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Mainstreaming Climate Change Adaptation

Agriculture

K.S. Kavi Kumar and Brinda Viswanathan

Climate change is likely to have large adverse effects on several climate-sensitive sectors, such as agriculture, particularly in developing countries. The scale of impacts is likely to be beyond the ability of climate finance to ameliorate and in any case, the prospects for large quantities of finance appear limited particularly for large, rapidly emerging economies like India. Consequently, the best available option that developing countries may have is to 'mainstream' climate change adaptation policy into their existing and future development policy and planning, that is, improving development prospects, while making the economy and its poorer sections of population climate resilient. Socio-economic development has the potential to reduce the existing development deficit, and in turn adaptation deficit, both of which could in turn augment the capacity of the country to adapt to climate change and natural disasters, exploiting synergies between development and climate resilience. Mainstreaming will also

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enable a more integrated and less of a piecemeal approach towards achieving development objectives.

Against this background, this chapter provides an overview of issues surrounding the mainstreaming of climate change adaptation in the agriculture sector. The chapter is structured as follows. The next section takes stock of climate change impact studies to understand knowledge gaps and research priorities. The subsequent section discusses the status of adaptation research focusing on triggers of adaptation and adaptation strategies. The following section deliberates on approaches for mainstreaming climate change adaptation policies and associated institutional requirements.

Climate Change Impacts on Indian Agriculture

Available evidence suggests significant welfare implications of climate change impacts on agriculture. Agronomic studies suggest that for every 1°C increase in temperature during the growing season, the wheat production in India could reduce by 4–5 million tons (Swaminathan and Kesavan 2012); and rice yields may decline by about 6 per cent (Saseendran et al. 2000). Studies analysing the changing climate trends indicate that minimum temperature during the kharif season is increasing at 0.19°C every decade, and that such a rise will have an adverse impact on paddy yields in about half of the total cultivated area in India (Bapuji Rao et al. 2014). Further, warming during the rabi season has serious implications for the production of crops like wheat, mustard, and chickpea in the Indo-Gangetic plains. With the growing contribution of rabi season production in the total food grain production in recent years, the adverse impact of climate on rabi production is of equal significance to that on kharif production. Besides direct effects on crops, climate change is likely to impact natural resources like soil and water (National Academy of Agricultural Sciences [NAAS] 2013). Increased rainfall intensity in some regions could cause more soil erosion, leading to land degradation. Increased temperatures will also increase crop water requirement. Studies indicate that irrigation requirement in arid and semi-arid regions could increase by 10 per cent for every 1°C rise in temperature (Venkateswarlu et al. 2011). In addition to the temperature and rainfall effects, studies show that climate change impacts will have significant distributional effects, with poorer farmers getting more adversely affected than better-off farmers (Gupta, Sen, and Srinivasan 2014), and that climate change will influence crop productivity along with several other stresses such as aerosol pollution (Auffhammer, Ramanathan, and Vincent 2006).

The climate change impacts on agriculture vary across studies based on the methodologies followed, crops considered, future climate change scenarios included, extent of adaptation considered, and geographic regions covered. The aggregate impacts of climate change on yields of rice and wheat crops are summarized here to provide a broad idea about the direction and extent of impacts. The irrigated rice yield is expected to reduce by about 4 per cent in 2020, 7 per cent in 2050, and 10 per cent in 2080 (Mall, Gupta, and Sonkar 2017; Naresh Kumar et al. 2013). Further these studies report that rain-fed rice yields are expected to reduce by about 6 per cent in 2020, and reduce only marginally in 2050 and 2080. Wheat yields are projected to reduce by 6 per cent and 15 per cent by 2050 and 2080, respectively, if sown on time and by 28 per cent and 35 per cent, respectively, if sown late (Naresh Kumar et al. 2014). Given that climate has already changed to some extent, few studies provided hind-casting estimates of the climate change on rice and wheat yields. The average rice yield would have been 8.4 per cent higher had the pre-1960 climatic conditions prevailed over the period 1969–2007, implying average annual production loss of 4.4 million tonnes per year (Pattanayak and Kumar 2014). Similarly, Gupta, Somanathan, and Dey (2016) estimate that the wheat yields in India were lowered by about 5.2 per cent due to climate change observed over the period 1981–2009.

While agriculture is one of the more widely analysed sectors with regard to climate change impacts, there is still considerable debate in the literature on the appropriate methodology to examine these impacts. Summarizing the debate, Blanc and Reilly (2017: 255) observe that 'unfortunately, even if climate change could be predicted with certainty, we are still far from conclusively determining its effects on agriculture, either globally or for specific farming regions'. Some of the research priorities in Indian context are outlined later in the chapter.

Methodological Issues

Climate change impacts have traditionally been assessed in terms of physical impacts (such as changes in yield and acreage sown), or the associated economic impacts. Over the years, there has been steady increase in both categories of studies, but significantly larger increase in physical impact studies than the economic impact studies. Further, there has been proliferation of 'statistical' method as a preferred method of impact estimation, both for physical as well as economic impact assessment.

Statistical models relying on data from different locations—cross-sectional data—have been in use from the mid-1990s in the field of climate change impact literature. Referring to the cross-sectional statistical model-based approach as the Ricardian approach, Mendelsohn, Nordhaus, and Shaw (1994), in their study of climate change impacts on the United States (US) agriculture, compare farms across different places—each of which is adapted to local climatic conditions—to empirically estimate the equilibrium climate response of farms to climate. One of the main advantages of the Ricardian approach is that it takes into account the full range of farm-level adaptation possibilities. However, in practice, it may be difficult to identify and include *all* the control variables that would affect agricultural variables (say, farm profitability) in the long term, in the regression models. The omission of some of these control variables is a misspecification of the regression model and hence would bias the quantitative estimates of the net impact of climate variable on the agricultural variable.

One of the approaches used to address this limitation is to increase the information base by including the data on the same cross-section units over several periods of time (referred to as a panel data set). This additional data enhances the scope to account for location-specific and time-specific heterogeneities that are unobserved by bringing in additional coefficients in the regression model. Such a model specification is called panel fixed effects model, as the omitted variables are absorbed as coefficients fixed over either time or over cross-section (see Dell, Jones, and Olken 2014; Deschênes and Greenstone 2007). In these models, weather variables are used instead of climate variables as the time-invariant nature of the climate variable clashes with the location-specific fixed effects coefficients. Hence, the panel fixed effects models estimate impacts due to weather shocks, and not necessarily impacts due to climate change.

In line with the global trends, there has been increasing use of statistical models in the context of Indian agriculture too, both for impact assessments based on physical outcomes, such as yield (see, for example, Auffhammer et al. 2012; Birthal et al. 2014; Gupta, Sen, and Srinivasan 2014; Krishnamurthy 2012; Lobell, Schlenker, and Costa-Roberts 2011; Pattanayak and Kumar 2014; and Saravanakumar 2015), and for impact assessments based on economic outcomes, such as net revenue (see, for example, Kar and Das 2015 and Kumar 2011). While these studies may be accurately assessing the impact of weather shocks, attributing the results to climate change could be misleading for several reasons, as highlighted by Dell, Jones, and Olken (2014). Even though the panel models correctly identify the causal effect of weather shocks on economic outcomes, they may not provide accurate insight on the likely effects of future climate change. The effects of weather shocks (as estimated by the panel fixed effects models) will be larger than the (true) effects of climate change if adaptation plays a dominant role. On the other hand, the effects of weather shocks will be smaller than the (true) effects of climate change if variation in temperature and precipitation become more intense.

Further, there is considerable uncertainty with regard to choice of climate variables in the impact literature. For example, in a study on the rice crop cultivation in India, Pattanayak and Kumar (2017) show that magnitude and distribution of simulated impacts of historical changes in climate on rice yield are significantly different when estimated based on a model that includes both minimum and maximum temperature (see Panel B in Figure 28.1 [between pages 326 and 327]) when compared to a model that includes only minimum temperature (Panel A in Figure 28.1). As it could be seen, the daytime temperature effects outweigh the positive effects observed in Panel A. Overall, there is still considerable scope for research on appropriate model specification in climate impact research.

While much research still needs to be done on assessing the aggregate impacts of climate change across sectors and at the macro level, there is significant evidence in the literature to suggest that aggregate impacts could be misleading if used for adaptation purposes. Pattanayak and Kumar (2017), for example, show in the context of rice crop that regional impacts are overestimated when simulated using an all-India yield response function, as against those based on region-specific yield response function that incorporates the features of regional crop calendar and regional crop management practices. Also, for effective policymaking, there is urgent need to improve our understanding about the impact distribution across geographic regions as well as various socio-economic groups (see Gupta, Ramaswami, and Somanathan 2017; Jacoby, Rabassa, and Skoufias 2014; Kar and Das 2015).

Vulnerability to Climate Change

Several studies have focused on assessing the vulnerability of climate sensitive sectors and geographical regions in India to climate change using the conceptualization promoted by the *Third Assessment Report* of the Intergovernmental Panel on Climate Change (IPCC). Accordingly, vulnerability is defined as a function of exposure, sensitivity, and adaptive capacity. Since it is difficult to accurately measure these three attributes of vulnerability, most studies have adopted an indicator-based approach to combine various aspects and express vulnerability as an aggregate index. Thus, O'Brien et al. (2004) used district-level data on several indicators to assess the exposure, sensitivity, and adaptive capacity components of vulnerability. The study considered vulnerability to globalization in tandem with climate change to define what they term as 'double exposure'. While this, and other similar studies, does not exclusively focus on agriculture, it remains one of the dominant factors characterizing the vulnerability of a region. In a recent study, Rama Rao et al. (2016) have assessed the vulnerability of Indian agriculture to climate change across 572 districts. The study identifies that most of the districts with very high and high vulnerability are those from the states of Rajasthan, Gujarat, Uttar Pradesh, Madhya Pradesh, Karnataka, and Maharashtra. By and large, the vulnerability literature highlights the role of multiple stressors and the importance of improving the adaptive capacity of vulnerable entities/regions in general, not specific to climate change alone.

Adaptation Research

Research on adaptation in the climate change context has evolved over the past two decades in line with the shift in the global climate change policy. Klein et al. (2017) provide a comprehensive summary of the evolution of climate change adaptation research, juxtaposing it with the evolving climate change policy context. In particular, they identify four generations of adaptation research:

1. First generation: potential impacts of climate change, along with costs and benefits of adaptation.
2. Second generation: the role of social factors in exacerbating vulnerability to climate change, including the role of adaptive capacity and factors that could improve it.
3. Third generation: distributional and financing issues as well as the policies/institutions to support adaptation activities.
4. Fourth generation: how adaptation actually works at the ground level, with a focus on implementation and approaches to 'mainstream' climate change adaptation.

One way to understand the evolution of these different generations of adaptation research could be to view them with reference to the temporal and spatial scales that these studies deal with. Figure 28.2 provides a visual representation of the progress in adaptation research. While the first-generation studies focused on

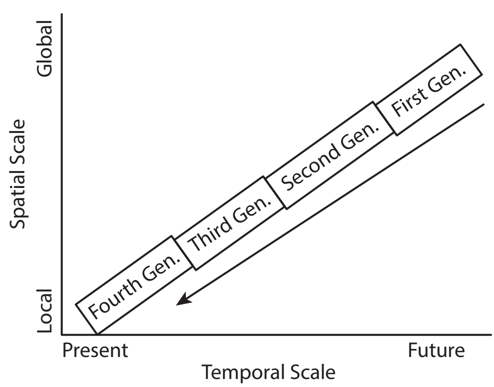

Figure 28.2 Schematic Representation of Evolution of Climate Change Adaptation Research
Source: Prepared by author.

adaptation needs at aggregate geographical regions and in distant future, the fourth-generation studies are more concerned about adaptation at specific locations, and in response to the weather/climate shocks that are experienced currently.

In the Indian context, there have been varying degrees of focus on these strands of adaptation research. While there were only a few studies that systematically analysed the role of adaptation in climate change impact studies (that is, the first generation of adaptation research), a large number of studies focused on vulnerability assessment. Many of the vulnerability assessments, however, tend to capture generic vulnerability rather than vulnerability in the climate change context. Studies that could be classified as those in the third generation of adaptation research are still evolving. A major challenge concerning these studies remains in establishing a robust climate change connection. Notwithstanding such concerns, there has been a proliferation of studies in India that broadly fall in the category of fourth-generation adaptation research studies. In their pursuit to implement the climate change action plans, many state governments are currently implementing several adaptation activities across India. However, the climate change context is often unclear in these activities and as a result, many such activities could be seen as activities implemented to bridge the existing 'development deficit'.

Adaptation Costs and Benefits

As discussed in the previous section, climate change will have significant 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. Some studies have tried to assess the costs of adaptation in the context of agriculture sector. In line with the adaptation continuum argument, adaptation costs can be expressed as investments needed to maintain certain welfare objectives (for example, maintaining a certain level of calorie per capita). The adaptation costs in such scenarios can be assessed by first estimating the productivity growth needed to meet, say, the calorie availability target (welfare objective), and then estimating the investment expenditure needed in, say, research and development, rural infrastructure, and so on, to generate the required productivity growth (see, for example, Nelson et al. 2009). Using such an approach, additional annual investments needed to counteract climate change impact on nutrition in India are estimated as US$3.3 billion,[1] with bulk of investments going to rural infrastructure (for example, roads) and irrigation. Another study, Bhadwal, Ghosh, and Martin-Ortega (2011), on the other hand, provided estimates of adaptation costs based on a bottom-up approach. The annual adaptation costs in agriculture (in India) are estimated as US$1.0–1.5 billion by 2020 and US$1.8–2.2 billion by 2050 towards autonomous adaptation. The planned adaptation will be over and above the autonomous adaptation.

With regard to benefits of adaptation, the bulk of the available evidence draws from the studies that model adaptation as a transition from one equilibrium to another in response to climate change shock. In the context of agriculture, the Ricardian approach, discussed earlier, follows such strategy (see Kumar and Parikh 2001; Sanghi and Mendelsohn 2008). However, these equilibrium-based models assume instantaneous adaptation and ignore adjustment costs, thereby overestimating the benefits from adaptation (Hanemann 2000).

Adaptation Strategies

Zilberman, Zhao, and Heiman (2012) highlight several strategies for the implementation of adaptation. These include innovation, adoption (of technology), risk management, and migration. Historically changing weather conditions as well as growing food demand have led to a variety of innovations that facilitated the movement of agricultural practices to regions that hitherto were not cultivated due to non-favourable climatic conditions. The

[1] It may be noted that comparable adaptation costs in South Asia and sub-Saharan Africa were estimated to range from US$7.1 to US$7.3 billion under different climate change scenarios. The recent assessments by the Government of India, on the other hand, are much higher.

literature has identified a number of factors contributing to innovations, including public research, conducive institutional structure, and policy environment. Existing regulations (on, say, land use) may, however, hamper development of technologies and crops that enable adaptation to climate change.

The literature on adoption focuses on decisions regarding new technologies. Studies focusing on autonomous adaptation, in contrast, focus on adoption of existing technologies—for instance, the Ricardian approach used for assessing climate change impacts on agriculture assumes that farmers will adapt to climate change along the current technology envelope. However, in case of proactive adaptation, there will be sufficient response time to the changes, and hence the emphasis will be on adoption of new technologies. Independent of whether the choice is between the existing and the new technologies, it is relevant to take stock of uptake of technologies by the farmers in India. Palanisami et al. (2015), based on the analysis of four decades of research on water management in India, observe that farm-level adoption rate is only 22 per cent of the technologies developed by the research centres. Since more than three-fourths of the practices followed by the farmers are still based on local and traditional wisdom, it is important to validate the traditional technologies. It is also important to understand the reasons behind non-adoption of new technologies and strengthen the outreach activities of the research centres.

There has been extensive literature on risk management through insurance. However, implementation of insurance in the agriculture sector has always been challenging, especially in countries like India. Cole, Gine, and Vickery (2014) use randomized control trial involving a sample of Indian farmers from two drought-prone districts, namely, Mahbubnagar and Anantapur, to study how rainfall insurance affects the real production and investment decisions of farmers, such as crop choices and usage of agricultural inputs. They find that the provision of insurance causes substitutions in agricultural investments towards cash crops that are more rainfall sensitive. This shift in behaviour is concentrated among more educated farmers. Similarly, Mobarak and Rosenzweig (2012) find evidence from India that insured households were more likely to plant higher-yield but less drought-resistant varieties of rice. Due to interdependency with other adaptation activities, insurance policies often need to be designed in congruence with other strategies to overcome moral hazard problems.

Migration is often considered as an effective adaptation strategy. However, one has to keep in mind that migration from agriculture occurs as a natural result of development. Further, in the developing country context, there is often short and long-duration migration. Viswanthan and Kumar (2015) analyse census data to show that while the weather-induced agricultural distress could lead to migration from rural to urban areas in India, the magnitude of the response is relatively small in India compared to those reported in the literature for developed countries. Specifically, the study argues that 1 per cent decline in rice yield leads to nearly 2 per cent increase in the rate of out-migration from a state in India. Similarly, a 1 per cent decline in wheat yield leads to a 1 per cent increase in out-migration. In another study, Kumar and Viswanathan (2013) highlight the differences in the influence of weather variability on temporary migrants as well as permanent migrants using National Sample Survey data for India. The study results show that the migrants involved in agriculture-related activities are usually temporary migrants for whom weather variability is a major determinant of migration decision. Further, it is argued that rainfall variability plays a relatively less important role in the context of permanent migration decisions. If one views migration as adoption of a new location, then one may expect to see synergy between adoption literature and migration literature. Future research in this context could also include analysis of migration decisions in the presence of regulatory and land-use constraints.

Mainstreaming Adaptation

The adverse effects of climate change are manifested through changes in development outcomes (for example, through increased population that is poor or malnourished). However, development outcomes are affected by a host of factors or stressors that may not be directly connected with climate. Thus, climate is only one amongst several factors determining the development outcome of a society. In reality, at a more local scale, there could be multiple stressors that determine the aggregate vulnerability of a system.

Assessing the society's vulnerability to climate change in isolation, therefore, is not warranted. Such assessment would undermine the role of other stressors in exerting direct or indirect (through interaction with climate) influence on societal welfare. The foremost consequence of this is the significant underestimation of the aggregate vulnerability to climate change. Further, this would lead to inappropriate choice of policies and measures. Moreover, while involving additional costs, the overall effectiveness of adaptation could be limited given the specific nature of the adaptation measures. The choice of inappropriate policy could prove to be significantly costly, especially for the developing countries, where climate change impacts will be more severe and the basic resources to tackle the problem are limited.

Similar arguments can also be made with regard to risks imposed by natural disasters, such as droughts, cyclones, and floods, and sudden onset events, like flash floods and hailstorms. While event-specific response strategies cannot be ruled out, it could be prudent to enhance the resilience of the society to absorb the adverse impacts caused by such natural disasters. Further, there are close linkages between the changes in climate and the frequency and magnitude of climate-induced natural disasters. This has brought forward the notion of climate risk management (CRM) (see Mechler and Schinko 2016, for more details). It is argued that the CRM framework could be particularly useful in complex situations characterized by large potential consequences, persistent uncertainties, long time frames, potential for learning, and multiple climatic and non-climatic influences changing over time.

Mainstreaming—Approaches

Based on various country experiences with regard to mainstreaming climate resilience into development planning, Pervin et al. (2013) identify three broach approaches: climate-proofing, climate-first, and development-first. The climate-proofing approach aims to protect development interventions that have been planned in isolation without taking climate change into context. It simply aims at making the development intervention resilient to climate variability and climate change. Climate proofing of watershed development initiatives of National Bank for Agriculture and Rural Development (NABARD) in the states of Tamil Nadu and Rajasthan is an example of mainstreaming of climate adaptation in the agriculture sector. Climate-first approach aims to address incremental change in existing climate-related risks. It typically involves designing pilot intervention strategies that are climate resilient and (if found effective) subsequently scaling up to sectoral and/or national plans. Examples include climate-smart agriculture practices and climate-smart village approach (Aggarwal et al. 2018). Emerging evidence suggests that development deficit often constrains the scaling-up of the climate-first interventions. Further, lack of synergy between strategies promoted under climate-smart agriculture and pricing policies could lead to unsustainability of the interventions (Kumar 2018). The third mainstreaming approach, namely, development-first approach, keeps climate resilience as an integral part of the development planning process from the very beginning. There is relatively less evidence of mainstreaming on these lines in India, as it requires significant changes in the institutional structures.

It is also relevant to note here the emerging literature on adaptation pathways. In contrast to conceptualizing adaptation as discrete actions made in response to specific changes (in, say, climate), this strand of literature characterizes adaptations as dynamic and continually unfolding pathways. Such a conceptualization of adaptation facilitates careful understanding of the synergy and contradiction between individual, household, and community-scale adaptation, and the higher-scale adaptation decision process (Burnham, Rasmussen, and Ma 2018). In the pursuit towards mainstream adaptation, such understanding is essential to avoid creation of new vulnerabilities while addressing climate change vulnerability. The adaptation pathways research would also establish the required connection between different generations of adaptation research discussed in the previous section.

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Under the National Adaptation Fund, NABARD has sanctioned several projects worth over Rs 660 crore (Rs 6.6 billion) across different states of India. Close to 60 per cent of these interventions can be classified as climate-proofing projects, with the rest constituting the climate-first type interventions. Yet, most of these projects could also be seen as sustainable development interventions. While most climate change adaptation interventions will have development co-benefits, caution must be exercised against using climate change adaptation to achieve development goals. The wide range of budgetary requirements given by different State Action Plans on Climate Change (SAPCCs) for the agricultural sector reflect the inherent difficulty in disentangling development and climate change adaptation, as well as the convenience that scope for climate change funding provides for meeting legitimate development goals. The budgetary requirement for adaptation in agricultural sector in states like Uttar Pradesh and Uttarakhand was as low as Rs 100 crores (1 billion), while Tamil Nadu estimated its requirements as above Rs 23,000 crores (Rs 230 billion) (Kumar 2018).

Effective mainstreaming of adaptation depends critically on how adaptive the existing institutional structure is towards integrating climate change concerns. In India, SAPCC and State Disaster Management Plan (SDMP) are the formal institutional platforms at state level to mainstream climate risk and disaster risk into development planning, respectively. For effectively addressing the climate risk and the disaster risk, it is important to synergize different plans into development planning (Bahadur, Lovell, and Pichon 2016; Dubash and Jogesh 2014). While in the existing institutional structure a nodal agency (such as Department of Environment in case of SAPCC) prepares the climate and disaster plans, there is a need for progression towards establishment of climate and disaster cells in the line departments to fully integrate such risks in the development plans. To effectively mainstream adaptation, subsequent iterations of state climate planning should take measures to ensure that adaptation policies do not exacerbate inequalities, identify trade-offs and synergies of different policies through public consultations and multi-criteria decision analysis, and adopt a programmatic approach as against a project approach.

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