Coping with global change

vulnerability and adaptation in Indian agriculture

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Institut international du développement durable

Canadian International Development Agency
Agence canadienne de développement international

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The Energy and Resources Institute

ISBN 81-7993-022-X

Published by
TERI
Darbari Seth Block
Habitat Place
Lodhi Road
New Delhi – 110 003
India

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Printed in India by IG Printers, Delhi

Contents

Acknowledgements

This monograph has been prepared by the following.

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- Stephan Barg, IISD (International Institute for Sustainable Development)

Comments and suggestions have been provided by the following.

- Henry Venema, IISD
- Robin Leichenko, Rutgers University

This work has been made possible by financial support from the Government of Canada, provided through the Canadian International Development Agency, and from the Government of Norway, provided through the Ministry of Foreign Affairs. Our research has also benefited from the valuable inputs provided by the Ministry of Agriculture, Government of India. The publication of this monograph has been facilitated by the editing, typesetting, graphic design, and production supervision undertaken by TERI's Publications Unit.

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Preface

Climate change is no longer a distant concern, but a serious threat to development and poverty eradication. The TAR (Third Assessment Report) of the IPCC (Intergovernmental Panel on Climate Change) draws attention to the fact that the impacts of climate change will fall disproportionately upon developing countries and the poor persons within all countries, thereby exacerbating inequities in health status and access to adequate food, clean water, and other resources. The Delhi Ministerial Declaration on Climate Change and Sustainable Development, adopted at CoP-8 (the eighth session of the Conference of the Parties to the United Nations Framework Convention on Climate Change), also affirmed this: 'Developing countries are particularly vulnerable… Effective and result-based measures should be supported for the development of approaches at all levels on vulnerability and adaptation, as well as capacity-building for the integration of adaptation concerns into sustainable development strategies.'

Of particular concern in several parts of the world is the increase in amplitude and frequency of extreme events, which are very likely in the future as a result of climate change. IPCC's TAR highlights the fact that this would involve frequent floods and landslides, which would result in loss of life and property as well as health effects such as epidemics, infectious diseases, and food poisoning. The TAR also projects a general drying of mid-continental areas during the summer; this would lead to an increase in summer droughts and could increase the risk of wild fires. Of particular relevance to India is the fact that global warming will lead to increased variability in summer monsoon precipitation. Given the fact that a large part of the rural population of the Indian subcontinent depends on rain-fed agriculture for its livelihood, erratic monsoon precipitation would adversely affect the lives of perhaps the majority of the population in this region. Such developments would have serious implications for the farming community in India and its ability to adapt to the impacts of climate change.

At the same time, we cannot fail to notice the sweeping economic changes that our world is undergoing. Developing countries are particularly concerned over the evolving rules of the global trade regime, and the threats that these could potentially present for the livelihoods of small farmers, fishermen, craftsmen, and labourers. It is the poorest – who have the least resources and the least capacity to adapt – that will be hit the hardest, whether by adverse climatic conditions or by inequitable trade rules.

This monograph presents an ongoing research project, which attempts to study the impacts of climate change in the context of ongoing economic changes, and how these will affect the adaptive capacity of Indian farmers. This collaborative project is being carried out by TERI, India; the Centre for International Climate and Environmental Research – Oslo, Norway; and the International Institute for Sustainable Development, Canada, and will be completed in March 2004. The methodology combines vulnerability mapping with participatory appraisals in villages, and places emphasis on understanding physical, socio-economic, and policy factors that can enhance or constrain coping capacity. We hope that the preliminary findings of this study, presented in this monograph, will underline the importance – to scientists and policy-makers alike – of understanding the regional and local dimensions of vulnerability, and building long-term adaptive capacity and resilience.

R K Pachauri
Director-General, TERI

Coping with global change: vulnerability and adaptation in Indian agriculture

Introduction

Climate change and globalization are two main processes of global change, and it is assumed that both have major impacts on Indian agriculture. Yet, their combined impacts are rarely studied in conjunction. This monograph presents the preliminary results from an innovative research project, which analyses the double exposure of Indian agriculture to these two processes. Pooling the expertise of TERI (The Energy and Resources Institute), India; CICERO (Centre for International Climate and Environmental Research – Oslo), Norway; and IISD (International Institute for Sustainable Development), Canada, this collaborative research project is funded by the Government of Canada through the Canadian International Development Agency and by the Government of Norway through the Ministry of Foreign Affairs. The project commenced in April 2001, and will conclude in March 2004.

The study uses a framework based on the concept of 'double exposure', which relates to the dual impacts that certain regions or social groups will experience as a result of climate change and of changes brought about by economic globalization (O'Brien and Leichenko 2000). The project identifies vulnerable areas and social groups, and assesses the nature of that vulnerability. Data is gathered at two levels. A macro-scale analysis at the district level maps a vulnerability profile for India, showing areas vulnerable to both climate change and economic changes. At the village level, case studies focus on the social and economic implications of double

Paddy cultivation in Orissa

exposure for inland and coastal agricultural areas and identify the possible implications of some public policy measures on the adaptation responses for the different regions. This approach recognizes that the impacts of economic changes and climate change vary across space, and that there are important yet complex interactions occurring at different spatial scales.

The first stage of the project involved the development of vulnerability profiles for Indian agriculture. Districts that are vulnerable to both climatic change and economic changes were identified. Data was gathered on social vulnerability (percentage of landless labourers in the agricultural workforce, literacy rates), infrastructure development, biophysical conditions (soil quality, groundwater availability), climate (rainfall patterns, evapotranspiration patterns), agriculture (crops, productivity), and transportation (distance from ports). These were combined into vulnerability indices and mapped as vulnerability profiles.

Five case studies were then carried out in regions identified as exposed or doubly exposed, in order to study the impacts of climate variability and economic changes on lives at the village level, the strategies used by the villagers in coping with these changes, and the impacts of government policy on those coping strategies. At each site, surveys and interviews were conducted with farmers and local officials. These surveys and interviews will help to identify the policies that influence the ability of farmers to adapt to climate variability and change. The results of the surveys will be analysed and integrated with the results of the vulnerability and policy analyses in order to develop policy recommendations regarding adaptation to climate change.

The study will result in better knowledge regarding the vulnerable areas in India, an exploration of how some villages have coped with these issues, and a discussion of the impacts that public policy has had on the vulnerability in the villages studied. The focus on vulnerability will assist decision-makers in targeting policies aimed at poverty reduction in agricultural communities in India. The methodology can be extended to many other parts of the world.

Background

Indian agriculture

Agriculture and allied activities constitute the single largest component of India's gross domestic product, contributing nearly 25% of the total. The tremendous importance of this sector to the Indian economy can be gauged by the fact that it provides employment to two-thirds of the total workforce. The share of agricultural products in exports is also substantial, with agriculture accounting for 15% of export earnings. With a weight of 57% in the consumer price index, food prices are closely linked with inflation and any adverse shock on agriculture could have cumulative effects on the economy. Agricultural growth also has a direct impact on poverty eradication, and is an important factor in employment generation (Planning Commission 1997; 2002).

Fodder collection in Jhalawar, Rajasthan

Wheat accounts for one-third of the total food grain production in India, while rice forms 43% of the total and is cultivated in 43 mha (million hectares), which is about 30% of the net cultivated area. During the last decade, food grain production registered an annual compound growth rate of over 3%. The National Commission for Integrated Water Resources Development has estimated that to meet the requirements of food grains alone, the net sown area will have to be increased to 145 mha and the cropping intensity to 145% by 2050 (Planning Commission 1997). However, there is not much scope for increasing the area under food grains in the country. For instance, a lot of area under rice in Kerala has been lost to cash crops like coconut and rubber. The yield of food grains in major producing states like Punjab and Haryana has reached a plateau. Consequently, the growth of food grain output can be achieved only through rapid increases in productivity. Finally, given that rain-dependent agricultural area constitutes about 60% of the net sown area of 142 mha (TERI 2003), Indian agriculture continues to be fundamentally dependent on the weather, with much of the recent high growth rates being the result of a number of successive good monsoons.

Impacts of climate change

Indian climate is dominated by the south-west monsoon, which brings most of the region's precipitation. It is critical for the availability of drinking water and irrigation for agriculture. Agricultural productivity is sensitive to two broad classes of climate-induced effects—(1) direct effects from changes in temperature, precipitation, or carbon dioxide concentrations, and (2) indirect effects through changes in soil moisture and the distribution and frequency of infestation by pests and diseases. Rice and wheat yields could decline considerably with climatic changes (IPCC 1996; 2001). However, the vulnerability of agricultural production to climate change depends not only on the physiological response of the affected plant, but also on the ability of the affected socio-economic systems of production to cope with changes in yield, as well as with changes in the frequency of droughts or floods. The adaptability of farmers in India is severely restricted by the heavy reliance on natural factors and the lack of complementary inputs and institutional support systems.

Kumar and Parikh (1998) show that economic impacts would be significant even after accounting for farm-level adaptation. The loss in net revenue at the farm level is estimated to range between 9% and 25% for a temperature rise of 2 °C–3.5 °C. Sanghi, Mendelsohn, and Dinar (1998) also attempt to incorporate adaptation options while estimating agricultural impacts. They calculate that a 2 °C rise in mean temperature and a 7% increase in mean precipitation would reduce net revenues by 12.3% for the country as a whole. Agriculture in the coastal regions of Gujarat, Maharashtra, and Karnataka is found to be the most negatively affected. Small losses are also indicated for the major food-grain-producing regions of Punjab, Haryana, and western Uttar Pradesh. On the other hand, West Bengal, Orissa, and Andhra Pradesh are predicted to benefit – to a small extent – from warming.

Impacts of economic changes

Extensive and dramatic changes are occurring in the Indian economy as a result of the globalization of economic activity and the implementation of structural adjustment reforms. The major objectives of the reform process that started in 1991 were to reduce the capital intensity of India's growth process, lessen its reliance on the unsustainable expansion of the public sector, and translate the country's relatively high investment rate into high and sustainable growth of output and employment (World Bank 1995).


Sunflower farming in Chitradurga, Karnataka

Since 1991, the Indian government has introduced significant unilateral trade reforms, with both tariffs and non-tariff barriers being reduced. The economy has been further opened up on the export side by reducing export incentives as well as barriers. The complex licensing system that regulated trade and investment has been dismantled, and the foreign exchange regime has been liberalized. Domestic policy reforms are being undertaken to reduce market imperfections, such as state monopolies, administered prices, and subsidies (Chadha, Pohit, Deardorff, *et al.* 1998; Ahluwalia and Little 1998; World Bank 1995). India is also impacted by the WTO (World Trade Organization) negotiations on agriculture.

Reducing import duties on the highly protected manufacturing sector and freeing agricultural exports would result in shifting of the terms of trade in favour of agriculture. This should encourage higher private investment and growth in the agricultural sector, thereby enhancing agricultural incomes and stimulating demand for industrial products and off-farm activities in rural areas (Gulati 1998; Chadha, Pohit, Deardorff, *et al.* 1998).

Although India is gradually opening up its agriculture to world markets and dismantling domestic controls, the main crops – rice, wheat, sugar, and oilseeds – remain subject to many barriers to internal and external trade, procurement policies, and implicit and explicit subsidies. Trade in food grains is still taking place as a residual between domestic demand and supply rather than as a policy instrument to integrate domestic agriculture with world agriculture to optimize the use of resources (Gulati 1998). This is because of the perceived threat to national food security. The world food grains market is narrow compared to India's domestic production and consumption. For instance, India produces 92 MT (million tonnes) of rice whereas the size of the international rice market is about 12–13 MT. Though the wheat market is relatively large at 110–120 MT, it is cartelized. In comparison, India produces 71 MT of

Orange and soybean mixed cropping in Jhalawar, Rajasthan

wheat (Planning Commission 2002). In such a situation, large-scale imports of food grains can make India vulnerable to sharp increases in world prices.

Thus, while greater openness will boost efficiency and competitiveness, it will also expose Indian agriculture to increased price volatility. Price volatility creates uncertainty and risks, which can threaten agricultural performance and impact negatively on the well-being of the poor. Winners and losers could emerge as different crops, farmers, and regions react differently to the changing incentive environment (O'Brien and Leichenko 2003). Goldin, Knudsen, and van der Mensbrugghe (1993) point out that agricultural production in India is diversified so that some farmers benefit from higher world prices while others, particularly rice farmers, lose from a reduction in the world price of rice. The gains would go to farmers and regions that are producing, or are quick to switch to, crops that have greater comparative advantage in production (Gulati 1998).

Vulnerability to climate change in the context of economic changes

Indian agriculture faces the dual challenge of feeding a billion people in a changing climatic and economic scenario. However, there is not much scope to increase the area under food grains. Switching to other crops is also difficult in regions like West Bengal, where three rice crops are grown in succession through the year. Agriculture is the predominant means of livelihood for a large number of peasant cultivators and agricultural labourers, for whom it is not easy to shift to other occupations. Due to their low financial and technological adaptability, such groups are potentially vulnerable to both climatic changes as well as economic change.

Hence, it becomes important to examine the vulnerability to climate change not in isolation but in the context of ongoing economic changes. This translates into a dynamic interpretation of vulnerability and has important implications for developing adaptation strategies. These issues are part of an evolving stream of literature on the concept of 'double exposure' (O'Brien and Leichenko 2000). This concept recognizes the synergies between the impacts of two long-term global processes – climate change and economic globalization – that will have differential consequences across regions, sectors, and social groups.

Mapping adaptive capacity and vulnerability

Climate change vulnerability

One objective of the project was to create a climate change vulnerability profile for India at the district level. We based our definition of vulnerability on the Intergovernmental Panel on Climate Change's definition and framework, whereby vulnerability is understood as a function of three components—exposure, sensitivity, and adaptive capacity (Box 1). These components are in turn influenced by a range of biophysical and socio-economic factors. To create the profiles, we assumed that exposure to climate change will influence sensitivity – either positively or negatively – and that Indian farmers will respond to these changes provided that they have the capacity to adapt. Vulnerability was thus seen as a composite of adaptive capacity and climate sensitivity, with sensitivity changing to reflect climate change exposure according to results from general circulation models.

A series of maps was constructed using GIS (geographic information systems), taking the district as a spatial unit of analysis (Figure 1). For each component of vulnerability, a number of indicators were compiled, normalized, scaled, weighted, and mapped. The details of the methodology are described by O'Brien, Leichenko, Kelkar, *et al.* (forthcoming). Here, we describe how

Box 1 Definitions of sensitivity, adaptive capacity, and vulnerability: from the Intergovernmental Panel on Climate Change

Sensitivity is the degree to which a system is affected, either adversely or beneficially, by climate-related stimuli. Climate-related stimuli encompass all the elements of climate change, including mean climate characteristics, climate variability, and frequency and magnitude of extremes. The effect may be direct (e.g. a change in crop yield in response to a change in the mean, range, or variability of temperature) or indirect (e.g. damages caused by an increase in the frequency of coastal flooding due to sea-level rise).

Adaptive capacity is the ability of a system to adjust to climate change (including climate variability and extremes), to moderate potential damages, to take advantage of opportunities, or to cope with the consequences.

Vulnerability is the degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate change and variation to which a system is exposed as well as the system's sensitivity and adaptive capacity.

Source IPCC (2001)

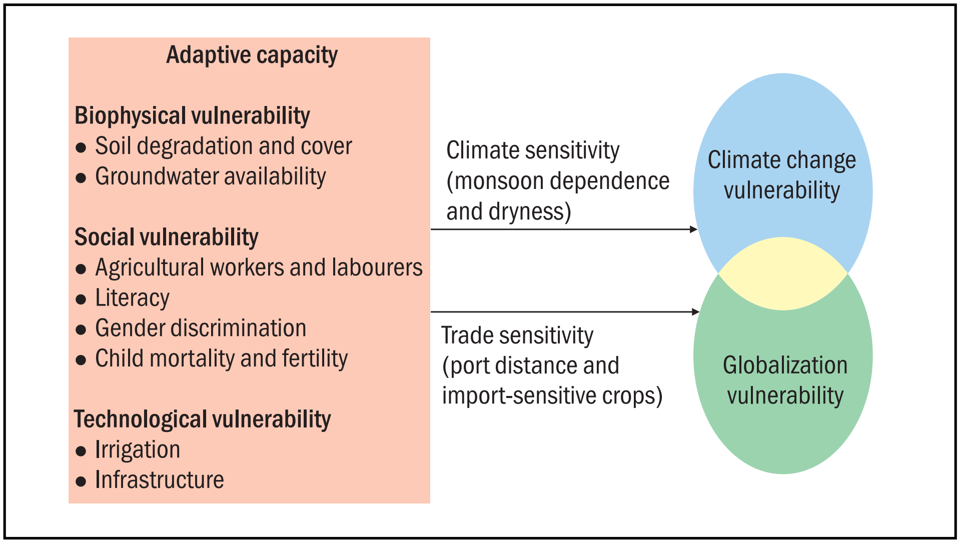

Figure 1 Elements of vulnerability profiles

the adaptive capacity component of the vulnerability profile was constructed. Adaptive capacity for agriculture is considered to be an outcome of biophysical, socio-economic, and technological factors. The data sources used to compile these indices include the 1991 Census of India;[1] the Ministry of Agriculture, Government of India; the Central Groundwater Board; and the Centre for Monitoring Indian Economy.

Biophysical factors that influence agricultural production include soil conditions and groundwater availability. It is assumed that areas with more productive soil and more groundwater available for agriculture will be more adaptable to adverse climatic conditions. Figure 2 shows the resulting map of the biophysical factors influencing adaptive capacity, referred to here as 'biophysical vulnerability'. This map shows that the highest vulnerability is associated with the semi-arid districts of India and with regions with high run-off, such as the north-eastern districts.

The social factors that influence adaptive capacity comprise indicators representing the percentage of workers employed in agriculture, the percentage of landless labourers in the agricultural workforce, human capital (as represented by literacy levels), gender discrimination

[1] These vulnerability profiles are being updated with data from the 2001 Census of India.

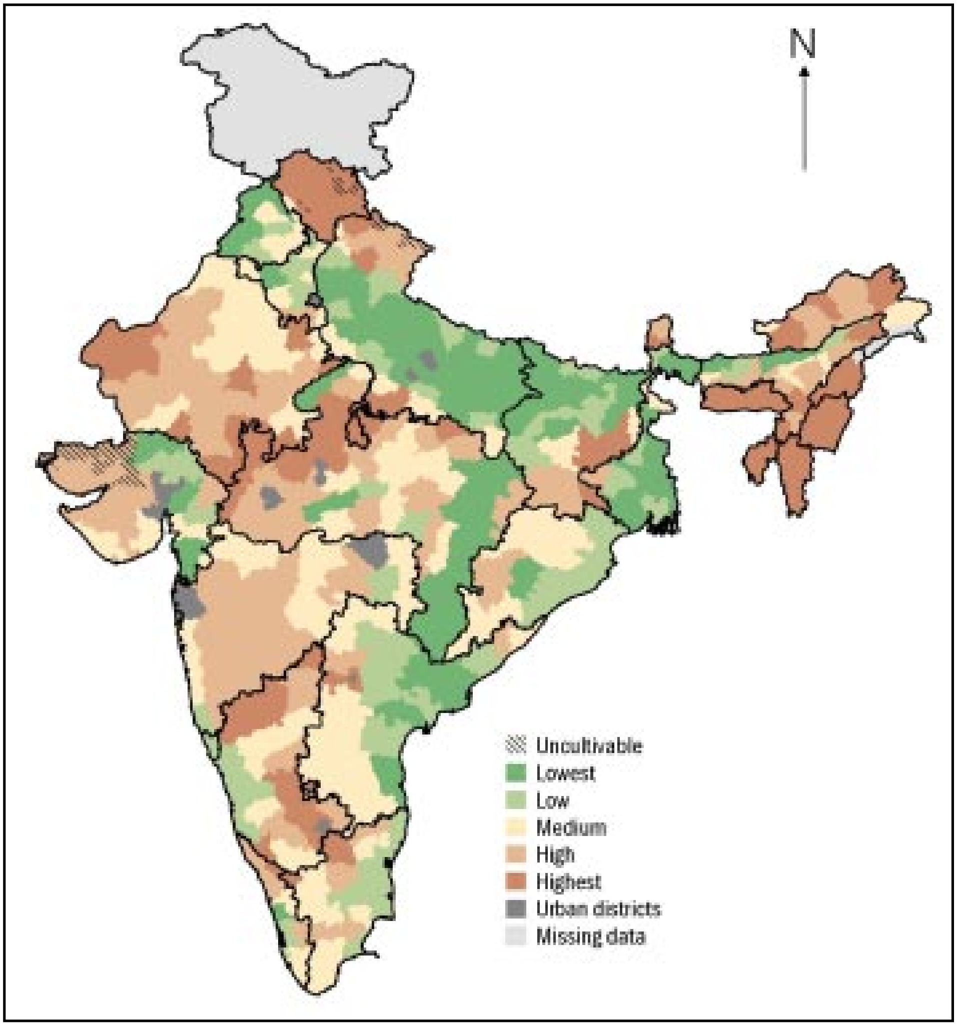

Figure 2 Biophysical vulnerability

(as measured by excess girl child mortality), and child mortality and fertility (as measured by female literacy rates). Figure 3 depicts the social factors that influence adaptive capacity, referred to here as 'social vulnerability'. Areas with high social vulnerability include districts in Punjab, Rajasthan, Haryana, Andhra Pradesh, Madhya Pradesh, Bihar, and Uttar Pradesh. These states have relatively lower levels of social development, with the exception of Andhra Pradesh, Haryana, and Punjab, which are relatively better developed. Social vulnerability in these

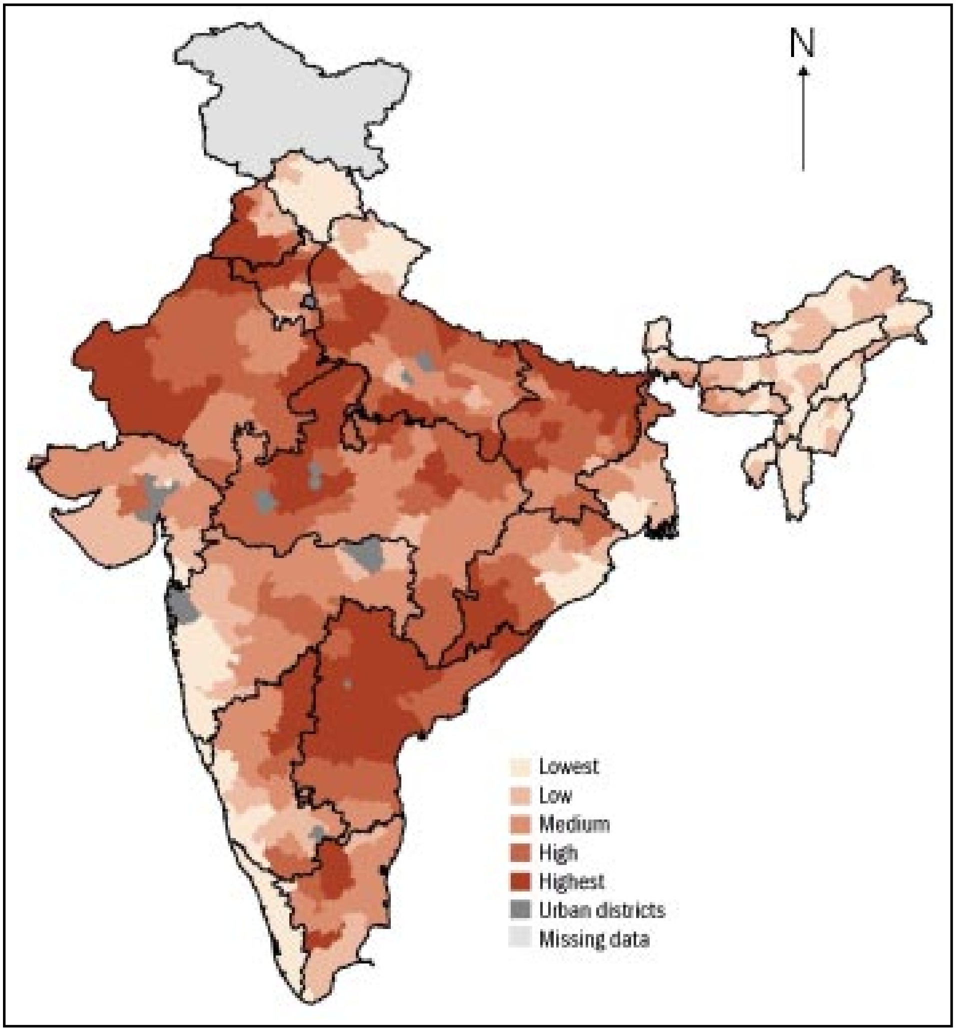

Figure 3 Social vulnerability

three states may be influenced by high levels of gender discrimination, high agricultural dependency, or a high percentage of landless labourers in the agricultural workforce. It is interesting to note that the western coast of India is characterized by relatively low social vulnerability.

Technological factors that influence adaptive capacity include irrigation and infrastructure. Irrigation was measured by net irrigated area as a percentage of net sown area, while infrastructure was measured by the existing Infrastructure Development Index (CMIE 2000). This index includes communication infrastructure, educational institutions,

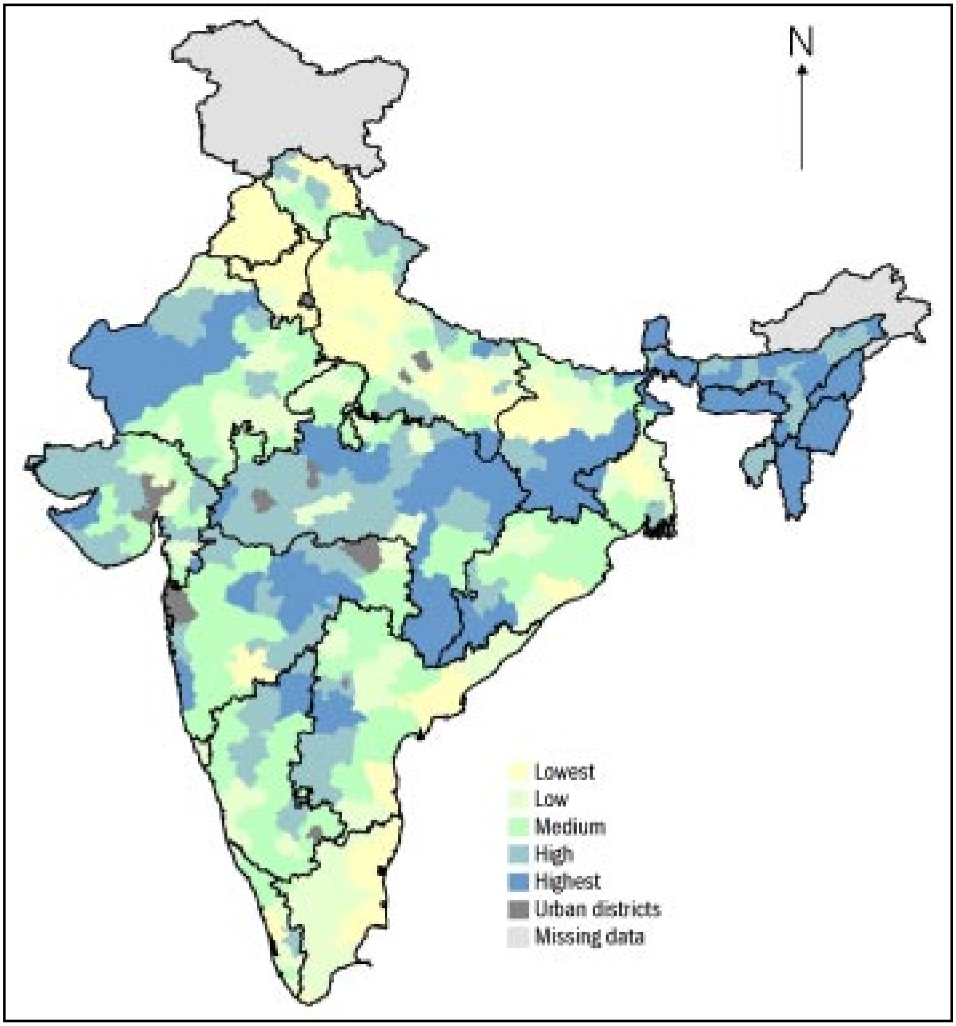

Figure 4 Technological vulnerability

energy, and facilities for transport, irrigation, banking, and health. Note that irrigation is counted twice in the technological vulnerability index. The additional weighting emphasizes the importance of irrigation to agriculture, including the capacity to adapt to changing agriculture conditions. The resulting map (Figure 4) indicates high technological vulnerability in districts in western Rajasthan, Madhya Pradesh, central Maharashtra, Bihar, and the north-eastern states.

The indices representing biophysical, social, and technological vulnerability were averaged (i.e. equally weighted) to produce a final

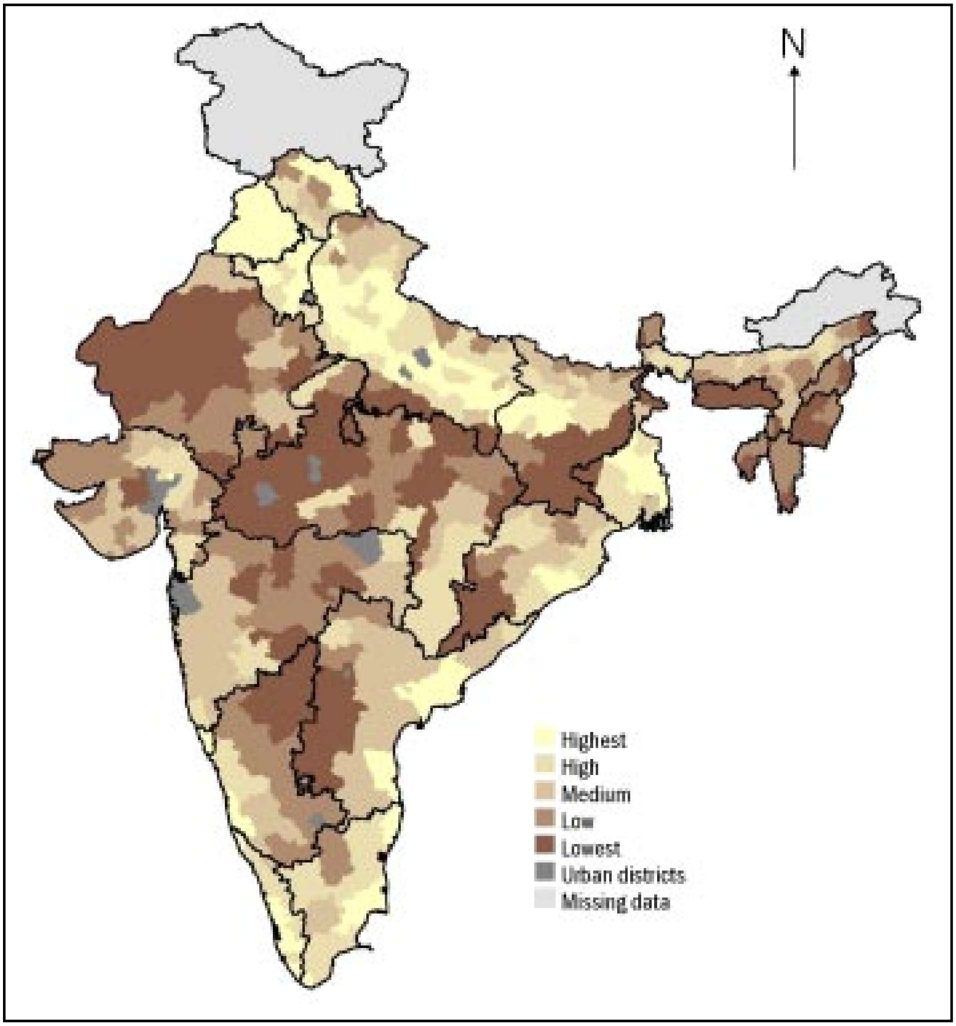

Figure 5 Adaptive capacity

index of adaptive capacity. This composite index was mapped as shown in Figure 5. The map reveals higher degrees of adaptive capacity in districts falling in the Indo-Gangetic plains (except for Bihar) and lower degrees of adaptive capacity in the interior regions of the country, including districts in Bihar, Rajasthan, Madhya Pradesh, Maharashtra, Andhra Pradesh, and Karnataka (O'Brien, Leichenko, Kelkar, *et al.* Forthcoming).

The adaptive capacity index was included in a more comprehensive climate change vulnerability profile, which included a climate sensitivity

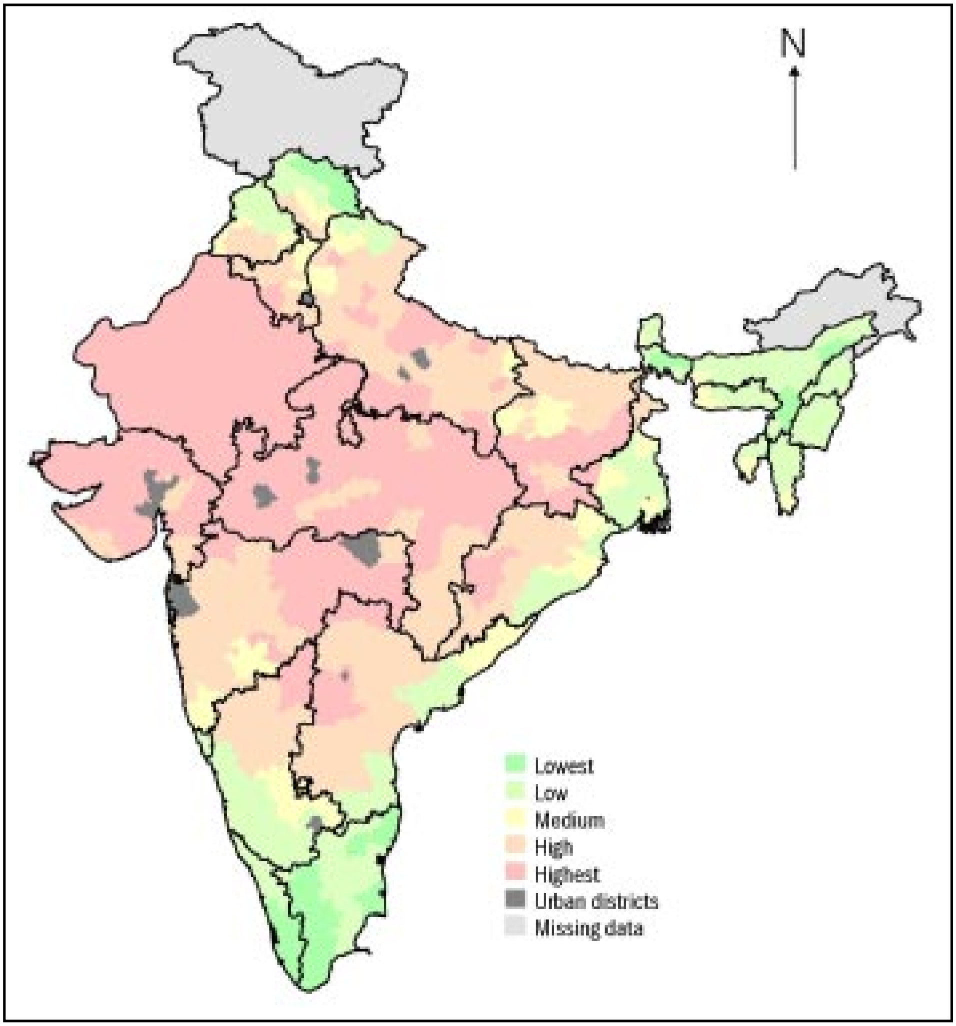

Figure 6 Climate change vulnerability

index as defined by dryness and monsoon dependency and based on a 0.5° × 0.5° gridded dataset for 1961–90 developed by the Climatic Research Unit of the University of East Anglia in UK (New, Hulme, and Jones 1999). The sensitivity index was recalculated using the output from the HadRM2 downscaled general circulation model (Turnpenny, Rossley, Hulme, *et al.* 2002) to show potential shifts in regional climate sensitivity resulting from climate change exposure (O'Brien, Leichenko, Kelkar, *et al.* Forthcoming). The resulting climate vulnerability map (Figure 6) illustrates the spatial distribution of vulnerability within India. It is notable that the districts with the highest climate sensitivity under exposure to climate change are not necessarily the most vulnerable, and vice versa (O'Brien, Leichenko, Kelkar, *et al*. Forthcoming). In other words, vulnerability is considered an outcome of both biophysical and social characteristics that influence exposure, sensitivity, and adaptive capacity.

Globalization vulnerability

A second objective of the project was to create a globalization vulnerability profile for Indian agriculture. This profile considers the import and export sensitivity of agriculture to trade liberalization measures. The methodology, described in O'Brien, Leichenko, Kelkar, *et al.* (forthcoming), considers vulnerability to globalization as an outcome of adaptive capacity and trade sensitivity. For adaptive capacity, the same indicators and indices used in the climate change adaptive capacity map were considered relevant to adapting to changing production conditions associated with economic globalization. Import sensitivity was calculated as the productivity of a representative set of import-sensitive crops, weighted by the share of production of each crop in the total area of production of the import-sensitive crops, combined with a measure of the distance of a district to the closest international port. The resulting globalization vulnerability profile (Figure 7) shows districts that may potentially experience the negative impacts of trade liberalization. The map is based on the degree of sensitivity and adaptive capacity, assuming uniform exposure to liberalization policies such as tariff reductions. Areas that are highly vulnerable to globalization include much of Rajasthan and Karnataka, and significant portions of Bihar, Madhya Pradesh, Maharashtra, Gujarat, and Assam. It is notable that the Indo-Gangetic plain – often referred to as the food belt of India – exhibits low vulnerability to globalization.

The two climate change and globalization vulnerability profiles were then superimposed to identify districts that are 'double exposed' to both processes. The resulting map (Figure 8) displays the regions of India that are categorized as having high or highest vulnerability to both processes. In other words, these areas are likely to experience negative impacts of both climate change and economic globalization. The map indicates that districts in western Rajasthan, southern Gujarat, Madhya Pradesh,

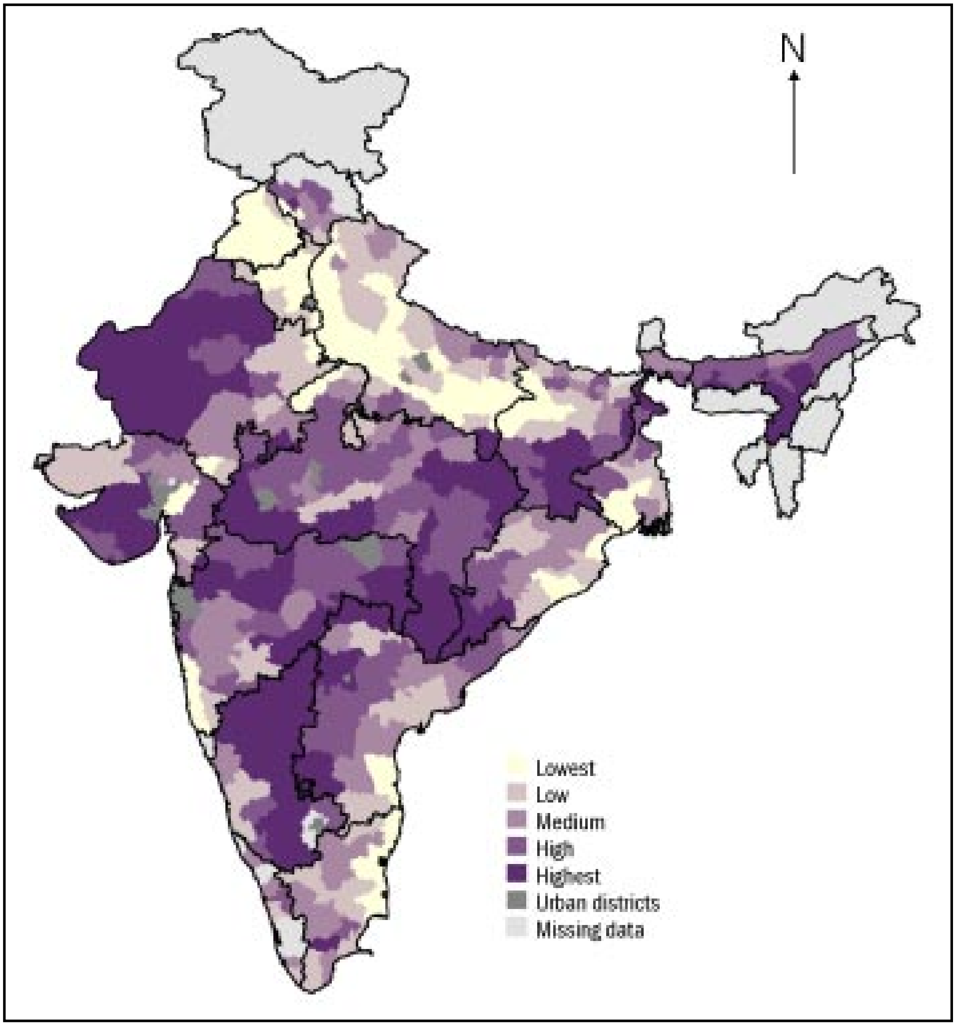

Figure 7 Globalization vulnerability

Maharashtra, northern Karnataka, northern Andhra Pradesh, and southern Bihar are considered double exposed. It is these areas where policy changes and other interventions may be needed the most to help farmers negotiate climate change in the context of economic globalization (O'Brien, Leichenko, Kelkar, *et al*. Forthcoming).

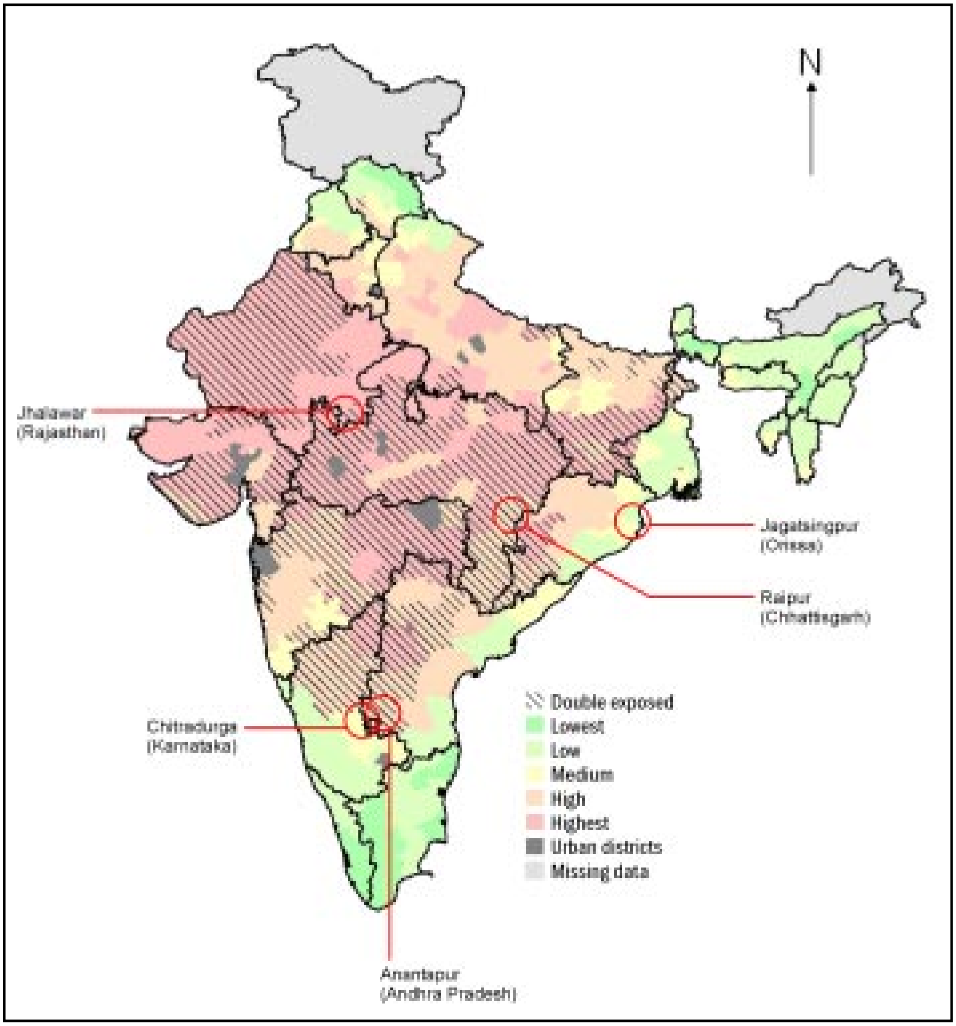

Figure 8 Vulnerability to climate change and globalization

Understanding vulnerability at the local scale

Methodology and site selection

To study the micro-level implications of vulnerability, case studies were conducted across five districts, chosen on the basis of the macro vulnerability profile (Table 1).

The first case study was done in Jhalawar district of Rajasthan, which in the macro vulnerability profile, stood out as double exposed—both to climatic factors and to globalization. Besides this, the district is classified

Table 1 Socio-economic profile of case study districts (1991)

Case study districts	*Population density* (persons per km²)	*Urbanization* (percentage)	*Literacy* (percentage)	*Net sown area* (as a percentage of total area)	*Net irrigated area* (as a percentage of net sown area)	*Ratio of labourers to cultivators*	*Relative index of develop-ment*
Jhalawar	154	16	33	50	21	0.30	61
Anantapur	166	23	42	42	13	1.04	92
Chitradurga	201	27	56	50	21	0.85	97
Raipur	184	20	40	44	35	0.57	65
Jagatsingpur*	496	12	58	61	06	0.56	65

* part of Cuttack district in 1991

Sources GoI (1991); MoA (1994); CMIE (2000)

as drought-prone and vulnerable in the context of low levels of irrigation coverage, literacy, and infrastructure development.

Anantapur district in Andhra Pradesh is another drought-prone area that can be considered double exposed to climate change and globalization. The focus of our case study here was the response of groundnut farmers to import competition.

Crop diversification in Chitradurga district

The third case study was conducted in Chitradurga district of Karnataka. This district was found to be singly exposed to globalization under the macro profile. However, its proximity to an urban centre – Bangalore – and the recent introduction of government and private initiatives to promote crop diversification for export markets made this an interesting case study site.

The fourth case study area, Raipur in Chhattisgarh, lies in the rice belt of central India. The district is double exposed to climate change and economic globalization in the GIS-based macro profile. Farmers in this dry region are also being encouraged to diversify from paddy cultivation to other crops to reduce their dependence on rain-fed agriculture in the *kharif* season.

Intuitively, we expected coastal districts to emerge as highly vulnerable but the emphasis on dryness in the climate sensitivity index did not capture the potential impacts of sea-level rise, or the higher intensity and frequency of extreme events induced by climate change. As Figure 9 indicates, the eastern coast of India is particularly vulnerable to cyclones. Therefore, we chose to carry out our final case study in the coastal district of Jagatsingpur in Orissa. This district was one of the worst affected in the supercyclone of 1999, and also experiences periodic river floods. Paddy cultivation is the principal occupation in this densely populated district with acute levels of poverty and poor infrastructure development.

The methodology for all the case studies combined a structured questionnaire-based household survey, with participatory rural appraisals, focused group discussions, and open-ended interviews with key persons.

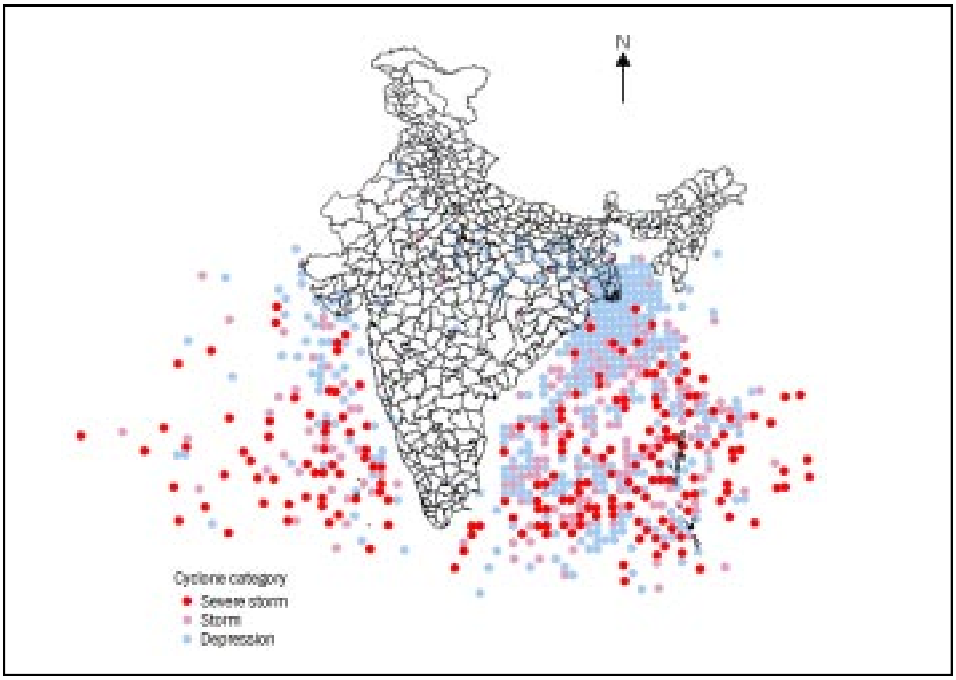

Figure 9 Frequency of cyclones on the Indian coast
Source IMD (1979; 1996)


Household interview in Chitradurga district

In each village selected for the questionnaire-based survey, at least 30% of the population was covered, through random selection of households. In all, we visited 22 villages, held 27 group discussions, and surveyed more than 400 households.

In terms of information elicited through questionnaires, certain themes were common to all the case studies, such as economic status, agricultural practices, coping mechanisms, and access to facilities and services. However, certain other issues specific to each district were also reflected in the selection of villages. For instance, the Jhalawar and Raipur case studies attempted to study the implications of differential access to irrigation facilities, whereas the Chitradurga case study focused on the opportunities offered by crop diversification and contract farming. In Jagatsingpur, the choice of two villages prone to river flooding and storm surges respectively offered insights into these two dimensions of coastal vulnerability.

Preliminary findings

Jhalawar district in Rajasthan is located in a semi-arid area that receives an average of 943 mm of rainfall annually. In addition to high degrees of climate sensitivity, it also ranks among the districts with the lowest adaptive capacity. Over the past 10 years, many farmers in Jhalawar have shifted from traditional crops, such as sorghum and pearl millet, to soybean, which receives higher market prices and yields quick returns owing to a shorter life cycle. Farmers in Jhalawar are also found to be highly vulnerable to climatic variability. Last year, Jhalawar experienced its fourth consecutive year of drought, and crop yields have been substantially reduced, particularly for the majority of farmers who lack access to irrigation. Rain-fed agriculture is practised in village Lakhakheri Umat, where 94% of the farmers have small or marginal landholdings. A review of coping mechanisms reveals that a very small group of

Rain-fed farming in Lakhakheri Umat, Jhalawar

semi/medium farmers is able to cope with adverse climatic conditions merely through the sale of available stocks. On the other end of the spectrum, landless labourers can only resort to seasonal migration due to lack of any productive assets or availability of alternative employment options in the village. Small/marginal farmers use a variety of adaptation options such as sale of cattle, shifts to other crops,[2] labour, as well as seasonal migration. This range of options, however, constitutes only temporary coping measures. Options that enhance longer-term adaptive capacity (such as institutional credit, crop insurance, and use of drought-resistant varieties) are not used by farmers due to procedural complexities and stringent eligibility criteria, compounded by lack of awareness.[3]

In Anantapur district in Andhra Pradesh, groundnut is the principal crop but farmers are now facing a crisis due to growing import competition and stagnating market prices, which have coincided with a multi-year drought. Although free market economics would predict that farmers in Anantapur should respond to price stagnation by shifting to production of more profitable crops, our case study results indicate that there is a lack of alternative, drought-tolerant, and economically viable crops because institutional barriers have made them unprofitable. Rain-fed crops (such as different fruit varieties), which could be economically viable, either require too much capital or do not have long enough shelf lives to be marketable under current circumstances. Without irrigation, water harvesting systems, or alternatives to groundnut, dry land farmers in Anantapur are highly vulnerable to both climate change and trade liberalization.

[2] Crops like gram have lower water requirement but offer only subsistence yields and lack market value.

[3] For instance, farmers who fail to repay a bank loan are rendered ineligible to apply again. Consequently, they prefer taking loans from private moneylenders, even at three times the interest rate.

By contrast, the neighbouring district of Chitradurga, located in Karnataka, emerged as vulnerable to the impacts of globalization but not of climate change. However, farmers in this district are being encouraged through state government and private initiatives to cultivate alternative crops, such as areca nut, pomegranate, and banana. Over the last five years, export companies have increasingly entered into buy-back contracts with farmers for gherkin production aimed at European markets, with plans to expand to other vegetables. Interestingly, due to the economics of gherkin cultivation, it is the small and marginal farmers with small landholdings and family labour that are most able to benefit from such contract farming. *Kisan kendras* (farmer centres) set up by corporates also provide scientific soil testing services, market information, and transport facilities to cultivators of horticultural crops, in return for a subscription fee. While a wider range of adaptation strategies are available to farmers in Chitradurga, as compared to Jhalawar or Anantapur, it is the larger farmers who tend to benefit from government subsidies (for drip irrigation, sericulture rearing houses, and other production technologies), formal bank credit, crop insurance, and access to larger markets. Smaller farmers are disadvantaged due to lack of information and dependence on local merchants for credit. Furthermore, irrigation may not be sustainable in the long run, particularly if water-intensive horticultural crops are produced for international markets while water availability is reduced due to climate change. The risks of globalization are also understood by farmers practising sericulture, whose numbers have come down drastically with Chinese silk flooding Indian markets in the last three years.

Gherkin farmer in Chitradurga district

The impacts of climate change on cropping patterns can be observed in Raipur, where farmers have traditionally grown a pulse crop known as *teevra* on residual soil moisture after the *kharif* season. Higher

Khet Ganga Yojana in Semhartara village, Raipur

temperatures in the region in the past few years have made *teevra* cultivation impossible, leaving many farmers dependent on a single paddy crop, and making them substitute home-grown *teevra* with market purchases. In contrast, fragrant varieties of rice – traditionally grown in the southern part of the district – have high economic value but adulteration at the merchant level has reduced the prices for these varieties over the last 10 years. In a bid to increase yields, farmers have started replacing organic manure with chemical fertilizers, but this has made the crop highly vulnerable to pests and diseases. Voluntary agencies are playing an important role in conserving indigenous varieties of seeds in the region by setting up village-level seed banks that are also useful in the event of drought and crop failure. In terms of government efforts, the Dabari Yojana for village-level rainwater harvesting is a noteworthy initiative, but subsidies for agricultural pump-sets under the Khet Ganga Yojana more often benefit larger farmers who are able to take advantage of the minimum landholding size criterion.

The vulnerability of India's coastal areas is highlighted in Jagatsingpur, where loss of mangroves due to biotic and abiotic pressures in the past few decades has left the coast exposed to the fury of cyclones and storm surges. The aftermath of the 1999 supercyclone witnessed intensive rehabilitation and reconstruction efforts, not all of which have been correctly targeted and effectively applied. For instance, three years of food-for-work programmes have supported farmers who lost their lands and homes, but have not really built their capacity to adopt alternative income-earning opportunities.

Coastal flooding and salinization in Dahibara village, Jagatsingpur

The proximity to Paradip port, however, has made it lucrative for some farmers to shift to prawn cultivation for export. However, stringent quality control regulations in this sector may eventually shrink the existing market for these farmers, who will no longer have the option of returning to paddy cultivation either.

Policy observations

This section presents preliminary observations from the case studies, which feed into ongoing policy analysis by the project partners.

The case studies offered a valuable complement to the macro profile by revealing insights about the determinants of vulnerability at the individual or community levels. Numerous physical and socio-economic factors come into play in enhancing or constraining the current capacity of farmers to cope with adverse changes. Prominent among the physical factors are cropping patterns, crop diversification, and shifts to drought-/salt-resistant varieties. The most important socio-economic factors include ownership of assets (like land, cattle, pump-sets, and agricultural implements), access to services (like banking, health, and education), and infrastructural support (like irrigation, markets, and transport/communication networks).

Group discussion with farmers in Timmanahalli village, Chitradurga

Policies that are designed to fortify current coping capacity also have the power to strengthen long-term adaptive capacity. This is best exemplified by measures such as crop insurance, seed banks, alternative (off-farm) employment options, and enhanced access to inputs and markets (Box 2). Another set of policy-relevant insights offered by the case study approach relates to the understanding of how certain factors change the vulnerability of a given community or place over time. One example is that of changes in cropping patterns: the widespread switch to soybean in Jhalawar has immediate economic benefits for farmers, but is

Box 2 Policy developments in the Indian agriculture sector

The National Agriculture Policy, 2000, aims to attain – over the next two decades – a growth rate in excess of 4% per annum in the agriculture sector. This growth should be resource-efficient, equitable, demand-driven, and sustainable. The policy explicitly recognizes that agricultural growth should cater to domestic markets and maximize benefits from exports of agricultural products in the face of the challenges arising from economic liberalization and globalization (MoA 2000).

The following developments in the last decade also have significant potential for enhancing the coping capacity of Indian farmers.

- The Rural Infrastructure Development Fund was launched in 1995/96 and the Kisan Credit Card Scheme was introduced in 1998/99 to facilitate short-term credit to farmers.
- The National Agricultural Insurance Scheme was introduced in 1999/2000 to provide cover against losses on account of natural calamities. The scheme covers all food crops, oilseeds, and annual horticulture and commercial crops.
- A pilot scheme on seed crop insurance was launched in 1999/2000 to provide cover to seed breeders/growers in the event of failure of seed crops (TERI 2003).

sensitive to climate change.[4] Another example is the strengthening of local institutions and higher education levels, which would have positive gender and equity impacts. Finally, case study examples such as private *kisan kendras* in Chitradurga or seed banks in Raipur demonstrate that the private sector and civil society have key roles to play in supplementing government efforts to reduce vulnerability.

The next stage in the policy analysis will be to examine how India's participation in the WTO and the agricultural trade liberalization pressures it faces will reinforce climate vulnerability. With possible reduction and elimination of export subsidies and domestic support, cropping patterns would change from protected crops like rice and wheat to profitable cash crops. There would also be welfare connotations related to the Agreement on Agriculture translated through income and employment effects. The policy analysis will consider, for example, the implications of agricultural trade policies proposed by the US and European Union and the Government of India at the recent WTO ministerial conference at Cancún.

Most important, this study and this monograph hope to bring attention to the need for strengthening institutions and better integrating policies with the goal of building long-term adaptive capacity and resilience to climate change.

[4] Lal, Hassan, and Dumanski (1999) reported that yields of soybean in India would vary between –22% and 18% under different climate scenarios considering +2 °C and +4 °C change in temperature and ±20% and ±40% change in precipitation. The study assumed no adaptation and included the direct effect of carbon dioxide increase.

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TERI – The Energy and Resources Institute – undertakes interdisciplinary scientific and policy research in an attempt to integrate developing-country concerns into the search for effective and equitable solutions to local and global environmental challenges. It also engages in training, information dissemination, and related activities focused on all forms of natural and human resources.

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Vulnerability to climate change varies across regions. sectors, and social groups. Understanding the regional and local dimensions of vulnerability is essential to develop appropriate and targeted adaptation efforts. At the same time, such efforts must recognize that climate change impacts will not be felt in isolation but in the context of multiple stresses. In particular, the dramatic economic and social changes associated with globalization themselves present new risks as well as opportunities.

Climate change and economic globalization are two main processes of global change. yet their impacts are rarely studied in conjunction. This monograph presents preliminary findings from an ongoing research project, which analyses the double exposure of Indian agriculture to these two processes. Pooling the expertise of The Energy and Resources Institute, India; the Centre for International Climate and Environmental Research – Oslo, Norway; and the International Institute for Sustainable Development, Canada, this collaborative research project commenced in April 2001. More information about the project can be found at <www.teriin.org/coping>.