The Economics of Climate Change Adaptation in India – Research and Policy Challenges Ahead[*]

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The failure of the Climate Summit in Copenhagen in December 2009 emphasized the limitations of greenhouse gas (GHG) mitigation as a singular policy response to climate change and highlighted the urgent need to design effective adaptation strategies. Current GHG mitigation efforts seek to limit the global average temperature rise to 2 degrees centigrade. There is some scientific evidence that suggests that this may not lead to catastrophic climate change impacts, but will still have significant effects on vulnerable populations. However, in the absence of any consensus on GHG mitigation plans, the target of limiting global average temperature rise to 2^{o}C appears difficult to achieve. Given the possibility of significantly adverse impacts of moderate as well as catastrophic climate change on developing countries, adaptation as a policy option requires careful attention.

The Madras School of Economics (MSE), the M.S. Swaminathan Research Foundation (MSSRF) and the South Asian Network for Development and Environmental Economics (SANDEE) organized a brain-storming workshop on the *Economics of Climate Change Adaptation* during 12-13 February 2010 at the MSE, Chennai to identify policy gaps, research questions and capacity-building needs related to India's need to adapt to climate change. This note provides a summary of the discussions at this workshop and draws some conclusions for future policy analyses.

The Chennai workshop was attended among others by K. Krishna Kumar (Indian Institute of Tropical Meteorology, Pune), Anand Patwardhan (Indian Institute of Technology, Mumbai), K.S. Kavi Kumar (MSE, Chennai), Sumana Bhattacharya (Winrock International India, Delhi), A.V.M. Subba Rao (Central Research Institute for Dryland Agriculture, Hyderabad), Bharat Ramaswami (Indian Statistical Institute, Delhi), A. Arivudai Nambi (MSSRF, Chennai), Shrinivas Badiger (Ashoka Trust for Research in Ecology and the Environment, Bangalore), S. Janakarajan (Madras Institute of Development Studies, Chennai), Sujatha Byravan (Institute for Financial management and Research, Chennai), Saudamini Das (Swami Shradhanand College, Delhi), Sudhir Chellarajan (Indian Institute of Technology, Chennai), Pranab Mukhopadhyay (Goa University, Goa), Arabinda Mishra (TERI University, Delhi), Priya Shyamsundar (SANDEE), Anupam Khanna (Global Development Network, Delhi), Shantanu Mitra (DFID, Delhi), S. Vidya (British Deputy High Commission, Chennai), S. Vaideeswaran (World Bank, Delhi), A. Vaidyanathan (Economist, Chennai), U. Sankar (MSE, Chennai), Brinda Viswanathan (MSE, Chennai), Indira Devi (Kerala Agricultural University, Thissur), Chandra Sekhar Bahinipati (MIDS, Chennai), and Sukanya Das (MSE, Chennai). Besides talks and discussion, the

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workshop also had a panel discussion on *Challenges in Mainstreaming Climate Change Adaptation* which was chaired by Prof. M.S. Swaminathan.

Climate Science and the Economics of Adaptation

Climate change impact assessment and adaptation studies require predictions from climate models. To plan for adaptation some important changes are required in the inputs provided by current climate models.

- First, climate predictions are needed at finer spatial resolutions than are currently available from the global climate models. This is beginning to happen – for example, the Indian Institute of Tropical Meteorology has developed high resolution (50x50 km) regional climate change scenarios for India using the Hadley Centre regional climate model (PRECIS) that is forced by the state-of-the-art coupled general circulation model (HadCM3). Similar exercises are underway to develop a suite of high resolution future climate scenarios for India by running three regional climate models (e.g., PRECIS, WRF and RegCM3) using the lateral boundary conditions from five IPCC-AR5 coupled models (Krishna Kumar, 2010).
- Second, future scenarios of climate need to go beyond predictions on temperature and precipitation. Along with these primary variables, the impact and adaptation community would benefit from knowledge on secondary variables such as heating degree days that combines information on available temperature range over the growing period of agricultural crops, heat index, starting and ending days of seasonal monsoon rainfall, storm surge etc. (Patwardhan, 2010).

As locally downscaled climate information becomes available, advances in policy responses and examination of climate implications will become more feasible.

Adaptation as a Development 'Continuum'

Any discussion on climate change adaptation must recognize two sometimes contrasting perspectives on the nature of adaptation: (a) climate change imposes a distinct and additional burden on the society; (b) climate adaptation, is one response among many, to a host of socio-economic and environmental pressures and cannot necessarily be isolated from regular development activities.

Under some circumstances, the additional vulnerability of economic agents to climate change and specific measures to reduce this vulnerability can be clearly identified. For example, if climate change is expected to increase precipitation and flooding in certain areas, the additional economic damages from these floods and 'adaptive' investments required to reduce these damages can be established. Thus, in these circumstances, it may be possible to identify clearly the additional burden of climate change and adaptation

However, climate adaptation may be rendered in-effective if policies are not designed in the context of other development concerns. For instance, a comprehensive strategy that seeks to improve food security in the context of climate change may include a set of coordinated measures related to agricultural extension, crop diversification, integrated water and pest management, and agricultural information services. Some

of these measures may have to do with climatic changes and others with regular economic development. Thus, in the broader development context, building adaptive capacity is much more than developing climate-related adaptation strategies. It is thus useful to examine climate adaptation, whether it is spontaneous or policy driven, in tandem with other economic development options.

The Costs of Adaptation

The origins of research on adaptation costs can be traced to climate change impact studies, where the objective was not to assess adaptation costs per se, but to refine impact estimates with proper accounting of adaptation to climate change. In this strand of literature, adaptation costs are defined as the expected value of avoided climate damages in the future, conditional upon some future state of socio-economic vulnerability. In a recent survey of such studies Agrawala and Fankhauser (2008) argue that with the exception of coastal protection, the knowledge on adaptation costs and benefits is fairly limited. Other studies, examine 'welfare' in future scenarios with and without climate change, estimate the costs of adapting to climate change and examine the 'benefits' in terms of reduced vulnerability (improved welfare) to climate change (e.g., Nelson et al., 2009).

Even though consensus on *a central estimate* of adaptation cost has not emerged, a relatively narrow range of estimates has emerged from various studies following variety of methodologies (see for example, UNFCCC, 2007; Parry et al., 2009; EACC, 2009; Nelson et al., 2009). With a view to supplement existing knowledge on adaptation cost estimates, BC3-TERI have attempted to estimate costs of adaptation for India. This collaborative effort identifies many methodological challenges and data needs (Mishra and Markandya, 2010). In another ongoing effort, the World Bank, JICA and ADB are assessing damage costs from climate induced flooding and required adaptation 'investment costs' in four major cities of the developing world including Kolkata in India. Future research in this context should focus more on fine-tuning methodologies and understanding a range of estimates and trade-offs and less on arriving at specific cost estimates. Research should also focus on integrating climate change concerns with other existing and emerging concerns.

Climate Adaptation in Agriculture

It is well established that climate change will have significantly adverse impacts on agriculture, especially in developing countries like India. Given the large proportion of the population dependent on agriculture – directly and indirectly – adverse effects on agriculture could easily translate into an escalation of poverty.

Increase in carbon dioxide concentration to 550 ppm could increase yields of rice, wheat, legumes and oilseeds by 10-20 percent. However, a one degree increase in temperature may reduce yields of wheat, soybean, mustard, groundnut, and potato by 3-7 percent (Aggarwal, 2009). The yield losses are likely to be much higher at higher temperatures. Studies assessing the economic impacts of climate change on agriculture have focused mostly on impacts on cereal crops like rice and wheat. New research findings from crop-models on non-cereal and commercial crops have not been integrated yet into economic modeling.

Kumar and Parikh (2001) and Sanghi and Mendelsohn (2008) have estimated that under moderate climate change scenarios, there could be about 9 percent decline in farm-level net-revenues in India. More adverse impacts are predicted in high-value agricultural regions such as Punjab, Haryana and Uttar Pradesh and dry-regions such as Gujarat and Rajasthan. On the other hand, eastern states of Bihar and West Bengal could benefit marginally.

Nelson et al. (2009) have estimated that the daily per-capita calorie availability in South Asia will decline by about 8 percentage points in 2050 due to climate change impacts on cereal crop yields compared to levels in 2000. In terms of the distributional effects of climate change impacts on agriculture, available preliminary evidence suggests that *changes* in poverty rates are not highly localized even though the adverse impacts are concentrated in the northern parts of the country – for example, Punjab is proportionately harder hit due to climate change but is a richer region to start with (Jacoby et al., 2009).

Citing the presence of strong spatial autocorrelation in the agricultural output data in India, Kumar (2009) argues in favor of controlling for spatial effects in climate change impact estimation. Among other things, strong flow of information amongst farmers may contribute to farmers being better able to adapt to climate change. Research priorities in this context include exploring the factors that facilitate information diffusion in agriculture.

Based on field level work carried out in Andhra Pradesh and Rajasthan, MSSRF (2008) suggests that there are effective ways to make farmers more adaptive to climate changes. They recommend specific changes in traditional water management practices such as *harren* in Rajastahn, establishing smart farmer networks that enable farmers to share knowledge on farm management practices, utilizing weather data from simple agro-met stations operated by the farmers and use of some new rice farming techniques such system of rice intensification. While, many such options appear rational at a case study level, the next step is to demonstrate through rigorous research their effectiveness when appropriately scaled-up.

Water and Coastal Sectors

Water and coastal resources are two other important sectors that could face significant adverse impacts in India due to climate change. Like agriculture, these sectors also face considerable non-climatic pressures. Hence the challenge is to integrate responses to non-climatic stresses with those that can minimize potential climate change impacts.

For India's National Communications (NATCOM) to the UNFCCC, river-basin specific impacts of various climate change scenarios and vulnerability to drought and floods has been estimated at the catchment, sub-catchment and watershed levels as well as administrative units such as districts[1]. While such exercises are useful, given the multiple pressures that act on water resources, integrated watershed modeling might be more appropriate. Following such a strategy, Badiger (2010) has studied the Malaprabha catchment area of the Krishna basin in detail and argues that much of the

[1] Please see http://gisserver.civil.iitd.ac.in/natcom for more information and results.

perceived water scarcity in the study area is attributable to the farming and land-use practices. Janakarajan (2010) on the other hand examined the current adaptation strategies of stakeholders in the Cauvery delta of Tamil Nadu and argues that the responses to climatic and non-climatic pressures have largely been ad-hoc and hence could be inadequate and unsustainable in the long-term. Some existing practices may have adverse implications as well. An example is the destruction of mangroves. Through a detailed analysis of the Orissa super cyclone in 1999 Das (2009) has shown that mangroves have a significant influence on reducing human and property losses compared to the institutional preparedness measures such as cyclone warning and evacuation.

The Intergovernmental Panel on Climate Change predicts that sea-level rise may be the greatest threat to sustainable development in South Asia. The consequences in terms of flooding of low lying deltas, retreat of shorelines, salinisation and changes in water table could cause potentially serious problems to large populations. Unlike other causes that force people to migrate, sea level rise poses a permanent problem with little or no scope for the migrants to return back to their homes. Byravan and Chellarjan (2009) argued that existing institutional arrangements may not be sufficiently equipped to handle within and across country migration resulting from sea level rise.

Establishing Impacts at Policy-Relevant Scales

From the above discussion it is clear that an important first step in the economic analysis of adaptation to climate change is to assess impacts of various climate change scenarios at disaggregated levels. The existing knowledge base in this regard is sketchy. While the NATCOM under the Ministry of Environment and Forests is working towards this objective, the social-science component of the NATCOM network is weak. Further, in addition to national analysis, state level exercises will be needed for designing effective adaptation strategies. Given the focus on adaptation, impact assessment exercises need not fine-tune or over-emphasize further improvements in our understanding of potential impacts. Instead, the focus should be on getting estimates at disaggregated levels so that more detailed studies can be undertaken at selective hot-spot areas and on state-level policies and individual sectors.

Estimating Adaptation Cost Curves

A research priority with regard to economics of climate change adaptation would be assessment of adaptation costs for India as well as sub-regions (e.g., states). Such estimates would be important for the climate negotiations as well as for resource allocation. Here, a useful way forward may be in constructing adaptation cost curves, which demonstrate the costs of multiple adaptation strategies. ECA (2009), for example, has estimated the costs of a variety of adaptation strategies in response to drought in Maharashtra. Establishing such cost curves is necessary if we are to identify least cost options. We note that while cost calculations can be relatively straight forward, careful attention may be required if the benefits of each strategy differ.

Examining Adaptation Instruments

In addition to the costs and benefits of adaptation strategies, careful economic analysis is required of instruments that could facilitate adaptation. Some emerging areas of research priority include:

- Assessing the usefulness of local weather stations in agriculture: It is often argued that weather data from simple agro-met stations can be of significant use to farmers for their farm management practices. This is well documented through studies undertaken by MSSRF (2008) in India and SEI (2008) in Africa. However, since this evidence is not based on random experiments, further analysis is needed to deal with problems of self-selection by farmers and the associated implications for understanding farm level outcomes.

- Effectiveness of insurance as adaptation strategy: It is widely believed that insurance could serve as an appropriate adaptation strategy. In India the entry of private insurance companies to offer index insurance to farmers has given rise to optimism. However, the costs of designing a contract are still very high and it is hard to establish basis risk[2]. Ramaswami (2010), for example, argues that while index insurance is potentially valuable to business entities and local governments that are exposed to pooled agricultural risks, it may not be very effective for individual farmers. For individual farmers (or households) catastrophe insurance may be more valuable. These issues need further research. Further, insurance as an instrument is amenable to fluctuations in weather around a stable climate. Its effectiveness in addressing fluctuations in weather around a changing climate is unclear.

- Addressing the challenges of migration as an adaptation strategy: The usual development paradigm has seen migration of people from inland towards coastal regions. However, with rise in sea levels and coastal inundation, reverse migration may be witnessed. An important researchable issue in this context relates to the triggers associated with sea-level rise and inundation that prompt migration. There is already much known about the behavioral dimensions of migration; how this knowledge applies to climate related migration needs to be more carefully examined.

- The role of information diffusion as adaptation strategy: Often lack of information can lead to catastrophic consequences. While the government might be doing its bit in undertaking the campaigns, say for instance, to reduce heat stroke effects, it may not be reaching the targeted end-users due to lack of adequate understanding about information diffusion pathways. Similar examples exist in case of knowledge dissemination in agriculture. Insights from behavioral and network economics may provide useful inputs in this context along with tools such as agent-based models.

- Economics of ecosystem based adaptation: While the general analysis points to the significant role of ecosystem services in mediating climate impacts, there is less evidence regarding actual adaptation costs. By linking such costs

[2] The mismatch between what a policy-holder expects insurance policies to cover and what the insurance contracts actually provide as loss indemnification represents basis risk in insurance.

with payments for ecosystem services, climate change adaptation can be effectively integrated with environmental management.

Building Capacity

Finally, adaptation to climate change and associated economic analysis are not widely understood, especially in policy circles and to some extent in the research circles in South Asian countries. Hence there is an urgent need for designing short-term training programs for different stake-holders and for careful long-term learning through collaborative research.

References

Aggarwal, P.K. (2009): "Vulnerability of Indian Agriculture to Climate Change: Current State of Knowledge", paper presented at the *National Workshop – Review of Implementation of Work Programme Towards Indian Network of Climate Change Assessment*, 14 October, Ministry of Environment and Forests, New Delhi, http://moef.nic.in/downloads/others/Vulnerability_PK%20Aggarwal.pdf (last accessed on 14 March 2010).

Agrawala, S. and S. Fankhauser (eds) (2008): *Economic Aspects of Adaptation to Climate Change: Costs, Benefits and Policy Instruments*. Paris: OECD.

Badiger, S. (2010): "Integrated Modeling Framework for Assessing Impacts of Changes in Land-use and Climate on Hydrologic Regimes and Water Distribution", presentation made at SANDEE, MSE and MSSRF Workshop on *Economics of Climate Change Adaptation,* during 12-13 February, at Madras School of Economics, Chennai.

Byravan, S. and S. Chella Rajan (2009): "Warming-up to Immigrants: An Option for US Climate Policy", *Economic and Political Weekly*, 44: 19-23.

Das, Saudamini (2007): "Storm Protection by Mangroves in Orissa: An Analysis of the 1999 Super Cyclone", SANDEE Working Paper No. 25-07, Kathmandu: SANDEE.

EACC (2009): *The Costs to Developing Countries of Adapting to Climate Change: New Methods and Estimates*, Consultation Draft, Economics of Adaptation to Climate Change, The World Bank, Washington.

ECA (2009): *Shaping Climate Resilient Development – A Framework for Decision Making*, a report of the Economics of Climate Adaptation Working Group.

Jacoby, H., E. Skoufias and M. Rabassa (2009): "On the Distributional Implications of Climate Change: A Methodological Framework and Application to Rural India", http://go.worldbank.org/XDJN920PA0 (last accessed on 14 March 2010).

Janakarajan, S. (2010): "Understanding the Impacts of Climate Change in the Context of Coastal Tamil Nadu", presentation made at SANDEE, MSE and MSSRF Workshop on *Economics of Climate Change Adaptation,* during 12-13 February, at Madras School of Economics, Chennai.

Krishna Kumar, K. (2010): "Climate Models: What is known and What is needed for Adaptation Assessment?", presentation made at SANDEE, MSE and MSSRF

Workshop on *Economics of Climate Change Adaptation*, during 12-13 February, at Madras School of Economics, Chennai.

Kumar, K.S. Kavi (2009): "Climate Sensitivity of Indian Agriculture: Do Spatial Effects Matter?", SANDEE Working Paper No. 45-09, Kathmandu: SANDEE.

Kumar, K.S. Kavi, and Jyoti Parikh (2001): "Indian Agriculture and Climate Sensitivity", *Global Environmental Change*, 11(2), pp. 147-154.

Mishra, A. and A. Markandya (2010): "Costing Adaptation: Preparing for Climate Change in India", presentation made at SANDEE, MSE and MSSRF Workshop on *Economics of Climate Change Adaptation*, during 12-13 February, at Madras School of Economics, Chennai.

MSSRF (2008): *A Road Map for Policy Development: Community Level Adaptation to Climate Change and its Relevance to National Action Plan*, Chennai: M.S. Swaminathan Research Foundation.

Nelson, G.C., M. Rosegrant, J. Koo, R. Robertson, T. Sulser, T. Zhu, S. Msangi, C. Ringler, A. Palazzo, M. Batka, M. Magalhaes, and D. Lee (2009): *Climate Change: Impact on Agriculture and Costs of Adaptation*, International Food Policy Research Institute, September.

Parry, M., N. Arnell, P. Berry, D. Dodman, S. Fankhauser, C. Hope, S. Kovats, R. Nicholls, D. Satterthwaite, R. Tiffin, and T. Wheeler (2009): *Assessing the Costs of Adaptation to Climate Change – A Review of UNFCCC and Other Recent Studies*, International Institute for Environment and Development and Grantham Institute for Climate Change, Imperial College London, U.K.

Patwardhan, A. (2010): "Towards an Integrated Agenda for Adaptation Research", presentation made at SANDEE, MSE and MSSRF Workshop on *Economics of Climate Change Adaptation*, during 12-13 February, at Madras School of Economics, Chennai.

Ramaswami, B. (2010): "Insurance Mechanisms", ", presentation made at SANDEE, MSE and MSSRF Workshop on *Economics of Climate Change Adaptation*, during 12-13 February, at Madras School of Economics, Chennai.

Sanghi, A. and R. Mendelsohn (2008): "The impacts of global warming on farmers in Brazil and India", *Global Environmental Change* **18**: 655-665.

SEI (2008): *Effective Use of Climate Science to Improve Adaptation in Africa*, policy brief, Stockholm Environment Institute, May.

UNFCCC (2007): "Climate change: Impacts, vulnerability, Adaptation in developing countries", UNFCCC, Bonn.