

**CLIMATE CHANGE AND FOOD SECURITY NEXUS FROM INDIAN PERSPECTIVES: A
SYSTEMATIC REVIEW**

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Abstract

The issue of 'Climate change' is no longer an environmental problem of concern per se but has various entangled dimensions to it. Climate change is a matter of significant concern among all over the countries of the world because it has the potential to make vulnerable life on the earth. Similarly, there is a scientific consensus on the issue of climate change expecting to have significant impacts on agriculture and food security. Achieving food security in a scenario of climate change and degrading natural resources seems to be a big challenge. Climate change in the recent past has resulted in higher intensity and frequency of floods and droughts, making the objective of achieving food security very complex. Climate change effects have already started impacting on agricultural production in several agro-climatic regions of India and added to the enormity of country's food security challenges. Climate change affects food grain productivity and this reason along with other socioeconomic and government policy variables affect food security. Though the relationship between climate change and food security is complex, most of the studies focus on one element of food security, i.e., availability. This present paper provides an overview of the impact of climate change on food security in India, keeping in mind main three dimensions- food availability, accessibility and utilization. Given this background, present paper reviews the issue of food security in the Indian context and the imminent crisis that awaits us.

Key words: Climate change, Agriculture, Food security, Foodgrains production, Availability.

1. Introduction

The earth's climate has noticeably changed on both global and local scales since the pre-industrial era due to anthropogenic activities. However, the problem of climate change is not a new phenomenon in the world. The increase in temperature of the earth surface and in atmosphere, variability in rainfall, diminishing ground water levels, flooding due to high precipitation, drought, soil erosion, rising sea level due to melting of glacier, heavy wind, cyclone, wind speed, fog, hail storm, landslide and earthquake etc., are all the perfect evidences of climate change phenomenon (Kumar & Sharma, 2013). There are many empirical evidences across countries where rise in the possibilities of climate change due to population growth, rapid urbanisation, use of modern technology, higher industrialisation, innovation, high economic development, building construction, transport, decline in forest area etc. are witnessed (Ahmad et al., 2011).

Climate change has positive impact on agricultural productivity or crop yield in mid, high latitude and developed countries, and on the other hand, lower-latitude and developing countries experience a negative effect on agricultural productivity. On the other hand, low income countries are the most vulnerable compared to developed countries. There are various reasons which increase the vulnerabilities for low income countries like less technological development, scarcity of resources to mitigate the adverse impacts of climate change on agriculture; and due to their larger dependence on agriculture for livelihood of huge populations (Nath and Behera, 2011). This may increase the severity of disparities in cereal productivity between developing and developed countries. Seasonal patterns, trends of rainfall and temperature constitute the important components of agrarian production systems in India.

It is projected that India will face a rise in the mean surface temperature by 2^o C to 4^o C coupled with the reduction in the number of rainy days and also an increase in the frequency and intensity of extreme precipitation events (Ranuzzi & Srivastava 2012). Approximately 60 percent of India's total agriculture regions are rain-fed and consequently are largely vulnerable to climate change effects all through the wet season. This burning concern of climate change has posed severe question marks on major crops production in particular foodgrains. Several research studies have already assessed bigger losses in the Rabi season as compared to the Kharif season (Jayaraman & Murari, 2014). This in turn increases the severity of disparities in cereal productivity between the developing and developed countries. India has been experience fast gross domestic production (GDP) growth which created the great opportunity to improvement of the developmental indicators comprising food security but in reality the results are much lower than expectations. There is a scientific consent on climate change having significant impacts on food security. In this background, the present study reviews the issue of food security with the help of empirical evidences. In addition, it comprehensively examines the impacts of climate change on agricultural yield, food crops production systems and food security scenario in India.

1.1. Impacts of Climate Change

Climate and its change impact all sectors of economy in different ways like abnormal rainfall, results in frequency and intensity of floods. Any percentage increase in maximum temperature perhaps increase average sea levels and it would affect large populations in coastal and peninsular areas. It may increase 15 to 40 percent precipitation there and increase the annual mean temperature by 3^o C to 6^o C degree. Climate variability adversely affects the food security in all countries through agricultural production. Climate change affects to food security is in four ways, food availability, food accessibility, food system stability and food utilisation. It will also have an impact on ecology, living creature, livelihood assets, human health and food production & distribution channels. Due to increasing global population, climate change will challenge agriculture production and food security (place of production, quality, supply, volume) and by 2080, agricultural output in Less Developed Countries (LDCs) may decrease by 20 percent due to climate change and productivity could decline by 15 percent around, while output in developed

countries is likely to decline by 6 percent (Masters et al., 2010). Climate change will affect almost 200 million people and their households worldwide who live by aquaculture and fishing (Greg et al., 2011). In India, gross domestic product may decline up to 6 percent and agriculture productivity may decrease up to 24 percent by 2080 due to climate change (Zhai et al., 2009).

1.2. Food Security and its Components

In the literature on concepts of food security, there are more than 200 definitions about food security and its determinants are available (Hoddinott, 2009). For first time, the concept of food security appeared in the conference of United Nations 'Food and Agriculture Organization' (FAO), World Food Conference in 1974; where availability of the food was considered the only component of food security. Later, in the year of 1986, World Bank has defined food security as "access by all people at all times to enough food for an active and healthy life" and this new definition has incorporated only two parameters of food security like accessibility and availability of food. In 1996, FAO has defined food security as situation where "all the members of the society have access to the food according to their needs, either from their own production, or from the market or from transfer mechanism of the government." This definition has incorporated three parameters of availability, accessibility and utilisation of food. Among these, FAO's definition in 2002 is worth Stating. In 2002, FAO has given a new definition for food security as the situation when "all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life." Shakeel et al. (2012) has mentioned that due to lack of accurate estimation of food security, the quantity of food availability in a specific period of time and a particular place for consumption of the people reveals the food security; that is a function of domestic agriculture production or through imports from excess areas. Dev and Sharma (2010) have also defined the food security at the national level that principally refers to availability in the country of adequate stocks of food to come across domestic demand, either through national supply or through imports. Planning Commission of India (Government of India) also has defined food security as a situation where "everyone has access, at all time, to food needed for an active and healthy life".

Now food security includes four major components like availability, accessibility, stability and utilisation of food. Availability of food point out the physical presence of food or national production of foodgrain from agricultural or allied sector in a particular area or region in certain period and with given local and international trade, technology inventory levels, commercial imports or food aid; and this primarily focuses on food production (ADB, 2012). The food accessibility refers to having to acquire sufficient amounts of food through production and purchase, stocks, gifts, aid and borrowing, and this interlinks with the ability of people to attain food, either through production, transfers or purchase; this components of food security is directly associated with economic capacity of the population to afford the appropriate food for their survival. Food stability is the situation where food is periodically and regularly available in domestic market so that it also contributes to the nutritional security and this comprises the

impact of weather extremes like floods and droughts on crop productivity; and this particularly focuses on continuity of supply and demand of foodgrain products (FAO, 2009). Last component of food security namely utilisation of food is defined as a situation when a household's ability to absorb and metabolize the appropriate nutritional content of the food consumed and nutrients; and ability of the body to use it well. Utilisation of food is principally associated with nutritional significance of food, interaction with physiological condition and food security; and this offers the quality, safety and also actual nutrition substances in the consumed food.

2. Search Strategy

A narrative and comprehensive literature review was effectively carried out from peer reviewed literatures, working papers, conference & seminar papers and reports from recognized organizations associated to climate change and food security nexus in the Indian context. To include only up-to-date information, a maximum time frame of 20 years has been positioned on the age of the works to be included in this particular review. In a nutshell, the full text documents were reviewed to evaluate the relevance of the papers for this review.

3. Climate Change and Food Security Nexus

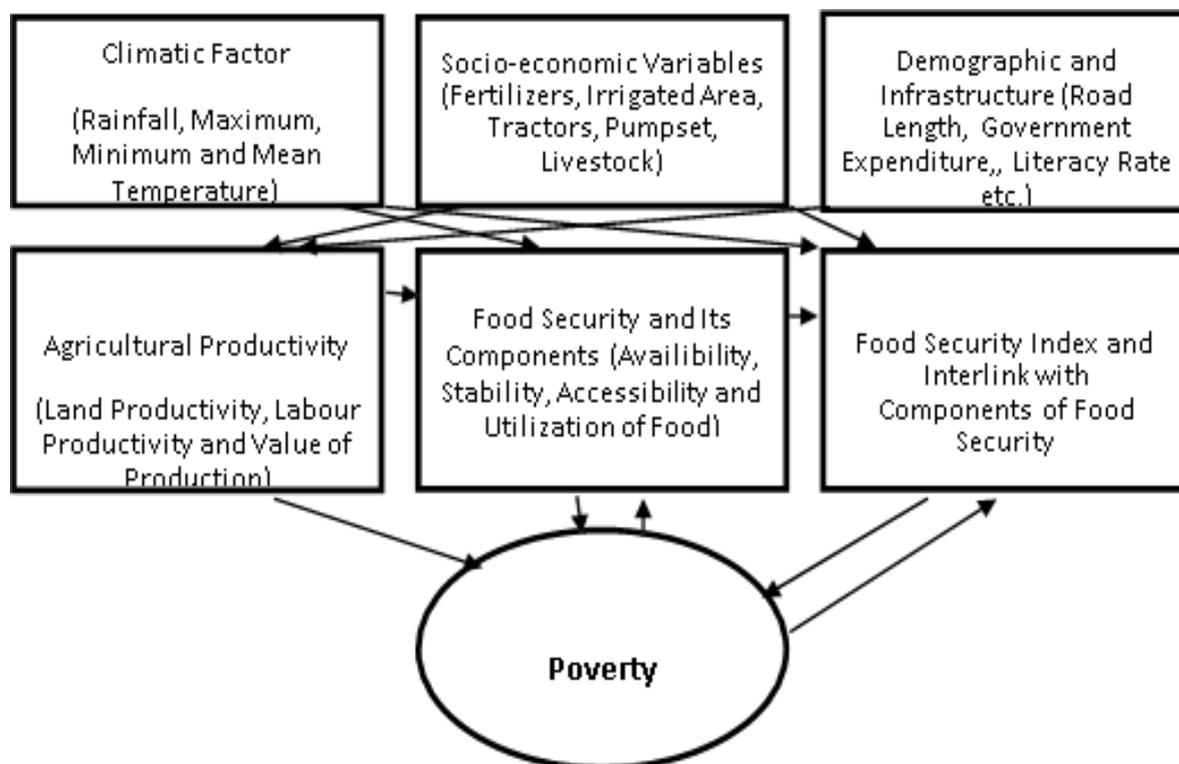
Food security is directly associated to climate change because any variability in climatic factors may directly affect a country's ability to feed its public (Ahmad et al., 2011). Climate change affects all the components of food security (FAO, 2008). Availability of foodgrains is directly get affect by climate change through its impact on agricultural productivity and production. Climate change has a negative impact on the crop yields, diseases and crop pests and soil fertility. It is also get affect by climate change ultimately via its impact on economic growth, agricultural demand and income distribution. Stability of crop yields, food, and food supplied is adversely affected due to any variability in climatic factors (Greg et al., 2011). Perhaps, it also negatively affects the economic capacity of people to access the food due to any percentage increase in food prices (Greg et al., 2011). The utilisation of food also would be negatively affects by climate change, it diminishes real nutritional content of food; and it possible to increase the various health problems. Overall impact of climate change may be decrease in agricultural production, productivity and employment opportunities of people resulting it would be severe threat for food insecurity, hunger, malnutrition and poverty in any region.

3.1 Climate Change, Agricultural Productivity and Food Security: Empirical Review

Any variability in agricultural crop productivity anchored in great variation in environmental and weather factors such as temperature, precipitation and other socio-economic factors presented in figure 1 unequivocally affects food security. Generally, food security directly gets affected due to any instability or variability in agricultural productivity. It is a multi-processing, complex and multidimensional phenomenon in the world. It includes interaction of several components of economy and it indirectly and directly gets affected by a lot of variables in economy like age, gender,

occupation, income level of the people; growing demand of foodgrain products due to increasing population; going up price of foodgrains, vegetarian as well as non-vegetarian diet; rising cost of cultivation, low yield of crops, degradation of arable area and diminishing ground water level; and less education level of farmers; and climate change and its variability (Shakeel et al., 2012). The variation in weather factors such as rainfall, temperature and others get affect to crop growth adversely and certain crops get affected positively due to change in these climatic variables. Thus changes in climatic factors may have negative and positive impact on agricultural productivity and food security position in the economy (Greg et al., 2011).

Figure 1: Interlinkage between climatic and non-climatic variables on agricultural production, food security and poverty.



The interrelationship between climate and non-climate variables and its impact on agricultural yield, food security and poverty has been displayed in figure 1. The association between climate change, agricultural output and food security, adverse implications for agricultural productivity would increase incidence of extra poverty, which in turn is familiarly linked to hunger. Therefore, farming productivity is an important factor of food security which is in turn an essential part of poverty eradication and hunger. Climate change and poverty are interrelated in several ways, for example, if temperature increase then the warmer climate perhaps increase the spread of illnesses like malaria and tuberculosis; and it can increase additional burden on poor people consequentially leading to an increase in poverty. Higher differences in rainfall patterns such as flooding or drought may damage households' assets and agricultural crops leading to an increase in poverty; and perhaps it will be a serious threat to food security in agrarian intensive countries. Usually speaking, agricultural yield, food security and poverty have a joint relationship (Goswami

et al., 2010).

Climate change, agricultural yield, food security, poverty and undernourishment, these all are directly associated to each other and strongly correlated as well. Agricultural sector is very important sector that may lessen poverty in various ways (Goswami et al., 2010) like increase in agricultural productivity directly generate more employment opportunities and improve the level of food security. Adverse implications for agricultural productivity might be increase the incidence of more poverty, which in turn is closely related with hunger. Therefore, agricultural productivity is a significant constituent of food security which is an important part of poverty eradication and hunger. Without achieving food security, poverty may turn out to be vicious cycle; and shortage of food security is thus both cause and effect on poverty (ADB, 2012).

3.2 Indian context

In India, copious studies have specified empirical evidence that climate change has caused decrease in the agricultural productivity. Most of the works examined economic impact of climate change on agriculture sector and few studies incorporated food security with agricultural productivity. The first systematic and scientific study by Kumar and Parikh (2001), they presented for wheat and rice crop that expected large scale changes in the weather would lead to substantial reductions in their crop yields, which in turn would unfavorably affect agricultural production by 2060 and also may affect the food security of more than 1.3 billion people in India. Kumar et al. (2011) have stated that reduction in irrigated area for wheat, mustard and maize in coastal regions and northeastern; and for rice, maize and sorghum in Western Ghats of India may cause loss of agricultural production due to climate change. Hundal et al. (2007) concluded that a raise in minimum temperature up to 1.0 to 3.0 degrees Celsius above threshold level has led to reduction in productivity of wheat and rice by 10 percent and 3 percent respectively in Punjab. Kaul & Ram (2009) found that extreme rainfall events and extreme deviation in temperature has harmfully affected the productivity and output of Jowar crop, thus this has affected the livelihood as well as food security of farming households in Karnataka, India. Geethalakshmi et al. (2011) have revealed that productivity of paddy crop has decreased up to 41 percent with 40^o C increase in mean temperature in Tamil Nadu. Saseendran et al. (2000) studied the projected results for duration from 1980 to 2049; found that percentage increase in temperature up to 50^o C may lead to continuous reduction in the productivity of rice and further, every one degree raise of temperature will lead up to 6 percent decrease in yield in Kerala, India.

Kapur et al. (2009) stated that any shift in precipitation and temperature may decline crop productivity by 30 percent by the mid-21st century which would lead to a decrease in arable land and as a consequence affect agricultural output severely. With the climate change farmers have shifted and shortened crop duration in principal crops rice, wheat and sugarcane, and it has considerably affected crops productivity. The impact of precipitation is insignificant for sugarcane crop production. Srivastava et al. (2010) have found that climate change would reduce monsoon sorghum productivity up to 14 percent in central-zone and up to 2 percent in south-central zone

by 2020; and also this model advocated that yields are expected to be affected even more in 2050 & 2080; climate change impacts on winter crops are likely to reduce yields up to 7 percent, 11 percent and 32 percent by 2020, 2050 and 2080 respectively in India.

Further, Asha et al. (2012) revealed that the productivity of sorghum, maize, pigeon pea, groundnut, wheat, onion and cotton has declined up to 43.03, 14.09, 28.23, 34.09, 48.68, 29.56 and 59.96 kg per hectare respectively in mainly rainfed area; they also indicated that almost 100 percent and 92.2 percent small and medium farmers respectively stated that the reduction in the precipitation was the main reason for decrease in the productivity levels over the period followed by the disease and pest to the extent of 72.2 percent; and changes in temperature and seasonal patterns were mentioned as the reason for the decline in the yield by 42.2 percent of the sample households in Dharwad district in Karnataka, India. CROPGRO Soybean model shows that the mean water non-limiting potential of the soybean crop across locations was 3020 kilograms per hectare, while water limiting potential was 2170 kilograms per hectare that is indicating a 28 percent decline in yield due to adverse soil moisture conditions; and actual yield was just 1000 kg per hectare which was 2020 and 1170 kg per hectare less than the water non-limiting potential and water limiting potential of soybean in India, respectively (Bhatia et al., 2008).

Kumar and Sharma, (2013) estimated the impact of climatic as well as non-climatic factors on foodgrains productivity to assist the development of proper agricultural policies to adapt with climate change. Cobb-Douglas production function for rice, wheat, barley and gram, crops for a panel of 13 major states have been employed from 1980 to 2009. They advocate that the agricultural yield in India is sensitive to climate change which is negatively affecting the foodgrains output and it would become a severe threat to food security in India based on the construction of a Food Security Index by incorporating all the four components of food security. Jayaraman & Murari, (2014) examined some of the results with respect to present and future patterns in temperature and precipitation in India, the two most important climate elements for agriculture using data during 1850-2010 from the Indian Meteorological Department. The results of the revealed that regionally, the temperature has fluctuated between 0.5°-1°C. Moreover, empirical results presented that the climatic factors have a significant impact on the yield of most crops but this effect differs across crops. The yield of wheat, rice, maize, ragi and sorghum crops has been adversely influenced with a raise in the average maximum temperature.

From the above literature review shows that climate change adversely affects the foodgrains productivity and production in India. Most research works empirically investigated the impact of climate change on agricultural yield based on single crop or two to three crops and restrained to one state, region and country. However, assessment of the overall effect of climate change on major foodgrain crops are essential empirical question because food security is not only a function of foodgrain crops. There are many other factors which may affect the level of food security including production of cash crops, geographical region, income of the people, availability of drinking water, level of employment, education level, reduction in cultivated land, rapid urbanization, higher

population growth, lack of foodgrains market and number of livestock etc. Therefore, climate change, agriculture productivity, food security, and hunger and poverty; and these all are directly associated to each other (Hollaender, 2010).

4. Conclusion and Future Research Possibilities

Climate change is important concern in Indian context because its impact is strongly felt on agricultural productivity and food security. The productivity levels of wheat and rice have severely declined after 1980 and are far lower than the global standards. The empirical review of literature shows that the food security components are greatly correlated. From these review, several conclusions might be drawn. To roughly summarise, an increase in rainfall coupled with mean and maximum temperature has a significant negative impact on the food security index and the four components of food security. There exists a bi-directional causality between food insecurity and poverty in the Indian context. In line with the empirical outcome findings of other studies for foodgrain crops the analysis revealed in this study also show that any increase in mean and maximum temperature has adverse impact on rice, maize, jowar, bajra and barley productivity and the impact is also statistically significant (Geethalakshmi et al., 2011). Ragi and gram productivity also get adversely affected due to raise in maximum temperature, while wheat and arhar productivity is positively affected due to raise in maximum temperature. Arhar, wheat, maize and gram productivity is adversely affected due to raise in minimum temperature (Kumar and Parikh, 2001). Any percentage increase in rainfall has an adverse relationship with rice, maize, barley and ragi productivity. Increase in irrigated areas and use of fertilisers are an important factor to increase the productivity of rice, wheat, bajra, jowar and, arhar. Based on empirical results, various suggestions could be drawn to increase the level of food security in India for example cropping intensity may enhance crop rotation resulting in more foodgrains production which may generate a repercussion effect by bringing in more employment prospects. Furthermore, it should be noted that there is a research gap relating to the problem of foodgrains price inflation and economic growth in the context of climate change and also how targeted decision making should take place.

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