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Impact of Climate Change on Agricultural Production: A Literature Review

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Abstract: *Climate change refers to a significant change in the measures of climate such as in temperature, rainfall, snow or wind patterns lasting for decades or longer. Climate change is real and happening. Its impacts are felt all over the world. The climate changes will have serious implications for a number of sectors such as agriculture, water availability and quality and aquatic ecosystems. This article provides an overview of the various studies concerning the impacts of climate change on agriculture. The vulnerability of the agricultural sector to climate change is well established in the literature. This article is produced by referring various climate change impact studies conducted worldwide. Assessment of the impacts of climate change on agriculture is imperative to increase agricultural production.*

Key Words: *Agricultural Production, Climate Change, Impacts, Impact Assessment.*

1. INTRODUCTION:

'Climate change' means a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods (UNFCC, 2007). The economic impacts of climatic change on agriculture continues to be a hotly debated research problem. More than sixty percent of Indian population is dependent on agriculture, a climate sensitive occupation. The impact of climatic change on agriculture assume significant importance for India. Climatic change impacts are increasing over time indicating increasing climate sensitivity of Indian agriculture. The predicted climatic change indicates an overall increase in temperature by 2-4 degree Celsius, increase in precipitation, and drop in yield of food crops, reduced water quality, increased soil erosion, reduced rainfall, and change in atmospheric CO2 etc. This will have direct and indirect impacts on agricultural production. Indiscriminate use of pesticides, weedicides are largely impacting greenhouse gas emission. Some regions may experience losses in agricultural productivity, while others may become more productive due to a changing climate. The agricultural sector is already threatened by limited availability of water resources, land degradation, biodiversity loss and air pollution and the changing climate conditions make it even worse. But changes in temperature and precipitation will not be uniformly distributed over the earth.

2. CLIMATE CHANGE AND ITS IMPACT ON AGRICULTURE: GLOBAL LEVEL STUDIES:

Various studies have examined the potential economic effects of global climatic change at the global level. Rosenzweig (1993) linked the results of climate models, crop yield simulation models and a computable general equilibrium world trade model to simulate potential economic effects of climate change. The authors simulated different climate change scenarios, CO2 fertilization and adaptation assumptions. The findings of this study were sensitive to assumptions regarding CO2 fertilization and potential adaptation. In the 'no CO2 fertilization' and 'no adaptation scenario', climate change reduced world grain production by 20 percent under the worst climate change scenario. On the other hand global grain production was predicted to decrease by 5 percent with CO2 fertilization and modest levels of adaptation. The economic model used by Rosenzweig (1993) predicted that commodity prices could rise substantially. The combination of decreased production by developing countries and increased prices due to climate change would increase the number of people at risk of hunger.

Reilly (1993) used a partial equilibrium world trade model called SWOPSIM (Static World Policy Simulation) along with the crop yield results of Rosenzweig (1993) to determine the economic impacts of climate change. Unlike Rosenzweig's economic model, SWOPSIM can summarize the economic impacts of climatic change into changes in country's welfare, as well as changes in prices and production.

Darwin (1995) used monthly mean temperature and precipitation levels from four global general circulation models (GCMs) to examine impacts on regional and world agriculture. The general findings of the Darwin (1995) study regarding global agriculture are; first, even with extensive on-farm adaptation, global climate change would likely to reduce productivity of existing agriculture land worldwide. Second, there would be regional gainers and losers due to climate change. For example, production of wheat, other grains, livestock and forestry products were found to increase in Canada, but found to decrease in Southeast Asia under the climate change scenarios. Third, farmers will respond to climate change by such adaptation strategies as using new inputs and outputs more suitable to the new climate, and by expanding into new areas.

David B. Lobell, Wolfram Schlenker, Justin Costa-Roberts (2011) explained how climatic change will affect future food availability. They found that in the cropping regions and growing seasons of most countries, except United States, temperature trends from 1980 to 2008 exceeded one standard deviation of historic year-to-year variability. Models that link yields of the four largest commodity crops to weather indicate that global maize and wheat production declined by 3.8 and 5.5%, respectively, relative to a counterfactual without climate trends.

A number of studies have looked at the potential effects of climate change on U.S agriculture. In one of the first studies, Adams (1990) analyzed the potential effects of climate change on regional comparative advantage in U.S agriculture. As in the study by Rosenzweig (1993), Adams (1990) generated separate yield impacts due to climate change with and without CO2 fertilization. Not surprisingly, the crop yield results were substantially different between the two climate scenarios, as well as between the CO2 scenarios. The negative impacts of climate change on crop yield under the two climate change situations were substantially mitigated and in some cases, yields actually increased under the co2 fertilization scenario. Using the yield results with a sector level mathematical programming model of the United States, Adams (1990) simulated the impact of the two climate change scenarios on prices, regional and national production, consumption, consumer and producer surplus and other market variables. The economic results also varied tremendously in magnitude and even direction among the various scenarios. Kaiser (1994) examined the potential agronomic and economic impacts of several climate change scenarios on grain farming in the United States. The analysis was based on a protocol that links climatic, agronomic, and economic models to form an integrated model. Three climate scenarios were investigated for their relative impacts on crop yields, cropping pattern and farm level productivity.

3. CLIMATE CHANGE AND INDIAN AGRICULTURE:

Many studies in the past have shown that India is likely to witness highest agricultural productivity losses in the world in accordance with the climate change pattern observed and scenarios projected. Climate change projections made up to 2100 for India indicate an overall increase in temperature by 2-4 degree Celsius (Kavi Kumar, 2010). Kumar and Parikh (1996) focuses on assessment of the climate change impacts on Indian agriculture, physical impact assessment and the economic implications of such physical impacts. Mckinsey and Evenson (1998) estimated the impact of a rise in normal temperatures and of increases in rainfall levels for different regions. The study incorporates technology–climate interactions enabling an assessment of the climate friendliness of the green revolution in Indian Agriculture.

The sensitivity of Indian agriculture to rainfall is both well-known and well established (Gadgil and Kumar 2006) particularly the conclusions with regard to the dependence of paddy cultivation on monsoon rainfall in India. There are some interesting observations with respect to the sensitivity of Indian agricultural production to temperature variability. Using data from the States of Punjab, Haryana, and Uttar Pradesh over the period 2000–09 Lobell *et al.* (2012) have analysed the impact of temperature variability on wheat production in India. They show that the number of days that the crop is exposed to temperatures higher than 34°C has a significant effect on the length of the growing season of the crop. In particular, the number of days the crop is exposed to temperatures above the critical temperature (expressed in units of Extreme Degree Days – EDD – above this temperature) is as significant as the number of days of its growth at temperatures lower than the critical temperature (expressed in units of growing degree days – GDD – below this temperature). EDD thus appears to be an independent variable. Since the length of the growing season is a determining factor in wheat productivity, it is evident that wheat yields are significantly dependent on climate variability. There are two broad approaches for assessing economic impacts –the agronomic- economic and the Ricardian approaches. In the Indian context, Kumar and Parikh (2001a) have estimated the macro level impact of climatic change using agronomic-economic approach. They have showed that because of the higher carbon dioxide concentration levels in the latter half of the 21st century, the GDP would decline by 1.4 to 3 percentage points. As the scope for incorporating adaptation into the agronomic-economic approach is rather limited, an alternative approach was proposed by Mendelsohn, Nordhaus and Shaw in their classic 1994 paper. This approach is known as Ricardian approach, similar to Hedonic pricing approach of environmental valuation. The approach is based on the argument that "by examining two agricultural areas that are similar in all respects except one has a climate change on average (say) 3 degree Celsius warmer than the other, one would be able to infer the willingness to pay in agriculture to avoid 3 degree Celsius temperature rise" (Kolstad 2000). Kumar and Parikh (2001b) have used this approach in the case of India and estimated that a 2 degree Celsius temperature rise and 7 percent increase in the rainfall would lead to an almost 8 percent loss in farm level net revenue.

4. CONCLUSION:

There is a vast literature on various aspects of potential economic effects of climate change on agriculture. Previous works have shed a lot of light on the impacts of climate change on farming sector, however there is a lot of uncertainty and tremendous discrepancies in predictions among the climate models. The existing models omit many possible impacts of climate change, more policy analysis is needed to integrate economic and environment impact. Uncertainty is one of the major challenges for valuing impacts. There are damages associated with the catastrophic climatic changes, to value these effects require suitable models which can accurately describe the direct and indirect

impacts of climatic change on agriculture in Indian context. To understand science and economics of climate change in an effective way, more effort is needed to improve substantial gaps. Economic analysis play a vital role, particularly in the policy debate over climate change.

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