

## **CHAPTER-II**

### **REVIEW OF LITERATURE**

The review of literature relating to the present study on "**Climate Change and Crop Diversification in Selected Study Blocks of Coimbatore District**" is discussed under the following heads:

#### **2.1 Historical Background of Agriculture**

#### **2.2 Importance of Climate Change on Water Resources and Agriculture**

#### **2.3 Impact of Climate Change on Agriculture**

#### **2.4 Cropping Pattern and Crop Diversification**

#### **2.5 Role of ICTs in Agriculture and**

#### **2.6 Other Related Studies**

#### **2.1 Historical Background of Agriculture**

Indian agriculture had a history that begins with the Indus valley civilization. One of the eldest water regulating structures in the World was the Grand Anicut dam on river Kaveri (1<sup>st</sup>-2<sup>nd</sup> Century CE). Agriculture in India began with the early cultivation of plants, and domestication of crops and animals, **Stein Burton (1998)**. Land and water management systems were developed to provide uniform growth. Wheat, barley, and jujube were cultivated in the Indian subcontinent by 9000 BCE. Domestication of sheep and goats soon followed the first domestication of the elephant. Barley and wheat cultivation along with the domestication of cattle, primarily sheep and goat was visible in Mehrgarh by 8000- 6000 BCE. By the 5<sup>th</sup> millennium, BCE agricultural communities became widespread in Kashmir, **Baber (1996)**. The Indus cotton industry was well developed and some methods used in cotton spinning and fabrication continued to be practiced till the modern Industrialization of India. A variety of tropical fruit such as mango and muskmelon were native to the Indian subcontinent. The Indians also domesticated hemp, which they used for several applications including making narcotics, fiber, and oil. The farmers of the Indus Valley grew peas, sesame, and dates. Sugarcane was originally from tropical South Asia and Southeast Asia. Rice was cultivated in the Indus Valley Civilization, **Murphy (2007)**. Agricultural activity during the second millennium BC included rice cultivation in the Kashmir and Harappa regions. Mixed farming was the basis of the Indus valley economy.

The summer monsoons might have been longer and might have contained humidity in surplus than required for normal food production. The effect of this extreme moisture would have been to aid the winter monsoon rainfall essential for winter crops. In India, both wheat and barley were held to be Rabi (winter) crops and like other parts of the World would have largely depended on winter monsoons before the irrigation became widespread, **Gupta (2004)**. The growth of the Kharif crops would have probably suffered as a result of excessive moisture.

The Mauryan Empire (322–185 BCE) categorized soils and made meteorological observations for agricultural use. Other Mauryan facilitation included the construction and maintenance of dams and the provision of horse-drawn chariots quicker than traditional bullock carts. Early Common Era High Middle Ages (200–1200 CE). The Tamil people cultivated a wide range of crops such as rice, sugarcane, millets, black pepper, various grains, coconuts, beans, cotton, plantain, tamarind, and sandalwood. Jackfruit, coconut, palm, areca, and plantain trees were also known. Systematic ploughing, manuring, weeding, irrigation, and crop protection were practiced for sustained agriculture. Water storage systems were designed during this period.

Kallanai (1<sup>st</sup>-2<sup>nd</sup> century CE), a dam built on the river Kaveri during this period, was considered one of the oldest water regulation structures in the World. Roman trade with India followed as detailed by the archaeological record and the Periplus of the Erythraean Sea. Chinese sericulture attracted Indian sailors during the early centuries of the Common Era. Crystallized sugar was discovered by the time of the Guptas (320- 445 CE), and the earliest reference of candied sugar come from India. The agrarian society in South India during the Chola Empire (875-1279) revealed that during the Chola rule land was transferred and collective holding of land by a group of people slowly gave way to individual plots of land, each with their irrigation system.

Early Modern Era (1200–1757 CE) the construction of waterworks and aspects of water technology in India was described in Arabic and Persian works. The diffusion of Indian and Persian irrigation technologies rose to an irrigation system that brought about economic growth and the growth of the material culture. Land management was particularly strong during the regime of Akbar the Great (reign: 1556-1605), under whom scholar bureaucrat Tomes formulated and implemented elaborated methods for agricultural management on a rational basis. Colonial British Era (1757–1947 CE) in 1857 a Rampur canal on the river Sutlej was constructed and a number of irrigation canals are located on the Sutlej river, **Roy (2006)**.

Agricultural performance in the interwar period (1918–1939) was dismal. From 1891 to 1946, the annual growth rate of all crop output was 0.4 per cent, and food-grain output was practically stagnant. The British regime in India did supply the irrigation works but rarely on the scale required. Community effort and private investment soared as the market for irrigation developed. Agricultural prices of some commodities rose to about three times between 1870-1920. The early British era was a report prepared by a British engineer, Thomas Barnard, and his Indian guide, Raja Chengalvaraya Mudaliar, around 1774.

Republic of India (1947 CE onwards) Bhakra Dam (completed 1963) was the largest dam in India. Special programs were undertaken to improve food and cash crop supply. The Grow More Food Campaign (1940) and the Integrated Production Programme (1950) focused on food and cash crops supply respectively. Five-year plans of India oriented towards agricultural development soon followed. Land reclamation, land development, mechanization, electrification, use of chemicals fertilizers in particular, and the development of an agriculture-oriented 'package approach' of taking a set of actions instead of promoting a single aspect soon followed under government supervision. The many 'production revolutions' initiated from the 1960s onwards included Green Revolution in India, Yellow Revolution (oilseed: 1986-1990), Operation Flood (dairy: 1970-1996), and Blue Revolution (fishing: 1973-2002), etc. Following the economic reforms of 1991, significant growth was registered in the agricultural sector, which was by now benefiting from the earlier reforms and the newer innovations of Agro-processing and Biotechnology.

Indian Agriculture under Five Year Plans On the eve of the first plan (1951-1956) agriculture was in a hopeless and deplorable condition. Our farmers were in heavy debt to the village money-lenders. They were having small and scattered holdings. They had neither the money nor the knowledge to use proper equipment, good seeds, and chemical manures. Except in certain areas, they were dependent upon rainfall and the vagaries of the monsoons. Productivity of land as well as of labour had been declined and was generally the lowest in the World. Even though nearly 70 per cent of our working population was engaged in cultivation, the country was not self-sufficient in food grains but had come to depend on imports of food grains.

## **2.2 Importance of Climate Change on Water Resources and Agriculture**

Climate change occupies a high priority on the environmental agenda of the international community. Climate change had a serious impact on the accessibility of different resources on the earth, particularly water, which sustains life on the earth. Water

plays an essential role, both in humanity's survival and prosperity. Its close involvement in the processes of life and its strong interaction with bio-societies reflects its vital significance. The global demand for water in agriculture increased about 20 per cent by 2050. Water was together with soil, the most important input for agriculture. Only if agriculture had sufficient clean water it could fulfill its role as a major supplier of food and ensure food supplies for the growing world population (**Global Form for Food and Agriculture, 2017**). It was frequently known that the economy of India and in particular its agricultural sectors would face serious water challenges over the coming decades. Population growth coupled with economic growth of nearly seven per cent per year to 2030 would translate into strong growth in food demand and hence crop production in India. Given that roughly 60 per cent of crops produced in India were irrigated this would likely require a major expansion in demand for water. Growing demand for irrigation, when coupled with increases in industrial, residential, and commercial demands for water, was projected to result in intense competition for water in India.

**Haque, et.al., (2012)**, revealed that changes in water demand would exert significant pressure on the water authorities to maintain the balance between water demand and supply. The study also evaluated the impacts of climate change on future water demand in the Blue Mountains region, New South Wales, Australia, and also projected from a global climate model, by the Common wealth Scientific and Industrial Research Organization (CSIRO). The study found that temperature and rainfall were the most used climate variables in water demand modeling; however, the maximum temperature, total rainfall, and number of rain days) and incorporation of other climate variables had identified more efficiently. The study concluded that the impact of climate change impact assessed the water demand demonstrated that the future water demand in the Blue Mountains region in Australia would not significantly impacted by the changed climate conditions.

**Zou et.al., (2013)**, their study provided a cost-effectiveness analysis of four water-saving irrigation techniques that were widely implemented in China to address the impacts of climate change: sprinkler irrigation, micro-irrigation, low-pressure pipe irrigation and channel lining. The study aimed was to understand the economic feasibility of water-saving irrigation as an approach to coping with climate change. Based on the cost-effectiveness analysis they founded that the water-saving irrigation was cost-effective in coping with climate change and had benefited for climate change mitigation and adaptation, and for sustainable economic development.

**Iglesias and Garrote (2015)**, made their study on the climate change and it was expected to intensify the existing risks, particularly in the regions under the water scarcity. The study revealed that the effort to develop adaptation strategies for agricultural water management could benefit from understanding the risks and concluded that the improved in adaptive capacity and responding to changes in water demands, however the implementation required restoring current water policy, adequate training to farmers, viable financial instruments and to assist stakeholders took up the adaptation challenge and develop measures to reduce the vulnerability of the sector to climate change.

**Kaur et.al., (2015)**, estimated the linear programming model had been formulated to suggested the optimal cropping pattern for maximizing net returns and ensuring significant savings of groundwater with the sustaining groundwater use in the Punjab agriculture. The dominance of paddy-wheat crop rotation had led to overexploitation of ground water resulting in rapid decline of water table in the entire state. The existing ground water draft for irrigation was 3.41 m ha m whereas the annual ground water availability was 2.03 m ha m, indicated a deficit of 1.38 m ha m of groundwater resources a case of severe water imbalance in their state. The study suggested a diversification plan for achieving water sustainability shift of area under maize and basmati in plan I, resulted into significant water saving of 8 per cent.

**Srivastava et.al., (2015)**, estimated the volume of groundwater use for irrigating different crops in the Punjab. The study found that groundwater depletion was a negative externality due to over-dependency on groundwater as a source of irrigation for cultivating water-intensive crops particularly paddy. The study concluded that time line of the existing groundwater crisis could be traced back to the introduction of paddy in Punjab as a green revolution technology backed by strong policy support of subsidized credit and electricity supply for installing and operating tube wells, and assured prices through minimum support price (MSP).

**Zaveri et.al., (2016)**, assessed the multidisciplinary approach on climate change challenges faced by the Indian agricultural system, and examined the effectiveness of large-scale water infrastructure projects designed to meet the challenges. The study found that even in areas that experience climate change induced precipitation increases; expansion of irrigated agriculture would require increased amounts of unsustainable groundwater. The study also recommended the large proposed national river linking project has limited capacity to alleviate groundwater stress.

**Nedumaran and Singh (2017)**, examined the trade-off between non-farm income and on-farm soil and water conservation (SWC) investment by smallholder farmers in the semi-arid tropics (SAT) of India. The study assessed the impact of improved off-farm employment opportunities on household welfare, land degradation and labour allocation for SWC activities. The study also revealed that improved non-farm employment opportunities increase the household welfare but reduce the households' incentives to deploy labour for soil and water conservation measures, lead to higher levels of soil erosion and rapid land degradation. The study had suggested that there was need of other complementary policy interventions to protect the natural resource to improve the nonfarm income opportunities does not produce a win-win solution in the watershed in the SAT region.

**Rao et.al., (2017)**, examined that input output ratio had been found highest in the farming system containing rain fed and irrigated cropping. The market dependency ratio for inputs had been found to be lowest (46 per cent) for the system containing rain fed and irrigated cropping along with livestock and the highest for the system with rain fed and irrigated cropping only and relationship between market dependency ratio and farm size, family size and number of components in a farming system had also been analyzed. The study concluded that farming systems could minimize the need for external inputs have a key role in sustaining agricultural systems in the rain fed agriculture.

**Singh et.al., (2017)**, conducted the study in north-western Rajasthan, had examined the capital cost and subsidy in the installation of solar tube well, its feasibility and benefits realization and had identified constraints in the adoption of solar tube wells. The study followed random sampling technique, primary data were collected from 124 sample farmers showed that adaptation of solar tube well had a direct relation with farm-size, a considerable proportion of small and marginal farmers also adopted the solar tube wells. The study found that due to financial considerations, all categories of farmers were reluctant in adoption of solar tube wells. The study also realized the benefits of solar energy use in agriculture, efforts should be directed towards more financial incentives to ensure faster adoption and group-adoption and provision for buy back of surplus power to discourage over-exploitation of groundwater and realization of extra income by the farmers.

**Kannan et.al., (2018)**, examined the structure, determinants and efficiency of groundwater markets and suggested the policy measures to contain over-extraction of groundwater in the Union territory of Puducherry on east coast of India. The study analyzed the structure of groundwater market showed a large proportion (82 per cent) of the farmers entering into one or the other activities related to water market. The study indicated that

resource use efficiency where increased productivity and better irrigation management due to ownership of the modern WEMs. The study concluded that selling price of groundwater was found markedly higher than the total cost of water extraction, implying exploitative nature of groundwater markets.

**Narayanamoorthy et.al., (2018)**, assessed the technical and economic feasibility of drip irrigation in a number of crops and had proven its potential to save water and energy, could increase crop yields. The study used survey data from Indian state of Tamil Nadu and assessed its potential in brinjal, a widely cultivated and consumed vegetable in the country. The study found that besides savings in water (40 per cent) and electricity (629kwh/acre), the drip irrigation reduced use of other inputs, e.g. fertilizers (31 per cent), and enhances crop yield by 52 per cent. The study resulted that 54 per cent higher net returns over the conventional method of irrigation and concluded that Benefit-cost ratio in drip irrigation was quite attractive making it a viable option for sustainable management of irrigation water.

**Meetpal and Irmak (2018)**, observed that temperature trend was beneficial for maize yields, but detrimental for sorghum and soybean yields, whereas observed precipitation trend was beneficial for all three crops. The study found that irrigated yields demonstrated increased robustness and an effective mitigation strategy against climate impacts than their non-irrigated counterparts by a considerable fraction. The study concluded that to guide for planners, managers and policy and decision makers to prioritize the agricultural resilience efforts and resource allocation or re-allocation in the regions that exhibit risk from climate variability.

Irrigation was essentially the artificial application of water to overcome deficiencies in rainfall for growing crops. Irrigation as a protective measure to supplement rainfall and precaution against the failure of crops was always practiced in the various parts of the world. Irrigation was very vital to overcoming the basis problems of the agriculture (**Economic Survey, 2019**). Irregular, uncertain and unevenly distributed rainfall in time amount and space was not sufficient for growing certain crops. These conditions make irrigation essential and indispensable for the successful crop production.

### **2.3 Impact of Climate Change on Agriculture**

The unimpeded growth of greenhouse gas emissions was raising the earth's temperature. The consequences include melting glaciers, more precipitation, more and more extreme weather events, and shifting seasons. The accelerating pace of climate change, combined with global population and income growth, threatens food security everywhere.

Agriculture was extremely vulnerable to climate change. Higher temperatures eventually reduce yields of desirable crops while encouraging weed and pest proliferation (**Gerald, et.al., 2009**). Changes in precipitation patterns increase the likelihood of short-run crop failures and long-run production declines. Although there would be gains in some crops in some regions of the world, the overall impacts of climate change on agriculture were expected to be negative, threatening global food security.

**Chattopadhyay and Das (2000)**, estimated the growth rate on agriculture in West Bengal. The study founded that the rainfall was insignificant effect on agricultural production and, the recent developments in West Bengal agriculture was unbalanced. The study concluded only a few crops had dominated the field of the farmers by elbowing out other crops, like high protein pulses, wheat etc., and the location base had also not been widened.

**Singh and Chandra (2000)**, focused the agricultural productivity in Madhya Pradesh. The study analyzed that the food grains production in the state improved from 5.896 to 17.41 million tons during 1951-52 to 1996-97 and achieved the annual growth of 2.38 per cent. The study found that the yield during the period improved from 461 to 1105 kg/ha but it was very low when compared to all over India. The study concluded that low yield was due to lower use of agricultural inputs of fertilizer and irrigation. The study also revealed that fertilizer consumption in the state increased and concluded that the growth of fertilizer use in the state had been erratic and low compared to all-India growth trend.

**Singh and Chandra (2001)**, estimated the growth trends in area, yield and production of food grains in Uttar Pradesh. The study founded that the state of Uttar Pradesh had registered a significant change in agricultural development during different phases of the green revolution. The study concluded that the introduction of High Yield Varieties of major crops in the State in the mid-seventies covered the way to significant increase in food grains production. The study suggested that the growth rate in production was low during the green-revolution period compared to post-green revolution era.

**Kumar et.al., (2004)**, analyzed the crop climate relationships for India, used historic production statistics for major crops (rice, wheat, sorghum, groundnut and sugarcane) and for aggregate food grain, cereal, pulses and oilseed production and correlation analyzed an indication of the influence of monsoon rainfall and some of its potential predictions on crop production. The study found that all-India annual total production from production in the monsoon and post-monsoon seasons were significantly correlated to all-India summer monsoon rainfall. The study resulted that state level crop production statistics and sub

divisional monsoon rainfall were generally consistent with the all-India, but demonstrated some surprising spatial variations, whereas the impact of sub divisional monsoon rainfall was strong in most of the country. The study concluded that influence of concurrent predictors related to El Niño southern oscillation and the Indian Ocean sea-surface temperatures at a long lead time seem greatest in the western to central peninsula.

**Deressa et.al., (2005)**, showed that the climate change has significant nonlinear impacts on net revenue per hectare of sugarcane in South Africa with higher sensitivity to future increases in temperature than precipitation. Irrigation did not prove to provide an effective option for mitigating climate change damages on sugarcane production in South Africa. The study suggested that adaptation strategies should focus special attention on technologies and management regimes that would enhance sugarcane tolerance to warmer temperatures during winter and especially the harvesting phases.

**Mall, R.K., (2006)**, observed the climate change in twentieth century. The study used the crop simulation models extensively to found the impact of climate change on agricultural production and food security. The output provided by the simulation models could be used to make appropriate crop management decisions and to provide farmers and others with alternative options for their farming system.

**Guiteras (2007)**, estimated the economic impact of climate change on Indian agriculture of random year to year variation in weather on agricultural output using a 40 year district level panel data set covering over 200 Indian districts from corporate farmer. The study derived from short run weather effects, were also relevant for predicting the medium run economic impact of climate change if farmers were constrained in their ability to recognize and adapt quickly to change in mean climate. The predicted medium run impact was negative and statistically significant and also projected climate change over the period 2010-2039 reduces major crop yields by 4.5 to nine per cent.

**Mendelsohn (2008)**, reviewed several studies to measure the size of the impact of warming on farms in developing countries. The study viewed the adaptation methods which would blunt some of the worst predicted outcomes, warming were expected to cause large damages to agriculture in developing countries over the next century.

**Kang (2009)**, provided a comprehensive review of literature related to the assessment of climate change impacts on crop productivity using climate, water and crop yield models. Crop production could increase if irrigated areas were expanded or irrigation was intensified, but these might increase the rate of environmental degradation. An increase in precipitation would increase crop yield and what was more; crop yield was more sensitive to the

precipitation than temperature. The study concluded that if water availability was reduced in the future, soils of high water holding capacity would be better to reduce the impact of drought while maintaining crop yield. With the temperature increasing and precipitation fluctuations, water availability and crop production were likely to decrease in the future. The study suggested that if the irrigated areas were expanded the total crop production would increase however, food and environmental quality might degrade.

**Jamet and Morlot (2009)**, reviewed the climate change was expected to have significant implications for the world economy and more broadly, for many areas of human activity. The study revealed that large uncertainties, which were not fully reflected in existing estimates of global impacts of climate change in monetary units, despite these uncertainties, policy action might be justified, provided that policies were cost-effective, even if the marginal cost of GHG emissions mitigation exceeds the marginal damage of one additional ton of carbon the impacts of climate change in favor of action their irreversibility and the risk that they were extreme.

**Ray et.al., (2009)**, focused on climate variability and occurrence of extreme weather events were the major concerns linked to global warming. The study used past 40 years data of all IMD observatories in Gujarat state of India had been analyzed. The study estimated the moving averages of Maximum Temperature during summer season and minimum temperature during winter season had been analysed and a significant increased trend had been observed where similarly for rainfall, some significant results have been obtained. The study found that significant trend in case of various extreme weather events like cold wave conditions, heat wave conditions and heavy rainfall instances. The study concluded that addition to above IMD's gridded data for Gujarat state for Maximum, Minimum and Mean temperature showed a significant steady increasing trend in the past 40 years.

**Chaudhari et.al., (2009)**, used to study the impact of future climate change on major food crops in India viz. wheat, rice, potato and rapeseed-mustard. The study concentrated on area weighted averages of district-wise crop yield data were computed at met sub-division level for 1977–2007 for 9 major wheat producing met sub-divisions, 16 major rice producing met subdivisions, 6 major potato growing sub-divisions of and 8 major rapeseed-mustard growing subdivisions. The study followed the fortnightly correlation weighted weather parameters like minimum and maximum temperature and precipitation for the respective met sub-division and periods of the crop season were used to develop the empirical relationships. The study resulted that negative response of yields to increased minimum temperatures was observed for all the crops. In general, the reduction in crop yields up to 13.4 per cent was

observed with unit increase in minimum temperature. The crop yield also showed negative response to increased maximum temperature and its unit increase reduced the yields up to 10.3 per cent and 5.3 per cent for rice and wheat crop, respectively. The crops like potato and rapeseed-mustard showed positive response to increased maximum temperature, which might be due to their strong positive correlations with diurnal temperature range (DTR). The study estimated impacts of diurnal temperature range (DTR) changes on yields were generally less (< 5 per cent change in yields) for wheat and rice crops while more up to 8.6 per cent for potato and rapeseed-mustard crops. Based on A2 scenario of temperature and precipitation change, as derived from PRECIS (Providing Regional Climates for Impacts Studies) regional climate model, it was found that, during the period 2071-2100, the rice yields in irrigated regions would reduce up to 32 per cent in Haryana followed by 18 per cent in Punjab while it might increase in rain fed regions up to 28 per cent in Orissa followed by 18 per cent in Madhya Pradesh. The reduction in wheat yields would be 21 per cent in East Rajasthan followed by 18 per cent in West Rajasthan and 14 per cent in East Madhya Pradesh. The climate change scenario might lead up to 39 per cent reduction in rapeseed-mustard and 19 per cent reduction in potato yields. The study concluded yield change projection uncertainties were large due to the uncertainties associated with the yield model.

**Hanif et al., (2010)**, made a study on Economic Impact of Climate Change on Agricultural Sector of Punjab. The main objective of the study was quantification of the impact of change in climate on the development of agricultural sector both at country and regional level. A one-way fixed effect panel model for eleven districts over time period 1970-2009 which was estimated by FGLS (Feasible generalized Least Square) panel regression technique. The results of panel regression of precipitation, maximum and minimum temperature were derived on Punjab Agricultural Land. The climate variable considered was Kharif and Rabi Seasons and found that the climatic factor- Precipitation in Rabi season had significant negative relationship. It was interpreted that decrease in Rabi Precipitation coupled with increase in maximum Rabi Temperature would tend to increase the land price in the season also; it was observed mean maximum Kharif temperature was not significant with the land prices.

**Jha and Tripathi (2011)**, analyzed the temperature and rainfall related data were 1901-2003 and 1871–2008 respectively to discern the trend in climatic variables like maximum, minimum temperature and rainfall the Mann-Kendall (MK) test using statistical software SYSTAT version 12 was used. The study founded there was significant correlation of wheat yield with temperatures and more recently with the winter rainfall. The yield of

wheat in Haryana and Bihar was regressed on the positive deviation in maximum temperature, square of positive deviation in temperature and also on time trend.

**Moorthy et.al., (2012)**, suggested that developing countries were more vulnerable to the negative climate change effects. The study examined the impact of historic climate change trends over a 50-year period, and develops a model that accommodates a number of farmer adaptation possibilities. The study found that the temperature and precipitation trends had no significant impact on major crop yields. The study also emphasized the importance of error measurement when predicting outcomes, and suggested that adaptation might play a role in mitigating adverse climate change effects.

**Gupta (2012)**, estimated the impact of climate change on food grain yields in India, namely rice and millets and crop-specific agricultural production function with exogenous climate variables, namely, precipitation and temperature and control for key inputs such as irrigation, fertilizer and labour. The study analyzed the district level using a panel dataset for physical yield (output per hectare - gross cropped area) for the period 1966-99. The study found that significant impacts of climate change (temperature and precipitation) on Indian agriculture.

**Acharya et.al., (2012)**, analyzed the growth in the area, production and productivity of different crops in Karnataka was estimated using the compound growth function. The secondary data were collected for a period of 26 years from 1982-83 to 2007-08. The study resulted growth rates showed a significant positive growth in area under pulses, vegetables and spices and fruits and nuts while cereals showed significant negative growth. The study revealed that the area under jowar, bajra, ragi and minor millets were experiencing a substantial annual decrement. The area under rice had recorded a mild annual increment. The growth in area under oilseeds and commercial crops was negative and insignificant. Similarly the production of cereals, pulses, vegetables and fruits showed a significant positive growth. The production of oilseeds and commercial crops registered insignificant positive growth. The productivity of different crops recorded significant growth in the case of cereals, pulses and fruits. Productivity of oilseeds recorded moderately positive growth. The productivity of commercial crops registered insignificant positive growth and for vegetables the growth in productivity was insignificant and negative. The study concluded that there was a need to take up productivity enhancing measures in these crops like varietal improvement, improved cultural practices, distribution of planting materials, disease control measures, and selection of appropriate crop according to agro climatic conditions and irrigation facilities.

**Prasad (2012)**, estimated the growth rates of the Maize crop and to fit the adequate trend equation for the future projections by 2014 AD. The study period was from 1969 to 2009 and carried for Telangana region of Andhra Pradesh. The study attempted to examine the trends in area, production and productivity of Maize crop. Ten growth models were fitted to the area, production and productivity of selected crop and the best-fitted model for future projection was chosen based upon least Residual Mean Square (RMS) and significant. The study revealed that the growth rates of production were higher than the growth rates of area, productivity for the study period of the maize crop in the Telangana region of Andhra Pradesh. The study found that the area, production and productivity of Maize marked a significantly increased trend during the study period and the same was observed in future projections by 2014 AD.

**Ninan and Bedamatta (2012)**, assessed the impact of climate change on Indian agriculture covering a cross section of crops, seasons and regions based on existing literature. The study noted that the impact of climate change would vary across crops, regions and climate change scenarios. The evidence of the study indicated that decrease in production of crops in different parts of India with an increase in temperature and reviewed number of studies indicated a probability of 10 per cent to 40 per cent loss in crop production in India with increased in temperature by 2080-2100. In areas located above 27° N latitude yields of irrigated and rain fed wheat were projected to rise in response to climate change whereas in all other locations yields were projected to decline by -2.3 per cent to -23.9 per cent. Temperature rises of between 2° C to 3.5 ° C was projected to lead to a loss of 3 to 26 per cent in net agricultural revenues, Increased climate sensitivity of Indian agriculture would lead to greater instability of India's food production which would also impact on poverty and livelihoods. They concluded that Indian farmers were able to adjust their farming practices to adapt to climate change, and what policies or technologies would enable rapid adaptation to climate change were issues that merit attention.

**Cai et.al., (2013)**, used principal component analysis, a climate index was developed to estimate the linkage between climate and crop yields. The indices based on three climate projections were then applied to forecast future crop yield responses. The study identified spatial heterogeneity of crop yield responses to future climate change across a number of U.S. northern and southern states. The study indicated that future hotter/drier weather conditions would likely had significant negative impacts on southern states, whereas only mild impacts were expected in most northern states.

**Gupta, et.al., (2013)**, analyzed the climate change impact on the runoff of river basins of India. The study estimated the Global Circulation Model (GCM) output of Hadley centre (HADCM3) projected the climate change data was used, scenario for 2080 was selected. The results of the study showed that there was a declined in the future climatic runoff in most of the river basins of India compared to normal climatic runoff. However, significant reduction was observed for the river basins in the eastern region viz: lower part of Ganga, Bahamani-Baitrani, Subarnrekha and upper parts of the Mahanadi. The study found that overall seasonal (June to September) runoff reduction was high for Subarnrekha basin (54.1 per cent). Rainfall to runoff conversion was high for Brahmaputra-Barak basin (72 per cent), while coefficient of variation for runoff was more for Mahanadi basin (1.88 per cent). The study also indicated that eastern India agriculture would be affected due to shortage of surface water availability.

**Kumar and Sharma (2013)**, analyzed the impact of climate change on agricultural productivity in quantity terms, value of production in monetary terms and food security in India and undertaken state wise based on secondary data from 1980 to 2009. The study resulted regression model showed that most of the food grain crops, non-food grain crops in quantity produced per unit of land and in terms of value of production climate variation cause negative impact. The study found that adverse impact of climate change on the value of agricultural production and food grains indicates food security threat to small and marginal farming households. The study also examined the state wise food security index and econometric model estimation revealed that the food security index itself also gets adversely affected due to climatic fluctuations.

**Valizadeh et.al., (2013)**, aimed to simulate the effects of climate change on the maturity period, Leaf Area Index (LAI), biomass and grain yield of wheat under future climate change for the Sistan and Baluchestan region in Iran, for this purpose, two general circulation models HadCM3 and IPCM4 under three scenarios A1B, B1 and A2 in three time periods 2020, 2050 and 2080 were used. LARS-WG model was used for simulating climatic parameters for each period and CERES-Wheat model was used to simulate wheat growth. The results of model evaluation showed that LARS-WG had appropriate prediction for climatic parameters and simulation of stochastic growing season in future climate change conditions for the studied region. Wheat growing season period in all scenarios of climate change was reduced compared to the current situation. This reduction in B1 scenario was less than A1B and A2 scenarios. Maximum wheat LAI in all scenarios, except scenario A1B in 2050, was decreased compared to the current situation showed that wheat production in the

future would be affected by climate change and would decrease in the studied region. The study recommended that to reduce these risks, the impact of climate change mitigation strategies and management systems for crop adaptation to climate change conditions should be considered.

**Gonzalez and Salinas (2013)**, observed the impact of climate change and their effect on agriculture and crop production of rural livelihoods in Karnataka and identified the indices for the whole-sample level showed that this community's vulnerability to climate change was moderate, whereas the household-level showed that most of the households' vulnerability was high-very high.

**Fazal (2013)**, focused on the effect of climate change on the agricultural sector and recent inventions and adaptations to cope up with the negative effects of climate change. The study attempted to review how climate and agriculture was interrelated. The study illuminated the vulnerability of the agricultural sector that depends highly on the climatic variables, like rainfall and temperatures. The study estimated economic costs of climate change on agricultural productivity of different regions and also gives an insight into how these climatic challenges at present and future could be best tackled in order to maximize agricultural output.

**Exenberger et.al., (2014)**, estimated the impact of climate change on agricultural production in a panel of 127 countries from 1961 to 2002. The study found that there was no significant impact of climate change on agricultural production in high income countries, but significant adverse effects in middle and low income countries. These adverse effects include a moderate negative impact of increases in temperature on agricultural output and for low income countries also negative effects of reductions in precipitation and of increases in the frequency of droughts. The study concluded that effects were particularly strong in Sub-Saharan Africa where low-tech rain-fed agriculture with very limited climate change adjustment capacities dominated.

**Kamble. P. S. (2014)**, identified the things of serious concerns of climate change for the Indian agriculture. The study was exclusively relied on the secondary data concerning agriculture as well as climate change for the latest period prominently. The study concluded that the climate change had created severe adverse impacts on agriculture and thereby things of serious concerns, which were necessary to be tackled with the joint efforts of the government policy and active participation of the people and the society as a whole.

**Sridevi et.al., (2014)**, attempted to analyze the vulnerability to climate change in different districts of four south Indian states, Andhra Pradesh, Karnataka, Tamil Nadu and

Kerala. The study was undertaken five sources of vulnerability indicators such as socio-demographic, climatic, agricultural, occupational and common property resources vulnerabilities to compute the composite vulnerability index. The composite vulnerability index found that, Adilabad, Chamarajanagar, Thiruvarur and Kasaragod were the most vulnerable districts of Andhra Pradesh, Karnataka, Tamil Nadu and Kerala respectively, whereas Hyderabad, Belgaum, Thoothukkudi, Kottayam were the least vulnerable districts.

**Birthal, B.S (2014)**, assessed the climate impacts used district-level data on climate variables (temperature and rainfall), and production and area of 19 major crops for the period 1969-70 to 2004-05 for 200 districts at their 1970 status. The study used district-level panel data, and assessed sensitivity of Indian agriculture to climate change. The study resulted that a rise in temperature would reduce agricultural productivity, while rainfall unless it was in excess, would tend to counterbalance with harmful effects of temperature. Irrigation was an important adaptation strategy to reduce harmful effects of warmer climate. The study evaluated that, a significant change in climate might reduce productivity of Indian agriculture by 25 per cent. Agriculture in arid and semi-arid regions was more sensitive to climate change and would be more impacted by climate change. The loss would be higher in the absence of adaptation.

**Birthal et.al., (2014)**, analyzed the changes in climate variables, viz. temperature and rainfall during the period 1969-2005 and had assessed their impact on yields of important food crops. The study observed a significant rise in mean monthly temperature, but more so during the post-rainy season. The study analyzed that changes in rainfall, however, were not as significant, while an increase in maximum temperature was an adverse effect on the crop yields, a similar increase in minimum temperature had a favorable effect on yields of most crops, but it was not sufficient to fully compensate the damages caused by the rise in maximum temperature. The study found that rainfall had a positive effect on most crops, but it could not counterbalance the negative effect of temperature. The study concluded that climate impacts towards 2100 had significant changes in temperature and rainfall; the rice yield would be lower by 15 per cent and wheat yield by 22 per cent. Coarse cereals would be affected less, while pulses would be affected more than cereals, the changes in climate were not significant, and damages to crops would be smaller in the short-run too climate impacts would not be so severe.

**Mahato (2014)**, global climate change was a change in the long-term weather patterns that characterize the regions of the world. The study found that long run, the climatic change could affect agriculture in several ways such as quantity and quality of crops where

increase in the mean seasonal temperature could reduce the duration of many crops and hence reduce the yield. He concluded that climate change had negative impact on agriculture which was projected to have a great impact on food production might threaten the food security and hence, require special agricultural measures to combat with.

**Roychoudhury and Arutchelvam (2015)**, aimed to examine the impact of climate variables on agriculture and bring out the awareness of the farmers who were quitting from their agricultural activities due to this correspondence of ill effects and helps to sustain their life of human beings for present and future generations too. The study found that increase in temperature by about 20°C would reduce potential grain yields in most places and region with higher potential productivity, such as northern India were relatively less impacted by climate change than areas with lower potential.

**Abubakari, F., and Abubakari, F., (2015)**, addressed the effect of climate changing on food crop in Ghana between 2001 and 2010. Some of the crops grown by farmers were cassava soybean, maize and millet and found that effect climate on the yield of cassava was 13.80 Mt/Ha and that of the achievable yield was 48.70 Mt/Ha, average yield of soybean was 1.5 Mt/Ha and its achievable yield 2.30 Mt/Ha, maize average yield was 170 Mt/Ha and achievable yield 6 Mt/Ha and that of millet 1.3 Mt/Ha and achievable yield 2Mt/Ha. They revealed that highest rainfall in the regions was record in (2003) was 12,229 mm and the least in (2004) was 9,928 mm. They also estimated that there was a positive co-variation between poultry population and the rainfall 30-year average under consideration, a perfect negative significant correlation between goat population and the rainfall 30-year average, a positive co-variation between cattle population and rainfall 30-year average.

**Saravanakumar (2015)**, used panel data for 39 years and estimated 13 districts for the yield sensitivity of major food crops to climate change in the South Indian state of Tamil Nadu. The study estimated the marginal impacts of climate variables on crop yield used Panel Corrected Standard Error (PCSE) models. The study identified yield sensitivities in the future based on projected climate variables from the Regional Climate Model version. The study resulted quadratic relationship between the rice and sorghum yield and climate variables as temperature and rainfall increase, crop yield initially increases up to a threshold level, and then decreases. Following the Regional Climate Model version projections that observed warming and anomalies in rainfall would continue, that could result in a significant loss in crop productivity. The study suggested that there might be a 10 per cent decline in rice yield and 9 per cent decline in sorghum yield by the end of the 21<sup>st</sup> century relative to average yields during 1971-2009. The study indicated a need for new seed varieties that were less

sensitive to rainfall and temperature thresholds, and, adaptation practices such as adjustments in sowing time.

**Sharma (2015)**, examined the trends and variability in the growth of cotton as nonfood crop in the Country. The study analyzed to purpose, the relevant secondary data from 1949-50 to 2011-2012 and estimated the compound growth rates had been with the help of exponential function and variability used the technique of co-efficient of variation for the convenient of comparison over the period, so it was subdivided into eight periods. The study analysed high significant growth had been observed in area, production and yield of cotton as a whole covering the study period. The study concluded that there persist wide.

**Nath and Mandal (2015)**, evidenced the heterogeneity in climatic impacts on crop yield in Assam, India applied the non-parametric quantile regression technique to district-level data from 1978 to 2005. The study examined the heterogeneity in temperature and rainfall impacts across seasonal rice varieties (autumn, winter, and summer), agro climatic (AC) zones, and the distribution of rice yield. The study resulted that the effects of temperature on yield were not statistically significant for any of the three seasonal rice varieties. However, these effects were not uniform in their magnitudes, signs, and statistical significance across AC zones and yield distribution for each variety of rice. The study suggested that an increase in temperature variability was beneficial and that rainfall variability was harmful to autumn and winter rice yield. For summer rice, the effects of these two climate variables were positive but statistically insignificant and the importance of rice yield for food security and poverty alleviation in Assam, and recommended the appropriate adaptation strategies and public policies to counter the adverse impacts of climate change on agriculture in Assam.

**Dermid et.al., (2016)**, evaluated the impacts of climate change on maize yields in Tamil Nadu, and assessed the efficiency of adaptation strategies and used a novel multi-climate, multi-crop model approach based on AgMIP Protocols. The study displayed consistent changes to rainfall and temperature, substantial uncertainty exists between the different climate-crop model adaptation strategies proved beneficial under a current climate context, but showed diminished efficiency under future climate conditions. The study recommend that the future work the main sources of climate-crop model uncertainty, and that additional work might focus on more transformative adaptation measures.

**Navadkar et.al. (2016)**, analyzed the arrivals of black gram in the post-harvest period were the maximum and during the lean period were the least, Whereas, in the case of prices, opposite trend was observed and also found that arrivals could not increase at the similar rate

of prices during this period, where they otherwise showed a casual increase which might be due to decline in production and productivity of black gram in the study area. The study concluded the situation could be improved by growing black gram on irrigated land, took timely and appropriate plant protection measures against insect infestation like pod borers and doing sufficient efforts to grow high yielding, pest resistant varieties, etc. The study recommended the subsidies, incentives and quick services should be given to the cultivators to encourage higher crop production for this purpose, HYV seeds, fertilizers, pesticides and irrigation facilities should be provided to cultivators.

**Kaur and Kaur (2016)**, discussed the climate change trends and their impact on agriculture and food security in the country. The study empirically analyzed by using Ordinary Least Squares (OLS) and Instrumental Variables ((IV) regressions showed that climate especially temperatures adversely impact both agriculture and food security. The importance of promotion of appropriate strategies to address agricultural productivity especially enhanced irrigation facilities, infrastructure and adoption of direct interventionist measures addressing food insecurity in the country.

**Dhakal (2016)**, identified the impact of climate change and adaptation practices on agriculture in the Rautahat district of central Nepal analyzed the atmospheric temperature, rainfall pattern, soil moisture, and direct field survey. Mann Kendall trend analysis and Sen's Slope methods were used for the analysis and quantification of temperature and rainfall trends. Spearman's rank correlation analysis was performed to found the relation of seasonal rainfall with the crop yields. The study showed that the annual average rainfall was decreasing at the rate of 10.21 mm per year and the annual mean temperature had increased at a rate of 0.02 C per year over the last 30 years, but their variations were found to be statistically insignificant. Seasonal rainfall also increased, except for the post-monsoon rain.

**Yohannes H (2016)**, reviewed on relationship between climate change and agriculture. The study also found the two way relationship of climate change and agriculture was of great significance in particular to developing countries due to their large dependence on agricultural practice for livelihoods and their lack of infrastructure for adaptation when compared to developed countries. The study concluded that agricultural activities were affected by climate change affects due to their direct dependence on climatic factors. The study recommended that agriculture could be a solution for climate change by the widespread adoption of mitigation and adaptation actions.

**Vettera et.al., (2017)**, focused on Green House Gases (GHG) emissions associated with the production of major food commodities in India were calculated using the Cool Farm

Tool. The study resulted that GHG emissions, based on farm management for major crops (including cereals like wheat and rice, pulses, potatoes, fruits and vegetables) and livestock-based products (milk, eggs, chicken and mutton meat), were quantified and compared. The study concluded that a shift towards dietary patterns with greater consumption of animal source foods could greatly increase GHG emissions from Indian agriculture and range of mitigation options were available that could reduce emissions from current levels and might be compatible with increased future food production and consumption demands in India.

**Bhovi and Savadatti (2017)**, attempted to estimate trends in area, production and productivity of coconut which was an important crop in the Karnataka State. The study analyzed the five major coconut producing districts of Karnataka state and state as a whole based on the time series data for the period 1975-76 to 2009-10 used appropriate growth models. The study resulted that, area and production registered significant growth in all the sample districts and state as a whole. The study found that growth in area was higher than that of production growth but growth rate of productivity was found to be stagnant during the study period. The study concluded that the decomposition model indicated that per centage contribution of productivity towards increased production of coconut was very inadequate in all the districts except in Chikmagalur and Dakshina Kannada districts. The study recommended that there was a need to boost productivity of the coconut crop in the state in order to increase overall production.

**Praveen et.al., (2017)**, aimed to simulate the crop yield under a plausible change in climate for the coastal areas of South India through the end of this century. The study used crop simulation model, the Decision Support System for Agrotechnology Transfer (DSSAT) 4.5, was used to understand the plausible impacts on the major crop yields of rice, groundnuts, and sugarcane under the RCP 4.5 trajectory. The study revealed that under the RCP 4.5 scenario there would be decreased in the major C3 and C4 crop yields in the study area and affected not only the local food security, but the livelihood security as well. The study concluded that appropriate adaptations and policy intervention at the sub-district level for achieving sustainable crop productivity in the future.

**Rao et.al., (2017)**, suggested a practical measure of increased focus on production of millets in the country. The study had looked into the impact of reduction in yield gap and inclusion of fallow and waste lands under cultivation. The study had also suggested a way to absorb the additional production of millets in the country. The study concluded that policy and incentive support for federating farmers, farm gate warehouse and processing in village

clusters, linking farmers to the value chains of both nutri-grains and nutri-fodder and the platform of e-NAM could enable better price and enhanced income to farmers.

**Pavithra et.al., (2017)**, adopted rates of modern wheat varieties in India had been estimated used expert elicitation methodology. The study had found that the wheat varietal output had increased during the period 2010- 2015. The temporal and spatial diversity indices have been calculated based on the perceived adoption rates. Wheat varietal turnover had been highest in Punjab (7.50 years) and lowest in Rajasthan (19.25 years). The Berger Parker index has shown that relative abundance of varieties was lowest in Punjab (1.76) and highest in Madhya Pradesh (7.10). The concentration of wheat area under dominant varieties was highest in Punjab and lowest in Rajasthan as indicated by the Marglef index. The study concluded that cultivation of older varieties and dominance of a few varieties deprive the farmers of the advantages of productivity gains, genetic improvement, in addition to increasing crop vulnerability to pests and diseases.

**Tripathi and Misra (2017)**, attempted to use group information collected on climate change farmers in eastern Uttar Pradesh, India to investigate farmers' perception of an adaptation to climate change using content analysis and group information. The study found out were then compared with climatic and agriculture and suggested that though farmers were aware of long-term changes in climate factors (temperature and rainfall), they were unable to identify these changes as climate change. Farmers were also aware of risks generated by climate variability and extreme climatic events. The study suggested some policy interventions to scale up adaptation to climate change in Indian agriculture.

**Paul et.al., (2017)**, evaluated potential climate change impact on productivity of twenty three major crops and correlation coefficient ( $r$ , Pearson's Product Moment) between any climatic parameter and crop yield implied that climate had strong linear correlation with yield of crops resulting in twenty-two strong correlations. The climatic parameters rainfall was found to had most significant impact on yield. The study observed in yield of Autumn Paddy and Winter Paddy by 8.75 and 20.44 during the year 2008-2009 due to 3.98 and 36.22 per cent decrease of rainfall with  $r$  values 0.95 and -0.76, respectively also, a quantum leap of 145.32 per cent increase of rainfall during Rabi season of 2007-2008 decreased the yield of Potato and Rabi vegetables by 22.96 and 16.89 per cent, respectively. The study revealed that climate change had significant impact on crop yield which could be alleviated by adopting rainwater harvesting technology at the top and foot hills of the hilly areas.

**Chandra and Kalra (2017)**, undertaken the effect of climate changes on agriculture in Rajasthan on the seasonal crops of Rabi and Kharif. Among the major elements of climate-

temperature, pressure, wind, humidity, area and rain the present study focused on temperature (Minimum and Maximum), rain fall and area under production. The study found that the Barley the Rabi Crop was the most effected crop and Sikar was the most effected district among the 21 districts taken under the study.

**Kumar and Priyanka (2017)**, revealed that the climatic variation such as occurrences of drought have high level of impact on the yield of rain fed crops. The study projected that with short periods of exposure of wheat crops to temperatures of 28°C to 32°C resulted in significant decrease in its yield by 20 per cent or more where unpredictable moisture deficits during crop growth were a major constraint to productivity. The study claimed that climate change would reduce the major crop yields by 4.5 to 9 per cent over the period of 2010-2039 and change in climate was reduced the agricultural production and posed a threat to long term food security.

**Raghuvanshi (2017)**, conducted the study in Uttarakhand state in the North Himalayan region of India. The study comprised 110 farmers selected by using simple random sampling. The study indicated that all the farmers were found to be aware of the climate change, and majority of them reported “erratic rainfall, diminishing agricultural yield and increase in temperature” as the indicators of climate change. The study recommended policy formulation as well as undertaking mitigation measures besides helping the agriculture extension agencies to design and plan locale specific adaptation strategies and agriculture development programmes.

**Varadan (2017)**, examined the occurrence of climate change in Tamil Nadu, the southernmost state of India and its impact on rainfall pattern which was a primary constraint for agricultural production. The study resulted that the south-west monsoon had been disturbed with August rainfall increased with more dispersion while September rainfall decreasing with less dispersion, thus, September, the peak rainfall month of south-west monsoon before climate change, had become the monsoon receded month after climate change. The study found that had been no change in the trend of the north-east monsoon, the quantity of October and November rainfall had considerably increased with increased dispersion after climate change. On the whole, south-west monsoon had decreased with decreased dispersion while north-east monsoon had increased with increased dispersion. The study concluded that season window for south-west monsoon crops had shortened while the north east monsoon crops were left to fend against flood risk during their initial stages. The study recommended that the incoherence in warming, climate change and rainfall impact seen across the state necessitates devising different indigenous and institutional adaptation

strategies for different regions to overcome the adverse impacts of climate change on agriculture.

**Vijayan and Viswanathan (2018)**, attempted a brief trend analysis based on the available data and comes to a conclusion that India should focus on earmarking adequate financial investments to those states which were highly vulnerable to the climate induced shocks, which would create positive impacts on agriculture sector in the long run. The study concluded that strategies might ultimately result in making the farmers resilient to the changing climatic scenarios and their pernicious impacts.

**Santiago et.al., (2018)**, examined the food security status and livelihood activities of 269 smallholder farm households (HHs) in Bihar, India. The study proceeded with a four-step analysis, first applied a multivariate statistical methodology to differentiate five primary farming system types next applied an indicator of food security in the form of HH potential food availability (PFA), and examined the contribution of crop, livestock, and on- and off-farm income generation to PFA within each farm HH type. The study also examined the potential impact of the adoption of 'climate smart' agricultural (CSA) practices in the form of conservation agriculture (CA) and improved livestock husbandry, and environmental shocks on HH PFA. The study indicated that compared to livestock interventions, CA might hold considerable potential to boost HH PFA, though primarily for wealthier and medium-scale cereal farmers. The study resulted that farm HH types were however considerably more vulnerable to food insecurity risks resulted from simulated drought, while part-time farmers and resource-poor agricultural labourers generating income from off-farm pursuits were comparatively less vulnerable, due in part to their more diversified income sources and potential to migrate in search of work. The study concluded that underscore the importance of prior planning for development initiatives aimed at increasing smallholder food security while maintaining social equity, while providing a robust methodology to vet the implications of agricultural interventions on an exact basis.

**Abhinav et.al., (2018)**, investigated on the impact of rainfall on coconut productivity was taken place in Kozhikode and Malappuram districts of Kerala and identified the variation in coconut production on an account of secondary data based on rainfall collected for a time period from 1991 to 2015. The study revealed that rainfall during 3<sup>rd</sup> (July-September) and 4<sup>th</sup> (October-December) quarters was founded the significant negative impact on coconut production. The study observed that rainfall during 1<sup>st</sup> (January-March) and 2<sup>nd</sup> (April-June) quarters had positive and non-significant impact on coconut production. The study showed

the growth trend of rainfall had increased trend in Kozhikode district whereas Malappuram district had a decreasing trend over the years.

**Duku et.al., (2018)**, analyzed the impact of climate change on the potential for increasing rain fed cropping intensity through sequential cropping and irrigation expansion in central Benin. The study combined hydrological model and scenario analyzed involving two Representative Concentration Pathways (RCPs), two water-use scenarios for the watershed based on the Shared Socioeconomic Pathways (SSPs), and environmental water requirements leading to sustained stream flow. The study analyzed that in Benin, warmer temperatures would severely limit crop production increased achieved through the expansion of sequential cropping. Depending on the climate change scenario, between 50 per cent and 95 per cent of cultivated areas could currently support sequential cropping or would need to revert to single cropping. The study resulted that the irrigation potential of the watershed would be at least halved by mid-century in all scenario combinations. The study outlined challenges and the need for planned development that need to be overcome to improve food security in the coming decades.

**Bhima (2018)**, reviewed the impact of climate change on crop water requirement, availability of irrigation water and suggested coping strategies. The study explored that most of the studies presented indicate that there was an increase in irrigation and crop water requirement and few studies which suggested that there might not be a change in crop water requirement in event of climate change. The studies also suggested that climate change would affect groundwater recharge and water availability for irrigation. The different studies revealed that the future would be tough for nations in the sensitive areas in particular whose irrigation water supplies were dependent on groundwater. The study identified the gaps and scope for future research so that suitable adaptation and mitigation measures could be taken for water resources planning and management under climate change scenarios.

**Ansari et.al., (2018)**, undertaken to ascertain farmers' perceptions about climate change and determine factors affecting and conducted in two purposively selected districts in the state of Uttar Pradesh (India) which were deemed to be vulnerable to climate change. The study sample comprised of 120 farmers selected randomly. The study found that farmers have fairly high level of perception about climate change and its various dimensions. Further, age, education, occupation, farming experience, knowledge about coping strategies, and mass media ownership and exposure were found to be significantly related with farmers' perception about climate change. The study recommended an appropriate policy framework

and specific programmes for sustainable agriculture growth were needed for enhancing farmers' perception towards climate change and for promoting climate smart agriculture.

**Ray et.al., (2019)**, constructed linear regression relationships using weather and reported crop data assessed the potential impact of observed climate change on the yields of the top ten global crops barley, cassava, maize, oil palm, rapeseed, rice, sorghum, soybean, sugarcane and wheat at -20,000 political units. The study found that the impact of global climate change on yields of different crops from climate trends ranged from -13.4 per cent (oil palm) to 3.5 per cent (soybean). The study resulted that impacts were mostly negative in Europe, Southern Africa and Australia but generally positive in Latin America. Impacts in Asia and Northern and Central America were mixed. The study suggested that climate change has already affected global food production.

**Birthala et.al., (2019)**, assessed variation between exposure and vulnerability of crops to production risks such as droughts, floods and pests; and subsequently the trade-off between risk and returns in farmers' choice of crops. The study found that, at any point of time, about one-third of the farm households were exposed to production risks and suffer a loss of about 12 per cent in their potential farm returns where drought accounts for about 47 per cent of the total loss, followed by insect-pests (27 per cent) and floods (20 per cent). The study was resulted that considerable variation in exposure and vulnerability of crops to drought risk, but not much to flood and pest risks. The low-risk crops, mainly stable cereals, generate less but stable returns, and the crops that were more remunerative to produce were also more vulnerable to risks. In general, the study concluded that risk-averse farmers choose low-return, low-risk crop portfolio, but those capable of bearing the cost of risks prefer a high-return, high-risk crop portfolio.

**Huong et.al., (2019)**, assessed the impact of climate change on agriculture would help to clarify the perception of the problem and quantify the impact, contributing to the formulation of sustainable livelihoods. The study used the Ricardian approach to explore the implications of climate change on agriculture in the Northwestern area of Vietnam by taking farmer adaptations into account. The study used secondary data of 1055 households which selected from Vietnam Household Living Standards Surveys in 2012 dataset and climate and examined the effect of an infinitesimal change of temperature and rainfall in Northwest farming; marginal impact analysis was conducted and predicted the impact of climate scenarios on net revenue for the years 2050 and 2100. The study found that relationship between household revenue and weather variables were nonlinear significant and inverted U-shaped relationships between the two seasons net revenue decreased as temperature and

rainfall increase in the dry season. Net revenue projected to decline about 17.7 per cent and 21.28 per cent due to climate change in 2050 and 2100 respectively in without adaptation model. Net revenue would be loss about 0.37 per cent and 0.20 per cent in 2050 and 2100 respectively in with adaptation model.

**Mandal and Singha (2020)**, examined the impact of climate change on mean yield and its variability of five principal crops of Assam used a district level panel data set for a period of 1991-2013. The study estimated the feasible generalized least square of a stochastic yield function indicated that daily average mean temperature during the growing season had beneficial impacts on the average yields of the crops while excessive temperature, which was expected in future, could have harmful impacts on the average yields of summer rice and mustard. Similarly, daily average mean temperature had non-linear impact on yield variability of summer rice, winter rice and potato. The study resulted that implication for the agricultural sector of Assam which had witnessed an increase in mean temperature, and decline in annual and seasonal rainfall.

Climate change impacts on agriculture on agriculture were being witnessed all over the world, but countries like India were more vulnerable in view of higher demographic pressure of natural resources and poor coping up mechanisms. Models generally predict that rising temperature, increased climate variability and extreme weather events could significantly affect food production in the coming decades (**Vettera, 2017**).

#### **2.4. Cropping Pattern and Crop Diversification**

Agriculture was a major sector that plays a crucial role in the development of agrarian economies. However, agriculture sector in India had witnessed drastic changes due to the impact of climate change where the introduction of modern technology during green revolution in mid-1960<sup>s</sup>. Green revolution provided to boost the economy by achieving significant uptrend in cereals-based cropping pattern than less profitable existing crop-mix (**Biswajit Sen et.al., 2017**), then gross cropped area comes under high productive major cereal crops, leading to cropping pattern very much skewed towards cereal based farming which resulted in low degree of diversification. Instability was an important characteristic of agriculture. It was caused by a number of factors like natural such as abrupt changes in rainfall and temperature and man-made such as technological change, quantity, and quality of inputs, irrigation etc. (**Senapatia and Goyari, 2019**). To improve the crop production had also adopt the modern methods of cultivation like inputs such as improved seeds, agro-chemicals and irrigation, and agronomic practices could potentially reduce instability in

agricultural growth caused by changes in the weather conditions, insect-pests and diseases helps agricultural growth was an result of widespread adoption of modern technologies.

**Chand et. al., (1986)**, highlighted the importance of diversification in Himachal Pradesh. The study found that diversification of agriculture was of complicated nature in Himachal Pradesh because of wide variation in agro-climatic conditions between different regions. The study examined diversification at all levels but, in the districts falling in mid and high hills, the diversification tends to be more benefitted. The same was also true for medium and large farmers. Thus, to induce the balanced development, in the state, there was a need to redefine the development strategies. The study recommended the weaker section, land constitutes major constraint for increasing farm family income, thus, extension of non-farm enterprises along with assured marketing facilities was essential to provide them sustained and minimum customary level of living.

**Pillai and Renuka (2001)**, examined the performance of paddy productivity growth in West Bengal and Orissa. The study founded that input productivity had certainly played an significant role in the growth performance in 1980 and 1990. The study analyzed the growth in inputs and total factor efficiency had contributed significantly to the output growth in both the states, the performance of West Bengal had been better than Orissa. The study concluded that development in input productivity in West Bengal had been brought about both by efficiency and technology in the existence of variations across seasons and seed varieties. Improvements in production technology were clear between 1986-87 and 1990-91. The study suggested that the use of inputs and technical efficiency improved over time, it had not been as remarkable as the development in the state of production technology.

**Culas and Mahendrarajah (2005)**, examined the farm diversification had been carried out from a sample of farms in Eastern Norway in which four measures of diversification were defined to incorporate the risk and uncertainties in relation to farm production income. The study used four alternative measures of diversification and panel-data techniques, it had been showed that larger farms were more diversified, and when there was productive location and accessed to labour the farmers had a greater incentive to spread risk. The study resulted that diversification and farm size were positively linked and that there might not be sufficient economies of scale to warrant specialization. The study concluded that farm diversification could be used as a strategy for managing the pollution caused by large scale less diversified farming systems, as well as to spread the risk related to farm income.

**Birthal et.al.,(2006)**, examined the status of agricultural diversification and its role in speeding up agricultural growth, the participation of smallholders in agricultural diversification towards high-value crops on different farm categories and the driving forces that enable the producers to harness the potential of high-value agriculture. The study revealed that coefficient of labour was positive and significant at less than one per cent, supporting the hypothesis that high value agriculture was labour intensive and tends to be concentrated among the households having sufficient supply of family labour.

**Kannan and Sundaram (2011)**, analysed the cropping pattern in India had undergone significant changes over time. The study found that food grains, the area under coarse cereals declined by 13.3 per cent between 1970-71 and 2007-08. Similarly, the performance of pulses in terms of area and output was not impressive during the period. The study concluded that use of technological inventions in the cultivation of other crops was also not so conspicuous in pulses. However, technological and institutional support for a few crops like rice and wheat brought significant changes in crop area and output composition in some regions. The study recommended the crop output growth model indicate that the enhanced capital formation, better irrigation facilities, normal rainfall and improved fertilizer consumption helped to improve crop output in the country.

**Kaur (2011)**, detailed view of a major parameter of climate change, i.e., rainfall in Punjab in the last 37 years (1971-2008) and its impact on ground water balance in the state as well as the rate of fall in water table as a result of change in cropping pattern. The study outlined some important management strategies for sustainability of groundwater resources and climate change in Punjab. The primary data was obtained from the “Cost of Cultivation of Principal Crops in Punjab” scheme being Ludhiana. The sample comprised a total of 30 villages with 300 farming households. The results based on linear programming analysis carried out by considering the constraints on the availability of land (during both kharif and rabi); labour (month-wise labour availability); capital (kharif and rabi seasons, separately) and irrigation water (month wise water use on the farm). The linear programming model had been formulated to suggest the optimal cropping pattern for maximizing the net return and ensuring significant saving of groundwater under changing climatic conditions.

**Angles et.al., (2011)**, assessed the impact of climate change a multi-stage random sampling design was employed for the selection of the sample respondents. The study revealed that the climatic variation such as occurrence of drought have high level of impact on the yield of dry land crops. The farmers perception on the impact of climate change on the crops grown in dry land condition, such as yield reduction and reduction in net revenue. The

farmers already act to the changes in the climatic changes both by adopting the technological coping mechanisms on the positive side and negatively through shifting to other professions. The small and medium dry land farmers were highly vulnerable to climate change and to a larger extent the small and medium dry land farmers adopted coping mechanisms for climate change compared to larger farmers. The study also suggested that as the impact of climate change was intensifying day by day addressed through policy perspective at the earliest to avoid short term effect such as yield and income loss and long-term effects such as quitting agricultural profession by the dry land farmers.

**Acharya, et.al. (2011)** analyzed the economics of crop diversification in Karnataka. By collecting secondary data for a period of 26 years from 1982-83 to 2007-08, the nature and extent of crop diversification in the state of Karnataka had been analyzed by them using Composite Entropy Index (CEI) and Multiple Linear Regression Model. The study revealed that almost all the crop groups have higher crop diversification index during post-WTO (1995-96 to 2007-08) than during pre-WTO (1982-83 to 1994-95) period, except for vegetable and oilseed crops. The results of the study emphasized that the creation of basic facilities of infra-structure such as proper roads, transportation, market, fertilizer availability and sustained supply of irrigation water is necessary pre-requisite for creating enabling situation for explaining the process of crop diversification and agricultural development, as most of these parameters were bound to affect the nature and extent of crop diversification.

**Iatha et.al.,(2012)**, examined the impact of climate change in many aspects in different locations in the country and it was concluded that there was high impact on agriculture compared to any other sector in the country. The climatic variations such as occurrence of drought have high level of impact on the yield of Rain fed crops. The farmer's perception on the impact of climate change on the crops grown in Rain fed condition, such as yield reduction and reduction in net revenue. The farmers already act to the changes in the climatic changes both by adopting the technological coping mechanisms on the positive side and negatively through shifting to other professions. The small and medium Rain fed farmers were highly vulnerable to climate change and to a larger extent the small and medium Rain fed farmers adopted coping mechanisms for climate change compared to large farmers.

**Akande (2012)**, evaluated the Technical Efficiency (TE) and Total Factor Productivity (TFP) growth of agricultural holdings in the EU-15 region was measured using Data Envelopment Analysis and agricultural data. The study observed that TFP growth rate were being driven by technology progress (technical change) and a decline in efficiency

change particularly between the year 1999 and 2002. The study found that growth rate was driven by catch-up (efficiency change) while there seem to be technological regression.

**Asefa (2012)**, estimated the small holder farmers' technical efficiency and its principal determinants using a rural Tigray micro finance survey. Both descriptive and econometric methods were used and estimated that except labour all input variables had positive and significant effect on production. The study revealed that number of oxen owned had the highest elasticity, then land, followed by labour and value of farm equipment. The study analyzed the mean technical efficiency of farmers was 60.38 per cent implying that could be increased by 39.62 per cent at the existing level of inputs and current technology by operating at full technical efficient level. The study estimated stochastic frontier production function revealed that all determinants (except households' sex, farm size, participation in irrigation, and member to association) had significant effect on efficiency of farmers. The sign of coefficients of determinants was found as the expected, except households' sex, education of household heads, family literacy, family size, share cropping, credit access, crop diversification, and land fertility.

**Ranade (2013)**, attempted to take an overview of the impacts of climate change on world agriculture. The study focused on the Indian scenario, i.e. on climate change impacts on Indian agriculture and explored how agricultural growth and environmental sustainability had to be achieved while coping with the climate change phenomena. Agriculture sector revealed high sensitivity and resilience to climate change. The study forced to extend their farming activities over the marginal rainfall areas and on degraded lands as well due to global warming, the frequency of droughts in several tropical countries had increased, which had impacted severely on agriculture, especially the small and marginal farmers. The study concluded that negative consequences for biodiversity and ecosystem goods and services, mainly food supply at lower latitudes, in dry and tropical regions, productivity of crops was likely to decrease with small local temperature increases (1 to 2°C). The study suggested that agriculture sector needs to be given an all-round push by adopting modern technologies especially by developing countries.

**Dasgupta and Bhaumik (2014)**, examined the trend and pattern of diversification of the crop sector in West Bengal during the period 1980-81 to 2009-10. The examined the impact of crop diversification on agricultural output growth in West Bengal and also undertaken the source of crops that accounted 80 per cent of total value of agricultural output in West Bengal. The factors contributing to diversification of the cropping pattern were also examined.

**Vijayasathy and Ashokan (2015)**, adapted the becoming an urgent priority of technology in crop production because large reductions in negative impacts of climate change were feasible when adaptation was fully implemented. The study was based on the data collected from 180 farmers in the Western Zone of Tamil Nadu, where climate variability was high. The determinants of climate adaptation technologies had been studied using a multinomial logit model. The study revealed that reeducation level, sex, household size, farm size, extension contact, temperature and rainfall had been founded to influence the adoption of technologies to mitigate the impact of climate variability. The study resulted that impact of technology adoption on technical efficiency of production of major crops using stochastic frontier production function had shown that technical efficiency was higher among technology adopters. The study reported that lack of finance, lack of knowledge about technology and high cost of adaptation had been constraints to climate adaptation. The study concluded that technology adoption significantly helps the smallholder farmers to continue farming in the changing climate.

**Meena et.al., (2016)**, examined the growth in the agriculture sector might be judged by the increase in agricultural production. The study focused on area under pulse had been fluctuating between 22 and 24 million ha however; there was improvement in production, which was mainly on account of increase in productivity as result of generation of new varieties or technology of their cultivation. The study found that there was decline in the area of pulses in Orissa, Punjab, Haryana and Bihar, Madhya Pradesh showed an increasing rate of growth in terms of area and production in comparison to the other states and Orissa showed a negative growth rate in area in all three decades while the production showed a negative level of significance along with a decreasing growth rate of production. The study concluded that 1981-90, it was 7.77 per cent level of significance decreased to -8.58 per cent in 1991-2000 further it was decreased. Punjab showed a declining growth rates for area and production in all three decades. Rajasthan showed a positive growth rate for area and production in all three decades, in 2000-14 it was 6.24 per cent and 5.90 per cent for area and production respectively while it was 1.44 per cent and 3.33 per cent for area and production in 1991-2000 which indicated a good level of significance.

**Chinnadurai et.al., (2016)**, studied the impact of crop diversification on dietary diversity of households in different regions of Tamil Nadu and two different types of data set were used: (1) National Sample Survey Organization's (NSSO) consumer expenditure survey data for the years TE 2004-05 and TE 2012-13, and Cropping pattern data from Season and Crop report for the years TE 2004 and TE 2012-13. Multiple linear regression model was

used to study the linkages between crop and dietary diversification. The study had revealed that dietary diversification of Cauvery delta zone, Northern zone and Northeastern zone was parallel with crop diversification. The study found that crop diversification influenced positively the dietary diversification, whereas vegetable diversification was negatively related with diet diversification, irrespective of income groups in the state also, larger household size, presence of own land, older age and higher education level of household-head have been found positively related with dietary diversity of households in Tamil Nadu. The current nutrients intake pattern had been found about 50 per cent of the RDA, particularly of crude fibre and iron and about two-thirds in case of energy and vitamin A. The nutrient intake gap was further widened in low-income non-farm groups. Appropriate nutritional security programmes might be initiated particularly covering children, pregnant women and aged people.

**Basantaray and Nancharaiah (2017)**, examined the extent and pattern of crop diversification and its impact on farm income across all the districts of Odisha. The study used the NSSO data, and found that three districts, namely Anugul, Jharsuguda, and Balangir, to be highly diversified districts and the average farm income in these districts was significantly higher than in both moderately and least diversified districts and medium farmers were the most diversified category of farmers in two out of the three highly diversified districts. The study also revealed that marginal farmers were the most diversified category of farmers in one high diversified district. The study concluded that SC households in Odisha were less diversified in comparison to other households and higher the extent of irrigated land, lower was the extent of crop diversification.

**Sen et.al., (2017)**, assessed the diversification scenario of agriculture at the national level and its reflection at farm level situation alongside. The study observed that concentration ratio (CR4) for four major agricultural sub-sectors had declined from 73.6 per cent to 69.6 per cent for the study period, 1999-00 to 2013-14. The study used Simpson Index for Diversification (SID) indicated that the average national SID for all agricultural enterprises was 0.83 which spans from 0.60 for Punjab to 0.89 for Karnataka. The study suggested that diversification of farm by adopting ancillary; horticulture and other HVE like mushroom, etc. would increase farm income.

**Khan et.al., (2017)**, examined the diversification of livelihood sources increase the income of farmers and conducted on 151 farm households in the districts of Moradabad and Aligarh in Uttar Pradesh. The study had considered three sources of income, viz. crops, animal husbandry and non-farm sector. The study used Simpson index of diversification, chi-

square test and censored Tobit regression model. The study observed that there was a significant difference between the incomes of diversified and undiversified farm households and also suggested that to increase farmers' income; policies should focus on the development of livestock sector to motivate them for rearing of animals for commercial purposes.

**Kumari et.al., (2017)**, attempted to evolve suitable cropping patterns to increase farm income with less use of irrigation water in eastern Uttar Pradesh. The study used Sen's Multi Objective Programming (MOP) model and optimized cropping pattern had shown an increase of 7 per cent in farm income and a reduction of 6 per cent in use of irrigation water. The study suggested the few policy implications to improve agricultural production per drop of water.

**Praveen et.al., (2017)**, analyzed the spatial distribution of wheat varieties in five Indian states used three spatial diversity concepts, to measure the richness, inverse dominance and evenness. The study found that all the three indices had revealed a higher spatial diversity in the states of Uttar Pradesh and Madhya Pradesh and a lower diversity in the states of Punjab and Haryana. The study concluded that effect of varietal demand and supply factors, and agro-ecologies on the spatial distribution had been established through Zellner's seemingly unrelated regression (SUR) estimation.

**Hui Li et.al., (2017)**, analyzed the agricultural productivity and technical efficiency examined agricultural performance in top twelve agricultural producing countries listed as China, India, Indonesia, Pakistan, Thailand, Vietnam, Bangladesh, Philippines, Myanmar, Japan, Malaysia, and Korea Republic. Zero inefficiency stochastic frontier model was applied as an econometric approach based on time series data of the twelve Countries mentioned above from 1961 to 2013. The study revealed that ZISFM could successfully estimate technical efficiency of both efficient and inefficient firms while the traditional SFM assumed that all of firms were inefficient and concluded that technology improvement and knowledge diffusion might enhance agricultural technical efficiency and productivity.

**Ghoshal and Goswami (2017)**, examined the production efficiency of agricultural system in four regions of India categorized as eastern, western, northern and southern regions using state level data for the period 2005-06 to 2013-14. The study used the Stochastic production frontier model using panel data, as proposed by Battese and Coelli (1995), estimated the efficiency variations taking an integrated effect model into consideration. The study analyzed the state level mean efficiency estimates of regions ranges from 0.8824 to 0.3759 for 2005-06 to 2013-14 and statistically significant variables explaining inefficiencies

in the agricultural production were total state road length per unit of area and share of agricultural NSDP to state NSDP. The major inputs were institutional credit, net irrigated area and consumption of both fertilizers and pesticides.

**Kiresura et.al., (2017)**, estimated the adoption of improved dry farming technologies, identified the factors governed their adoption and assessed the socio-economic impact owing to their adoption, included enhancement in farm incomes. The study was largely based on the primary data collected from a sample of 500 farm households spread across 50 villages chosen from 25 taluks in all the five dry zones of Karnataka. Technology Adoption Index (TAI), multiple regression model and descriptive statistics were used to analyze the data. The TAI was found highest in the Improved Livestock Management Practices (ILMP), followed by Improved Crop Production Technologies (ICPT), Improved Energy Management Systems (IEMS) and Improved Soil and Water Conservation Technologies (ISWCT), and was least in Improved Land Use Systems (ILUS). The study resulted that due to adoption of improved dry land technologies, across all dry zones, the average increase was 21.37 per cent in resource-use efficiency, 22.75 per cent in profitability, 14.96 per cent in standard of living, 13.50 per cent in women's participation and 8.19 per cent in reduction of women's drudgery. The study concluded that given the technology adoption levels much below the desired levels, the extension gap (Yield Gap-II) needed to be more focused than research gap (Yield Gap-I) in the next 4-5 years. The study recommended that "doubling of farmers' income by 2022", a multi-pronged approach need to be adopted by all concerned in a consistent and planned manner, since the contributions to double the farm incomes came not only from technological innovations, but also significantly from institutional support, infrastructural facilitation and policy intervention.

**Mathew et.al., (2017)**, determined the resource-use and allocate efficiency in ginger production in Wayanad district of Kerala. The study used multi-stage random sampling technique was used to select 80 ginger farmers. The study resulted that the Cobb-Douglas production function showed that seeds, fertilizers and manures on small farms, fertilizers and manures on large farms, and seeds, plant protection chemicals and manures on overall pool of farms could contribute to increase the yield of ginger. The study highlighted the allocate efficiency had the MVP/MFC ratios were more than unity for seeds, fertilizers and manures on small farms, and seeds and plant protection chemicals on pooled farms. The study suggested some measures also to enhance yield and hence farmers' income in ginger production.

**Sharma et.al., (2018)**, assessed the adoption of improved soybean technologies, their effects on yield, and the factors determining their adoption. The study found that adoption of improved technologies does improve crop yield and farm profit, but their adoption largely remain confined to economically well-off, better-informed, educated large farmers. The study recommended that need for strengthen linkages between research and extension systems for widespread adoption of improved technologies and cropping practices.

**Raj et.al., (2018)**, assessed the farm-level impacts of rice blast on yield, cost and returns and resource use efficiency in paddy cultivation employed the Bayesian approach. The study resulted that about 27 per cent of less yield and 19 per cent of higher cost on the disease affected farms compared to that on unaffected farms, caused a difference of 80 per cent in the net returns. The study concluded that resource use efficiency showed a positive impact of plant protection measures on both disease affected as well as unaffected farms.

**Xi Ai et.al., (2018)**, aimed to analyze the agricultural technical efficiency of top 10 agricultural provinces in China. The study used classical Stochastic Frontier Model (SFM) and a Stochastic Frontier Model (SFM) with entropy was applied. The study found that the Stochastic Frontier Model (SFM) with entropy was much better than the classical SFM in terms of economic interpretation, from the perspective of technical efficiency; Guangdong Province had been approaching the frontier of agricultural technology efficiency. The study recommended that a national perspective stood improve in technical efficiency and productivity in other provinces. The study suggested that provinces with technical inefficiency should learn from sample provinces to increase agricultural productivity.

**Ghosh and Mazumdar (2018)** estimated the cost inefficiencies of rice production for twelve major rice producing states of India used farm level data at two points of time namely 2000 and 2013 used stochastic frontier cost function. The study determined the determinants of cost inefficiencies and examined whether there exists any relationship between the cost inefficiencies and farm size. The study found that there existed non-linear relationship between cost inefficiency and farm size. Cost inefficiency was first increased with the increase of farm size then it was decreased and cost inefficiency depended negatively on proportion of family labour, mechanization, type of seed used, etc. The study concluded would enable us to know the determinants of cost inefficiency and would guide various states to adopt suitable policies thereafter.

**Raju and Mathur (2018)**, measured the efficiency in sugarcane production in Satara district of Maharashtra employed frontier methods for a sample of 77 sugarcane farms in Bhiridachiwadi. The input oriented Data Envelopment Analysis (DEA) model was pointed to

a substantial amount of inefficiency which was also corroborated by the founded the Stochastic Frontier Analysis (SFA) model. The study also found that the average input slack was the highest for repairs and purchase of machinery followed by that for fertilizers and labour. The Tobit analysis indicated that size of farm and off-farming income were the significant determinants of efficiency.

**Sugihardjo et.al., (2018)**, aimed to examine the application of cropping patterns applied by the farmers in the Cemoro Watershed, Central Java, Indonesia. The study used the descriptive analysis approach was employed and the study resulted that farmers' cropping pattern was not based on the availability of water. The study applied the cropping pattern on irrigated paddy farmers in Cemoro watershed area consists of two types: rice-rice-rice and rice-rice-secondary crops. Among those two types, most farmers applied the rice-rice-rice pattern. The study found the majority of farmers apply the second pattern (rice-rice-secondary crops) and cropping pattern was not in accordance with the recommendation of the local government.

**Peshin et.al., (2018)**, assessed the technology adoption and its impact on the agricultural productivity for small-scale full-time and part-time farm households in the subtropical region of Jammu and Kashmir. The study found that 24 per cent of the farm households being exclusively dependent on farming for their livelihoods and remaining households, agriculture was a secondary economic activity. The study resulted that farmers were engaged in nonfarm economic activities, and use more of external inputs, such as fertilizers and pesticides than do the fulltime farm households. The study concluded that high-yielding varieties, irrigation, herbicides and nitrogenous fertilizers were identified as important determinants of crop yield.

**Khandker and Gandhi (2018)**, tried to understand the post-adoption experiences of hybrid rice technology of the Indian farmers and its influences on their level of satisfaction, as well as their willingness to continue with the use of this technology. The study found that number of factors, such as agronomic potential, agro economic potential, effective demand, distribution, location, geography and cropping pattern impacting farmers' levels of satisfaction as well as their willingness to continue with cultivation of hybrid rice. The study concluded that the farmers in the predominantly rain fed regions, characterized by low crop yields, were more satisfied than others and they were also willing more to grow hybrid rice in future. The study recommended that policy perspective and need for appropriate targeting of the technology while ensuring adequate supply of seeds and other inputs.

**Nayak and Kumar (2019)**, examined the subtleties of crop diversification in Odisha, an eastern state in India through spatial trends across 30 districts and determinants of crop diversification. The study analyzed from data 1993-94 to 2012-13 indicated sluggishness and unevenness in crop diversification. The revealed that greater use of high-yielding crop varieties and accessed to irrigation had influenced crop concentration, whereas rural roads and income had led to crop diversification.

**Mehta (2019)**, estimated the changes in mean technical efficiency in herbicide tolerant cotton and conventional Bt cotton crops. The study indicated that use of herbicide-tolerant technology was technically more efficient, as it reduced wastage of purchased farm inputs due to absence of crop-weed competition, in addition to ease of cultivation related operations termed in literature as no pecuniary benefits. The macro-economic trends indicated that particularly agricultural male workers were found enhanced employment in non-agricultural sectors viz. construction, services and manufacturing. The study found that growth of agricultural labour productivity depends on the pace of technical progress that in turn raises the growth of output. The concluded that the burden on female family workers reduced to notice with the adoption of HT technology. The study recommended that technological innovation and adoption was likely to accelerate such trends and enable greater participation of women in non-farm activities and also in education.

**Senapatia and Goyari (2019)**, analyzed growth and instability in the productivity of major crops grown across the districts of Odisha, and examined its sensitivity to weather conditions during different phases of technological change. The study found that except gram, the rate of growth in yield of other crops in the state was dismal where productivity of rice, potato, maize, groundnut, and sugarcane had not only experienced deceleration but also witnessed instability over time. The composite index of agricultural development showed large inter-district variations and concluded that the role of irrigation and fertilizer in boosting agricultural growth and productivity and reducing variability.

Agriculture growth was a necessary condition for development of economy where modern technology of cultivation had significant growth in production/yield accompanied by a low level of instability was advantageous for sustainable development of agriculture. The government should provide more resources for agricultural research to boost agricultural growth and development. Crop diversification was a process of reallocation of resources across crops based on their comparative advantage. It was generally viewed as a shift from traditional lower-value to higher-value crops, and an important pathway for agricultural

development (**Nayak and Kumar 2019**). It also enhances farmers' adaptability to external shocks and promotes self-reliance and sustainability in agriculture. The significance of crop diversification becomes more pronounced in the WTO-led globalized regime that restricts the scope for prices as an incentive to increase production. Farmers would remain in a disadvantageous position unless they adapt to market signals. The adoption of improved technologies include higher for activities such as weeding and harvesting, difficulties in the use of technology, high cost of fertilizers and pesticides, high cost of accessing crop loan, and lack of knowledge about integrated nutrient and pest management practices. The government should contribute more policy interventions required to increase in yield include; improving outreach and efficiency of extension services, strengthening of input supply and enhancing farmers' access to institutional credit.

## **2.5 Role of ICTs in Agriculture**

ICTs in agriculture were an emerging field focusing on the enhancement of agricultural and rural development in India. It involves application of innovative ways to use Information and Communication Technologies (ICTs) in the rural domain. The advancements in ICTs could be utilized for providing accurate, timely, relevant information and services to the farmers, thereby facilitating an environment for more remunerative agriculture (**Bhavesh Kataria, 2015**). E agriculture focused on the enhancement of agricultural and rural development through improved information and communication following processes.

- Set up Village Information Shops that enable rural families to access modern information and communication technologies.
- Train rural youth in the organization and maintenance of a system that generates locally relevant information from generic information.
- Update and disseminate information on entitlements to rural families using a blend of modern and existing channels of communication.
- The impact of information shops and ICTs through surveys, participatory rural appraisal and other methods and
- Information dissemination and exchange in rural areas that use advanced information and communication technologies (**Chauhan, 2015**).

**Mahapatra, et.al., (2012)**, analyzed the role played by the information and technology in Odisha for agricultural development and found out that like other instrument of development of agriculture the provision of right information to the agricultural stakeholder

had yet to design. Access to right information and its proper utilization could make agriculture more competitive.

**Kameswari and Kishore, (2012)**, reported on the availability, use and information seeking behaviour of a farming community with specific reference to Information and Communication Technologies (ICTs). The study examined the use of ICTs and digital divide issues arised due to differential access and capabilities. The study was conducted in a state in North India, and provided insights into intentions and factors surrounding the use of various media by farmers. The study also highlighted the socio-cultural context within which information seeking and use occurs in rural India.

**Raj (2013)**, detailed with the implementation methodology, innovations and lessons of the ICTs initiative in providing agricultural extension services to the rural tribal farming community of North-East India. The study documented the ICTs project implementation challenges, impact among farmers and briefly indicates lessons of the e-agriculture project. The study found out the e-agriculture prototype demonstrated that the Rs. 2,400 (USD 53) cost of the extension services to provide farm advisory services was saved per farmer per year, expenditure was reduced 3.6 times in comparison with the conventional extension system. The study also argued that in less developed areas, information through ICTs alone might not create expected development. The study concluded that appropriate agricultural information and knowledge, field demonstrations and forward (farm machinery, manure, seeds) and backward linkages (post-harvest technology and market) need to be facilitated with appropriate public private partnership (PPP) between knowledge and other rural advisory service providers for agricultural development.

**Muthiah et.al., (2013)**, described that the experiences gained in terms of challenges encountered and lessons learned in an exploratory initiative of mobile phone-based multimedia agricultural advisory System (MAAS), which helps to provide timely agricultural expert advice to farmers on their mobile phone. The study found that when a farmer was calling, a call-centre-like interface containing personalized information of that farmer pops up at the expert's end. The experts viewed the farmer's dashboard and analyzed the situation and query based advisory was provided to the farmer. The agricultural advisory system formed part of a research study under National Agricultural Innovation Projects (NAIP), New Delhi. The MAAS was developed by Indian Institute of Technology Madras's Rural Technology and Business Incubator and it was field tested with 1200 farmers in three districts of Tamil Nadu (Kancheepuram, Erode and Dharmapuri), India, during December 2010 to June 2012. The study described the experiences, highlighting a number of specific challenges and

lessons associated with providing mobile based agricultural advisories to farmers in rural areas.

**Thankachan and Kirubakaran (2014)**, reviewed that the technological importance had been a great support for making decisions in various fields especially in agriculture. The main aim of the study was to reach farmers for their awareness, usage and perception in E-Agriculture. The study used statistical survey design technique to collect data from farmers for their awareness in e-Commerce. The results of the study obtained and indicated the level of awareness was less such that there was a need for e-agriculture for their support. The study concluded that E-Agriculture was a platform for supporting marketing of agricultural products.

**Mathur and Goyal, (2014)**, investigated the application of agricultural knowledge was progressively important, particularly for small and marginal farmers, who require relevant information in order to improve, sustain, and diversify their farm enterprises. The study founded that how information technology was useful for decision making, improve planning and better produce of agro products and studied the key elements and basic issues of information technology in farm practice. The study concluded that the Information technology support new methods and ideas for precision and healthy agriculture like computerized farm, weather forecasting, use of pesticides, fertilizers, and kind of crops.

**Gandhi and Armstrong (2014)**, described an assessment of attitudes of farmers from the Lanja tehsil of Ratnagiri district of Maharashtra in order to understand the information seeking behavior and reasons for the farmers seeking that agricultural information through different sources. The study analysed that demographic data, educational qualification, family background, income range, land ownership, use of ICTs, source of getting information, belief on the sources of getting the information and the information required by the farmer. The study provided an insight into information needed to the villagers and their attitudes to whether the information may facilitate better decision making about their agricultural activities

**Chatterjee and Nath (2015)**, progressed the internet technologies, ICTs had a big impact on rural areas and rural lives especially in agricultural field there was significant role of ICTs in rural areas. The study investigated that how innovators were experimenting innovative ICTs initiatives solely for agricultural information and knowledge delivery. The study also made a systematic review of the role which ICTs could play in the development of rural areas in India. The study concluded that there was inequitable distribution of economic gains between the urban and the rural population was the gap in access to information.

**Derso and Ejiro (2015)**, assessed the contribution of information and communication technologies to the Ethiopian agricultural extension system and reviewed the recently developed agricultural knowledge systems in Ethiopia. The study was based on a systematic review of existing literature of agricultural knowledge management work in the country and focused on contribution of Information and Communication Technologies to the Ethiopian agricultural extension system. The study revealed that the various forms of Information and Communication technology had been used in agricultural service delivery and were more in tune with the circumstances and requirements of smallholder farmers.

**Abuja (2015)**, influenced the use of Information and Communication Technologies (ICTs) and the effect on the efficiency of maize marketing in North-Central Nigeria were analyzed; based on profit margins, factor effects and log it regression model. The Result of the study showed that age of marketers, education, regulatory bodies, market channels, marketing cost and ICTs significantly affect maize marketing efficiency; and that maize marketing was price efficient but operationally inefficient (ranging from 194.83 to 399.46 per cent). Sources of market information were extension agents (53 per cent), radio and television (53 per cent), mobile phones (47 per cent), video programs (30.5 per cent), and internet (25 per cent). The study concluded that the costs of mobile phones and air time, electricity, phone support services, internet services, radio and television network services, and literacy of marketers significantly influence the use of ICTs. The study recommended that use of mobile phones should be promoted for disseminating market information and market infrastructure should be improved.

**Pradhan, and Mohapatra, (2015)**, explored the potential contribution so far been attempted under the protection of e-agriculture or Information and Communication Technology (ICTs) to the livelihoods of farming community in India. Further, a general framework of the current state of the art wireless sensors network was given as a challenging technology for Indian farming community to monitor their crops from a remote place.

**Anbarasan (2016)**, e-velanmai was the enhanced version in satisfying the farmer agro technological information needs. The innovated technological boons like Computer, Internet, and Mobile would be helpful for the farmers to get consultancy for their farming issues from various eminent scientists. The study was conducted in Tamil Nadu State of India. Aliyar and Palarriver sub basins of Coimbatore and Tiruppur districts were selected and identified for knowing the effectiveness of e-velanmai. The study also evaluated as E-velanmai was an effective means to transfer agro technologies to farmers.

**Acharya (2017)**, highlighted some doable action points in the realm of implementation of agricultural prices and marketing policies that need emphasis by policy makers and development agencies in the country. The study reviewed that two important initiatives within the National Agricultural Research System (NARS) was presented along with the capacity that had been built in the country. The study also suggested on speed up of third phase of agricultural marketing reforms and outlined the progress on move towards National Agricultural Market (e-NAM) it brings out the issues related to farmers' demand for 'cost-plus formula' for decided the level of MSPs by the government and finally concluded that doable actions on the implementation of agricultural prices and marketing policies to enhance farmers' income.

**Pavithra et.al., (2018)**, analyzed the effectiveness and challenges of e-tendering marketing system focused on pigeon pea. The study indicated that e-tendering had been successful in reducing transaction time, bringing transparency in price discovery and increasing market revenue, besides enhancing market competition. The study found that system, however, had not been effectively implemented among all the markets because of traders' resistance. The study identified that factors behind the success of e-tendering in some markets and the lack thereof in others and provided certain key insights into obstacles in successful implementation of innovative marketing reforms with specific reference to the e-National Agricultural Market (e-NAM).

**Das (2018)**, examined sources of technological knowledge and their effect on farm output in India. The study found that farmers accessing information on technologies from several sources involved information and communication technologies (ICT). The study resulted that use of ICT however was limited to 21.8 per cent of households and had increased over time. The econometric analysis found that both use of ICT and non-ICTs differentiates farm output, but it was only the large farmers who realize more if they use ICTs. The study concluded that, small farmers get higher return if they had access to ICT as well as non-ICT sources of information.

**Bisen and Kumar (2018)**, reviewed the developments in Indian agricultural marketing and addressed the challenges in implementation of e-NAM to achieve the goal of doubling farmer's income; hence the challenge of poverty reduction as envisaged in SDGs. The study captured various challenges in the implementation of e-NAM in terms of 3 I's (Infrastructure, Institution and Information) and advocated for strengthening the back end of the supply chain with public-private interventions; amendment in state APMC Acts to

accommodate for e-tendering operations and wide publicity of benefited by e-NAM among farmers.

Agricultural and Development was a complex endeavor. ICTs Extension could'nt and should not be assumed to resolve the variety of agricultural and rural development problems, although it might serve in information coordination amongst relevant agencies. Enough ICTs initiatives have been pilot tested in Indian context, so far. There was a need to look beyond the pilot testing of ICTs to evolve the proper extension efforts that harness ICTs. For this, there was need to incorporate the ICTs into structural and functional components of the extension organizations (**Anbarasan, 2016**).

## **2.6 Problems of Agriculture sector**

The primary challenge confronted in Agriculture sector was the need for increased production with the increasing population and decreasing natural resources needed for production. The key factors that impact on this were the scarcity of water, declining of the soil fertility level, effects of climate changes and the decreasing fertile lands that were utilized in cultivation in the past, due to rapid urbanization. The major problems were faced by farmers were monsoon dependent, supply of inputs, market facilities, storage facilities, crop management and government policies. However, this rapidly growing demand and the need for high quality products provide opportunities for the improvement of the livelihood of the rural communities (**Narmilan, 2017**).

**Meena et.al., (2010)**, concentrated on wheat production in western states of India. The study was aimed to formulate an effective price policy food security and supply of factors and products, to relative prices and technological changes, applied new production theory used Trans log function model based on shepherd's duality theorem. The study resulted that all own-elasticity of factor demand had the correct signs, which was negative and the demand for machinery was influenced significantly by a change in the price of bullock labour and concluded that change in the wage rate of labour did not appear to influence machine labour demand significantly so the demand for labour was influenced much more by a change in the bullock labour prices than by a change in the wage rate and fertilizer prices since they were close substitutes for certain crop production activities.

**Gautam et.al., (2012)**, examined the technical, economic and allocative efficiency and identify their determinants. The study found that an increased cropped area had decreased the output. The study resulted that the coefficients of the labour inputs were larger than other inputs and revealed that mostly Indian agriculture were labour intensive. The result revealed

that the factor input prices (agricultural wage rate, price of seeds, price of fertilizer, rental rate of irrigation and rental rate of hired machinery) had increased the cost of production. The coefficient of quantity of output per acre was positively and significantly related to the cost of production. The coefficient of wage was a larger than other input prices. These results revealed that the labour cost increases more the cost of production.

**Singh, O.P., (2014)**, assessed the impact of electricity on groundwater use and water use efficiency. The study was confined to three Indian states viz., Uttar Pradesh, Bihar and Punjab. The state of Uttar Pradesh and Bihar, diesel pump owners were using less irrigation water for all the crops as compared to electric pump owners. The diesel pump owners were got the highest physical and economic water productivity for all the crops except paddy as compared to electric pump owners. The state of Punjab, farmers was used less groundwater for all the crops as compared to canal water. The physical water productivity was higher for all the crops grown underground water irrigation except bajra and barseem. The net economic value of water productivity was found higher for groundwater irrigated field in maize, bajra and wheat. The study suggested that the introduction of pro-rata pricing of electricity supply to farm sector could be the best option for better management of groundwater.

**Kumar et.al., (2014)**, concentrated on benefits of agricultural growth in India's richer states, leaving the poorer states lagging further behind. The agricultural economic growth in globalisation and economic liberalisation would reveal the implications for support for or withdrawal from economic reform and for further opening of the Indian economy. Evidence of absolute  $\beta$ -convergence in per hectare net state domestic product (NSDP) agricultural levels across Indian states revealed the tendency of states to converge to identical steady states level. Bernard Jones approach confirmed that convergence was conditional. Fertilizer, public finance, small-landholdings, cropping intensity, agricultural research and education, physical infrastructure, agricultural mechanization and diversification were the discerned factors for causing conditional convergence.

**Pattnaik and Shah, (2015)**, examined the major factors contributing to the agriculture growth performance in Gujarat and identified the factors by undertaken a decomposition analysis with reference to price, area, cropping pattern and yield. The decomposition analysis suggested that the individual effect of price alone had increased over time along with a reduction in the yield effect. The price-area interaction effect which was negative during the 1990<sup>s</sup> turned out to be positive in the recent phase. Similarly, the interaction of yield and price had become positive in the recent phase. The study implied

most of the crops for which there was substantial price increase showed favorable change in yield and area.

**Singh et.al., (2015)**, aimed higher infrastructure and agricultural research investment priority should be given to relatively backward states of eastern India, as the region stood had poor infrastructure and higher concentration of subsistence producers which make private sector hesitant to invest. Enhanced public investment was justified to strengthen infrastructure and also attract private investment leading to high pay offs as the region was well endowed with natural resources.

**Thakur Prasad Sharma Wagle (2016)**, investigated the logical relationship between production and expenditure as well as labour. The study was developed unorthodox model for production function in Nepal and also analyzed of the basic model used for estimation, estimates of elasticity of substitution equation on National agricultural panel data from economic survey (1983/84 – 2013/14) in averages. The study revealed that, sum of the regression coefficients was less than unity i.e., 0.976. So, system was less efficient or ‘diminishing return to scale. The study concluded that was less efficient trend of the agriculture production in developing country like Nepal.

**Madhura et.al., (2017)**, analyzed the rainfall induced risks in coffee production and mitigating strategies adopted by the coffee growers in Chickmagalore district, Karnataka. The study resulted that there was high variability in production of Robusta variety than of Arabica variety and mitigating strategy adopted against production risks by coffee farmers include sprinkler irrigation, and more use of nitrogenous fertilizers. The study concluded that use of crop insurance as the risk mitigating strategy was limited to a small proportion of farmers yet, the reward for risk taking by coffee growers was higher than the cost of mitigation.

**Srivastava et.al., (2017)**, examined economics of crop cultivation at the aggregate level over the past 25 years, identified sources of cost escalation and evaluated the effects of factor prices, substitution and technological effects on the production cost. The study revealed that a disproportionate change in gross return vis-à-vis cost resulted in varied rate of return from crop enterprise during the past 25 years. The study estimated negative and inelastic demand of inputs revealed a great scope to reduce the cost by keeping a check on input prices, particularly labour wages. The study recommended that there was necessary to accelerate appropriate farm mechanization through the development of farm machinery suitable and economical at small farms and improvement in its access through the custom hired.

**Debnath et.al., (2017)**, revealed that the judicious use of resources could enhance the income of rice growers through increase in productivity and saving of costs on unnecessary use of inputs in rice cultivation. The study examined that human labour, fertilizer and agrochemicals contribute positively to rice production. The study concluded that increase manure application in the hill region, whereas, use of fertilizers and agrochemicals should be increased as per recommended doses and machine labour should be used in a judicious manner in the valley region of the state. Since landholding size was very small in the state, use of machines like big tractor was not advised. The study recommended that the state government should provide necessary region-specific trainings and education to the farmers for judicious use of resources like fertilizers and agro-chemicals in rice cultivation.

**Das (2017)**, analysed the determinants of farm income by Simultaneous Quantile Regression Model (SQRM) and highlighted that contribution of farm income to double farmers' income would not be attainable without considered the variability of impact of different factors across farm income groups. The study result that loan outstanding per hectare and machinery hired inversely impact farm income at lower quantiles of agricultural households contrary to, insignificant or positive impacts on higher quantiles of farm income households. The study concluded that alternative sources of income had an immense role in the up gradation of the economic situation of the agricultural households, a frontal strategy to raise farm income would naturally had to took into account the determinants of this income of different groups of farmers, and in particular, strategies must target specific issues faced by low farm income groups.

**Mandal et.al., (2017)**, analyzed the past performance of agriculture sector in the state's economy from the available secondary data and also had looked into effectiveness of the existing price policy. Besides, technology options, agricultural market scenario/linkage had been analyzed through primary information from the most vulnerable group of farmers in the coastal region to understand how far doubling of income was achievable. The study found that micro-level households' data had indicated sufficient opportunities to increase farmers' income through enhanced cropping system intensification and technology options were also available for increased cropping intensities. The study had concluded that doubling of farmers' income in West Bengal was a challenging task, particularly due to low agricultural growth, lack of market innovations and private investment, but was achievable. The study recommended that the farmers in the state were not only to achieve higher (double) income for farmers but also to sustain the enhanced farmers' income which was inclusive across the farmers' groups.

**Bathlaa et.al., (2018)**, examined the effect of public investments on agricultural income inequalities across 17 major Indian states for the period 1981/82 to 2013/14 and for the pre- and post-liberalization periods. The study resulted that impact of conventional inputs and various types of public investments on income inequality was found to be significant but spending on education and health had larger adverse effects compared with spending on roads, energy, and irrigation over time and concluded that public investments should target roads, energy, irrigation, and agricultural research and development in the less-developed, more agriculture-dependent states to improve regional income equality, increase agricultural productivity, and alleviate rural poverty. The study recommended that marginal returns to each of these investments, in terms of reducing income inequality, were generally higher in the low-income, agriculture-dominant states, implying the potential benefit of a location-specific expenditure policy.

**Satyasai and Balanarayana (2018)**, examined the spatial and temporal patterns in the cost of production for major crops, its determinants and potential in enhancing farm incomes and also examined whether farm mechanization could help reducing the cost of production (COP) in agriculture. The study found that COP grew between 2004-05 and 2014-15 with mechanization but declined with increase in the human labour and yield. The study resulted higher level of use of farm machinery as revealed by the Input Surveys of the Ministry of Agriculture and Farmers Welfare, Government of India, might be inelastic substitution of machine use for human labour and incompatibility of the type of farm machinery along with the existing format of custom hiring with land holding structure. The study concluded that making available professional custom hire services that could ensure timely and dependable services through schemes like Custom Hire Centres (CHS) and start-ups might shape the future of farm mechanisation.

**Pandey (2018)**, examined the factors that were responsible for rural poverty; the relationship between poverty and inequality; and between poverty and debt-to-assets ratio among farm households in Bihar, one of the economically most backward states in India. They used primary data on consumption, income, and assets for the agricultural year 2010–11. The study applied logit model to empirically identify the factors responsible for poverty. The study found a strong positive, correlation between poverty and debt to- assets ratio, but not between inequality and poverty or any impact of inequality on poverty. The study concluded that poverty was more prevalent among the households having little access to land, livestock and other productive assets, low level of education, larger family size, and higher dependency ratio.

**Vatta et.al., (2018)**, used a nationally representative data-set and examined the sources of farmers' income and their determinants. The study found that middle income regions were more diversified relative to the poor and rich regions around 60 per cent of the total income was contributed by agricultural and allied activities and remaining comes from farm and non-farm wage including salaries and non-farm businesses. The study found that diversification was more prevalent in agro-climatically fragile regions characterised by greater risks to primary source of income and found to be higher in low-income regions with relatively better infrastructure. The study suggested the region-specific policies for sustenance of income generating activities for a smooth economic transformation.

**Kumari et.al., (2018)**, focused on this crop and found that, at national level, most of the inputs were used below optimum, and their usage could be increased to attain profit maximising yield, about 17 per cent higher than the existing yield. However, across states, existing use of resources was different than that at the national level and in Punjab, Haryana and Tamil Nadu the use of almost all inputs was more than optimum. The study revealed that seed accounts for 8.6 per cent of the cost of cultivation was overused in major rice growing states, namely Assam, West Bengal, and Chattisgarh, while fertilizer use was sub-optimal except in Chattisgarh, where human and animal labour together account for about 80 per cent of the total cost, and were found to be overused in most states. The study concluded that pathways for states that could be followed to attain optimality and overall, the optimum level of input use ensured 8.5 per cent higher farm profits.

**Pandey and Ranganathan (2018)**, examined the dynamics of land-use pattern in India with a focus on fallow lands. The study found that there were significant changes in the land-use pattern, and a continuous expansion of fallow lands in spite of increasing demand for land for agricultural and non-agricultural purposes. The study resulted that fallow lands were distributed across the country but had a greater concentration in the states of Bihar, Andhra Pradesh, Rajasthan, and Karnataka. The study concluded that changes in the temporal and spatial distribution of fallow lands were due to increasing variability in the precipitation and irrigation water, and low level of mechanization if these lands could be brought under cultivation would enhance agricultural production and food security of the poor and marginal farmers.

**Nithya et.al., (2019)**, described a survey conducted with 200 smallholder producers in Indian state of Karnataka and examined social capital formation in different networks of organic and conventional farming systems. The study determined the factors that motivate social capital (cognitive and structural) formation among organic and conventional farmers;

and then analyzed their social capital levels focusing on micro-level cognitive and structural capital. The study revealed a significant difference between both the two communities in respect of social trust, collective action, associated and satisfaction, and these make us to conclude that the organic farmers had a higher level of participation in different formal, informal and social organizations than do the conventional farmers. The study found that overall, the organic farming community was at a higher level of social capital compared to the conventional farming community, further, within the organic farming community those had higher social capital had effective market linkages than the farmers with lower social capital.

**Thorat and Sirohi (2019)**, delineated the extent of incidence of events that lead to occurrence of environmental, health and economic risks in two high risk prone regions viz. Vidarbha and Marathwada in Maharashtra. The study analyzed of various strategies that rural households adopt to avoid consumption shortfalls due to income shocks had been carried out empirically using the logit model based on a primary survey of 200 rural households in the region indicated that irregular rainfall along with pest and disease outbreaks before crop harvest were the main sources of environmental risks. The study concluded that in the distressed regions, effective social risk management strategies were imperative to improve the socio-economic status of rural households.

The agriculture sector faced by several problems like climate, input, labour, market facilities, profit etc. The farmers were mainly affected of climate change poses many threats; one of the important consequences was bringing about changes in the quality and quantity water resources and crop productivity. There was an urgent need for coordinated efforts to strengthen the research to asses' impact of climate change on agriculture, forests, animal husbandry, aquatic life and other living beings.

## **2.7 Other Related Studies**

Agricultural sector plays a strategic role in the process of economic development of a country. It had already made a significant contribution to the economic prosperity of advanced countries and its role in the economic development of less developed countries was of vital importance.

- By providing food and raw material to non-agricultural sectors of the economy,
- By creating demand for goods produced in non-agricultural sectors, by the rural people on the strength of the purchasing power, earned by them on selling the marketable surplus,

- By providing investable surplus in the form of savings and taxes to be invested in non-agricultural sector,
  - By earning valuable foreign exchange through the export of agricultural products,
  - Providing employment to a vast army of uneducated, backward and unskilled labour.
- As a matter of fact, if the process of economic development was to be initiated and made self-sustaining, it must begin for agricultural sector.

**Rakesh et.al., (2009)**, investigated the importance of realistic representation of land surface in a regional model for simulating the meteorological features associated with the southwest monsoon. The study conducted the impact of satellite derived land surface data such as vegetation fraction, vegetation type (both derived from SPOT VEGETATION) and surface soil moisture (derived from SSM/I) on MM5 simulated meteorological fields for the contrasting Indian summer monsoon years 1998 and 2002. The study found that incorporation of satellite derived land surface data in the MM5 initial condition improved the simulations both in 1998 and 2002 monsoon season, but improvement was not significant when the satellite derived land surface parameters individually incorporated in the model initial condition.

**Ghabru et.al., (2017)**, estimated agricultural sustainability in Gujarat by computing Sustainable Livelihood Security Index (SLSI) for 26 districts of the state used secondary data on various indicators under the ecology, economy and equity headed for the years 2001, 2011 and TE 2013-14. The study had found that in the year 2001, the district Surat (0.584) ranked first in SLSI, while Narmada (0.265) ranked the last. Later in the year 2011, Rajkot (0.589) ranked highest in SLSI, while Porbandar (0.257) ranked the lowest. During the TE 2013-14 two the districts Rajkot and Porbandar maintained their first and last ranks. The study had suggested some measures for agricultural sustainability in the state to overcome the government should focus on dissemination of micro-irrigation, high-value crops, market institutions and extension and information service institutions.

**Chouhan et.al., (2017)**, analyzed the impact of Soil Health Card Scheme on farmers' income and studied the economics of cultivation of three major kharif crops paddy, soybean and maize in Madhya Pradesh. The study data were collected from 30 soil tested farmers/beneficiaries before and after application of recommended doses of fertilizers (RDF). The study found that yield of paddy, soybean and maize increased by 19.42 per cent, 13.79 per cent and 9.6 per cent, respectively after adoption of RDF. The net income per acre increased from 11231 to 17385 (54.8 per cent) in paddy, from 6696 to 11228 (67.7 per cent)

in soybean and from 3380 to 8105 (139.8 per cent) in maize after soil tested by the farmers. The BC ratio increased from 1.5 to 1.7 in paddy, from 1.6 to 2.0 in soybean and from 1.4 to 1.9 in maize on adoption of RDF by the farmers. The study concluded that soil health card scheme was found highly beneficial to the farmers in term of increasing their income. The study recommended that there was a need to generate awareness about the benefits of the scheme among the farmers on one hand and strengthening of soil testing services / laboratories on the other hand for a wider adoption of RDF.

**Sharma et.al., (2017)**, assessed trends, issues and prospects of Nepal-India agricultural trade and revealed the comparative advantage, trade complementarity index and indicative trade potential had been estimated to understand the performance and prospects of Nepal's agricultural trade with India. The study resulted that depicted a high comparative advantage for most of the exported agricultural items from Nepal with almost perfect complementarity in the agricultural export profiles of both India and Nepal. The study concluded that Nepal's export potential in the Indian market was not very encouraged, and in most cases the binding constraint to trade potential of Nepal was its limited export capacity and not the lack of opportunities in the Indian market.

**Sharma (2018)**, verified US claim about the extent of domestic support in China and examined the policy space available for product-specific support in China and India. The study found that as against the claim of product-specific support of more than US\$100 billion it is just US\$17 billion. The study also highlighted different aspects of food security, domestic support in US and the need for a level-playing field in international trade.

**Parikh et.al., (2018)**, explored till 2040 the role of technical change in agriculture, irrigation and concern for food security in rapid economic growth in India. India aspires to achieve double-digit growth. For a densely populated country of 1.2 billion people with growing incomes meeting its increasing and diversifying food needs would be a challenge.

**Manjunatha et.al., (2018)**, addressed the impact of Varuna Mitra from 1350 sample farmers distributed across nine districts of high, moderate and low rainfall regions where the data were collected with and without information from farmers for 2016-17 examined the impact of the service. They found to have increased at an annual rate of 61.55 per cent from 6,565 in 2011 to 10.42 lakh in 2016. The study indicated a reduction in the cost of cultivation and post-harvest losses, improvement in the crop yields and net incomes. The study concluded that farmers could realise incremental net gain of Rs 5,106 per acre from the forecast and Rs 18,005 in terms of per capita income.

**Kishore et.al., (2018)**, aimed to map agricultural policies and programmes, with components of climate smart agriculture, implemented by the Government of India (GoI). The study analysed that the GoI had been spending 15 per cent of the total expenditure for agriculture towards enhancing resilience on agriculture to climate change, this expenditure had been made through micro-irrigation, watershed development and conservation agriculture under National Food Security Mission (NFSM), National Mission for Sustainable Agriculture (NMSA), National Horticulture Mission (NHM), Rasthrya Krishi Vikas Yojana (RKVY), crop insurance, neem coated urea, and weather advisory systems. The study argued that the increase in public expenditure would also attract significant additional investments from farmers, private sectors and state governments. The study concluded that large resource commitment by the central and state governments and the farmers of India would had a greater impact on agrarian economy and environment only if there was a greater convergence among different programs.

**Swain et.al., (2018)**, analyzed gender inequality in the rural labour market in Odisha in comparison to the agriculturally advanced state of Punjab and all India. The study used data from Reports on Employment and Unemployment in India published by the National Sample Survey Office over the period from 1972-73 to 2011-12. The study found that even with agricultural development and technological change, gender-based wage differential persists and there was a need to reduce the wage disparity between male and female by enforcing the laws and regulations on equal paid for equal work. The study recommended that planners, policy makers and development practitioners in India were required to formulate appropriate policies, programmes and strategies for generation of additional employment for females and removing gender-disparity in work allocation and wage payment in rural labour market.

**Dkhar and Kumar De (2018)**, assessed the impact of government expenditure on agriculture and allied activities on economic growth (GSDP) in Meghalaya during the period 1984-85 to 2013-14. The study found that there was significant positive impact of agricultural expenditure on crop husbandry on GSDP growth and on the other hand, the impact of public expenditure on forestry, dairy and irrigation was found out to be negative. The study concluded that although crop husbandry happens to have a significant positive impact of economic growth, the need for strengthening its linkages with other sectors could not be undermined given the small and declining size of landholdings in the state.

**Murlidhar et.al., (2018)**, examined export competitiveness of Indian groundnut during the period 1996-97 to 2013-14 using PAM. The study resulted that export of

groundnut from India was highly competitive and had great potential in international market. The study also measured values of NPC, EPC and ESC had been less than unity throughout the period where DRCR also remains below unity pointed towards efficient utilization of domestic resources in groundnut cultivation. The study found that positive social profit all through the years revealed social welfare gain and groundnut export was found generating resources to the Indian economy as the measured total policy transfer was negative.

**Kumara et.al., (2019)**, identified determinants of farmers' participation in contract farming of paddy seed and its impact on farm income used survey data from 502 farmers engaged in paddy seed production in Nepal. The study resulted that contract farming enhances profits for paddy seed cultivators and participation in it was influenced by farm size and main occupation of the cultivators and concluded that empirical evidence on benefits from contract farming needed for conducive policies for promotion and up scaling of contract farming for augmenting seed production.

**Nanda et.al., (2019)**, assessed the importance of non-farm activities and identified factors that influence farm households' participation in these activities in the Indian state of Jammu and Kashmir on the based on survey of 630 farm households in 2016-2017. The study analyzed participation of farm households in non-farm activities in Jammu and Kashmir state of India. The study found that nonfarm activities were categorized into different types, namely, non-farm labour, government services, private job, business, skilled labour, daily wage labour, and paying guests and others. The study indicated that non-farm labour was the most common non-farm activity, while the government service was the second-most important activity. The study concluded that education had significant influence on participation in nonfarm activities furthermore; the households with large family size were involved more in non-farm activities.

**Thingbaijam et.al., (2019)**, examined the gender dimensions in agriculture utilizing data from a survey of 120 households distributed over two valley districts in Indian state of Manipur. The study indicated that the remains crop-specificity, operation-specificity and source-specificity in labour use by gender. The study resulted that females were found to be dominant in non-traditional crops (e.g., tomato, mustard and peas) and female-managed households also hire more of females. Important operations like sowing, harvesting and weeding were mostly performed by female labourers and female-employers. The study concluded that increased cropping intensity by bringing more and more non-cereal crops in the cropping system favours engagement of more female labourers which might be helpful

both in crop diversification and in enhancing farm income and farm mechanization had a positive influence on female employment.

### **Conclusion**

Agricultural development was a must for the economic development of a country. Even developed countries lay emphases on agricultural development. “Agricultural progress was essential to provide food for growing non-agricultural labour force, raw materials for industrial production and saving and tax revenue to support development of the rest of the economy, to earn foreign exchange and to provide a growing market for domestic manufactures.”

The various studies enumerated above various dimensions of impact climate change on agriculture the literature reviewed in depth of the study, the researcher found that they had not focused in farm level. This gap is concentrated by the researcher to analyze the climate change and crop diversification in selected farm households.