and temperatures regimes and their relationship with the agricultural production.

In this regards, proposed study attempts to examine following issues:

(i) The present situation of climatic change specifically in relation to temperature and precipitation changes; and

(ii) The effect of climate change on agricultural production across the major three Agro-Climatic Zones.
1.3 Conceptual framework of Climate Change Impact on Agriculture Development

Figure 1.1: Conceptual framework of Climate Change Impact on Agriculture Development of Sri Lanka

**Key Changes:**
Rainfall and Temperature Changes

**Historical climate change:** rainfall and temperature

**Relationship between climate change and main crops:**
- Rainfall - main crops
- Temperature - main crops

**Forecast:**
- rainfalls and temperature

**Agricultural Production:**
- coverage and yield:
  - Paddy
  - Tea
  - Rubber
  - Coconut & Fish

**Growth of:**
- Paddy
- Tea
- Rubber
- Coconut

**Influences on:**
- cropping practices and land management

**National economy GDP**
1.4 Objectives of the Study

The main objectives of the study are as follows:

(i) To study the present climate changes and the fluctuations, annual and seasonal variability of rainfall and temperature conditions (between 1950 and recent times) with available recent data (since most scientific studies indicate important climate changes after 1970);

(ii) To study the area, production and yield changes within the study area, in respect of the principal crops like rice, tea, rubber and coconut;

(iii) To study the impact of climate changes on the broad Agro-Climatic Zones—the Wet Zone, the Intermediate Zone the Dry Zone in respect to crop production, coverage and yield of the crops; and

(iv) To study the response of varied farming communities to perceived threats of climate change and its consequences.

1.5 Research Questions

During the course of the study the following research questions were addressed:

(i) Located closer to the Equator and surrounded by the sea, the island nation of Sri Lanka is expected to demonstrate a more stable climatic regime. But from studies and empirics available, it appears not to be so, i.e., the island is equally susceptible to climate changes and rise in un-predictability of climate,
especially after 1970. This debate needs to be addressed and some degree of resolution is necessary, particularly in respect of the changes in rainfall regimes and temperature conditions, not only over the entire island but the variations thereof within major agro-climatic regions.

(ii) The second issue relates to the effects of climate change on major farming activities, i.e. subsistence crops like rice, plantation (commercial) crops like tea and rubber and coastal farming like coconut and marine fisheries. All these are of vital consequence to the majority of the population of Sri Lanka and their livelihood system and also that, all these activities are extremely susceptible to long-run and short-run changes in climate, which in effect affects hundreds of thousands of families. Measuring productivity changes, cropping pattern changes and these, to the extent influences by climatic changes is one of the major objectives. Indeed, major cropping practices are localised in distinctive regions within the country, i.e., rice in dry-zones, but lower elevations to the north, rubber and tea around the central and south-central high lands and coconut and fishing in coastal areas.

(iii) It is also important that the impacts of climate changes are not uniform over the entire country. In deed, the variations and fluctuations in rainfall and temperature regimes are more pronounced in a lower regional scale. The study therefore, also aims at unravelling the specificities of changes at a regional level (within the study area of Sri Lanka that spans all the three major relief
and agro-climatic regions) and in the manner these variations and changes influence various farming practices.

(iv) The final issue to be addressed is how people in general but specific communities like, the rice farmers, the plantation farmers and the fishing communities view the climate changes and the manner in which they cope with the problems.

1.6 Organisation of the Study:

The study has been organised into three major parts and nine chapters. Outline of the study contents can be summarised as follows:

Part I: Chapter I to IV

(i) Chapter I: Introduction:

Chapter I (Introduction) includes introduction, statement of the problem, the conceptual frame-work of the study, objectives, research questions, the organisation of the study etc.

(ii) Chapter II: Literature Review:

Chapter II deals with a detailed review of scientific literature on the subject and consists sub-sections on global climate change, regional changes and the present situation
of climate change in Sri Lanka, especially on temperature and rainfall. Previous studies have been mentioned in relation to climate change and its effects on agricultural production.

(iii) Chapter III: Data and Methodology:

Chapter III deals with the methods and techniques of data collection and analyses of the study. Study areas for different analyses are also discussed in this chapter.

(iv) Chapter IV: Biophysical Environment, Agriculture and Socio-Economic Conditions in Sri Lanka, with Special Reference to the Study Area:

Chapter IV deals with the general background of Sri Lanka, with special reference to the study area, in particular reference to the biophysical environment and socio-economic conditions, along with major relief and agro-climatic zones that become important both from the point of view of evaluation influences of climate change at a lower regional scale. It also discusses geographical distribution of Agro-Climatic zones and regions, agricultural production of selected crops, land use pattern, brief review of the fisheries industry and agricultural policies with related to agricultural systems of Sri Lanka.
(v) Chapter V: Climate Change:

Under Chapter V analysis of climate change, particularly in respect of temperature and rainfall changes for a 40 year period has been carried out. This chapter devoted to comprehensive analysis of rainfall and temperature changes, their variability over time and space, and analysis of extreme events.

(vi) Chapter VI: Agricultural Changes:

Chapter VI examines changes in area, production and yield of major crops (1970-2000). This chapter devoted to the study of changes in crop production, coverage, yield of major crops as outlined in respect to the designated districts in Agro Climatic Zones for the past few decades.

(vii) Chapter VII: Impacts of Climate Change on Major Crops:

Chapters VII examine the impacts of climate change on major crops: (crop production, coverage and yield) in districts wise in three major Agro-Climatic Zones.

(viii) Chapter VIII: Adaptive Response of Farming Communities:

Chapter VIII is included an adaptive response of farming communities: With the help of primary data at the farm level, response of farming communities to climate
change have been studied. Three farming communities have been concerned for this analysis.

Part III: Chapter IX

(ix) Chapter IX: Findings and Conclusion:

The first section of this chapter summarises the specific outcome of the present study. The second section of the chapter deals with generalisations arising out of specific findings. The final section deals with limitations of the study, suggestion for further research, recommendation as well as policy implications of the study.