Project Terminal Report
Climate Change Enabling Activity (Phase II) Project

1.0 INTRODUCTION

In the implementation of the United Nations Convention on Climate Change (UNFCC), national communications are the principal instruments particularly for highlighting and disseminating climate change concerns to a wider national and international audience. National communications will not only continue to be the main reporting instrument of the Convention but will also be an important strategic tool to help countries align their interests and priorities to the overall goals of the Convention. As such, national communications continue to serve as an educational tool and an information resource to the COP and other international, multilateral and bilateral processes. However, Non-Annex 1 Parties still find it difficult to prepare and submit their national communications. By the middle of November 2003, only 106 Parties not included in Annex 1 to the Convention had presented their initial national communications (INC) to the COP. After having implemented INC project, countries still face some problems in preparing their second national communications. Therefore, under the Operational Guidelines for Expedited Financing of Climate Change Enabling Activities, the Global Environment Facility (GEF) designed a funding window to provide interim additional funding for Non-Annex 1 Countries that have submitted their INC to undertake additional activities to fulfil the commitments under the UNFCCC.

Article 12 paragraph 1 of UNFCC and the COP8 Guidelines determines the scope of the national communications to include: a national inventory of anthropogenic emissions by sources and removal by sinks of all greenhouse gases (GHG); a general description of steps taken or envisaged to implement the Convention; any other information relevant to achieve the objective of the Convention such as constraints and gaps, and related financial, technical and capacity needs.

Sri Lanka submitted its initial national communication (INC) in 2000. Still Sri Lanka does not have this information. The latest GHG inventory available is for year 1994. The INC identified several areas which need urgent attention, that include the assessment of vulnerability of the different sectors to climate change impacts particularly vulnerability of coastal region due to sea level rise; development and introduction of adaptation measures; adaptation to measures of reducing GHG emissions in the industrial, transport and agricultural sectors; regularly update the GHG emission inventory.

2. Project objectives

The Government of Sri Lanka under the Operational Guidelines for Expedited Financing of Climate Change Enabling Activities requested additional interim funds to the value of US$ 100,000 to conduct Phase II of Enabling Activities as a follow up of UNDP/GEF Enabling Activity Project on Climate Change SRL/97/G32. The project was expected (1) to address the issue of a lack of country specific studies on Climate Change and related issues and (II) to help in maintaining and enhancing the capacity of

Sri Lanka institutions and experts in anticipation of the preparation of the Second National Communication on Climate Change in the future.

The project document (Annex 1) was approved by the Secretary/ Ministry of Environment and Natural Resources and the Director-General/ Department of External Resources on 22nd March 2001, and the Resident Representative of the UNDP on 23rd April 2001. The project was expected to end on 31st December 2002 but was subsequently extended until 30th July 2004. (Annex 2)

2.1. Major project activities

The Phase II project has three major activities:

A.Technology transfer

i)Identification and submission of technology needs
ii)Capacity building to assess technology needs, modalities, to acquire and absorb them, design, evaluate and host projects

B.Studies leading to the preparation of national programs to address climate change improvement of emission factors

2.1.1 Technology transfer - Identification and submission of technology needs

Under the Climate Change Enabling Activities Phase I Sri Lanka prepared the Greenhouse Gas Inventory for the year 1994. Under this project, evaluation of relevant technologies for abating GHG emissions was not evaluated. Therefore Phase II Enabling Activity project will focus on examining technologies and related measures to reduce emissions from greenhouse gases. The project was expected to undertake following activities to assess technology needs:

- Sectoral assessments, discussions on policies and measures, integration of CC concerns into development planning resolutions on the integration of CC in development planning
- Analysis of RETs for GHG abatement
- Analysis of energy efficient technologies on GHG abatement
- Analysis of clean energy technologies, e.g., wind, solar and geothermal
- Analysis of technology transfer needs (series of analyses on SLR, agriculture, forestry
- Development of a portfolio of CC technology transfer projects for future action

2.1.2 Capacity building to assess technology needs, modalities, to acquire and absorb them,
design, evaluate and host projects

The project was expected to implement following activities in relation to capacity building to assess technology needs:

- Technical Training to relevant officers to assess GHG emission reducing technology.

- Providing additional information to access to analyze the technology transfer needs.
- Analysis of physical and socio-economic risk of sea level rise, agriculture and forestry due to climate change
- Development of Climate Change, technology transfer projects
- Development of database and climate change information.
- Participate in international regional workshops in order to build the capacity in this area

2.1.3 Studies leading to the preparation of national programs to address climate change improvement of emission factors

The project was expected to implement following activities in relation to emission factors:

- Two days workshops to identify the work plan
- Conduct mini workshops to prepare detail activity plan
- Developed improved emission factor for each sectors as necessary
- Training of officers, experts on establishing and using country specific emission factor.
- Update database for emission factors.

3.0 METHODOLOGY

3.1. Establishment of the Project Management Unit

A project management unit was established at Environmental Economics and Global Affairs Division to function as a secretariat of the project. In order to internalise the project activity into the mainstream programme of the ministry the director in charge of the Climate Change Unite was appointed as the Project Director. The Steering Committee decided not to appoint 7 project staff members as indicated in the project documents in order to efficiently use the funds for real project activities. Therefore, only a consultant and two programme officers were appointed to work at the project management office. The project management Unit worked closely with the UNDP and the other stakeholder organizations.

3. 2. Establishment of the National Steering committee

National Steering committee was established under the chairmanship of Secretary, Ministry of Environment and Natural Resources and consists of representatives of relevant line agencies, experts private sector and non-governmental organizations in order to manage the steering committee. Members of the Steering Committee is attached Annex 3. The National Steering Committee was responsible for overall supervision and advising on the project activities.

3.3. Establishment of Technical Evaluation Committee

The research studies and the implementation of capacity building programme require technical advice. The technical Evaluation Committee was established to advice the project management unit and the National Steering Committee on the technical aspects of the project. The composition of the technical Evaluation committee is attached Annex

3.4. Establishment of a consultative process with stakeholders.

Consultative process with stakeholders to prioritise project activities was initiated in November 2001. During this process it was expected to develop methodology for project implementation and prioritise activity to be undertaken during the project. This was important since the project document did not include specific project activities with detailed budget. At this consultative process it was decided to undertake a series of research studies rather than giving consultancies for experts to undertake specific project activities. The list of participants of the first stakeholders workshop is attached (Annex 5).

The rational for undertaking research studies on project activities was that the researchers would adapt specific methodology and come up with new findings on the issue. The stakeholders were of the view that all three major components of the project namely, 1)Technology Transfer; 2) Capacity Building; and 3) development of emission factor; can be effectively implemented by way of research rather than consultancy assignments. In view of this with the agreement of UNDP and the all the stakeholders, it was decided to design a comprehensive research programmes on climate change issues of Sri Lanka covering the all the project components of the project.

It was decided to design the research programme in two categories namely, Senior Research Programme and Junior Research Programme in order to build the capacity of junior as well as senior professionals. The stakeholder group was of the view that the training and capacity building to assess GHG reducing technologies and other climate change issues can effectively done through scientific mentoring process undertaking research under the supervision of senior scientists.

The decision was to design the junior research programme for junior scientists to undertake research on project activities to build their capacity while contributing to t the knowledge base on climate change. The senior research programme should be designed for senior scientists and professionals to undertake research studies on project activities to contribute to the knowledge gaps of climate change and provide additional information

3.5 Senior Research Programme

The senior research program was designed to fill the knowledge gaps in the field of technology transfer, capacity building, adaptation and development of emission factors. The stakeholders were of the view that assigning project activities for consultants to prepare study reports will not be effective, since the researcher will be constrained by the TOR. In order to get primary research findings it was decided to call for proposals from researchers and professionals in the field on given project activities. Researchers were expected to develop their own research methodologies and proposal. The idea was that the only the relevant proposals to the project objectives would be selected and provided assistance from the project.

Research proposals were called through local news papers on major areas covered by the project activities including the assessment of the impact of climate change on the different sectors of the National Economy i.e. vulnerability; identifying the measures that are required to address the potential impacts of Climate Change i.e. adaptation and identifying measures to reduce the impact on human activities in altering the composition of the global atmosphere i.e. mitigation. The priority areas for the programme were decided at a workshop held on 15th November 2001 by a group of invited senior specialists in the field of Climate Change and research proposals were called from senior researchers in the field.

A total of 40 proposals were received under Vulnerability (18), Adaptation (11) and Mitigation (11). The forty proposals that were received were evaluated by the Technical Evaluation Committee (TEC) and based on their recommendations 20 proposals which were relevant to the project objectives were selected for funding. These 20 researchers selected were from government technical departments, research institutions and independent researchers. Only senior researchers with vast research experience were selected. The Project Management Unit entered into agreements with all researchers clearly agreeing on the results areas, targets, and monitoring plans. Of these 20 research proposals 1 was on general patterns, 2 on Greenhouse gas emissions, 10 on vulnerability and 7 on adaptation (Annex 6).

3.6 The Junior Research Programme (JRP)

The main objective of this programme was to encourage junior researchers with at least a bachelor's degree to undertake studies in the field of climatic change and thereby build their capacity to undertake similar studies in the future. The senior research program was also designed to fill the knowledge gaps in the field of technology transfer, capacity building, adaptation and development of emission factors while building the capacity of junior scientists through a scientific mentoring process making arrangements for them to undertake research under the direct supervision of senior researchers. The steering committee as well as the stakeholder consultation meetings agreed that this is effective way to build the capacity of researchers and young professionals.

Initially research proposals were invited through a newspaper advertisement but the response was not very encouraging. Subsequently a request was made to the heads of the relevant ministries, government technical departments, research institutions and relevant departments in the Universities to encourage junior research workers in their respective institutions to submit research proposals. This proved to be successful and 40 junior researchers recommended by the TEC were awarded research contracts. (Annex 7). The studies were to be supervised by senior researchers. Of the 40 proposals 4 were on general patterns, 2 on GHG emissions, 15 on vulnerability, 11 on adaptation/ mitigation and 6 on general topics patterning to Climate Change.

3.7 Training workshops on technology transfer and emission factors

The Steering Committee decided to assign the training component of the project to the Climate Change Studies Centre (CCSC) at the Department of Meteorology. The objectives of this component were to build the capacity of relevant technical officers to develop proposals related to climate change technology transfer through technical training. The Project management unit entered into an agreement with the CCSC to undertake following training activities: provide technical training to relevant officers to access GHG emission reducing technologies; organise two days workshops to identify the work plan for training of officers on emission factors; conduct mini workshops to prepare detail activity plans for technology need assessment; and training of officers, experts on establishing and using country specific emission factor.

3.8 Participation at international conferences

The Steering Committee decided to send a selected Sri Lanka experts to attend the Eighth Session of Conference of parties(COP-8) held in New Delhi, India in October 2002. During the COP- 8 meetings there are large number of workshops, exhibitions and discussions are taken place. The Steering Committee decided that making arraignments for Sri Lanka experts to participate in COP meetings and the side events is an effective way of training on negotiation skills and other technical aspects of climate change. A team of 7 member delegation was sent to attend the COP meeting.

4.0 ACHIEVEMENTS

4.1 TECHNOLOGY TRANSFER - TECHNOLOGY NEEDS ASSESSMENT

A number of studies undertaken under the senior research program and junior research program have focused on technology transfer and technology needs assessment. Abstracts and summary of findings of the studies undertaken by the project on technology need assessment and technology transfer are given below:

4.1.1 Social Impact of Vulnerability to Climate Change (A Case study of Hikkaduwa Coral Reef in Sri Lanka)

Climate change is considered as one of the important issues at present, which can affect the existence of life on earth. It has local, regional and global effects and, a variety of policy and institutional measures have been implemented to mitigate those impacts. Many climate related studies are based on air, water, or land, social impacts have been given relatively low importance or not estimated. The objectives of this study are to examine the socioeconomic impact on the people of an increase in temperature in a selected location in Sri Lanka. The Hikkaduwa coral reef habitat of Sri Lanka has been selected to assess this net socioeconomic impact. The study also makes recommendations to mitigate the adverse impacts, of a temperature rise.

An extensive literature survey, a socioeconomic survey and meetings with different line agencies were the major instruments used to collect data and information for this study. Glass bottom boat operators, beach vendors, divers, fishermen, and tourist guides were the major groups that become victims of the increased temperature. Even after five years the majority of the coral species have not settled as yet indicating that a change in water temperature has a significant impact. The absence of water temperature data has become a problem in monitoring this situation.

The average family size in the study area is 4.22 which is smaller than the average rural

family in Sri Lanka. The average age in the sample is 47 which is relatively high. The number of persons engaged in different groups such as glass bottom operators, beach vendors, divers, fishermen, divers and tourist guides have been reduced significantly due to coral bleaching at Hikkaduwa. The average income level of all the groups has declined significantly due to temperature change and many persons have left Hikkaduwa.
The survey results showed that there is a significant relationship between temperature increase and socioeconomic characteristics such as employment, savings/indebtedness, and income levels. The average annual gross and net value of the income loss due to temperature was calculated. The average annual loss in gross income due to the change in temperature was Rs. 14.4 million, the net loss was Rs. 13.6 million.

Conducting regular and systematic water temperature measurements for monitoring, establishment of temperature resistant coral species, directing and assisting to find alternative employment opportunities for persons who become victims of coral bleaching are the major recommendations made in this study. This study was done by C.M.M. Chandrasekara.

4.1.2 Effects of climatic change on harnessing off-grid village micro-hydro power generation in Sri Lanka

The objective of the study was to examine the effects of climatic changes on harnessing micro hydro power generation in Sri Lanka and make recommendations to mitigate any negative effects if any.

Five micro hydro sites identified for the study by the ITDG was visited and land use features were identified. Rainfall data of the sites were collected from Natural Resources Management Centre (NRMC), Peradeniya in order to characterize the sites. In addition results and observation of the recent studies done by other scientists on climatic change was reviewed in order to complement the lack of long-term climatic data to estimate the climatic change. Relationships established between land use and water yield derived after recent research investigations were used to interpret and discuss the results of the study.

Review of literature indicate that climatic change seems to have lowered the water availability. Studies conducted by other scientists on climate change have revealed lowering of rainfall and increasing of temperatures after analyzing long-term climatic data. Study clearly indicates that land use factors have to be considered when estimating water yield for micro hydro development. The difference between rainfall and water yield in the streams could be high especially when catchments are covered with tree-based (taller) vegetation. The most important finding of the study is that the lowering of rainfall due to climatic change will have differential impact on the actual water yield of the catchments due to the nature of land use of the catchments. Introducing water saving land use may be an option to increase the water yield. However practicality of such solution will be very low as selection of crops by farmers and type of natural vegetation is determined by many other factors. This study was done by Upali Pannilage

4.1.3 Implication of climate change on land degradation: A study on changing rainfall regime and its effect on soil erosion in Central Highlands of Sri Lanka

Land degradation is a phenomenon in which the degradation of biophysical elements occurs leading to lowering of the current and/or future capacity of the land to support human life. Several processes have been identified as responsible for this. In Sri Lanka, soil erosion is one of the major processes of land degradation. It has been estimated that nearly 33% of the total land extent in Sri Lanka is subject to soil erosion (Stocking, 1992). Though the impact of rain (erosivity) on soil is the primary reason for soil erosion, it depends on other factors such as vulnerability of soil to erosion (erodibility), land characteristics and land management practices. Among these factors, the effect of land management is determined by the activities of human being. Among the human activities, agricultural activities are widely spread over the land. Therefore, land degradation may be very severe in areas where agricultural activities are taking place without proper soil conservation measures. In this context, land degradation may be high in Central Highlands where intensive agricultural activities (cultivations) are practiced, and also soil and land characteristics are very conducive for soil erosion (erodibility of soil and terrain).

The climatic change that is taking place includes the increase of environmental temperature. Analysis of temperature data over a period of more than 100 years have shown that air temperature over Sri Lanka is increasing slowly (Fernando and Chandrapala, 1992; Kumar and Patil, 1996). Higher temperatures can cause direct influence on the rainfall regime of the country through enhanced convectional activity. Under such situations, more erosive rains could occur than before which will lead to increase of the effect of rainfall on soil erosion resulting accelerated land degradation. However, the increase of erosive rains in climate change is not proved yet and therefore, there is a need to investigate whether there is an increase of erosive rains under a changing climate, and if so, to estimate the extent of soil erosion taking place with increased rainfall intensity in order to plan soil conservation activities in future in the Central Highlands of Sri Lanka. This study was done by R.S.K.Keerthisena, B.V.R.Punyawardena and K.M.Seneviratna Banda

4.1.4 Identification and Evaluation of the Adaptive Measures to Offset the Anticipated Drought Occurrences with Special Emphasis on Rice Production in DL5 Region in Hambantota District

This report consists of three sections. The first section deals with the prediction of anticipated climate change in Hambantota in terms of number of dry days. This involves time series model fitting for four major seasons using 100 years rainfall data obtained from Tissamaharamaya weather station, Hambanatota.

The section 2 of the study deals with prediction of the effect of anticipated drought on paddy production in Hambantota district using predicted drought days and other climatic variables as well as non-climatic variables.

In the third section of the study, adaptation and mitigation measures practiced by the farmers in the district to offset the effects of anticipated droughts on the paddy production are evaluated based on a sample survey. This study was done by L.H.P.Gunaratne, V. D. Nirusha Ayoni

4.1.5 Climate change and its impact on the upper watersheds of hill country

In several earlier research studies (Hamamori 1967, Madduma Bandara & Kuruppuarachchi, 1989, Madduma Bandara, 1997, Wickramagamage, 1995), some indications of trends in climatic change were detected at high elevations of Sri Lanka. These studies were however, only exploratory analyses that did not lead to any conclusive results. They were also based on monthly rainfall and temperature data confined to the Nuwara Eliya Climatological Station, though the trends they indicated were suspected to be more widespread. At the time of these studies, global climatic changes and their local effects were less well known and their impacts were only poorly understood. The present study was undertaken to advance this knowledge further and to understand the impacts of such climatic changes on a few aspects of the economy and ecology of the upper watershed areas of the hill country. A more comprehensive early research proposal for this study had to be curtailed due to certain constraints of funding and access to available climatic data.

The study was focused on climatic change (trends) as distinguishable from seasonal and short- term natural variability, except where the two appeared to be closely related. In order to get a better understanding of climatic change, daily and pentad (five day) rainfall data had been used wherever possible. In view of the more explicit impact of global warming on temperature across the country, rainfall data formed the main focus of this study. Any change in rainfall is also assumed to have more visible and far reaching impacts on the economy and ecology at high elevations.

In the first round of analysis, rainfall trends in the main climatological stations in the hill country were subjected to trend analyses using linear regression models. This indicated that at most stations located in the periphery of the central mountain mass, such as Kandy, Badulla and Ratnapura, the trends observed were not statistically significant. However, significant trends were observed at Nuwara Eliya representing the highest elevations, and Abergeldie and Watawala near Hatton representing the highest rainfall region of the country. These preliminary findings led us to concentrate on those two localities and to strive towards tracing any possible impacts.

The meteorological stations selected for this study represent a cross-section of the highlands extending from the Watawala in the west to Badulla in the east. A larger area was selected in the analysis of monthly and annual patterns of rainfall and temperature trends, while a smaller number of stations with reasonably reliable records were selected for a more detailed analysis of critical areas. Long-term data availability and the cost of procuring the data were the limitations of this study. The selected stations represent both southwest and northeast monsoon regimes of the possibly affected areas.

This study was done by C.M.M.Bandara, P.Wickramagamage, Kumari Arambepola, and Rekha Nianthi

4.1.6 Impacts of Climate Change on Land Productivity of Rubber, Possible Adaptation Measures and the Role of Rubber Plantations as a Mitigation Option

Environmental issues like climate change have become increasingly important not only in global context but also in maintaining the long-term productivity of Sri Lankan agricultural sector. The diverse impacts of these environmental issues are not confined to agricultural sector alone. By the shortfalls in agricultural production, the sectors servicing agricultural crops could also be adversely affected. The exact reasons behind recent changes in weather patterns are still not known. Scientists feel that this is one of nature's ploys to conceal its intricate workings from man! Nevertheless, it is not possible to completely avoid adverse weather condition or its impact on the agricultural sector. What is most important is to introduce agricultural systems that could withstand such adverse weather conditions or make it more bearable and thereby to protect the country's agricultural system.

Rubber cultivation is mainly limited to the wet south- west comer of Sri Lanka because the rubber plant grows well in areas where moisture is not a limiting factor. Productivity of rubber depends on good management practices and on factors mostly related to the weather, over which the grower has no control. All these management practices in a planting cycle are linked with the weather pattern. Several studies were reported in India, Malaysia and Sri Lanka, where rainfall is considered as a major factor influencing land productivity of rubber plantations (Anon, 1998; Devakumar *et al*., 1998 and Samarappuli, 1998). Rainfall is of great concern to the rubber grower as it affects the tree at all stages of growth from planting through felling. Hence, any changes in the seasonal pattern may have adverse impact on the application of recommended agronomic practices in rubber plantations. Some important events of interest on this regard are, start, end and length of the rainy seasons, amount of rainfall in different seasons and risk of extreme events. Therefore, appropriate times for carrying out various cultural operations involved in rubber cultivation is a basic necessity to attain optimum land productivity.

In general, it is not possible to completely avoid adverse weather conditions or its impacts on agricultural crops like rubber. Therefore, developing countries like Sri Lanka should focus more on adaptation measures – a relatively neglected area of research that will help survive adverse climate change impacts. Moreover, from the ecological point of view cultivation of deep rooting perennial crops like rubber is a highly desirable form of land use. Rubber plantations provide a canopy, which reduces the impact of sun as well as high intensity rains. Rubber plantations are therefore be considered as a self sustaining environmentally acceptable eco-system which can mitigate extreme weather conditions. However, it must be emphasized that there is only about 150,000 ha. of rubber plantations left in the country at present, though there were 202,000 ha. towards the end of 1970's. This remarkable decline is largely due to diversification of rubber lands for other alternative ventures. Government policies and initiatives in place towards protecting the existing rubber lands are therefore of paramount importance. Therefore, an information base to support the importance of rubber as an alternative to the native forest, which sustains the greatest productivity, most efficient soil and moisture conservation system and greatest diversity, is of paramount importance.

This study, therefore, was carried out to identify changes in weather patter in major rubber growing districts, to investigate the impact of such changes on productivity of rubber and to develop possible adaptation measures to combat climate change and also to asses the role of rubber plantations as a mitigatory system for extreme weather conditions. This study was done by Lalani Samarappuli and Wasana Wijesuriya

4.1.7 Coconut Cultivation as a measure of Adapting and Mitigation of Climate Change

As far as the climate change is concerned the coconut tree is the ideal choice for it could be grown even using sea water. Considerable amount of bio mass such as coconut husks, coconut shells and coconut leaves could be harvested annually to be used as an alternative fuel for electricity power generation if coconut cultivation is properly promoted. Various other economic benefits could be derived by taking to large-scale coconut cultivation in Sri Lanka.

Suggesting a massive coconut cultivation drive is easier said than done. Only way to undertake coconut cultivation in a larger scale in the dry zone of Sri Lanka is through rainwater harvesting. An attempt is made to develop a low cost rainwater-harvesting container in this study. A solution to the elephant menace, which is a main obstacle to grow coconuts in parts of Sri Lanka, is also given.

Recommendations of experts on climate change include fixing more and more CO2 in trees and switching on to alternative fuels such as bio mass. Therefore by undertaking a massive coconut cultivation drive we are not only fully complying with the recommendations of the experts on climate change but also solving a host of other problems which exist in Sri Lanka. Since Coconut is an oil crop, coconut oil cake or 'Poonac' could be used as a cattle feed which in turn would help to increase milk production of the country. Timber from mature coconut trees would ease the pressure on forests. Excess quantities of coconut oil cake if available could be used to feed wildlife, which in turn would make it possible to maintain healthy populations of wildlife in ever diminishing wild habitats. Especially the elephant population, which is facing extinction, could be protected. It would not make any difference by providing food from outside to wildlife for most of these animals frequent municipal garbage dumps for food. As stated earlier the power generation sector could be provided with enough bio mass which in turn save valuable foreign exchange. Using coconut treacle even sugar could be produced.

Therefore, this study explores the ways and means of undertaking coconut cultivation as a measure of mitigation of and adapting to climate change and at the same time tries to justify the selection of the coconut palm against other woody trees, which could be grown with less effort under dry conditions. This study was done by K. P. S. P. Perera Supervised by Mr. M. Sivapatham

4.1.8 Screening of High Yielding Clones of *Hevea* for Marginally Dry Area

Rubber growing areas in Sri Lanka belong to several agro- ecological regions; low country wet zone (WL), low country intermediate zone (IL), mid country intermediate zrone (IM) and up country intermediate zone (IU), Out of above zones rubber cultivation is mostly confined to low country wet-zone, where annual rainfall is in the range of 2540 mm-5000mm. Most of the potential areas in this zone have already been brought under plantations. There had been a huge drop of the rubber extent in this zone at a rate of nearly 2500 ha per annum since 1980 (MP1, 2001), probably due to land fragmentation among siblings, urbanization and diversification of lands for more profitable ventures.

Although the extent is diminishing, the domestic natural rubber consumption has continuously increased from 18,000MT in1980 to over 57000MT in year2000 (MPI 2001). With increase in demand for natural rubber and wood products, the necessity has arisen for the expansion of rubber cultivation to low rainfall area in the country. Moisture stress that is resulted due to low rainfall is a major drawback in expansion of rubber into drier area.

Moisture stress may reduce growth and productivity of many crops. An assessment of the physiological responses of a plant to moisture stress is of importance in identifying traits, which could form a basis for the selection of drought tolerant genotype. Analysis of stress resistance is a way of identifying clones suited to the drier ecological zones. Stress resistance may arise from tolerance (ability to survive the stress) or avoidance (ability to exclude the stress) although the latter is not important for rubber.

Those plants that are stress tolerant posses and morphological or metabolic properties, which enable them to maintain a high degree of tissue hydration even under limited water supply. Plants respond to water deficits by changes in most physiological process during plant growth and development. It is well known that imbalances in physiological responses induced by environmental stresses are good indicators of subsequent growth reduction (Kozlowski, 1975). Among those, stomatal responses and photosynthesis are criteria, which could determine the efficiency of regulation of water loss when plants are subject to water stress.

Difference in drought tolerance between different plant species or between varieties of the same species may also depend on the relationship between relative leaf water content at different leaf water potentials, since this would give an indication of relative tissue desiccation resistance under similar moisture stress conditions. Also, the variation in gas exchange in plant; under stress depends on stomatal conductance and net photosynthesis. These parameters could therefore serve as indicators for selecting vigorously growing, high yielding cultivars under moisture stress.

Soil and atmospheric moisture stress and high temperature are major environmental factor, which limit the expansion of rubber cultivation into marginally dry area in Sri Lanka. Identification and breeding of clones tolerant to these stresses one important. Early evaluation if stress resistant traits will be very useful in this context. Physiological parameters such as stomatal conductance, photosynthesis rate, and leaf water potential are important indices associated with moisture stress in *Heave.*

During the past four decades (from 1964 to 2000) the amount of rainfall received in major rubber growing areas showed significant decline trend (Wijesuriya, 2002) with that moisture stress would become a substantial problem in future. Therefore the ability of genotypes to withstand under such conditions should be assessed in order to determine suitable cropping systems.

Moreover, Rubber Research Institute of Sri Lanka has already targeted to expand the rubber cultivation to marginally dry area to cater the increasing demand for rubber both locally and internationally. Identification of clones that thrive even under moisture stress is a prime importance in this regard.

This study aimed to asses how different genotypes of rubber, in particular recently introduced high yielding clones, response to water stress using physiological parameters. Thereby the vulnerability and adaptability of rubber for expected dry condition under climate change was evaluated and best suitable genotypes for such conditions identified. This study was done by N.A.A.D. Wickramarathna and Supervised by Dr. V. H. L. Rodrigo

4.1.9 An Assessment on the vulnerability of *Hevea* seed production to climate change

Rubber, *Hevea brasiliensis* (Muell. Arg.), a forest tree which is indigenous to the tropical rain forests of Central and South America and the only major commercial source of natural rubber (NR) (George *et al.,* 2000). The rubber tree provides 99 per cent of the global natural rubber and in Sri Lanka, it plays an important role in the economy contributing a significant share of the GNP and employing over 500, 000 people (Status Review Report of Rubber Research Institute of Sri Lanka 1992).

The total area under rubber in Sri Lanka appeared to be ca. 114,679 ha (Unpublished data, Ministry of Plantation). The annual replanting hectorage is therefore around 3440 ha, i.e. 3% of the total hectorage. Therefore nearly 1.89 million budded plants (550 plants/ha) are required for replanting of 3440 ha, i.e. 9.45 million of seeds are required per year. Studies have shown that (Seneviratne *et al*., 1996) only 25% of the seeds sown in the germination bed ultimately produce vigorous root stock. Generally, 1kg holds about 250 seeds and therefore about 37.8 metric tons of seeds are required annually. The estimated hectorage in Moneragala to be planted with rubber in year 2004 is around 2000 ha annually, i.e. 1.1 million plants and to reprocess of further expansion. However, if the area increases, planting material requirement will also increase accordingly. Hence the seed requirement in the future would be much greater than that at present.

Climate change is one of the two major global environmental problems faced by the present scientific and politics forums, the other being the depletion of ozone layer. Few scientists dispute that human activity is causing the atmospheric concentrations of greenhouse gases and particles to increase, and that this, in turn, is leading to global climate change. From about 1900 to the present concentrations of atmospheric carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) have increased substantially (Weare, 2002).

The change in climatic conditions, both region wise or as a country on the whole may have affected the rubber plantation too and there by it may affect aspects related to the seed production. In Sri Lanka, no records are available on flowering pattern and seed production of rubber under natural conditions and/or under different climatic conditions.

Production of seeds is highly correlated to the region. This may be due to direct or indirect influences of the climate and the weather during flowering and pod set and also seed fall. The inflorescence production per tree and thereby per hectare and also the percentage of trees flowered varied in two years in two zones giving high flower production in the Intermediate Zone. It suggests that the climatic conditions prevailed during flowering and pod set period affect the seed production. The mean monthly rainfall for February in the Wet Zone was comparatively higher during 1990-2002 compared to the period during 1980-1989 probably due to change in the climate. Favourable climate for the development of the pathogens during refoliation and flowering period reduced the number of seeds then produced. Unfavourable conditions occurred for flowering and also for the post flowering period in the Wet zone area of Sri Lanka as a result of the climate change may have contributed to the low seed production in this area during past 15 years compared to those with the Intermediate Zone. This study was done by N.M.C. Nayanakantha and Supervised by Dr. (Mrs.) P. Senaviratne and Dr. V.H.L. Rodrigo

4.1.10 Urban climate change mitigation through urban vegetation: Strategies for Colombo Metropolitan Region

While the global population has increased six times during the last hundred years, urban population has grown 128 times. Urban climate is one physical environmental attribute, which has influenced through this "urbanization." Global climate change has influenced mainly due to urban air pollution by greenhouse gases, aerosols, and soot. Urban complexes are being affected by form of pollution resulting from the urban traffic as well as from industries. So air pollution poses a general problem for city dwellers, architects, and planners. In almost all developing countries, meanwhile, urban air pollution is worsening. Also with this urbanization rapid increase of vehicle emissions has caused the atmospheric pollution.

The atmospheric aerosols impact affects the climate by direct and indirect ways. This has impact on the global temperature too (Harvey, 2000). So this has been identified as a significant source of global climate forcing. Urban air pollution becomes a prominent problem in many cities in the world and most of population lives in these urban areas. So many features of urban physical structure can affect the urban climate. As urban planning and design can control the structure of urban area it is possible to modify the urban climate through urban policies and designs of neighborhoods and whole new urban areas.

Sri Lanka has limited experience in urban vegetation impact on site local climate. The objective of the study is to investigate vegetation as urban design tool to reduce total particulate matters in Colombo Metropolitan Region and to devise urban design guidelines. As urban areas, especially mega cities expand further, increases in traffic congestion, water, and air pollution. Air pollution in Colombo is rising rapidly with the growing level of motorization. In Colombo more than 80% of air pollution is due to this vehicular emission. Few studies of air particulate pollution conducted by University of Colombo, presented the high level of SPM within Colombo at ten different locations in 1995. Also recent studies in Colombo show that high level of suspended PM is a significant threat to its public health. So by these urban vegetation design details well helps to identify Colombo City for physical comfort in urban environment. To be limiting the study it only considered the public urban areas in Colombo.

The increase in vehicular population is the main cause of air pollution in Colombo as identified. The study has considered the link between pavement landscape and control of traffic emissions along the streets through urban vegetation because some urban vegetation species are capable to combat air pollution. Therefore these urban plants will mitigate global climate change into some extent. Also in proper urban planting guidelines will help to protect urban dwellers health too. This study was done by B.V. Sathya Sajeewa and Supervised by Dr. Rohinton Emmanuel

4.1.11 Urban climate change mitigation through manipulation of urban morphology: Strategies for Colombo

Urban climate is one of physical environmental attribute, which has influenced through the urbanization. Many features of urban physical structure can affect the urban climate. Some of these are, building forms, greenery, Street width, Etc. Among these Building forms with all it concerns for location, mix of uses, open spaces and building density, site coverage, heights of structures and site layout itself, have considerable impact on micro-climate changes.

The consideration and necessary attention towards natural forces (climatology) has been overshadowed by market forces in cities like Colombo. Most of the International cities have built forms with borrowed culture rather than their own indigenous character. These built forms have no bearing on the natural forces. As a result they consume very high amount of both end-use and embodied energy. The manipulation of internal environment with little concentration to dynamic and complex issues of natural forces has led to environmental degradation. Therefore this research will establish the ground rules to guide the energy efficient design at urban level. The ground rules are established through qualitative and quantitative analysis based on PMV and COOLING LOAD as the major yardstick.

This study analyses the cooling energy and thermal comfort implications of the changing urban climate of Colombo Sri Lanka. More recent climatic average is assumed to be indicative of urban heat island phenomenon. Using parametric building energy simulation software, the research document analyses the cooling energy and thermal comfort differences arriving from the recent years. Three options are examined to determine their potential to mitigate the negative impacts of the altered urban climate. This study was done by Mrs.Nirosha Thiangi Lloyd and Supervised by Dr. Rohinton Emmanuel

4.1.12 Study on changes of water potential in the Mahaweli upper watershed area due to climatic change

The Mahaweli Development Programme in Sri Lanka was implemented with the aims of providing water to the dry zone of the country through a massive diversion scheme and also generating hydropower. Under this development Programme, a series of large reservoirs was constructed across the main water course at Kotmale, Polgolla, Victoria, Randenigala, Rantembe and etc. The catchments areas to these reservoirs are categorized as Upper Watershed Management Area of Mahaweli. Located in mostly at the heart of Sri Lanka, The Upper watershed management area of Mahaweli is at the middle of a growing crisis empowered by triggering climatic changes in global, and local climatic changes. Approximately 30 percent of the total hydropower capacity in Sri Lanka, and 23 per cent of lands irrigated under major irrigation schemes in the island, are depend on the water resources of the upper Mahaweli catchments, under a major diversion scheme of the Mahaweli River.

With the changes of the climate in the local level such owing to changes in land-use patterns, industrialization and other natural and artificial alterations to the nature in the hill country of Sri Lanka, and the global level climatic changes are prominent than any other time in the history. While the growing population, industrialization process demands more and more energy. Past several decades the government of Sri Lanka as the main supplier and planner of energy sector based its policies on the hydro power. But frequently occurring droughts and serious power cuts pressured them to set-up new installations using alternative energy sources. This study was done by W.W.A.Shantha and Supervised by Dr. J.M.S.B.Jayasundara

4.1.13 Effect of wintering on the latex and raw rubber properties of *Hevea brasiliensis*

Natural Rubber, which is native of the Amazon forests, was brought to the Sri Lanka by Sir Henry Wickham in 1876. *Hevea brasiliensis* not only economically viable but also act as a versatile resource. It is socially very important as it provides employment opportunities both in plantation sector and processing sector. Now it is a well known fact that green cover of the NR act as rainforest and its ability to absorb large quantities of CO_2 in atmosphere, there by minimizing green house effect.

The *Hevea* tree defoliates and renews its foliage annually and this phenomenon is commonly known as "wintering ". Normally wintering takes place during drier months of the year, specially during February and March. This wintering pattern may be advanced or delayed by few weeks depending on the climatic condition of the prevailing year.

Rubber yield and stability varies widely during the year. A steady drop in yield is observed during February to April (Wintering period) and, during May to July the trees recover again. (Post-wintering period) Fairly high yields are observed during August to October (High Yielding period) and followed by peak yielding period during November to January (Wijesooriya et.al.,1997).

Quality of latex too varies widely during the year specially during wintering months, showing some anomalous behaviors stated below.

A. Difficulty to coagulate latex using the recommended dosage of formic acid due to some unknown biochemical changes taking place during wintering months. As a result, large quantity of rubber in the latex goes down the drain uncoagulated there by increasing the cost of production of the rubber grades produced.

B. Owing to the increase in carbohydrate content in the latex starting with the beginning of the yellowing of leaves before wintering, there is an increase in the Volatile Fatty Acid (VFA) formation causing instability of latex.

C. Even lowering of the Plasticity Retention Index (PRI) of Technically Specified

Rubber(TSR) to below 60 has been reported during wintering; there by making the rubber non exportable as TSR.

All these facts altogether, make losses of profits during wintering period. Hence, a detailed study is needed to be carried out to identify the biochemical changes taking place in NR latex there by affecting quality of the rubber produced out of such latex.

This study focused mainly on the investigation of biochemical changes taking place in NR latex during wintering months and the variation of technical properties (VFA & PRI) along with them. Special attention was given to compare the results obtained with the results obtained from the artificially defoliated trees.

As wintering may be advanced or delayed depending on the heavy rainfall or drought experienced during the previous year, climatic conditions are highly influential towards the yield and the possible profits for the industry. Rubber production some times runs with marginal profits depending on the demand in the world market. Therefore all the required precautions should have been taken to increase the productivity. If yield drop and above-mentioned anomalous behaviors occurs at the beginning of the year and at the end of the year due to the drastic climatic changes taking place, profitability from the industry will also change accordingly. So intensive studies should be carried out to identify the remedies to nullify these seasonal changes. As there are not much studies done in the past on the change of wintering pattern with the rainfall, in this study special attention has been given to identify the same. This study was done by G.V.L.Nilmini and supervised by Dr. L. M. K. Tillekeratne

4.1.14 Possibility of the popularization of *Oidium* susceptible high yielding clones with the predicted climate change

The rubber tree (*Hevea brasiliensis*) is one of the most environmental friendly agricultural crops in the world. This forestry crop gives a major industrial raw material securing the income of its growers. It is a source of income for more than 20 million families worldwide. Further, it provides many ecological and socioeconomic advantages.

The rubber tree is susceptible to various pests and diseases. The secondary leaf fall (SLF) caused by *Oidium heveae* & *Colletotrichum* spp. is of widespread annual occurrence in all rubber growing countries including Sri Lanka. The disease causes severe defoliation of the new leaves producing February - March immediately after the annual wintering. Repeated attacks, which occur under conducive weather conditions results poor canopies, loss of considerable yield (up to 75%) (Liyanage *et al*., 1971) and poor girthing. When clones are recommended for planting, one of the major factors considered is the resistance to secondary leaf fall. However, if the performance of the clone is very high with regard to the yield and vigor they are recommended for planting though they are susceptible to secondary leaf fall.

It is generally believed that weather conditions during the refoliation period determine the severity of the SLF (Liyanage *et al*., 1985). One of the major factors considered by the growers when selecting clones for cultivation is the resistance to SLF especially to *Oidium*. An ideal example for this is the high yielding clone PB 28/59. Rubber clone

PB 28/59 is a prestigious clone recommended in group 1 by the RRISL. However, it was planted in Sri Lanka to cover only less than 0.1% of the cultivated rubber land mainly due to its susceptibility to secondary leaf fall disease and whereas RRIC 100, another group 1 clone resistant to *Oidium* & *Colletotrichum* is highly accepted by the growers and cultivated over 60% during the recent past.

Climate changes interfere with the biological processes of plants causing various impacts on their growth and behaviour. It was reported that a declining behaviour in rainfall and the temporal variation in maximum dry run observed during January & February shows an increase when compared to the period before 1970 in major rubber growing districts (Wijesuriya, 2002). Under these circumstances there may be marked variations in the disease severity of secondary leaf fall in susceptible clones. If chances of occurring epidemics become less growers will be able to make use of *Oidium* susceptible clones, which are superior in latex production for future replanting.

The present study was proposed to investigate the influence of climate change indicators on the incidence and severity of secondary leaf fall. The final objective is to investigate the possibility of popularizing the high yielding clones, which are susceptible to *Oidium* with the predicted climate change. This study was done by T.H.P.S. Fernando and supervised by Dr. C.K. Jayasinghe

4.1.15 An Investigation of ambient air temperature trends at Hambanthota-Angunukolapelassa, Nuwara-Eliya –Thalawakelle and Colombo-Bombuwala

From about the 1980's, the unpredictable climate changes were considered as an issue of great concern in Sri Lanka. Within this period extreme events of weather were noticed. One of these events of grate significance is the drought that affected Hambanthota and recently, (in 2001) and other areas. In the Sri Lankan context it is important to distinguish between the past and present climate conditions and to study the fluctuations of mean maximum air temperature, mean minimum air temperature, whether they are due to greenhouse effect or due to urbanization or any other local effect. These analyses will certainly be helpful for planners and policy makers who are engaged in fields such as agriculture, engineering and water resource management etc.

Mean minimum air temperatures at Talawakelle have shown decreasing trends in all 12 months while at Nuwara Eliya minimum temperatures have shown statistically significance trends in all months. These warming trends at Nuwara Eliya could probably be due to local effect of urbanization in addition to the enhanced greenhouse effect. It was noted that the Angunakolapelassa maximum temperatures were little higher than the Hambantota maximum temperatures. This could probably due to the well exposure to the sea of Hambantota station. Rate of increase of minimum temperatures at Angunakolapelessa are higher than that at Hambantota also indicate the influence of microclimate effect at Hambantota station. This study suggests that the local effects could be more dominant than the global effects in small Islands like Sri Lanka. This study was done by J.C.Vithanage and supervised by Dr. B.R.S.B.Basnayake and Dr. B.V.R.Punyawardena

4.1.16 "Vulnerability of paddy extent and irrigation systems to climate change – A case study using Batalagoda wewa and Hackwatuna wewa reservoirs in the

Kurunegala district"

The Earth's climate is not steady. Temperatures and rainfall vary from year to year and fluctuate widely over much longer periods of time. Indeed, changes in the Earth's average annual temperature of only 4 – 5 ^{0} C brought about the onset and retreat of the Ice Ages. And ever since the past Ice Age, there have been periods when regional temperatures were much higher and much lower than at present. (*The impact of climate change*, UNEP Nairobi, UNEP, 1993)

It is widely accepted that a rise of 0.3 – 0.6 ^{0} C in global mean temperature has taken place over the past 100 years.

Agriculture has been the backbone of Sri Lanka's economy for over 2,500 years. But it is gradually declining in importance and is currently beset by low productivity in cultivated lands. Higher temperatures will influence production patterns.

Paddy cultivation, which provides the staple diet of the population, has received the highest attention in the agricultural sector in Sri Lanka. It is even now the backbone of Sri Lanka's agriculture and forms a way of life, which links the present with the country's ancient agrarian civilization. The main paddy cultivating districts in Sri Lanka are Anuradhapura, Polonnaruwa, Kurunegala, Ampara and Hambantota. The extent of area under paddy cultivation for both seasons is 479,000 ha in 1959 and 930,000 ha in 1994 while the average annual yield of paddy has more than doubled from 1,500 kg / ha in 1950s to 3,500 kg / ha in 1990. As revealed in pervious studies, improvement of paddy productivity has been attributed to more intensive cultivation practices, using new high yielding varieties, new recommended inorganic fertilizer and new methods of crop husbandry. As a result the dependence on rice imports had declined from 534,000 t in 1970 to 58,000 t in 1994.

Batalagoda wewa and Hackwatuna wewa reservoirs are the main irrigation systems in the North Western Province, which irrigate a considerable proportion of paddy fields of the dry zone in the North Western Province. During the past 50 years rainfall patterns directly influenced water levels of the above reservoirs and its paddy cultivation lands. This situation affects the paddy production of North Western province. The main purpose of this research is to study the effects of climate change in irrigation systems and how it affects paddy extent. This study was done by D.M.C.N.Kumari and supervised by Mr. T.K.Fernando

4.1.17 Screening of selected forest tree species of Sri Lanka for their response to increasing atmospheric carbon dioxide

Increasing atmospheric carbon dioxide concentration (C_a) is one aspect of global climate change (De Costa, 1999). The C_a had remained stable around 280 ppm for a long period until around 1750. However, with the advent of the industrial revolution in Europe and the expansion of industries, a rise in C_a was initiated. This has continued up to the present times and C_a has increased up to around 365 ppm. It has been observed that the pattern of increase of C_a is exponential during the last 50 years. This means that

C_a increases at an increasing rate so that it will reach 700 ppm by the end of the present century.

While large-scale deforestation and burning of biomass contributes significantly to the increase of C_a, reforestation tends to slow down the increases of C_a. This is because of the utilization of CO_2 in photosynthesis by the extensive forest canopies (Ceulemans et al., 1999). Hence, reforestation also provides an effective mechanism of carbon sequestration in the form of biomass. This sequestered carbon may later be used as a source of energy.

Despite the well-accepted potential of reforestation as a mechanism of slowing down increases in atmospheric carbon dioxide levels and in carbon sequestration, very little work has been on how the forest species in Sri Lanka would respond to increased C_a. In fact, no actual experimental work has been carried out. One reason for this lack of research work is the practical difficulty in carrying out carbon dioxide enrichment for large trees growing in forests. In the proposed study, as a first step in a long-term experimental programme, investigations were carried out on potted seedlings of a selected set of forest plant species grown in Sri Lanka. This was done by K.G.R.Chinthaka and supervised by Dr.W.A.J.M.De Costa

4.1.18 Identifying and mapping salt-affected lands in Hambantota district, Sri Lanka: An integrated GIS and remote sensing approach

Accumulation of excess salts in the root zone resulting in a partial or complete loss of soil productivity is a worldwide phenomenon. It hampers crop production adversely and reduces the utility of lands. The salt-affected lands in Sri Lanka are about 223,000 hectares or about 3% of land area of the island. In this regard, identification of salt affected lands and present land use systems in areas of different salinity levels are very important to necessary actions to restore these lands.

An attempt has been made to identify salt-affected lands in Hambantota district of Southern Sri Lanka and demarcate in to different categories according to the salinity levels and mapping salt-affected lands. An extensive soil survey was conducted to collect soil samples throughout the district. The sampling was done by using a manual soil auger. Chemical analysis in laboratory has been carried out to determine salinity and Ph.

This study shows that salinity is higher along the coastal belt of Hambantota district. When considered as divisional secretariat areas, Tangalle, Ambalantota, Hambantota, Lunugamwehera and Thissamaharama D.S. divisions can be considered to be high saline areas where salinity is >4 dSm^{-1} . Katuwana, Weeraketiya and Okewela can be considered as non saline D.S. divisions of Hambantota District as salinity is lower than <2 dSm^{-1} , while Beliatta, Angunukolapalassa and Sooriyawewa D.S. divisions can be considered as moderately saline areas where salinity is 2-4 dSm^{-1}.

The study concluded that, from the total area of 2615.7 square kilometres of Hambantota district, total non saline area is 1000.1 square kilometres (38.3%). Area of

1032.1 square kilometres (39.5%) is slightly or prone to saline areas. There are 558.6 square kilometres (21.4%) of land are of moderately saline which need improvement. From the total area of the district there are 24.9 square kilometres (1%) of land of strongly saline areas. This study was carried out by Chandana Perera Gunasena and supervised by Prof. K.D.N.Weerasinghe and Dr.S.Subasinghe

4.2 Capacity Building To Assess Technology Needs, Modalities, To Acquire And Absorb Them, Design, Evaluate And Host Projects

Several research studies were undertaken under the senior research program and junior research program that have focused on capacity building to assess technology needs, modalities, to acquire and absorb them, design, evaluate and host projects Abstracts and summary of findings of the studies undertaken by the project are given below:

4.2.1 Agro-climatic potential and risk assessment for crop intensification in home gardens of Southern Sri Lanka

The research assesses the changes in the onset, duration, risk and magnitude of rainfall during the last 50 years in different regions in a selected part of southern Sri Lanka using the climatic water balance approach and the rainfall probability concepts. It further identifies changes in the cropping calendar and attempts to introduce an optimum cropping calendar and crop commencement time for annual crops grown in home gardens in the selected area.

The daily rainfall data for 50 consecutive years (1950 ~ 2000) were collected from 10 stations in different agro-climatic regions in the study area. Pan evaporation data were obtained from Angunakolapalassa Agricultural Research Station. Computer programs 'First', 'CROPWAT' and MSExcel were used for the data analysis. The change in the onset, magnitude and duration of rainfall and the number of dry weeks per year were assessed with the help of 3-year moving averages curves and linear trend lines. 10 mm weekly rain < 75% probability and Hargreave's Moisture Availability Index < 0.34 on a weekly basis were used to assess the dry weeks in the area. The Optimum week for crop commencement was simulated by the least irrigation water requirement method. A farmer survey was conducted to find out the current cropping calendar of annual crops grown in home gardens.

\ The results revealed that within the study area the annual rainfall and the maximum length of the wet period are decreasing and the number of dry weeks per year and maximum length of dry period are increasing. The onset of the rain in the *Maha* season is also delayed. The number of dry weeks per year varies from 44 to 48 depending on the assessment method. The wet weeks are concentrated between the 42nd and the 49th week in all of the selected regions.

Farmers rarely grow vegetables during the *Yala* season. Crop establishment week for *Yala* varies from the 11th to the 18th week. This is late when compared to the simulated crop establishment time (10th week). The crop establishment varies between the 38th and 41st week for *Maha,* which is earlier than the simulated crop establishment time (41st week). If farmers can amend their cropping calendar to match the simulated cropping calendar, the irrigation demand would be minimized and better crop production could be expected from home gardens. This study was done by C.M.Navaratne and K.D.N.Weerasinghe

4.2.2 Vulnerability of the North Western Province to Climate Induced Incidences of Vector (Mosquito)-borne Diseases

The study investigated, over a thirty year periods of retrospective phase with the past data and one year prospective phase for four mosquito-borne diseases in the North Western province in Sri Lanka. The diseases considered were malaria, dengue, filariasis and Japanese encephalitis. In the retrospective study the past incidence data were collected and recorded and prospective data collections were carried out. Data collected in health institutions for four diseases were used for analysis. Climatic data taken form the past thirty years from the meteorological department.

The data were analysis for study the correlation between disease incidence data/rate and climatic factors that effected on the mosquito-borne diseases. The climatic factors considered were rainfall, temperature and humidity. The one month and two month lag period of climatic factor were also considered. The other control factors such indoor residual house spraying were corrected in the data analysis.

The results showed that the climatic conditions were gradually changing in the province and increasing the effect on mosquito-borne diseases. The API for malaria were positively ($p<0.001$) correlated with the two months lag period of rainfall. Temperature in the present month ($p<0.001$), one month lag period of rainfall (0.001), and two months lag period of humidity (0.001). Dengue incidence in the two districts, Kurunegala and Puttalam were positively correlated with the one month lag period of rainfall and temperature in the current month (0.001). JE incidence was positively correlated with the two month lag period of rainfall (0.001). Incidence of filariasis was not correlated with the any of the climatic risk factor, rain fall, temperature and relative humidity.

The results of the study showed that although the present control activities could maintain the low incidence rates, these climatic factors have a role in increasing mosquito-borne diseases in the province specially, in the areas with intermediate climate. It proved that the temperature is gradually increasing in the North Western province. Therefore, the more attention should be given by the health authority on these naturally operating risk climatic factors that may be gradually affected on mosquito-borne diseases in future. This study was done by Dr. Sunil de Alwis

4.2.3 Insects and climatic change: A comparative study on the seasonal abundance and diversity of terrestrial insect fauna in Hambantota district.

Global Climatic Change studies predict that animal distribution in the world may change as a result of the response of animals to the changes of climatic conditions. As a preliminary step to test this hypothesis a short-term field study was conducted to analyse the impacts of climatic variability on terrestrial insect fauna in Hambantota district.

Insect samples and weather data collected from 11 randomly selected sampling sites across the Hambantota district representing different climatic zones. Weather data was collected daily and the insect samples were collected weekly using sweep nets and light traps.

Approximately 670 species of insects and spiders belongs to 10 orders of arthropods were collected from November 2002 to November 2003. Collected insects were identified up to the highest taxonomic level using the taxonomic keys.

Percentage abundance of insects in wet, intermediate and dry zones are not significantly different but it showed gradual decrease when moving from wet zone to dry zone. However the dominant insect groups in each climatic zone varied remarkably and Diptera, Orthoptera and Hymenoptera were highly abundant in wet zone while hard bodied Coleoptera and Hemiptera were abundant in dry zone.

During the dry periods of wet zone Dipterans and Hemipterans became the dominant insect groups replacing other groups of insects. Abundance of those insects positively correlated to the temperature but negative correlation was observed for rainfall of the area.

Similar pattern was observed in intermediate zone though the insect abundance of this area positively correlated to both temperature and rainfall of the area.
In dry zone throughout the sampling period the most abundant insects were Coleoptera and Hemiptera, which have relatively hard bodies. Their abundance is positively related to the temperature of the area and their abundance was reduced during the rainy periods.

Important agricultural pests were identified from these samples and most of them belong to the order Diptera, Coleoptera and Hemiptera which abundance show positive relationship to the temperature of the area. Abundance of most of the natural enemies belongs to order Hymenoptera has shown negative correlation to the environmental temperature.

The results of this field study were consistent with the idea that the insect abundance and distribution may alter with the climatic change. Climatic variability may regulate the insect communities in constant levels but gradual rising of temperature may strongly favors abundance of certain insect groups such as Diptera, Coleoptera and Hemiptera, which consists of very important pests and vectors, which cause serious economic losses to humans. This study was done by Chandani E.Wegiriya and Rohan Rajapaksa.

4.2.4 Vulnerability of rice industry, rain fed farming, livestock and water resources in the dry zone of Hambantota district to climate change

This study on vulnerability of four socio-economic systems to Climate Change has been done without access to country or region specific quantitative information on Climate Change, which are not yet available. Therefore, the next best available information, climate change phenomena observed over the recent past, was used as the basis for the study. These observed changes could be most likely resulting from a combination of possible causes; natural global climatic phenomena, local environmental degradation, and local anthropogenic activity enhancing green house gases (Climate Change). Though the contribution of Climate Change to the total of observed climate change for the country or the district in not known it is reasonable to assume that at least the types of Climate Change impacts are quite similar to the generally observed climate change impacts. Some consider the magnitude of their impacts to be stronger.

The types of Climate Change impacts identified are too many for consideration in this study. Therefore the most apparent form for Sri Lanka, which is intensification of the hydrological cycle, particularly of rainfall occurrences, was selected.

As the study progressed, the relatively uninformed and unprepared manner in which the country manages the already experienced hydrological cycle emerged as a major management issue for consideration in this study. It is no secret that droughts which build up over months and seasons in this country are only recognized often after they have had a substantial toll. So, impact management of extreme rainfall events has been largely limited to provision of relief to overcome their symptoms, with little or no attention to problem avoidance, aversion or adaptation. This leaves us with little background information to go by.

Therefore, the strategy selected was to first study and understand the significance of the rainfall cycle, then see how the past performance of the four systems correlate with the seasonal rainfall, make observations on their vulnerability to rainfall cycle, and finally recommend adaptive/preventive measures. After starting with the study in the field, it became known that the agencies in Hambantota district (same in the rest of the country) do not maintain project/systemwise data on a seasonal basis. Nor do they undertake internal monitoring and evaluation relative to rainfall. Therefore the basis of the selected strategy had to be changed to an assessment/analysis of available information. This study was done by James Handawela, B.V.R.Punyawardena, B.R.S.B.Basnayake, M.A.K.Munasinghe and W.A.K. Karunathilake

4.2.5 An assessment of the climate change vulnerability of Hambantota area to national parks, tourism and industry

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 compared to other areas of the country because of its inherent dry, high temperature and low rainfall situation. 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 habitats, flora, fauna, tourism and industry to the drastic effects of such climate changes. Preliminary studies suggested that reliable numerical data on tourist arrivals and hotel industries are available only for the last couple decades. In late 1980s and early 1990s tourism in Hambantota area was hampered greatly due to insurrection prevailed in that period. Further the area is still far less developed with regard to modern industries. The principal aim of the present work at the commencement of the study programme was to study the patterns of climate changes in terms of temperature and rainfall and their effects on the vegetation, fauna, human interests such as tourism and industry. Consequently, after preliminary studies, it was decided to concern more on the patterns of climate change and, effect of climate change on flora and fauna. This study was done by S.P.Samarakoon, S.Hettiarachchi, C.P.Jayatissa and S.Abeysinghe

4.2.6. Vulnerability of human settlements, women and children and Vulnerability to vector borne diseases in The Hambantota area

Prolonged drought prevailed in Hambantota area from 1998 to the later part of 2002 and the water stress situation experienced even thereafter are indications of regional changes in climate along with changes in socioeconomic factors such as land use change i.e. over development of land for agriculture and settlements by vast destruction of dry zone forests, clearing of other vegetation cover, destabilization of ancient village level small irrigation tanks and demographic shifts along with new settlements resulting in inefficient use of available water resources.

Industrial development is a prerequisite for the creation of off-farm employment opportunities for settlers to raise their standard of living and investment capabilities. The area of industrial development options may be restricted by the quantity and quality of water available in the area. The proposed Southern Area Development Project led by 'Ruhunupura' covering parts of four river basins will demand for the development of more assured sources of water supply for successful implementation.

The envisaged Hambantota Harbour and Airport (at Sooriyawewa, Thanamalwila or Wellawaya) and infra-structure development would create rapid demand for water. Water stress situation would be further aggravated unless effective and well defined integrated water management strategy is developed and implemented and also including rehabilitation of abandoned tanks, enhance the storage capacity of operational reservoirs, introduction of crops with less water requirement, implementation of action plans for conservation of soil, natural vegetation and forest cover, water (irrigation, rain, ground and used water) and trans-basin diversion schemes such as Menik Ganga and Nilwala Ganga in the Wet Zone.

An integrated and well- coordinated action plan is vital to address the effect of potential impact of climate change and to mitigate and arrest the adverse effects of already severely affected inhabitants in the Hambantota area. The most important aspect of this coordinated effort has to be an awareness- raising programmes encompassing all sections of the community and solicit their fullest participation and contribution towards the achievement of the ultimate goal. This study was done by P.W. Mohottala, M.B.A.U.Leelasena and Ranga Kalansooriya

4.2.7 A Research Program to Monitor Quality of Rainwater - Case Study of Kurunegala and Putalama District

Sri Lanka has an average annual rainfall of 2400 mm with a range of 900mm in the dry zone and 5000 mm in the wet zone. The rainfall is bi-modal and varies both seasonally and spatially. In the dry zone more than 2/3rd of the rain falls during the wet season (NE monsoon) from October to March of which 70% falls during the period October to December. The large variation in rainfall experienced due to effects of climate change leads to spatial and seasonal variation in water supply. Change of rain fall due to climatic variation and concentration of rainfall during specific period in different zones causes water shortages during months of low rainfall.

Due to the bimodal (2 seasons) pattern of rainfall in Sri Lanka rain water harvesting practice which collects, store and save rain water during the rainy seasons for usage during the dry season is feasible. People of Sri Lanka have used rainwater for both domestic and agricultural purposes for many centuries. Traditionally rainwater is collected for domestic use from tree trunks using banana or coconut leafs or from rooftops into barrels, domestic containers and small brick tanks. In recent years there has been revival of rainwater harvesting and many research were conducted to improve the technology. In 1995, Community Water Supply and Sanitation project initiated by the government of Sri Lanka with World Bank funds introduced rain water harvesting as a water supply option in Badulla and Matara districts. Since this, government and non- government organisation throughout the country have promoted rain water harvesting technology.

Changers in water availability and accessibility are predicted and experiences due to climate change. A 7% decrease in annual average rain fall in Sri Lanka is been observed over last few years (Chanadrapala, 1997). A larger variation in rainfall pattern is been experienced. Longer dry spells and shorter heavy rainfall is been experienced. The monsoon rains failed last season (Maha 2003) and many of the reservoirs and wells in Kurunegala and Puttlam district is already (at the beginning of the dry season) dry.

Having a rainwater tank in the households enable people to be better prepared for dry spells. Although even the dry zone of Sri Lanka get enough rain fall during the year, usually rainwater is mostly run off and lost the after the rainy season. Rain water harvesting system collects and store water in the households for use during the dry season. Therefore, rainwater harvesting can be used as an effective adaptation measure to over come the irregularities and variation of rain fall predicted due to climate change. Householders can also use the rain water harvesting tank to store water brought from else where when there is no rain, thus increasing the storage capacity in the home and better water security. This study was done by Tanuja Ariyananda

4.2.8 A Study of Climate Change Impacts on Peasant Behaviour and Natural Resources in North Central Province

The Dry Zone accounts for about 60% of the land area, 6.54 million hectares in Sri Lanka. The North Central Province, the largest province in the Dry Zone, consists of two administrative districts, Anuradhapura and Polonnaruwa. Anuradhapura district shares about 10.9% of the country's total land area while the Polonnaruwa shares 5%. The forest cover as a percentage of the total land area in 1985 in the Anuradhapura district was 28.6 while the ratio for the Polonnaruwa district was 53.7. In the year 2000 the share of the forest cover as a percentage of total land area had dropped to 27.5% in the Anuradhapura district and the ratio for the Polonnaruwa district had reduced to 40.9% for the same year. The decline in the forest cover in the Polonnaruwa district was found to be significant as compared to the decline in the forest cover in the Anuradhapura district. The reduction in the forest cover in these two districts could be due to reasons like, migration of war affected people, opening of new villages, and increase in population pressure in the existing settlements, chena cultivation, and extensive mining of forest resources by drought affected farmers.

The Anuradhapura administrative district is divided into 16 Divisional Secretariat Divisions(DS), of which 11 DS divisions are, located basically in the areas of minor irrigation. The chena cultivation, the most traditional system of farming, covers about 25000 ha in the Anuradhapura district. This is totally a rain-fed farming system adopted by the people who do not have lowland and also those who live under irrigation schemes. In case of Polonnaruwa District, the minor irrigation system is not so popular, only 5% of the cultivated area, owing to expansion of Mahaweli Scheme.

The climate change is a global phenomenon. Sri Lankan experience is not an exception. However the dry zone, which is the main agricultural area in the country, is more sensitive to climate changes and the worst affected area. Within the dry zone, the minor irrigation systems, which basically depend on rainwater, are the worst affected by climate changes. Therefore, this study focuses its attention to analyze the impacts of climate changes in areas of minor irrigation.

This study also made an effort to investigate the monthly changes in temperature during the past four decades. Findings proved that there had been significant changes in average monthly temperature. Such changes would affect the cropping pattern, crop calendar and flowering, milking and maturing of crops. Increases in temperature affect the evaporation, humidity and photosynthesis and in general the entire system of the environment. Since this is a long term trend, study of this nature cannot analyze the actual impacts of such changes.

Reduction of rainfall and insufficient irrigation water supply are probably the main issues in the Dry Zone today. The standard of living of farmers depends on the availability of water and land. Data collected from Msahakanadarawa tank showed that out of 44 seasons only in 6 seasons, the total irrigable area was cultivated. Farmers were compelled to adopt upland cultivation during those seasons of insufficient rainfalls. The expansion of chena cultivation always correlated with the reduction in rainfalls and affects the natural environment in an adverse manner.

Two types of solutions can be recommended in order to over come the problem of climate change. First, long term solutions are necessary to improve and protect the entire system in the face of population pressure. Second, Short-term solutions are also necessary as adjustments to maximize the agricultural production in order to improve the standard of living of farmers. This study was done by G.D.Siripala, D.Siripala and Neil Liyanage

4.2.9 Development of rainfall and temperature scenarios for Sri Lanka

The global mean temperature would rise in the range of 1.4 – 5.8 ^{0}C by the year 2100 under the SRES scenarios. This large range of uncertainties is probably due to the uncertainties involved in the global emissions of greenhouse gases in the future. IPCC has proposed four scenario families (SRES scenarios), which are further divided into several storylines (A1FI, B1, A2 etc.). Due to this large range of uncertainties of emissions, two extreme storylines (A1FI and B1) have been considered to project rainfall and temperature scenarios in Sri Lanka. B1 is the cleaner approach, in which less emission and less economic growth are expected while A1FI is the more unpleasant approach, in which more emissions and rapid economic growth are expected.

Average maximum temperature increments over the baseline would be about 0.4 ^{0}C and 0.8 to 1.1 ^{0}C in the years 2025 and 2050 respectively. Average minimum temperature increments over the baseline would be about 0.5 ^{0}C and 0.8 to 1.4 ^{0}C in the years 2025 and 2050 respectively. These increments are under the both A1FI and B1 SRES scenarios. As expected with the climate change, the minimum temperature would increase much faster than the maximum temperature in the future.

According to the present study, rainfall would be increased in both NEM and SWM seasons under the both A1FI and B1 scenarios with different magnitudes. The rainfall change (over the baseline) in NEM season is quite small (about 20 mm in 2025 and 50 – 70 mm in 2050) with compared to change in SWM season (190 - 200 mm in 2025 and 350 – 520 mm in 2050) season. It is clearly observed that the areal extents of which the highest rainfalls are confined would certainly be increased in the future. However in addition to this inclination of rainfall with respect to the baseline averages, rainfall has shown some temporal variability in the recent past and this behavior would be much more persistent in the future with the climate change. This study was done by B.R.S.B.Basnayake, K.H.M.S.Premalal and W.A.L.Kumara

4.2.10 Screening of different rice varieties of Sri Lanka for their response to increasing atmospheric carbon dioxide

Rice is the staple food of Sri Lanka and therefore is its most important annual agricultural crop. However, the land area under rice cultivation is decreasing as a result of many reasons such as conversion of rice lands for human settlement and shortage of labour for rice production. Therefore, rice yields of the remaining areas under cultivation have to increase substantially to meet the increased demand for rice in the future.

The above increases in rice yield have to be achieved in the future under a changing climate. One aspect of climate change that has been identified clearly is the continuous increase in atmospheric carbon dioxide concentration. Atmospheric carbon dioxide (CO_2) concentration has been rising during the last two centuries since beginning of the industrial revolution (Houghton, 1997). This occurs due to various human activities such as burning of fossil fuels, deforestation and burning of biomass. This rise has become exponential during the last 50 years with a rate of 2.4% per year (Goudriaan, 1995). The current atmospheric CO_2 concentration is around 365 μmol mol^{-1} and this is expected to rise above 700 μmol mol^{-1} by the end of the present century (Watson et al., 1995; Houghton, 1997), despite several policy initiatives to control CO_2 emissions.

This rise in CO_2 would have a significant impact on the productivity of agricultural crops (Kimball, 1983; Drake et al., 1997), including rice. This is because CO_2 is an essential substrate for photosynthesis, which is the primary physiological process responsible biomass production and yield formation in crops. Therefore, it is important to quantify the response of physiological processes, biomass production and yield formation of major agricultural crops to elevated atmospheric CO_2. A large body of experimental evidence exits to show that biomass production and yield of C_3 crops (including rice) increase with increasing CO_2 (Kimball, 1983; Lawlor and Mitchell, 1991). In the specific case of rice in Sri Lanka, De Costa et al. (2002) have shown that the yield of a three-month variety (i.e. BG300) increases in response to an increase of CO_2 by 200 ppm (which is expected to occur during the middle of this century) from the current ambient CO_2 level. The respective yield increases during the maha and yala seasons were 24% and 38% respectively.

Therefore, the above results provide an opportunity/option for increasing the future rice production of Sri Lanka in the face of climate change. It has been shown that the yield response of crops to elevated CO_2 varies for different varieties, with certain varieties showing greater responses than the rest. Such highly-responsive varieties could be selected and used as parents in breeding programmes to produce high-yielding varieties in the future. This will be vitally-important to ensure food security of Sri Lanka in the face of future climate change. However, no work has been done to explore the inter-varietal variation in the response to elevated atmospheric CO_2 within the Sri Lankan rice germplasm. This study was done by R.M.Indranie Abeywardena and Supervised by Dr.W.A.J.M.De Costa

4.2.11. Adapting Cultural measures of banana cultivation to climatic changes in low country dry zone

Banana is one of the most popular fruit crops of the island. In addition to that it is used as a vegetable crop. The production is year round and it is profitable in all parts of the country except in higher elevations.

From the ancient time, farmers in low country dry zone areas are growing paddy in large scale. But during past (recent) few years farmers are shifting from paddy cultivation to other cash crops due to unprofitable condition. With the unexpected climatic change raining pattern shows high variability and long dry periods can be identified according to weather data.

Leaf plays a vital role in both physiological reactions of photosynthesis and evapo-transpiration. This investigation was carried out with the objectives of minimizing water losses by evapo-transpiration by maintaining few leaves without significant effect on yield and to find out number of leaves which determine the highest yield. Leaf removing was practiced just after the male bud differentiation.

Among different treatments applied, remaining 15 leaves /plant showed better performance having highest bunch weight ,highest finger lengt , highest finger girth. The lowest bunch weight was recorded in the treatment of no leaf remaining.

Yield was significantly increased by removing 25% of leaves and effective leaf number for maximum yield was 15 leaves / plant in variety Embul which cultivated under Low Country Dry Zone following high density planting system. This study was done by R. G. S. Iroshini and Supervised by Dr. (Mrs.) S. Weerasinghe & Dr. S. Subasinghe

4.2.12 Climate variability in Hambantota district

Climate is one of the most important limiting factors for agricultural crop production. Agricultural productions are quite sensitive to the ordinary rhythm of the climate (Hare, 1985). Climate is the result of simultaneous effects of many whether variables such as precipitation, surface air temperature, relative humidity, sunshine duration, wind velocity etc (Peiris, 2000). Among these climate variables, rainfall and air temperatures are most important variables, which lead to economy losses of agricultural crops and livestock productions.

Hambantota district is one of three districts in southern province. It is situated in the southeastern end of Sri Lanka between the latitudes 6.00N to 6.54N and the longitudes 80.64E to 81.68E. The total extent of the district is 2609km^2. It is 4.0% of the land of Sri Lanka (Statistical Pocket Book, 2002). Half of the boundary of this district covers with the coastal belt of southern part of Sri Lanka and rest with the land. According to the classification of agro-ecological regions the district is categorized as, low country high dry region (DL_5) contributing 1020mm mean annual total rainfall. The mean surface air maximum and minimum temperatures of the district are 30^0C and 24^0C respectively. The economy of this area mainly depends on farming practices of rain fed crops. Coconut, paddy and short term crops are important crops cultivated in this area. Many lakes and irrigation schemes have also been established for the purpose supplying water. Also Hambantota is one of the rapidly urbanizing district among the developing districts of Sri Lanka. Therefore, it is clear that the study of climate variability in this district is important.

The global climate change has strongly influenced the pattern and amount of rainfall and temperature in Hambantota district. All annual temperature parameters (maximum temperature, minimum temperature, mean temperature and diurnal temperature) showed highly significant increasing trend. Significant increasing trend was also found for all four temperature indices for most of the weeks. The rate of increase is the highest for maximum temperature irrespective of the time scale. The maximum temperature has the highest negative significant correlation with rainfall irrespective of time scale. Annual rainfall showed a declining trend. The chance of receiving rainfall in a year below the minimum requirement of water for coconut (1125 mm/year) is around 66%. The amount of rainfall per rainy day (> 0 mm) and per effective rainy day (> 5 mm) showed highly significant declined trend over the years. The probability of having longer dry spells in a year has been increasing. The increasing temperature could demand more water to plants.

Based on the climate analysis it can be recommended that expected future climate conditions would not be suitable for coconut cultivation in Hambantota district. The amount, intensity and length of rainy spell are not sufficient to reserve rain water for future use. The increase of maximum and minimum temperature will seriously affect the development of annual and short-term crops and their potential yield. Thus alternative methods to obtain water such as exploration of ground water is necessary if agriculture to be promoted in Hambantota. The increasing temperature could also lead to more rapid amplification of epidemic spread and other infrastructural activities in Hambantota. This study was done by J.D.K.S. Kularatne and supervised by Dr. T.S.G. Peiris

4.2.13 Effect of rainfall on the pollution problem associated with natural rubber processing factories

Natural rubber collected as latex by tapping the bark of rubber tree (*Hevea brasiliensis*) is one of the excellent raw materials suitable for many industrial products. The 70% of aqueous non-rubber part contains several organic and inorganic compounds. This organic part is responsible for the organic waste load in the rubber industry.

According to Central Bank statistics from 1989 to 2002, the mean annual production of natural rubber in Sri Lanka is about 100 million kg per year. Production of 1 kg of dry rubber, results in approximately 0.18 kg of dissolved chemical oxygen demand (COD) due to organic non-rubber constituents (Anon, 1992). This means that the natural rubber industry in Sri Lanka discharges approximately 18 million kg of COD annually to the environment. As a consequence, the Central Environmental Authority (CEA) of Sri Lanka had identified the natural rubber processing industry as the most significant water polluting industry in the island.

Rubber Research Institute had developed several cost effective wastewater treatment systems for the growing demand of the industry. It is an acceptable fact that the rainfall is the primary factor that decides crop of natural rubber plantation.

The waste load of a factory depends on the rubber production therefore to design a proper wastewater treatment system it is very essential to identify the behavioural pattern of rubber yield and its relationship with the rainfall.

Rubber production, which discharges a considerable amount of waste to the environment, is linked with the rainfall pattern. Therefore any changes in rainfall can affect the pollution problem due to rubber factory effluent.

No marked changes in annual rainfall were observed in the study sites; but temporal changes were observed in monthly rainfall; resulting changes in the annual pattern.

There is evidence of increasing dry spells, which leads to reduce the stream flow, and resulting an aggravated pollution problem. Human contributions make this problem more complex.

The treatment systems designed for rubber factories are almost biological and some times failed to operate to the satisfaction of factory personals as they are highly affected with varying waste loads due to varying production of dry rubber which is dependent on rainfall.

During dry weather periods the management is trying to cope up with the days of tapping lost, during the wet period by tapping during the dry period. This makes the condition worst, resulting sudden high waste loads which results adverse effects in streams when water is limited to flush the wastes away. These sudden fluctuations of waste loads also affect the satisfactory operations of biological wastewater treatment systems.

Hence avoiding the fluctuations in waste loads is an adaptation measure in this regard.

Rainguards recommended by the Rubber Research Institute is very important in this regard to maintain a standard production through out the year.

It is also important to get the views of the people who are living in the affected areas in planning effective waste removal systems to combat adverse effects of weather conditions on the pollution problem created by rubber factory effluent. This study was done by K.V.V.S. Kudaligama and supervised by Mrs. Wasana Wijesuriya, & Mr. W. M. Thurul

4.2.14 Changing rates of interest, prices and the cost to the climate with specialreference to rubber cultivation

This study analyzed the effect of the market interest rate and market prices for rubber on the time of uprooting. As the time of uprooting shortens, the benefit of key function of the rubber tree, viz., Carbon Dioxide (CO_2) sequestration is forgone. The study treats the benefit foregone as a cost to the climate attempts to quantify and value the cost in monetary terms.

Primary and secondary data were used in the study. Primary data were collected from a questionnaire survey of 50 estates in the country. Secondary data were obtained from past studies.

The study reveals that the interest rate has a clear impact on rotation length. Higher the rate, lower is the rotation period. However, same cannot be concluded with the prices. Effect of prices is rather indeterminate and depends on the level of interest that prevails.

The results give the cost to the climate in monetary terms. Various policies that influence this environment cost are discussed. The benefits that could be obtained from carbon trading options such as Kyoto Protocol have also been discussed. This study was by Jagath Chandima Edirisinghe & N.G.S.C Ratnasiri and supervised by Dr. (Ms.) A. M. T. P. Athauda

4.2.15 Impact of climate change on yield of rubber

Rubber is the second important plantation crop in Sri Lanka and its management practices are linked with the weather pattern. The contribution of rubber to the national GDP is about 5%. It is an accepted fact that the global climate is changing due to various reasons. There are evidences that there is a change in the rainfall pattern in Sri Lanka. Some of the scientists in Sri Lanka have done research on relationship between rainfall and rubber yield. There are few studies have been done on the relationships between other meteorological factors and latex yield. There are hardly any researches done on the combine effect of the climatic parameters on rubber yield. With this background this study focus on the relationship between individual meteorological factors and latex yield and the combine effect of the climatic factors on rubber yield. Further any significant changes in the climate and there impact on rubber yield is identified.

Simple linear regression analysis technique was employed to find the individual impact of meteorological factors on latex yield and multiple regressions was employed to assess the combined effect of meteorological factors. Descriptive statistical methods, probability analysis and regression techniques were employed to investigate any change in the rainfall pattern. Using regression techniques any significant temporal variation in other meteorological factors was identified.

There are evidences that there is a significant decline in the total annual rainfall with the time. A change in the onset, cease and length of the first spell of rain was identified. The risk of having long dry spells has increased. There is a significant rise in temperature, which may influence rubber yield if it continues further. However, morning relative and sunshine duration has increased with the time. This may lead to possible increase in rubber production in future. Further it was revealed that the effect of the climate is different in different periods. The influence of meteorological factors on latex yield is less compared to the other factors influencing yield of rubber (management practices, type of clone and tapper etc.). Therefore, rubber will be able to combat against any unfavourable climate change in the future, by practicing proper management practices recommended by Rubber Research Institute of Sri Lanka. This study was done by Keminda Herath and supervised by Mrs. Wasana Wijesuriya

4.2.16 Recent changes of extreme rainfall events due to climate change in Wet and Intermediate zones of Sri Lanka

As rainfall of Sri Lanka is largely governed by three different mechanisms, namely convectional, monsoonal and weather systems in the lower atmosphere, it is not uncommon to find high spatial and temporal variability of it. Nevertheless, the physical and biological environment of the country was able to cope up the impact of such variability owing to their sustainable nature. In the recent past, it has been observed that extreme rainfall events recur more often resulting high variability of seasonal rainfall. When extreme rainfall events are experienced natural hazard like floods, droughts and landslides are inevitable. Such situations adversely influence the society in particular the agricultural economy of the country.

The resistance of the agricultural systems for extreme rainfall events varies in different climatic zones. In the dry zone where major and minor irrigation schemes exist, the extremely high rainfall events can be managed through surface storage while survival during extreme dry situations can be maintained through life saving irrigation either by surface storage or shallow ground water. However, in Wet and Intermediate zones where rainfed agricultural systems are predominant, the sensitivity or the vulnerability of the system for extreme rainfall situations are high. Moreover, effects of high rainfall occurrences will cause hazardous situations such as droughts, floods and landslides, which will directly affect the economy and the social stability.

This study aimed at assessing the occurrences of extreme rainfall events (excessive rainfall events and drought conditions) over the past three decades. Daily rainfall data for 36 years (1964-1999) from 8 locations distributed over wet and intermediate zone were analysed. The results do not provide evidence to suggest long-term change in number of excessive rainfall events and the annual basis 99th and 90th percentiles of the daily rainfall values. Excessive rainfall events show some trend over last 10-year period (during 1990-1999). Trend analysis suggested that no changes in dry day occurrences over the 36-year period. Anyway, time series trend analyses for dry day occurrences over last 10 years period have shown a decreasing trend at all the locations. This study was done by H. K. Kadupitiya and Priyanjani Madana Supervised by Mr. kapila Munasinghe and Dr. B. V. R. Punyawardena

4.2.17 Trends in seasonal rainfall and behaviors of growing season characteristics due to climate change in Wet and Intermediate zones of Sri Lanka

Agriculture production potential in both Wet and Intermediate Zones mainly depend on the variability of seasonal rainfall to catchments and the characteristics of the season like onset, withdrawal and the length. It is a common belief that rainfall regime in these two regions has undergone a considerable change. However, a little number of comprehensive studies has been carried out to ascertain whether such changes exist. Therefore, this study was undertaken with the objectives of identifying the changes in characteristics of the season and the trends of seasonal rainfall over the time in 3 stations named Welimada, Henarathgoda and Duckwari Estate. The descriptive statistical method was used to analyze the data to recognize the changes in parameter values of distribution of data. Nonparametric procedure Wilcoxon rank sum test was used to test the hypothesis on deviations from standard week. Time series trend analysis was performed to study the changes over time. The probability of time of onset of Yala season in Locations Duckwari, Henarathgoda is higher in standard week 9 and week 14^{th}. In the case of Welimada, the probability of onset is higher in 9^{th} and 13^{th} week. The probability distribution of time of onset of Maha rains is right skewed and hence the probability for onset is higher from 35^{th} to 39^{th} week in all 3 locations. The probability of time of withdrawal of Yala season in location Duckwari is highest in the 19^{th} week and it is highest in 19^{th} and 26^{th} week in location Henarathgoda. However, withdrawal of Yala season in Welimada is comparatively earlier as it is higher in 16^{th} and 19^{th} weeks. The time of withdrawal of Maha season is 53 week in locations Duckwari and Welimada and it is highest in 51^{st} week in Henarathgoda. The length of Yala season is 8 weeks or 10 weeks in location Duckwari and it is 10 weeks in location Henarathgoda. However, in Location Welimada, the length would be 5 to 9 weeks that is shorter compared to other two locations situated in the wet zone. The length of Maha Yala season is from 14 weeks to 17 weeks in location Duckwari and it is 13 weeks to 16 weeks in location Henarathgoda. However, in Location Welimada, the length would be 12 to 16 weeks. The results of regression analysis show the seasonal characteristics of both Yala and Maha seasons have not changed over time. Total rainfall data of Yala season of all 3 stations have shown a decreasing trend. The results of analysis of total Maha rains indicate no trend in the total rainfall except Duckwari Estate. This study was done by Priyanjani Madana and H.K.Kadupitiya and supervised by Dr. B.V.R.Punyawardena & Kapila Munasinghe

4.2.18 Climate changes in the coastal region of Ampara district and its impacts on paddy production

This study was done by S.H.A.Ashraff and supervised by Mr. A.M.Razmy

4.2.19 Impacts of climate change in rice farming in the low country wet zone

Rice is the main agricultural commodity as well as the main agricultural production of

Sri Lanka. A significant proportion of the Gross domestic production of the country comes from paddy and related products. There are mainly three types of paddy cultivation systems in the country based on irrigation methods namely, irrigated systems, semi irrigated systems and rain fed systems. A majority of irrigated schemes is situated in the dry zone where as most of the rain fed cultivation is done in the wet zone.

The study area is in the Low Country wet Zone (WL3) Agro ecological Region which is mainly located in south- western part of the country. It is characterized by near bimodal pattern of rainfall with two major rainfall seasons, *Yala* and *Maha.* The annual average rainfall of the low country wet-zone according to 75% probability level ranges between 1700 –3200 mm. About two to three decades back this area accounted for about 30-40% of total paddy production in the country (Rupasena 1990).

The analysis of rainfall data shows that there is no significant deviation of annual average rainfall in the study area. Hence it can be concluded that there is no significant influence of climate change in large- scale abandonment of rice lands in the low country wet zone. In addition to various socio economic reasons, numerous human induced development activities greatly contribute for the gradual declining of paddy extent in the area. Water shortage reported in larger paddy tracts is closely related to stream- bed deepening which is a direct consequence of sand mining of stream beds. Filling of rice lands for development activities should not be encouraged but, where it is a sheer necessacity, providing adequate drainage is very important without which crop damage due to floods and poor drainage can become major threats for rice farming. The rice lands, which were previously thought to be homogeneous, represent diverse hydrological conditions and hence with very clear understanding of these conditions, productivity enhancement of rice lands could be ensured by adoption of suitable land and crop management technologies either for improved rice production or crop diversification. An introduction of long aged rice verities (one season), with correct time of planting would ensure some farmer income in flood prone rice lands from which farmers are otherwise deprived of any income during both seasons due to flood damage. This study was done by Nimal Jayaratne Banda and supervised by Mr. T.M.J.Bandara

4.2.20. The relationship between the occurrences of El-Nino events and Brown Plant Hopper (BPH) outbreaks in the dry zone of Sri Lanka

Rice (*Oryza sataiva*) occupies an important position in the economy of Sri Lanka as the staple food, where per capita consumption fluctuated around 100kg/year (Abeysiriwardena, 2000). In the average Sri Lankan diet, rice accounts for about 45% of the per capita calorie and 45% of the per capita protein requirement. Rice is the single most important annual crop occupying 33% of the total cultivated area (Sandanayaka et al., 1990), which provides the livelihood for more than 800,000 farm families (Palipane, 2000). Currently Sri Lanka has 730,000 ha of land suitable for rice cultivation and average of 560,000 ha are cultivated during maha and 310,000 ha in yala. The average annual extent sown with rice is 870,000 ha, accounting for an annual cropping intensity of 119%. Sri Lanka produces an average of 2.6 million tons of rough rice (Abeysiriwardena and Dissanayaka, 2000), which accounts for about 95% of the national rice requirement. It is projected that the demand for rice will increase at 1.1% per year over the next decade. Therfore, cropping intensity and the national average yield should rise to 135% and 5t/ha levels from the current 119% and 3.6t/ha respectively to achieve this growth rate of production (Abeysiriwardena, 2000).

The control of insect pest damage is a strongly felt need to achieve this target. In Sri Lanka, nearly 10-20% of the annual rice production is lost due to insect pest damage, particularly of brown plant hopper, thrips, leaf folder, gall midge, stem borer and paddy bug (Nugaliyadde et al., 2000) which are considered as major pest of rice in Sri Lanka (Kudagamege and Nugaliyadda, 1990).

The Department of Agriculture has adopted several strategies to minimize the impact of these biotic stresses though a need has arisen to establish a surveillance and forecasting system for rice pest to help farmers to make prompt and correct decisions to manage their pest problems. Department of Agriculture has developed package of practices to control the pest successfully. Integrated pest management (IPM) approach was developed in very recent past for pest management in various crops is presently adopted even for BPH control in these districts given successful result. In spite of these technological advances occasional severe outbreaks of BPH is still inevitable in some years and it could be due to arisen of favorable weather conditions for multiplication and survival of BPH, farmer negligence including lack of monitoring of pest and poor knowledge on control of this pest. However, the reasons for occurrence of BPH outbreak are not yet known. However, high humidity, high cloudiness, high temperature and high rainfall are favourable climatic conditions for reproduction of the pest (Matteson et al.1994). Occurrences of variability in climatic conditions are very frequent in recent time. In view of the above reasons this study was conducted with an objective of finding whether there is any link with the El- Nino events and the climatic change on the occurrence of BPH outbreaks and to use such relationships if any, as a tool for early warning

Amount of RF, RF distribution pattern, temperature, RH, and wet days per month could individually or collectively responsible for the occurrence of BPH outbreaks in selected area. The favorable environment conditions required for the occurrence of BPH outbreaks would be maximum RF, high temperature and high RH in extended yala or maha seasons that having low RF and lowest wet days per month especially in December and June i.e. month immediately before the symptoms of BPH outbreaks are appeared in cultivation season at particular location. Therefore, if the above climatic conditions are formed within the cultivation season farmers, researchers and extension officers should be alert and it should have a monitoring programme in the field to apply necessary control measures when and if it is really needed. Then farmer will be able to cut down the cost of production considerably. This study was done by W.R.W.M.S.N.P.Weerakoon and supervised by Mr. K.M.Senevirathna Banda

4.2.21 Adaptability/Stability of different rubber genotypes for agro-climatic variability of Sri Lanka

Sri Lanka being a tropical country rainfall is a very important factor in determining growth and yield of crop plants.Rubber (*Hevea brasiliensis)* is an economically important crop in the humid tropics, not only as a natural rubber producer, but also as a sustainable agro-forestry system, which is almost equivalent to native rainforest system. It forms an important tree crop plantation, which provides reproducible stable ecological system and gives high economic value, than natural forests, by producing natural rubber (1:4 cis polyisoprene) which is ecological friendly industrial raw material. *Hevea brasiliensis* is mainly grown in the low country wet zone (WL) in Sri Lanka. Recently government has taken steps to expand rubber cultivation in relatively drier areas in Monaragala and Batticalo districts.

Now it is well known that the climate of the earth is changing. This will make changes in Agro-climatic conditions in Sri Lanka with associated changes in growth and economic performance of rubber. It was reported that Sri Lanka would experience extreme rainfall intensities and warmer temperatures due to this climatic changes and possibility of ten percent increase in the length of dry and wet seasons per year, in the main planting areas (Plantation world – December 2002).

Two experiments were conducted to study the effect of the environment on rubber cultivation. In the first experiment, fifteen new Hevea clones which were planted in eight different sites in 1998 were studied to select stable clones for wide range of agro-climatic variability. The analysis of variance indicated the presence of significant genetic, environmental and genotype environment interaction for 5th year girth measurement. Variance of clones over environments used as a stability indicies. Mean stability and the mean performance were used to categorised the fifteen clones into four groups with different levels of mean performances and stabilities. The clones RRISL 215 and RRISL 217 were shown to be highly stable over all the environments with high mean performance.

In the second experiment, the influence of the rainfall on rubber yield of two popular rubber clones RRIC 100 on RRI 121 was studied. It showed that the yield of RRIC 121 was influenced by the Rainfall factor but not in RRIC 100. This study was done by S.P.Withanage and supervised by Dr.D.P.S.T.G.Attanayake

4.2.22 Influence Of Changing Weather Patterns On Earth Movements: A Case Study Of The Puwakgahawela Area

The study was based on the recent earth-slip that occurred in Puwakgahawela on the one hand and on the other hand weather-changing patterns (Rainfall and Temperature) of the same area.

A devastating earth-slip took place at the above hamlet, on the 5th of October 2002, causing copious environmental and socioeconomic impacts. This was one of the major natural disasters in this part of the island. The study area is located in Imbulpe divisional secretariat, Balangoda electorate in the Ratnapura district, and is in close proximity to the Sabaragamuwa University of Sri Lanka. The earth-slip hit area comprises about 60 households with 342 family members. The Sabaragamuwa University Centre for Environment and Sustainable Development (SUCEDS) implemented a research study to monitor the earth movements at the earth slip affected area using surveying techniques. Primary data were mainly used for this study. Having inspected the earth-slip struck area; suitable locations were identified for the detection of possible earth movement (i.e. 16 observation points). Readings were taken to the 16 points at regular intervals (once a month) with respect to the established ground control points (i.e. 3 ground control points) on either sides of the causeway of the stream. The resultant displacements of earth were then calculated using Euclidiance distance. This research disclosed that all the observation points showed significant earth movements within a short period of time.

There is increasing trend in the rainfall in the Puwakgahawela area. The predicted recurrent interval for the rainfall is five years within which two peaks and two falls were identified.

The minimum, maximum and average temperatures of the interested area show decreasing, increasing and decreasing trends respectively. This was carried out by E.P.N.Udaya Kumara and supervised by Prof. I.K.Perera

4.2.23 Estimation Of Global Warming Damage Cost Due To The Forest Fires In The Imbulpe Divisional Secretariat, 2003 In Sri Lanka

The scope of the study was to estimate the global warming damage costs caused by man made catastrophic forest fires in the Imbulpe divisional secretariat division (23140 ha), Balangoda electorate in the Ratnapura district in Sri Lanka in respect of the year 2003. The climatic forest fires occur every year during the period June to mid October in this area, creating numerous environmental and socio-economic problems. Some of these issues have been identified and are listed below; decline of water table, extinction of endemic flora and fauna species, loss of bio diversity and pollution of air, water, and land. Occasionally people are also rendered homeless.

Even though the gravity of the forest fires in this region had been devastating every year the majority of the researchers did not take this aspect into their consideration. Hence to combat this menace the Sabaragamuwa University Centre for Environment and Sustainable Development (SUCEDS) had launched a number of projects since the year 2000 and the current study is one such project, which was carried out with the courtesy of the Climate Change Enabling Activity (Phase II) Project of the Ministry of Environment and Natural Resources, Sri Lanka.

To accomplish this task primary data such as household surveys and land surveying techniques were mainly used. In addition secondary data such as maps and previous reports pertaining to the area were used. Finally using Turner's evaluation method (94) the damage to each affected forest type in the area was identified and corresponding monitory value was established. Due to these forest fires the global warming damage costs based on lost carbon sequestration function was Rs. 126.5 million.

Further this research disclosed that the main reasons for such forest fires were fires set out for unknown reasons, fires to prepare fresh grazing land for cattle feeding, hunters also set fire to forests for poaching of wild animals, fires caused by butt-ends of cigarettes and fires set to clear virgin forests for agricultural purposes. This study was carried out by E.P.N.Udaya Kumara and supervised by Prof.I.K.Perera

4.2.24 Impact Of Changing Rainfall Pattern On Rainfed Paddy Cultivation- (Case Study In Kamburupitiya)

Paddy is the staple food in the Sri Lanka. It is a crop which highly sensitive to the rainfall changes. Kamburupitiya is a divisional secretarial area with large number paddy farming peasant in Matara district. More than one third of paddy lands are cultivated under pure rain fed conditions. More than sixty percent of paddy lands are less than 2 ac in size and average size is about 1.7 ac.

According to latest research findings amount of rainfall and rainfall distribution has changed due to effects of global environmental changes. Yala and Maha paddy growing season are planned considering rainfall pattern of the country. However those past adjustment never match with present rainfall pattern .The incompatibility of rain fall pattern and cropping pattern is been considered as a main cause for substantial yield reduction of paddy crop. The research has one main objective and two specific objectives. This research carried out to find out the most appropriate cropping pattern which perfectly match with current rainfall pattern and specific physiological phases of the rice plant this is the main objective of the research. The specific objectives of the research understand effects of rainfall change on input application and finding out yield loss due to incompatibility of climatic changes and farm practices.

The research conduct in Kamburupitiya divisional secretariat area. Both Primary and secondary data were obtained to achieve objectives. Primary data were collected through pre tested structured questionnaire to achieve specific objectives. Secondary data from Mapalana meteorological station was utilized to achieve main objective. Descriptive and inferential statistical method was used to analyse data related to specific objectives. Main objective related data were analysed using markov chain analysis package based on micro soft excel.

Rainfall changes have affected on cultural practices, seed paddy broad casting and harvesting significantly than other cultural practices. Farmer has not shown successful adoption against climatic changes in respect to these two cultural practises. Variation in seed paddy broadcasting and harvesting gaps due to rainfall changes are higher in yala season than Maha season in recent years. Thus these unexpected climatic effects have increased from year to year.Farmers have to incurred Rs 491.41 surplus cost per one acre of paddy cultivation due to unexpected climatic variation. It increases unit production cost from Rs.5.69 to 5.90.

Rainfall distribution in Kamburupitiya fixed with bi-modal pattern. All twelve month of the year can be considered as wet month for upland crop but this level of rainfall not sufficient for rice cultivation especially in critical period. Critical month of paddy cultivation August, October, and February showed increasing trends in rainfall and May showed decreasing trend. It is most appropriate to establish their paddy in between April 30 and May 6 by pure rain fed farmers using short duration paddy varieties for yala season. In maha season rain fed farmers to be established crop with long duration paddy varieties within second week of Octomber.
Overall distribution of wet spell with in both season of yala and maha are match with initial growth stages of rice plant. However after flowering stage some dry condition occurs, may negatively affect on the crop yield in the both season. This study was carried out by Y.Y.Kalyana De Silva and H.D.A.C.Bandula supervised by Dr. Mangala De Zoysa

4.2.25 Effect of Elevated CO_2 Levels on Epiphytic Microbial Populations of the Phyllosphere of Rice in Relation to Biological Control of Rice Diseases

Management of rice diseases is a major problem in rice growing areas of the world. Biological control of rice diseases is a significant part of integrated disease management and commonly accepted as an environmentally friendly procedure. Solitary and bio film bound microorganisms, as epiphytes, play a crucial role of disease prevention in natural conditions. Majority of them are saprophytic bacteria and fungi. Population structure and composition of the antagonistic microbes on rice phylloplane can be utilized for rice disease management.

Present study was conducted to determine the epiphytic microbial population dynamics of rice phyllosphere under elevated CO_2 levels and also to determine the effect of elevated CO_2 levels on natural antagonistic epiphytes of rice pathogens. For this study, three improved varieties of rice grown in Sri Lanka were used, namely BG-300, BG-357, BG-379-2. These varieties were grown under three different environmental conditions or treatments; namely elevated CO_2 (T1), ambient CO_2 (T2) and open field conditions with ambient CO_2 (T3).

Microbial population densities on the rice phyllosphere of three rice varieties under the three environmental conditions were estimated for two rice growing seasons when the rice plants are at four different growth stages.

Results of the study revealed that, there is no significant difference in epiphytic microbial population densities under elevated CO_2 levels compared with ambient CO_2 levels. However, in both seasons, rice plants of different growth stages showed a significant difference in their bacterial and fungal population densities. Bacterial and fungal diversity were significantly higher in the early vegetative stage of rice in the first growth season but this tendency was not shown in the second growth season. Twenty different bacterial and 15 different fungal isolates obtained from season 1 were subjected to *in vitro* antagonism with *Magnapothe grisea.* Bacterial isolates did not show a significant level of *in vitro* antagonism against the rice blast pathogen. However, 16 fungal isolates obtained from two seasons showed more than 50% *in vitro* growth inhibition of *M. grisea.* Occurrence of antagonists showed no influence by different treatment conditions, rice varieties, growth stages or their interaction effects. This study was carried out by Dr. (Mrs.) Devika M. De Costa

4.3 STUDIES LEADING TO THE PREPARATION OF NATIONAL PROGRAMS TO ADDRESS CLIMATE CHANGE IMPROVEMENT OF EMISSION FACTORS

A number of studies undertaken under the senior research program and junior research program that have focused on studies leading to the preparation of national programs to address climate change improvement of emission factors. Abstracts and summary of findings of the studies undertaken by the project are given below:

4.3.1 Boiler survey and development of emission factor in desiccated coconut industry in Sri Lanka

Sri Lankan Desiccated Coconut (DC) sector contributes 2 % to Gross National Products

(GNP) being the second largest DC supplier to the world. By doing so, it guaranteed an annual foreign income of over US$ 65 Million. The sector consumes approximately 10 GWh of electricity from the national grid and around 12 million liters of fuel oil annually. The cost of this oil at current price of Rs. 24.00 per liter is estimated to be over Rs. 275 million in foreign exchange.

Boilers provide most of Sri Lanka's thermal power requirement in factories. Most of boilers operate at lower efficiencies than what they should be. As a result, most of the boiler systems contribute highly to the Green Hose Gases (GHG) emission in Sri Lanka. There is no proper record of number of boilers used in factories, making it is difficult to provide options for GHG mitigation.

To overcome some of these barriers and to quantify and identify the number of boilers and their operating locations in the Sri Lankan industries and to estimate the GHG emissions from the boilers as the first step, a pilot boiler survey was conducted in the DC sector. During the survey, each and every DC factory was visited and the factory data was collected and the emission parameters were measured in order to quantify the GHG emission and to propose the possible GHG mitigating options.

This survey is a pioneering effort in Sri Lanka and this is mainly focused on analyzing the present status of boiler usage in DC sector, GHG emission from boilers in DC factories and giving feedback to boiler users on the current performance level and mitigating options. Another main goal of this survey is to develop a database of the DC sector in order to provide necessary information to equipment suppliers and other stakeholders.

GHG estimation has been finalized, based on preliminary data collections at the factories, for which three calculation techniques were used. They are (Intergovernmental Panel of Climate Change (IPCC) guidelines, fuel oil usage basis and flue volume basis of boilers.

According to the summarized final results of this project, about 72% of DC factories have boilers in their installations. Their main source of energy is imported fossil fuels, which are very sensitive to highly changing market prices. Average daily fuel consumption of a mill is about 1000 liters. Most of the factories operate around 200 days per year.

Most of the factory boilers in this sector operate at low efficiencies as low as 83 %, which can be easily increased to well above 85%. With the increasing trend of oil prices, the energy cost component plays a major role in the production cost. Hence, an efficiency improvement in boilers assists in cutting down the increasing production cost. Based on our survey, it has been calculated the total GHG emission from DC sector is around 25,000 tons/year. Also it was noticed that, GHG emission has a close link to fuel oil usage. Therefore, any reduction of fuel oil usage will bring down the GHG emissions from this sector.

In addition to the GHG emission estimation and boiler data collection, the survey revealed other vital information of the DC sector in Sri Lanka such as DC dryer details, human resources details, maintenance details, etc. Further, this GHG estimation verifies the other GHG estimations done for the sector, especially the GHG estimation done by Industrial Services Bureau in early 2003 with the assistance of Asian Institute of Technology (AIT) Thailand.

The other indirect benefits of the survey are as follows; Gathered data during the survey will help in resource planning and the technology up- grading in the sector. Also this data will trigger further studies in the DC sector on Energy and Environment. Finally it is recommended to use the same methodology to other industrial sectors too in order to have a precise estimation of GHG in the entire industrial sector. This study was done by Mr. Gamini Senanayake

4.3.2 Quantification of carbon fixing capability of rubber crop and its adaptation to climate change

This report presents the results of a fifteen months research programme under the Climate Change Enabling Activity (Phase II) Project of the Ministry of Environment & Natural Resources. It aimed to explore the potential capability of the rubber plantations in Sri Lanka for the mitigation option of climate change with threefold objectives, viz. firstly to develop simple protocol to assess the carbon fixing capability of rubber, secondly to quantify the growth and development of rubber under different climatic regimes and finally to assess the capability of carbon fixation of rubber with respect to different climatic regimes, planting density and genotypes.

Information required for the study programme was collected through nondestructive growth assessment in existing rubber plantations, destructive growth analyses of rubber trees due for uprooting and collection of growth and yield data recorded in previous experiments. The study was focused on aboveground components of rubber plants with that girth/diameter of the main trunk, total height, wood density and, biomass composition and the levels of organic carbon in different aboveground components were assessed.

Two simple mechanistic models were developed to estimate the unsawn timber production of a rubber tree based on 1) tree diameter and 2) both tree diameter and total height. However, the preference was given to the model based only on tree diameter due to its simplicity and fact that tree diameter and the total height are the parameters closely associated with each other. Knowing wood density and the proportions of biomass and organic carbon contents in aboveground components, biomass and the amount of carbon fixed in the rubber tree were assessed. In order to do so, ontogenetic increase in wood density was also modeled. In addition, for the purpose of quick assessments (as required in auditing), models were developed for the direct estimation of biomass and organic carbon content in timber and total aboveground components.

On average for plantations in the wet zone of Sri Lanka, rubber tree achieves a trunk girth of 50.75, 60.03, 70.59, 78.08, 83.89 and 88.64 cm in 7, 10, 15, 20, 25 and 30 years, respectively with that a tree is capable of producing 0.128, 0.231, 0.369, 0.48, 0.574 and 0.656 m3 of timber, 97.35, 178.31, 291.35, 387.61, 473.42 and 552.15 kg of biomass and fixing 39.97, 73.21, 119.61, 159.14, 194.37 and 226.69 kg of atmospheric carbon, respectively. Since the carbon in rubber timber could be considered as a permanent fixing of atmospheric carbon, that amount to be fixed in above age categories were estimated as 35.07, 64.23, 104.94, 139.62, 170.53 and 198.88 kg per tree and 16.63, 28.48, 41.11, 47.48, 49.18 and 53.67 MT per hectare.

Obviously, growth of rubber crop in the traditional low country wet zone (< 300m msl and > 3000 mm rainfall) outperformed that in the low country intermediate zone (<300 msl and > 1500 msl) and high altitudes (600 msl). Hence the amount of timber produced and carbon fixed was 49 % and 31% less in intermediate zone and high altitudes, respectively compared to the values in the wet zone. However, improved management conditions may facilitate the meet this gap.

As reflected by the growth, there are genotypic differences in timber and biomass production hence the amount of carbon fixed. Compared to the genotype RRIC 100, RRIC 121 has shown less growth retardation for the exploitation of latex, hence was capable of producing more timber and fixing more carbon in long-term. Inevitably, increase in planting density affects the growth of the rubber tree hence the timber production and carbon fixation. However on area basis, higher the planting density greater the amount of timber produced and carbon fixed. For instance, planting rubber at a density of 700 trees per hectare has a capacity of producing 118.84 m^3 of timber and fixing 37.24 MT of atmospheric carbon aboveground at 9 years after planting and values are ca.10 % higher than those at 500 trees per hectare.

Future studies could be focused to assess the amount of carbon fixed in underground components of the rubber crop and then to develop new models accordingly. Also, economic analyses are required to assess the importance of rubber crop for mitigation option of climate change under Sri Lankan conditions. This study was done by V.H.L. Rodrigo and A. Nugawela of Rubber Research Institute of Sri Lanka.

4.3.3 Estimation of Methane and Nitrous Oxide Emission from Rice Fields in Low Country Intermediate Zone of Sri Lanka

Rice is the staple food for all the Sri Lankans and therefore rice cultivation has to be intensified to increase the production to feed the growing population in the future. Use of chemical fertilizer particularly N fertilizer with organic manure plays a major role in the intensification. At present, it is estimated that 68% of the methane (a potential green house gas) emission from the Sri Lankan agriculture is from rice cultivation and with the intensification of rice cultivation; there will be an increase in methane and nitrous oxide production from the rice fields. Therefore, an experiment was conducted at the Rice Research and Development Institute, Batalagoda in the Low Country Intermediate Zone of Sri Lanka in 2003 yala season to estimate the potential emission of methane and nitrous oxide gasses from rice fields, when chemical fertilizer and organic manure were applied to high yielding rice varieties. There were four treatments in the experiment, viz. application of organic manure only, application of chemical fertilizer only, application of both organic manure and chemical fertilizer and non-application of either fertilizer or manure. Water level of the field was maintained at 5-6cm high throughout the growing season. Static close chamber method was used to collect air samples and samples were analyzed using Gas Chromatography. There was no detectable level of methane inside the chambers until the 7th week after planting under any of the treatments. Emission of methane from all the treatments was observed at 7th weeks after establishment of the rice crop and emission continued until the standing water was withdrawn. Emission of methane was significantly higher in treated plots than untreated control plots. Emission was not significantly different among the treated plots. However, a combined application of both organic manure and chemical fertilizer, recorded the highest average daily methane emission (0.84 g m^{-2} d^{-1}) and the highest seasonal methane emission (30 g m^{-2} $season^{-1}$) while control plots receiving neither manure nor fertilizer recorded the lowest daily emission (0.81 g m^{-2} d^{-1}) and the lowest seasonal emission (27 g m^{-2} $season^{-1}$). Since there was no significant difference methane emission among the treated plots it can be concluded that intensification in term of higher application of organic manure and inorganic fertilizer will not increase the CH_4 and N_2O emission seriously under flooded conditions. The level of daily emission and total seasonal emission recorded in this experiment is tallies with the IPCC default value for continuously flooded soils. There was a positive relationship between methane emissions vs. number of panicles, shoot and root biomass and grain yield. As such rice varieties that produce minimum productive tillers with high yields (more number of grain per panicle) can be introduced to reduce the methane emission from rice fields. However, nitrous oxide emission was not at a detectable level throughout the growing period in all treatments. Overall results, showed that methane emission takes place only during the latter part of the growing period irrespective of the treatments applied. Therefore experiments should be undertaken to observe the reduction of methane emission if intermittent drying of paddy fields is practice between 7 and 11 weeks after transplanting for 3 1/2 months rice varieties. This study was done by By D N Sirisena, W M J Bandara and D B Wickramasinghe of Rice Research and Development Institute,Batalagoda,Ibbagamuwa,Sri Lanka

4.3.4 Vulnerability to Urban Warming and Adaptation response options for the City of Colombo and suburbs

The rapid urbanization in the tropical regions of the world has brought in its wake many hitherto unknown changes to humans, other life forms and the physical environment (Detwyler & Marcus, 1972). Changes caused by urbanization on humans include diseases associated with crowding (tuberculosis, pneumonia, respiratory illnesses, measles, common cold, etc.), air pollution-related illnesses and psychological and emotional disorders (cf. Harrison & Gibbs, 1976; Lake, *et al*., 1993). Urban effects on other life forms include physiological changes in urban flora and fauna and their diversity (Sukopp & Werner, 1982) and disease and growth retardation in vegetation (Stulpnagel, *et al*., 1990). Urbanization's effects on the physical environment are apparent in air and water quality (U.N., 1992) and the microclimate (cf. Oke, 1987).

Many of the changes brought about by urbanization are well studied by researchers in diverse fields such as medicine, agriculture and engineering. However, the human consequences of climate changes due to urbanization have not been understood nor the knowledge base applied by urban designers, planners and architects. In particular, the energy and bio-climatic implications of urban warming have received very little attention in urban design and planning. This problem is particularly acute in Sri Lanka where urban transition is beginning to gather momentum.

While climate change at a much larger scale (regional and global) is beginning to receive research attention even in Sri Lanka, it is equally important to focus on the microclimate changes induced by human action. Not only is there definite agreement among scientists that these changes are caused by human actions, but the possibility of adaptation due to policy instruments is more promising. Focusing on urban warming at local scale is one way of putting into practice the environmental maxim, "think globally but act locally."

It is in this light the present study quantifies the bio-climatic implications of urban warming in the primate city region of Sri Lanka (the Colombo Metropolitan Region – CMR). Based on empirical measurements of the degree of urban warming the study has developed adaptation options for the consideration of city planners and designers to reduce the negative impacts of urban warming. This effort is seen within the larger context of climate change adaptation, which is a regime Sri Lanka has committed itself to under the Kyoto Protocol. This study was done By Rohinton Emmanuel

4.3.5 Performance Of Hevea Genotypes In The Mid Country High Elevation Region Of Sri Lanka.

The para rubber (*Hevea brasiliensis* Muell. Arg.) is one of the most important plantation crops in Sri Lanka. *Hevea* latex is an economically important natural product, mainly because of its natural rubber, i.e. *cis*-1, 4 Polyisoprene. Rubber plantations, which accounts for 2.5% of the total land extent of the country is similar to natural forests in many attributes. The biomass fixed by a 33 year old stand of tapped trees is ca. 444.9 t/ha, a value nearing for forest ecosystems (Samarappuli 1996). According to Hamwey (2000), the total carbon fixed over a 25 year lifecycle of a rubber plantation is 140 t/ha (Timber~92t, latex~48t). Therefore the impact of rubber plantations on the environment both locally and regionally can be significant.

Mid country high elevation region of Sri Lanka has been identified as one of the potential areas for expansion of rubber cultivation. Performance of four genotypes of Hevea brasiliensis namely RRIC 100, RRIC 102, RRIC 130 and PB 260 were evaluated by studying the growth, yield and their interaction with climate in high elevation regions of Sri Lanka. The clone RRIC 130 showed most promising yield performance (kg/ha/yr) followed by RRIC 100. The clones RRIC 130 and RRIC 100 showed highest girth level at the seventh year after planting. A significant positive correlation between dry rubber yield (g/t/t) and maximum temperature were evident for both RRIC 100 and PB 260. Highest CO_2 assimilation rates were observed between 1200h and 1300h in all clones. Although a high rainfall and high number of rainy days are evident in this area, a remarkably higher number of tapping days have been possible. Hence, the possibility of cultivating rubber up to an elevation of 650m has been demonstrated in this experiment. This study was done by S. T. G. C. de Silva and Supervised by Dr. A. Nugawela

4.3.6 Assessment on potential capability of fixing carbon in different genotypes of the rubber crop

Rubber (*Hevea brasilensis*), being an industrial crop with consistent demand, provides a practical alternative addressing the current needs with an economically viable and environmentally sustainable system (in terms of both latex and timber production). Its social acceptance is obvious by the fact that over 75% of world natural rubber is produced by smallholder sector (IRSG, 2002) and it is the livelihood of large number of people in rubber growing countries. Benefits of rubber cultivation are not second to those of any other crop in economic terms, more particularly due to its capacity to act as a forest. Rubber could provide quality timber once properly treated, and supply significant portion of firewood demand in Sri Lanka.

Clonal/genotypic difference in CO_2 assimilation as a measure of the capacity of fixing carbon has clearly been shown before (Nugawela, 1989), however, all these measurements have been confined to the leaf level on either potted or field grown small plants. Mature rubber crop provides a closed canopy allowing little light to penetrate (Ibrahim, 1991), therefore its capacity in fixing carbon would differ from small plants which behave like discrete units. Also, exploitation of latex could influence the carbon fixing capacity due to its effect on carbon 'sink'. Therefore, the present study aims to establish the genotypic differences in carbon fixing capability of field grown mature rubber cultivations.

Having recognised the important of rubber (*Hevea brasiliensis* Mull. Arg.) in socio-economic context and as a suitable crop for the mitigation of climate change, the present study was conducted with twofold objectives, first to quantify the potential carbon fixation of the mature rubber plantations through the CO2 assimilation and second to establish the genotypic differences of rubber in fixing atmospheric carbon. A mature rubber clearing with two genotypes viz. RRIC 121 and RRIC 100 was selected for the study. CO2 assimilation rates in rubber leaves under varying light levels were monitored dividing the canopy into three strata and parameters of light response curve of photosynthesis were estimated. Leaf area distribution and light attenuation within the canopy were also measured. With previous weather records, the available light for the photosynthesis in different canopy levels was estimated using existing ecophysiological models and then canopy photosynthetic rates calculated.

In general, mature rubber is capable of sequestering 22 MT of carbon per hectare annually. The value estimated for the whole economic lifecycle was 660 MT. The genotype RRIC 121 was superior over RRIC 100 in fixing atmospheric carbon with that the annual rate for RRIC 121 was 160% greater than that of RRIC 100. Differences in the capacity of photosynthetic apparatus and canopy architecture were identified as the reasons for the genotypic differences in carbon sequestering. This study was carried out by Enoka Shiromalee Munasinghe and supervised by Dr. V. H. L. Rodrigo

4.3.7 Accounting For Forest Resource Value As A Carbon Sink In National Income Of Sri Lanka

In the next century climate change resulting from a build up of concentration of Green House Gases in the atmosphere may profoundly affect both human activity and natural ecosystems. Carbon accumulates in forest ecosystems through the absorption of an atmospheric Carbon dioxide and assimilation into biomass. Any activity that affects the amount of biomass in vegetation and soil has potential to sequestration from or to release in to atmosphere.

Factors, which influence carbon absorption rate, include climatic factors, site factors and forest types, density, Biodiversity growth rate and age of forests. Existing forest stands may persist for sometime under a change climate, but long-term responses to climate change will depend on the capacity to adapt to new conditions.

An accelerated a forestation program supported, as financial as well as political aspect is needed in order to upgrade the wood biomass Current status of the forest cover of Sri Lanka has been gradually depleting and presently stands at 22.5% of the total land area. Extent of Natural forest cover has assessed as 1888781ha and man made forests as 135525 ha. Depletion of forest cover contributes to the elevation of CO_2 concentration in the atmosphere. The forest resource serves many diverse functions, which can be listed as economic functions as they contribute to human welfare either directly or indirectly. However, not all the services provided are associated market values; especially the carbon sinking and release play a major role.

Forests in Sri Lanka contribute to mitigation of global climate change through net sequestration of carbon dioxide and maintenance of carbon stocks. So this research is sought to analysis present situation and importance of the stock of forest resource through economic estimation towards the mitigation of climate change. This study was carried out by K.G.S.P. Karunarathna and supervised by Dr. Prashanthi Gunawardene

4.3.8 Greenhouse gas emission of automobiles in Sri Lanka

The water vapour and other greenhouse gases such as CO2 and CH4 in the atmosphere absorb most of the infrared radiation emitted upward by the earth's surface. These gases prevent energy passing directly from the surface out into the space. This energy gives rises all the activities of our climate such as maintaining desired temperature levels, air currents, evaporation, cloud-formation and hence the rainfall. By increasing the ability of the atmosphere to absorb infrared energy, our greenhouse gas emissions disturb the climate activities. This study was carried out by Kalinga Herath and supervised by Mr. Sanjeewa Herath

4.3.9 Release of Methane and Carbondioxide Gases from Municipal Solid Waste Landfills in the Colombo Metropolitan Region.

Sri Lanka is a developing and third world country in south Asia. Population is increasing with their needs. Sri Lanka has a high population density. With an average density of 278 person per sq.km. Sri Lanka the 21 st highest density population in the world, with the average in the western province riding the highest at 1296 per sq. km. An acute land problem is building up in Sri Lanka. Technology is also increasing. As result of this use of non degradable things are increasing.Also Land space is decreased. When considering CMR, solid waste disposal is the biggest environmental problem in Sri Lanka at present. Because this region is more developed than other areas of Sri Lanka land space of houses and other places are limited. Therefore back yard filling practice can't be used.

Local government authorities collect waste from residential places, markets fairs and other institutions. It is the responsibility of Local government authorities Services of solid waste collection is not satisfactory because of poor labor facilities and vehicle problems. Every local government authority has health units. The health unit does solid waste collection. Public health Inspectors guide the solid waste collection in every place. Most of local government authorities in waste collection staff work for 8 hours. However the allocated money for solid waste disposal is not enough. Therefore waste collection service is not 100%. They generally collect waste in once three days.

Current waste management is ineffective in the Sri Lanka. In the research it was found that so many problems are created from haphazard disposal of municipal solid waste. Finance allocation for the disposal of the solid waste is not enough in C.M.R. Also most of laborers are working on contract basis for low salary. Their satisfaction is very poor. Then their service is not well. Because of this they try to do other work to earn money. In addition solid waste disposal equipment and vehicles are not enough and most of these are broken. JCB vehicle is poorly distributed among local authorities. JCB vehicles should be increased among the local authorities because these vehicles are very effective and healthy to collect waste.

The composition of solid waste separately for municipal councils, urban council and pradeshya sabbas were found in the study. According to my results organic composition is higher than other waste composition. Urban council has the highest organic waste composition than other municipalities and Pradeshya sabbas. When considering the molecular formulae for organic waste in municipal council is $C_{356} H_{524} O_{213} N_{16} S_1$, in Pradeshya Sabba $C_{388} H_{584} O_{244} N_{14} S_1$ and urban council $C_{371} H_{551} O_{227} N_{15} S_1$.

It was a found that methane gas emission is 1507.681 m^3 and CO_2 gas emission is 9474.516 m^3 in CMR 2003. When the considering gas emission value, CO_2 value is higher than CH_4. But CH_4 gas contribution for greenhouse effect is higher than Co_2.

This study was carried out by S.M.S.R.K.Samarakoon and supervised by Ms. N.J.G.J.Bandara

4.4 Participate In International Regional Workshops In Order To Build The Capacity In This Area - Capacity Building

Five young officers nominated by the Ministry of Environment and Natural Resources the Department of Meteorology and the Forest Department participated at the Eighth Conference of the Parties (COP-8) – held in New Delhi, India from 23rd October to 01st November 2002. Their participation represented a capacity building exercise on Clean Development Mechanism and negotiations; Intergovernmental Panel on Climate Change (IPCC) activities and Climate Change; greenhouse gas inventory and National Communications; land use change and forestry; and technology transfer and adaptation. The report is at annex 8

4.5 Technical Training To Relevant Officers To Asseesghg Emission Reducing Technology And Emission Factors

4.5.1 Technical Training of officers to assess GHG emission reducing technologies and denvelopment of research skills and researchers

The primary focus of the junior research program was on the Junior Researchers many of who were undertaking research for the first time. The necessary skills were developed by the project by adapting two strategies:

Appointing senior researchers to supervise the studies

By holding periodic training workshops.

Initially a training workshop was held on 28th February 2003, at which the participants were the junior researchers, their supervisors, invited resource persons and officials of the Ministry of Environment and Natural Resources. Three specialists in the field of Climate Change provided the necessary background by making introductory presentations on “Climate change and climate variability” (Mr. G.H.P. Dharmarathne, Deputy Director of the Department of Meteorology), “Climate Change in Sri Lanka (Mr. T.K.Fernando”, Consultant to the climate Change Enabling Activity (Phase II) Project) and “Research Methodology” (Dr. B.M. S. Batagoda, Director of the Climate Change Enabling Activity (Phase II) Project). Following on this the participants were divided into four discussion groups according to the nature of the study and each group was chaired by a resource person.(Annex 9). Each of the researchers made a short presentation on his/her research study and suggestions were made by the invited resource persons and the supervisors to improve the research proposals, methodologies etc.

A second workshop was held on 22nd and 23rd September 2003, to review the progress of the studies (Annex 10). Each presentation was discussed and suggestions were made where appropriate to improve the quality of the report.

A third workshop was held on 21st and 22nd April 2004 where all the researchers were expected to present their reports, to the Director, the Project Management and the Consultants (Annex 11). Only 26 researchers were able to present their reports. The deficiencies in these reports were indicated to the researchers along with the remedial action that was needed to improve their quality.

A fourth workshop was held on the 27th April 2004 (Annex 12) to enable the researchers who could not participate in the earlier workshop, as in the case of the earlier workshops to present their reports (Annex 13) deficiencies in the reports were pointed out and suggestions made to enhance their quality.

A list of trained officers is at Annex 14.

4.5.2 Training of officers, experts on establishing and using country specific emission factor

Several research studies focused on the development of country specific emission factors for industries, automobile, paddy cultivation, rubber plantation, and forestry.

Training on emission factors were carried out together with the progress review of these studies. Several workshops were held to provide an opportunity for the Senior Researchers to present their findings and also to receive comments and exchange ideas with senior specialists and fellow research workers.

The first workshop was held on 26th September 2002 at which each researcher made a presentation on her/ his research study (Annex 15). Each presentation was followed by a discussion during which comments and suggests were made by the invited resource persons and fellow research workers.

A second workshop was held on 07th August 2003 to enable the researchers to present the progress of their studies (Annex 16). This was followed by a third workshop held on 22nd March 2004 (Annex 17) where the researchers presented then the Draft Final Reports to the Director and Project Management (Annex 11). At these workshops each presentation was discussed and suggestions made where appropriate to improve the quality of the report.

4.5.3 Training of senior level officers at both national and provincial level and Creating an awareness of climatic change

Although five seminars of one-day duration were planned seven seminars were held as follows.

The seminars were targeted at district level administrators, Policy makers, University students / staff members and master teachers. As such the audience comprised mainly at highest – level administrators and policy makers in the Monaragala, Badulla, Anuradhapura and Polonnaruwa Districts, senior lecturers and students of the Ruhuna University and master teachers in the Polonnaruwa district. The regional heads of institutions dealing with matters that are important to agriculture, irrigation, health and education also participated.

Many of the participants were selected partly because they contribute to regional and national policy making and partly because they implement, coordinate and monitor government projects pertaining to the development at the provincial and district levels. They also have a large network of village level officers working under them as planning and statistical investigators. There officers would be a great asset to the intended work in the future.

As mentioned earlier, the participants included experienced administrators who by the nature of their education and experience were not well informed about climate change and related issues. However at the seminars they participated enthusiastically in the discussions, based on their experience at the district and provincial levels. Some of the important questions raised at the seminars were:

The recent floods which occurred on 17th May 2003 affecting Rathnapura, Galle and Matara Districts.

Carbon trading and clean development mechanism (CDM)

The availability of carbon fixation data (activity data) relevant to the major crops grown in Sri Lanka, and the possibility of using data from other countries.

Compatibility of CDM with existing policies and practices, and the applicability of carbon trading to mitigate the effects of this problem.

General issues pertaining to climate change such as changes in sea level etc. and the need for an appropriate strategy for adaptation / mitigation of the effects of climate change for a developing country such as Sri Lanka.

The resource persons were drawn from several government institutions as follows

Department of Meteorology

Mr. G.H.P. Dharmaratna,
Senior Deputy Director of Meteorology
Mr. P.M. Jayathilake Banda, Deputy Director of Meteorology
Mr. Lalith chandrapala, Senior Meteorologist, Department of Meteorology
Mr. S.R. Jayasekara, Senior Meteorologist, Department of Meteorology
Dr. B.R.S.B. Basnayake, Senior Meteorologist, Department of Meteorology
Mr. D.A. Jayasinghearachchi, Senior Meteorologist, Department of Meteorology

Ministry of Environment and Natural Resources

Dr. B.M.S. Batagoda,
Director, Ministry of Environment and Natural Resources

Mr. S.S.B. Yalegama,
Assistant Secretary, Ministry of Environment and Natural Resources

Natural Resources Management Centre, Department of Agriculture

Dr. B.V.R. Punyawardane,
Senior Scientist, Natural Resources Management Centre, Department of Agriculture, Peradeniya.

Mr. W.A.K. Karunatilaka,
Research Officer, Agriculture Research Centre, Department of Agriculture, Angunakolapelessa.

The target group at these seminars included the highest – level officials of the provincial and district level administration; University student / staff members and master teachers who were not familiar with the subject of climate change. The seminars created the necessary awareness on climate change among them. At the end of the seminars a good rapport was established among the participants, the resource personnel and the officials of the Meteorology Department. These links are invaluable in the context of linking science and technology, i.e. the effects of climate change and its mitigation. The understanding and cooperation of these planners and the policy makers are essential for future work. They are aware of the implications of climate change and would undoubtedly consult the scientific community before arriving at decisions affecting the environment at the provincial and district levels.

The seminars were also instrumental in identifying areas needing further attention. There included

Mr. W.A.K. Karunatilaka,
Research Officer, Agriculture Research Centre, Department of Agriculture, Angunakolapelessa.

The target group at these seminars included the highest – level officials of the provincial and district level administration; University student / staff members and master teachers who were not familiar with the subject of climate change. The seminars created the necessary awareness on climate change among them. At the end of the seminars a good rapport was established among the participants, the resource personnel and the officials of the Meteorology Department. These links are invaluable in the context of linking science and technology, i.e. the effects of climate change and its mitigation. The understanding and cooperation of these planners and the policy makers are essential for future work. They are aware of the implications of climate change and would undoubtedly consult the scientific community before arriving at decisions affecting the environment at the provincial and district levels.

The seminars were also instrumental in identifying areas needing further attention. There included

Non-availability of carbon fixation data for trees grown in Sri Lanka.

Inadequate training and experience of the district level administrators in project formulation, implementation and monitoring of projects involving adaptation / mitigation of climate change effects.

Identification of the need for better communication between the district level administrators/policy makers and the national level scientific institutions dealing with the effects of climate change.

Building up a data base

A data base is now available on the following topics pertaining to Climate Change.

Sri Lanka – Future Climate scenarios

Regional Climatic Variability
Emissions from forestry, rice cultivation, solid waste and automobiles.

Vulnerability of land and water; selected food crops (rice, home garden crops) selected plantation crops (rubber and low grown tea); coral reefs; health and pests to climate change.

Mitigation – through forests, rubber cultivation, vegetation in urban areas and the desiccated coconut industry
Adaptation- rice cultivation; rubber and coconut cultivation; micro hydro power generation

Global warming damages costs.

5.0 OUTPUTS

5.1 Publishing a book titled Climate Change in Sri Lanka: Mitigation, Adaptation and Vulnerability

As mentioned earlier 58 studies were completed by researchers came at a senior level and others at a junior level. The studies were expected to fill the gaps in the knowledge of climate change scenarios in Sri Lanka. Since these studies cover important areas of climate change the results will be presented in a publication titled " Climate Change in Sri Lanka – Vulnerability, Mitigation and Adaptation. The book will be an important reference document for future policy development on Climate Change in Sri Lanka and hence each section will carry a set of relevant policy recommendations. The book will make available both at the local and the international level.

The book will be divided into two parts. Part I will comprise 4 chapters as follows:

Chapter I – Introduction- Climate change; Global and Regional Scale(Vulnerability, Mitigation and Adaptation)

Chapter II – Impacts of Climate Change; The Sri Lankan situation (includes future climate scenarios)

Chapter III – Assessment of vulnerability to Climate Change

Land and water resources

Ecosystem and biodiversity
Coastal resources
Agriculture and food industry
Human settlements and health
Infrastructure and energy

Chapter IV- Mitigation and Adaptation

5.2 Releasing 58 Climate Change Working Papers or booklets

A total of 58 booklets will be prepared as Climate Change Working Paper Series Covering the following themes.

Abeywardana R.M.I.Y., (2004), Climate Change Secretariat Working Paper No.51. 2004, Screening of different rice varieties of Sri Lanka for their response to increasing atmospheric carbon dioxide (Annex 18).

Abeywickrama D. R., Sumanarathne H. M. C., Kumara A. G. I. P., (2004) Climate Change Secretariat Working Paper No.22. 2004, Effects of vegetation changes on climatic changes in Hambantota District (Annex 19).

Ariyananda T., Climate Change Secretariat Working Paper No.3. 2004, A research programme to monitor the quality of water (Annex 20).

Ashraff S.H.A., Climate Change Secretariat Working Paper No.45. 2004, Conservation of Mangrove vegetation for the benefits of people in Potuvil and Thirukkovil (Climate View Point) (Annex 21).

Bandara C.M.M., Wickramagamage P., Arambepola K., Nianthi R., Climate Change Secretariat Working Paper No.18. 2004, Climate change and its impact on the upper watersheds of hill country(Annex 22).

Basnayake B.R.S.B., Premalal H.M.S., Kumara W.A.L., Climate Change Secretariat Working Paper No.17. 2004, Development of rainfall and temperature scenarios for Sri Lanka (Annex 23).

Chandrasekara C.M.M., Climate Change Secretariat Working Paper No.9. 2004, Social Impact of Vulnerability to Climate Change (A Case study of Hikkaduwa Coral Reef in Sri Lanka) (Annex 24).

Chinthaka K.G.R., Climate Change Secretariat Working Paper No.50. 2004, Screening of selected forest tree species of Sri Lanka for there response to increasing atmospheric carbon dioxide(Annex 25).

De Costa D.M., Climate Change Secretariat Working Paper No.42. 2004, Effects of elevated CO2 levels on epiphytic microbial populations of the phyllosphere of rice in relation to biological control of rice diseases (Annex 26).

De Silva Y.Y.K., Bandula H.D.A.C. Climate Change Secretariat Working Paper No.56. 2004, Impact of rainfall pattern change on rice production in Mapalana G.S.division in Kamburupitiya divisional secretariat area (Annex 27).

De Silva S.T.G.C., Climate Change Secretariat Working Paper No.21. 2004, Performance of Hevea Genotypes in the mid country high elevation region of Sri Lanka(Annex 28).

Edirisinghe J.C., Ratnasiri N.G.S.C Climate Change Secretariat Working Paper No.33. 2004, Changing rates of interest, prices and the cost to the climate with special reference to rubber cultivation (Annex 29).

Emmanuel R., Climate Change Secretariat Working Paper No.6. 2004, Vulnerability to Urban Warming and Adaptation response options for the City of Colombo and suburbs(Annex 30).

Fernando T.H.P.S., Climate Change Secretariat Working Paper No.37. 2004, Possibility of the popularization of *Oidium* susceptible high yielding clones with the predicted climate change (Annex 31).

Gunaratna L.H.P., Climate Change Secretariat Working Paper No.1. 2004, Identification and evaluation of the adaptive measures to offset the anticipated drought occurrences with special emphasis on rice production in the dry zone of Sri Lanka(Annex 32).

Gunasena C.P., Climate Change Secretariat Working Paper No.55. 2004, Identifying and mapping salt-affected lands in Hambantota district, Sri Lanka: An integrated GIS and remote sensing approach (Annex 33).

Handawela J., Punyawardena B.V.R., .Basnayake B.R.S.B, Munasinghe M.A.K., Keerthisena R.S.K., Punyawardena B.V.R, Seneviratna K.M., Climate Change Secretariat Working Paper No.10. 2004, Implication of climate change on land degradation: A study on changing rainfall regime and its effect on soil erosion in Central Highlands of Sri Lanka (Annex 34)

Iroshini R.G.S., Climate Change Secretariat Working Paper No.27. 2004, Effect of number of leaves and leaf area on yield performances of banana grown under annual planting systems(Annex 35).

Jayaratne Banda N., Climate Change Secretariat Working Paper No.46. 2004, Impacts of climate change on rice farming in the low country wet zone (Annex 36).

Jayasinghe G.Y., Climate Change Secretariat Working Paper No.58. 2004, A comparative study of biogas liberation statistics from straw and market garbage as an alternative energy supply(Annex 37).

Kalinga Herath., Climate Change Secretariat Working Paper No.52. 2004, Greenhouse gas emission of automobiles in Sri Lanka (Annex 38).

Karunarathna K.G.S.P., Climate Change Secretariat Working Paper No.25. 2004, Accounting for forest resource value as a Carbon sink in national income of Sri Lanka (Annex 39).

Karunathilake W.A., Climate Change Secretariat Working Paper No.8. 2004, Vulnerability of rice industry, rain fed farming, livestock and water resources in the dry zone of Hambantota district to climate change (Annex 40).

Keminda Herath., Climate Change Secretariat Working Paper No.34. 2004, Impact of climate change on yield of rubber (Annex 41).

Kudaligama K.V.V.S., Climate Change Secretariat Working Paper No.32. 2004, Affect of rainfall on the pollution problem associated with natural rubber processing factories (Annex 42).

Kularatne J.D.K.S., Climate Change Secretariat Working Paper No.30. 2004, Climate variability in Hambantota district (Annex 43).

Kumari D.M.C.N., Climate Change Secretariat Working Paper No.48. 2004, Vulnerability of paddy production and irrigation systems to climate change- A case study using Batalagoda wewa and Hackwatuna wewa reservoirs in Kurunegala district (Annex 44)

Lloyd N.T., Climate Change Secretariat Working Paper No.40. 2004, Urban climate change mitigation through manipulation of urban morphology: Strategies for Colombo

(Annex 45).

Madana P., Kadupitiya H.K. Climate Change Secretariat Working Paper No.38. 2004, Identification of recent changes in growing season characteristics in Wet and Intermediate zones of Sri Lanka (Annex 46).

Madana P., Kadupitiya H.K. Climate Change Secretariat Working Paper No.39. 2004, Identification of areas prone to extreme rainfall events in Wet and Intermediate zones in Sri Lanka (Annex 47).

Mohottala P.W., Leelasena M.B.A.U., Ranga Kalansooriya, Climate Change Secretariat Working Paper No.15. 2004, Vulnerability of human settlements, women and children and vulnerability to vector borne diseases in the Hambantota area (Annex 48).

Munasinghe E.S., Climate Change Secretariat Working Paper No.28. 2004, Assessment on potential capability of carbon fixation in different genotypes of rubber crop (Annex 49).

Navarathne C.M., Weerasinghe K.D.N., Climate Change Secretariat Working Paper No.7. 2004, Agro-climatic potential and risk assessment for crop intensification in home gardens of Southern Sri Lanka: A case study in Embilipitiya area (Annex 50).

Nayanakantha N.M.C., Perera B.T.J Climate Change Secretariat Working Paper No.36. 2004, Assessment on the vulnerability of the rubber crop (with respect to growth) for climate change (Annex 51).

Nayanakantha N.M.C., Climate Change Secretariat Working Paper No.35. 2004, An assessment on the vulnerability of *Hevea* seeds production to climate change (Annex 52).

Nilmini G.V.L., Climate Change Secretariat Working Paper No.31. 2004, Effect of wintering on the latex and raw rubber properties of *Hevea brasiliensis* (Annex 53).

Nugawela A., Rodrigo V.H.L., Jayasinghe C.K., Seneviratne A.M.W.K, Climate Change Secretariat Working Paper No.12. 2004, Quantification of carbon fixing capability of rubber crop and its adaptation to climate change (Annex 54).

Pannilage U., Ranjith de Silva, Climate Change Secretariat Working Paper No.11. 2004, Effects of climate change on harnessing of off-grid village micro hydropower generation in Sri Lanka (Annex 55).

Perera K.P.S.P., Climate Change Secretariat Working Paper No.23. 2004, Coconut cultivation as a measure of adapting to and mitigation of climate change (Annex 56).

Perera R.S.N., Climate Change Secretariat Working Paper No.26. 2004, A comprehensive assessment of the climate change vulnerability of rice industry (Annex 57)

Samaradivakara G.V.I., Climate Change Secretariat Working Paper No.43. 2004, Identification of the influence of mining activities on climate change (Annex 58).

Samarakoon S.P., Hettiarachchi S., Jayatissa L.P., Abeysinghe S., Climate Change Secretariat Working Paper No.4. 2004, An assessment of the climate change vulnerability of Hambantota area to national parks, tourism and industry (Annex 59).

Samarakoon S.M.S.R.K., Climate Change Secretariat Working Paper No.57. 2004, Contribution to greenhouse effect from municipal solid waste landfills in the Colombo Metropolitan Region (Annex 60).

Samarappuli L., Wasana Wijesuriya, Climate Change Secretariat Working Paper No.13. 2004, Impacts of climate change on land productivity of rubber, possible adaptation measures and the role of rubber plantations as a mitigatory option (Annex 61).

Sathya Sajeewa B.V., Climate Change Secretariat Working Paper No.41. 2004, Urban climate change mitigation through urban vegetation: Strategies for Colombo Metropolitan Region (Annex 62).

Senanayake G., Climate Change Secretariat Working Paper No.14. 2004, Survey of steam boilers in order to quantify and mitigate greenhouse gases in the desiccated coconut industry (Annex 63).

Shantha W.W.A., Climate Change Secretariat Working Paper No.24. 2004, Study on changes of water potential in the Mahaweli upper watershed area due to climatic change (Annex 64).

Siripala G.D., Siripala D., Liyanage N., Climate Change Secretariat Working Paper No.19. 2004, Investigation of climate change impacts on land degradation, Crop Production and watershed management (Annex 65).

Sirisena D.N., Bandara W.M.J., Wickramasinghe D.B. Climate Change Secretariat Working Paper No.2. 2004, Estimation of Methane and Nitrous Oxide Emission from Rice Fields in Low Country Intermediate Zone of Sri Lanka (Annex 66).

Sunil de Alwis., Abeyewickreme W., Rajamanthrei M.D., Senaviratne A.K., Climate Change Secretariat Working Paper No.16. 2004, Vulnerability of the North Western Province to climate induced incidences of vector borne diseases (Annex 67).

Udaya Kumara E.P.N., Climate Change Secretariat Working Paper No.53. 2004, Weather changing patterns and related issues at recent earth slip areas (Puwakgahawela) (Annex 68).

Udaya Kumara E.P.N., Climate Change Secretariat Working Paper No.54. 2004, Rehabilitation of burnt forests in Belihuloya sub catchment area of Samanalawewa (Annex 69).

Vithanage J.C., Climate Change Secretariat Working Paper No.44. 2004, A

comparative study of the ambient air temperature trends at Hambantota and Angunukolapelassa (Annex 70).

Wegiriya H.C.E., Rohan Rajapaksa, Climate Change Secretariat Working Paper No.5. 2004, Insects and climate change: A comparative study on the seasonal abundance and diversity of some important terrestrial insect fauna in Hambantota district (Annex 71).

Weerakoon W.R.W.M.S.N.P., Climate Change Secretariat Working Paper No.47. 2004, The relationship between the occurrences of El-Nino events and Brown Plant Hopper (BPH) outbreaks in the dry zone of Sri Lanka (Annex 72).

Wickramarathna N.A.A.D., Climate Change Secretariat Working Paper No.29. 2004, Screening of high yielding clones of *Heava* for marginally dry area (Annex 73).

Withanage S.P., Climate Change Secretariat Working Paper No.49. 2004, Adaptability/Stability of different rubber genotypes for agro-climatic variability in Sri Lanka (Annex 74).

5.3 Technical Training of scientists/ professionals at various level

Following scientists/academics/officers were trained on Development of emission factors

1. **Sirisena, Mr. D. N.**
Research Officer, Rice Research and Development Institute, Batalagoda.
B.Sc.(Honours) (Agriculture) University of Peradeniya, M.Phil (Agriculture Science), University of Aberdeen, UK.

2. **Herath Mr.Kalinga**
Analyst Programmer, John Keells Computer Services. B.Sc.(Computer Science, Mathematics, Physics), University of Colombo.

Following scientists/ academics/officers were trained on Development of emission reduction technologies assessment

1. **Senanayake, Mr. Gamini**
Director/CEO, Industrial Services Bureau of North Western Province, Kurunegala. B.Sc. (Engineering) (Honours) in Mechanical Engineering;

2. **Emmanuel, Dr. Rohinton**
Senior Lecturer, Faculty of Architecture, University of Moratuwa, B.Sc. (Built Environment) University of Moratuwa; M.Sc. (Architecture) University of Moratuwa; Ph. D. (Architecture), from the University of Michigan, Ann Arbor, MI, USA

3. **Samarappuli, Dr. (Mrs.) Lalani**
Head of the Soils & Plant Nutrition Department, Rubber Research Institute of Sri Lanka. B.Sc. (Honours) (Agriculture), University of Peradeniya; M.Sc. in Soil Science University of California, USA and Ph.D., University of Perdeniya.

4. **Samarakoon Ms.S.M.S.R.K**
Reading M.Sc.(Forestry and Environmental Science), Department of Forestry and Environmental Sciences, University of Sri Jayawardenapura. B.Sc.(Hons)(Zoology, Chemistry and Forestry and Environmental Science).

5. **Ashraff Mr. S.H.A.**
Lecturer, Geography Unit, Social Science Department, Faculty of Arts and Culture, South Eastern University of Sri Lanka, Sammanthurai. B.A.(Hons)(Geography), Reading M.Sc.(Forestry and Environmental Management), University of Sri Jayawardenapura.

6. **Karunarathna Ms.K.G.S.P.**
Research Assistant Eco-Friendly Products and Services Project, University of Sri Jayawardenapura. B.Sc (Hons), University of Sri Jayawardenapura.

7. **Lioyd Mrs.N.T.**
Architect,Avent Grade Urban Design Partnership. B.Sc.(Hons)(Built Environment), M.Sc.(Architecture), University of Moratuwa.

8. **Munasinghe Mrs. E.S.**
Research Assistant, Rubber Research Institute of Sri Lanka B.Sc.(Hons)(Agri.).

9. **Perera Mr.K.P.S.P.**
G.A.Q, University of Peradeniya; B.A. (Legal Policy), Open University of Sri Lanka

10. **Sajeewa Mrs.B.V.S.**
B.Sc.(Built Environment), M.Sc.(Architecture), University of Moratuwa.

Following scientists/academics/officers were trained on climate change impact and Vulnerability assessment

1. **Samarakoon, Prof. S.P.**
Professor in Botany, University of Ruhuna.
B.Sc. (Honours)(Botany), University of Peradeniya; M.Phil. Queensland University, Australia; Ph.D., University of Ruhuna. Ecologist, Taxonomist.

2. **Siripala, Mr. G.D.**
Lecturer, Department of Social Sciences Rajarata University of Sri Lanka.
B.A. and M.A. (Specialised in Geography), University of Peradeniya and Post Graduate Diploma in Economics.

3. **Navaratne, Ms. Champa M.**
Lecturer, Department of Agricultural Engineering, University of Ruhuna.
B.Sc. (Honours) (Agricultural Engineering) University of Ruhuna; M.Sc. in Computing, College of Cardiff, University of Wales,UK; Reading for a Ph.D. in Irrigation and Water Management at University of Ruhuna.

4. **Mohottala, Mr. P.W.**

Former Principal of a school and former Deputy Executive Director, Sarvodaya, B.A.(Ceylon), University of Peradeniya; Postgraduate Diploma in Education, Vidyodaya University;

5. **Handawela, Dr. James**
Agricultural Scientist, ETC Lanka (Pvt.) Ltd. Consultant in Natural Resources Management and Facilitation of Project on Indigenous Knowledge.
B.Sc.(Agriculture), University of Ceylon; M.Sc.(Agriculture), Kyoto University, Japan; Ph.D. (Agriculture), Kyoto University, Japan.

6. **De Alwis, Dr. Sunil**
Provincial Director of Health Services, NWP.
M.D. in Community Medicine (USSR), M.Sc.(Community Medicine), Sri Lanka.

7. **Chandrasekera, Mr. C.M.M.**
Director, Natural Resources and Environmental Management, Department of National Planning.B.Sc.(Honours) (Agriculture), University of Peradeniya; M.Sc.(Agricultural Economics – Specialization in Natural Resources Economics) University of Missouri, U.S.A.

8. **Bandara, Prof. C.M.M.**
Senior Professor in Environmental Geography at the University of Peradeniya. He obtained his Ph.D. from the University of Cambridge, U.K.

9. **Keerthisena, Mr. R.S.K.**
Research Officer, Natural Resources Management Centre, Department of Agriculture, Peradeniya. B.Sc. (Agriculture), University of Peradeniya; M.Sc (Soil Science), University of Reading, UK

10. **Pannilage, Mr. Upali**
Programme Manager, Intermediate Technology Development Group – Transport and Manufacturing. B. A. (Honours) (Sociology), University of Ruhuna; Post - Graduate Diploma in Community Development, University of Colombo.

11. **Abeywardena Ms. R.M.I.Y.**
B.Sc.(Hons) (Agric), University of Peradeniya.

12. **Bandula Mr. H.D.A.C.**
B.Sc.(Hons)(Agric), University of Ruhuna.

13. **De Silva Mr. S. T. G. C.**
Research Assistant, Plant Science Department, Rubber Research Institute of Sri Lanka, Agalawatta B.Sc (Special) Degree in Agriculture, University of Ruhuna.

14. **De Silva Mr.Y.Y.Kalyana**
Temporary Assistant Lecturer, Department of Agricultural Economics, Faculty of Agricultura, University of Ruhuna. B.Sc.(Hons)(Agric), University of Ruhuna.

15. **Chinthaka Mr. G.R.**

B.Sc. (Agriculture), University of Peradeniya

16. **Iroshinie R.G.S.**
Temporary Assistant Lecturer, Department of Crop Science, Faculty of Agriculture, University of Ruhuna. B.Sc. (Hons) (Agri.) University of Ruhuna.

17. **Kumari Ms. D.M.C.N.**
Programme Officer, Climate Change Enabling Activity (Phase II) Project, Environmental Economics and Global Affairs Division, Ministry of Environment and Natural Resources. B.A.(Hons)(Geography), University of Peradeniya,

18. **Naynakantha Mr.N.M.C.**
Assitant Botanist, Plant Science Department, Rubber Research Institute of Sri Lanka. B.Sc.(Hons)(Botany), University of Peradeniya.

19. **Nilmini Mrs.G.V.L.**
Assitant Biochemist, Department of Bio Chemistry, Rubber Research Institute of Sri Lanka.B.Sc.(Hons)(Chem), University of Ruhuna.

20. **Perera Ms.B.T.J.**
Research Assitant, Plant Science Department,Rubber Research Institute of Sri Lanka. B.Sc.(Hons)(Bio Science), University of Colombo.

21. **Perera Mr.R.S.N.**
B.Sc. (Forestry, Zoology, Chemistry), University of Sri Jayawardenapura

22. **Shantha Mr.W.W.A.**
Graduate (Agri Business Management Course), Sabaragamuwa University of Sri Lanka.

23. **Kumara Mr.E.P.N.U.**
Research Assistant, Sabaragamuwa University Environmental Centre, Sabaragamuwa University of Sri Lanka. B.Sc.(Hons)(Agric), University of Ruhuna, M.Sc.(Forestry and Environmental Management), University of Sri Jayawardenapura.

24. **Herath Mr.H.M.L.K.**
Assistant Biometrician, Biometry section, Rubber Reserch Institute of Sri Lanka. B.Sc.(Hons)(Agric),University of Peradeniya.

25. **Banda Mr. Nimal Jayaratne**
Natural Resources Management C`entre, Department of Agriculture.

Following scientists/academics/officers were trained on adaptation technologies

1. **Gunaratne, Dr. L.H.P.**
Senior Lecturer, Department of Agricultural Economics, University of Peradeniya. B.Sc.(Statistics), B.Sc.(Honours) (Agriculture) University of Peradeniya; M.Sc. (Crop Modelling); M.A.(Economics), University of Hawaii, USA; Ph.D. (Agricultural and Resource Economics) University of Hawaii, USA.

2. **Nugawela, Dr. Asoka**
Deputy Director (Research), Rubber Research Institute of Sri Lanka.
B.Sc. (Honours) (Botany) University of Peradeniya; M.Sc. in Applied Plant Science, University of London; Ph.D in Plant Productivity, University of Essex.

3. **Wegiriya, Dr. (Mrs.) H.C.E.**
Senior Lecturer, Department of Zoology, University Of Ruhuna.
B. Sc. Special (Honours) (Zoology), University of Kelaniya, Doctor of Philosophy in Entomology, University of Reading, UK.

4. **Ariyananda, Ms. Tanuja**
Director of Lanka Rain Water Harvesting Forum.
B.Sc. (Honours) (Applied Biology), University of Wales College of Cardiff (UWCC); M.Sc. in Aquatic Resource Management, King's College, London.

5. **De Costa Dr. (Mrs.) D.M.**
Lecturer in Plant Pathology, Department of Agricultural Biology, Faculty of Agriculture, University of Peradeniya. B.Sc(Hons)(Agriculture), University of Peradeniya. M.Sc.(Technology of Crop Protection), University of Reading,U.K., Ph.D, Hiroshima University, Japan.

6. **Fernando Mrs.T.H.P.S.**
Experimental Officer, Department of Pathology, Rubber Research Institute of Sri Lanka. B.Sc. ,University of Colombo.

7. **Jayasinghe Mr.G.Y.**
Assistant Lecturer, Department of Agricultural Engineering, Faculty of Agriculture, University of Ruhuna. B.Sc.(Agric), University of Ruhuna.

8. **Withanage Mrs. S.P.**

Assistant Geneticist & Plant Breeder, RRI Substation, Nivithigala, Matugama. B.Sc.(Hons)(Agric), University of Ruhuna, M.Sc.(Genetics), Punjab Agric University, India.

9. **Wickramarathna Mr.N.A.A.D.**
Assistant Botanist, Rubber Research Institute of Sri Lanka. B.Sc.(Hons)(Agri.), University of Peradeniya

Following scientists/academics/officers were trained on climate change variability and Trend studies

1. **Basnayake, Dr. B.R.S.B.**
Meteorologist, Department of Meteorology.
B.Sc. (Physics), University of Kelaniya; Postgraduate Diploma in Meteorology, University of Philippines; Ph.D. in Meteorology, University of Philippines

2. **Kadupitiya Mr. H.K.**
Research Officer, Natural Resources Management Centre, Department of Agriculture.

B.Sc.(Hons)(Agric), University of Peradeniya, M.Sc.(GIS and Remote Sensing), Netherlands.

3. **Kularatne Mr.J.D.K.S**.
Biometry Division, CRI, Lunuwila B.Sc

4. **Madana Ms. P.**
Agricultural Officer, Natural Resources Management Centre, Department of Agriculture. B.Sc.(Hons)(Agric), University of Ruhuna, M.Sc.(GIS and Remote Sensing), Netherlands.

5. **. Vithanage Mr. J.C.**
B.Sc. (BioScience), Open Uinversity of Sri Lanka.

6. **Abeywickrama Mr.D.R.**
Graduates (Environmental Engineering), University of Moratuwa.

7. **Edirisinghe Mr.J.C.**
Assistant Economist, Rubber Research Institute of Sri Lanka, B.Sc.(Hons)(Agric), University of Peradeniya.

8. **Kudaligama Ms.K.V.V.S.**
Experimental officer, Rubber research institute of Sri Lanka. B.Sc., University of Colombo,M.Phill.Botany (environmental Management).

9. **Ratnasiri Ms.N.G.S.C.**
Lecturer, Department of Agribusiness Management,Wayamba University of Sri Lanka. B.Sc.(Hons)(Agric), M.Sc.(Agricultural Economics).

10. **Samaradivakara Mr.G.V.I.**
Lecturer (Prob.), Department of Mining and Minerals Engineering, University of Moratuwa. B.Sc.Engineering (Hons)(Mining and Minerals Engineering), Reading P.G.Dip./M.Eng. on Geothechnical Engineering, University of Moratuwa.

11. **Sumanaratne Mr. H.M.C.P.**
Graduate (Environmental Engineering), University of Moratuwa.

5.4 Awareness creation of senior level officers

Following officers participated in the awareness creation workshops.

6.0 LESSONS LEARNT

6.1 The need to select persons with the ability and commitment to undertake the research

The Senior Researchers were selected by calling for proposals from experienced research workers. The proposals were based on a list of topics pertaining to climate change prepared by the Ministry of Environment and Natural Resources.. The proposals were evaluated and the contracts awarded on the assumption that the persons selected had the capability and the commitment to undertake the research. However some of the final outputs of a few senior researchers have fallen short of expectations despite the fact that suggestions were made periodically through workshops to improve the quality of the output. This problem may be addressed in the future by evaluating the research records of the applicants prior to the award of the contract.

The Junior Researchers were selected primarily on the basis of recommendations made by the Heads of the institutions to which they were attached. They were expected to work under the guidance of a supervisor and the progress was monitored through several workshops. Nevertheless the output of the researchers have been disappointing. Hence it may be useful in the future to interview junior researchers before the proposals are accepted in order to assess their capability to undertake the research.

The need to ensure that all the persons awarded research contracts are familiar with research methodology

A few of the Senior Researchers and several of the Junior Researchers appeared to be unfamiliar with research methodology. Their unfamiliarity was reflected in their inability to (a) clearly identify and focus on the main issues; (b) present the conclusions and recommendations meaningfully ; (c) select appropriate areas for field investigations ; (d) collect relevant data ; (e) rigorously analyse the data collected; (f) make proper use of illustrative material; and (g) adhere to correct procedures in presenting a research paper.

The above weaknesses were also highlighted by the specialists who were appointed to review the draft reports.

A short training programme should be held before the commencement of the research to ensure that all persons awarded contracts are conversant with research methodology.

The need to ensure that monies allocated are in relation to the expected output.

The final outputs in the case of some of the researchers (both Senior and Junior) did not seem to justify the amount allocated. The impression was created that the budgets submitted by these researchers were in excess of what was needed to obtain the results that were presented. Steps should therefore be taken to ensure that the monies requested for the research are not in excess of what is really required.

The need to ensure that the appointed supervisors provide the necessary guidance to the junior researchers.

Although supervisors were appointed in the case of junior researchers, some do not seem to have discharged their responsibilities satisfactorily. This was reflected in poor quality of the reports submitted by those who were expected to be supervised. A strategy will have to be formulated to ensure that the appointed supervisors provide systematic guidance. The contract should also stipulate that the final draft report presented by the researcher will not be accepted unless it is submitted through the supervisor.

6.5 The need to ensure that the final report is well written

Most of the junior research reports and a few of the senior research reports were poorly written and needed considerable editing. This is not satisfactorily because some of the statements in the report could be misinterpreted by the person editing the reports if he or she is not familiar with the subject. The final draft should therefore be edited by the supervisor for which he should be compensated. If for some reason the supervisor is unable to undertake this responsibility, the editing has to be handed over to a person who knows the subject and has a good command of the language.

7.0 OBJECTIVES MET OR NOT ACHIEVED

The project objectives have been achieved. However, more work needs to be done before Sri Lanka is ready to prepare its national communications without difficulties.

A significant proportion of the research studies have been confined to a few areas in the country, notably the Southern, North Western and Central Provinces. Nearly two-thirds of the Senior Research Studies and one third of the Junior Research studies were undertaken in these provinces.

The database on climate change for other provinces is very weak. Even basic data on the variability of rain fall and temperature; extreme climatic events; and their impacts are not available for these areas. These and other useful data therefore have to be collected early.

The research programme has enabled the collection of data on some aspects of emissions, vulnerability, and mitigation adaptation. However more data are needed on these topics. In the case of vulnerability for example, information is not available for crops such as coconut, high-grown tea, minor export varieties and vegetables. Likewise in the case of adaptation answers are required to a number of questions. We need to know for example (a) how small holders in the food crop sector adapt and could adapt to extreme climatic events and (b) how people could adapt to increasing health risks. More information is also needed on several topics pertaining to emissions and mitigation eg livestock farming, shifting cultivation, industry, transport and the energy sector.

8.0 STRUCTURES AND SYSTEMS IMPLEMENTED

8.1 Project Steering Committee

National Steering committee was established under the chairmanship of Secretary, Ministry of Environment and Natural Resources and consists of representatives of relevant line agencies, experts private sector and non-governmental organizations in order to manage the steering committee. The National Steering Committee was responsible for overall supervision and advising on the project activities. Members of the Steering Committee include:

Steering Committee

Ministry of Environment and Natural Resources

Mr.D.Dissanayake, Secretary/ (Chairman).
Dr. B.M.S. Batagoda, Project Director
Mr. M.M.S.S.B. Yalegama, Deputy Project Director
Dr. W.L. Sumathipala, Coordinator – Montreal Protocol Unit
Mr. Gamini Gamage, Director – Bio-Diversity
Mr. T.K. Fernando, National Consultant

Ministry of Plantation Industries
Mrs. Malini Peiris, Senior Assistant Secretary (Policy)

Ministry of Power and Energy
Mr. W.M. Bandusena – Director (Policy Planning)

Ministry of Industries
Mr. W.A. Karunasena – Additional Secretary

Ministry of Irrigation and Water Management
Mr. Vijitha de Silva – Additional Secretary

Ministry of Agriculture and Livestock
Dr. Nihal Atapattu, Director – Projects

Department of Meteorology
Mr. G.H.P. Dharmaratne –Director

Department of Agriculture
Dr. B.V.R. Punyawardena – Research Officer/ Natural Resources Management Centre

Forest Department
Mr.Sarath Fernando - Additional Conservator of Forests

Irrigation Department
Eng. P.C. Senaratne, Deputy Director (Hydrology)

Coast Conservation Department
Mrs. Mangala Wickramanayake – Chief Engineer

University of Moratuwa
Prof. G.T.F.De Silva, Professor/ Department of Mathematics

Public Utility Commission of Sri Lanka
Prof. Priyantha Wijayatunga, / Director General

University of Peradeniya
Prof. E.R.N. Gunawardena, Dean / Faculty of Agriculture
Dr.Buddhi Marambe, Head / Department of Crop Science

Ceylon Electricity Board
Mr. Shavindranath Fernando – Deputy General Manager

LGA Consultants
Mr. Lalith Gunaratne- Managing Director

UNDP
Darshani de Silva – Programme Officer

National Committee of IGBP
Dr. Janaka Ratnasiri, Chairman – National Committee of IGBP

8.2 Establishment of a Secretariat

The main obligations for the developing countries under the UNFCC are to:

Submit periodically National Communications on Climate Change to the UNFCCC Secretariat, including an Inventory of Greenhouse Gas (GHG) Emissions and Removals, from activities such as energy generation, agriculture, land use changes and waste management.

Formulate policies and initiate measures that would mitigate emissions of greenhouse gases, and enhance sinks and reservoirs of all greenhouse gases such as biomass and forests as well as other terrestrial, coastal and marine ecosystems.

Promote transfer of technologies that would reduce emissions of greenhouse gases in all relevant sectors, including the energy, transport, industry, agriculture, forestry and waste management sectors.

Prepare plans for adaptation to the adverse impacts of climate change including appropriate capacity-building, studies of the likely impacts of climate change, and for the management, protection, and rehabilitation of areas vulnerable to the impacts of climate change, and

Promote and cooperate in scientific, technological, technical, socio-economic and other research, systematic observation and development of data archives related to the climate system.

The Ministry of Environment and Natural Resources (ME & NR) is the Focal Point for both the UNFCCC and KPCC. As the Focal Point, the ME & NR is required to undertake activities to comply with the above obligations, to communicate with the UNFCCC Secretariat on various matters raised at the annual Parties' meetings, respond to specific questionnaires sent by them, undertake studies on various aspects of mitigation and adaptation to climate change and develop project proposals seeking financial assistance from funding agencies such as the Global Environment Facility and bilateral programmes to comply with the above commitments.

Climate Change secretariat should be mentioned the response of the ME & NR to decisions taken at the Parties' meetings has been enhanced capability rather minimal due to the lack of institutional mechanism. Another reason is that climate change being a subject cutting across all sectors, several organizations falling outside the purview of the ME & NR are involved in gathering the required information as well as in the implementation of any follow up activity. Hence, the Ministry needs to have the mandate to coordinate activities pertaining to climate change involving other Ministries.

In order to fill this lacuna, it is proposed that a separate Climate Change Secretariat (CCS) be established affiliated to the Ministry of Environment and Natural Resources, with branch offices in other connected organizations, as described below.

The Structure and Activities

In view of the wide variety of activities that have to be undertaken by the Secretariat covering different sectors, it will be desirable to have one central unit along with several sub-units or Centres to handle the different sectors separately. Hence, the following structure is proposed.

The objectives of the Climate Change Secretariat are to:

Serve as the National Focal Point for UNFCCC activities,
Provide a one-stop facility to disseminate information relating to the implementation of the decisions taken at the Parties' Meetings,

Promote research studies on mitigation, impacts, and adaptation to be undertaken by researchers,
Initiate measures to be undertaken by different line ministries and authorities to comply with the provisions in the UNFCCC and its KPCC,
Promote private sector participation in CDM projects, by undertaking awareness programmes, project identification and seeking partners in developed countries, and
Serve as the Designated National Authority (DNA) for the approval of CDM Projects.

8.3 Setting up a system to store data

Electronic copies of reports submitted by both the senior and junior researchers will be stored in diskettes and made available for browsing by any interested party.

The formatted booklets will be stored electronically and a set of hard copies will be made. Hard copies will be made available on request.

8.4 Building a network

Scientific net work
Prof. S.P. Samarakoon
Dr. Sunil de Alwis
Prof. C.M.M.Bandara

Mr. D.N. Sirisena
Mr. Upali Pannilage
Dr. Rohinton Emmanuel
Dr.(Mrs.) Lalani Samarappuli
Dr. L.H.P. Gunaratna
Mr. Gamini Senanayake
Dr. B.R.S.B. Basnayake
Dr. A. Nugawela

Policy maker's network

Institutional net work

Meteorology Department
Industrial Services Bureau / North Western Province / Kurunegala
University of Peradeniya
University of Moratuwa
University of Ruhuna
University of Sri Jayawardanapura
University of Ragarata
University of Sabaragamuwa
Department of Agriculture / Peradeniya
Rice Research and Development Institute / Batalagoda
Rubber Research Institute / Agalawatta
Department of National Planning
Ministry of Environment and Natural Resources
Crop Research Institute, Maha Illuppallama.

NGO and private sector net work

Intermediate Technology Development Group (ITDG)
ETC Lanka (Pvt.) Ltd.
Lanka Rain Water Harvesting Forum.

9.0 POLICY AND TECHNICAL RECOMMENDATIONS STUDIES

Based on the recommendations of the studies undertaken by the project, following recommendations are made for priority consideration by the government for future project or policy development.

Vulnerability

<u>Vector – borne diseases</u>

There is a close relationship between rainfall, temperature, humidity and the incidence and spread of vector borne diseases. The present control activities can maintain low incidence rates but with anticipated Climate Change there is a danger that vector borne diseases would increase in the future. The authorities and the general public should therefore be more aware of the danger signals, and disease control measures should be undertaken urgently.

2. Biodiversity

The most abundant insects in the dry zone are the harmful hard bodied pests and vectors such as Coleopterans, Dipterans and Hemipterans that increase rapidly during the warm/ hot months, while Hyminopteran species (beneficial ones) tend to decrease. Hence species composition is likely to change with increasing temperature. Since insect abundance and destructions may occur with Climate Change, appropriate steps should be taken to mitigate the effects.

3. Water Resources

Water Stress is a major constraint in the Dry Zone. The available water resources are not used efficiently. The water stress situation would be aggravated unless suitable adaptation measures are undertaken. An integrated Water Management Strategy, including should be adopted the rehabilitation of abandoned tanks and enhancing the storage capacity of operational reservoirs. At the same time there is a need for Introduction of less water demanding crops, Forest conservation and reforestation, Conservation of water, Trans basin diversion of water, Creating an awareness of water related issues and more community participation in decision making

4. National Parks

Decreasing ground water availability and increased evaporation contribute to the spread of woody weeds (Lantana camara), mesquite and thorny shrubs that demand less water. At the same time there is forest dieback which is characterized by the death of weera trees, palu, maliththan and mangrove species. This has become a serious problem since the early 1990's. Hence there is a need for the propagation of drought tolerant species and the practice scientific water management.

Mitigation

1. Mitigation and Adaptation Options in Sri Lanka

Recommended biological mitigation options are,
a) conservation of existing carbon pools such as forests
b) carbon sequestration by increasing the size of the carbon pool by reforestation and afforestation of degraded forests, croplands in marginal and waste lands
c) Identify selected forest tree species that are most suitable for carbon sequestration because reforestation provides an effective mechanism of carbon sequestration in the form of biomass and secondly, because sequestered Carbon can be used as a source of energy.
d) Quantifing the carbon fixing capability of rubber.
e) Adoption of Agronomic practices in rubber cultivation such as planting hole application of organic material, mulching around rubber plants at the time of planting and the application of a higher dose of K fertilizer as suitable adaptation measures to

combat adverse effects of low rainfall and to minimize the effects of moisture stress, growing mucuna - a leguminous creeper, as a ground cover crop.
f) Identifying high yielding rubber clones that respond to moisture stress.

2. Reduction of Methane Emissions

(1) Currently paddy cultivation in Sri Lanka contributes 68% of the Methane emitted from the Agricultural sector. Emissions from paddy fields amounted to 250 Gg which is considerably less than the amount estimated earlier ie. 881 Gg in 1990 and 358 Gg in 1997.

(2) The most crucial period for emission of methane was 6-12 weeks after the crop was established. Further a positive relationship between the number of productive tillers and the rate of methane emissions could be observed. Therefore, rice varieties that produce minimum productive tillers with high yields should be introduced to reduce methane emissions from paddy fields.

(3) Further research is needed to observe the amount of methane reduced by intermittent drying that is commonly practiced by farmers 7 to11 weeks after transplanting of 31/2 month rice varieties.

(4) A study of municipal waste disclosed that waste in municipal landfills emitted 150.680 m3 of Methane (CH_4) and 9474.516 m3 of Carbon Dioxide in 2003. Hence there is a need to dispose of waste and reduce methane emissions through bio gas generators.

3. Mitigation of the Urban/Heat Island effect

Urban warming has resulted in significant increases in the cooling load of residences, offices, institutions etc. The indepth study of energy consumption in residences in Colombo indicated that conventional design options do not result in acceptable indoor comfort. At current domestic electricity rate of US$ 0.08-0.10 / kWh, the economic cost is estimated at an annual value of US$ 3 million per square km of residential development.
There is the need for the

(a) Introduction of Guidelines for building construction and landscape control Ordinances since energy efficient designs in building construction can reduce electricity consumption by 50%.

(b) Changing the exterior colour (roofs and walls) from dark to light which could eleminate the need for increased thermal generation for cooling particularly during peak hours.

(c) Facilitating deeper penetration of sea breeze by a) discouraging construction of high rise buildings along the coast b) creating wind corridors perpendicular to the sea

(d) Encouraging shading in street canyons.

(e) development of neighbourhood - specific urban development controls

(f) Permitting air movement through buildings and by providing shading along streets.

(g) Changing of the orientation of windows north-south rather than east- west and reducing the size of glass facades in building so that they should not exceed 50% of the total area of the facade.

In the city of Colombo more than 80% of air pollution is due to vehicular emissions. Growth of selected vegetation species as an urban design to reduce particulate matter.

4. <u>Fuel switching</u>

GHG emissions in the DC sector can be reduced by improving combustion efficiencies and by fuel switching. Wood gasification technologies are considered as Zero GHG emission technologies and will save foreign exchange for fuel oil (Rs.400 million / year) and increase the income of the rural poor through the growth of forests for boilers. The use of hot water boilers instead of steam boilers would ensure that there is a 40% saving of full oil usage and a 40% reduction in annual GHG emissions.

5. <u>Mini/micro hydro power projects</u>

The establishment of Mini/micro hydro projects is one of the most sustainable alternatives to the use of large scale hydroelectricity systems and fossil fuels in Sri Lanka. The success of micro hydro projects depends on selecting suitable sites in the hill country. Water yield is affected not only by the amount of rainfall but also by land use practices in the catchments areas. Hence the anticipated change in rainfall in the hill country would have a differential impact on water yield depending on type of natural vegetation cover and type of crops. Hence there is a need for reforestation and proper forest Management

Adaptation

1. <u>Adaptation to scarcity of water resources - Rain Water Harvesting</u>

Rain water harvesting is an effective adaptation strategy to overcome the anticipated decline of rainfall in the Dry Zone. However, not all the tanks used in rain water harvesting provide good quality water. the most suitable types should be selected.

<u>Adaptation to increases in vectors</u>.

There is a close relationship between climate and mosquito-borne diseases. The API (Annual Parasite Incidence) for malaria and JE were positively ($p<0.001$) correlated with the 2 month lag period of rainfall while that of dengue was positively ($p<0.001$) correlated with one month lag period of rainfall and current month's temperature.

Changing climatic conditions in the <u>North Western Province</u> can increase the effect on mosquito-borne diseases. Although the current vector control activities can maintain the low incidence rates of Dengue, malaria and JE. in the North central Province in future, more surveillance by the Health authorities and a continuation of current disease control programmes (cleaning the environment with community participation and indoor residual spraying) and immunization programmes before the peak transmission period are required .

3. Adaptation of paddy to elevated CO2

Field experiments on selected high yielding, new improved and traditional rice varieties indicated that varieties such as BG452 that are highly responsive to elevated CO2 could be selected for breeding programmes.

4. The problem of Water stress in paddy cultivation could be addressed by

(a) Using ultra-short term varieties that can tolerate biotic and abiotic stress.

(b) Adoption of suitable land and crop management technologies.

(c) Adaptation of rain fed paddy to rainfall variations

- cultivation of short duration paddy varieties in the Yala season and the cultivation of long duration paddy varieties in the Maha season (de Silva, 2004).

(d).Adaptation/ Reduction of pest attacks on paddy

Certain climatic conditions favour the outbreak of the Brown Plant Hopper (BPH) in the low country Dry zone. Recommended adaptation measures include a) changes in agronomic practices in paddy cultivation such as advancing the time of cultivation from May to March, introducing pest resistant varieties and the use of recommended insecticides. Further, there is a need to establish a surveillance and forecasting system

(e) Adaptation of rubber genotypes to suit different environments.
- Clones RRISL 215 and RRISL 217 are highly stable over all the environments with a high mean performance and are not as sensitive to changes in environmental conditions,
- RRIC 100 is the most suitable clone for areas with low rainfall (Withanage, 2004)

(f) Adaptation/home gardens
- The cropping calender should be altered to match the simulated cropping calender in order to minimize irrigation water demand for crops