LIFE-CYCLE ASSESSMENT OF PRIMARY SECTOR

a case study of tea plantations in kerala

INTER UNIVERSITY CENTRE FOR ALTERNATIVE ECONOMICS
University of Kerala, Kariavattom Campus

LIFE-CYCLE ASSESSMENT OF PRIMARY SECTOR:
A Case Study of Tea Plantations in Kerala

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This is to certify that this report "Life-Cycle Assessment of Primary Sector: A Case Study of Tea Plantations in Kerala" is a record of bonafide work carried out by Syamlal G.S. under my supervision. No part of this report has been submitted for the award of any degree or diploma of any university.

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Chapter 1
INTRODUCTION AND METHODOLOGY

Earth is deemed to have formed about four billion years ago from a mixture of gases and solids. When earth started cooling down, atmosphere was shaped from gases that erupted during volcanic eruptions which comprised of Carbon dioxide (CO_2), Carbon Monoxide (CO), Water (H_2O), Nitrogen (N_2) Hydrogen (H_2) and Methane (CH_4). With the condensation of water-vapor, oceans were formed along with aquatic organism like blue-green algae which can be regarded as the first form of life. It is they who used energy of the sun for splitting molecules of CO_2 and H_2O into Carbon and Oxygen (O_2) or Hydrogen and Oxygen which was later released into the atmosphere. Splitting and combination that occurred in highest layers of atmosphere resulted in the formation of Ozone (O_3) that absorbs the UV rays and heats the atmosphere thus ensuring life on earth.

Carbon is an element which cannot be broken down into smaller or simpler substances. It is found both in living and non-living things that comprise of plants and animals along with other non-living things like rocks and soil. But the most popular form of carbon is in solid form (diamond), liquid form (crude oil) and gaseous form (carbon-dioxide). It is considered as the building-blocks of life as all the living things are based on carbon and carbon compounds. Though the amount of carbon is fixed, yet it is regarded as dynamic as it moves from living to non-living things.

Photosynthesis is the process whereby plants capture carbon dioxide from the atmosphere and releases oxygen. Carbon, which the plant had captured, is stored both above the ground (stem and leaves) and below the ground (shoots and roots). Likewise, animals and human beings eat these plants, inhale oxygen and exhales carbon-dioxide. Carbon that is left in the plant which is not eaten by animals finally gets decomposed and result in the release of carbon into the atmosphere or it get stored in the soil. In short carbon moves from the carbon sources (plants or animals) to the carbon sinks which is popularly known as Carbon Cycle.

For the most part of last few centuries, significant amounts of carbon got locked up in earth surface or ground in the form of coal [bituminous coal ($C_{137}H_{97}O_9NS$) and high-grade anthracite ($C_{240}H_{90}O_4NS$)] and petroleum (complex mixture of hydrocarbons) deposits. But since industrialistion, man had started harvesting these resources for his increasing energy demands that resulted in release of significant

amounts of carbon and other gases into atmosphere. This human induced release of large amounts of carbon compounds is regarded as the primary cause of anthropogenic (human-influenced) global warming.

1.2 Global Warming

Over the years, CO_2 is produced and exchanged between plants, animals and other organisms, but Industrial Revolution which began in 1760 had altered conventional carbon-cycle by enhancing CO_2 emissions and other heat-trapping gases of the atmosphere. Global greenhouse gas concentration based on carbon dioxide is estimated to have increased from 280 ppm before Industrial Revolution (1750) to 408.84 ppm in July 2016 (co2.earth, 2017). Along with CO_2, heat-trapping gases like CH_4, N_2O, HFCs, PFCs and SF_6 gets accumulated in the troposphere. It is this heat-trapping gas that absorbs heat and re-emits it back to earth and ensures life on earth. That is why it is rightly opined that "Venus is too hot, Mars is too cold, and Earth is just right."(Alaudeen et.al, 2008,p.42) Variations in the average temperature will have adverse impacts on climate and weather resulting in ecological degradation like the rise of sea level, decrease in glaciers, northward movement of plant habitats, changes in animal habitats, and increase in ocean temperature, shortened winter and early arrival of spring all of which will adversely affect human life in the long run. Approaches to deal with the issue of global warming should include mitigation measures, focusing on reduction and absorption of greenhouse gases.

1.3 Significance of the study

Production activities under the primary sector are carried out through cultivation of location specific crops which include climatic elements like temperature, moisture content, sunlight and other hydrological factors. Hence success of this bio-industry entirely depends on various notable regional characteristics. But studies had pointed out that there is a slow and sustained increase in ambient temperature, which will adversely affect the tea producing belt. It is opined by experts that an increase of ambient temperature above 35^0 C will slow down photosynthesis in tea bushes, beyond 39^0 C food production stops and at 48^0 C the tea leaves stop breathing and are ultimately destroyed. Change in climate is also conducive to pests such as tea mosquito bugs (*Helopeltistheivora*) infesting plants' shoots. This will result in the random and excessive use of fertilisers which degrade the quality of tea and an ultimate blacklisting of the major foreign exchange earner of India.

1.4 Objectives framed for the study

- Analyse the level of carbon emissions in agriculture sector with respect to tea in Kerala
- Suggest the plan of action to regulate, control and finance future development strategies.

1.5 Methodology

Decisions are made on the basis of beliefs or value system rather than driven by sufficient analysis. Hence, the most effective methodology that can be adopted in the decision-making process is through Data Informed Decision Making (DIDM) which takes into account collection and analysis of data to ensure its effectiveness with respect to environmental decision-making process. Moreover, nature of climate change envisages the use of cross-cutting interdisciplinary approach to address its impact and to evolve mitigation measures.

Land use changes had resulted in the variation of sunlight reflected back to troposphere which is popularly known as *albedo*. About half of land use changes resulted during Industrialisation was due to the conversion of forests into agricultural land to meet growing demands of cities which culminated

in climate change phenomenon. It is only through a proper scientific analysis of the change in land use pattern; a researcher can have proper understanding of the resultant impact. In this study, we had used surface records of land use pattern which is further corroborated with satellite imagery to derive meaningful conclusions. With the help of Geographical Information System (GIS), we had undertaken multi-criteria analysis in the study area.

Life Cycle Assessment (LCA) is a process to evaluate the effects on environment caused by production of a particular commodity through the quantification of raw materials and energy used along with waste released into the environment. Thus it encompasses extraction and process of raw materials, production process that is involved in the making of the product, gauges the effect of transportation and distribution network on the environment along with the three R's (reduce, reuse and recycle) and waste disposal. Life Cycle analysis computes energy and material usage of inputs and outputs and generalises its effect on environment.

Though there are many complex tools like GaBi, Simapro in LCA analysis, due to non-availability of certain critical technical inputs and trends, we had used a beta version of Climate Change Agriculture and Food Security Mitigation Options Tool (CCAFS- MOT). CCAFS-MOT is the best tool that can be used for LCA analysis of the primary sector. In the developed countries, it is a popular tool in the ecologically oriented farmers for analysing emission from multiple crops (e.g. barley, maize, sugar cane), or among crop groups (e.g. vegetables, legumes) and livestock. Region-specific analysis can be undertaken through this tool which gives due consideration even to specific factors like soil quality, pH value etc.

Chapter 2
REVIEW OF LITERATURE

2.1 Introduction

Climate and climate change issues are at the forefront of research studies that are devoid of any concrete boundaries envisaged by disciplines. It is this intrusion or engagement of disciplines to evolve viable alternatives that ensures enrichment of various domains. Yet what we observe today is that there exist a wide gap between communications that scientific or research community desires to convey and receptive nature of stakeholders. Hence to highlight the growing environmental concerns, there is an urgent need to review literature encompassing interlinked disciplines to provide innovative insights to the problem under consideration and to suggest due course of action. Based on its resultant impact, literature can be classified as follows.

2.2 Commercialization and Ecology

A closer perusal of the pages of history, one can witness references of two flowers *Papaversomniferum* (poppy-processed into Opium from India) and *Camellia sinensis* (tea from China) under which maps of World Economy was drawn after the famous *Opium Wars*. A dominant country with imperialistic designs was interested in regulating Botanical World trade which was the engine of world economy. These imperialistic designs resulted in war over these two flowers (Rose 2009,p14). Though the Opium wars ended with signing of a peace treaty under which Hong Kong was ceded to Britishers along with opening of mainland China to foreign traders, yet they were suspicious about the bruised Chinese ego. Robert Fortune, from Royal Horticultural Society (RHS) landed in China to discover hidden botanical treasures of the land of mysticism and dragons. He is now regarded as greatest theft of trade secrets in the history of mankind. As a part of breaking Chinese hold on Tea Industry, Britishers started growing tea in foot hills of Himalayas which resembles the terrain of China. As a result of this tea was not just limited to rich but became every ones cup of tea (Dailymail.co.uk, 2016) it is further boosted by support provided by Maniram Dutta Barbhandari Baruah who finally became the first private tea planter in India. On closer examination and analysis, it is observed that the tea species provided was *Camellia sinesnsis var Assamica* which is a variety similar to popular Chinese species (Teacoffeespiceofindia.com,

2016). The first twelve tea chests were made from indigenous Assam variety was shipped and auctioned in London which was declared as excellent by buyers. Expecting a similar response for the future shipment as well, East India Company initiated the Assam Tea Company in the town of Darjeeling. Gauging the public acceptance, company pushed its cultivation into similar terrains in India like the Terai regions, Dooars and Kangara Valley (Teamuse.com, 2016). Later, the Britishers also realised that the tea saplings are also best suited to Nilgiri hills on the Western Side of India and later it also became one of the important regions for commercial tea cultivation. As per estimates, in 1853, India exported 183.4 tonnes of tea which increased to 6,700 tons by 1870 and to 35,274 tonnes in 1885. This expansion in area and productivity finally resulted in India becoming one of the world's largest producers of tea.

Tea bush, a tropical or a sub-tropical plant requires hot and humid climate with an ambient temperature of 20°-30°C. Variations in temperature will adversely affect this crop as temperatures above 35°C and below 10°C are regarded as harmful. Along with ambient temperature, it also needs sufficient rainfall within the range of 150-300 cm annually and extreme spells of humidity or heavy dew will adversely affect both the plant and tea produced from the region. Virgin forest soils rich in humus and iron content are considered to be best soils for tea plantations. Relatively large proportion of phosphorus and potash in soil gives special flavour to tea as is in the case of Darjeeling (Mondal 2013,p57).

Tea plucking is a laborious process that requires skilled manipulation of fingers for plucking two leaves and a bud at a time. Women constitute 50 percent of labour force. Main issues that were raised against tea production, world over is that tea production demands vast land area and needs enormous labour for its production and processing. Human rights violations have been reported in majority of plantations because tea is a labour intensive industry and a slight reduction in cost of labour will increase profit margins and often leads to inhumane treatment of workers (Theecologist.org, 2016). This inhumane attitude still persists even today and the *Jasmine Revolution* in Kerala is the clear testament to perils faced by plantation workers. What unfolded in Kerala was the usual case of vested agendas prevailing over worker's interest and the usual role played by Government as peace broker (Devaprakash, 2015. p68). What we witness today is that still tea estates are regarded as the last ruminants of feudalism were exploitation of workers is a routine. Individual income is very minimal and workers lead a life of 'hand to mouth' without any dream of future. Exploitation of workers can also be attributed to fiddling of Indian Auction system based on trade power of its giant corporations. As auctions are not compulsory in India, tea companies directly sell a major portion of their produce and only substandard variety is provided for auctioning which fetches a low price. This price is then used as the benchmark for determining wages in the plantation sector (Asopa, 2007.p9). Only solution to this impasse is to enhance their standard of living and to encourage them to be part of management through granting of preferential shares. To maximise profits, we had observed that cheap child labour is still rampantly used in many countries like Uganda, Indonesia etc. Research studies thus shed light on the fact that even after 150 years of existence, India Tea Industry which survives and sustains on labour as the major factor of production and is yet to adopt a labour inclusive policy.

Tea plantations in India are as old as 100 years or more and are found at elevations varying from 600 to 1,800 meters above sea level. It is estimated that tea production levels in India were about 1000 kg ha^{-1} during the 1950s and these increased up to about 1800 kg ha^{-1} in the mid-1980's, due to the introduction of green revolution technologies such as synthetic chemicals and fertilizers. As per the information provided by Tea Research Association of India, it is observed that there is a decline in yield which can be attributed to old age of plantations and incompetency in competing internationally (Dutta, 2011.p83), Though scientifically one can assume that life of tea plants is more than 15 years, but their productive/ economic life is limited to 40-50 years. Moreover one can observe that the stress in primary sector in India is more on quantity rather than quality which finally eroded the international market competency of tea. Ensuring of quantum can be achieved only through a subsequent enhancement of the quantum

of inputs in the form of fertilisers and pesticides along with frequent use of growth hormones convey the level of impoverishment of soil (Senapati et al, 2016,p51). Research studies conveyed that unit price realisation from export of tea by Sri Lanka has increased by 73 percent, while that of Indian tea has shown an increase of only 43 percent. The reasons which can be attributed are inferior quality, adverse product mix and other marketing factors. Though world market demands orthodox tea, India produces only 10 percent while the remaining production of 90 percent is CTC - Crush, Tear and Curl. (Report of the CAG, 2011-12). Heavy or excessive use of fertilisers to maintain quantity will lead to low soil organic matter content, low water holding capacity, soil erosion and accumulation of toxic substances which reduces plant health, plant root growth and limits the potential benefits of chemically-based recovery of soil fertility.

Tea production is spread over 16 Indian states of which Assam, West Bengal, Tamil Nadu and Kerala accounts for about 96 percent of the total tea production. If we consider north-south divide, it can be observed that in 2006, 76.3 percent of the tea produced came from northern part of India, while south leads in exports as it accounts for 50.6 percent. India's performance in terms of productivity (1690 kgs) is lower than Kenya's (2235 kgs), but it is better than Sri Lanka (1611 kgs) in terms of average yield per hectare of the total production of tea (Kadavil, 2016p212). Likewise when we consider yield per hectare in India, it can be observed that it is higher for South India (2004 kgs) than that of Northern India (1601 kgs). This variation can be attributed to the fact that in South India, it is a yearlong affair, while periodicity of plucking in North is occasional. Based on research studies undertaken, it is opined India's prospects of bouncing back in the global tea market are very weak. Hence only option left for them is to concentrate on domestic market and to evolve an export strategy by producing good quality teas at competitive price (Shwetajain 2009, p.43).

An investigation carried out by Greenpeace India has found residues of hazardous chemical pesticides in majority of main brands of package tea produced and consumed in India. Study viewed that half of the samples contain pesticides are 'unapproved' for use in tea or which were in excess of the recommended limits. Samples that contained residues of at least one active ingredient above the Maximum Residue Level set by European Union (EU-MRL) is 59 percent (29), with 37 percent (18) of the tea samples exceeding these levels by more than 50 percent (Greenpeace India, 2014,p7).

The trend that we witness today in India is an increasing fascination towards 'Organic' products'. Considering the benefits of organic and green tea, there has been a surge in the demand for these types of tea varieties over the last few years. The world market for organic tea is expected to be $15 billion and the in the next few years, it is expected to reach $100 billion. India is facing competition not only from the present dominant countries but new entrants as well. Considering the excellent potential for Organic tea, government has decided to set up a working group of scientist from producing and examining countries to determine issues of Minimum Residual Levels (MRLs) of pesticides. The findings of the Working Group will assist international bodies like Codex Aliment Arias (CAC) to arrive at harmonising and in developing universally acceptable standards. India's focus on organic tea got a boost when the Common Fund for Commodities (CFC) under Food and Agriculture Organisation (FAO) approved a funding of $3.5 million for a joint project for development of organic tea in India (Atkotiya 2005,p24). But in reality, Indian tea producers are unable to meet this growing demand as supply of organic tea is very limited in India. Among the 5,000 tea producers in India, organic tea is produced only by 50 of them (Ghosal 2016, p34).

Conventional farming is popularly known as mono-cropping were a single crop is grown year after year and depleted vital nutrients are restored through the excessive use of synthetic fertilizers (Conrad 2013, p47). It became a prominent form of cultivation during the 1940s and 1950s as farming achieved a transition from subsistence-based to commodity based. Malady of subsistence farming is that when

a farmer grows a crop and pays for transport and its allied costs, the revenue/income generated from it will not be sufficient to cover his costs. This is because of the fact that they adopt eco-friendly models of farming where they are likely to use organic manures, less of chemicals such as herbicides and insecticides whose productivity is directly influenced by risk of weather rather than markets (Tow et al, 2011p133).

Subsistence farming is, in effect, farming performed under conditions of high market margins. It is widely opined that green revolution, a bi-product of post-war era focused on economies of scale and export-oriented growth. It replaced the traditional varieties with a variety of crops which are short in size, immune diseases but can provide a rich yield. It is this rich yield which was able to meet the ever increasing needs of the quadrupling population. But in the processes, Green Revolution has fostered critical contradictions while politically privileging some at the exacting price of others (Jacques and Jacques, 2012, p61). Finally what we observe today is that there is an increased use of high yielding varieties with scant regard to climatic zones. To meet the growing population and excess global market demands, chemical fertilizers are liberally used with these biotechnological mutations which will finally end in a crisis. Likewise, to produce more than four million tonnes of dried plant material whose demand is ever increasing, a great deal of land is utilised for growing it conveys that some native plant and animal species had suffered. It is observed that the tea plantations in India is as old as 150 years and to restore its nutrient content, excessive fertiliser ought to be used and to protect the new buds they also need pesticides and weedicides (Greenlivingtips.com, 2016).

Studies on viability in primary sector (Deme, 2008 p56) is of the view that viability is the difference between revenues generated and the cost of managing i.e., it is limited to financial aspect of the operation. To analyse the exact cost of operation one should not limit his attention to financial aspects alone but should include ecological, economic and social costs. Based on his studies related to Senegalese demersal fisheries, he opined that the important costs is societal costs which is linked to fishing activities which may be ecological (alteration of the capacity of a system), economic (all costs linked to production, management, subsidies, and external factors) and social (the costs of poverty, social injustice, gender discrimination, food security and food safety). It is only through such an exhaustive analysis; we can not only achieve sustainability but can also develop the production sector achieve overall well-being of the population.

If it pays, it stays' is the old catch phrase which highlights the importance of generating incentives for conservation strategies. Biodiversity is often un-priced and in-valued and will finally result in market failures as there is no incentive for those using or affecting biodiversity to take into account in their decision-making process. But researchers are of the view that regulation of biodiversity should be complemented by policy measures which provide incentive for conserving and for promoting sustainable development (Mohammed, 2016 p121). Researchers (Bräuer et.al 2006.p7, Pirard, 2012.p59) had pointed out that in EU countries there are certain Market-based Incentives (MBIs) to achieve biodiversity conservation. They observed that taxes and charges for flora protection are most preferred ones while tradable permits are used for fauna conservation. Tradable permits are most popular instrument adopted in conservation strategy in the United States of America. The study finally concluded that it is difficult to formulate a clear recommendation regarding when and where MBIS are appropriate as biodiversity is heterogeneous concept and policies as such should be tailor made according to the local needs (Bräuer et.al 2006 p6). Based on these success stories, Government all over the world are trying to incorporate market-based or market like conservation strategies. Researchers are of the view that traditional method of conservation only addresses avoidance of harmful effects of biodiversity, but it doesn't provide sufficient incentive to shift to positive incentives. Hence they urged for a market based approach as it will be more cost effective and requires more clarity regarding what they want, why they want and how much they might want to (Zammit, 2010 p21) Notable examples

that can be suggested is development of new markets for conserving terrestrial biodiversity through use of a price-based approach using auctions in Australia. Under this approach, the buyer (Australian Government) favours value-for-money investment proposals to protect specific biodiversity assets and uses an auction to create a pool of bids. While undertaking a study on Djibouti, it was rightly opined that economic measures for biodiversity conservation which targets both the commercial, market-based urban sector and the subsistence-based rural sector as a single entity will not be an effective one (Emerton, 2001 p34).

A lot of questions are raised with respect to biological effectiveness and economic efficiency of individual incentive mechanism to achieve biodiversity conservation. This can be attributed to the stochastic nature of conservation efforts, which will be impacted by factors beyond the mechanism of incentive mechanism and it can be streamlined only through initiation of monitoring and evaluation. Along with the monitoring setup, goals must be set regarding the identity of habitats that need to be conserved and how much habitat is it necessary in order to achieve biological effectiveness (Defenders of Wildlife, 2016).

Products attribute that influence decision making of consumer is not limited to physical characteristics, convenience and also gimmicks shown in visual made but other serious factors like environment. As a part of imparting environmental consciousness not only to the producers of products but also of consumers as well, authorities had evolved concepts like eco-labeling. These programs evaluate products with regard to established environmental standards set by an independent third party and, if the product meets the standards, allow the producer or marketer to use a specific label in their marketing efforts (Donath et al, 2000 p36).

Eco- labeling is regarded as another important measure that can be adopted for biodiversity conservation. Research studies (Salem et.al, 2010p41) conveyed that eco-labeling can be regarded as a dual edged weapon both for tackling conservation of marine biodiversity and for development related issues. Researchers are of the view that labels and official signs to quality products assist both consumers and producers. It allows the consumers to make informed choices and also the producers in getting their share of market. Researchers also had suggested that the seal of approval is better understood by them and the government patronage lends credibility and recognition (Lindagarza, 2010 p101). They also opined that in developing countries such labels had resulted in creating tensions as power had shifted from producers to the consumers. In short, tools that are considered to alleviate poverty will rather result in creating and widening inequalities and disparities.

2.3 Traditions of Climate Change

Oral traditions stress the fact that there is no separation between human beings and environment. It is only through synchronisation and harmony between different entities that ensures sustainability in the long run. Folklore or oral traditions should not be categorised as the knowledge of the illiterates but should be given due importance. Folklore and Folklorists should act as facilitators of the community and to arrive at a group consensus for action and to deal with development possibilities and alternatives (Jones, 1994 p159). Locations like home, field and forest are sacred to them as they are regarded as place to live, to farm and to bury the dead (Thao 1970, p42). Research scholars always used these narratives as a means to end i.e., to strengthen the relationship between the three worlds – natural, cultural and supernatural. We all are familiar with monsters in folklore, but there are those who attack us if we violate the prevailing norms in the environment (Cormick and White, 2011,p108). But the prevalent truths about the well-being of environment are based on historical experiences of environmental issues and reactions to environmental pressures which are collectively condensed under the term environment folklore (Nelson 2016,p22). Finally, environmental conservation strategies are

influenced by prevailing customs and beliefs which provide us with an insight into morals, motivations, fears and uncertainties of the area.

2.4 History of Climate change

Right from ancient time, it is believed that elimination of trees and vegetation will have an adverse effect in the region. Student of Aristotle, Theophrastus ('father of botany') observed that draining of marshes had made a particular locality more susceptible to freezing and speculated that lands became warmer when the clearing of forests exposed them to sunlight (Dryzek et.al 2011, p.67). In nineteenth century there was a prevalent belief among the public in America which was popularly known as '*Rain Follow Plough*' which conveys that the soil beneath the grasslands was rich and often moist and sloughing releases it which results in formation of clouds and rain (Moench et.al, 2003,p13). This theory postulates that as more land is brought under cultivation, more moisture is realised which in turn results in more rain. But in reality, opposite happened and the region ended up as the *Dust Bowl* of America. It is opined that only by the 18th century, farmers and mariners started reading environmental signs. A popular idea that evolved out of this analysis is the 'notion of cycle' which means that drought occurred in cycles. Though the duration of the cycle was a subject of contention yet it had a significant impact on determining the land use pattern (Anderson, 2014, p 22). European Renaissance witnessed the rise of astronomy as a leading science under the leadership of Johannes Muller who created the astronomical calendar. They used planetary conjunctions in predicting weather conductions, harvest, availability of wind or water power etc (Behringer 2010, p12). When we analyse great civilisations like Egypt and Mesopotamia, it is climate which ought to be regarded as the most determinant factor for their flourishing. Egypt, an oasis with consistent flooding of Nile developed a sense of security and stability even beyond the point of death while Mesopotamians felt a constant threat to their existence (Arie and Zohar, 2007, p 112).

Based on a research study undertaken by the British Council, it is opined that there was an abrupt weakening of summer monsoons in the North West India during 4100 years ago (Sinha 2016,p76). Through the adoption of combination of archaeology and geo-science techniques, they linked the decline of Indus Valley civilisation to a global scale climate change which also destroyed the old kingdom of Egypt, early Bronze Age civilisation of Greece and Crete and the Akkadian Empire in Mesopotamia. The Indus Valley civilisation which was situated in the present Pakistan and parts of north-west India was home to the Harappan civilisation. The peculiarity of this civilization is that it was characterised by large well-planned cities with advanced municipal sanitation systems. But the Harappans seemed to slowly lose their urban cohesion which finally led to its abandonment (Ians, 2014 p121).

2.5 Politics of Climate Change

Rational choice theories have highlighted the problem of Collective action in area of public goods and common-pool resources – clean air and water. The problem with such goods is that it may not be rational for any individual to do the work required to provide a public good as it will be used by others and he only gets a marginal benefit. Thus a corporate polluter may gain economic benefits from dirty production, but any individual will be reluctant to bear the cost of cleaning up the mess (Gupta, 1997, p 29). Likewise, developing nations feel that they are asked to clean up the mess that was created by the developed countries which according to them is not a prudent one (Fred 2005,p21). In his new book, Antony Giddens suggest a paradox which is popularly known as 'Giddens Paradox'. He opines that since the dangers posed by global warming are not immediate or visible to most people, they ignore it and the only solution is through politics (Giddens 2011, p12). He viewed that first the politicians should be made aware of the gravity of the situation which will form the first wave followed by the second wave through the embedding of institutions and into the everyday concerns of the citizen.

2.6 Components of Climate Change

In the post-war era, what we witnessed was arrogance of Science as a supreme entity. Through disciplines like biotechnology, the supreme entity had gone to the extreme to convey the public that it even has the ability to dominate nature. Researchers had always highlighted that there is a new ominous trend visible today where mankind intoxicated with a sense of power and pride seems to be going farther and farther into more experiments for the destruction of he and his world. Technology seems to be moving on a faster trajectory than mankind's sense of moral responsibility. Pollution of the environment through the excessive use of toxic synthetic chemicals like Dichloro Diphenyl Trichloro (DDT) can be regarded as the ultimate act of human hubris, a product of ignorance and greed (Carson, 2002, p 14). Researchers even exclaimed that if the scientific community cannot even predict today's weather, how they are going to convey the real intensity of climate change in future (Dinger 2010 p156). Dogmatic resistance by power groups who staunchly opposed the Theory of Climate Change was influenced by various forms of visual media like documentaries and cinema. It is because of the role played by visual media like the epoch documentary film 'An Inconvenient Truth' by Al Gore which altered Americans resistance towards global environment philosophies (Weber and Jentleson 2010, p190).

2.7 Economics of Climate Change

Though innumerable number of opportunities is provided through advancement of technology, institutional and societal GHG mitigation technologies, yet the impending reasons are that industrialized countries face barriers that are mostly related to their affluent lifestyles while developing countries are hampered by a culture of energy subsidies, institutional inertia, fragmented capital markets and vested interests. Hence the need of the hour is a new alignment of forces that shape the economy (Ravindranath and Sathaye1972, p162).

But if the climate change regime develops, then it will be mandatory for major energy and manufacturing company to acquire a license to emit CHG which will lead to a more pertinent question regarding how it should be sanctioned which will be a politically tricky question. Each and every suggestion will put both the industrialised and the developing world at logger heads. Main reason is that the developing nations are coming under pressure of emission norms before they are given sufficient space for development (Pearce 2005, p24). Any serious environmental arrangement or agreement will regulate economic activity or at least have economic consequences which will culminate in raising socio-economic equity in a straight forward way. It seems unfair to ask developing countries to forgo economic gains (the gains from trade or otherwise) when rich countries can bear the economic sacrifices of environmental conservation (James 2012, p127). Developing countries are suspicious that environmental standards will be used as a pretext for discriminatory trade practices given the growing trend in non-tariff barriers to market access (Weiss and Thakur 2010, p205).

In 1972, the Club of Rome's infamous report "*The Limits to Growth*" (Meadows et.al 2006 p.24) presented some challenging scenarios for global sustainability and highlighted the need for understanding and controlling pollution in the long run. First World Climate Conference (1979) opined that "continued expansion of man's activities on Earth may cause significant extended regional and even global changes of climate". The conference ended with a clarion call for global cooperation to explore possible future course of global climate and to take this new understanding into account in planning for future development of human society. Planners and Policymakers were skeptical about the newfound concern about environment and articulated that the developing nations should resist participating in environment conferences on the terms set by the developed countries (Alam et al, 2015, p112). If the cleaning up of mess requires the cooperation of poor countries, it is only fair for poor countries to be guaranteed a minimum level of emissions to ensure the means of material subsistence (Gough

and Stables 2008, p24). The G7 nations had achieved their economic advancement at the expense of climate and it is not just on their part to argue and deny the poor countries the right to do the same. This is the reason why poor countries demand the access to energy whereas the industrialised countries tend to stress the importance of 'clean energy' (Lesage et.al 2010, p40).The Kyoto Protocol and Marrakesh Accord adopted a flexible series of market mechanism as to how carbon credits (buying the right to pollute) can be traded. This is done to provide economic motivation through market justification to invest in emission reduction goals anywhere in the world (Woodcock 2008, p298). International emission cooperation is now happening not under uncoordinated or unilateral agreements, but under the framework of United Nations Framework Convention on Climate Change (1992) and the Kyoto Protocol (1997) along with the inputs from Bonn and Marrakesh. Now it has become the duty of each one to play a fair role in ensuring the greening of Earth.

2.8 Conclusion

Ignoring adaptation measures will result in dampening economic growth and well-being. Under certain extreme situation lack of environmental consciousness can even lead to reversing the past gains made by the country. For effectively addressing this issue, it is urged that ecological issues should be brought to the forefront of the development process. When climate change issues are addressed, it envisages the application of appropriate adaptive measures which involves financial obligation. Yet the developing countries should convert the threat of climate change into an opportunity through adoption of shifting practices along with adoption of innovative agricultural practices and technologies can minimize the adverse effects of climate change. The suggested course of action that ought to be incorporated in the fight against climate change is an improvement in forecasting and early warning system and adoption of participatory forest and environment practices

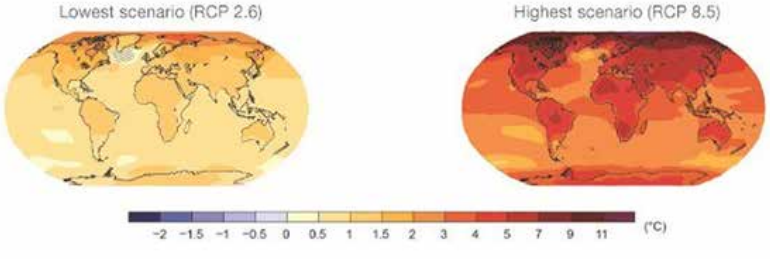
Chapter 3

SITUATION ANALYSIS OF WESTERN GHATS

3.1 Introduction

Researchers are of the view that if the current trends of climate change continue; the most affected will be the vulnerable sections of the society, can cripple markets and in extreme cases can even lead to the rollback of development which the mankind had achieved so far. The Building Resilience Report (Hallegatte et.al, 2017p22) is of the view that between the periods, 1980 – 2012, the disaster related losses amount to $ 3.8 trillion worldwide. As per the IPCC Report of 2013, credits the human induced activities as the major causative factor for climate change phenomena. According to Prof Thomas Stocker, Co-chair of IPCC Report – 2013 observed that the climate change phenomena is threatening two primary resources of humans and ecosystems i.e., land and water which in the end is even questioning the existence of life on earth. Based on the present scenario, the report predicted future scenario of the earth. According to them by the year 2100, ocean waters will rise at a faster rate than we have experienced over the past 40 years. Expected global mean sea level rise for the year 2100 is projected to be between 26 cm (at the low end) and 82 cm (at the high end), depending on the greenhouse emissions of this century.

Figure 3.1
Predicted Temperature Increase (2081-2100)



Source : IPCC (2013)

Disasters like the Indian Ocean Tsunami in 2004 conveyed that India is exposed to sudden environmental disasters and the management strategy adopted is still a wait and watch policy or rather disaster assistance after it had happened than disaster management. Hence there is a need for a strategic management of disaster rather than humanitarian based disaster assistance.

3.2 Western Ghats – a Biodiversity Hotspot

Biodiversity hotspots are a method to identify those regions of the world where attention is needed to address biodiversity loss and to guide investments in conservation. It is the British biologist Norman Myers, who is credited for coining the term "biodiversity hotspot" in 1988. According to him if a region is characterised by increasing levels of destruction of flora which gets reflected in the change in habitats of fauna, then it can be regarded as a 'hotspot'.

> *Large regions containing exceptional concentrations of plant endemism and experiencing high rates of habitat loss (Meyers 2000, p853).*

Too much importance is given to identify hotspot regions as they are based on vulnerability and irreplaceability of species found in the area. Hence any operation which is routine or drastic should be initiated only after undertaking rigorous biodiversity assessments to minimise future losses. New regions are being added to the list of the regions declared as hot spot based on the suggested criteria given below.

Hotspot Criteria

- it must contain at least 1,500 species of vascular plants (> 0.5% of the world's total) as endemics;
- it has to have lost ≥ 70% of its original native habitat.

Report of OECD (Upton, 2014, p15) conveyed that there is increasing loss of biodiversity in developing countries of Asia and Africa which is expected to continue with the same trend till 2030. This can be attributed to rapid increase in population along with unlimited demand for achieving rapid economic growth through sustained manipulations and alterations of environment. Future pressure will also be increased as there is an ever increasing demand for agricultural products for the rapidly growing population and a sizeable decline in productivity.

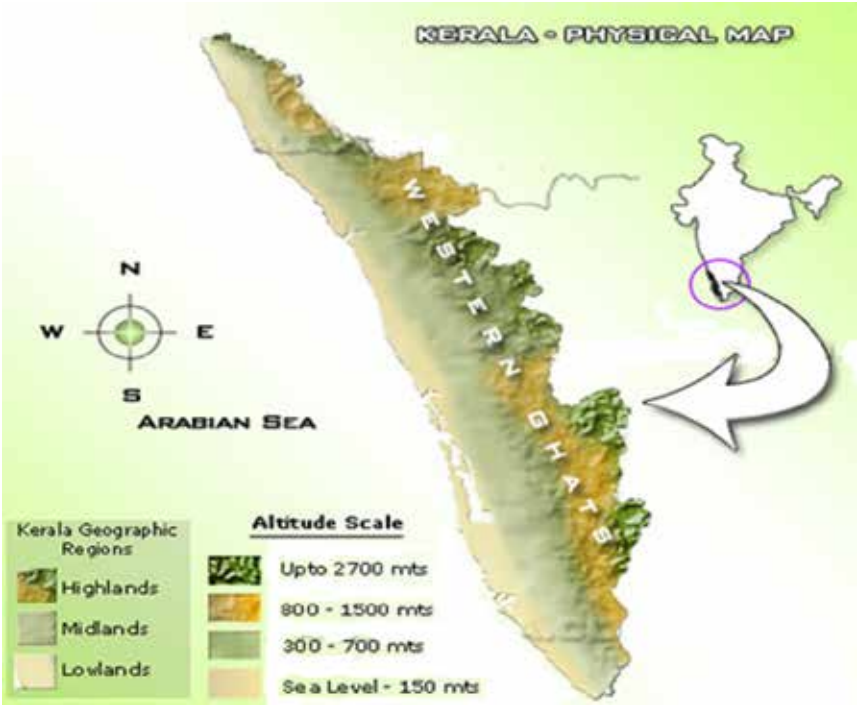
Following the footsteps of Meyers, Conservation International (CI) adopted the blueprint of Meyers and decided to undertake a global review in 1996. In the Year 2005, they came forward with a report specifying 34 areas as hotspots ranging from the Himalayas to the regions belonging to Japan, Australia. Central Asia etc., but the 21st hotspot identified by CI is the Western Ghats and Sri Lanka.

Figure 3.2
Details of Hotspots

Source : Conservation International (2005)

Faced with tremendous population pressure, the forests of the Western Ghats and Sri Lanka have been dramatically impacted by the demands for timber and agricultural land. Remaining forests of the Western Ghats are heavily fragmented; in Sri Lanka, only 1.5 percent of the original forest remains. The region is home to a rich endemic assemblage of plants, reptiles, and amphibians, as well as important populations of Asian elephants, Indian tigers, and the endangered lion-tailed macaque (Bawa et.al 2007p12).

Figure 3.3
Physical Map of Kerala



Source : Prokerala.com (2015)

Sahyadri Mountains, scientifically known as the Western Ghats runs parallel to the west coast of Kerala and houses the highest mountain peak Anamudi. UNDP has reported that Western Ghats harbour 27 percent of India's floral wealth comprising of vegetation types like tropical wet evergreen, montane evergreen moist deciduous along with high altitude shola-grassland ecosystems. The original inhabitants of this area comprise of tribal communities belonging to Hill Pulaya, Muthuvan, Mannan, Oorali, Malavedan and Malayan and the demographic profile of the communities is given in Table 3.1. They adopted '*slash and burn*' system of agriculture practices respecting the unwritten rules and regulations of the forest for their livelihood.

Table 3.1
Details of Tribal Population in Study Area

Community	No of families	No. of persons	% among the Scheduled Tribes	% of Population
Hill Pulaya	960	3415	10.63	10.09
Mannan	1776	6688	19.67	19.77
Muthuvan	3334	12399	36.93	36.65
Paliyar	358	1281	3.97	3.79
Ulladar	609	2379	6.74	7.03
Oorali	823	3044	9.12	9
Malaipandaram	12	45	0.13	0.13
Malayan	151	551	1.67	1.63

Source : Compiled from Census of India, 2011

There were only four Revenue Divisions in the erstwhile Travancore state and it was only in 1909, a new division (Devikulam) was carved out from Kottayam Division. The present population of this region are decadents of the migrators whose journey was marred by labour struggles braving inclement weather, wild animals and epidemics. *Kuthakapattam* or the land grants programme initiated by the Government in 1941 in this region conferred unlimited cultivation rights to the grantees. According to rough estimates, 14,000 acres of land was granted for cultivation purposes with a rider that these are temporary arrangements devoid of any permanent or legal claims. But this initiative had resulted in large scale encroachments in this region. The period 1930 to 1951 marked the migration of Christian families from Travancore to the hills of Western Ghats and Independence was regarded as the real catalyst for opening of this region to outsiders. It is under the leadership of the then Minister T.K. Narayana Pillai for the '*Grow-more Campaign*' (1941-50), the State had initiated serious agricultural practices. The present population that is directly or indirectly engaged in agricultural operations are as follows.

Table 3.2
Details of Population involved in Agricultural related Operations (*Devikulam Taluk*)

	Marginal Workers			**Cultivators**			**Agricultural Labourers**		
	Persons	Males	Females	Persons	Males	Females	Persons	Males	Females
Devikulam (Total)	17,540	7,658	9,882	2,554	1,317	1,237	5,076	2,095	2,981

	Marginal Workers			Cultivators			Agricultural Labourers		
	Persons	Males	Females	Persons	Males	Females	Persons	Males	Females
Devikulam (Rural)	17,540	7,658	9,882	2,554	1,317	1,237	5,076	2,095	2,981
Marayoor	1,480	709	771	102	62	40	1,100	480	620
Keezhanthoor	468	187	281	16	10	6	409	156	253
Kanthalloor	376	146	230	23	11	12	303	109	194
Kottakamboor	35	12	23	15	2	13	8	3	5
Vattavada	190	83	107	10	6	4	113	54	59
KannanDevan Hills	5,239	2,674	2,565	1,430	706	724	120	65	55
Mankulam	844	341	503	110	45	65	325	144	181
Mannamkandam	5,147	1,934	3,213	488	258	230	1,651	693	958
Anaviratty	341	122	219	55	8	47	152	60	92
Pallivasal	862	397	465	25	10	15	127	56	71
Kunjithanny	724	249	475	76	50	26	216	64	152
Vellathuval	1,834	804	1,030	204	149	55	552	211	341

Source : Census of India, 2011

Agricultural practices can be regarded as stimuli for modern economic development of the region. This phenomenon is clearly visible in Devikulam taluk as the region cultivates majority of the crops produced in Kerala (Table 3.3), but it is the emergence of Capitalistic agricultural practices in the form of plantation industries that resulted in over exploitation of the sensitive environment in Devikulam.

Table 3.3
Comparison of Crops cultivated in Devikulam

(Area in hectares)

Crop		Devikulam	Idukki	Idukki	Devikulam	Crop
Paddy	Autumn		259.85	14.28	2.01	Koorka
	Winter	30.31	937.82	5.71	1.08	Sweet potato
	Summer	23.14	66.07	2.48		Nanakizhangu
	Total	53.45	1263.74	4.75	0.04	Other Tubers
Tapioca	Autumn	66.71	938.76	94.9	15.87	Pulses
	Winter	110.16	2741.66	155.46	155.46	Garlic
	Summer	227.93	2637.48	654.25	48.72	Ginger
	Total	404.8	6317.9	204.36	11.94	Turmeric

Crop	Devikulam	Idukki	Idukki	Devikulam	Crop
Drumstick	15.25	581.36			Ground Nut
Amaranthus	4.37	58.06	17158.12	677.68	Coconut
Brinjal	4.07	45.83	2708.92	372.66	Arecanut
Ladies Finger	1.76	21.28	1497.12	45.12	Cashew
Bitter gourd	8.68	529.73	44010.47	3016.08	Pepper
Snake gourd	1.15	18.13	13866.25	1351.19	Jack
Little gourd (Koval)	2.6	48.67	5298.17	346.85	Mango Tree
Ash gourd(Kumbalam)	1.13	25.68	483.92	15.76	Tamarind
Payar (Achinga)	23.87	521.61	596.73	1.56	Clove
Pumpkin (Mathan)	6.67	48.61	2400.69	33.21	Nutmeg
Cucumber (Vellari))	0.61	6.51	8137.52	190.19	Cocoa
Bottle gourd		0.55	923.88	44.31	Pappaya
Green Chilli	4.64	54.46	2900.57	114.94	Banana
Potato	604.77	604.77	857.8	3.09	Pineapple
Carrot	1347.71	1347.94	3492.48	219.12	Plantain
Beetroot	42.41	42.99	285.99	33.63	Orange
Cabbage	415.1	418.59	2123.82	2123.32	Sugarcane
Tomato	3.53	15.59	0.97		Sesamum
Cauliflower	0.36	1.42	241.31	216.69	Lemon grass
Beans	793.76	880.75	1422.83	161.19	Fodder grass
Onion	0.52	0.52	1368.17	22.64	Green Manure Plants
Other Vegetables	4.53	31.59	208.98	4.74	Vanila
Elephant foot yam	10.8	817.14	1027.06	22.84	Teak
Colocasia	17.57	715.28	653.61	280.34	Medicinal Plants
Yam	3.05	169.54			

Source :Compiled from Agriculture Survey, Government of Kerala (2017).

3.3 Environmental Degradation by the Plantation Model

Plantation Model of agriculture is a by-product of the colonial past. The main objective of this model is to meet the increase in demand for commodities like beverages (tea/coffee) and Spices (cardamom/pepper). The demand for such products is showing an upward trend due to the insatiable needs of the modern society.

It is in the Plantation Convention of ILO in 1958, which defined plantations as any agricultural undertaking regularly employing hired workers which is situated in the tropical or subtropical regions and which is mainly concerned with the cultivation or production for commercial purposes of coffee, tea, sugarcane, rubber, banana, cocoa, coconut, groundnut, cotton, tobacco, fibers (sisal, jute and hemp), citrus, palm oil, cinchona or pineapple; it does not include family or small-scale holdings producing for local consumption and not regularly employing hired workers. The basic characteristics that one can observe in a plantation sector are as follows

i. Crops that are planted are tropical or sub-tropical in nature with a wide export market.

ii. Mono-cropping practices are very popular in this sector as it easily enables scientific agricultural practices.

iii. Huge initial capital investment in the form of tree crops, factories for processing and packing or even infrastructure investments in the form of plantation roads are essential for initiating this project,

iv. There is sufficient scope for taxation of this sector based on its scale of operation and its market inclinations

v. Standard management and marketing practices can be easily adopted in this sector based on the scale of operation.

vi. This sector is exposed to international price fluctuations as they are excessively depended on one crop and it is generally produced for export rather than for local consumption.

Plantation Industries are generally welcomed in the initial stages of development in a less developed or developing countries. But it is the Caribbean Economists like Lloyd Best, Kari Levitt, and George Beckford who argued that the plantation economies of the New World create and encourage a structural environment lacking in the internal dynamism needed to generate sustainable growth. They are of the view that the Plantation Model of Growth begins with the objective of achieving long-term growth and development but during the course, this model loses its direction. Long-term growth can be achieved only if there is a sustained increase in output along with backward linkages with industry and forward linkages in demand for farm inputs. Moreover, this sector should also generate surplus through an increase in productivity that will enable transfer of excess labour and capital to other sectors. Beckford is of the view that this synchronisation is not achievable due to externalities related to a foreign market. They even clamoured for the liberation of third world countries from the clutches of Capitalist oriented primary production ventures.

Sustainability of the Plantation Model can also be questioned from its attitude towards ecological forces prevailing in the third world countries. The essence of these plantations is to maximise profit through the plunder of virgin surroundings. Mono-cropping is the strategy adopted where large areas are cultivated by a single crop year after year. Mono-cropping suits the capitalist ideology as it encourages specialistion through the division of labour. This will assist in enhancing economies of scale as it encourages easy implementation of corporate management practices and techniques. But the negative side of this practice will be visible only in the long-run. Environmental research studies had conveyed that lack of variety in plants, in turn, will limit the diversity of plant, animal and insect species available in the region which will alter the prevailing ecological balance. As per an approximation, about 70

percent of the plant species require animal pollination for fruit production (Aizen et.al, 2009 p147). This disruption in balance will reduce the instinctive ability of the ecosystem to restore its fertility and assist in pollination and growth of the plant species. Studies conducted among canola farmers in Canada even highlighted that leaving some part of the land as fallow will even lead to a bumper crop. This situation is more serious when we consider the fact that these plantation industries are in fact created by clearing rich biodiversity regions like the Amazon Rainforest that provides habitat for 70 percent of plant and animal species.

Another important defect of such a system of cultivation is that mono-cropping reduces the number of predators which are insects and birds that feed on the pests and locust of the farm land. As a result there will be an uncontrolled multiplication of pests and insects and regulating them will be both uneconomical and unhealthy. According to a study (Harte et.al 1991 p119) conducted by Cornell University, in a developed country like the US, where the health standards are very high, there is a 10 fold increase of pesticides during the last 40 years. Selective application is not possible when using pesticides and hence it not only kills the harmful one but also those that are beneficial to farmers as well which enhances the negatives on the fragile environment.

Mono-cropping generally mean cultivating a single crop year after year which in turn gets reflected in productivity. As these cultivations are undertaken under a capitalistic model they adopt every possible strategy to maintain their profit margin. Research studies (Steve, 2012) are of the view that mono-cropping depletes fertility 18 times faster than that can be restored by fertilisers. Hence the only viable solution is to use excessive fertilizer along with uncontrolled use of growth hormones to maintain capitalistic productivity standards.

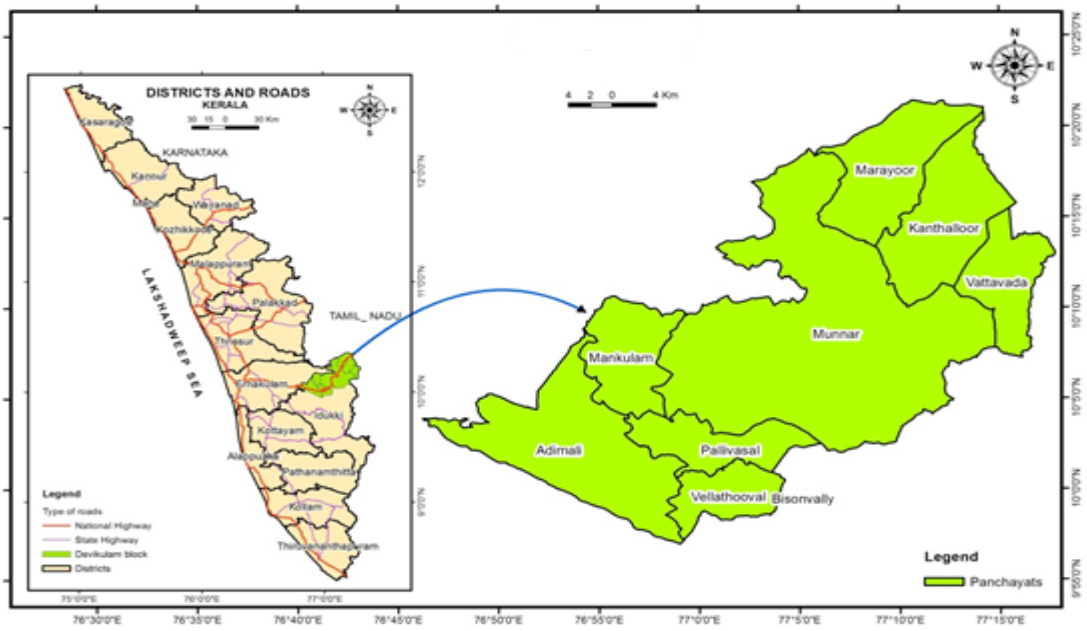
Hence there is a need for analyzing the change in land use pattern to gauge the capitalist mono-cropping production strategies on ecologically sensitive environment of the Western Ghats.

3.4 GIS Mapping of Land use Pattern

For viewing and analysing spatial data, Geographical Information System (GIS) analysis is a vital component. GIS applications are widely used in pure science research studies like environmental sciences, geology, and geography and even in engineering. Social Scientist can be regarded as the recent entrants who are trying to master the GIS application in analysis and to evolve viable solutions.

*Location of the Study Area :*Devikulam block is located on the eastern side of Idukki district between latitudes9°56’ 47” and 10°21’35”N; longitude 76°46’12” and 77°17’58”E which can be regarded as a high altitudinal region. Anamudi, the highest peak in South India is placed within the block at an altitude of about 2695 m above mean sea level (amsl). Marayoor, the rain shadow region and Nallathanni popularly known as Chirapoonchi of South India is also situated in this block which illustrates the ecological diversity of the district.

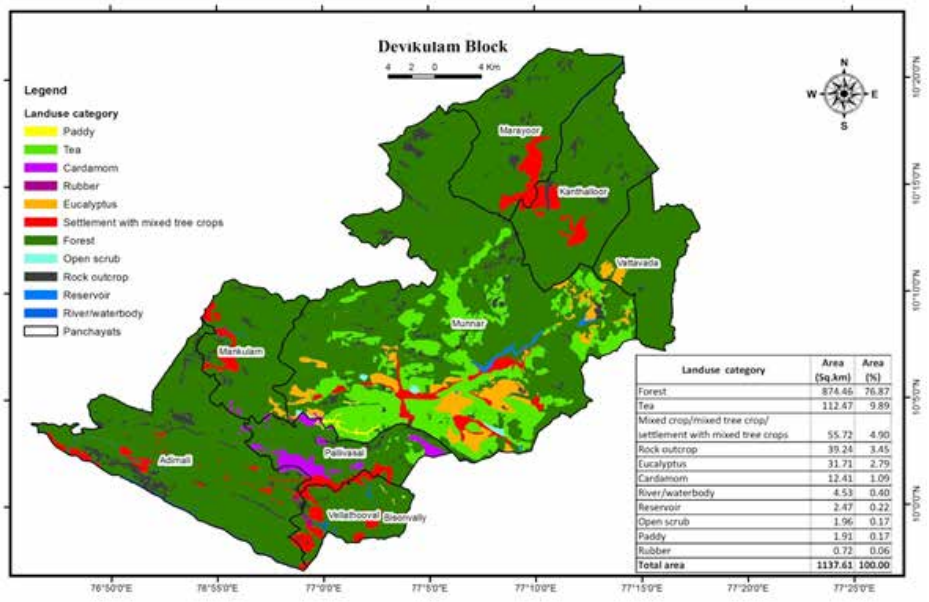
Figure 3.4
Location Map of Devikulam Block



Source : Compiled from GIS Analysis(2017)

Methodology Adopted : Land use map of 1975-77 has been prepared using Survey of India Topo sheet of 1: 50,000 scale. Land use map (2016) has been prepared based on extensive field work of the area and also with assistance from Google Maps. The maps thus prepared have been input into GIS (version Arc GIS 10.1). The time series land use maps are then subjected to spatial overlay in order to analyses land use changes.

Figure 3.5
Details regarding Land use Pattern (1975-77)

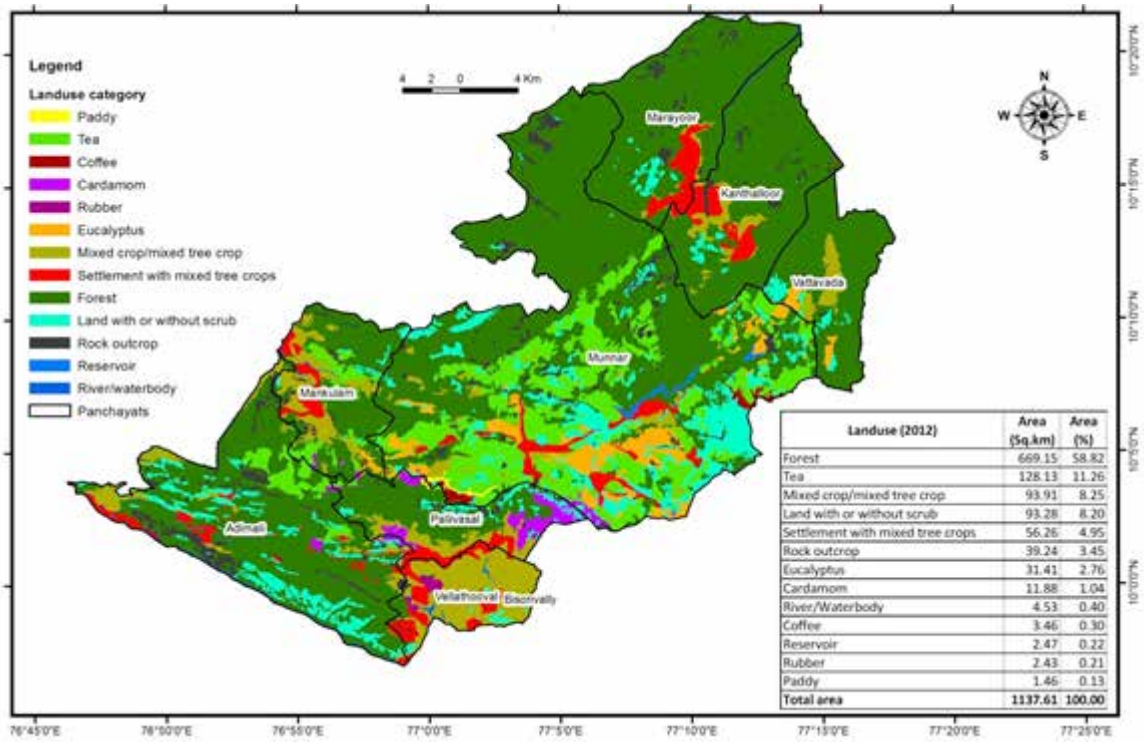


Landuse category	Area (Sq.km)	Area (%)
Forest	874.46	76.87
Tea	112.47	9.89
Mixed crop/mixed tree crop/ settlement with mixed tree crops	55.72	4.90
Rock outcrop	39.24	3.45
Eucalyptus	31.71	2.79
Cardamom	12.41	1.09
River/waterbody	4.53	0.40
Reservoir	2.47	0.22
Open scrub	1.96	0.17
Paddy	1.91	0.17
Rubber	0.72	0.06
Total area	1137.61	100.00

Source : Compiled from GIS Analysis(2017)

Excessive Deforestation :From spatial overlay analysis it is was obvious that deforestation is the major land use change in Devikulam block. In 1975-77 the areal extend of forest was 874.46 sq.km which got reduced to 669.15 in 2016. Hence the area that has been converted into other land use categories is about 205.31 sq.km which amounts to a change in forest area by about 23.48percent. First land conversion that was witnessed through this study is that the forest area is being converted into mixed crops/mixed tree crops (82.39 sq kms), land with or without scrub (66.45 sq.km) and tea (44.44 sq.km). The study also observed downgrading of tea plantation into area with or without scrub (16.70 sq.kms). Through this study, we observed a marginal increase in area under tea cultivation in areas in and around Adimaly and Mankulam Panchayats.

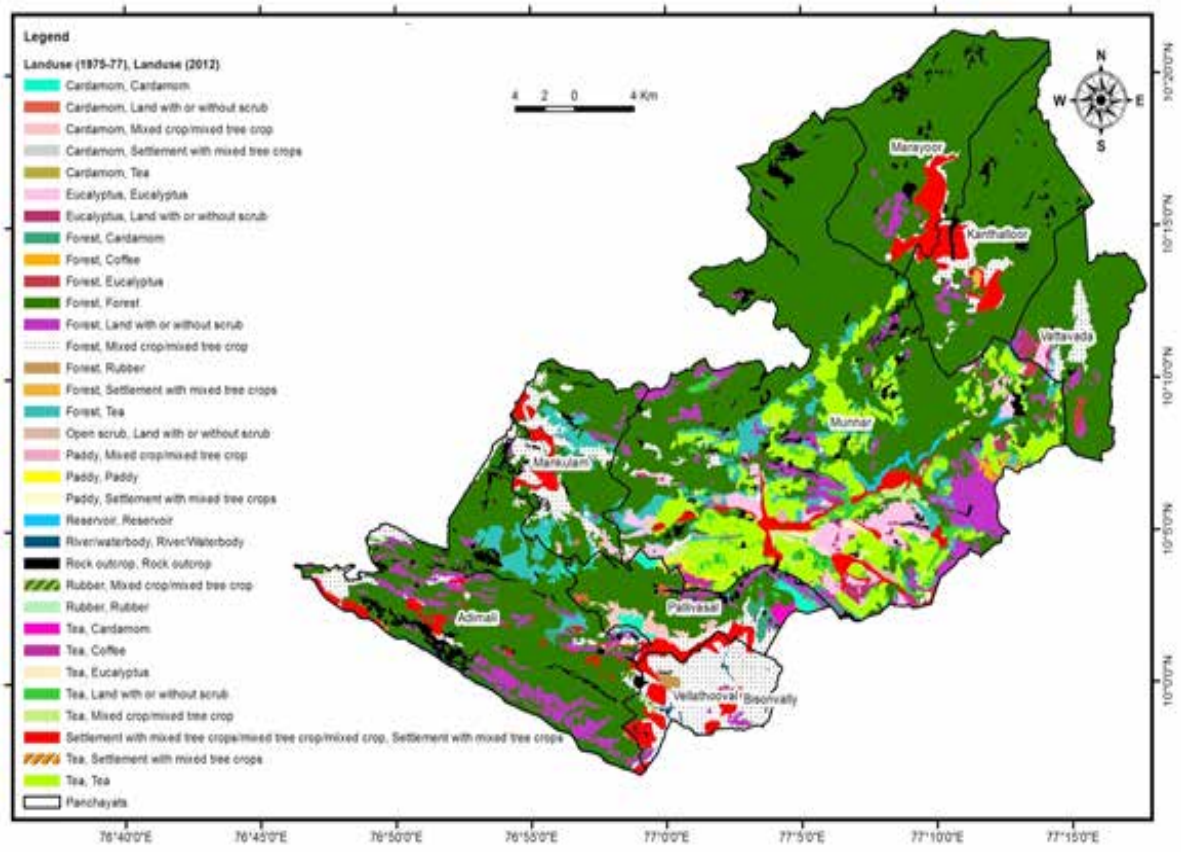
Figure 3.6
Details regarding Land use Pattern (2016)



Source : Compiled from GIS Analysis(2017)

Likewise most of the degraded forest which is converted into land with or without scrub was in Munnar and Adimaly panchayats. This is a more dangerous change as these areas can be regarded as denudation hills and during heavy rains; there is every probability of landslides. Geological research studies conducted in this area had highlighted that these regions surrounding Munnar can be regarded as the most hazardous region which required urgent mitigation strategies. Moreover, uncontrolled clearing of the pristine forest had also resulted in increasing the temperature in this area which had adversely affected not only the quality but also the productivity of tea plantations.

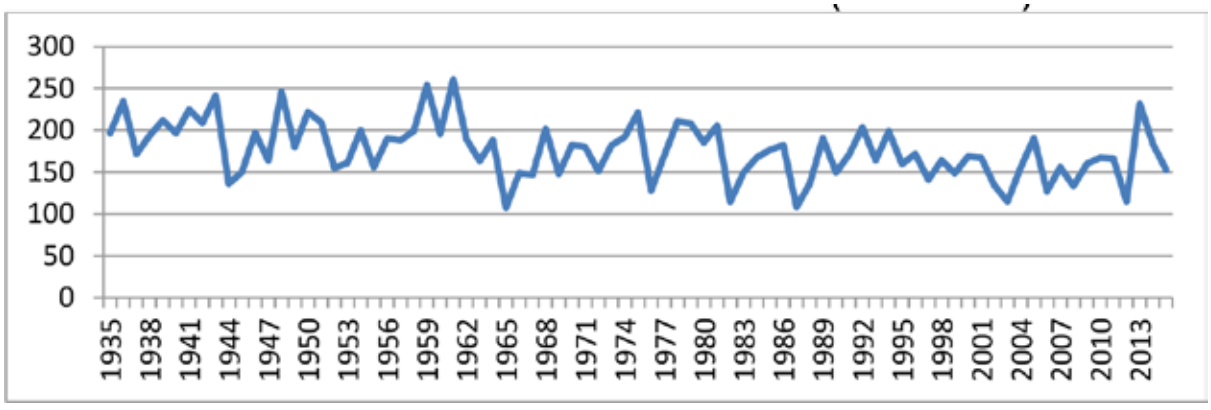
Figure 3.7
Details regarding Change in Land use Pattern (1975 - 2016)



Source : Compiled from GIS Analysis(2017)

When the erosion of topsoil occurs during heavy rains, it exposes the hard bare crystalline rocks found underneath it resulting in the creation of Heat Island Effect. This effect will influence atmospheric temperature, wind speed, wind direction and variations in the intensity of rainfall. This is clearly evident from the analysis of rainfall data from 1930 – 2016.

Figure 3.8
Trends in Annual Rainfall in Munnar(1935-2015)

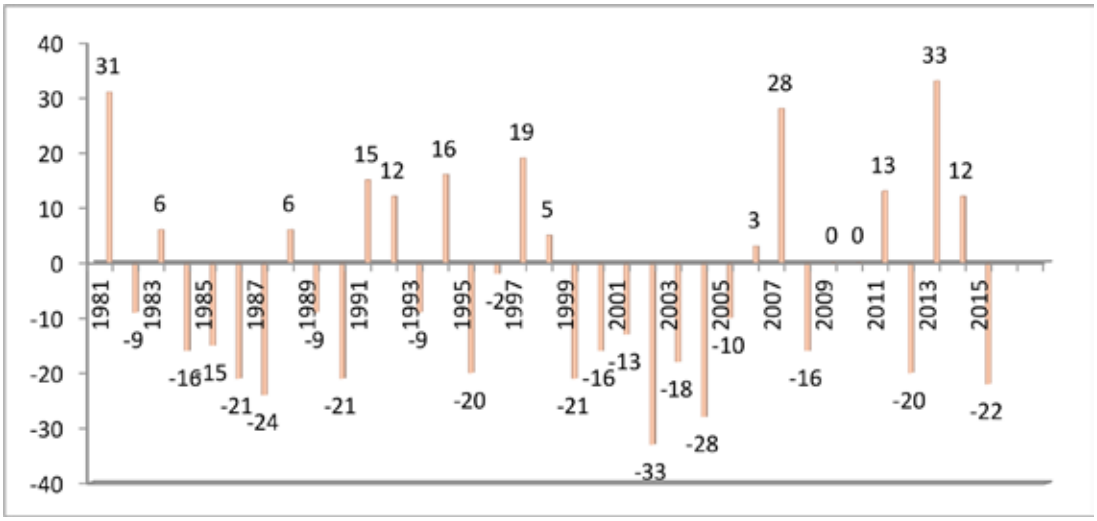


Source: Compiled from Harrisons Malyalam, Tata Tea and Upasi(2017)

When the temperature rises in a region, other environmental effects that one can witness in a region are change in relative humidity, temperature, water percolation and soil profile etc, which easily gets reflected in the change in carbon sequestration pattern and on the rate of biogeochemical cycles. A research paper (Divya et.al 2016 p302) published in the proceedings of National Academy of Sciences conveyed that increase in atmospheric temperature or global warming will affect the capacity of trees to store carbon through the altering of forest nitrogen cycle. A warmer climate will result in rapid decomposition of organic matter in the soil leading to an increase in carbon-dioxide being released into the atmosphere. In short this phenomenon is resulting in an increase in atmospheric carbon.

Research studies (Xavier and Joseph 1999, p93; Kumar and Dash, 2001 p45) reported that the frequency of monsoon depression is showing a decreasing trend during the last 100 years and preliminary estimates convey that it is less than half of the depression which we witnessed in the beginning of this century. This view can be further supported by the analysis of meteorological data provided by Meteorological Department, Government of Kerala. From the data, it can be inferred that the percentage departure of monsoon is showing increasing trend right from 1980s.

Figure 3.9
Percentage Departure of Monsoon Rainfall over Kerala
(Since 1981 onwards)



Source: Compiled from Meteorological Department, Government of Kerala(2017)

From the analysis of agro-climatic scenario of areas in and around Munnar, it can be observed that Munnar had started receiving heavy and intermittent rainfall during non-monsoon seasons which had resulted in an increase in incidence of weed growth in the cropped area which directly affects productivity of tea. During the dry season due to increase in temperature beyond the normal level had resulted in forest fires on a large scale. These uncontrolled forest fires will also adversely affect the prevailing scenario in this area.

Nall.ar and Palla.ar which originated from the Western Ghats merge together at the Munnar town to form the Muthirapuzha.ar which finally debouches into the Periya.ar. During the field study, it was observed that the river is highly polluted due to excessive waste disposal. This contamination of river will result in the formation of algae which produce methane which can be regarded as 25 times highly potential than CO_2 (globalmethane.org).

Pressure of Floating Population: Another problem that is faced by Munnar is population pressure created by a sudden influx of inbound and international bound tourists into a very sensitive ecological hotspot.

Decline in Water Table : The extensive erosion of top soil reduce the infiltration capacity of pink granitic gneisses and hornblende gneisses along its lineaments and fractures which reduce the prospects of ground water. Rainwater thus infiltrated are the main source of underground water in this region which is used for both irrigation and drinking purpose. As infiltration reduces, there will be a simultaneous reduction in ground water table. This reduction will affect productivity of crops and steps must have to be taken to control deforestation and to encourage afforestation.

Optimum temperature that is needed by tea plants is 30^0 C and when the temperature increases beyond 30^0 C, the rate of photosynthesis declines rapidly which happens during the summer season. Hence to ensure photosynthesis and growth in tea plants, a canopy of moderate shade are essential which can be provided by the planting of tree species of eucalyptus. Tree species also assist in pulling up the nutrients from the deep soil to the reachable limits of tea plants. They also reduce the level of soil erosion but the main disadvantage is that it will increase the probability of pests like mosquito bug and blister blight. One of the features that were witnessed in Devikulam block is that wood was used extensively to meet the energy demands in the processing of tea. Hence we witnessed an indiscriminate cutting of forest for planting eucalyptus. Preliminary analysis conducted in this area observed that eucalyptus and other vastly growing alien tree species were planted indiscriminately. These alien species will reduce infiltration capacity and will not only reduce water for irrigation purpose but also of the rivers which can be regarded as the lifeline of Munnar. Such indiscriminate agriculture practices should be avoided to ensure a healthy ecology and ecosystem to the Munnar economy

Table 3.4
Details of Tourist Arrivals in Kerala

District	Foreign			Domestic		
	2015	**2014**	**% variation over 2014**	**2015**	**2014**	**% variation over 2014**
Thiruvananthapuram	310223	289,612	7.12	1861470	1,707,199	9.04
Kollam	14100	12467	13.1	277109	257,097	7.78
Pathanamthitta	1667	1379	20.88	126132	112,548	12.07
Alappuzha	63838	60,337	5.8	270507	246,156	9.89
Kottayam	49976	44,366	12.64	458101	413,182	10.87
Idukki	83894	77,905	7.69	668537	635,621	5.18
Ernakulam	383643	372,997	2.85	2897894	2,724,718	6.36
Thrissur	7874	7,391	6.53	2659897	2,545,376	4.5
Palakkad	2232	2093	6.64	502244	475,361	5.66
Malappuram	23409	21,613	8.31	470261	449,420	4.64
Kozhikode	12251	11,313	8.29	811538	769,425	5.47
Wayanad	12377	11,795	4.93	607335	564,274	7.63
Kannur	9022	7,563	19.29	613199	584,343	4.94
Kasaragod	2973	2535	17.28	241347	210,691	14.55
Kerala	**977479**	**923366**	**5.86**	**12465571**	**11695411**	**6.59**

Source: Department of Tourism, Government of Kerala(2016)

Statistics provided by the Department of Tourism, Government of Kerala conveys that Idukki is third most internationally attractive state in Kerala which follows Ernakulam and Thiruvananthapuram. Likewise, it is also a centre of attraction for domestic tourists as well which increases the vehicular pollution in this area. Moreover, at higher altitudes, the atmospheric pressure of the ambient air is lower than at low altitudes and this result in a lower partial pressure of oxygen. Unless adjustments are made to increase air flow in engines, the lower oxygen content will result in higher emission rates of un-reacted hydrocarbons from the vehicular sources. Hence it can be opined that the indiscriminate opening of the fragile and sensitive ecosystem of the Western Ghats to tourism development had resulted in further aggravating the crisis in this area.

3.5 Predictive Analysis

Through GIS analysis, it can be clearly observed that there is a critical change in land use pattern which is going to adversely affect prevailing climate scenario in the study area – Devikulam Block.

Agriculture, Forestry, and Other Land Use (AFOLU): Land use pattern that can be observed under this classification comprised of forest, cropland, wasteland, wetland, grassland, settlements and other type of lands. These land classification will not remain the same forever and many of them will be under a gradual process of transition from one form to another. Hence such a changing scenario can be regarded as a unique feature of this sector as they are in the process of leading to emission or limiting the levels of emissions which can be natural or anthropogenic (direct-indirect). Analysis of AFLOU region in the Devikulam taluk comprises of the following

- CO_2 emissions and removals resulting from C stock alterations caused by changes in biomass, dead organic matter etc., due anthropogenic/indirect reasons.
- Emissions from managed land
- N_2O (fertiliser) emissions from soils of the managed land
- C_2O (fertiliser) emissions associated with managed land
- CH_4 (bio-fertiliser, cow dung) emissions from livestock of managed land

Analysis of AFLOU will provide us with sufficient information regarding the available stock, trends in carbon emission and the strategies for its removal. An analysis was undertaken to assess CO_2 equivalent emissions based on the global warming potential of each gas under consideration. Each factor is considered independently in this study as emission factor and the related uncertainties differ from each other as the category under consideration along with its vegetation had a significant role in influencing the emission level.

Carbon Stock Change Estimation: Right from the pages of history, we had understood that mankind leads a nomadic life wandering through the forest in search of food and shelter. But it is only after the adoption of agriculture, they adopted a settled life. The first cultivation practice, they had adopted is extensive agriculture, where they had brought more and more lands under cultivation through '*slash and burn*'. Hence, it is generally believed that the initial vegetation (forest) is cleared to cultivate crops. So if the initial vegetation the soil biomass is known, it is easy to calculate the loss of carbon due to the clearing process. Due to heavy littering of leaves and presence of relatively high moisture, a lot of decaying happens under the canopy of the forest. So a variation from a forest to grasslands or crop area can be concluded as a decline in carbon. But to gauge the real effect of this loss, a Carbon Stock Change is being undertaken.

Due to rapid increase in population and an ever increasing demand for food and other allied products, there are rapid changes happening in emission and removals of CO_2 from the AFLOU sector. The

changes in emissions can be estimated by analysing the change in land use categories like the area of land remaining in the present status and the area of land converted to other forms. The equation that is used for analysing changes in land use pattern is given below.

i.e.,

$$\Delta C_{AFOLU} = \Delta C_{FL} + \Delta C_{CL} + \Delta C_{GL} + \Delta C_{WL} + \Delta C_{SL} + \Delta C_{OL}$$

where

ΔC = carbon stock change Indices denote the following land-use categories

AFOLU = Agriculture, Forestry and Other Land Use

FL = Forest Land

CL = Cropland

GL = Grassland

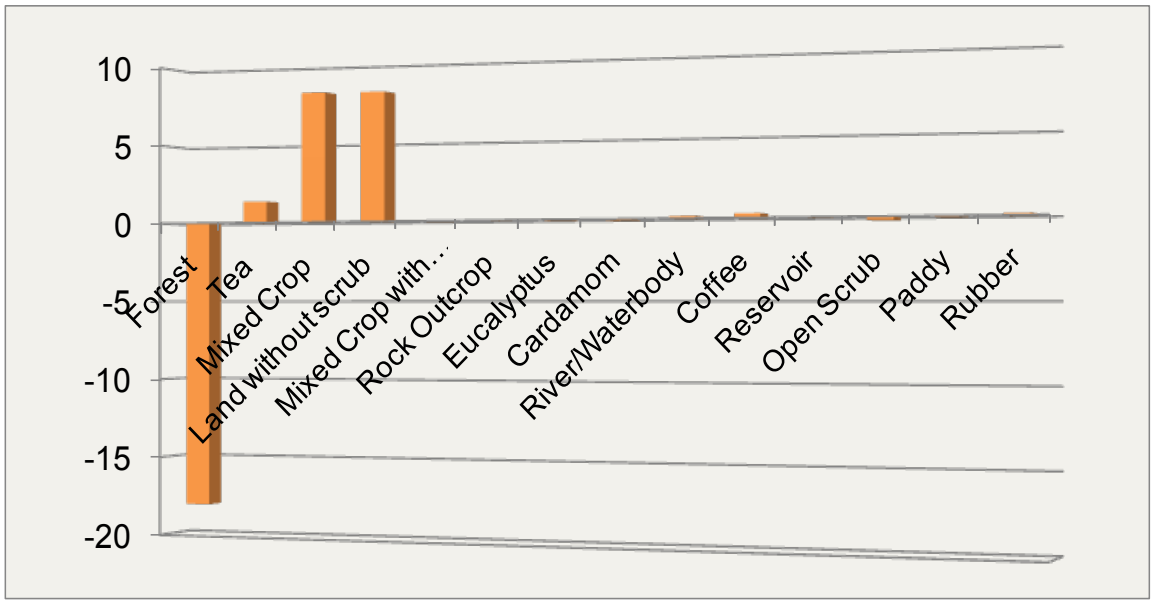
WL = Wetlands

SL = Settlements

OL = Other Land

Based on the GIS Analysis of land use pattern over a period ranging between 1975-77 and 2016, one can observe that there is a 20 percent decline in forest land along with a subsequent decline in other types of land like eucalyptus, cardamom and open scrub.

Figure 3.10
Change in Land Use pattern based on GIS Analysis (1975-77 to 2016)



Source : Compiled from GIS Analysis (2017)

Substituting the observed values in the above mentioned equation, it can be observed as follows

$$\Delta C_{AFOLU} = \Delta C_{FL} + \Delta C_{CL} + \Delta C_{GL} + \Delta C_{WL} + \Delta C_{SL} + \Delta C_{OL}$$

$$= 0.21$$

Carbon stock change of Devikulam block is estimated to be nearer to zero which means that there is no change in carbon stock. In the analysis of carbon emission, numerical values of each component have got only secondary importance as the main objective is to signify the trend in stock changes. This analysis is undertaken to analyse the aggradations or degradation of carbon stock in the study area – Devikulam Block. Since the calculated value is nearer to zero, it can be inferred that there is degradation in Carbon Stock Change.

3.6 Conclusion

Graphical and empirical analysis of the study area observed that there is a gradual depletion of natural wealth and a subsequent reflection on the degradation of carbon stock in the study area. There is an urgent need for an in-depth study on land use change patterns vis-à-vis with carbon stock changes and based on these findings proper land and forest management practices should be undertaken to restore the carbon content in the environment.

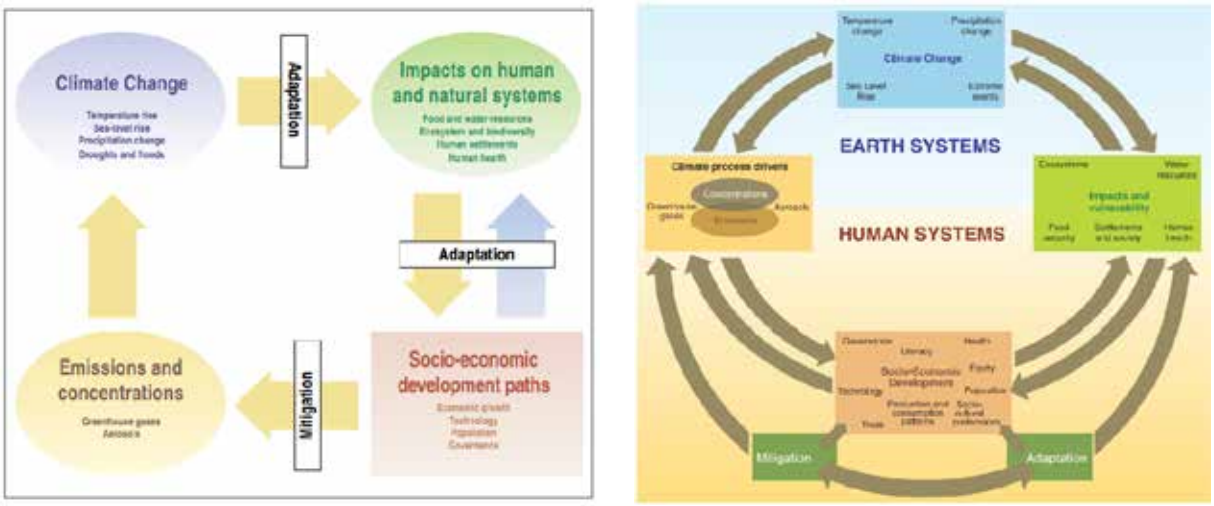
Chapter 4

EMISSION ANALYSIS OF PRIMARY PRODUCTION SECTOR : TEA PLANTATION

4.1 Introduction

Climate Change and Global warming are the most relevant topics that are discussed among academic circles and scientific communities from the last few decades. But they are yet to reach a consensus regarding over the causes and its consequences or even the concepts that ought to be considered in the final assessment. Researchers from various disciplines are devoting both their time and energy in coming up with viable solutions or alternatives which are expected to assist technologists and planners to evolve feasible solutions for making the world a better place.

Figure 4.1
IPCCs Schematic framework of climate change drivers, impacts and responses TAR (2001) & FAR (2007)



Source : IPCC(2005)

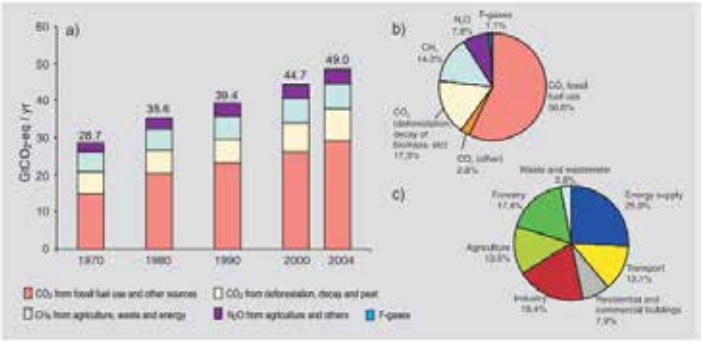
Third Assessment Report (TAR) in 2001 by IPCC based on the assessment carried out by the three Working Groups (WGs) can be regarded as the first official document which shifted from scientific discussions regarding the impending crisis of climate to a document for the assistance of policy makers. This document highlighted the dangerous anthropogenic (induced) components that intrude the existing climate system. Through a proper gauging of the linkages, it is now possible to assess/evaluate the possible pathways for development and the global emission constraints for achieving the cherished goal. A schematic framework representing anthropogenic drivers, impacts of and responses to climate change, and their linkages as suggested by IPCC, is shown in Figure 4.1.

But there exist a unanimity regarding the real villain for climate change phenomenon – Industrial Revolution. Levels of several greenhouse gases have increased by 25percent since industrialisation began in the West and following their footsteps, many of the developing countries like China, India and Brazil had adopted an industrial oriented growth and is demanding their share of oil, coal and fossil fuels. As a result of these global discussions, climate change had degenerated into a north-south confrontation without any solution in the near future. According to them, average, carbon emissions per capita in developed world is about five times than the developing countries. The problem that is being faced by developing countries is that they are yet to ensure the minimum basic needs of its growing population. These developing countries are not intending to replicate the growth models of developed countries but are trying to ensure basic necessities of life with respect food, shelter, clothing, sanitation etc. which will require more resources and will result in more carbon emission as well. For achieving a synchronised strategy between the opposing parties (north-south) imaginative solutions should be put forward. Hence the need of the hour is to look beyond Gross Domestic Product (GDP) as a criterion for assessment. In the developing world, we should not limit climate strategies within the preview of industries but should look beyond them i.e., to other menace sectors like agriculture.

4.2 Potential of Primary Production Sector

It can be easily concluded that increase in human activity can be regarded as the most important cause of Green House Gas (GHG) emissions during the past 150 years. Studies conducted by World Resource Institute (WRI), was of the view that farms emitted 6 million tonnes of GHGs in the year 2011 which accounts for 13 percent of the total GHG emissions. This makes agriculture sector the world's second largest emitter after energy sector (which includes emissions from power generation and transport). According to Food and Agriculture Organisation (FAO), increase in GHGs emission occurred mainly in developing countries, due to an expansion of total agricultural outputs. Sources of farming emissions are shown in Figure 4.2 given below.

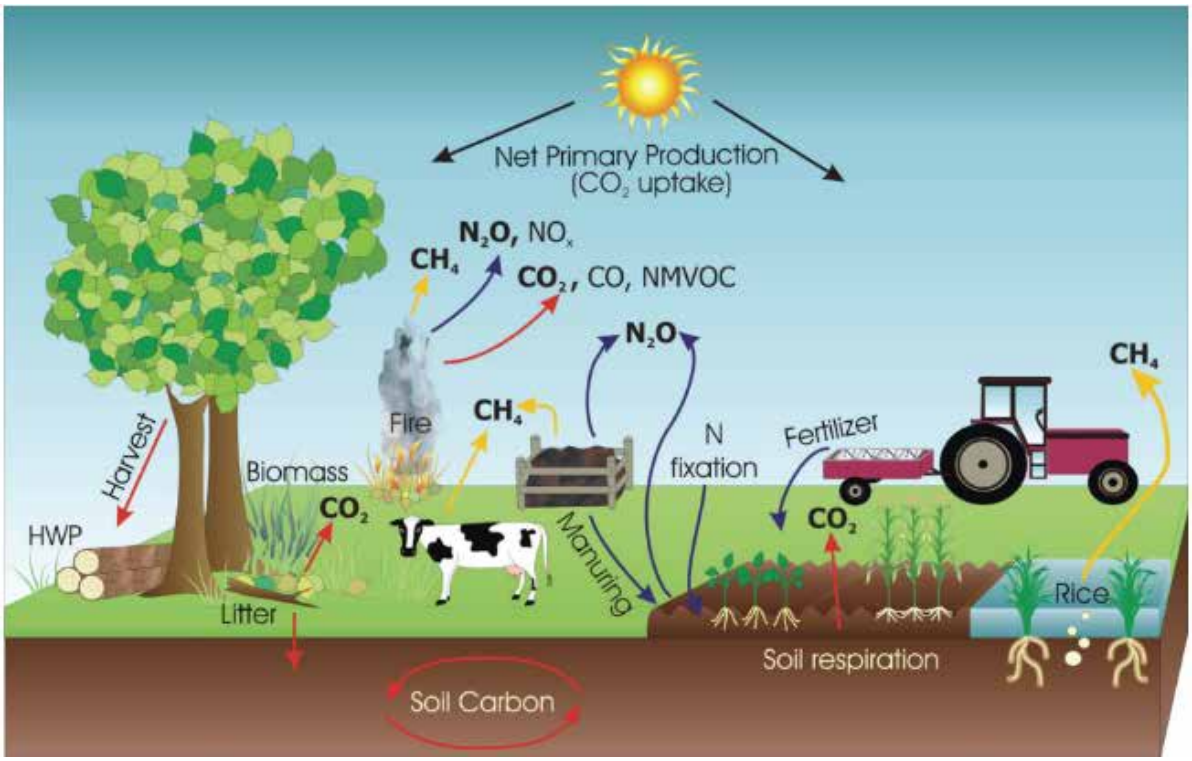
Figure 4.2
IPCCs Global Anthropogenic Emissions (2007)



Source : IPCC (2007)

According to IPCC Panel Report (2007) while deliberating on Global Anthropogenic Emissions opined that emission from burning of coal, oil and gas for energy leads the list followed by emissions from industrial sector which again is caused by burning of coal, oil and gas (26 percent) and agriculture process. In the conduct of agricultural operations, there is a need for land use changes through the clearing of forest/deforestation which amounts to 17 percent along with this; the resultant agriculture operation also contributes another 14 percent in carbon emission. Hence agriculture sector should be given due priority in any GHG discourses.

Figure 4.3
Sources of Farming Emissions



Source : IPCC (2007)

GHGs are directly emitted during various agricultural production processes which involve the demand for heat; fuel for agricultural equipment's and transport vehicles in addition to indirect N_2O and CO_2 emissions induced by agricultural activities. Agricultural activities comprise of emissions from soils and animals as a result of meeting the demands for energy along with the manufacturing of essential inputs like organic and inorganic chemicals and fertilisers. Emissions occur at various stages of the production chain and full life cycle analyses are necessary to identify the real extent.

4.3 Life Cycle Analysis of Tea Plantation

Most popular perennial crops in the highland regions of India are *Camellia sinensis* popularly known as Tea. Tea can be regarded as the most profitable cash crop as it is equally demanded both in domestic and international markets. At times it is even reported that domestic production is not even sufficient to meet the demands of domestic market. According to the report by the Business Standard (Rakshit 2016), the financial year 2015-16 witnessed a record in tea production which amounts to 1,233 million kg (mn.kg) and exports crossing 230 mn kg amounting to Rs 4,493. When we analysed production wise, CTC leads total production with 91 percent. Tea Board is of the view that the total production

grew by 3 percent out of which the northern region comprising Bengal, Assam and Himachal's Kangra led by 5.5 percent but the south Indian plantations are showing a declining trend due to adverse climatic conditions and labour issues. When we took a closer look at the trends in tea production, 90 percent of the tea producing centres had witnessed a decline and among them, regions like Assam and Kerala lead the list.

Table 4.1
Details of Estimated Production in the Month of February - 2017

State/District	2017 (E)	2016	Increase/Decrease	% of Increase/Decrease
Assam Valley	0.24	0.49	-0.25	-51.02
Cachar	0.11	0.08	0.03	37.5
Assam	0.35	0.57	-0.22	-38.6
Dooars	0.94	1.12	-0.18	-16.07
Terai	0.66	0.53	0.13	24.53
Darjeeling	0	0.01	-0.01	-100
West Bengal	1.6	1.66	-0.06	-3.61
Others	0.04	0.06	-0.02	-33.33
NORTH INDIA	1.99	2.29	-0.3	-13.1
Tamilnadu	8.41	10.5	-2.09	-19.9
Kerala	2.83	3.99	-1.16	-29.07
Karnataka	0.31	0.35	-0.04	-11.43
SOUTH INDIA	11.55	14.84	-3.29	-22.17
ALL INDIA	**13.54**	**17.13**	**-3.59**	**-20.96**

Source :Compiled from Tea Board, Government of India (2017)

4.4 Tea Plantations in Munnar

When we trace the history of plantations in Munnar, it can be observed that the plantations were pioneered under the leadership of John Daniel Munro who approached Royal Family of Poonjar seeking their assistance in starting a plantation. He was able to start his project in 1879 under the label of North Travancore Planting and Agricultural Society. Crops like coffee, cardamom, and cinchona are the first group of crops that were initiated in this project. Though plantation cultivation was initiated by Munro, yet the credit for starting tea plantation goes to A.H Sharp, a European Planter in 1880. The Seven Mallay Estate, which even now is a popular centre for tea production was the place where Sharp had initiated his pet project. Though there are many small and medium-sized plantations in Munnar, yet consolidation of tea producing regions happened under the leadership of Kannan Devan Hill Plantations Company Limited in 2005.

4.5 Harissons Malayalam Limited

Harrisons Malayalam Limited, a 150-year-old agriculture business corporation is one of the leading players in Tea Industry of India. As per statistics of 2016, total area under cultivation is 23337 hectares of which 6021 hectares is under tea plantations while the remaining 7273 is under rubber plantations.

Their business interest is not limited to these two crops but also spread to certain other minor crops like banana, pineapple, cocoa, coffee, cardamom, pepper vanilla and other spices. It is Harissons Malayalam which is regarded as the largest tea producer in South India. They later consolidated their position in India through the initiation of rubber plantation and thus became the leading producer of two important cash crops – tea and rubber.

It is in 1980s; because of changing priorities of Harrisons & Crosfield saw R. P. Goenka Group popularly known as RPG, the largest business group in India, taking control of this Company. Listed on National, Bombay and Cochin stock exchanges, Harrisons Malayalam Ltd. has a paid up capital of INR 1845.43 lakhs and a shareholder base of around 33000. Details of their agricultural operations and its spread effect are given in Table 4.2.

Table 4.2
Details regarding Agriculture Practices undertaken by Harrisons Malayalam (2017)

State, District and Region	Tea			Rubber			Total Planted	Other Plantings	Reserves etc.	Total
	Mature	*Immature*	*Total*	*Mature*	*Immature*	*Total*				
KERALA										
Venture Valley										
Nagamallay				367	162	529	529	174	175	878
Isfield				524	141	665	665	98	286	1049
Venture				306	181	487	487	46	94	627
Ranni Valley										
Koney				406	229	635	635	91	337	1063
Kumbazha				480	481	961	961		87	1048
Lahai				565	294	859	859	43	110	1012
Mundakayam				315	212	527	527	6	39	572
Mooply Valley										
Mooply				160	361	521	521	27	49	597
Palapilly				215	320	535	535	7	209	751
Kundai				476	545	1021	1021	3	80	1104
Kaliyar				373	160	533	533	2	58	593
Vandiperiyar										
Wallardie	420	96	516				516	109	203	828
Moongalaar	652	51	703				703	19	343	1065
Pattumalay	232		232				232	58	10	300
High Range										
Upper Surianalle	644	21	665				665	162	165	992
Lockhart	374	12	386				386	151	108	645
Panniar	301		301				301	49	51	401

State, District and Region	Tea			Rubber			Total Planted	Other Plantings	Reserves etc.	Total
	Mature	*Immature*	*Total*	*Mature*	*Immature*	*Total*				
Wyanaad										
Achoor	631	18	649				649	259	2577	3485
Chundale	232	34	266				266	46	570	882
Arrapetta	721	10	731				731	14	723	1468
Sentinel Rock	455	50	505				505	5	1005	1515
Touramulla	143		143				143		150	293
TAMIL NADU										
Niligiris-Wyanaad										
Wentworth	616		616				616	226	520	1362
Mayfield	308		308				308	72	427	807
Total	**5729**	**292**	**6021**	**4187**	**3086**	**7273**	**13294**	**1667**	**8376**	**23337**

Source :Compiled from Harrisons Malayalam

Table 4.3
Income and Expenditure Patterns of Harrisons Malayalam

Components/ Year	06-07	07-08	08-09	09-10	10-11	11-12	12-13	13-14	14-15	15-16
Personnel Cost (` *in Crores*)	65.69	70.02	89.33	103.13	104.59	111.14	116.21	123.9	133.01	140.33
Raw materials & Purchases (` *in Crores*)	50.95	52.69	92.62	126.18	115.93	93.83	89.07	107.44	94.31	63.62
Power & Fuel (` *in Crores*)	11.2	11.05	14.12	15.1	14.91	16.6	19.62	20.43	21.31	19.86
Cultivation & Operating Expenses (` *in Crores*)	41.32	42.73	58.09	66.32	97.32	104.15	91.86	99.81	89.3	84.06
Selling Expenses (` *in Crores*)	10.47	12.09	15.62	10.62	10.63	9.37	8.35	8.85	10.24	6.94
Cost of Sales (` *in Crores*)	182.6	191.58	273.2	325.75	349.49	341.58	331.87	366.9	355.46	320.33
Total Income (` *in Crores*)	208.56	209.14	292.58	350.65	366.55	368.91	349.93	386.86	334.36	288.6
Production of Tea (MT)	-	-	771.107	594.464	611.2	584.7	590.3	603.4	617.5	613.2

Components/ Year	06-07	07-08	08-09	09-10	10-11	11-12	12-13	13-14	14-15	15-16
Bought Tea(MT)	-	-	450.833	505.106	498.13	487.45	423.56	434.76	572.19	523.45
Total Tea Production (` *in Crores*)	-	-	1221.94	1099.57	1109.33	1072.15	1013.86	1038.16	1189.69	1136.65
Average Price per Kg (`)	-	-	69.27	85.38	71.10	77.95	100.50	114.80	96.29	107.05
Production of Rubber(MT)	-	-	131.738	121.266	127.32	129.18	127.98	132.21	125.4	126.12

Source : Compiled from Harrisons Malayalam (2017)

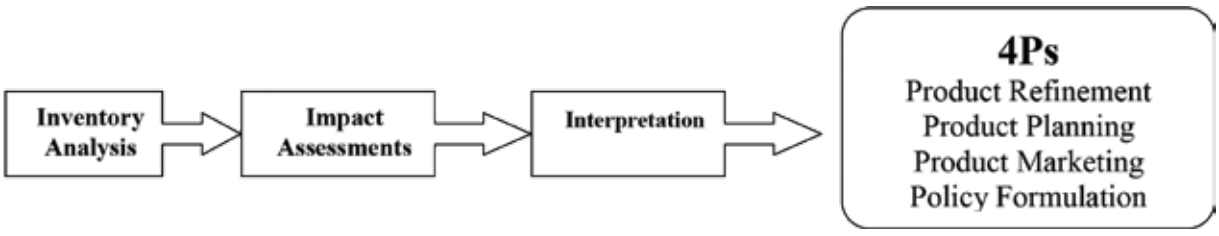
Analysis of income and expenditure data of Harrisons-Malayalam, one can observe a steady increase in their earnings but it can also be observed that a decline trend had started in their income earning capacity even after adopting sufficient diversification in agriculture practices. Along with income, production trend is also exhibiting a declining trend among their most dominant crop - tea and rubber. This conveys that their plantations had crossed their artificial threshold for productivity enhancement (Table 4.3)

4.6 Life Cycle Assessment

Life Cycle Assessment is undertaken to quantifying environmental performance of products giving due consideration to entire life cycle of the product starting from production of raw material to final disposal of the product. Material recycling can also be incorporated into the product cycle to predict the real impact. This analysis/assessment provides scope for identification of environmental hot spots in the products life cycle along with assessing overall environmental load for the benefit of environment and for the well-being of mankind.

Life Cycle Assessment has become an important topic of discussion in the present decade as a large number of national and international agencies like World resource Institute (WRI) are encouraging nations and business entities to reduce their load on the environment. What we are witnessing today is a shift from government-led initiatives to private or non-governmental-based evaluation, assessment and monitoring. Sustainability Consortium and Product Category Rules (PCR's) can be cited as the leading non-governmental initiative.

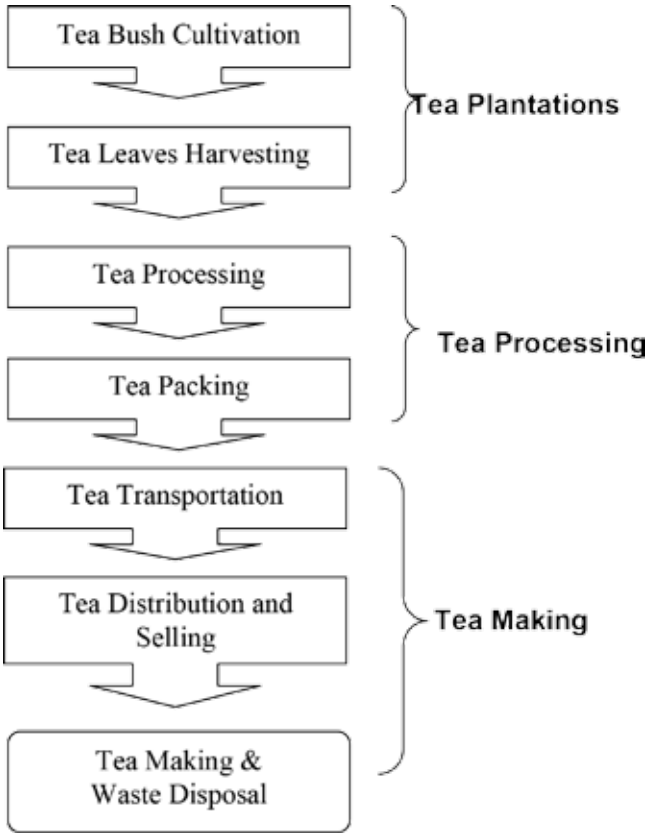
Illustration – 4.1
Components of Life Cycle Assessment (ISO Standards)



Source : Tan (2005)

International Organization for Standardization (ISO) has put forward certain standards in the conduct of Life Cycle Assessment (LCA - ISO 14040 and ISO14044). The general procedure that can be adopted in the analysis of LCA comprises of analysis of inventory, assessment of impact, interpretations of findings and application of the findings on Ground Zero. Important components as suggested by ISO are illustrated (Illustration – 4.1).

Illustration – 4.2
Process of Tea Making



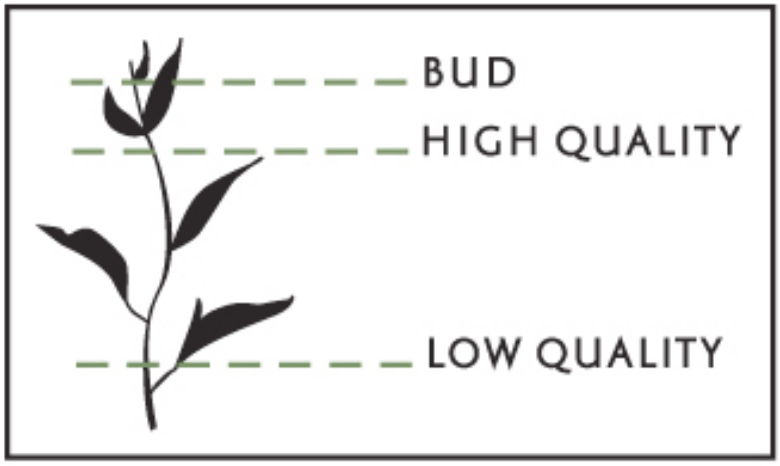
Source : Tan (2005)

In LCA we use two different strategies – '*Cradle to Gate'* and '*Cradle to Grave'* method. In Cradle to Gate analysis, analysis deals with production of the product to its final utilisation, but 'Cradle to Grave' can be regarded as the best strategy as it deals with the production of the product to its final residue which is its grave. Due to paucity of time and other related technicalities the study was restricted to Cradle to Gate strategy.

LCA Phase I - Inventory Analysis : In the first Phase, we undertook an inventory analysis of the largest consumed beverage in India – Tea. Tea growing tracks in Western Ghats is at an elevation of 300 – 2300 m above MSL and experiences an annual rainfall of 90 -750 cms. It can be opined that the deep-rooted tea plantations are playing an important role in maintaining the fragile ecosystem through the prevention of soil erosion. For proper growth, tea prefers a warm and humid climate, properly distributed rainfall along with sufficient sunlight. The pH (potential of Hydrogen) in the tea plantations should be below 6.0 and a range of 4.5 – 5.5 can be regarded as the best for growing good quality tea. Though tea is regarded as a tree plant, yet it is the adoption of periodic pruning to maintain the 'plucking table' that enables plucking. Normally, two or three leaves and the fresh bud near the top of the tea canopy is plucked which finally get transformed into the tea which we brew daily (Illustration – 4.2). Leaves used

for processing determines the quality and taste of tea. Though in some plantations, machines are used for harvesting, yet the most preferred and least expensive is the traditional method. High-quality tea uses top bud and the leaves while low-quality one is obtained from the remaining leaves.

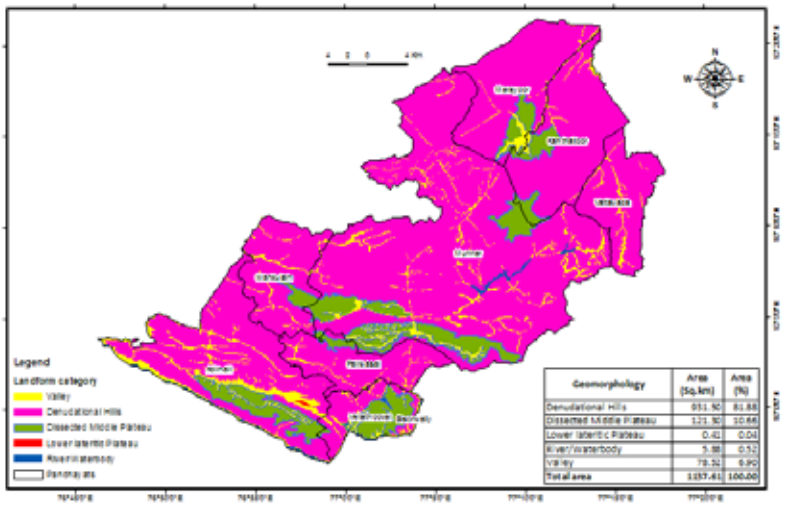
Illustration – 4.3
Tea Bud



Norm is that tea bushes are plucked within the duration of seven to ten-day cycle. The number of tea shoots plucked is directly related to the land area under cultivation and the rate of growth of shoots. Research studies have highlighted that change in climatic conditions and availability of water can also influence tea productivity.

Process of Cultivation: Based on our study, it can be inferred that the actual age of plantations in Munnar and adjoining areas in Western Ghats is 120 years old. An agricultural practice adopted in this region is traditional where liberal doses of fertilisers are combined with pesticides to get the resultant output. Based on GIS analysis we can classify the study area into the following regions based on the soil/terrain.

Figure 4.3
Landforms of Devikulam Block



Source : Compiled from GIS Analysis (2017)

From Figure 4.3, it can be observed that Munnar can be classified under denudation hills. Denuded hills are regarded as hazardous zone because a slight change in topography will pose serious threats in the form of landslides and other hydro-meteorological disorders like flood and drought. Various Studies (Krishnan 2014 p420) infer that the soils in South India can be categorised as lateritic which are derived from granite and are acidic in nature. Moreover, in case of these soils where tea plantations are undertaken for the last 100 years, there is lack of sufficient nutrients and it can be replenished only by adding more than the required fertilizers, to nourish the crop and to achieve desired productivity. Hence it can be opined that though periodic investments are needed, yet there is no surety regarding productivity.

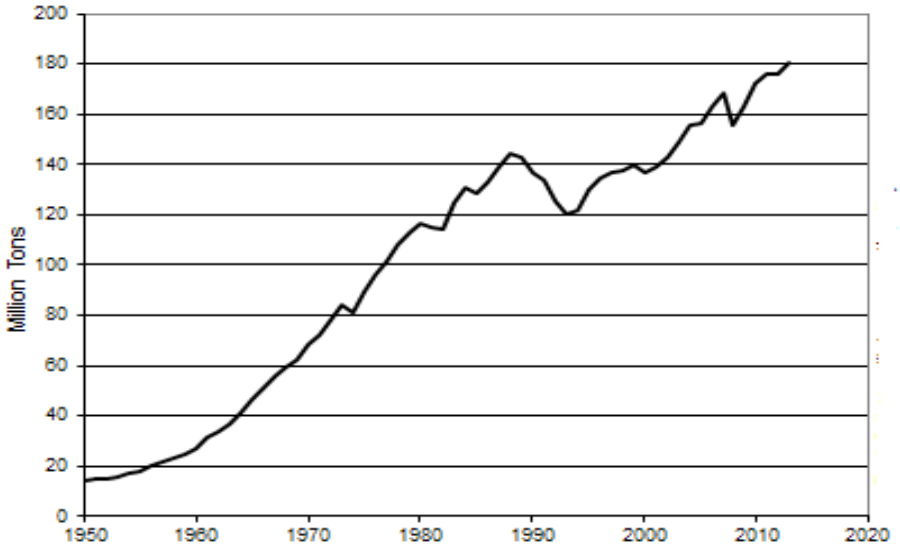
Nitrogen can be regarded as the most important nutrient that is needed by plants for the growth of their tender shoots and leaves. Potassium encourages the formation of strong roots and increases the ability of plants to resist adversities like disease, insects, pests and unfavourable climatic conditions. Like nitrogen and potassium, another important ingredient that is needed by the plant is phosphorous which ensures optimum growth of the plant. For effective use of the above-mentioned fertilisers, there is a need for proper irrigation facilities, but the analysis of rainfall trends (Figure 3.8) conveys that the tea plantations in Devikulam block had started facing water shortages.

Type of Soil : Another important component that is needed to be analyzed in detail is the type of soil. The study depended on scientific knowledge of Centre for Earth Science Studies and their periodic research on Western Ghats. In their latest study (Divya et.al) carried out in the adjoining areas of Munnar town, they are of the view that soil type falls into two important categories - sandy clay loam and clay type.

Soil Organic Carbon (SOC), another important component needed for analysing carbon emission is formed by plants through photosynthesis which occurs with the assistance of carbon dioxide and gets retained in soil through decomposition. According to the study (Divya et.al 2016p302), SOC content prevailing in this area ranges from 0.13 percent to 13.89 percent, while the estimated average presence of SOC content is 1.81 percent. The study is also of the view that shola forest, peculiar ecosystem that is popular in this part of the world has maximum SOC content. From these findings, it is clear that SOC content can be attributed to a high littering of leaves along with a strong canopy which protects it from the excessive heat outside. Regarding nitrogen emission, Devikulam block has a higher percentage of nitrogen emission with an average emission of 0.09 percent and a higher emission of 1.09 percent.

Analysis of Other Inputs :It was the German chemist Justus von Liebig who in 1847 conveyed to the world that it is possible to re-apply the depleted major soil nutrients in a mineral form which finally resulted in the formation of the multi-billion dollar business of manufacturing fertilisers. Till the nineteenth-century, productivity in agriculture was related to increase in area under cultivation but from beginning of this century we witnessed an increase in productivity without any subsequent addition in land area. What we really witnessed was a simultaneous link between rapid increase in population and advancement in agricultural technology. After the synthesis of ammonia, a new era of excessive use of fertiliser was ushered in the agriculture sector. As a result of this, the World is fed by agricultural produce that is mainly produced from artificial fertilisers (Figure 4.4). It is predicted by UN that the population is projected to reach 8.5 billion by 2030, 9.7 billion by 2050 and exceed 11 billion in 2100, while India is expected to surpass China as the most populous region in the world and hence there will be an increased demand for this artificial chemical agent.

Figure 4.4
Trends in Global Fertilizer Usage



Source : Earth Policy Institute (2015)

Tea is cultivated on hilly terrain in the form of terraced farming through the adoption of '*Up and Down*' with long lines of bush running from top to bottom. The spacing that is adopted in '*Up and Down*' scheme is 1.2 x 1.2m with a total population of 6,800 plants per hectare. Though there are many new methods of planting like Contour planting single hedge (1.2 x 0.75m with 10,800 plants per hectare) and Contour planting double hedge (1.35 x 0.75 x 0.75 m with 13,200 plants per hectare). Except the first all other methods of planting are more beneficial as it ensures early and high yields along with better soil conservation, less weed growth in the hedge and efficient cultural practices. Hence it can be concluded that the agriculture practice of '*Up and Down*' popular in Munnar is not a viable strategy to be adopted. Moreover, as these plantations are more than 100 years old prospects of converting to Contour ploughing of single or double hedge will result in long gestation period.

Table 4.4
Details of Plant population under Harrisons Malayalam

State/District	Location	Tea (Area in Hectares)			Plant Population		
		Mature	Immature	Total	Mature	Immature	Total
Idukki	Vandiperiyar						
	Wallardie	420	96	516	2856000	652800	3508800
	Moongalaar	652	51	703	4433600	346800	4780400
	Pattumalay	232		232	1577600		1577600
	High Range						
	Upper Surianalle	644	21	665	4379200	142800	4522000
	Lockhart	374	12	386	2543200	81600	2624800
	Panniar	301		301	2046800		2046800

State/District	Location	Tea (Area in Hectares)			Plant Population		
		Mature	Immature	Total	Mature	Immature	Total
Wayanad	Wyanaad						
	Achoor	631	18	649	4290800	122400	4413200
	Chundale	232	34	266	1577600	231200	1808800
	Arrapetta	721	10	731	4902800	68000	4970800
	Sentinel Rock	455	50	505	3094000	340000	3434000
	Touramulla	143		143	972400		972400
Tamil Nadu	Niligiris-Wyanaad						
	Wentworth	616		616	4188800		4188800
	Mayfield	308		308	2094400		2094400
Total		**5729**	**292**	**6021**	**38957200**	**1985600**	**40942800**

Source : Compiled from Harrisons Malayalam (2017)

When we analyse the Tea plant population of Harrisons Malayalam, it can be observed that the total number is 40942800. Unit expenditure on fertilizer and pesticides is difficult to obtain as their will be an overlapping of operation or distribution from one excess stock region to a scarce one, hence for this research study, the total tea population will be taken into consideration. That means regions like Wentworth and Mayfield which falls under the Nilgiris-Wayanad range of Tamil Nadu state is also included in this study.

Care of Tea Plants: Tea planting also coincides with the rainy season – South-West monsoons (June-July) and North-East Monsoon (September-October). Planting is done on the pit of 30x30x45 cms were a 12-15 month-old plant is planted. The soil surface around the new plant should be mulched by cut grass and the estimate is that 25 tonnes of cut grass are needed for one hectare of fresh tree plantings. Moreover, to ensure proper growth, shading of plants should be undertaken to regulate temperature, increase soil fertility and for assisting in recycling of nutrients.

Proper Weeding for Tea Plants : Manual weeding is not suggested for tea plantations as plucking of weeds with its roots will result in soil erosion along with damaging of surface roots of the Tea plants. So it is prudent to adopt chemical weeds control programme. The popular weedicides are used for tea plantations are given below (Table 4.5). Among these popular weedicides, the most preferred by Harrisons Malayalam is Glyphosate.

Table 4.5
Details regarding Weedicides used for Tea Plants

Type of weeds	Herbicides	Dosage
Dicots	Paraquat (gramoxone)	1.12 lit. /ha.
Dicots	Sodium salt of 2,4-D (Fernoxone)	1.4 kg. /ha.
Grasses	2,2-Dichloro propionic acid (Dalapon)	5.6 kg. /ha.
Dicots and Grasses	Glyphosate	2.3 lit. /ha.

Source : Compiled from Harrisons Malayalam (2017)

Scientific studies had pointed out that Glyphosate is the most popular weedicide which is marketed in India under the name of Monsanto's Roundup. Researchers are of the view that Glyphosate should be used only in genetically modified plants as it has the resistance to withstand this enzyme destructive chemical. These weedicides are ecologically harmful as it spreads through the wind/air and contaminates the nearby area and habitat. It destroys both the intended agent and also the passive ones which finally disturb the ecological environment of the area.

Fertilizers for Tea Plants : Munnar tea plants are 100 years old and they need sufficient dozes of fertilisers/ manures. Based on our study it was observed that to produce 100 kg of tea, a tea plant needs fertilizers like Nitrogen, Phosphorous and Potash in the proportion 10.2 : 3.2 : 5.4.

For mature tea, fertilisation is based on soil organic matter status and anticipated yield from the crop. The study assumes that present and the anticipated organic matter status of Harrisons Malayalam is average with an expected output of 3000kg/ha. So the amount of fertiliser used in tea plantation is shown in the table given below (Table – 4.5). It is also assumed that fertiliser is done on a four split basis – I Split (Month of April), II Split (Month of May), III Split (Month of September) and the final split (Month of October). In this study, both tea produced by Harrisons Malayalam and tea bought from other Plantations are included to ensure that intermediaries are also brought under the ambit of policy formulation for Climate Change.

Table 4.5
Details regarding Nitrogen and Potassium used by Harrisons Malayalam

Year	Production of Tea (Kgs)	Bought Tea (Kgs)	Total Tea Production (Kgs)	Nitrogen(Kgs)			Potassium(Kgs)		
				Production	Bought	Total	Production	Bought	Total
08-09	771107	450833	1221940	77110.7	45083.3	122194	7711.07	4508.33	12219.4
09-10	594464	505106	1099570	59446.4	50510.6	109957	5944.64	5051.06	10995.7
10-11	611200	498130	1109330	61120	49813	110933	6112	4981.3	11093.3
11-12	584700	487450	1072150	58470	48745	107215	5847	4874.5	10721.5
12-13	590300	423560	1013860	59030	42356	101386	5903	4235.6	10138.6
13-14	603400	434760	1038160	60340	43476	103816	6034	4347.6	10381.6
14-15	617500	572190	1189690	61750	57219	118969	6175	5721.9	11896.9
15-16	613200	523450	1136650	61320	52345	113665	6132	5234.5	11366.5

Source : Compiled from Harrisons Malayalam (2017)

- Suggested proportion between N & K is 1:1
- N @ 10/100kg of Tea & K @ 10/100kg of Tea

Another important fertilizer that is used for agriculture activities in tea plantations is Phosphorus. The suggested rate of application is 90 Kg P_2O_5/Ha for every alternate year. So the total consumption of Phosphorous can be calculated as follows.

Consumption of Phosphorous by Harrisons

= (Total Area of Harrisons) * (Annual rate of application)

= 6021 x 90

= 541,890 kgs

Phosphorus incurred on Bought Tea

= (Total Area of Intermediaries) *(Annual rate of application)

= 5141.94 x 90

= 462774.6 kgs.

Therefore the total phosphorous consumption of Harrisons tea is

= Consumption of Harrisons + Consumption of Intermediary

= 541,890 + 462774.6

= 1,004,664 kgs

Hence it can be assumed that the annual consumption of phosphorous is 1,004,664 kgs.

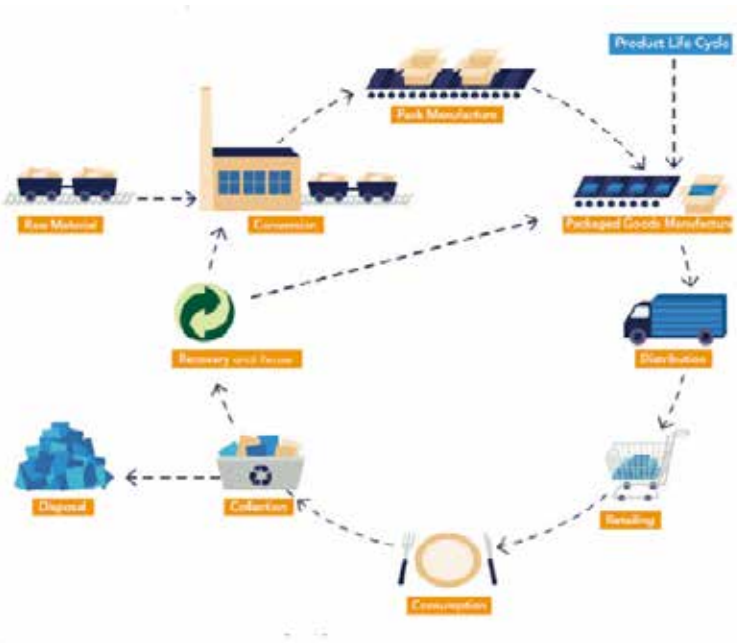
Pesticides for Tea Plants : Like any other plant species, tea can also be infected with insects and pests that can cause huge economic losses. The pest that attacks tea plants is Tea Mosquitoes which can be eradicated by spraying of 0.1 percent of Malathion or 0.05 percent of Lindane, Shot-hole borer with the help of Heptachlor and Red Spider with the help of Tetradifon.

Tea plants are also not free from diseases and the important diseases among tea plants are Blister Blight, Black Root, Red Root, Brown Root. The control measures that can be adopted vary from use of Copper Oxycholoride, Dithane M-45 along with traditional steps like uprooting and burning the infected plants etc.

Processing of Tea :There are two dominant methods that are adopted in the processing of tea – Orthodox and CTC Method. In the orthodox method, tea is processed under a rolling operation done by a series of rollers. Each roller had a rotary table along with battens and jackets for loading the leaf. It is then pressurised to produce the processed product, but the tea that is popular in India is CTC. It is processed in a machine consisting of a series of rollers mounted in such a way that they rotate in opposite direction and the clearance between them is so adjusted to crush and tear the leaves.

Harrisons Malayalam is famous for Orthodox tea which is manufactured for the international markets. In domestic market, the processed orthodox tea can be purchased only through online. It was observed that while processing tea leaves, the first quality one is classified into Leaf tea, while the Second Quality is classified into Granules tea and the leftovers are categorised as Dust tea.

Illustration –4.4
Packaging Life Cycle of Tea



Source : Mehmetia et.al (2016)

*Packing of Processed Tea :*Another critical component in the process of LCA analysis is packaging of processed tea. It not only ensures longer life of the product but can attract potential customer through attractive packaging. As packaging is regarded as an integral part of the Supply Chain Management, hence due regard should be given to this particular aspect. It reduces product loss while in transit, limits the time needed for loading and unloading the product and can even be extended as the symbol of a particular brand. Hence companies are seriously looking into aspects regarding 4Rs – reduce, reuse, recycle and refuse. Packaging Life Cycle can be clearly explained with illustration – 4.4.

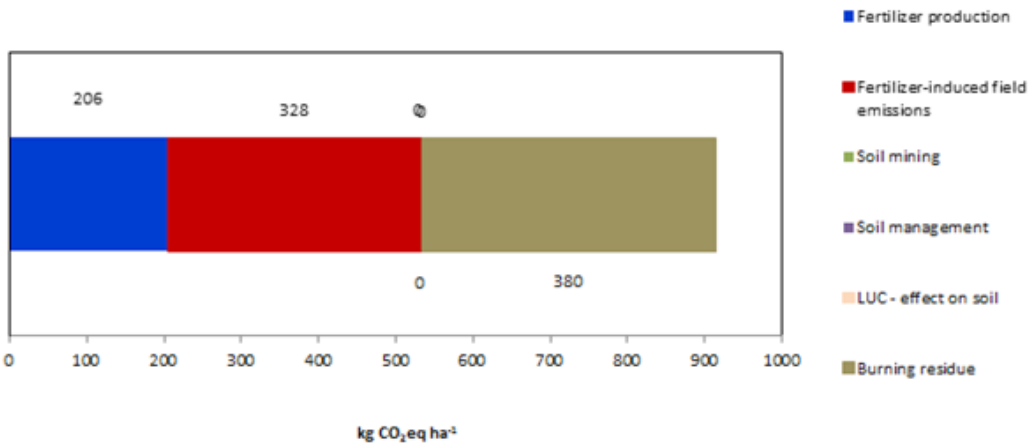
Based on our study, it was observed that tea after being graded is packed in plywood tea chest. The components that were used in the manufacturing of tea chests are plywood, metal frames for sealing the chests, iron nails for making cross sealing, jute bag, tissue paper and other items for absorbing the moisture content.

Power Requirements for Processing Tea: There are two essential components that need energy in a tea factory – energy for running the machines and another energy source for heat generation which an essential component in tea processing. Though earlier a combination of both wood and electricity was adopted, but now factories depends only on hydro-electric power.

Tool of Analysis: Though there are many complex tools like GaBi, Simapro in LCA analysis, due to the non-availability of certain critical technical inputs and trends, we had used a beta version of CCAFS Mitigation Options Tool (CCAFS- MOT). CCAFS-MOT is the best tool that can be used for LCA analysis of the primary sector. In developed countries, it is a popular tool among ecologically oriented farmers for analysing emission from multiple crops (e.g. barley, maize, sugar cane), or among crop groups (e.g. vegetables, legumes) and livestock. Region-specific analysis can be undertaken through this tool as it gives due consideration even to specific factors like soil quality; pH value etc. Merit of this tool is that it integrates several empirical models into the estimation of GHG emissions. CCAFS-MOT provides policy-makers across the globe with fast, accessible, and reliable information needed to make informed decisions about emissions reductions within agriculture.

Emission from Agriculture Operation*:* Based on the critical values regarding the texture of the soil, soil nitrogen content, biomass content and with details regarding the proportion of fertiliser and pesticides used is depicted in Figure 4.5.

Figure 4.5
GHG Emissions based on Source



Source : Analysed from Harrisons Malayalam (2017)

To overcome age factor of the plantations, it was observed that old plants are slowly replaced by new high-yielding hybrid varites. During the process of replanting, existing trees had to be killed inorder to avoid any passage of diseases from old plants to new ones. According to the estimates of Central Pollution Control Board (2007), it takes at least a period of three years for the older tea plants to die. Hence a strategy of burning and chemical spraying is adopted to eliminate the traces of the older species. Large fires or not encouraged, as it will increase the pH value and hence for clearing the popular strategy that is adopted is a mix of burning and chemical applications and the resultant carbon emission is 380kgCO_2 eqHa^{-1}.

Table 4.5
Total GHG Emissions

		Gross GHGs	Net GHGs + SOC + LUC
Per area	kg CO_2eq ha^{-1}	914.8	914.8
Per yield	kg CO_2eq kg^{-1}	0.501	0.501

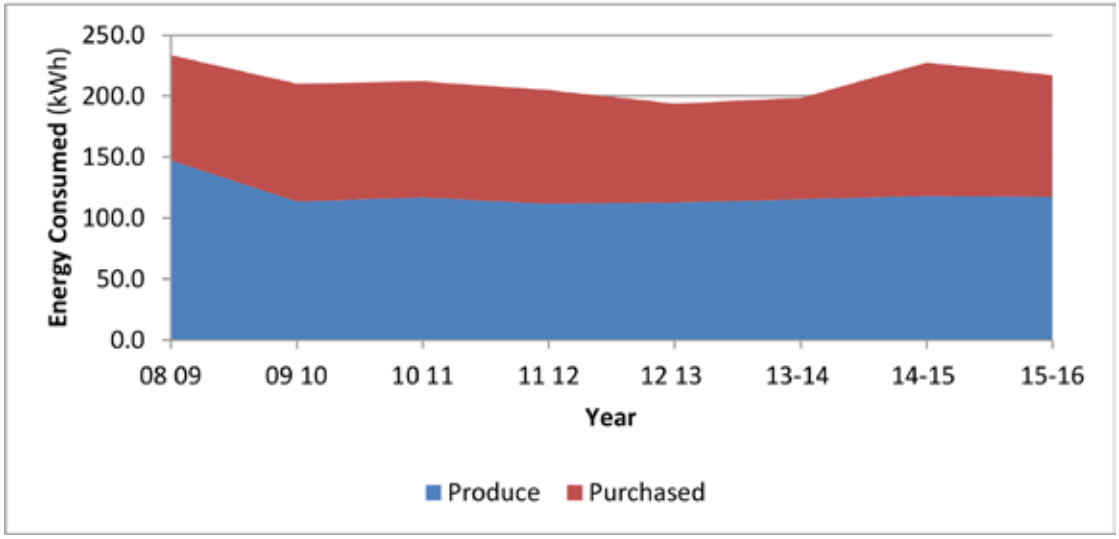
Source : Analysed from Harrisons Malayalam (2017)

Ensuring or maintaining the productivity levels is the main objective in any corporate style of cultivation practice, it can be observed that there is excessive use of fertiliser and the quantified emission component of fertiliser is 328 kgCO_2eqHa^{-1}. The emission that was incurred in the production of fertiliser used in the plantation amounts to 206 kgCO_2eqHa^{-1}. When we analyse the total GHG emissions from the

study area, it can be observed that per area value is 91.48 $kgCO_2eqHa^{-1}$and the per yield emission is 0.501 $kgCO_2eqHa^{-1}$.

Emission from Tea Processing, Packaging and Transportation: Processing of tea is being undertaken in Tea Factories which are in the process of modernization. Earlier forest area are indiscriminately cleared for starting eucalyptus plantations which are undertaken to ensure a continuous supply of cheap source of energy. But the vigilante groups in this area had raised their voice against encroachments by Harrisons Malayalam. Hence the only alternative that is left is to modernise their plants is to adopt hydro-electric power as their main energy source. Based on our research, it is observed that the average energy used in the processing of tea by Harrisons is 5.23 kWh/kg and the trend in total energy consumed over the years is shown in Figure 4.6. From the figure, it is clear that the energy incurred in processing tea produced in Harrisons Plantations maintain a consistent trend (Constant Productivity) while the company adopts its purchasing strategy of tea leaves from nearby plantations based on the market demand.

Figure 4.6
Trend in Energy Consumption by Harrisons Malayalam



Source : Analysed from Harrisons Malayalam (2017)

When we analysed the CO2 emissions with the Cool Farm Tool based on international standards, it can be observed that the direct energy used for primary processing is 0.11. Carbon emission factor for diesel is taken into consideration while analysing the transportation component of tea. A component under the name of selling expenses is included in accounting by Harrisons, which gives us an insight regarding the expenditure incurred on transportation. As diesel is important component used in transportation, the emission factor when computed with the selling cost gives us the emission of transportation. The equation that is adopted in this study is the one suggested by IPCC Emissions (kg) = $\Sigma_{\text{type of fuel}}$fuel sales (kg) * combustion value (MJ/kg) * Emission factor (kg/MJ).

4.7 Conclusion

For the analysis of total emission of GHG from Harrisons Malayalam Plantations, we had used all the available emission components ranging from the land use pattern, agricultural practices adopted by the organization for maintaining corporate productivity standards, the amount of energy incurred in processing the final product and also the last component, the energy incurred for transporting the product to the sellers to gauge the emission from the primary product – tea.

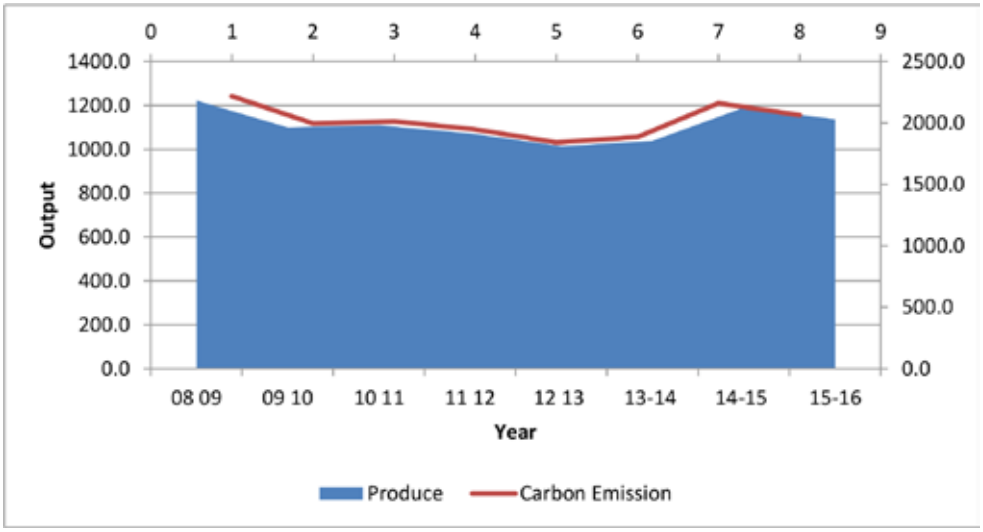
Chapter 5
CONCLUSION AND POLICY RECOMMENDATIONS

Climate Change studies had become an important part of discussion and discourses in academic circles. Main objective of these deliberations is not only to highlight the issue among the public domain but also to inculcate the habit of chalking out interdisciplinary strategies for deriving viable solutions or alternatives. With this objective in mind, this study has been undertaken which uses a mix of both primary studies based on field survey/verification to assess the change in land use pattern and scientific analysis was adopted to compare/analyse the observed values with that of the standards suggested by international organisations.

Corporate agriculture practice undertaken under the umbrella of Plantations Sector tries to ensure their productivity and profit through all available means. Extensive strategy which they had earlier adopted was to bring more and more areas into plantation cultivation. In the over-eagerness to extend the cultivation practices had resulted in accusations of land grabbing by public and finally resulted in a long drawn legal battle with the authority.

Hence the only option that is left with age-old plantation industry is to increase productivity through intense cultivation practices which normally will resulted in liberal use of chemical fertilisers. As explained earlier, the most popular fertiliser component nitrogen is regarded as the most GHG emitter which in the long run will adversely affect the ecologically sensitive environment of Western Ghats. Based on the study undertaken in tea plantations of Harrisons Malayalam, it can be observed that along with an increase in production there is a simultaneous increase in emission of GHGs which is depicted in Figure 5.1. Hence the need of the hour is to evolve strategies to curtail the use of these chemical fertilisers.

Figure 5.1
Trend in Production and Emission by Harrisons Malayalam



Source : Analysed from Harrisons Malayalam (2017)

Customer Oriented Strategies: Plantation industry can be regarded as the most customer sensitive one as its customer is not restricted to home country which normally is a developing country but also right conscious customers from the developed world as well. It is because of this reason that the tea plantations had developed a strong R&D wing to monitor not only the growth of the plants but also to ensure their customer base. Strict monitoring is undertaken to analyse the Minimum Residue Level (MRL) which clearly reflects the amount of pesticide used in the production process.

What we witness today is an environmentally conscious customer determining the consumption pattern in society. This is clearly evident from the fact that there is a spurt in demand for organic products and organic farming. But the real problem in India is the fact that there is a lack of effective monitoring agencies to ensure that a product is really organic. Yet the customers are ready to pay a higher price for such a namesake product.

This environment consciousness among the consumers should also be channelized to other sectors as well. Plantation sector that concentrates only on cash crops undertakes agriculture operation with the sole objective of making sufficient profits. Hence consumers should be made aware of the fact that it is this plunderers attitude which is causing more harm to the environment. The need of the hour is to shift the attitude of the planters from plunderers to preservers through the imposition of a tax based on the level of carbon emissions and to term it as 'Carbon Tax'.

Industry Oriented Strategies: Before initiating such a tax, the lead players of the system – plantation industry and the fertiliser industry should be taken into confidence with the assurance that the incidence of tax is not against them but to achieve the social objective of a better world. Both parties should be encouraged to adopt best management practices for achieving productive efficiency and to minimise the loss to the environment.

Conclusion - Green Generation

In the consumer market, consumers are bombarded with information regarding existing and upcoming products. Hence he is rather in a dilemma regarding how to make prudent decisions. Though one cannot find environmental consciousness among the Generation Y or the Millennial (1982-2004)

yet we observed that the Generation Z is showing much more inclination towards the environment. According to them, productivity should be in tune with the system in which they live in and should not be given more regarded or consideration as the only important entity or objective. The Generation Z or the Green Generation is most willing to pay a price for social or environmental well-being than the others (Present/Generation Y). Hence brands can achieve brand loyalty only through enhancing their CSR activities and to concentrate on environmental stewardship.

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APPENDIX I

Geographical Information System

Research Community on climate Change tries to understand and analyse the nexus among economy, environment and society for maximising social welfare. Predicting future climate scenarios require in-depth knowledge regarding weather forest, wind patterns, rate of rainfall etc and its effect on the society and environment.

Geographical Information System (GIS), is the application of technology to the science of climate change and analysing the resultant impact on natural and human systems. A high-performance computer system is used for capturing, storing, checking, and displaying data related to various climatic attributes like land use pattern, rainfall pattern and geo-morphological patterns. Digitised GIS based maps improve communication between different teams, departments, disciplines, professionals, organizations, and the public for charting out the future course of action. Stopping deforestation and growing new forests, particularly in the tropics, are the easiest and fastest ways for society to reduce carbon dioxide in the atmosphere and mitigate global warming. GIS can act as the key component forest carbon monitoring systems needed by developing countries to manage their forest wealth. Thus GIS technology offers a means to assess, plan, and implement sustainable programs that can affect us 10, 20, and 100 years into the future.

APPENDIX II

Life Cycle Assessment

Life Cycle Assessment (LCA) is a tool to evaluate the environmental effects of a product or process throughout its entire life cycle. LCA examines the product from extraction of raw materials for the manufacturing process, through the production and use of the item, to its final disposal, and thus encompassing the entire product system. Thus LCA can help in compiling an inventory of relevant energy and material inputs and environmental releases; evaluating the potential impacts associated with identified inputs and releases and interpreting the results to help make a more informed decision making.

The late 1980s and early 1990s have seen international attempts to standardise the principles underlying LCA and to develop codes of good conduct in this field. The list of products that have been subjected to LCA has grown quickly and now includes more complex products such as paints, insulation materials, window frames, refrigerators, hotplates, television sets, etc., as well as the entire service systems or technologies such as electricity production.

LCA also assist in passing the environmental knowledge to the other stakeholders and end users. Government and customers who purchase products are keen to know the environmental properties of their products. In future environmental-knowledge based consumption or decision making will get established in the market. Based on this tendency, EMAS and ISO 14000 are demanding continual improvement in the process of production and in the environmental management system. In such a scenario, a tool like LCA helps organisations meet the demand to improvise process/product.

APPENDIX III

Tools for Life Cycle Analysis

GaBi - Software which supports collecting, organising, analysing and monitoring the environmental performance of products and processes. It combines modelling and reporting software, data content and expertise to analyse impacts on environment, enhance brand value of the product and in reduction of risk. GaBi reduces the process of selecting the best dataset for the particular kind of data documentation and incorporates embedded database documentation in the design of product and process. The data set that is incorporated in GaBi is based on International Life Cycle Database formatting.

Simapro - SimaPro life cycle analysis software can calculate carbon footprint of many kinds of products and systems. Using its customizable parameters and analytical capabilities, it can even determine the potential environmental impact that a system or service produces with statistical accuracy. With its ability to determine key performance indicators, it can provide a clear picture regarding the full environmental report of the product. The important feature of this software is that it presents a full view of the potential impact any design will have under realistic conditions.

APPENDIX IV

Climate change, Agriculture and Food Security Mitigation Options Tool (CCAFS-MOT)

It can be regarded as simple and most effective tool for analysing GHGs, its emissions and emission reduction options particularly from agriculture sector. CCAFS-MOT estimates greenhouse gas emissions from crop, livestock, agro-forestry and rice management systems by country or geographic region. The tool ranks mitigation options for each system according to mitigation potential and compatibility with food production, and in relation to current management practices and climate and soil characteristics. CCAFS-MOT suggests options based on empirical models and data from over a dozen research studies. Developed by University of Aberdeen, CCAFS-MOT tool takes account current farming practices and growing conditions to suggest a wide range of mitigation options. CCAFS-MOT can be regarded as a decision-support tool for policy makers around the world. It was first introduced CCAFS-MOT at a learning session in Lima, Peru in December 2014.

INTER UNIVERSITY CENTRE FOR ALTERNATIVE ECONOMICS

Set up in 2015 by Professor Abdul Salim.A of the Department of Economics, University of Kerala, the Inter University Centre for Alternative Economics (IUCAE) promotes research and studies in alternative economics which would address the problems of the economy and society beyond the neo-classical mainstream ideas. The centre is attached to the department of Economics, University of Kerala in Karyavattom campus, within 15 Kilometers from the city of Thiruvananthapuram.

FOCUS AREAS

• Neuroeconomics • Open Economics • Institutional Economics • Ecological/ Green Economics Gandhian Economics Marxian Economics • Islamic Economics • Law and Economics • Economics of Human Capital • Economics of alternative development paradigms

ACADEMIC ACTIVITIES

- Two months' internships to postgraduate and M.Phil students
- Two months' associateships for researchers and faculty members of regular colleges and universities
- One year Short term research projects
- Three years Ph.D. programmes.

RESEARCH THEMES

- Migration and institutions
- Institutions and economic development
- Social capital, human capital and development
- Financial institutions, human capital and development
- Globalisation and marine resources
- Environmental policy and economic development
- Ecology, Sustainability and Tourism
- Interest free banking system
- Globalisation and Islamic finance
- Islamic economics vs. neo classical economics
- Gandhian vs mainstream economics
- Gandhian path and sustainable development
- Marxism vs. liberalism
- Marxian analysis of inequality
- Capitalism and labour rights
- Cognitive science of economic decisions
- Uncertainty, rationality and neuroeconomics