# Chapter III

## Introduction

This chapter includes the review works and studies which have been already done globally and nationally. These works are directly and indirectly related to the present study. It is very important to investigate the past research work done in order to get insights and understand the study more clearly and also fulfil our thirst for knowledge. Similarly, the thorough review of the earlier work, can help in selecting appropriate methodology and tools and also help in avoiding involuntary duplication of the same kind of work.

Various studies have been taken by numerous researchers in the field of long term impact of climate change on agriculture, food security, livelihood, water availability, soil condition etc. The study shows that the long term climate change has already started threatening the world, so there is an urgent need to bring awareness about climate change mitigation and adaptation techniques to cope up with the climate change situation.  Here we have made an attempt to review some study, collected from various journal, books, thesis, dissertations, encyclopaedia and various websites. It has been found from the review that the impacts of climate change on agriculture, food security, livelihood etc are conducted by the scholars at both national and international level.

### 3.1: The Studies Conducted in National and International Levels

A study on global climate change and its impact on agriculture by Adams et al (2001) found that agriculture can be affected by future climate change and current or relatively near-term efforts to mitigate climate change is necessary. In terms of projected long term climate change, the global agricultural production system appears to be able to continue high productivity without global threats to food security although substantial regional disturbances can also occur. In terms of climate change mitigation, there is vulnerability in terms of agricultural production with mitigation efforts competing with traditional agricultural food production. Climate change mitigation effects may largely benefit producers at the expense of consumers and help support agricultural producers income.

Aberra (2011) highlighted that rainfall variability had significant negative impact on the crop agriculture in Ethiopia. The result showed that when the annual rainfall diverged from its mean (upward and downward), the production level of all the agricultural crops diminished significantly.

Ainsworth et al (2010) focused some present overwhelming evidences that ‘business as usual’ crop development will be insufficient to adapt crops over the wide range of growing regions that will be required to meet expanding global agricultural demand. Where moving crops pole-ward would seems an inevitable element of the multifaceted adaptation to increasing global temperatures that must be implemented, but it would be misleading to believe that this alone can maintain yields. For example, migration of the North American Corn Belt into Canada vacates the high-quality prairie soils for the less productive soils farther north and in many important agricultural areas of the world, pole-ward migration is not possible, such as the Wheat Belt of Australia, where an ocean lies to the south (Long and Ort, 2010). On the other way adapting crops in the highest priority regions will require broad investment in the field of integration of new technologies with conventional selection-based breeding, the coordinated involvement of public and private sectors of the agricultural enterprise. Specifically current and future increases in temperature signify the most important and most urgent challenge for the adaptation of crops to overcome the crucial problem of global food scarcity.

Antle et al (2010) presents an intensely reviewed paper where they revealed that there is a urgent need for the kinds of information that can support both private and public decisions about adaptation investments in the context of agriculture and food systems to climate change. Private decision makers need information that can reduce uncertainty about climate change. Public decision makers need information that can show the economic and other public benefits of investments that reduce uncertainty about climate change and adaptation options to the farmers. These public investments will have to compete for scarce public resources and will have to be justified in terms of economic, environmental and social net benefits for the farmers which they produce, taking into account likely tradeoffs among the various relevant outcomes.

Bharwani et al (2005) revealed from the study that the relentless pressures of increasing populations on land and water use are major factors in determining future scenarios for food security and are likely to be the key factors in risks of famine. There is a gradual decline in 'carry over' food stocks with implications for food security (Haile, 2005). Understanding and assessing the vulnerability of populations requiring engagement across a wide range of disciplines with the recognition that risk is multi-dimensional. Rapidly changing socio-economic factors can lead to increased sensitivity to climate shocks; for example, the high incidence of HIVs and increasing levels of poverty in Africa increases the exposure of the population and its inability to cope with climatic stress. Simulation methods that integrate climate and human behavior provide a novel approach to understanding adaptations options for climate variability and change.

Brklacich (1992) has indicated that, in the context of agriculture in Ontario, changes in long-term climatic variability, or simply shifts in extreme because of changes in averages, may well have a greater impact on socio-economic activity than anticipated changes in the climatic averages themselves. At the farm level, future climate is characterized by longer warmer growing seasons and increase in seasonal precipitation suggests greater fluctuations in annual farm profits. The farm community in Ontario already experiences considerable economic stress given 'abnormally' wet or dry years, and its capacity to manage this potential increase in risk is questionable. An altered climate certainly implies new opportunities for crop production in northern Ontario, but it is doubtful that this enhanced potential could offset possible decline in southwestern Ontario. An altered thermal regime coupled with relatively low precipitation levels would imply a less favorable environment for agriculture in southern Ontario. In northern Ontario, the benefits of a longer warmer growing season would be impaired during relatively dry years. It is anticipated that changes in climatic averages would have only a modest impact on Ontario's food production potential, but a changed thermal regime coupled with relatively low precipitation levels may well threaten the security of the province's food supply.

CGIAR (2009) report revealed that climate change promises serious negative impacts on agricultural systems. These same systems and the natural resources that support them are already under severe strain from over-exploitation due to current climate and multiple other stresses. Many of the world’s most poor and indigenous people depend directly on these systems for their food and livelihoods and many countries’ economies are also highly dependent on them. Besides, agriculture is also adding to the climate change problem.

Chattopadhyay (2005) highlighted that the IPCC had already forecasted in the early nineties that in the coming decade agriculture worldwide will have to face negative aspects due to climate change situation. It is anticipated that the effects on crop yields in mid and high latitude regions would be less adverse than such effects in low latitude regions. Decrease of potential yields in warmer areas is likely to be caused by such effects as shortening of the crop growing period, decrease in water availability due to higher rates of evapotranspiration, and poor vernalization of temperate cereal crops. India, with 15% of the world's total population, has kept great economic dependence on agriculture despite considerable progress in industrialization in the recent decades. The impact of climate change on agriculture and water resources is of great concern to national scientists as well as to policy makers. Rice and wheat have a major share in total food grain production in India. Any change in rice and wheat yields, positive or negative, may have a significant impact on food security of the country. Productivity of these crops in the coming decades will depend on changes of sensitive weather parameters such as temperature, rainfall and solar radiation. On the basis of various General Circulation Models, in an Indian Country Report of 1994, IPCC predicted changes in southern Asia (5-30 0N;70-1050E).

The consequences of climate change for US agriculture will be influenced by changes in climate variability and extreme events. A spatial analogue study by Chen et al (2000) showed that the projected climate change was likely to increase yield variability. One major source of weather variability is the El Niño Southern Oscillation (ENSO) whose effects varied widely across the country. Although better prediction of these events allowed farmers to plan ahead, altering their choices regarding which crops to plant and when to plant or cropping pattern changes by the farmers. The value of improved forecasts of ENSO events has been estimated at approximately $500 million per year. As climate warms, ENSO is likely to be affected. As Timmermann et al, (1999) focused that models project of El Niño events and their impacts on US weather are likely to be more intense. There are also chances that La Niña events and their impacts will be stronger. Chen et al (2001) took the study and established that changes in such events can impose significant costs on the agricultural sector.

Decker (1974) tried to examine that the grains production in relatively small areas of the world provides the abundant necessity for the world market supply and demand of food for trade to deficient regions. The central and great plain areas of the U.S. are one of these "granaries." Generally, the July and August rainfall determines whether the harvest in these regions will be bountiful. Rice production without irrigation depends on the surplus of water sufficient to inundate the paddy for more than three months. In the subtropical border of the equatorial region, the strength of the monsoon determines the success of production for an individual year. A great deal is being said about the impact of worldwide climate change on food production. It is generally agreed that the earth has cooled since 1940 and that associated with this change has been a reduction in the amount and dependability of the rain from the monsoon climates of the world. Some climatologists also believe that increased variability in the year-to-year weather of the mid-latitudes has occurred. Although there is some uncertainty about the effect of temperature decline on food production in the mid-latitudes, there is general agreement that a real crisis surrounds the expectations for reduction in rain in the monsoon climates of the sub-tropics.

Exenberger et al (2011) used empirical production function on their study, where the result of the analysis shows that climate change influenced agricultural production in Sub-Saharan Africa in an unfavourable way. When considering traditional and modern inputs like labour, land and livestock, as well as capital and fertilizers respectively in a fixed-effects model, particularly the effects of rainfall were significantly positive and important. This is also in line with expectations that the effects of temperature, which is significantly negative in some specifications which will be less relevant and lower. Further, by separating countries into a low and a med-tech group with respect to modern inputs, different relationships between the standard factors could be revealed and by refining the specifications with respect to regional, climatic differences some complexities in these general patterns could be drawn. Especially these extensions already shows that a more differentiated picture has to be drawn to come up with more detailed conclusions, notwithstanding data availability restrictions on the sub national level. Overall, these findings are not encouraging given the actual trends in rainfall and temperature in Sub-Sahara Africa, both having a negative impact on agricultural production.

Feng et al (2010) critically examined the link between climate-driven productivity changes in the agricultural sector and out-migration with regards to Mexico as an example. According to the author the results were conservative in at least two respects-First, projected changes in crop yields were considerably larger than those observed in their data. If crop yield affected emigration in a nonlinear fashion, linear specification would likely underestimate the full impact of climate on crop yields in the future. Secondly, as the author intensively focuses on only crop yields, the estimated result provided a lower bound for the overall impact of climate change on emigration through agriculture, which could also be affected by changes in the total acreage of land cultivated. Even so, the estimated elasticity of emigration with respect to crop yield changes is statistically significant and larger in practical sense. This suggests that crop yield–induced migration will be a significant issue in many areas of the world that are expected to experience a substantial reduction in yields as a result of climate change, including much of Africa, India, Bangladesh, Latin America, and Australia among others. Because climate change may induce out-migration through channels not examined in this study, the overall effect may be larger, particularly if atmospheric greenhouse gas concentration levels continues to increase sharply and countries fail to implement aggressive adaptation measures.

Finger et al (2007) conducted a case study on impact of climate change on Swiss corn production, which showed that simple adaptation measures such as earlier sowing and changes in production intensity are sufficient to generate positive effects of climate change on corn production in Switzerland. They took into account that further adaptation measures such as breeding of new varieties and financial instruments (e.g. weather derivates) were found to be valuable adaptation strategies for Swiss corn production (Torriani et al. (2007), the latter to benefit from climate change. Moreover in this study, increase in need for irrigation in corn farming is indicated and considered as revealing one of the major challenges in Swiss corn production in the future i.e. the sustainable use of water.

Hanif et al (2010) used two econometric approaches to analyse the economic impact of climate change on the agricultural sector of Punjab. These two approaches are hedonic approach and one way panel fixed effect approach. The result of these two analysis revealed that all the climate related variables, except for maximum temperature, have highly significant relationship with land prices. On the one hand climate change is imposing cost, while in the other hand it brings in benefit of increase in land prices during rabi season due to increase in maximum temperatures. Benefits from the analysed result showed that adaptation made by farmers in changing climate leads to increase in long run net revenues. The increase in precipitation in kharif season tends to increase land value. The increase in precipitation in rabi season results in loss from decrease in production. The increase in mean minimum rabi temperature is negatively significant and imposes cost to agricultural sector with increase in temperature in this season. It is for the planners to evolve policies so that benefits are maximised and costs are minimum as a result of climate change.

Huho et al (2012) attempted to focus on the changing rainfall patterns and the subsequent effects on subsistence agriculture in the Lakipia East District of Kenya. The observed data revealed that the subsistence agricultural production in Laikipia East District has been affected by a myriad of factors such as escalating costs of farm inputs, poor market prices and reduced arable lands due to land fragmentations caused by population increase, changes in rainfall patterns are the major contributing factors. Changes in rainfall patterns are evidenced by the declining number of rain days in March and May, increasing rainfall intensity and rainfall variability. Shifts in timings of rainfall onset led to altered planting dates and shortened growing periods with the overall effects on final yields and hence continued food insecurity in the district.

Joshi et al (2011) analyzed the impact of current climate trends on yield of six main food-crops in Nepal. These food crops were divided into two groups based on their growing season, namely- summer and winter season crops. The impact was assessed for each crop based on the growing season of the respective crop. Yield of potato, wheat, paddy, and maize was in the growing trend, but experienced fluctuates over the years, whereas yield of millet and barley, two minor cereal crops, was growing very steadily. In summers, each of the climate variables was in increasing trend, whereas in winters, rainfall and minimum temperature were decreasing. They showed in their paper that the food crops grown in summers were adversely affected by the current trend of climate change. Except for paddy, which has high water demand and thrives on water logging condition, other summer crops were adversely affected by increase in rainfall and maximum temperatures. On the other hand, though rainfall was at declining trend in winter, increase in temperature had positively contributed to the yield growth of both winter crops. With this they recommended that any program dealing with minimizing adverse impact of climate change on food crops production should first consider the crops like maize and potato, which are being affected at higher degrees than compared to other food crops. Moreover, these two crops are important staple food in Nepal, especially in mountains and hills that are also exposed to higher degree of vulnerability to climate change. The main shortcoming of this study was treating the whole country as one basket despite the huge diversity existing within. Therefore, it is highly recommended to conduct similar studies considering the variation caused by ecological and administrative division of the country.

Karthick et al (2013) had used Cobb-Douglas production function to interpret the result of the analysis. The results from the study suggests that field level research should be done to identify the strategies as well as come up with measures to overcome the problems of climate change impact on agriculture. The strategies for increasing adaptive capacity of crops may include change in planting dates to bridge the yield gaps, evolving adverse climate tolerant genotypes. Farmers may be assisted by providing weather linked value-added advisory services and weather based crop insurance. Other measures are improved land and water use management, popularization of resource conservation technologies. i.e. zero/reduce tillage to save input and enhance output, increased public investment to tackle issues relating to changes in weather parameter and price polices. The mitigation of climate change can include utilization of opportunities offered by conservation agriculture, use of bio-fuels, development of watersheds in rainfed areas and nutrient management. Stakeholders of agriculture are to be proactive to avoid the problem of climate change and thereby food security.

Khanal (2009) examined that although there were very little information available related to organic agriculture and its associations with climate change mitigation and adaptation in Nepal, this review of international literature revealed that organic agriculture could support both GHGs emissions reduction as well as the development of resilient farming systems for adaptation. It is imperative to bring this issue to the forefront of discussions by government and non- government sectors to assess the potential contribution of organic agriculture in the climate change mitigation and adaptation process.

Kotschi (2007) revealed from the study that by 2080, the 40 poorest countries, located predominantly in tropical Africa and Latin America, could lose 10 to 20 percent of their basic grain growing capacity due to drought. Where according to Morton (2007) the biggest problem for food security will be because of the predicted increase in extreme weather, which will damage crops at particular developmental stages and make the timings of farming more difficult, reducing farmers' incentives to cultivate .

Kumar (2000) used two methodological approaches i.e. crop-modelling approach and net-revenue approach on climate change impact on Indian agriculture the author come to the conclusion that adaptation by farmers as well as the economic agents would lead to lesser impact on Indian agriculture due to climate change. The adaptations are significant in bringing down the climate change impact on agriculture.

Liverman (1990) conducted a study on climate, agriculture, technology and land tenure in Maxico revealed that drought was a serious problem for some Mexican farmers in 1969. The census reports areal drought losses in excess of 20 percent in several areas of Sonora for both the winter and summer harvests also widespread and severe losses of more than 25 percent of the area planted in much of the state of Puebla. Meteorological drought, measured in terms of precipitation deficits, was also recorded at many stations in the two states having very few recordings above average rainfall in either of the two crop seasons. The summer of 1969 was particularly dry in Puebla with many stations recorded less than 70 percent of normal rainfall. These data, especially in Puebla, supports the comments of Florescano (1980) and Duran (1972) concerning the severity of drought in Mexico in 1969. A more extensive time series study of meteorological data reported drought impacts throughout Mexico could place the work of the author and the results of the present study, in a broader geographical and historical context.

Lobell et al (2007) defined an effective global growing season for each crop based on the contiguous months for the major growing regions in order to show the results in this paper. The results depicted that changes in the global production of major crops are important drivers for food prices, food security and land use decision makings. Average global yields for these commodities are determined by the performance of crops in millions of fields distributed across a range of management, soil and climate regimes in the globe. Despite the complexities of global food supply, the author shows that simple measures of growing seasons, temperatures and precipitation i.e. spatial averages based on the locations of each crop which explain ~30% or more of year-to-year variations in global average yields for the world's six most widely grown crops. For wheat, maize and barley, there are clear negative responses of global yields to increased temperatures. Based on these sensitivities and observed climate trends, the author estimates that warming since 1981 has resulted in annual combined losses of these three crops representing roughly 40 Mt or $5 billion per year, as of 2002. While these impacts are small relative to the technological yield gains over the same period, the results demonstrate already occurring negative impacts of climate trends on crop yields at the global scale.

Lobell et al (2012) found that growth rates in aggregate crop productivity by 2050 will continue to be mainly driven by technological and agronomic improvements, just as it had for the past century. Even in the most pessimistic scenarios, it is unlikely that climate change would result in a net decline in global yields. Instead, the relevant question at the global scale is how much of a headwind climate change could present in the perpetual race to keep productivity growing as fast as demand. Overall, the net effects of climate change and CO2 on global average supply of calories is likely to be fairly close to zero over the next few decades, but it could be as large as 20 percent to 30 percent of overall yield trends. Of course, this global picture hides many changes at smaller scales that could be of great relevance to food security, even if global production is maintained (Easterling et al., 2007).

Makki et al (2012) made an attempt to evaluate the impact of climate change on productivity and technical efficiency in paddy farms of tidal swamp lands. The analysis of this paper showed that the climate change impact on productivity was not encouraging, the impact was negative. Technical efficiency analysis uses frontier production functions. The analyses revealed that the farmers in tidal swamp lands have good efficiency with an average of 78 percent. The farmers cultivated local paddy varieties in tidal swamp lands. The productivity was positively and significantly affected by land use, fertilizer, labor and climate in this study. The number of seeds had no significant effect on the productivity. Production factors had significant influence on the farmers technical efficiency. Age and farm business experience had no real effect on the productivity.

Maria et al (2010) came to the conclusion that if there are enough climatic variations across the sample and suitable control variables are introduced in the model, cross-sectional analysis can reveal the influence of climate on a small territorial scale. Unfortunately, they treated all the control variables in the models as exogenous, even if some of them (crops protection and irrigation) were adaptation strategies directly related to different extent, with climate change. Therefore they planned to make full use of the panel nature of their data set and to investigate the spatial effects, which were attracting increasing interests in the most recent Ricardian approach applications.

Nagothu et al (2012) used Stochastic Frontier Function and Cobb Douglas function to study the technical and economic efficiencies of this paper. The analysed result revealed that the east coast of India and especially Andhra Pradesh (AP) state is highly vulnerable to extreme weather events, including cyclones, floods, in addition to changes in temperature, sea-level rise and monsoon patterns. The shrimp farming sector and small scale farms that dominate the sector in AP are vulnerable to the climate changes. Measures need to be taken to reduce the vulnerability and improve adaptive capacity of the small scale farmers.

Ortiz et al (2009) reviewed numbers of literature on the impact assessment models currently used in the climate change debates. From the reviewed literature they select some relevant models and tried to highlight their important features and identify ways to treat climate change damages. A common feature of the treatment of climate change damages within the existing models seems to be of significant degree of subjectivity involved in the choice of parameters, functional forms and the potential damages in case of temperature changes above the current predicted (low) levels. This is in part due to the small number of studies available from which the author can estimate climate change damages. It forces upcoming researchers to extrapolate from a small set of figures, damages for higher temperature changes and for regions of the world other than those where the original studies were undertaken. Thus, uncertainty surrounding damage functions is inevitably high.

Parry (2007) revealed from the study that climate change might lead to increase in yield potential at mid and high-mid-latitudes, and decrease in the tropics and subtropics, but there were many exceptions, particularly where increase in monsoon intensity or more northward penetration of monsoons lead to increase in available moisture. He also pointed out in his study that risk of hunger appears to increase generally as a result of climate change, particularly in southern Asia and Africa. However, this geographic distribution in some areas is more the result of projected increase in number of poor people in these regions (i.e. the exposed population) than of the regional patterns of climate change. In particular, he is unclear about the potentially beneficial effects of elevated $CO_2$ on crop growth. The study estimates were based on field experiments that assumed near-optimal applications of fertiliser, pesticide and water, and the possibility that the actual 'fertilising' effect of higher levels of $CO_2$ is less than the expected. Moreover, the author had not taken into account the effects of altered climate on pests and weeds, which are likely to vary greatly from one environment to another.

Pearson (2008) conducted a study on biophysical productivity and its sensitivity to changes in climate. The result shows that there have been some initial attempts to integrate biophysical and economic models to predict the economic impacts of climate change on farm incomes and regional economies. Most of this model-based research focused on broad acre agriculture, and few covered other industries across Australia. Most models are 'run' for specific climate variability scenarios, meaning there's little comparable analysis between models and modelling outputs. Outcome vulnerability is the implicit framework used for this research work. The agricultural sector involves a dynamic interaction between ecological, industrial and social processes. It is subject to multiple interacting drivers, including climate change, market forces and threats to the natural resource base. Consequently, the ultimate focus of vulnerability research needs to be on the socio-economic outcomes of these dynamic interactions, including conservation, production and livelihood options. These have not previously been considered in particular regions and industries.

Porter et al. (2005) empirically examined the simulation and experimental results where the altering of the variability of temperature had the same order effect on the development and growth of wheat as changing its mean value. These results support the conclusions of Semenov et al. (1995), who highlighted the importance of representing changes in both the mean and variability of climatic conditions in order to predict the impact of climatic change on crop development and yield. According to Long et al (2005) there need to be further studies, perhaps under free air CO2 exchange systems to link simulation and experimental investigations. The author pointed out two other important facts for the future investigation, particularly in the context of climate change studies. Firstly climate scientists should recognize the large body of information often published in non-traditional references such as plant breeding trial reports and that may be useful in defining what can be considered as 'dangerous' amount of climate change from the point of view of food production. Secondly, there is a need to develop joint modelling, especially the experimental studies for this topic to examine the predicted degree of temporal overlap between extreme events such as high temperatures, storms and sensitive times in the agricultural calendar. Crop modelling can predict the timings of crop stages when they are sensitive to threshold temperatures and experimental studies can provide the quantitative responses that would permit the modelling efforts to progress. In this endeavour, plant scientists could be guided by their zoological colleagues who have very carefully characterized the temperature limits in the range of physiological processes as suggested by Meats et al (1976) and quoted by Cossins et al (1987). There is a need for equivalent information for the major food crops.

According to Ronald (2011) in the recent times the United States and the world has started facing serious challenges in the areas of food, environment, energy and health. Historically, advances in plant genetics have provided new knowledge and technologies needed to address these challenges. Plant genetics remain a key component of global food security, peace and prosperity for the future. Millions of lives depend upon the extent to which crop genetic improvement can keep pace with the growing global population, changing climate and shrinking environmental resources. Fourteen years of extensive field studies by Carpenter (2010) demonstrated that genetically engineered crops are tools, when integrated with optimal management practices, help make food production more sustainable. The vast benefits accrued to farmers, the environment and consumers explain the widespread popularity of the technology in many regions of the world. The path toward a future sustainable agriculture lies in harnessing the best of all agricultural technologies, including the use of genetically engineered seed, within the framework of ecological farming.

According to Rosegrant et al (2008), climate change is also likely to have a significant negative impact on agricultural production, prompting output reductions that will greatly effect parts of the developing world. Adaptation, including crop choice and timing, has the ability to partially compensate for production declines in all regions. While a number of models have predicted this development, there is still a range of specific regional effects to be considered. Furthermore, insufficient attention has been given to multiple stressors, like extreme weather events, pests and diseases. In addition, till date, only a limited number of studies have focused on the climate change and carbon fertilization effects related to crops of importance to the rural poor people, such as root crops and millet. As a result of changes in production, food security will be affected by climate change. Indeed, climate change alone is expected to increase the number of food insecurities by an additional 5 to 170 million people by 2080, especially in Africa. Nevertheless, socio-economic policy, especially trade liberalization, can compensate for some of the negative impacts.

Schlenker (2009) revealed that the United States produces 41 percent of the world's corn and 38% of the world's soybeans. These crops comprise two of the four largest sources of caloric energy produced and are thus critical for world food supply. In this study, the author paired a panel of county-level yields for these two crops, plus cotton (a warmer weather crop), with a new fine-scale weather dataset that incorporates the whole distribution of temperatures within each day and across all days in the growing season. They find that yields increased with temperature up to 29° C for corn, 30° C for soybeans and 32° C for cotton but it was also revealed that the temperatures above these thresholds would be very harmful. The slope of the decline above the optimum is significantly steeper than the incline below it. The same nonlinear and asymmetric relationship was found when they isolated either time-series or cross-sectional variations in temperatures and yields.

Seo et al (2005) described a Ricardian analysis of agriculture in Sri Lanka. The study was able to measure both temperature and precipitation effects. In general, warming is expected to be harmful to Sri Lanka but increase in rainfall will be beneficial. Applying the estimated regression results to five climate scenarios of Sri Lanka, they estimated the range of effects from loss of 20 per cent to gain of 72 per cent. The scenarios with losses had overall harmful temperature impacts, with offsetting precipitation benefits. The scenarios with gains also had harmful temperature effects, which were dominated by beneficial changes in rainfall. Also in the beneficial scenarios, there was large increase in precipitation during beneficial months and decrease of precipitation in harmful months (November).

Sinha (2006) investigated that an increase of $2^{o}C$ temperature could decrease the rice yield by about 0.75 ton per hectares in the high yield areas, and $0.5^{o}C$ increase in winter temperature would result to reduce wheat production by 0.45 tons per hectares.

Soussana (2010) revealed from the review paper that there is no single approach to the complex task of modelling the impacts of climate change on agriculture and food security. In climate sciences, with the development of computer capacities, simpler models have not disappeared. On the contrary, a stronger emphasis is being given to the concept of ‘hierarchy of models’ as the only way to provide linkage between theoretical understanding and the complexity of realistic models (Held, 2005). In the same way, a hierarchy of models ranging from simple ‘theoretical’ models to complex models is useful for crop and pasture modelling, which will have a continuing central, heuristic role to support scientific investigation of climate change impacts on agriculture and to facilitate adaptive decision making by farmers and land managers.

Tesso et al (2012) conducted a research, which was basically devoted to the investigation of the impact of adaptation to Climate Change on food production levels in North Shewa farm households. The statistical and econometric result of the analysis showed that adaptation to climate change played significant role in boosting food production levels in the region. This result underlined the need to provide appropriate and timely information on future climate change to the farmers so as to prepare them for taking appropriate averting actions for future climate change impact on food production. The fact that the adaptation variable is positive and significant in the estimates of production function, it indicated that adoption of yield related adaptation strategies had critical importance in terms of ensuring food security for rural households. Averting the adverse effects of climate change and achieving food security are the two top development agendas of policymakers and development agencies in present days. Therefore, future research should focus on location specific adaptation measures that need to be adopted by households for sustainable food security.

Verdin et al. (2005) examined that the food security monitoring in sub-Saharan Africa provides the early warning needed to save lives and livelihoods in the face of a wide range of potential socio-economic and environmental shocks. Climate monitoring and forecasting are especially important given the large number of rural people dependent on subsistence agriculture on pasteurise. Because conventional climate station networks are sparse, remote sensing and modelling methods developed to support food security assessment. The global climate forecast to change significantly as a consequence of increasing concentrations of green house gases in the atmosphere, and scenarios for Africa are consistently negative. Increased probability of crop and livestock losses implies increased food insecurity for vulnerable pastoralists and subsistence farmers. Changes in agricultural practices and improved natural resources management techniques will be needed to adapt to new conditions. However, adaptation strategies cannot be developed and implemented until trends and shifts in climate have been identified. The case of Ethiopia is instructive. The country confronts a food security emergency, where 8-10 million people cannot meet the annual food needs without external assistance. A wide range of reforms and restructuring are urgently required. In agriculture, there is a need to strengthen the research and extension work in the introduction of high-yielding short-cycle crops, to compensate for consistently poor irregular rains. The apparent shift in rainfall patterns since 1996 coincides with a steady warming trend in SSTs that is affecting countries all around the Indian Ocean. However, people now are becoming aware of this shift in climate, not because Ethiopia lacks qualified scientists (though more could certainly be used) but because they lack access to modern methods of data capture, data management, telecommunications, modelling and analysis. The developed countries must act now to transfer advanced climate related science and technology to African counterparts, for it is in the hands of those with local knowledge that creative adaptation strategies will be forthcoming.

Vien (2011) conducted a study on climate change and its impact on agriculture in Vietnam which shows that climate change had a clear impact on all sector in Vietnam including economic, social and human health. Increasingly erratic and variation in rainfall, higher temperature, more extreme weather events like typhoons, drought and heavy rainfall causes floods. On the other hand rising sea level also will have a significant impact across the globe in terms of sectors, regions, different income groups and particularly on the livelihood of the poorest masses which are intensively dependent on the nature for their livelihood.

Warrick (1988) examined that global agricultural models combine countries or regions to simulate food production and trade at the world scale. Given the global nature of the green house effects, as well as the interconnected global network of food trade, this sort of model is ultimately the most appropriate for examining the agricultural impacts of climatic change, at least conceptually. There are probably about ten major global models in existence. Unfortunately, none has incorporated a climatic component. However, in many such models the crop yield or production component can be manipulated exogenously as a surrogate for climatic change or variability. The potential impacts on agriculture from the 'greenhouse effect' arise from the direct effects of enhanced ambient C02 concentrations on plants, and from the effects of changes in climate. With respect to the direct effects, evidence from controlled experiments suggests that-1) Higher C02 will have a positive effect on growth and yield of major food crops. 2) For a C02 doubling to 680 ppm, yield increases of 10 to 50 per cent for C3 plants (e.g. wheat) and 0 to 10 per cent for C4 plants (e.g. maize) may be possible. 3) Globally, the potential benefits may be unevenly distributed because of differences in where C3 and C4 plants are grown. 4) Positive growth and yield response occurs under most environmentally stressful, as well as under optimal conditions. Studies of the agricultural effects of climatic changes are fewer, and vary considerably with respect to methodological approach, focus and scale. Crop impact analyses using crop-climate models suggest that, 5) For the core areas of mid-latitude cereal regions of North America and Europe, an increase in average temperature would decrease yields. A $2^0$C increase may decrease yields in those areas by 3 to 17 per cent. Increases in precipitation would offset the losses, while decreases in precipitation would accentuate them.

Weber (2003) conducted a study on climate change impacts on Canadian agriculture, the author mainly focused on yield impacts for particular crops, the full range of potential adaptations has not been considered, overestimating the costs associated with climate change. The author addresses this gap by developing a cross-sectional econometric model of agricultural land values for Canada. Optimal adjustments to climate variation are assumed to be capitalized in agricultural land values. Estimates of the impact of climate on agricultural land values are used to project changes in productivity due to climate change. The results of the analysis in this paper suggested that previous studies have been overly pessimistic in estimating the costs of climate change. The author states that while all regions benefit from climate change, the relative gain is greatest for the prairies and lowest for coastal regions. In absolute terms, Ontario experiences the largest gain. The regional ranking of agricultural land values does not change.

In spite of the limitations of the Ricardian approach he believed that the results illustrate the potential direction of change in agricultural land values. Future research if utilizes this approach should aim at extending the method in order to identify physical constraints leading to adaptation, such as climate threshold effects, soil profiles and soil moisture deficits that are not fully captured in the model presented in this paper. Finally, if any of these gains are to be realized, governments will have to dismantle policies that may inhibit the adjustment process. Such policies include provincial crop insurance programs that cover only selected crops based on current cropping patterns or other agricultural support policies that target particular activities.

Welch et al (2010) specified that the data from farmer-managed fields have not been used previously to disentangle the impacts of daily minimum and maximum temperatures and solar radiation on rice yields in tropical/subtropical Asia but the author used a multiple regression model to analyze these data from 227 intensively managed irrigated rice farms in six important rice producing countries. The farm-level details, observed over multiple growing seasons, enabled them to construct farm-specific weather variables, controled for unobserved factors that either were unique to each farm but did not vary over time or were common to all farms at a given site but varied by season and year, and obtain more precise estimates by including farm and site-specific economic variables. Temperature and radiation had statistically significant impacts during both the vegetative and ripening phases of the rice plant. Higher minimum temperature reduced yield, whereas higher maximum temperature raised it; radiation impact varied by growth phase. When combined, these effects implied that yield at most sites would have grown more rapidly during the high-yielding season but less rapidly during the low-yielding season if observed temperature and radiation trends at the end of the 20th century had not occurred, with temperature trends being more influential. Looking ahead, they imply a net negative impact on yield from moderate warming in coming decades. Beyond that, the impact would likely become more negative, because prior research indicates that the impact of maximum temperature becomes negative at higher levels. Diurnal temperature variation must be considered when investigating the impacts of climate change on irrigated rice in Asia

Ziska et al (2013) examined that the agricultural production is under increasing pressure by global anthropogenic changes, including rising population, diversion of cereals to bio-fuels, increased protein demands and climatic extremes. Because of the immediate and dynamic nature of these changes, adaptation measures are urgently needed to ensure both the stability and continued increase of the global food supply. Although potential adaption options often consider regional or sectoral variations of existing risk management (e.g. earlier planting dates, choice of crop), there may be a global-centric strategy for increasing productivity. Inspite of the recognition that atmospheric carbon dioxide (CO2) is an essential plant resource that has increased globally by approximately 25 per cent since 1959, efforts to increase the biological conversion of atmospheric CO2 to stimulate seed yield through crop selection is not generally recognized as an effective adaptation measure. In this review, the authors challenged that viewpoint through an assessment of existing studies on CO2 and intraspecific variability to illustrate the potential biological basis for differential plant response among crop lines and demonstrate that while technical hurdles remain, active selection and breeding for CO2 responsiveness among cereal varieties may provide to be one of the simplest and direct strategies for increasing global yields and maintaining food security with anthropogenic changes.

According to INCCA report 2010, in the northeast region of India, the number of rainy days is likely to decrease by 1-10 days. The intensity of rainfall in the region is likely to increase by 1-6mm per day. In terms of the agriculture, according to INCCA report due to the climate change in the region irrigated rice yields may range between about 10 percent to 5 percent with respect to 1970's, while the impact on rain-fed rice is likely to be in the range of 35 percent to 5 percent in A1B 2030 climate scenarios.

According to Kingwell (2006) study on the climate change in rural regions of Australia, it was found that in the next couple of decades, it is more likely to produce a diverse set of spatial impacts. Many traditional agricultural regions are likely to face more challenging environmental hazards for crop, pasture and animal production. In larger farming situations the prospects are for warmer and drier conditions and an increased likelihood of more extreme events such as drought, fire, excessive summer heat and severe storms. In some regions the alteration in climate poses significant business challenges, with strong downward pressure being exerted on farm incomes. The unfolding nature of climate change does mean that farmer's reliance on regionally-relevant, climate-related, anticipatory R&D will increase. In many regions farmers will need access to knowledge and innovation that assists them to ameliorate the adverse impacts of climate change. Climate change will complicate farmers and other investor's decisions regarding large and long lived investments whose returns are climate dependent. Some investments in agro-forestry, salinity prevention, viticulture, tree crop plantation establishment, irrigation infrastructure, road and rail capital works and biodiversity preservation are likely to become problematic in the face of climate change. Assessing the vulnerability of these investments to adverse or favourable impacts of climate change will be both a scientific and economic challenge.

According to R. M. Adams et al (1998), Lewandrowski and Schimmelfennig (1999) and Reilly et al (2000), in the next century, regional increase and decrease regarding global food production and its association with climate change as now foreseen is not expected to result in large changes or any large global economic disaster in total food productions. This likely occurs because the projected range of climatic alterations is less than the range of temperatures now experienced across productive areas of global agriculture as elaborated by Adams et al. (1998), Lewandrowski et al. (1999) and Reilly et al (2000).

Hodges et al. (2006) examined that agriculture sector is one of the most climate-sensitive sectors of the Australian economy. The combined and interacting influences of climate variability and change directly affects Australian agriculture through rainfall and temperature conditions on plant and animal production, and indirectly through changes in soils, water, pests, diseases and biodiversity interactions. Climate variability and changes are two inextricably linked drivers of climate risk that also contributes to economic risk in agriculture through the variability of commodity prices and input costs that determine Australia's comparative advantage in export markets.

As per the study taken by Adams and Hurt et al. (1998), effects of global climate change in agriculture, they came to the conclusion that within the US and the rest of America, there will be losers and winners in terms of agricultural production as a result of global climate change. Climate change may also affect the welfare of economic groups differently (e.g. consumers vs producers). However, the consensus of economic assessments is that, climate change at current magnitudes is being discussed by IPCC and other organizations which will have only a small (likely positive) effect on US agriculture.

Aydinalp et al (2008) conducted a study on the effects of global climate change on agriculture in UK and suggested that, there will be both losers and winners. Some areas are benefitting due to increase in agricultural production resulted by climate change while other areas suffering due to decreases in the agricultural production in the world. Climate change could also affect the welfare of the economic groups differently.

Barrios et al (2003) tried to investigate the extent of using cross-country data on rainfall and temperature as well as agricultural output and inputs. The result of the study suggested that climatic changes have had important effects on total agricultural output on the Sub-Saharan African continent, but not in other developing countries. From the policy perspective, given the conflicting evidence as to whether the general decline in rainfall will continue in Africa as revealed by Nicholson (1994) Hulme et al (2001) and IPCC (2001) it seemed important that policy makers take specific steps that will likely lower African agricultural sector's sensitivity to rainfall variations. This could entail the adoption of agricultural techniques that optimises water use through increased and improved irrigation systems and develop crop grazing areas.

Basak (2009) examined the impacts of climate change; food production and food security and the global concerns particularly the threat for Bangladesh. The population of Bangladesh is increasing at a rate of two million every year and the total population will be 233.2 million in the next 40 years, if the current trend continues. Therefore, Bangladesh will require more than 55.0 million ton rice by the year 2050. The study has been conducted on the basis of IPCC fourth assessment report (temperature is projected to rise in a range from 1.8°C to 4.0°C by 2100) and found a considerable yield reduction (1.5 per cent, 2.5 per cent, 4.4 per cent and 5.4 per cent) in the specified years which directly affects the total rice production in Bangladesh (base year 2008). About 13.93 million ton rice production shortage may be encountered by 2050 which accounts for about 50.10 per cent of the total rice production of the year 2006-07. As a result, more than 11.50 per cent (3.43 million ton) rice shortage may occur only for temperature and its effect on Boro rice production during 2050 (38.43 per cent rice shortage may occur for increasing population and 50.10 percent for increasing population and temperature effects in 2050, compared to 2007).
If rice production is not adequate to meet the demands, a major part of our population will be deprived from food and pass a hungry life with their family and face malnutrition problem. Consequently, our next generations are going to face a great challenge for their daily food due to changing climatic condition and the pressure of huge population.

Brown et al (2008) revealed that some of the most profound and direct impacts of climate change over the next few decades will be on agriculture and food systems. All quantitative assessments showed that climate change will adversely effects the food security as illustrated by Schmidhuber et al. (2007). According to Parry et al. (2007), Kotschi (2007), Morton (2007), Brown et al. (2008) and Lobell et al. (2008) increasing temperatures, declining and more unpredictable rainfall, more frequent extreme weather and higher severity of pest and disease are among the most drastic changes that would impact food production. However, Diaz et al. (2006) examined that global trends also marks tremendous regional differences, with the poorest being the most at risk both by global climate variations and global commodity price fluctuations. Some of the most important effects of global climate change will be felt among small holder farmers, predominantly in developing countries as examined by Morton (2007).

Christopher et al (2008) examined the impacts of recent climate change on wisconsin corn and soybean yield trends, where they found that crop productivity along the northern parameter of the corn belt could be adversely effected by continued temperature rise during the summer growing seasons, and the response could be even greater than anticipated if heat and drought combined together. One hypothesis presented by them in their study was that the farmers may not be switching cultivars as quickly as needed to adapt to recent regional climate changes. It appeared that a significant amount of spatial variability in climate trends at the county level across Wisconsin had contributed to variable trends of soybean and corn yields. Some regions with the highest yield gains over the past 30 years had experienced a trend towards cooler and wetter conditions during the summer seasons, while other areas that had experienced a trend towards drier and warmer conditions had experienced suppressed yield gains. These widely varying climate trends made it more difficult for farmers to adapt to long-term local climate change.

Reilly et al. (1994) and Darwin et al. (1995) investigated that climate change is likely to shift the comparative advantage of agricultural production in some regions. Such shifts are likely to alter the places in which specific crops are grown, both within a country as well as internationally which alters the patterns of trade in agricultural commodities among the regions as well as in countries.

Extensive uses of pesticides in US agricultural fields are major problem and climate change might increase the problem more. A spatial analogue study by Chen and McCarl (2001) found that pesticides use would be expected to increase for most crops in most states under the climate change scenarios as studied recently by U.S. National Assessment. This assessment approach did not consider increased crop losses due to pests, they implicitly assumed that all additionallosses were eliminated through increased pest control measures. In the earlier studies McCarl (1999) revealed that increase in pesticide use would result in reduced overall national economic welfare. In addition, there could be substantial environmental consequences due to increase in pesticides use.

Extensive uses of pests in agricultural field are presently a major problem in US agriculture and climate change may increase the problem. A spatial analogue study by Chen and McCarl (2001) found that pesticide uses are expected to increase for most crops in most states under the climate change scenarios as per the recent U.S. National Assessment. This assessment approach did not consider increased crop losses due to pests, implicitly assuming that all additional losses were eliminated through increased pest control measures. In the earlier study McCarl (1999) showed that increase in pesticide uses resulted in reduced overall national economic welfare. In addition, there could be substantial environmental consequences to increased pesticide use.

Holst et al (2010) revealed that China might actually be a net beneficiary of climate change in the short or medium run, though there will certainly be regional winners and losers within the country. Particularly an increase in average annual temperatures at the margin will have a positive impact on mean output and will in addition reduce the level of production risk. The role of an increase in precipitation, which is expected in the future, is somewhat less clear. While it also seems that it will decrease production risk at the margin, its influence on mean output remains ambiguous. The variability of temperature again has a positive effect on mean output but doesn’t seem to affect production risk. Considering all these influences together, they arrived at a conclusion that China should be able to keep up its food production in the near future and drawing on their earlier calculations, it is expected that the country will even be able to have an economic benefit of around $1.1 billion from a 1 °C increase in annual average temperature. However, they expected the positive net gains to be of temporary nature. Since all crops feature certain ranges of climate conditions, in which they can grow optimally, a continued change in these conditions will, with high probability, eventually lead China to a point where the net benefits from climate change will turn negative. However the point in time when this happens is not known, it would be an advisable strategy for China to start investing in region-specific adaption measures as soon as possible.

Increased uncertainties in climatic variability have become a major challenge for sustaining agriculture as well as its allied sectors in the face of already declining natural resource base. Agriculture is the main livelihoods system of most of our people and along with allied sectors like livestock and fisheries, contributes to twenty five per cent of the country's Gross Domestic Product. India's food production is likely to be affected by the climate sensitivity of its agriculture. This in turn will impact on poverty and livelihoods as studied by NCDHR & SPWD (2013).

It has been found that a large number of economic effects of climate change on agricultural studies have been done. According to R. M. Adams et al (1998), Lewandrowski and Schimmelfennig (1999) and Reilly et al (2000b), in the next century, regional increase and decrease is associated with climate change as now foreseen are not expected to result in large changes in global food production or any large global economic disaster in total food productions. This will likely occur because of the projected range of climatic alteration which is less than the range of temperatures now experienced across productive areas of global agriculture.

Juliano et al (2008) investigated the impact of climate change on agricultural productivity and poverty in Brazil. In their paper they structured a model to guide them in the empirical analysis. The model is projected and pretends to be based on IPCC (Inter-governmental Panel on Climate Change) predictions about temperature and rainfall. Results of the investigation suggest that not only is global warming expected to generate significant effects in the country, but also the impact is heterogeneous in the territory. Although the average effect is adverse, there are gainers and looser in the process. It also showed that the climate change adaptation is an important issue. The impact on poverty for the whole country reduced from 3.2 percentage points to 2.0 percentage points if labour mobility was allowed.

Kamugisha (2009) tried to focus mainly on the African developing countries agricultural sector, which has been threatened by the most vulnerable problem in the recent days that is climate change. He argues in his study that agriculture was the most important sector in the economies of most non-oil exporting countries. Climate change, especially indicated by prolonged drought is one of the most serious climatic hazards affecting the agricultural sector in most of the African societies. Therefore climate change is expected to worsen the food supply of the region and also widespread the poverty in the region. Climate change is also likely to be the cause of manifestation of vector and vector born diseases, where an increase in temperature and humidity will create ideal conditions for malaria, sleeping sickness and other infectious diseases that will directly affect the availability of human resources for the agriculture sector. So here the most important concern is better understanding of the potential impacts of the current and projected climate change on agriculture and to identify ways and means to mitigate and adapt its detrimental impact.

Kaul (2007) examined that climate plays an important role in determining agricultural production in India. The effects of climatic inconsistency are quite visible in case of majority farmers who are marginal and small as well as lack the resources required for adjustments in climatic variations. The study covered rice and jowar crops for the country as a whole as well as for the states of Orissa and Karnataka. The study revealed that excessive rains and extreme variation in temperature would affect the productivity of these crops adversely thereby affecting the income of farming families in a negative manner. Thus suitable strategies pertaining to resource use, planting flood and drought resistant varieties of crops, better irrigation networks, and crop mix are to be adopted for mitigating the harmful effects of climatic changes.

Kawasaki et al (2011) revealed from the study that global climate could affect crop yield of rice in the future. The study showed that area, solar radiation and temperature were the most important factors in improving rice production. As solar radiation and temperature increased, rice yield decreased. Therefore, the common adaptation or practices to minimise the harmful impact of climate change found in rice farming were selection of new rice varieties for higher yield and improving the soil fertility. While many farmers also opted for shifted cultivation dates to avoid the drought hazard every year.

Liu (2004) pointed out that global warming might have a positive impact on agricultural production whereas the findings of more recent Ricardian study by Wang et al (2008) shows the opposite. Their results suggest that a 1°C increase in temperature would reduce farm revenues per hectare by US$10. However, not all the findings of both the studies disagree. Besides, both the studies concluded that higher precipitation would increase agricultural production. Furthermore, both studies found high seasonal variations as the effects of climate change.

According to Mendelson et al. (1999) most developing countries depends heavily on agriculture and the effects of global warming on productive crop lands are likely to threaten both the welfare of the population as well as the economic development of those countries. Tropical regions in the developing world are particularly vulnerable to potential damages from environmental changes because the poor soils that cover large areas of these regions already have made much of the land unusable for agriculture.

Reddy (2009), argued critically about climate change impacts on the Indian agricultural sector. The author claims that delay in monsoon coming in the year 2009 was because of the global climate change. The food prices were already high in India that year, and reduced crop yield especially food crops raised prices still higher. As per the author global average temperatures will cause more variability in the monsoon, leading initially to both an increase in precipitation in some areas, as well as a decrease in others, causing a rise in both floods and droughts. The prediction claims that eventually the monsoon will bring less rain, over fewer parts of the country, with the rain concentrated in short but intense bursts. Due to more rainwater runoff, there will be a decrease in groundwater aquifers, leading to widespread water shortages for irrigation and human consumption.

Richard et al (2001) revealed that climate change might affect agriculture in future. In the long run the substantial regional disturbances can effect in food security of a country and the global agriculture system must be able to continue high productivity without global threat in terms of projected long-term climate change.

Sinha et al (2006) showed that an increase of $2^{o}$C temperature could decrease the rice yield by about 0.75 ton per hectares in the high yield areas, and $0.5^{o}$C increase in winter temperature would result in decrease of wheat production by 0.45 tons per hectares.

Sneddon (2009) found in his study that most common wealthy small states, less developed and low-income countries were highly dependent on agriculture which was basically combined with low adaptive-climate capacity, even though they were very low contributors to global carbon dioxide emissions. The writer suggests that there would be critical rethink of approaches to formulate development oriented trade and climate policies, which will not undermine the economic growth of the developing countries. As agriculture provides livelihood for more than half of the world’s poor population, climate change will heavily impact on the three quarters of this population. Therefore to ensure the sustainability in agriculture sector in developing countries, the most vulnerable problem i.e. climate change will have to be considered. It will also be necessary to mitigate and adopt appropriate measures, which are required immediately in order to prevent stalemate or reversal of achieved economic progress. Without taking necessary environmental measures and investment in infrastructure, developing countries are at the most risk to subsequent socio-economic repercussion arising from climate change.

Szwed M et al (2010) used multi-model ensemble climate projections in the ENSEMBLES Project of the EU to evaluate the changing risk of weather extremes in Poland. Increase in temperature and changes in rainfall, water availability during the plant development phases were found to have a strong impact in agriculture of Poland.

Thapa et al (2010) focused on the impact of climate change on agriculture using Ricardian approach. They found some interesting results to understand the impact of climate change non Nepalese agriculture. As there is a variation in the impact of the climate change (i.e. change in precipitation and temperature) on agriculture in different seasons and climatic zones, the policy needs to address these variations while formulating the adaptation and mitigation strategies in order to avoid the negative impacts of climate change in the country.

The consequences of climate change for US agriculture will be influenced by changes in climate variability and other extreme events. A spatial analogue study by Chen et al (2000) shows that the projected climate change is likely to increase yield variability. One major source of weather variability is the El Niño Southern Oscillation (ENSO) which effects vary widely across the country. Although better prediction of these events allows farmers to plan ahead, altering their choices of which crops to plant and when to plant them. The value of improved forecasts of ENSO events has been estimated at approximately $500 million per year. As climate warms, ENSO is likely to be affected. Models project that El Niño events and their impacts on US weather are likely to be more intense which is shown by Timmermann et al. (1999). There is also a chance that La Niña events and their impacts will be stronger. Chen et al (2001) establishes that changes in such events can impose significant costs in the agricultural sector.

The World Bank Report (2013) projects that a scenario of $4^{o}$ C rise in global temperature, would result in increased climate extreme events such as heat waves, sea level rise, more storm surges, droughts and flooding in the South Asian region including India. The coastal and deltaic regions of India are reported to be particularly vulnerable to the risks of flooding including two Indian cities of Mumbai and Kolkata. The Ganges, Indus, and Brahmaputra are also vulnerable to the effects of climate change due to the melting of glaciers and loss of snow cover resulting in significant risk of flooding. The Central Government is implementing the National Action

Plan on Climate Change (NAPCC) with a view to enhance the ecological sustainability of India's development path and address Climate Change. The Government regularly reviews the progress under the National Action Plan on Climate Change (NAPCC), based on the information provided by the concerned nodal Ministry (Lok Sabha Secretariat, 2013).

Walter et al (2003) revealed that in South Eastern nations, South Africa, Asia and Australia under the currently loose network known as RES AGRICOLA, learned about the 'climate proof" farming system. In this paper they included that future research on the interactions of agriculture and climate change variability should be focused on risk management and risk assessment. This paper also showed different types of risk and work to be oriented in order to tackle and understand climate at different spatial and temporal scales and explore ways to reduce it.

**3.2: Research Gap**

From the above review it has been found that there are several studies that have been conducted nationally and internationally regarding impacts of climate change on agriculture, but no specific study has been found on impact of climate change on agriculture sector in Assam. Agriculture plays a very important role in contributing to the Gross State Domestic Product (GSDP) and engages major proportion for employment in state. Climate here plays a very significant role, therefore, there is an urgent need to focus and enhance the understanding of long term climate change impact on agriculture sector in Assam. This study has tried to focus on the long term (1970-2010) climate change regarding temperature and rainfall variations in Assam and its districts as well. Further we have focused on impacts of climate change on major crops in Assam and on rice separately for various districts. This study suggests some policy implication to cope up with long term climate change effects in the state.