SANDEE
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POLICY Brief

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The Impact of Climate Change on Indian Agriculture

In India, as elsewhere in the world, climate change is now high on the political and public agenda. In the sub-continent, particular attention is being paid to the impact of climatic changes on agriculture since there could be serious implications for food security.

A new SANDEE study examines how climate change will affect agricultural revenue in India. The study, which is the work of K.S. Kavi Kumar from the Madras School of Economics in Chennai, uses a pioneering approach that incorporates spatial features in examining the sensitivity of agriculture to climate change. This approach takes into account spatial linkages across farmers and postulates that farmers are influenced by their colleagues in surrounding areas and learn from each other to adapt to changes in climate.

Incorporating spatial effects lowers our current understanding of climate change impacts on agriculture in India. If there is a +2°C temperature change and a +7 percent precipitation change uniformly across India, Kumar estimates that climate changes will result in a 9 percent decline in annual farm-level net revenue. However, when spatial effects are taken into account, the impact of climate change on revenue is reduced to 3 percent. The study concludes that if certain spatial effects are harnessed (for example by promoting better dissemination of knowledge among farmers) then adaptation to climate change will become more feasible and less costly.

THE CLIMATE CHANGE CHALLENGE

Most scientists and policy makers now acknowledge that climate change will have far-reaching impacts on human society unless significant steps are taken to deal with it. Current climate change projections for India for the 2050s suggest an increase in temperature of 2-4°C for the country's south and of more than 4°C for its northern region. While there is likely to be little change in the average amount of monsoon rainfall, the number of rainfall days are expected to decrease over a major part of the country. Climatologists also predict an increase in the intensity and frequency of extreme events such as droughts, floods and cyclones.

There are several approaches used to estimate climate change impacts on agriculture (see the Side Bar for details). Kumar employs a method known as the Ricardian approach, which uses observed differences in agricultural production and climate among different regions, to estimate how climate change will affect agriculture.

ESTIMATING THE IMPACT OF CLIMATE CHANGE FOR INDIA

Kumar assesses the impact of climate change by looking at how it affects the net revenue from agriculture. Using districts as units of analysis, his assessment incorporates the impact that climate change could have on a range of different crops and takes into account the behaviour of farmers (e.g. switching crop types as climate changes). Kumar includes the impact of spatial features into his assessment by looking at the cross-effects of characteristics of neighboring districts. Kumar estimates the yearly impact of climate change at the district level, and then uses these findings to derive a national picture. In order to gain further insights, Kumar assesses a number of climate scenarios.

This policy brief is based on SANDEE working paper No. 45-09, 'Climate Sensitivity of Indian Agriculture: Do Spatial Effects Matter?' by K.S. Kavi Kumar from the Madras School of Economics in Chennai. The full report is available at : www.sandeeonline.org

The data used for this study includes a district-level agricultural dataset for the period 1966 to 1986. The data covers thirteen major states in India and includes information on 271 districts. Kumar also uses climate data from over 390 meteorological stations spread across India. This climate data gives details of the average observed weather for the period 1951-1980. The climate information includes details of the average daily temperature and monthly total rainfall in the four months of January, April, July and October. The information therefore covers the four main seasons. Alongside these climate factors, Kumar also assesses the impact of a whole range of other factors on agricultural revenue. These factors include soil type, the extent of mechanization, local literacy, population density, the number of cultivators and the fraction of agricultural land under irrigation and under high-yielding seed varieties.

ASSESSING THE IMPACT OF CLIMATE CHANGE

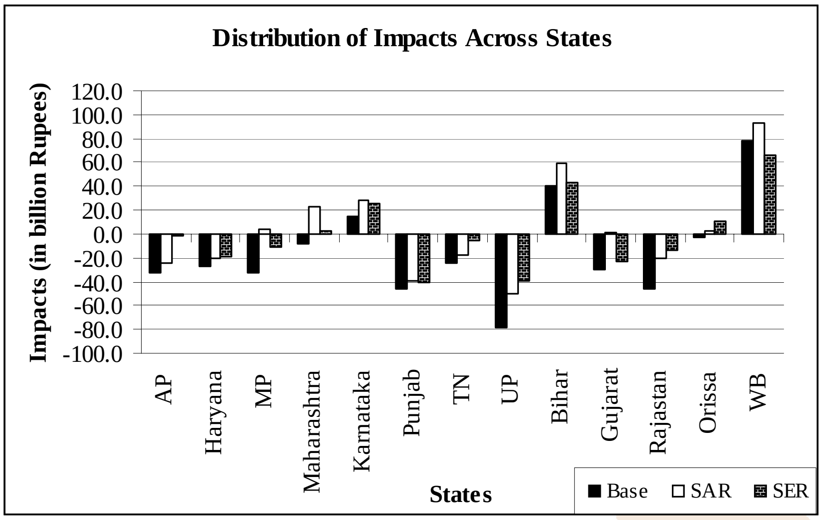
Researchers use a number of different methods to assess the economic impacts of climate change. The agronomic-economic approach uses modelling to predict the physical impacts of climate change and then its economic consequences. This is done by, for example, predicting yield changes and/or crop area changes using crop simulation models. In the Indian context, Kumar and Parikh have assessed in the past the macro level impacts of climate change using such an approach. They showed that if carbon dioxide concentration levels double in the latter half of the 21st century then India's gross domestic product would decline by 1.4 to 3 percentage points (under various climate change scenarios).

Table 1: Projected Changes in Climate in India: 2070-2099

	Jan-March	April-June	July-. Sep	Oct.-Dec.
Temperature Change (°C)				
Northeast	4.95	4.11	2.88	4.05
Northwest	4.53	4.25	2.96	4.16
Southeast	4.16	3.21	2.53	3.29
Southwest	3.74	3.07	2.52	3.04
Precipitation Change (%)				
Northeast	-9.3	20.3	21.0	7.5
Northwest	7.2	7.1	27.2	57.0
Southeast	-32.9	29.7	10.9	0.7
Southwest	22.3	32.3	8.8	8.5

Source: Cline (2007)

Figure 1: State-wise Distribution of Climate Change Impacts: Without and with Spatial Correction



Base Model without spatial correction; SAR – Spatial-lag model; SER – Spatial-error model

One of the major limitations of the agro-economic approach is how it deals with the way in which farmers adapt to changes in climate. Under this approach, the physical impacts of climate change on agriculture must be re-estimated for each adaptation strategy; this means that researchers using the agro-economic approach can only assess a limited number of such strategies.

The main alternative method, which is used in this study, is known as the Ricardian approach. This approach is based on the argument that it is possible to assess the economic impact on farmers of a (say) 3°C temperature rise by studying two agricultural areas that are similar in all respects except that one has a climate on average 3°C warmer than the other. Since this approach incorporates in its analysis the responses of farmers to climate change, it can, in principle, include all adaptation possibilities. The Ricardian approach has received widespread attention due to its elegance and several studies in India have followed this approach to assess the climate sensitivity of Indian agriculture. For example, Kumar and Parikh earlier used a variant of this approach and showed that a 2°C temperature rise and a 7 percent increase in rainfall would lead to almost a 8.4 percent loss in farm level net revenue.

A few studies have used a third approach to look at the impact of climate change. This is based on the agro-ecological zones (AEZ) methodology of the UN Food and Agricultural Organization. This approach assesses crop suitability to agro-ecological zones under present and changed climatic conditions. This is done to estimate the changes in production potential that climate change will produce and, consequently, to assess its economic implications.

SPATIAL FACTORS MAKE AGRICULTURE MORE ROBUST

Overall, the study finds that climate change would have a significant negative effect on agricultural revenue across India. It also finds that changes in temperature would have a much larger effect than changes in rainfall. However, the impact of climate is not uniform across the year: while higher temperatures during the hot spring and summer days would adversely influence crop growth, warmer autumns could lead to an enhanced growing season. Higher temperatures during winter could also favourably influence pest growth and could therefore have an adverse impact on crop growth. As expected, higher precipitation would be beneficial in the winter and autumn seasons, but harmful during spring and summer.

From a regional point of view, the impact of climate change is also not uniform (see Figure 1). Climate change is likely to have an adverse impact on agriculture in most parts of India, apart from in the eastern states of Bihar and West Bengal and the inland region of Karnataka. The high-value agricultural regions of Haryana, Punjab and Uttar Pradesh, together with the dry regions of Gujarat and Rajasthan, will be affected most, while coastal states such as Andhra Pradesh and Tamil Nadu will also be affected, but to a lesser extent.

The study finds that spatial effects do make a significant difference to the impact of climate change on Indian agriculture (see Figure 2). For example, one of the climate change scenarios Kumar assesses involves a +2°C temperature change and a +7 percent precipitation change uniformly across India. If spatial effects are not considered, this scenario would result in an estimated 9 percent decline in annual farm-level net revenue. When spatial effects are taken into account, the impact of climate change on revenue is found to be only 3 percent. From a regional perspective Kumar's research finds that in Andhra Pradesh, Tamil Nadu, Rajasthan, Madhya Pradesh and, to some extent, Uttar Pradesh, incorporating spatial effects results in a reduction in the impact of climate change on agriculture. Among other things, a strong flow of information amongst farmers in

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The South Asian Network for Development and Environmental Economics (SANDEE) is a regional network that seeks to bring together analysts from the different countries in South Asia to address their development-environment problems. Its mission is to strengthen the capacity of individuals and institutions in South Asia to undertake research on the inter-linkages among economic development, poverty, and environmental change, and, to disseminate practical information that can be applied to development policies. SANDEE's activities cover Bangladesh, Bhutan, Nepal, India, Pakistan and Sri Lanka.

SANDEE's Policy Brief Series seek to inform a wide and general audience about research and policy findings from SANDEE studies.

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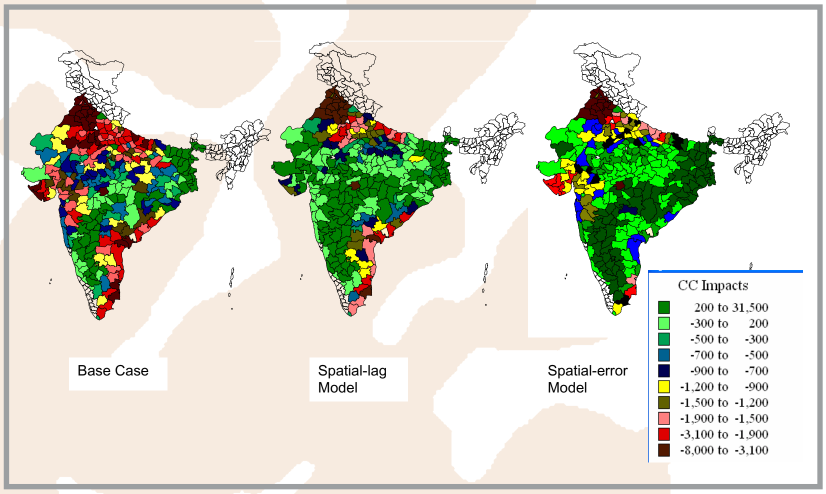
Figure 2: Distribution of Climate Change Impacts across Districts – Without and With Spatial Correction



these states may contribute to farmers being better able to adapt to climate changes (through changes in, for example, the mix of crops they grow and the crop management practices they use).

POLICIES CAN HELP FARMERS ADAPT

In comparison to most past studies, it is clear that Kumar's assessment provides a more accurate picture of the potential impacts of climate change on Indian agriculture. It also shows the importance of incorporating spatial effects into any similar analysis.

To show how his results could be converted into useful policies, Kumar highlights the main sources of information that farmers use to help them adapt to climate and other changes (assessed through focus group discussions). These sources include the more affluent farmers in an area, fertilizer and pesticide dealers, seed providers, and better-informed family members. Contrary to popular belief, agricultural extension centres do not operate as a primary source of information. Kumar therefore concludes that policy makers should explore and experiment with new ways of getting information out to farmers. Given the fragmented nature of Indian agricultural lands, large-scale participation of the corporate sector may be difficult. Furthermore, farmers seem to favour the participation of agricultural cooperatives, NGOs, and fertilizer dealers.

The above proposals deal largely with private adaptation measures undertaken by farmers, for whom adapting to climate change is preferable to doing nothing. However, dealing with climate change also requires large-scale public adaptation measures. There is considerable policy analysis that needs to be done on the different public adaptation strategies that will help ameliorate the adverse impacts of climate change on Indian agriculture.

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