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REVIEW ARTICLE

Climate Change and Agriculture Sector in a Global Perspective: a Review

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Abstract

Climate linkages with agriculture industry are being considered as an impotent modern day debate which is getting serious attention at a rapid pace. This is due to the fact that agriculture sector and allied practices associated to this sector are the source of livelihood for large number of global population. This paper is intended to review the existing knowledge and literature related to climate change and its effect on agriculture sector. Under this umbrella, current review covers the economic effect of changing climate on agriculture in terms of mutual outcomes and also demonstrates an overview of the state of knowledge of likely impact of variability in climate. The common findings compiled that the impact of this change will vary across regions and aggregate average influence can be negative or positive, however it depends on the climate scenarios. Farmers may help themselves to combat climate change by varying planting dates and times, adding new varieties, altering irrigation practices, and changing land utilization under crop production. More studies are demanded for visualizing overall and specific influence of climate change on yields and crop nourishment, uncertainties in rainfall pattern, duration and specifically the frequency of different natural disasters event which are contributing toward the changing climate.

Introduction

Climate is considered as one of the most important and primary determinant of agricultural production. Analyses regarding importance of agriculture sector on human welfare have shown serious concerns. It has been articulated by numerous agencies and research think tanks. Potential and foresighted effects of climate change on agricultural productivity include distress crop and livestock production, altering input supplies, hydrologic equilibriums and other components of agricultural systems. Yield harnessed from different agriculture sectors including crop and livestock are directly affected by deviations in climatic parameters which include but are not limited to temperature and precipitation. Any extreme event which may be drought, wind storms and floods can also impact agriculture steadiness heavily. In addition to this, human response is thoughtful for understanding while evaluating for the impacts of climate change on agricultural sector and eventually on food supply (IPCC, 2011).

Agriculture system operates in a dynamic manner, where producers and also the consumers are always countering in deviating crop production and livestock yields rather than normal. Agriculture sector is strongly dependent on input prices, resource availability, technological changes and natural climatic factors. The climate factor has become mode of discussion for agriculture system holders and also the research players which has taken the shape of climate change.

The forth coming climatic changes include increment in the atmospheric temperatures. This happens due to increase in intensities of greenhouse gases like carbon dioxide, ozone, methane, chloro-fluoro carbons and nitrous oxide. Elevation in concentrations of these gases produces concerns for

future changes in global climate which can lead to direct or may be indirect influence on agriculture (Garg*et al*., 2001; Krupa; 2003; IPCC, 2001).

Before 1840, which is known as pre-industrial time, carbon dioxide concentration was within a sturdy state (280 ppm). Since then this rate is mounting at a rate of 1.5 to 1.8 ppm annually. It is insight that at the end of this century, the concentration of carbon dioxide is probable to increase as much as double as compare to this rate (Keeling *et al*., 1995). According to studies, the role of carbon dioxide is considered as driving factor for climate change. However, direct effect of it on plant is positive (Warrick, 1988). It impact plants in two ways while enriching the atmosphere positively. Firstly, it upsurges the process of photosynthesis in plants. This effect is widely known as carbon dioxide fertilization effect. C3 plants show more prominent effect of it on them. This is due to the fact that elevated level of CO_2 enhances the rate of fixed carbon in addition to suppression of photorespiration (Hanif*et al*, 2012). Secondly, augmented level of CO_2 in the atmosphere reduces transpiration by moderately closing the stomata. In this manner it reduces water loss by the plants. Though increase in temperature can impact positively and negatively on the yields of crops, but generally, increment in temperature have been found to decrease yields and also quality of many crops. Most importantly cereal and feed grains are some of the victims of it. Rise in precipitation rate may benefit semi-arid areas by incrementing moisture contents of soil.

Crop yields are also prejudiced by other environmental aspects. These include the moisture and temperature. Agriculture is one of the most susceptible sectors to changing climate. Its productivity is affected by many factors including rainfall pattern, temperature increment, deviations in sowing and harvesting dates, obtainability of water, land suitability and last but not the least evapotranspiration (Kaiser *et al.,* 1993). The impression of changing climate on agriculture can be observed from declined agricultural produce and shortening of growth period for many crops. Countries that lie on tropical and sub-tropical regions are estimated to face unsympathetic consequences. However, regions of temperate zone would be advantageous.

The current review accumulates research on economic impact of changing climate on agriculture sector. The primary objectives include the review of possible effects of climate change across different regions and also to identify the looser and winner scenarios from these climate changes. In addition to this the role of human adaptations in responding to potential climate change is also analysed.

Crops and Livestock Reactions against Climate Change

Effect of climate change on agriculture production differs from region to region and also from crop to crop. Current study reflects crop sensitivity to water availability and temperature changes. Richter and Semenov (2004) assessed the climate change impact on wheat in England and Wales. Droughts are more likely to occur due to global warming which will enhance the evapotranspiration and variability in rainfall patterns. Weather variables will affect less to the grain yield in England and Wales. Deressa*et al.* (2005) in another research on South African farms analysed climate change impact on sugar cane production. He comments that there is a negative effect of temperature increase on sugarcane production. Similarly Gbetibouo and Hassan (2005) analysed the African cropland and its vulnerability due to climate change. Production of field crops are more sensitive to change in temperature levels than the changes in precipitation level. Fleischer (2008) observed climate sensitivities of relatively warmer climate of Israel. He concluded that Temperature and rainfall increases at certain level and after a certain level decrease in net revenues were observed in case of farms. Wang *et al*., (2008) evaluated that increasing temperatures in china are not much harmful as many areas of country are cold and temperature is very low, so a slight increase in temperature will harm up a small extent but if the temperature keeps on going higher and higher, then rain fed areas of china will face loss over time. Guiteras (2007) commented that a 1^{o}C increase in the mean temperature will reduce the fertilizer use by 4.5 percent. Jaehyuk Lee (2012) explored that South and south East Asia is going to bear losses in result of increased temperature in fall season also concluding overall negative effects of temperature increase in the region. Temperature increase and precipitation during the summer increase agriculture productivity in tropical Asian countries.

Deressa (2006) summed that unit increase in temperature in summer and winter would make a reduction of US $ 177.62 and US $ 464.70 respectively in the net farm revenues. Marginal impact of increasing rainfall during the season of spring would increase the net farm revenues by US $ 225.09. Increasing temperature and decreasing rainfall was damaging for the Ethiopian agriculture.

Eid *et al.* (2007) assessed the economic impact of climate changes on Egyptian agriculture. He concluded that climate change will pose serious threats to the crop production. Mano and Nhemachena (2007) said that higher the precipitation, beneficial impact will be there on the crop production. While elevated levels of temperature can

regress the crop production. Mariara and Karanja (2007) argued that higher summer temperature has negative impact on net farm revenues while high winter temperature has positive impact on net farm revenues. Similarly, change in temperature is more crucial for agriculture sector in Kenya as compare to change in precipitation. Seo*et al*. (2008) revealed that increase in temperature will be harmful for production of crops while rainfall in both the seasons i.e. summer and winter will be beneficial. Ajetomobi*et al*. (2010) concluded that impact of climatic variables on Nigerian rice crop is more severe.

Increase in temperature has different impacts on dry land and irrigated farms. In dry lands, it has negative impacts while in irrigated farms the impact was positive. Precipitation has also the same trend as of temperature. Shakoor*at al.* (2011) showed that increasing temperature has negative while increasing rainfall has positive impact on net farm revenues as well as on crop production.

Climate change has also affected the livestock sizably. There are some studies that address the climate change impact on livestock. For instance, warmer summer temperatures are projected to have a conquering impact on livestock hungriness. Adams et al. (1998) detected that with 5.0°C increase in temperature, livestock production in United States fell down by 10 percent. Seo and Mendelson (2007) studied climate change impact on animal husbandry in Africa. Temperature hurts not only the size of stock in the large farms but also the net revenue per value of stock for the large farms. However, the case is opposite for the small farms. The reason they mentioned for the different impact of warming on small and large farms was that in large farms mostly species of beef cattle are reared which are not high temperature tolerant while in small farms small species of animals are reared like goats which are high temperature tolerant. On the other hand, precipitation would reduce livestock net revenues and size of stock for both small and large farms. Increase in precipitation with warm and wet conditions; enhance the diseases in the cattle. Many farmers are also shifting their farms from livestock rearing to crop production in case of higher precipitation. Hanson *et al*. (1993) used simulation to identify effects on rangeland livestock production under the 3 GCM (global climate model) scenarios. Results revealed that climate change is going to have opposing impact on livestock production (low milk production). Seo*et al*. (2008) highlighted the switching of farmers to livestock keeping which are more heat tolerant than the crops and hence farm revenues are generating at a good pace without being affected by the climatic vulnerability.

Warming has positive impact on livestock production and hence beneficial for this sector and it can offset the losses in crop sector due to the warming. Mendelson (2010) studied that warming is also beneficial for small scale or household livestock holders than large and commercial livestock holders in Africa. Nhemachena*et al.* (2006) predicts that irrigated mixed crop-livestock zones will be less affected by warming than dry land farms. The dilemma for South African agriculture is that mixed crop-livestock zone is in small scale and is more tolerant than the dry land, specialized crop zone.

Economic Methods\Quantitative Methods Used to Measure Climate Change Effects

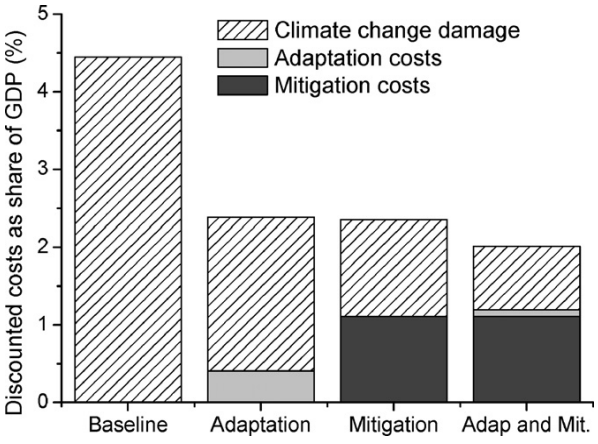
The quantitative techniques developed to evaluate the impacts of changing climate include experimental and cross-sectional studies. In experimental approach, it includes agro economicsimulation models, estimated in earlier studies. Carefully controlled experiment was used and operated in which adjustments are made in climate variables and also other variables of interest to analyse the impacts on crop productivity. Mendelsohn *et al.* (1994) and Mendelsohn and Dinar (1999) recognized the weakness in the usage of agronomic (known as production function) method. One of the serious criticisms made is the usage of such functions or techniques over the estimated damages. Underlying constraint in this regard is that; yield estimates from these approaches which uses controlled experiments do not take into the book the adaptations in the form of changed farming techniques i.e. estimation model are truly based on the assumption that seems to be unrealistic. In recent studies, importance has been given to techniques that contained efficient adaptation in to account. In economic research Ricardian approach attempts to show or highlight the effect of climatic, economic and environmental factors on the income of farm, land values or net revenues (Mendelsohn *et al.*, 1994). The approach is truly preferable comparing other traditional estimation approaches because this technique automatically integrates the use of full adaptations adopted by farmers against climate change.

However, Ricardian approach is criticised because of its incapability to completely grab the impact of significant variables that could explain changes in farm incomes. The underestimation of damages and overestimation of benefits are some of the problems associated with this technique. Constant price assumption is one important drawback of the technique. Mendelsohn and others (1994, 2001, 2009) recognises constant prices inclusion are problematic but all agronomic models are weaker or carrying this price problem.

Adaptation and Mitigation towards Climate Change

United Nations Framework Convention on Climate Change (UNFCCC) classifies two possibilities in order to address climate change. These are the mitigation and adaptation in human or natural systems in reply to expected or actual climatic stimuli, which curbs exploit beneficial opportunities. It mentions any alteration that takes place in human or natural systems in response to actual or expected impacts of climate change, that are aimed in moderating harmful beneficial opportunities.

Mitigation is the matter of government and international negotiations. On the other hand, adaptation is primarily the matter of indigenous managers of natural resources, and also individual households and companies dealing with local economy and society. Dessai and Hulme 2001; Tol, 2005; Pittock and Jones, 2000 argued that even with strong mitigation efforts, climate change will continue to happen for the next few decades. Adaptation alone can limit negative impacts of climate change but cannot remove them (van Vuuren D.P. *et al*., 2011). Klein *et al*. (2005) explained that relying on adaptation alone could extend the degree of climate change in which an actual adaptation is possible only with very high cost. *"Thus, it is no longer a question of whether to mitigate climate change or to adapt to it. Both mitigation and adaptation are essential in reducing the risks of climate change."* Adaptation can be more operative while dealing with sea-level rise. However mitigation is useful in reducing costs and damages. In agriculture both mitigation and adaptation are necessary, because absence of both have negative impacts on crop yields (van Vuuren and Issac, 2011).



An effective climate change policy should include both mitigation and adaptation (van Vuuren and Issac, 2011). Fig.1. Shows, cost of impressions of changing climate can only be lessen by combining both adaptation strategies and mitigation approaches. Adaptation costs, mitigation costs and residual harms due to varying climate as a share of GDP according to the FAIR model (Hof *et al*., 2009).

Suspicions and Restraints to Adaptation

Developing countries lack the capacity for adopting new and innovative techniques to cope climate change. This is due to the fact that these countries have limited access to input and output markets, necessary infrastructure, and development in other sectors is least. For the successful implementation of adaptation, access to local physical and financial capital, technical knowledge and support and other inputs (such as water and fertilizer) is required. Further adaptation may come with some un-intended environmental consequences. This is because, in order to increase the production, there is some cost associated with this in the form of increased use of pesticide and more use of marginal lands.

Conclusion

The combined effects of warming and precipitation variation are expected to differ by location, crop variety, course and magnitude of precipitation change, magnitude of warming and nature of CO_2 fertilization effect. Due increase in temperatures and decrease in yields of different crops are observed while increase in rainfall offsets this result. Winners and losers from climate change will depend or vary from region to region, given that net drop in yield is higher in low latitude, warmer and semi-arid areas. Yield changes of different crops will also be effected by adaptations options adopted by farmers, net users, governments and other stakeholder institutions. Farmers may help them to contest changing climate by altering planting dates, planting new varieties, altering irrigation practices and changing land utilization under crop production. Country specific and region specific studies can only build partial or incomplete justifications of possible impacts. Globally appreciated approach is one in which regional responses are habituated by global changes in production and price. Founded on diverse evaluation reports and figures, it can be determined that agricultural effects of climate change are more of uncertain and all forecasting about impact of climate change will carry doubt and uncertainties. Nevertheless, aggregate average influence may be negative or positive, depending on climate scenarios. Impacts of changing climate changes both qualitatively and quantitatively by crop, the level of agronomic contain ability and also by season and specific region. More studies are demanded for visualizing overall and specific effect of changing climate on yield and crop nourishment, uncertainties

within rainfall pattern, duration of different natural disasters event which are contributing toward the changing climate.

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