INTRODUCTION

The impact of weather and climate on human communities is so varied and all pervading that they naturally become the most important components of our physical environment. The welfare, safety, and quality of human society are subject to the profound effects of the vagaries of weather and climate. In developing countries the effects may be calamitous. In highly industrialized countries the effect tends to be neutralized by complex socio-economic systems, but even in these countries there are certain climatic phenomena such as droughts, floods, violent tropical storms of hurricane intensity, heat and cold waves which may endanger lives and property and disrupt even the most sophisticated systems. Moreover, human society has developed to such an extent that its activities unintentionally produce weather and climate modification on a large scale. Besides modification of local climate, highly sophisticated human activities have the potential to modify global climate, and there is no denying that our present technology is in a position to bring about short-term changes in some areas of weather and climate. There are of course, two long-term effects of climate modification that are causing grave concern. One is the increase of carbon dioxide in the atmosphere and the resultant increase in global temperature expected by the middle of the next century. The other is the prediction of changes in the ozone shield, which may give rise to the penetration of more and more harmful ultra-violet rays of the sun.

Man’s efforts towards weather modification may lead to serious meteorological consequences. Large-scale activities such as crop production, artificial precipitation, hail suppression, and long dissemination are some of the efforts directed towards weather modification of our environment. Today, man is seriously speculating on the future possibilities of climate control on a global scale. Thus, deliberate weather modification on the micro and macro scale has been in progress for the past few decades. However, any fair measure of success in large-scale weather modification will ultimately depend on how much more we know and understand the mechanisms of the general circulation, the terrestrial heat budget, boundary layer exchange systems and cloud physics. Even if our science and technology are capable of modifying the weather and climate to a certain desired level, we should not forget
about a number of international implications and the possible consequence. It is because of the ever-growing awareness of climate and its vagaries that under the leadership of the World Meteorological Organization (WMO) and with the active participation of the International Council of Scientific Union (ICSU), the United Nations Environmental Programme (UNEP), the Food and Agricultural Organization (FAO), the UNESCO and other organizations, a number of programmes have been launched to meet the new challenges. These include the World Climate Programme (WCP), which has been decided into four components; the World Climate Research Programme (WCRP), the World Climate Applications Programme (WCAP), the World Climate Impact Studies Programme (WCIP) and the World Climate Date Programme (WCDP). (Lai. 1999).

1.1 Definitions and Importance of Climate

1.1.1 Definitions of Climate

Some definitions of climate enunciated by eminent climatologists are given below:

Trewatha: "Climate represents a composite of the day to day weather conditions and of the atmospheric elements, within a specified area over a long period of time. It is more than "average weather" for no uniform definition of climate is possible without appreciation of seasonal and diurnal change and of the succession of weather episode generated by mobile atmospheric disturbances. While in a study of climate emphasis may be given to the average, still departures, variations, and extreme are also important".

According to Critchfield: "the process of exchange of heat and moisture between the earth and atmosphere over a long period of time result in conditions which are called "climate". Climate is more than a statistical average, it is the aggregate of atmospheric conditions involving heat, moisture, and air movement, extremes must always be considered in any climatic description in addition to means. trends, and probabilities".

Koeppe and De Long define "Climate as a summary, a composite of weather conditions over a long period of time, truly portrayed: it includes details of variations - extremes frequencies, sequences of the weather elements which occur from year to year. Particularly, in temperature and precipitation, climate is the aggregate of the
Kendrew opines that "Climate is a composite idea, a generalization of the manifold weather conditions from day to day throughout the year - certainly no picture of it is at all real unless it is painted of the seasons which are the really prominent features. It is inadequate to give merely the mean state of any element".

G.F. Taylor states that "Climate is the integration of weather, and weather is the differentiation of climate. The distinction between weather and climate is, therefore, mainly of time".

C.W. Thomwaite has given a comprehensive and systematic analysis of climate. He broadens the scope of climatology when he suggests that "the study of the atmosphere as well as that of the earth's surface from the case of this discipline. This is so true because each and every characteristic of climate is determined by the exchange of heat, moisture, and momentum between the earth's surface and the atmosphere". (Lai, 1999, pp. 6-7).

1.1.2 The Importance of Climate

1.1.2.1 Climate as the key to regional differentiation

As we are aware, geography is the study of the earth as the home of mankind, the ultimate goal of geography is the scientific analysis of the regional diversities, and the spatial variations found on the earth surface. In other words, geography aims at a correct and systematic appraisal of the inter-relationship between man and his environment. If we discuss the inter-relationship between man and physical environment, we are bound to arrive at the conclusion that human society was shaped by the geographic influences it was exposed to. Moreover, critical analysis of diverse environmental effects makes it clear that climate is the most fundamental and far reaching of the natural elements that control human life.

1.1.2.2 Climate and human affairs

The climatic hypothesis of civilization, as propounded by Ellsworth Huntington, assigns a very high place to climate, which is considered to be most dominant and essential factor in the development of civilization. It is a historical fact that many advanced civilizations in the past have grown up and flourished in different regions of the world having dissimilar climatic regimes ranging from the hot, and
ban-en deserts of the Nile Valley to the extremely cold highlands of Sweden. The main factors that determine life are health, climate, food, diseases, and people's cultural level and among all these controlling factors climate occupies the first rank because of its direct control over the quality and quantity of not only man's food, but of most of his other resources. Climate is undoubtedly one of the principal determinants of people's culture through its effects on human occupations as well as modes of living and habits. The climatic influences are three folds. Firstly, climate has a direct bearing on man's health and activity. Secondly, it has a strong indirect but immediate effect through food and other resources. Lastly, climate has been the most dominant factor in causing migrations, racial mixture, and natural selection. In other words, climate may be said to be a determining factor in the geographical distribution of human progress (Lai. 1999. pp. 2-3).

1.2 The Interaction of Climate and Environment:

1.2.1 Some Definitions of Environment

The dictionary meaning of the word environment is "a surrounding of external conditions influencing development or growth of people, animals or plants, living or working conditions".

C.C.Park. (1980): "Environment refers to conditions which surround man at a given point in space and time".

A.Goudie (1984): "The nature of the environment has, in fact, taken environment as the representative of physical components of the earth wherein man is an important factor affecting the environment".

K.R.Dikshit, (1984): "Environment is defined more comprehensively by others as a holistic view of the world as it functions at any point of time, with a multitude of spatial, elemental and socio economic systems distinguished by quality and attributes of space and mode of behaviour of abiotic and biotic forms".

While environment is viewed in different ways with different angles by different groups of people, yet it may be summed up that. "Environment is an inseparable surrounding and is constituted by the interacting systems of physical, biological and cultural elements which are interlinked individually as well as collectively in myriad ways. Physical elements (space, landforms. water bodies, climate, soils, rocks and minerals) determine the variable character of human habitat.
its opportunities as well as limitations. Biological elements (plants, animal's microorganisms and man) constitute the biosphere. Cultural elements are essentially man-made features which go into the making of cultural milieu" (Singh and Dubey, 1983).

In another sense, environment is the sum total of the different spheres that exercise its influence upon itself and interact with other spheres of environment. The different spheres of planet Earth's environment are Hydrosphere, Geosphere/Lithosphere, Atmosphere and Biosphere. Nature as such tries to maintain an ecological balance. The phenomenon of maintenance of balance has been identified as Homeostasis. A state of equilibrium is always observed between all the components of environment. In the recent times man has technologically advanced to a great extent, but such a technological advancement has challenged this stage of equilibrium of nature.

In this context, man's role has been critical because he has in the name of technological development exploited the resources and damaged the environment at the alarming rates. Thus there has been much disruption of the functioning of natural environment. Such an influence has been greatly observed in developed world where people have begun to realise and correct the side effects of their wrong policies. While in the developing world people have started thinking on this line and there has been growing concern of such harmful effects.

1.2.2 The Impact of climate on Environment
1.2.2.1 Effect of individual climatic elements on human life

As we know, climate is the summary on the resultant of all the manifold weather influences. The air temperature, pressure, direction and velocity of wind, humidity, the amount of cloudiness and precipitation are some of the most important weather elements. Each of these elements affects human activities in its own way. It would be worthwhile to focus attention on some of these elements which are directly related to our physical and mental energy, and which largely determine our health and happiness.
From the point of view of both health and work, the best climate would be one in which the mean temperature rarely falls below the mental optimum of 38°F, or rises above the physical optimum of about 64°F. The ideal condition would be found where the mean annual temperature is about 51°F. The great metropolitan cities of London, Paris, New York and Peking do have this mean annual temperature. Almost all the industrially advanced countries of the world have their mean winter temperatures not far from 38°F and the mean summer temperatures near about 64°F.

The relative humidity of air is also an important climatic element. Everybody is familiar with the harmful effects of the dry air during winter. Similarly, hot and humid air is equally harmful. High temperature combined with high relative humidity produces sultry weather, which does not favour either physical or mental labour. Besides, relative humidity and temperature are closely related with our physical comfort and efficiency. The optimum temperature apparently controls the phenomena of life from the lowest activities of protoplasm to the highest activities of the human intellect.

Climatic conditions have complex bearing on soil, crops, vegetation, commerce, plant diseases and above all, human health. Even the surface of the land is modified to a large extent by the action of climatic elements. For example, in hot wet climate regions, humid landforms are different from those arid landforms where a dry hot climatic condition exists. Similarly, the landforms of Polar Regions where climate is extreme will contrast from the landforms of temperature and equatorial regions.

Kendrew, an eminent weather Scientist, has aptly remarked that Climate is the most fundamental and far reacting of the natural elements, which control life. According to him, the vegetation of the earth is closely dependent on it, and the adaptations in the animal kingdom are numerous. Eskimos of the snow bound Arctic region, the white races of the temperate regions, and the Negros of the tropical rain forests are all products of the different climatic conditions. Thus, the effect of climate on human life has been aptly remarked by Pepadakis that climate is the most effective
and the most powerful component of our natural environment". (Papadakis, 1975)

1.2.2 Effects of Climate on adaptation of ecosystem

The speed and magnitude of climate change affects the success of species, population, and community adaptation. The rate of climatic warming may exceed the rate of shifts in certain range species, these species could be seriously affected or even disappear because they are unable to adapt. Some plant and animal species (such as endangered species generally) and species adapted to narrow niches for which habitat is discontinuous and barriers impede or block migrations and natural systems (such as coral reefs, mangroves, and other coastal wetlands, prairie wetlands, remnant native grasslands; montage eco-systems near ridges and mountain tops; and ecosystems overlying permafrost) could be adversely affected by regional climatic variations.

1.2.3 Impact of Climate on bio geophysical environment

Global climate change will affect the bio-geophysical characteristics of the oceans and coast, modifying their ecological structure and affecting their ability to sustain coastal residents and communities. Impacts in the coastal zone will reflect local geological, ecological, and socio-economic conditions within a broader regional and global context. Some times one inherently respond to short and long term variability and trends in sea level, wave energy, sediment supply, and other forcing. Coastal communities particularly on low lying deltas, atolls and reef islands, face threats of inundation, increased flooding, and salt water intrusion, with impacts on health and safety, water supply, fisheries, agriculture, aquaculture, property, transportation links and other infrastructure.

1.2.4 Impact of Climate on Agriculture

All the agricultural activities rely on climate; crops grow best, only when optimum temperature and rainfall are available. And, climate change may increase demands for irrigation from the agricultural sector, and if these extra needs are drawn from rivers or aquifers, there will be an effect on hydrological and ecological regimes. Different kinds of crop patterns can be seen due to the variable climatic pattern, crops from arid regions would not be similar to that of humid climate areas.
Indirectly, ecological disturbances, air pollution, changes in food and water supplies, and coastal flooding are all examples of possible impacts that might affect human health. How people and nature adapt to climatic change will determine how seriously it impacts human health. Some people and places are likely to be affected more than others. Generally, poor people and poor countries are less likely to have the money and resources they need to cope with preventing and treating health problems. Very young children and elderly adults will run the highest risk.

1.3 Environmental impacts on climate

1.3.1 The effect of environmental change on climate can be seen with the Greenhouse effect and Global warming

"Greenhouse Gases" let sunlight through the earth's surface then impede the escape of energy (heat) into space. These gases act in much the same way as glass panels in a greenhouse, which allow sunlight through and trap heat inside, thus the term Greenhouse effect. Without naturally occurring Greenhouse gases it is estimated that the earth's average temperature would be nearly 33°C colder. This would result in a planet much less suitable for human life.

Global warming is the term used to refer to the possible increase in global temperature due to increased atmospheric concentrations of Greenhouse gases. Over the last 100 years, average global temperature has increased between 0.3°C and 0.6°C while atmospheric Greenhouse gas concentrations have increased significantly due to human activities (Carlson Key. 1995).

The major Greenhouse gases include carbon dioxide (CO₂), methane (CH₄), chlorofluorocarbons (CFCs) and nitrous oxide (N₂O). CFCs are non toxic, non flammable and chemically unreactive. This was one of reasons they were considered ideal candidates as coolants in appliances like refrigerators and as product propellants in spray cans. But these properties also will remain in the atmosphere for extended period of time, estimated to be 6- to 130 years, before being destroyed. Each CFCs molecule has a Greenhouse effect 5000 to 10,000 times greater than that of a molecule of CO₂. This means that although the total atmospheric CFCs are small
relative to CO2, it accounts for approximately 10% of CCb equivalent emissions. Before CFCs were associated with global warming, they were associated with stratospheric ozone depletion. In the upper atmosphere molecules of ozone are destroyed in natural process when they absorb solar ultraviolet radiation. This radiation would otherwise be harmful to life on earth. The addition of CFCs to the atmosphere due to human activity affected the natural formation/destruction process of ozone.

Most Greenhouse gases have two sources, natural processes and human activities. The major Greenhouse gas sources are outlined in Table 1.1. The atmospheric concentration of these gases has increased in recent history. Scientists have been able to determine the concentration of these gases in ancient atmosphere. For some cases, scientists are able to analyse the tiny bubbles found in the ice core from areas like Antarctica then determine the concentration of these gases in ancient atmosphere. In more recent times, scientists have measured atmospheric CCb concentrations from on top of Mauna Loa in Hawaii. Scientists consider CO₂ the most important gas being produced by human activities. However, the other major Greenhouse gases, especially CH₄ and the CFCs play significant roles in Greenhouse gas affects.

Table 1.1 Greenhouse Gas and its sources

<table>
<thead>
<tr>
<th>Greenhouse Gas</th>
<th>Natural Sources</th>
<th>Human Activity Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>CFCs(CFC-11&amp;CFC-12)</td>
<td>None</td>
<td>Chemical products and processes, including solvents and blown foam insulation</td>
</tr>
</tbody>
</table>

1.3.2 Impact of industrial development and environmental degradation on climate

Exploitation of natural resources in order to meet the industrial demand of raw materials has resulted in: (1) reduction of forest covers due to reckless felling of trees, (2) reduction in available land due to industrial expansion (3) excavation of land for mining purposes (4) lowering of ground water table due to excessive withdrawal of ground water (5) collapsing of ground surface due to withdrawal of mineral oil and ground water etc.

Development in agricultural sector in order to supply raw materials to factories such as sugarcane (for sugar industry, cotton for cotton textile industry), etc, has been responsible for over utilisation of soils, which has resulted in soil pollution due to excessive use of chemical fertilisers and pesticides and insecticides.

Release of gases, smoke, ashes and other aerosols from the chimneys of the factories adversely affects the environment in a number of ways. The burning of hydrocarbon fuels (coal and petroleum) has increased the concentration of CO$_2$ in the atmosphere and this has changed the natural gaseous composition of atmosphere. The increase in the concentration of CO$_2$ content of the atmosphere may change global radiation and heat balance by increasing the level of sensible heat in the atmosphere because CO$_2$ intensifies the Greenhouse effect of the atmosphere as CO$_2$ allows more absorption of outgoing long wave terrestrial radiation and thus more counter radiation towards the earth's surface.

Release of chlorofluorocarbons in the atmosphere through spray can dispensers. Refrigerators, air conditioners and fire extinguishers is capable of depletion of ozone layer. Depletion of ozone layer means less absorption of ultraviolet solar rays and thus substantial increase in the temperature at the earth's surface. Thus changes in the global radiation and heat balance caused due to increase in the concentration of CO$_2$ in the atmosphere and depletion of ozone layer may cause changes in weather and climatic conditions at alobal and regional levels. The rate of
increasing sulphur dioxide and hydrogen sulphide gases released from the rayon manufacturing plants cause sulphuric acid falling as acid rain over large industrial cities.

### 1.3.3 Impact of urbanization and environmental degradation on climate

Previously towns and cities were considered to be the centres of higher standard of life because of better living conditions but now most of the urban centres of developed countries in general and of the developing countries in particular have become unsuitable for human beings because of marked lowering of environmental quality due to phenomenal increase in the level of air, water and noise pollution, crowded streets and roads, slums, increasing trend of murder, theft, dacoity and other crimes, etc. In fact, increasing urbanisation means phenomenal increase in the concentration of human population in a limited space which resulted in the increase of buildings, roads and streets, sewage and storm drains, pucca surface area, vehicles (motor cars, trucks, buses, scooters etc.), number of factories, urban wastes, aerosols, smoke and dust, sewage water etc, which causes several environmental problems. For example, increasing population of the urban centres use enormous amount of water. Also, sewage water, if untreated, pollutes the streams and lakes, which are further polluted by industrial effluents allowed to be drained into them.

Urban centres affects rather modify patterns of air circulation in and above the cities and their immediate surroundings and the modified air circulation in turn affects temperature, humidity, pressure and precipitation patterns. Tall buildings in the cities obstruct free flow of air and thus retards wind speed. According to the findings of Landsberg, (1970) annual mean wind speed is usually 20 to 30 per cent less over the cities than the surrounding countryside. And the speed of extreme gusts is 10 to 20 per cent more frequent in the cities than their immediate surrounding countryside. The pattern of airflow in the cities located in the coastal areas is complicated by sea breezes during daytime and land breezes during night. This mechanism of land and sea breezes is responsible for circulation and recirculation of atmospheric pollutants over the cities.
Urban air pollution largely modifies the climatic conditions of large urban centres in a variety of ways. Most of the urban pollutants are released to the atmosphere as waste products from different combustion processes, mainly human volcanoes (chimneys of factories) and automobiles. The main pollutants emitted through the chimneys of factories are mono oxidised nitrogen, carbon dioxide, coarse ash, fine smoke, sulphur dioxide etc; where as the pollutants emitted from automobile exhausts include lead, unburned hydro carbons, carbon monoxide, nitrogen monoxide, water vapour, carbon oxide and unoxidised nitrogen. These pollutants form a thick layer over the cities generally at the height of 1000m. Such a thick layer of the concentrated pollutants over the city is called a "pollution dome". This urban particulate concentration is responsible for absorbing or reflecting up to 20 per cent of the solar radiation, which arrives above the pollution dome and can also reduce solar radiation (Rouse. 1981).

Higher concentrations of particulate pollutants decrease visibility in the city and form dense fog when there is abundant moisture in the urban air. In fact, particulate pollutants provide numerous hydrosopic moisture which increases the incidence of fog by 100 per cent and water vapour readily condenses around numerous hydrosopic nuclear and thus forms innumerable tiny water droplets which form fog. When fog is formed due to the combinations of smoke, dust, aerosols, water droplets and nitrogen oxide, it is called smog or urban smog. This smog when associated with sulphur dioxide becomes poisonous because the resultant form of sulphuric acid becomes very injurious to organisms in general and human beings in particular.

Photochemical smog caused due to the reactions of nitrogen dioxide, hydrocarbons and sunlight becomes very dangerous when they mix up with ozone. The nitrogen dioxide emitted from anthropo-genetic sources after absorbing ultraviolet rays of solar radiation is decomposed into nitric oxide and atomic oxygen, which combines with molecular oxygen and forms ozone. This process is called photochemical process. The photochemical produced urban smog reduces atmospheric visibility, solar radiation and influence precipitation. The cities located in the valleys are very often affected by persistent inversion of temperature. This
inversion of temperature intensifies fog and enhances their duration. Thus persistent smog in the cities causes irreparable loss to human health and biological communities, (e.g. the poisonous smog of Donna town located in Pengy valley USA, (October 20, 1948); Meuse valley of Belgium (december 1930) and of London (1952) are a few examples of the deadly after effects of urbanisation and smog).

1.3.4 Impact of deforestation and environmental degradation on climate

Forests are a very important part of the ecosystem and carbon cycle. They are home to a vast amount of the plant and animal life and their loss has far reaching effects on biodiversity. As part of the carbon cycle, forests serve as huge carbon reservoirs. Loss of forests affects the amount of carbon in the cycle in two ways; one, is that they are no longer available to remove carbon from the cycle and the other is that the burning or decay of the trees adds carbon back into the cycle.

Worldwide forest coverage is approximately 80% of what it was 3,000 years ago when agriculture began to expand. Activities resulting in the deforestation include logging, farming, and ranching, use as fuel wood and lumber, mining, building of hydroelectric dams and urban expansion. In temperate zones, logging roughly balances growth of new trees. Abandonment of farmlands due to economic factors has increased in recent decades resulting in new woodlands. Tropical forest clearing for fuel wood, farming and ranching was estimated at 1% per year for the last decade. In many cases, development of tropical forests is seen as the only possibility that some population have for survival. However, often the soils and other conditions on the cleared land do not allow sustainable production, they are abandoned and serious land and soil degradation begins. In addition, since the 1970s the increased demand for tropical land woods has seen wood production in Asia and South America has risen dramatically which suggests further deforestation. It is estimated that every square kilometre of tropical forest contains from 20,000-50,000 tons of carbon. This means that since the 1970s approximately 1.3-giga tone of carbon, in the form of CCB has entered the atmosphere due to deforestation (Carlson Key, 1995).
The major causes of deforestation at global and regional levels are conversion of forest land into agricultural land. Shifting cultivation, transformation of forests into pastures, overgrazing of forest, forest fires, lumbering for domestic and commercial purposes, multi purpose of river project (dam construction) and biological factors.

Deforestation also results in the increase of concentration of carbon dioxide in the atmosphere because forests consume carbon dioxide during the process of photosynthesis for the manufacturing of their food but absence of forests allows more concentration carbon dioxide in the atmosphere because of its non-consumption. It is thus; obvious that deforestation increases Greenhouse effect of the atmosphere, which raises the temperature of the earth's surface, and the atmosphere. Increased rate of soil erosion consequent upon deforestation and destruction of grassland has been responsible for soil pollution in addition to land degradation and leads to subsequent desertification.

In some cases, deforestation can be beneficial given the right mix of social needs, economic opportunities and environmental conditions: it can be rational conversion from one type of land use to a more productive one. But, most lands that have been deforested in recent decades are not suited for long-term farming or ranching and they quickly degrade once the forest has been cut and burnt. Unlike the fertile soils of temperate latitudes, most of tropical soils cannot sustain cropping. The earning capacity of soil will not support intensive annual cropping without rapid, irreversible degradation. Similarly, intensive cattle grazing cannot be supported because of grasses grown on forest soils do not have the same productivity levels as those available soils.

Deforestation is an important contribution to global warming of climate. The negative consequences of global warming are catastrophic increasing drought and desertification, crop failures, melting of the polar ice caps, coastal flooding, and displacement of major vegetation regimes. The principal cause of global wanning is the excessive discharges in industrialised countries of Greenhouse gases, mostly from the burning of fossil fuels. Annual discharges from burning of fossil fuels are estimated to be about 6000 million tons of carbon, mostly in the form of carbon
dioxide. It is thought that an additional 2000 million tons or about 25 per cent of the total carbon dioxide emissions are a consequence of deforestation and forest fires (WCFSD, 1997). At the regional level, deforestation disrupts normal weather patterns, creating hotter and drier weather.

1.4 Select Literature Review

1.4.1 The Asian Monsoon Circulation

Originally the term "Monsoon" was applied to the surface winds of Southern Asia, which reverses winter and summer. The characteristics of the monsoon climate are to be found mainly in the Indian sub continent including Mvanmar, where over much of the region the annual changes may conveniently be divided into the Northeast (dry) and Southwest (wet) monsoon seasons.

When upper winds are taken into account, it is found that the Asian monsoon is a fairly complex system. During the Northern winter season, the sub tropical westerly jet stream lies over Southern Asia, with its core located at about 12 km altitude. It divides in the region of the Tibetan Plateau, with one branch flowing to the north of the plateau, and the other to the South. The two branches merge into each of the plateau and form an immense upper convergence zone over China. In May and June the subtropical jet stream over Northern India slowly weakens and disintegrates, causing the main westerly flow to move North into central Asia. While this is occurring, an Easterly jet stream, mainly at about 14 km builds up over the equatorial Indian Ocean and expands westward into Africa. The formation of the Equatorial Easterly Jet stream is connected with the formation of an upper-level high-pressure system over Tibet. In October the reverse process occurs, the Equatorial Easterly Jet stream and the Tibetan high disintegrate, while the Sub-Tropical Jet Stream reforms over the Northern India. The driving force for the India summer monsoon is high-level heating over the Tibetan Plateau together with latent heat release in tropical storms over India. It is a good example of tropical circulation patterns being modified by a powerful heat source. The Southwest Monsoon is of particular importance to India and Mvanmar because it provides much of the rainfall required for agriculture.
The Himalayan-Tibetan Plateau is of importance because it appears to be accelerating the onset of the Asian Monsoon and to increase its ultimate intensity. Satellite data indicates that the central and southwestern parts of Tibet remain free of snow throughout most of the year. Hence, the Plateau must heat rapidly during the northern spring. This direct warming of the middle troposphere creates an upper-level anticyclone which is readily observed as synoptic charts, upper-level divergence, and low-level convergence. Thus, suitable conditions are produced for the Asian monsoon in the north spring. Latent heat released in intense tropical storms over India keeps the system functioning during the northern summer. Since a complex feedback system produces the southwest monsoon, failures in the system are common and produce extensive breaks in the monsoon rains. When the whole system starts sign of collapsing, variations in winter snow cover over Tibet will influence the start and intensity of the Southwest monsoon. General cooling over southern Asia at the end of the Northern summer causes its collapse.

According to Miller and Keshawa Murthy (1968), the Southwest Monsoon current in the lower 5 km. near India consists of two main branches: The Bay of Bengal branch, influencing the weather over the Northeast part of India and Myanmar, and the Arabian Sea branch, dominating the weather over the central and northwest part of India. The low level flow across the equator during the southwest monsoon is not evenly distributed the latitudes 40°E and 80°E. but has been found by Findlater, (1969, 1972) to take the form of low level high-speed southerly currents, which are concentrated between about 99° E and 55°E. A particularly important feature of this flow is the strong Southerly current with a mean wind speed of about 14 ms⁻¹ observed at the equator over Eastern Africa from April to October.

The strongest flow occurs near the 1-5 km level but it increases to more than 25 ms⁻¹ and occasionally to more than 45 ms⁻¹ at heights between 1-2 and 2-5 km. According to Find & et al (1969). this high speed current flows intermittently during the Southwest monsoon from the vicinity of Mauritius through Madagascar, Kenya, eastern Ethiopia, Somalia and then across the Indian ocean towards India (the low-level southerly current off the coast of East Africa is generated by the dynamics of flow patterns of this nature and has fundamental consequences for the climate of
1.4.2 Global Circulation Patterns and the Monsoon Rains in Myanmar

The atmosphere circulation in winter December, January, February, exhibits substantial low frequency variability. This fluctuation often strongly influenced the temperature and precipitations due to major shift of locations and intensity of jets and storms. The primary circulation patterns are the Pacific North American Pattern (PNA), the West Pacific Oscillation (WPO), the North Atlantic oscillation (NAO), the European Teleconnection Pattern (EU) and the ENSO (El-Nino and Southern Oscillation Patterns).

Preliminary review of these air circulation patterns in relation to the general monsoon rainfall in the whole country of Myanmar by San Hla Thaw (1996) indicated that
1. When P.N.A. is normal or above normal, the seasonal rain tends to be normal in the whole country.
2. When NAO is highly positive or around normal, monsoon rain is around normal.
3. When EU is around normal, rainfall of Myanmar is around normal.

Among the circulation patterns, the ENSO is a major phenomenon of the tropical world with widespread repercussions within the global system and it has a marked relationship with rainfall variability of Myanmar.

In the assessment of droughts based on the monsoon rainfall and climatology for the union of Myanmar. during the period of 1950-1997. the driest years were 1957-58, 1972-73, 1979. 1982-83. 1986-87. 1992-93 and 1997-98. During this period El Nino was weak in 1951-52. 1953 and 1963. moderate in 1968-69. 1976-77. 1982-83 and strong in 1957-58. 1965-66. 1973-74. 1980-83. and 1997-98. The dry year in 1979 is due to the failure of the Southwest monsoon. All the remaining driest years coincide with the strong El Nino episodes. Therefore a major drought may be predicted in the Asian region by monitoring El-Nino/ENSO events and abnormal shift/extension of semi permanent regional synoptic features. There is a need for
research and studies for prediction of El Nino events that markedly related to the insufficient rainfall in Myanmar (Thaw. 1997).

Variability of rainfall in different parts of the world is estimated by researchers by using different techniques. Naumann (1990) analyzed inter-annual rainfall variability to 17 meteorological stations in Srilanka for a period 1980-81 found that the inter-annual variability of rainfall was high in Dry Zone when compared to wet zone. Dyer (1982) investigated the behaviour of inter-annual rainfall variability over both time and space by using principal component analysis for the period 1921-1974 in South Africa. Krepper et al (1989) examined rainfall variability over time and space for control and coastal regions of Argentina. They used both orthogonal function and spectral analysis for a 30 years record. This analysis identified area of maximum rainfall variability in the region. Wang and Lis (1990) investigations regarding the rainfall fluctuation in the semi arid region of northern China revealed a trend towards drain and warmer climates. Blandford (1986) made an extensive study of rainfall variability over India.

Patnaik et al (1977) analyzed the temporal variation of summer and winter rainfall over the country, India. Raghavendra (1974) analyzed seasonal and annual rainfall variability in meteorological sub divisions of Mahahrastra State. Parthasarathy (1984) tried to examine the inter-annual and long term variability of summer monsoon rainfall for 29 subdivisions of India taking 108 year of time period and found high and low inter-annual rainfall variability over Saurashtra and Kutch sub-divisions and South Assam sub-division, respectively. Varma et al (1985) did a statistical analysis of summer monsoon rainfall of India for hundred years period (1881-1980). They found that the last two decadal periods (1960-1980) were the periods of the highest coefficient of variation and the lowest average monsoon rainfall for India. Muoley and Shukla. (1987) studied summer monsoon of India over three destined spaces scales, i.e. large, medium and small scale variability. The result of all three analyses is different. The study of Ananthakrishnan and Soman (1987) highlighted the nature of troposphere thermal conditions for years of excess, deficit and normal monsoon rainfall over India and concluded that the decrease in monsoon rainfall is associated with weakening of the troposphere thermal gradient across the country-. In another
analyses, they (1989) also studied the daily rainfall data from 15 rain gauge stations of India over 1901-1990 and found that normal was uniquely determined by the coefficient of variation of the rainfall series. Ram Mohan and Nair (1991) worked out monthly and annual rainfall variability for Kerala State during the period (1901-1989) and concluded that more than five consecutive wet or dry years do not occur in the state. Singh and Mulye (1991) demonstrated that the value of standard deviation, absolute mean deviation and mean absolute inter-annual variability increased linearly with the amount of mean rainfall.

In 1970, the first long range - prediction of seasonal rainfall in Myanmar was statistically developed by Dr. Po.E (1970). He imposed the pressure departure at selected global position as predictors.

Yin (1948) has put forward a very outstanding ecological synoptic feature related to the southeast monsoon onset in Asia. Particular attention was given more to the long-range weather forecasting in the later years.

Teleconnection approaches, statistical approach, typhoon remnants that originated from the N.W. Pacific and South China Sea in Myanmar was first presented by Po.E (1956).

Tropical storm related floods were studied by different authors such as San Kyaw (1968). Htay Aung (1968). Sein Shwe. U & et al. 1968) etc.

Droughts in Myanmar in April-May 1957 were analyzed by Thuta (1958). Some synoptic situations responsible for the rain in central Myanmar area were studied by Hla (1908).

The study in the low and middle Ayeyawady floods in relation to heavy rainfall fall in the headwater region of Chindwin and Ayeyawady River was undertaken by Pe Kyi (1968).
The assessment of the monsoon rainfall and synoptic situation responsible for dry and wet monsoon season of the country was studied by Htay Aung (1981). In the early season rainfall in Ayeyawady Division that serves as rice bowl of Myanmar was attempted by U Hla and San Hla Thaw (1969) by using change of geopotential at selective locations.

So as to prepare the agricultural activity, early monsoon rainfall for the month of June was developed by San Hla Thaw (1974) by using change of semi permanent features in the troposphere from April to May. The rainfall of later part of monsoon were carried out for September by Htay Aung (1975) and for October by San Hla Thaw (1975).

The study "Summer Monsoon of Myanmar" was done by Khin Swe Win. Daw, in 1976. The study was emphasized on the upper circulation patterns and seasonal rainfalls of Summer Monsoon.

In 1995, "Rainfall regimes of Myanmar "have been analyzed by Swe Swe Aung. Daw. In the study, distribution patterns of rainfall were assessed spatially and seasonally.

Myanmar is one of the countries having rainy season in the region of Asiatic Summer Monsoon. The most important feature in the meteorology of Myanmar is the alternation of seasons known as monsoon. Strictly speaking, monsoon and seasonal winds whose direction more or less reverse twice during the year lying in their the tropics and with the great Asiatic continent to the north and the wide expense of the Indian ocean to the south. Myanmar furnishes are of the best examples of a monsoon country.

During the winter part of the year, the general flow of surface air is known North to South in the Northern parts and Northeasterly in the rest of the country. In this season the air over the country is mainly of continental origin and hence of low humidity and the season is known as the Northeast or winter monsoon. In the summer
months May to September the general flow of wind is from the opposite direction from sea to land and the season is one of much humidity, cloudiness, and rain. The direction of winds in the Bay of Bengal and Andaman Sea being Southwesterly, the season's name is Southwest monsoon or rainy season, or summer monsoon or simply monsoon. Between these two principle seasons are the transition seasons of the hot weather months of March, April, and May, and the retreating month of October and November. Out of the two-monsoon season, the Southwest or summer monsoon is more pronounced and important in Myanmar.

Das (1995) stated that monsoon circulations are important to many countries of Asia and Africa because of their capacity to generate seasonal rains. Agriculture and the replenishment of water resources rely heavily on monsoon rains. The economy of many countries is thus dependent on the timely arrival and subsequent distribution of rains.

Myanmar is an agricultural country and most of the major crops are grown during the Southwest monsoon or rainy season, which is usually known as summer monsoon. Most of the rains that are crucial to the farmers are more or less continuous during the monsoon period. As the monsoon in Myanmar is one of the most important natural meteorological phenomena for the agricultural sector of the country, agricultural activities each year are regulated according to its behaviour.

1.4.3 Role of mid latitude frontal systems intrusion in Myanmar

Mid latitudes frontal system intrusion into the monsoon marginal area was observed when cloud images from the operational meteorological satellite were receiving the system moved into the southwest monsoon region during the cold season, hot season and also in the rainy season. Though there is no clear identity of the cold frontal system in the conventional temperature, dew point temperature and wind field. The cloud pattern would be extending across northern part of South East Asian region when compared with the cyclone in the Bay of Bengal. San Hla Thaw (1983) in his extensive study on mid -latitude and the cyclones in the Bay of Bengal, concludes that the interaction of the mid-latitude frontal system and the cyclone in the Bay of Bengal would lead to prolonged heavy rainy season and post monsoon season.
With the mid latitude system, out break of cold air takes place in the whole country except the southern coastal strip and in hot season this is believed to reduce the thermal potential of the land and the adjacent sea by reduction of sea surface temperature. The lowering of thermal potential in turn affects the cyclone genesis potential in the bay until a few weeks before the recovery of the seasonal temperature (Thaw, 1995).

Monsoon depression in the Bay of Bengal has long been recognized as one of the semi-permanent features. Downstream amplifications is one of the causes for the formation of the depression in certain times, at another times, it is required to confirm that the depression is due to interaction of Southwest monsoon current and the mid-latitude frontal cloud system.

1.4.4 Influence of Tropical Storms

The influence of pre-monsoon cyclones in the Bay of Bengal upon the seasonal rainfall of Myanmar by using 30 years date, was studied by San Hla Thaw and Htay Oo Kyi (1983). the Bay storms were classified into 13 categories and it was found out that (1) below normal monsoon rainfall condition when there was absence of pre monsoon cyclones in April, May and June. (2) About/around normal monsoon rainfall condition when one cyclone occurred each month in April, May and June. (3) Above normal monsoon rainfall conditions when the disturbances have long span of life over the Bay of Bengal.

The effect of the typhoon in the North west pacific and the South China Sea has long been recognized by many meteorologists such as Thu Ta (1957), San Kyaw (1961) etc. among others.

1.4.5 Geography and Environment: A Review

Environment refers to the sum total of conditions, which surround man at a given point in space and time (Park, 1980, p.28). In the beginning the environment of early man consisted of only physical aspects of the planet earth (land, air and water) and biotic communities but with the march of advancement of society, man extended
his environment through his social, economic and political functions. Goudie (1984) in his book "The nature of the environment" has taken environment as the representative of physical components of the earth wherein man is an important factor affecting the environment.

Right from the beginning 'Man and Land', 'Man and Nature', 'Man’s relationships to his earthly environment', etc. have been the recurring themes of Geography irrespective of the dichotomy of "Earth made Man" versus "Man made the Earth". Whether visible or not the concept of ecosystem and emphasis on environment has been always lurking in the background but the approach has been too fragmentary and hardly any composite picture of environment emerged. Obviously, the objective was never to understand the environment but to make use of it for demonstrating its role in emerging cultural landscape or the regional diversities (Dikshit, 1984). Elements of physical environment like topographic characteristics: climate, soils etc. were taken as physical or geographical factors to explain variable distribution of matter in the general and human population in particular over space, location of industries etc. It may be emphasized that the study of environment has always been associated with geography but with varying significance during successive phases of methodological development of the subject. It may also be stressed that the environmental studies were based on much more generalizations and assumed relationships involving secondary data and information rather than on in depth study of different components of environment based on empirical studies.

Geography is a spatial Science, which studies spatial attributes of various phenomena on the earth's surface through time. In other words, phenomena, which exist in space-time framework, becomes the subject matter of geography. Besides this traditional definition in a highly generalized sense, geography has been variously defined as the study of areal distribution of phenomena, spatial patterns, locational analysis, human ecology, man-land relationship, environment-man and man-environment relationships, spatial organization, ecological studies etc.

Peter Haggett (1972) has attempted to integrate the structure of geography and
various approaches of study into three broad modes of analysis viz. (i) Spatial analysis involves the study of locational variation of significant property or series of properties of objects on the earth's surface (ii) Ecological analysis interrelates human and environmental variables and interprets their links and (iii) Regional complex analysis combines the results of spatial and ecological analyses.

Variable phenomena on the earth's surface can be treated separately or in association. They are classified or categorized into physical phenomena or human phenomena or are treated as interrelated phenomena. So the subject of Geography, which studies those phenomena, also has two branches. Physical Geography, and Human Geography. Physical geography is concerned with the study of the descriptions of physical phenomena, encompassing the systematic sciences of Geology. Meteorology, Botany, Zoology, and Chemistry. Physical geography has its origin in antiquity when the ancient Greeks and Roman scholars developed their interest in the study of nature and its different attributes and became a very prominent subject during the later phase of nineteenth century. Physical geography has a number of sub-branches which studies different kinds of phenomena, e.g. Astronomical geography, mathematical geography, Geomorphology, Climatology, Oceanography and Biogeography, etc.

K.J. Gregory and D.E. Walling (1981) summarized the development of ideas concerning the impact of man on environmental processes and have pointed out four major trends in this field. The first theme was related to the deduction of the rate of erosion in various areas and the presentation of a comparative picture. The second theme of interest was the initiation of investigation of natural hazards/environmental hazards. The third trend was the initiation of International Programme to study the influences of man on natural processes e.g. I.H.D (International Hydrological Decade (1965-74). M.B.P (Man and Biosphere Programme. 1970). The fourth trend was the realization of environmental concern which was reflected in a number of writings. The influence of man on gully erosion in S.W U.S.A. (W.M Denevan. 1967). on fire and floods (J.G Nelson and A.B Byrne. 1966). on changes of geographic environment through industrialization and urbanization (S.Gilewska. 1964) etc. are few examples that demonstrate the initiative taken to study man-environment processes and relationships. These developments internal to geography were achieved within the
intellectual environment that embraced growing concern for the future, and this
provided one of the motivating reasons for the initiation of international research
programme. (Gregory and Walling, 1981,p5). This trend resulted in a number of
studies, organization of national and international symposia and conferences and
publication of a number of research papers, research monographs and books on
impact of man on environmental processes and on man environment relationships,
(e.g., Environmental problems (I.R.Manners and M.W Mikesell, 1974). Man's
impact on environment (T.R Detwyler, 1971). Environmental geomorphology
Geomorphology (D.R Coates. 1976), Geography and ma’s Environment (A.N Strahler
Change and tropical Geomorphology (Ian Douglas and T.Spencer. 1985),
Environmental management (L.R Singh.Savindra Singh. R.C Tiwari and R.P
Srivastava . 1983). First International Conference on Geomorphology and
Environmental management (Allahabad. India.1987) Geomorphology and
Environment (Savindra Singh and R.C.Tiwari,1989). Second international Conference
on Geomorphology and Geology (1989.Frankfurt. West Germany etc.).

Human geography as a branch of geography is a more recent development.
According to Vidal De La Blache. "Human geography is a recent sprout from the
venerable trunk of geographical science and it offers a new conception of the
interrelationships between the earth and man". Knowledge of the natural environment
in which man has played a function and of the part physical factors play in the
interpretation of human activities, is in fact, human geography.

In the words of Ellen Semple, "Human geography is the study of the changing
relationships between the unresting man and the unstable earth". Efforts on the part of
man to make adjustments to his natural setting are universal and involve some of the
major and important problems in which the drama of human life and activity is
constantly being enacted. Professor Roxby summarized the modern concept of human
geography in his presidential address before the British Association in 1930. In his
view it consists of "First, the adjustment of human groups to their physical environment, including the analysis of their regional experiences, and of second, inter-regional relations as conditioned by the several adjustments and geographic orientation of the group living in respective region" (Negi, 1992).

Human geography and physical geography are inseparable; the reason being the variable phenomena on earth’s surface have human elements on them. Human geography is the study of three closely linked components; the spatial analysis of the human population (i.e., its numbers, its characteristics and activities, its distribution over the earth's surface); the ecological analysis of the relation between human population and its environment; and the regional synthesis which combines the first two themes in an area of differentiation of the earth's surface.

In Environmental Geography, the physical environment is more significant than the social or cultural element. The economic function of man becomes more significant than his other functions as it is more concerned with the functioning of ecosystem. Thus, the interaction of man through his economic functions and hence as an environmental process and human response to the environment is the fundamental concern of Environmental geography. Environmental Geography is the study of various aspects of the environment on the ground, and it can be differentiated from other disciplines studying environment because geography studies the spatial attributes of matter and phenomena on the earth's surface. Moreover, the nomenclature of the theme of environmental studies as "environmental geography" instead of "geography of environment" lays more emphasis on the application of geographical information (both physical and human) to the solution of environmental problems. Environmental geography may serve as the bridge between physical and human branches of geography on the one hand and it may associate geographers in general and environmental geographers in particular with other allied life and earth scientists on the other hand.

Thus, Environmental Geography may be defined as the branch of geography which studies the characteristics, composition, and functions of different components.
various processes that link the components, the interactions of different components of the natural environmental system (including man as a biological organism—a physical man), mutual dependence of different components, various processes that link the components, the interactions of different components with each other and among themselves and consequent responses in spatial and temporal contexts in terms of "geoecosystem," as well as interactions of technologically advanced 'economic man' with different components of natural 'geoecosystem' and resultant modifications and changes leading to environmental degradation and pollution, the techniques and strategies of pollution control measures and management of ecological resources" (Singh, 1989).

Geography is a discipline that can pursue the study of environment in a holistic manner because:

1. It studies the spatial attributes of all the phenomena including man in a given space and highlights complex man-environment relationships at different stages and phases in a time-space continuum while other sciences study individual phenomenon and do not focus on spatial organization.
2. Being an integrating science, geography synthesizes all the elements and components of planet earth into one body and links the Social Sciences with the Natural Sciences.
3. It lays stress on the synthesis of all the near surface spheres into interacting systems (Annuchin, 1974). That is to say geography studies the biosphere (the interface of air, land, and water) in totality, all components of biosphere-abiotic and biotic, their characteristics, and interrelationships.
4. With regard to the physical system, it is geography that has an advantage over other sciences because geographers have the knowledge of physical structure, geomorphic processes, climate, vegetation and soils while other scientists specialize in only one of these aspects.
5. Geographers besides identifying complex relationships between man and physical environment have the capability of locating the distribution of such relationships in space, mapping them and exploring the causes of variations in distribution, and
6. Geographers recognize that the quality of life layer varies from place to place in terms of richness or poverty of life forms capable of being supported. Geographers are
the only scientists who can recognize and identify the environmental regions, locate them in space and present them on maps (Singh, 1999).

There is a dualism in geography between physical and human geography. Some scholars study problems in each separate field either physical or human geography. This particular study draws on the interface between the physical and human as it argues that Geography as environmental studies integrates both these very vital branches of geography.

1.4.6 Environmental study of Myanmar - A review

The analysis of "Environmental Law in Myanmar" has been done by Peter Gutter in 2001. He found that the main problem is that there is no up-to-date laws that regulate pollution and no regulations for environmental impact assessments of projects. He further pointed out that reasonably effective environmental laws were enacted under the British rule. The Democratic period in Burma, from 1948 to 1962 did not improve the laws. After 1962, the Military Junta repealed and replaced the British laws. The current legislation is too general and has never significantly provided for the protection of the environment.

The study of "The Changing faces of the Ayeyawady Delta from 1850 to 2000" has been done by Mya Than in 2001. He stated that unless measures are taken to prevent the further degradation of environment by over logging (legal or illegal), over fishing, improper mining, and misuse of water resources, the impact on the Delta and its inhabitants would be enormous and most probably irreparable.

"Environmental Issues in Land and Water Development in Myanmar" was studied by Tha Tun Oo. U. Land use Division. Agriculture Service. Yangon. in 1991. His study was focused on the Land capacity and its environmental issues in Myanmar under two main categories i.e. Low Potential Production Area (LPPA) and High Potential production Area (HPPA).

"Wood fuel Production and marketing in Ayeyawady delta" was studied by Tun
Paw Oo in 1999. He summarized the current situation of Ayeyavady Mangrove Forest and its degradation. He further suggested giving more attention for the development of mangrove reforestation and establishment of forest nurseries to reduce the local wood fuel requirement.

The study of "Wood Fuel Flows in the Dry Zone of Myanmar" has been done by FAO, Bangkok in 1993 in collaboration with the pilot integrated watershed Development Project for Kinda (MYA/81/003) Ministry of Forestry, Myanmar.

Myint Thein. U. has made an assessment of the current state of agriculture, forestry and marine resources of Myanmar. He stated that at present, Myanmar resources are sufficiently endowed to support its population but the development and extraction of these resources were adversely affected to some extent by the policies. He suggested having better sectoral policies, objectives and strategies in agriculture, forestry and fisheries for the sustainable development of the resources.

A study "Country Profile on Environment of Myanmar" was done by Japan International Cooperation Agency in 1999. In the study, we can see that Myanmar still needs to concentrate on environmental conservation especially on pollution.

From the studies that were done on environment pertaining to Myanmar, it was found that not enough academic research was taken to bridge this gap between environment and other variables. It is therefore hoped that this study on climate-rainfall variation and its impact on environment of Myanmar from an interdisciplinary perspective would provide some understanding on this issue.

1.5 The Focus of the Study and the Choice of the Study Areas

1.5.1 The Focus of the Study

The development of agricultural economy of Myanmar with its growing Population is closely related to the availability of water or annual rainfall for crop production. This is considered to be the life and soul of Myanmar because the livelihood
of the population depends upon timely and adequate amount of rainfall. A large proportion of rainwater is used for agricultural purposes. Due to this reason, it is important to know whether the available rainfall is adequate and how well distributed it is for crop production in various parts of the country. Abnormalities in the amount of the rainfall are manifested as flood in one part and drought in another part of the country. Furthermore, it is also important to know about the nature of rainfall trends in Myanmar. The statistical analysis of a time series data of rainfall may enable us to understand the long-term behaviour of rainfall. The seasonal pattern of rainfall is a general feature of the rainfall distribution over the year. Apart from the monsoon season, agricultural production depends on other sources of irrigation, which are also indirectly influenced by rainfall. This analysis is intended to find out the extra amount of rainwater available, which can be utilized in the period of scarcity.

The cropping pattern of a region depends mainly on the availability of irrigation water; it may be from rainfall or from ground water. The analysis of rainfall behaviour of a region helps in considering a particular cropping pattern. It also guides other agricultural schedule related to farm operations. The rainfall information is also considered to be an important factor in estimating the agricultural production of a region. The planning for soil and water conservation programme cannot be done without an analysis of rainfall because it determines the efficiency of soil and water conservation activity in the region.

Rainfall is very important for both physical and human environment as well as for every socio economic activity. The present study concentrates only on rainfall as the dominant climatic factor that shapes the physical and human environment of Myanmar. Myanmar does not have many studies that are attempted from an interdisciplinary perspective. The debates on deforestation in the country make the research excited about examining the links between climate and environment.

1.5.2 Choice of the Study Areas

The study area consists of two different geographical entities, with differing rainfall regimes viz. the Central Drv Zone region and the humid Ayeyawady Delta
region of Myanmar. The researcher belongs to one region (Ayeyawady Delta) and this is an advantage in research, the availability of comparable data on the two related regions was a crucial consideration in the selection of these two regions for study. In terms of rainfall variability, the Dry Zone shows the highest variation over the last few decades, while the Delta region too has high rainfall variation. This prompted the choice of these regions as the study areas. Other reasons for choosing these two areas are: these two regions are located on the passage of Ayeyawady river channel, they have fertile alluvial soils that are producing the largest amounts of rice and other crops: they consist of numerous large and small irrigation projects; they both support the highest density of population in the country, both regions have smooth communication routes on both western and eastern sides of the Ayeyawady river; have good conditions of accessibility and transferability of commodity flow’s at national and international level: and the two areas have a high density of industries and manufacturing areas. These two areas are the most important zones for the economic development of the country and hence a comparative study becomes meaningful.

A comparison of these two regions reveals the following:

Ayeyawady delta region is humid with low variability of rainfall, soil fertility is high, it is rich in agriculture, has the highest density of population, is more developed in every sector of economy, the environmental degradation is high due to high loss of mangrove forest due to high demand for wood fuel in the region.

The Dry zone has a semi arid climate with high variability of rainfall. Dry zone is dry because of lying in the leeward side of Western Mountainous ranges as rain shadow area and does not receive well the southwest monsoon rain like other locations in the windward side of the mountains. Moreover, being in the location of central basin and far from the sea, with the lack of mechanism of lifting force in the passage of the southern winds. Central dry zone has less chance to get rain from conventional rain. Being a semi arid climate area. Central Dry Zone experiences top soil erosion, with scarce vegetations with dry forest (thorn and shrubs forests). But, it has fertile soils through deposition of Ayeyawady River and its tributaries. In Myanmar history. Central Dry zone was the strategic location of Myanmar kingdoms. Mandalay. Inwa. Amarapura. Sagaing, Pinya. Bagan are the famous historical places of Myanmar. Till
today, Central Myanmar has a number of irrigation reservoirs, dams, water pumps, and canals in the area and agriculturally is the second most important area of the country. It has the second highest density of population. Thus, the government in the construction of development of the country has concentrated Ayeyawady Delta Region and Drý Zone Area. Both are lying in the Ayeyawady River basin as the lowland areas, but because of the differences in weather and climate, the Dry Zone Region is obviously lagging behind in development compared to the Ayeyawady Delta Region.

Although the physical environments are different, both regions are environmentally fragile or high-risk areas by having problems of high wood fuel needs. The natural forests in the vicinity of the villages are affected by repeated cutting of wood fuel and by being encroached for cash crops cultivation. As a result, the degraded forests are gradually expanding in Dry Zone Region, making it into the area of desertification. A similar condition exists in Ayeyawady Delta Region where mangrove forests have been excessively exploited and reduced due to increasing demand of wood fuel and charcoal, and eventually turned into agricultural lands.

1.6 Objectives of the Study

Rainfall data is most readily accessible among various climatic elements. In the present analysis, intensive observational analysis was carried out to understand the rainfall behavior in Myanmar. The variability of rainfall and its impact on the environment was examined. The focus of this research is to understand the links between deforestation-environmental degradation and rainfall changes. The broad objectives of the present study are:

1. To attempt an interdisciplinary study of rainfall and environment in Myanmar.
2. To study distribution, variability, seasonally and the trends of rainfall over the last 50 years,
3. To con-elate the environmental situation of Myanmar with rainfall variability by focusing attention on the wood fuel crisis in two regions; the humid Ayeyawady Delta and the Drý Zone area.
1.7 Hypotheses

(a) Rainfall variability in Myanmar has increased over the last decades.

(b) Variation in rainfall is highest in the lowest rainfall regimes, e.g. Dry Zone,

(c) Environmental degradation is high in the Dry Zone,

(d) In high rainfall regions with high population density (Ayeyawady Delta), deforestation rates are high resulting in a wood fuel crisis.

1.8 Data Sources

The information on rainfall in Myanmar for 45 rain gauge stations for the period (1950 to 2000) is collected from the Department of Meteorology and Hydrology, Yangon, Myanmar. The present analysis is based on 45 rain gauge stations distributed throughout the country.

Besides the rainfall data, the reports and monthly bulletin of World Meteorological Organization (WMO) are also used as secondary sources, besides other secondary sources that include books, articles, reports on rainfall and environment. The data regarding the environmental issues are obtained from the Myanmar Agriculture Service (MAS), Ministry of Planning and Finance, Ministry of Forestry, Department of Irrigation, Dry Zone Greening Department, Myanmar Agenda 21, National Commission for Environmental Affairs, Yangon, Myanmar. Myanmar CD ROM 1998, and Internet source websites, www.myaimar.com and www.google.com. Primary data on the wood fuel crisis in the Dry Zone and Delta region was collected through field survey.

1.9 Methodology

The nature of rainfall varies over time and space. To understand this variability different methodologies are proposed. A detailed analysis of different aspects of rainfall is carried out through different statistical methods.
In this study the methodology subscribed to both qualitative and quantitative methods for the rainfall analysis and for the wood fuel analysis respectively. No one particular method can be used to study the rainfall variability, as rainfall is a complex variable. The simple rain gauge method, seasonality method, statistical method and analogue method are adopted to analyse the trends of rainfall.

1.9.1 Distribution of rainfall

The spatial distribution of rainfall is analysed with the help of sample rain gauge stations by plotting the mean annual or monthly rainfall of each rain gauge station on the map of Myanmar. In the present analysis, average method is used for mean annual rainfall in the region due to the fixed area of the region. The distribution of annual, seasonal and monthly rainfall across the country or various climatic zones will be analysed to have a clear picture of rainfall situation over space and time in the country.

1.9.2 Seasonality of rainfall

Seasonality Index can easily understand the seasonal variation of rainfall. The seasonality of rainfall considers the monthly distribution of rainfall in a year. This mean refers to degree of variability in the monthly rainfall throughout the year. Two types of hypothetical extreme conditions emerge in the calculation of seasonality. (1) Total rainfall of the year occurs in a single month and the other months of the year remain rain less or dry. This reflects that maximum concentration on rainfall occurs in that short span of time and is represented by the maximum seasonal index value. (2) Total annual rainfall is fairly distributed across all the twelve months of the year. It shows that there is no seasonality and this is represented by a minimum index value. The seasonality of a particular place always lies between these extreme values.

Dividing all the twelve months of the year into four standard seasons carries out the seasonal distribution of rainfall. Winter or cold season is between January and February, summer or pre-monsoon season is for three months from March to May, monsoon or rainy season extends from June to September and the period from October to December is considered to be the post-monsoon season.
1.9.3 Variability of rainfall

Rainfall variability can be analysed by the different statistical method like mean, standard deviation, coefficient variation of rainfall.

The onset and withdrawal dates of monsoon rainfall are important factors for production and growth of a crop in a season. The onset and withdrawal dates of monsoon rainfall in the country can be estimated by simple graphical method plotting the daily rainfall distribution between June 1st and October 15 of each year. On the basis of this information, the mean and standard deviation (SD) are calculated. The mean of SD gives the extreme values with respect to the onset of monsoon. The onset date of monsoon is also fixed on the basis of the daily rainfall. According to this method, daily rainfall of all the sample rain gauge stations is analyzed and a date is obtained based on high widespread rain and it generally occurs on probabilities. That date is considered as the onset date for the country. In the same way, date of rainfall withdrawal is also obtained.

1.9.4 Analogue Method

The sequence of meteorological pattern in the monthly mean charts of the mandatory levels in the troposphere from the month of March, and where possible February and January were examined for the onset. If the pattern closely resembles any of the previous year, the date of the onset for the year, is chosen for the forecast. And for the retreat, August and earlier months were examined. If the pattern closely resembles any of the previous years the date of retreat for the year is chosen for the forecast (Sein Shwe U. 1974). In Myanmar, analogue method is still used for forecasting the date of onset and withdrawal of monsoon.

1.9.5 Trends of rainfall

Using various statistical tests such as Mann-kendall rank statistics can carry out the trend analysis of rainfall in the country: regression analysis, student "t" test and low pass filter methods. The study of trends examined by more than one statistical method confirms the existence or otherwise of an general trend in rainfall time series data of annual, cold, hot, monsoon, and post monsoon seasons. In the present studies simple graphical methods also used for rainfall trends. Coefficient
variation is also calculated by statistical method. For this purpose rainfall series from 1950-2000, of the 45 meteorological stations in Myanmar is studied.

1.9.6 Regional Analysis

Further to study the interdependent and interface of rainfall variability and environment, two regions of Myanmar were selected as areas of field study. These are,

(1) Ayeyawady Delta Region (Kyunyarshay village (Pathein district), Yaedwingon village (Hinthada district) and Theinlargutsu village (Myaungmva district) which is a heavy rainfall area, and (2) the central Myanmar Dry Zone Area (Sagaing, Monywa, and Shwebo districts) which experience the least rainfall in the country. It is intended to compare how the variation of rainfall has a bearing on environment especially on agricultural patterns and its impact on the socio economic conditions of the people.

The study will focus on the wood fuel collection and marketing economy of the people in Sagaing division. Monywa, Sagaing and Shwebo districts at a macro level (at the district level) and wood fuel collection from non forest area of the Ayeyawady division (Pathein, Hinthada, and Myaungmva districts) at micro level (at the village level) that cause the forest degradation in both areas. Using the random sampling technique. I have selected 200 houses from each region as respondents and some government officers of the areas were also interviewed. Information was elucidated using open and close-ended questions and from target group discussions with local people from the two regions.

1.10 Organization of the Study

The study is organized into six chapters.

Chapter one comprises the introduction to the study and includes definition of climate and environment and their inter relationship, the focus of research and choice of study area. Objectives of the study. Methodology and Data sources, and organization of the study.

The second chapter highlights the profile of Myanmar providing a background to the study. It consists of the physiographic setting, climatic setting and socio economic setting of Myanmar.
The third Chapter examines the rainfall variability of Myanmar. In this chapter, rainfall characteristics are analysed in terms of annual rainfall variation, rainfall with abnormal condition, spatial rainfall distribution, seasonal or temporal distribution, and trends of rainfall study by accumulative coefficient method.

The fourth chapter deals with environmental problems of Myanmar and focuses on the major environmental issues such as deforestation and desertification, soil erosion and land degradation problems, marine resource degradation, and pollution.

The fifth chapter provides an account of Environmental Degradation in Myanmar on the basis of wood fuel use in the two selected rainfall regime regions. This chapter is divided into two sections; one is the case study of Dry zone in Sagaing Division, which discusses the wood fuel collection, the wood fuel productivity, and marketing which is accelerating forest degradation in central Myanmar. The second section focuses on the Ayeyawady delta region where wood fuel collection from non-forest area has been taking place that has caused the mangrove forest degradation.

Chapter six summarises the major observations and concludes with the major findings of the study.

1.11 Limitations of the study

At the outset it needs to be confessed that there are some major limitations in this research work that has had an impact in shaping the thesis. They are:

(1) Myanmar's political history has kept it away from mainstream global research agendas for decades. It was in this context, and the fact that studies from an inter-disciplinary perspective are few, that this study was conceived to explore the climate-rainfall variation-deforestation links. The initial excitement of undertaking research on a fairly new area became difficult to sustain as detailed secondary data on environmental variables was not easy to collect.
(2) The second major constraint was the fact that fieldwork was done by the scholar before leaving Myanmar to register for her doctorate degree in India. Hence, this primary data was collected in 1998 and could not be improved upon and updated, as it was not possible for the researcher to go back to Myanmar for more intensive fieldwork.

(3) This meant that the study had to be structured around whatever data was available here in India. While data on rainfall was recent and detailed, the study could not weave in detailed environmental data as required during the formulation of the research outline. This has meant some gaps in data on environmental variables.

(4) Also, there is not much research work on Myanmar available in India and this is reflected in the lack of material for review. This poor documentation limited the background information available for the study.

(5) Keeping these factors in mind, the thesis has attempted to work around these data constraints. In some ways, this study assumes significance in the light of these limitations as it seeks to provide some interdisciplinary insights into a country not much is known about to the outside world.