

## *Chapter 15*

# **Climate Change in Plantation Crops: A Socio-Economic Reflection on Vulnerability, Risks and Way Forward**

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### **1. Introduction**

Climate change is one of the manifestations of the environmental change. It has gained global attention since 1990s when the first assessment report of the Intergovernmental Panel on Climate Change (IPCC), which is the major scientific body associated with climate change at international level, was published in 1990 and when United Nations Conference on Environment and Development (UNCED) developed United Nations Framework Convention on Climate Change (UNFCCC) in 1992. In 2001, the IPCC defined climate change as “any change in climate over time, whether due to natural variability or as a result of human activity”. According to the report from IPCC, there is convincing evidence that climate change is occurring and that it poses important global risks (IPCC, 2007). Agriculture is one sector of the economy that is exposed directly and considerably affected by climate and its changes. The impacts of climate change are likely to be highly spatially variable. The report of fourth assessment report of IPCC in the year 2007 showed that there would be significant impact on the agricultural productivity and potential for food production in different regions of the world as a result of the projected changes in the future climate.

Coconut, the small holders’ plantation crop is cultivated in 18 states in India and support the livelihood of over 10 million people. The coconut growing regions in the country are scattered to different agro climatic zones, which are characterized

by variable rainfall and temperature. Estimated trends of projections of climate models show that along with inherent climate variability, some of these regions are vulnerable to current and future climate change. Attributable to the strong relationship between the weather and plantation crops' output, climate change will significantly impact crop yields and farm income. The climate change is characterized by extreme weather events such as unprecedented drought, flood, sea level rise, cyclones etc. and coconut is known for its higher vulnerability to these kinds of extremities. This paper outlines different conceptual and methodological approaches to impacts, vulnerability and adaptation assessment in climate change research. Further the paper attempts throw light on issues pertinent to plantation sector with special reference to coconut sector.

## 2. Assessment of Vulnerability to Climate Change

Numerous definitions to vulnerability can be found in climate change literature. Some of them are discussed below to have an understanding on different dimensions of climate change vulnerability. So far there is no consensus in their application to vulnerability studies. We can find many studies using different vulnerability assessment framework based on the definitions and conceptual approaches developed by different organisations. IPCC (2001) definition for vulnerability is "the degree to which the system is susceptible to, or unable to cope with, adverse effects of stresses including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of change in stresses to which a system is exposed, its sensitivity, and its ability to adaptation or adaptive capacity".

The natural disaster literature defines vulnerability as "the characteristics of a person or group and their situation that influence their capacity to anticipate, cope with, resist and recover from the impact of a natural hazard" (Paavola, 2008). Moser (1998) argues vulnerability is closely linked to asset ownership. The more assets people have, the less vulnerable they are, and the greater the erosion of people's assets, the greater their insecurity. Vulnerability also varies across geographical scales, temporal scales and must be addressed within complex and uncertain conditions and hence calls for interdisciplinary and multiple expertise (TERI, 2005). Chaudhuri, Jalan and Suryahani (2002) pointed out that vulnerability is the *ex ante* risk that households will be poor, if not so currently, and if they are currently poor, the risk that they will remain poor. Poverty is therefore an *ex post* measure of wellbeing, and vulnerability an *ex-ante*. In a vulnerability framework, the poor are considered active agents, and interventions can build on those strengths (Baschieri, A, 2009).

According to numerous authors who worked on vulnerability, poverty and its causes such as inequality and marginalisation are among the most important determinants of vulnerability (Adger and Kelly, 1999; Ribot, 1996 In Olmos, 2001). However, some authors argue that both the wealthy and the poor could be adversely affected by the impact of extreme weather events (O' Brien and Leichenko, 2000 In Olmos, 2001). From the above discussions on vulnerability, it can be viewed as "a function of exposure, sensitivity and adaptive capacity". The term "exposure" addresses the incidence of climate change impacts, the term "sensitivity" addresses

the capacity of actors to be affected by climate change impacts and the term "adaptive capacity" or "resilience" addresses ability of actors to shield themselves and to recover from adverse climate change impacts. Vulnerability thus comes from social and physical factors, among physical factors concentrates on exposure and sensitivity and social factors accounts for assets, distribution of income, class etc. This means environmental and social systems together construct the vulnerability of households in a context dependent way (Paavola, 2008).

### **3. Conceptual Approaches to Vulnerability Assessment**

#### **3.1. Socio Economic Approach**

Adger, 1999 described that the socioeconomic approach is mainly concerned with the social, economic, and political aspects of society and it focuses on the assessment of the socioeconomic and political status of individuals or social groups. The main limitation of the socioeconomic approach is that it focuses only on variations within society or social groups and overlooks the environment-based intensities, frequencies, and probabilities of environmental shocks, such as drought and flood (Deressa *et al*, 2008).

#### **3.2. Biophysical or Impact Assessment Approach**

The biophysical, or impact assessment, approach is mainly concerned with the physical impact of climate change on different attributes, such as yield and income (Fussel and Klein 2006). Fussel (2007) pointed that this is a risk-hazard approach and Kelly and Adger (2000) considered it as an end-point analysis. One major limitation of this approach is it only focuses on the physical damages due to climate change variables (Deressa *et al*, 2008).

#### **3.3. Integrated Approach**

According to Fussel (2007) the integrated assessment approach combines both the socioeconomic and the biophysical attributes in vulnerability analysis. He argued that this approach to vulnerability analysis conceptualizes vulnerability as a function of adaptive capacity, sensitivity, and exposure to climate change. According to Fussel and Klein, 2006 the risk-hazard framework (biophysical approach) corresponds most closely to sensitivity in the IPCC terminology. Adaptive capacity is largely consistent with the socioeconomic approach (Fussel, 2007). In the IPCC framework, exposure has an external dimension, whereas both sensitivity and adaptive capacity have internal dimension, which is implicitly assumed in the integrated vulnerability assessment framework (Fussel, 2007 in Deressa *et al*, 2008).

Even though the integrated assessment approach corrects the weaknesses of the other approaches, it also has its limitations. The main one is that there is no standard method for combining the biophysical and socioeconomic indicators. The relative importance of different variables used in this approach has not been taken into account and thus need much care in using this approach. The other weakness of this approach is that it does not account for the dynamism in vulnerability. The dynamism underlying in the process of adaptation involves continual change of

strategies to take advantage of opportunities and which is missing in this approach (Deressa *et al.*, 2008).

#### 4. Adaptive Capacity and Vulnerability to Climate Change

Adaptive capacity is defined by IPCC (2001) as the “potential, capability, or ability of a system to adapt to climate change stimuli or their effects of impacts.” One of the major focuses of our study is to characterize adaptive capacity of the selected regions to understand the factors influencing the adaptive capacity of that region. The Table 15.1 outlines the situations of climate risk based on the degree of impacts and adaptive capacity of a region or group or community. The quadrants represent artificial boundaries of our knowledge of anticipated impacts of climate change and capacity of livelihoods or regions to adapt to climate change impacts.

**Table 15.1: Climate Change Adaptation Matrix: Common Situations of Vulnerability and Clusters of Climate Risk**

Impacts	Adaptive Capacity	
	Low	High
High	Vulnerable communities	Development opportunities
Low	Residual risks	Sustainability

Source: Tol *et al.*, 2004.

Presumably, adaptive capacity varies widely but, to date, it has been difficult to empirically measure it and establish the relative importance of the factors identified by the IPCC (Brooks *et al.* (2005), In Alberini *et al.*, 2005). Brooks *et al.* (2005) argue that because adaptation does not occur instantaneously, the relationship between adaptive capacity and vulnerability depends crucially on the timescales and hazards with which we are concerned. The vulnerability, or potential vulnerability, of a system to climate change that is associated with anticipated hazards in the medium- to long-term will depend on that system’s ability to adapt appropriately in anticipation of those hazards. However, vulnerability to hazards associated with climate variability that may occur in the immediate future will be related to a system’s existing short-term coping capacity rather than its ability to pursue long-term adaptation strategies. We need hazard- and context-specific, determinants of vulnerability as vulnerability will exhibit substantial sub-national geographical and social differentiation at regional levels (Brooks *et al.*, 2005). Downing (2003) argue that adaptive capacity is seen as beyond wealth, which includes technology, institutions, social networks etc. which includes the kinds of processes underlying sustainable livelihoods.

#### 5. Climate Change and Plantations

The study by Sivakumar *et al.* (2005) showed that warming trend in India is about 0.57°C per 100 years. Analysis of rainfall data for India highlights the increase in the frequency of severe rainstorms over the last fifty years. Kumar and Parikh,

2001 showed that even after accounting for farm level adaptation, a 2 °C rise in mean temperature and a 7 per cent increase in mean precipitation will reduce net revenues by 8.4 per cent in India. These research results show that people are and will be with the challenge to address new threats beyond their experience or capacity to cope. Research study conducted at CPCRI showed that the elevated CO<sub>2</sub> and temperature influence entire physiology and biochemistry of coconut, arecanut and cocoa plants. Varietal differences in response were also observed in this study. Based on the simulation studies, it was reported that the coconut yields are likely to increase in Kerala, parts of Tamil Nadu and parts of Karnataka due to climate change. However, yield is projected to reduce in Andhra Pradesh (mostly irrigated area) and rain fed areas of other states. This study also indicated that climate change will alter the quality of copra and coconut oil during storage and the shelf life of copra and coconut oil is likely to reduce if the current storage practices are continued. Vulnerability to climate change comes from social and physical factors, among physical factors concentrates on exposure and sensitivity and social factors accounts for assets, distribution of income, class etc. (Paavola, 2008). The impacts and vulnerability are integrated with adaptation responses of farmers at their farm or household level, which may reduce the vulnerable status by affecting the livelihoods of farmers who are engaged in growing plantation crops.

The field studies conducted at CPCRI indicated that soil moisture conservation is one of the potential and important adaptation strategies to reduce the climate change impacts particularly in water scarce/limited conditions. Efficiency of adaptation strategies depend heavily on the accuracy and reliability of information collected. Extensive data collection on crop characteristics, soil and other natural resources in a large geographical platform is very time consuming and almost impossible using the traditional approaches. Indian Council of Agricultural Research (ICAR) and Indian Space Research Organization (ISRO) jointly conducted first multi spectral air borne study for identification of root wilt disease in coconut in 1969. Later on country level studies related to application of remote sensing technologies were initiated after the launch of IRS-1A. Crop acreage estimation, Yield and production estimation, disease stress identification, etc are some of the areas wherein remote sensing and advances in GIS technologies were utilized. Application of remote sensing is widely employed in natural resources management and precision farming. Advanced GIS tools compliment remote sensing in compilation, analysis and presentation, which in turn can be utilized for quick action plans, especially in disaster management. Adaptation of efficient strategies on cropping systems, microbial dynamics, crop and resource management is therefore a plausible option for increasing the resilience of farmers whose livelihood is based from growing plantation crops. Thus, there is strong need to assess and analyse the existing adaptation strategies followed in the plantation crops sector. Further, developing innovative climate resilient adaptation strategies in a multidisciplinary system approach will help to strengthen the coconut economy of India by alleviating the associated climate change risks in the sector.

## **6. The Research Gaps and Way Forward**

Climate change phenomenon has positive or adverse effects on biophysical and socio economic aspects. These changes vary from region to region depending on their

biophysical characteristics, development status etc. Therefore, these factors have much to do with impacts and vulnerability to climate change and climate change response options in that region. Thus, climate change impacts and vulnerability of a region need to be understood thoroughly to plan appropriate adaptation strategies for climate change resilience in plantation crops. The impacts of climate change on coconut based cropping systems have emerged as a critical concern in recent years as these are strictly suffering already from constrained use of natural resources, particularly water. The cropping system changes in these areas have much to do with the natural resource use, income, and living standards of the people. The management aspects in coconut based cropping systems related to plant health, soil and water management techniques are to be evaluated and modified in order to fit in the new climate change scenarios with higher efficiency in the pursuit of sustainable production.

Climate change and its variability significantly affect the crop-weather relationship and yield potential of the crop, physiology of which has to be understood wherein advanced crop modeling studies can be employed. Climate change and associated changes in structural and microbial dynamics of soil has a key role in crop growth and hence in nutrient management strategies. Weather parameters play a major role in determining the occurrence and severity of pests and diseases in coconut. Hence an efficient forewarning system incorporating the weather associated risks and uncertainties needs to be developed to improve the preparedness to handle biotic stress. Information on natural resources, socio economic variables, plant characteristics and their temporal changes in association with climate change is vital in planning climate adaptive strategies. Remote sensing and GIS tools are sophisticated and effective in collection analysis of extensive spatial and geographical data. Disaster management is complete only when the research findings and thus developed strategies reach the beneficiaries. A major link in this process is the effective collaboration of research organizations and implementing agencies.

It is imperative to assess the climate change impacts and vulnerability of plantation crop sector in the present scenario of unprecedented climate fluctuations. In this regard it is pertinent to evolve location specific climate resilient adaptation measures in plantation crops by conducting strategic research on cropping systems, associated microbial dynamism, plant health management and management of natural resources. Mapping of biophysical and socio- economic vulnerability to climate change in the plantation crops sector of the selected regions and analysis of past and present adaptation practices to evaluate its resilience to climate change are important aspects. The satellite data assimilation techniques to monitor crop systems and hydrological state over coconut based plantations incorporating GIS based thematic maps can create a big impact. It is also desirable to strengthen the functional linkages with various research and development institutions including Disaster Management Cells of different states.

## 7. Conclusions

Most of the regions in developing countries, particularly semi arid tropics, are vulnerable to the current climate change and climatic shocks in future. Therefore, understanding the nature and degree of vulnerability is the initial concern of any climate change study which helps to build adaptation strategies along with understanding the ground level adoption of adaptation strategies, to cope better with the climate change and variability in future.

Unlike in the case of annuals, it is not possible to make sudden changes in cropping systems with perennials and hence it is required to evolve appropriate adaptation measures in a time bound manner for sustained production and risk reduction. This in turn requires strategic research on cropping systems, associated microbial dynamism, plant health management and management of natural resources. For evolving robust technology products, functional linkages with concerned institutions need to be strengthened. For effective management of resources in the event of natural disasters, a pre-requisite is its impact and vulnerability assessment, appropriate protocols with remote sensing techniques and GIS has to be evolved in collaboration with front line research organizations. Further, liaison with State Disaster Management (SDM) Cells is required to deliver the technology products evolved for the benefit of farming communities in the occurrence of any disaster.

## References

- Adger, N. and Kelly, M. (1999). Social Vulnerability to Climate Change and the Architecture of Entitlements, In Olmos, S. (2001), *Vulnerability and Adaptation to Climate Change: Concepts, Issues, Assessment Methods*, Climate Change Knowledge Network, Foundation Paper, www.cckn.net.
- Adger, W. N. (1999). Social vulnerability to Climate Change and Extremes in Coastal Vietnam. *World Development*, 27(2), 249–269.
- Baschieri, A. (2009). Poverty and vulnerability: a static vs dynamic assessment of a Population subjected to climate change shock in Sub-Saharan Africa. XXVI IUSSP International Population Conference, 2009(forthcoming), Session: 1203 Interrelations between population and climate change, Morocco.
- Brooks, N., Adger, W.N. and Kelly P.M. (2005). The determinants of vulnerability and adaptive capacity at the national level and the implications for adaptation. *Global Environmental Change*, 15, 151–163.
- Chaudhuri, S., Jalan J., Suryahadi A. (2002). "Assessing Household Vulnerability to poverty from Cross-Sectional Data: A Methodology and Estimates from Indonesia". Columbia University, Department of Economics, Discussion Paper Series 0102-52.
- Deressa, T., Hassan, R. M. and Ringler, C. (2008). Measuring Ethiopian Farmers' Vulnerability to Climate Change Across Regional States, IFPRI Discussion Paper 00806. International food policy research institute(IFPRI) Washington.

- Deressa, T.T., Hassan, R.M., Ringler, C., Alemu, T. and Yusuf, M. (2009). Determinants of farmers' choice of adaptation methods to climate change in the Nile Basin of Ethiopia. *Global Environ. Change*, doi,10.1016/j.gloenvcha.2009.01.002.
- Downing, T.E. (2003). Lessons from famine early warning and food security for understanding adaptation to climate change: toward a vulnerability/adaptation science, In (Eds)Joel, B. Smith, Richard, J.T Klein and Huq, S, *Climate change, adaptive capacity and development*, chapter 5, pp. 71- 100 imperial college press.
- Fussel, H. (2007). Vulnerability: A Generally Applicable Conceptual framework for Climate Change Research. *Global Environmental Change*, 17(2), 155–167.
- Fussel, H.-M., and R. J. T. Klein. (2006). Climate change vulnerability assessments: An evolution of conceptual thinking. *Climatic Change* 75(3), 301–329.
- IPCC, (2007). *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on climate Change*, Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller (eds.). Cambridge: Cambridge University Press.
- IPCC, (2001). *Climate change, 2001: Impacts, Adaptation and Vulnerability. Contribution of working group II to the third assessment report of the IPCC*. Geneva: UNEP/WMO.
- Kelly, P. M., and W. N. Adger. (2000). Theory and practice in assessing vulnerability to climate change and facilitation adaptation. *Climatic Change*,47(4), 925–1352.
- Kumar, K.S.Kavi, and Jyoti Parikh (2001). Socio-economic Impacts of Climate Change on Indian Agriculture, *International Review of Environmental Strategies*, 2(2), pp. 277-293.
- O' Brien, K. and Leichenko, R. (2000). Double Exposure: Assessing the Impacts of Climate Change within the Context of Globalisation, In: Olmos, S. (2001), *Vulnerability and Adaptation to Climate Change: Concepts, Issues, Assessment Methods*, Climate Change Knowledge Network, Foundation Paper, www.cckn.net.
- Olmos, S. (2001). *Vulnerability and Adaptation to Climate Change: Concepts, Issues, Assessment Methods*, Climate Change Knowledge Network, Foundation Paper, www.cckn.net.
- Paavola, J. (2008). Livelihoods, Vulnerability and Adaptation to Climate Change in Morogoro, Tanzania, *Environmental science and policy*, II,642-654.
- Ribot, J., Magalhaes, A., and Panagides, S. (eds). (1996). *Climate Variability, Climate Change and Social Vulnerability in the Semi-arid Tropics*, In Kao, C-W(2009). *A White Paper on the Impacts of Climate Change on Drylands*, Seminar on Climate Change, Department of Geography, University of Florida, USA.
- Sivakumar M. V. K., DasH. P., Brunini O. (2005). Impacts of present and future climate variability and change on agriculture and forestry in the arid and semi-arid tropics. *Clim. Change*, 70,31–72.

- TERI. (2005). *Adaptation to Climate Change in the Context of Sustainable Development*, Background paper, The Energy and Resources Institute (TERI), New Delhi, India.
- Tol, R.S.J., Downing, T.E., Kuik, O.J. and Smith, J.B. (2004). Distributional aspects of climate change impacts, *Global Environmental Change*, 14, pp. 259–272.