

Agricultural Adaptation to Climate Change: Issues for Developing Countries

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ABSTRACT

One of the burning issues of the world is climate change. The objective of this paper is to review the issues of agricultural adaptation to climate change in the context of developing countries. Literature review type methodology is used here. Total 54 numbers of secondary materials comprising journal articles, books, working papers and documents are used for this research. It is found that Climate Change is real but highly uncertain. It poses threat to agricultural sector of developing countries and adaptation would be a possible solution. Apart from the perception of farmers other factors like the farm family characteristics (e.g. farmers' education level, farm size, and farm's financial health) and government support (e.g. access to extension, credit and climate information) could be the potential factors to influence adaptation. There could also be several barriers to adaptation from farmers' perspective in the face of climate change. Lack of awareness, access to credit, information, knowledge and education to evaluate and implement new methods are the major constraint on adaptation. The appropriate science, actions and policy is required to improve the capacity and to facilitate adaptation in developing countries.

Key Words: Climate Change, Adaptation, Vulnerability, Agriculture, Developing Country

JEL Classification Code: Q02; Q18

1. INTRODUCTION

Climate change is one of the burning issues of the world these days. Recent events like the forth assessment report of the IPCC, the documentary 'An Inconvenient Truth' by Al Gore, and the Nobel Peace Prize in 2007 given to IPCC and Al Gore are some big events related to this. Research is expanding into the possible drivers of climate change (natural as well as anthropogenic), the understanding of the climate system, the character and magnitude of changes, their impacts on human living conditions and ecosystems, and the possible approaches to the human responses to climate change. This paper reviews the issues related to those to have a laconic understanding about climate change scenario, it's probable effects, and possible solution to that. More focus is given here to agriculture in developing countries.

1.1 Review of Literature

Reports of Intergovernmental panel on climate change are the most widely acceptable documents related with climate change. The first assessment report was published in 1990 and the latest one is the fourth assessment report which is published in 2007. The fifth assessment report is in under construction and will be completed in 2013/2014. These reports provide an update of knowledge on the scientific, technical and socio-economic aspects of climate change. Hundreds of experts around the world are involved in writing these reports. These reports are the most complete review paper related with climate change which covers almost all aspects of climate change. The problem is that it is quite a huge volume of text with detail and technical explanation. That is why this present research tried to have a gist of knowledge related to climate change. Moreover, apart from the IPCC's report, to the best of my knowledge no other review paper is available related with the issues of agricultural adaptation to climate change for developing countries. The present research is an attempt to fill that gap.

1.2 Objectives of the Research

The main aim of this paper is to review the issues of agricultural adaptation to climate change for the developing countries. For the convenience of our analysis we are making some specific objectives for this study as follows:

- To discuss the understanding and knowledge about climate change.
- To find the effects of climate change and possible responses to that.
- To understand about adaptation to climate change.
- To find the possible adaptation option on agriculture in the face of climate change.
- To find out some pertinent policy implication.

1.3 Methodology and the Data Used

This research uses the literature review method where different secondary materials were reviewed. Those secondary materials are journal articles, books, documents and working papers related to our research topic. The text and findings of those materials are reviewed thoroughly to have the findings related to our research objectives. Total 54 materials are used where the numbers of journal articles are 33, the numbers of books are 4, the numbers of documents are 13 and the numbers of working papers are 4. As this is a review type of research so the findings related to the objectives are discussed in textual format with topic headings and to substantiate the findings the proper reference is given during the discussion.

2. RESEARCH FINDINGS

Findings of this research are discussed using related topic headings in accordance with the research objectives. First of all the findings related with the climate change understanding and knowledge are discussed as *climate change scenario* with *observed climate change* and *projected climate change* sub-headings. Then findings related with the effects and responses are discussed in the subsequent sections in the name of *effects of climate change: especially on agriculture* and *possible responses to climate change*. Findings related with the concepts of *adaptation to climate change* are discussed later on with *development of climate change adaptation agenda, vulnerability and adaptation* and *concerns of adaptation to climate change* sub-headings. Then findings related with adaptation options are discussed in the name of *agricultural adaptation to climate change* with *barriers to adaptation*.

2.1 Climate Change Scenario

The climate system is a complex and interactive system of atmosphere, land surface, snow and ice, oceans and other bodies of water, and living things. Among all these components the atmospheric component, often referred as weather, mainly characterizes climate. In terms of weather components the climate is usually describe as mean temperature, precipitation and wind over a period of time. The climate change issue thus seen on the basis of those variables. For this issue Intergovernmental Panel on Climate Change (IPCC) was established in 1988 brings together the world's top climate scientists to assess the scientific, technical and socioeconomic information relevant for understanding the risk of human induced climate change. Though their previous assessments in 1990, 1995 and 2001 had provided strong indications that by various measures Earth's climate are becoming warmer - but with the latest report in 2007 the picture had become clearer. In the following two sections a brief description of the observed and projected climate change is summarized by reviewing the IPCC's latest report and recent literature.

Observed Climate Change

The global mean surface temperature has risen over the last century (1906-2005) and the rate of warming is almost double in the last half than the first half (Trenberth et al., 2007). The largest temperature increases have occurred over the past 30 years, mostly over the continental interiors of Asia, north-western part of North America, and over some mid-latitude ocean regions of the Southern Hemisphere. Consistent with this observed increases in temperature, it has also been found an almost worldwide reduction in glacial mass, melting of Greenland Ice sheet, decrease in snow cover in many Northern Hemisphere regions, decrease in sea ice thickness in the Arctic, warming of the oceans, and rising of sea level due to thermal expansion of the oceans and melting of ice.

Precipitation trends also have a noticeable change after 1970, significantly wetter in eastern part of North and South America, northern Europe, and northern and central Asia, but drier in the Sahel, the Mediterranean, Southern Africa and parts of southern Asia (Trenberth et al., 2007). Droughts have also become more common, especially in the tropics and subtropics, since the 1970s (Dai et al., 2004).

There is a significant upward trend of destructiveness, longer lifetime and greater intensity of tropical cyclones since the mid-1970s (Emanuel, 2005). This trend is also found strongly correlated with the higher tropical sea surface temperature and global warming. There also found a large increase in numbers and proportion of hurricanes that reach categories 4 and 5 since 1970 and the largest increase was in the North Pacific, Indian and southwest Pacific Oceans (Trenberth et al., 2007).

Projected Climate Change

The report of IPCC (2007) has attributed the observed changes as anthropogenic. If the current trends continue then the equilibrium global mean surface air temperature (SAT) is likely to increase by 3°C by 2050 (Meehl et al., 2007). However, warming is projected to be similar to this in Southeast Asia (Cruz et al., 2007) and Latin America (Magrin et al., 2007) but well above in central Asia and Africa (Christensen et al., 2007). Variability of precipitations is projected with reduced rainfall in subtropics and increases at high latitudes and parts of the tropics (Meehl et al., 2007; Christensen et al., 2007; Magrin et al., 2007; Boko et al., 2007; Dai et al., 2005). It is likely to increase tropical cyclones in East Asia, Southeast Asia and South Asia (Christensen et al., 2007) with more destructive power (Emanuel, 2005). Moreover, the sea level is projected to rise on an average 0.02 meter by the middle and 0.15 meter by the end of 21st century.

In summary, many changes are expected in the global climate system during the 21st century that would even very likely to be larger than those observed during the 20th century (Meehl et al., 2007). Of course, it is difficult to produce a credible projection of climate over the next century but the problems posed by climate change require our immediate attention.

2.2 Effects of Climate Change: Especially on Agriculture

The scientific evidence of climate change is now overwhelming (Stern, 2007; Stern, 2009), although some may disagree to some extent because of uncertainty (Lomborg, 2001). The effects of climate changes on natural and human environments are already felt, although many are difficult to discern. The ultimate significance of this issue is related to its global reach, affecting sectors and regions throughout the world in complex and interactive ways. This would affect the world in terms of access to water, food production, health and the environment. Thousands of people would suffer from hunger, water shortages and coastal flooding (Stern, 2007). Although the scientific evidence of anthropogenic causes are associated with mainly rich industrialized and post-industrial countries but the impacts are expected to be felt more severe on the regions of poor developing countries (IPCC, 2007).

One of the severe impacts of climate change is expected to be on agriculture (IPCC, 2007; Mendelsohn, 2009). The changes will in turn alter the availability of water resources, productivity of grazing lands and livestock, and the distribution of agricultural pests and diseases (IPCC, 2007). This will not only affect the productivity of crop species but also their geographic distribution (Reilly, 1995). So a changing climate will affect agro-ecosystems in heterogeneous ways, either benefits or negative consequences, depending on domination of factors in different agricultural regions (Figure 1).

The adverse effect of climate change on agricultural production are likely to be felt more on the lower latitude countries where most developing countries are situated (Parry et al., 1999; Mendelsohn, 2009). The empirical evidence shows that the agro-ecological shift is likely to reduce not only the yield but also affect the national income and employment of many developing countries as they rely heavily on agriculture (Zilberman et al., 2004). Therefore, a key challenge is to identify actions to reduce vulnerability of each and every sphere of our life, especially agriculture in developing countries, so that impacts can be avoided or at least reduced.

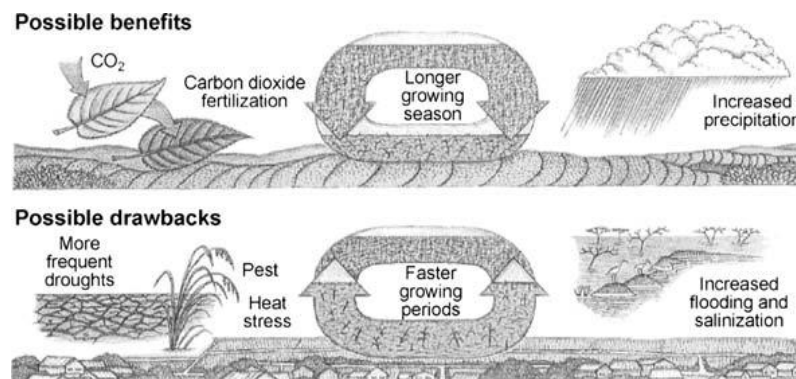


Figure 1: Effects of Changing Climate on Agro-Ecosystem (Bongaarts, 1994)

Possible Responses to Climate Change

Mitigation and Adaptation is the two main responses that we have in our hand in relation to climate change (Stern, 2009; Ayer and Huq, 2009). Mitigation refers to limiting the production of greenhouse gases (GHGs)¹ against further anthropogenic climate change. It is mostly related with developed countries as they are the main producers of these GHGs. On the other hand, adaptation simply refers to as the adjustment made in the changed circumstance to reduce the adverse effect.

In agricultural sector farmers have to adapt as well as reduce emissions at the farm level. But choosing effective adaptation and mitigation strategies is a key challenge for them. Optimal strategies could be careful management of land, increase the resilience and stability of production systems, and while sequestering soil carbon and reducing emissions from farm activities (Rosenzweig and Tubiello, 2007). Although many positive interactions can be identified but it is important to note that synergies will not be possible under all socio-economic scenarios and regions. Therefore adaptation strategies will likely to take precedence over mitigation, especially in developing countries, to maintain production and livelihood. It is no longer possible to prevent climate change because of its inertia, but possible to minimize the effect through adaptation (Stern, 2007). Moreover, there are nothing much to do in terms of mitigation except adaptation in some sectors and regions especially agriculture in developing world (Tingem and Rivington, 2009). Adaptation strategies are also considering now in line with the poverty reduction strategies in developing countries (Halsuæs and Traerup, 2009).

2.3 Adaptation to Climate Change

Scholarly literatures are many those explain the concept of adaptation related to climate change (Burton et al., 2008; Smit et al., 2000; Smit et al., 2001; Smit and Wandel, 2006; Leary et al., 2007; Mitchell and Tanner, 2006; Stern, 2007). Simply, it is the adjustments in ecological, social or economic systems to better cope with or adjust to the conditions, stresses, hazards, or risk associated with climate change. Though the main objective of adaptation is to reduce vulnerability but it will also enhance the capability to capture any benefits of climate change. The forms of adaptation can be technological, economic, legal or institutional. It can also be specific actions, a systemic change or an institutional reform. As specific action farmers may switch from one crop variety to another which is better suited in changed conditions. As a systemic change it can be diversifying rural livelihoods against climatic risks. It even includes learning about risks, evaluating responses, creating the conditions for adaptation, resource mobilization, and continuous revision of choices with new learning. As an institutional reform it can be revising ownership rights of land and water for better resource management. Adaptation can also be autonomous or planned (Smit et al., 2001; Stern, 2007). It is autonomous when done independently, and planned when done with setting policies or taking direct actions through public initiative.

Development of Climate Change Adaptation Agenda

Adaptation did not get much attention in the early stages where more attention was given to mitigation and impacts (Kates, 2000). When the climate change issues were first addressed by the UN General Assembly in 1988 then the focus was on mitigation. The global campaign on climate change issues then associated with only emissions trajectories and mitigation responsibilities. Adaptation got its recognition in climate change science and policy after

¹ A greenhouse gas is a gas that traps heat in the atmosphere. The principal GHGs that enter the atmosphere because of human activities are Carbon Dioxide, Methane, Nitrous Oxide, and other Fluorinated gases.

publishing IPCC's third report in 2001. It argued that mitigation efforts would not prevent climate change impacts, particularly in low and middle-income countries. Adaptation began to attach mostly with the developing countries after then. So to assist adaptation in developing countries three new fund² were created then at the seventh Conference of the Parties to the UNFCCC (COP7) in 2001: 1) fund to support 49 least developed countries (initially finance the design of National Adaptation Programmes of Action – NAPA); 2) fund to support climate change activities; and 3) fund to support concrete adaptation projects. Adaptation gradually gained prominence in climate change literature. Later IPCC's Fourth Assessment Report in 2007 also emphasises it. Adaptation now is seen as a legitimate policy option for developing country. Even these days it is considered in development effort (Adger et al., 2002; Ayer and Dobman, 2010). NGO communities have incorporated this in the name of Community Based Adaptation (CBA) into the design and development of their projects to increase resilience of local livelihoods (Reid et al., 2010; Blanco, 2006; Klein et al., 2007).

Vulnerability and Adaptation

Climate change issues are also now seeing with vulnerability and adaptation. The term vulnerability was coined in development debates from 1990s (Mertz et al., 2009a). Several literature of climate change explains adaptation with relation to vulnerability (Smit and Wandel, 2006; Adger et al., 2007; Schneider et al., 2007). Vulnerability to climate change is the degree to which geophysical, biological and socio-economic systems are susceptible to, and unable to cope with the adverse impacts of climate change. It is very much contextual and linked with specific hazards. Effective adaptation will manage or reduce the vulnerability and even maximise the potential benefit from changes. But the vulnerability of a community not only depends on the magnitude, rate and the impacts of climate change but also on their adaptive capacity which are constrained by a lack of resources, poor institutions and inadequate infrastructure (Adger et al., 2002). The linkage between vulnerability and adaptation are portrayed by Smit and Wandel (2006) in their nested hierarchy model of vulnerability (Figure 2). It argued that generally a community will be more vulnerable if it is more exposed or sensitive to climate stimuli, or hazards. On the other hand a community that has more adaptive capacity will tend to be less vulnerable. This approach is being identified as a key response to climate change by development organizations. That is why it focuses more on enhancing adaptive capacity by improving access to education, financial resources, and information such as climate forecasts or diversifying livelihood. So adaptations in this sense are nothing but ways of reducing vulnerability.

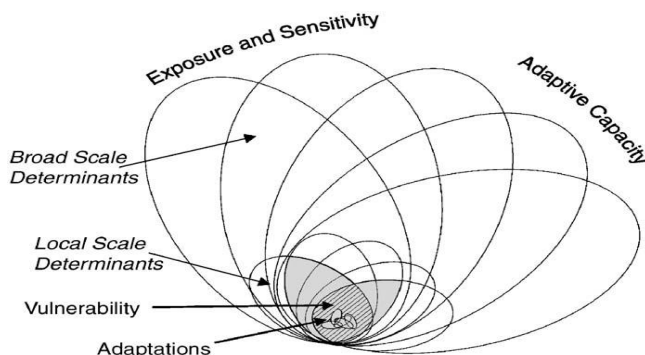


Figure 2: Nested Hierarchy Model of Vulnerability (Smit and Warden, 2006)

² Also known as Kyoto Protocol Adaptation Fund, for more information see http://unfccc.int/kyoto_protocol/items/2830.php

Concerns of Adaptation to Climate Change

Adaptation to climate change is fraught with difficulties and challenges. Several concerns could be identified there in relation to climate change adaptation. Firstly, how it will occur in the grass root level? Because the adaptation decisions are embedded in social processes that depend upon the relationship among individuals, their networks, social capital, risk acceptance attitudes and the state (Adger, 2001; Adger et al., 2009a; Adger et al., 2009b).

Secondly, if it occurs then is it correct or not? , mal-adaptation may occur. So the adaptation involves a governance issue through which it can be guided to the society or to the sectors. In this respect the threshold³ for adaptation is important. Adger and others (2009b) argue that the limits to adaptation depend on social, physical and ecological factors, and so the integration of all these is very much important. In this respect government intervention is expected. Economists called this as the issue of market failure to justify government intervention. There could be three types of market failure which prevent efficient adaptation: uncertainty and imperfect information, missing and misaligned markets, and financial constraints (Aakre and Rubbelko, 2010).

Lastly, where and how government intervene? In the climate change literature government's adaptation support is predominantly recommended in the areas of education, livelihood assistance, and compensation to catastrophic losses (Aakre and Rubbelko, 2010). At the national level it is necessary to encourage research, training, and communication concerning the most appropriate adaptive measures. Development agencies are pressing to incorporate climate change adaptation into mainstream development assistance and policies. But it is not easy to undertake these policies in an effective and equitable way to design effective adaptation at the local level. Overall, it is recommended to introduce more climate resilience development strategies to support climate change adaptation.

2.4 Agricultural Adaptation to Climate Change

Climate change literature on agricultural adaptation shows a wide range of options based on experience, observation, and speculation (Adger et al, 2007; Burton and Lim, 2005; Leary et al., 2007; Bryant et al., 2000; Smit and Skinner, 2002; Maddison, 2007; Yang, 2007; Bryan et al., 2009; Deressa et al., 2009). The list typically includes (1) changes in seasonality of production, dates of sowing, choice of crop varieties or species, and tillage practices, (2) development of new varieties, (3) improved water supply and irrigation systems like construction of water reservoirs and distribution systems, (4) inputs and management adjustments like disaster management and insurance, and (5) improved short-term weather and seasonal climate forecasting. The stakeholders in agricultural adaptations are the farmers, non-governmental organizations, credit organizations, technology dissemination groups and central and local governments. Adaptation done by farmers differs from place to place, availability and need.

Several factors could influence farmers' adaptation decision at the farm level (Bryant et al., 2000; Maddison, 2007; Yang, 2007; Bryan et al., 2009; Deressa et al., 2009). Farmers' perception of climate change could be a factor to influence adaptation, but studies do not found strong relation to them (Bryant et al., 2000; Bryan et al., 2009; Mertz et al., 2009b). It is found that despite having perceived changes in temperature and rainfall, a large percentage of farmers did not make any adjustment to their farming practices. At the same time it is also found that those farmers who perceived about the changes in climate

³ Simply it is the level or point at which something starts or ceases to happen or come into effect.

variables done at least one changes in their farming practices (Maddison, 2007). Apart from the perception other factors like the farm family characteristics (e.g. farmers' education level, farm size, and farm's financial health) and government support (e.g. access to extension, credit and climate information) could be the potential positive factors to influence adaptation.

Barriers to Agricultural Adaptation

There could be several barriers to adaptation from farmers' perspective in the face of climate change in developing countries (Leary et al., 2007; Bryan et al., 2009; Maddison, 2007; Croppenstedt et al., 2003; Chauhan et al., 2002; Kaliba et al., 2000; Hintze et al., 2003; Maddison, 2007; Ransom et al., 2003). These barriers could be related to financial, natural, physical, human and social capital. It is also found that sometimes people have knowledge of many traditional practices for coping with climatic stresses, but have little knowledge of new or alternate methods due to poor access to inputs and information. Even some places farmers are reluctant to change their inherited traditional practices. In general lack of awareness, access to credit, information, knowledge and education to evaluate and implement new methods are the major constraint on adaptation.

Even from the planning perspective there could be several technical and institutional barriers to adaptation (Bedsworth and Hanak, 2010): (1) uncertain information on climate-related impacts, (2) conflicting goals and tradeoffs, (3) backward-looking regulatory regimes, (4) coordination failures, and (5) limits on institutional authority. Uncertainty about the extent and nature of some climatic impacts pose a significant barrier to decisions on appropriate adaptation measures. Again adaptation planning will face problem because some strategies may cause conflicts among different goals and interests. Then adaptation planning requires to affects a range of future physical conditions, but many current regulatory frameworks are built around historical data. Then adaptation planning will face an inadequate coordination among relevant public entities with overlapping geographic and functional boundaries. Last but not the least, legal limits on institutional authority can prevent agencies that might like to engage in more extensive adaptation planning.

3 POLICY SUGGESTIONS

Related to agricultural adaptation certain policy suggestions are presented below:

- a) Apart from other factors government support is one of the vital factors to influence agricultural adaptation. So government support like extension services, credit facilities and the climate information have to be provided to the agriculturist to facilitate agricultural adaptation.
- b) Appropriate adaptation measure suitable for particular area is still not certain. Proper science and research is required for deciding appropriate adaptation option. Government has to encourage and facilitate research to find appropriate adaptation options for regions.
- c) Government has to facilitate the dissemination of the knowledge related to adaptation options. Both knowledge and technology required for appropriate adaptation option should available to the door steps of the farmer.
- d) Lastly, inadequate coordination among relevant public entities with overlapping geographical and functional boundaries creates a barrier for the successful adaptation. So government should take these into consideration and maintain a more coordinated approach in planning adaptation.

4. CONCLUSION

Developing countries have specific needs for adaptation because of their geographical exposure, low incomes and greater dependence on climate sensitive sectors such as agriculture. Economic and technological capacities are the main limitation for them. In the micro level farmers' are the most affected portion of human in relation to climate change. A better understanding of their social and institutional frameworks and demand-side strategies is needed for an effective adaptation. There are significant gaps in understanding the processes by which adaptation is occurring and will occur in the future. But this area is very much important for future policy and action to increase adaptation and adaptive capacity. Though most agricultural adaptation to climate change will ultimately be taken at the local level but their speed and spread depend on national policy. So the appropriate science, actions and policy is required to improve the capacity and to facilitate adaptation.

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