MODULE **5** Vulnerability index and hotspot mapping

This module explains how climate change projections have helped in identifying climate-vulnerable hotspots, to inform the policy-making framework in making climate-smart policy decisions. For example, to analyze the impacts of climatic changes on the Indian agricultural sector in the context of ongoing economic and policy changes, a double exposure of Indian agriculture was assessed through findings from various case studies. Case study sites were selected based on their exposure to extreme climatic conditions, including droughts, floods and cyclones.

What is vulnerability?

According to the Third Assessment Report of the IPCC (Inter-governmental Panel on Climate Change), vulnerability is 'the degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change'. The Third Assessment Report further to this defined vulnerability to climate change as a measure of 'the extent to which regions are likely to be influenced by climate change, given the inherent adaptive capacities that exist in those regions in being able to respond effectively to the expected changes'. The vulnerability of a system to ongoing climate variability and future climate change would also depend on the level of anticipated and unanticipated risks and the ability of the system to adapt/ respond effectively to such risks; both in the short term and the long term.

The stressor, the vulnerability, and the ability

To address the concept of vulnerability to a stressor in its entirety, it is essential to cover the possible impacts of the stressor on human and natural systems. Such a framework would span three elements: the 'stressor', which triggers the impacts and consequent response, 'vulnerability' of the entity exposed to the stressor, and the 'ability' of the exposed entity to cope or respond to the stressor (Noronha 2003). Several national, regional, and local case studies indicate that variations in climatic patterns have already affected physical and biological systems to varying degrees and further threaten to have effects that would burgeon in case of inaction.

Major climate-related threats for India

India's initial National Communication to UNFCCC (NATCOM) highlights that the major threats that India faces in the context of predicted changes in the climate change include:

- Reduction in the availability of fresh water and impacts on agriculture and food security due to predicted decline in rainfall
- Boundary shifts for different forest types, with consequent implications for species diversity and forest-dependent communities
- Adverse impacts on natural ecosystems such as wetlands, mangroves and coral reefs and mountain ecosystems
- Threat of sea-level rise along coastal zones
- Changes in virulence and disease patterns especially vector borne diseases because of changes in the environmental conditions for their survival and,
- Increased energy demands and subsequent impacts on climate-sensitive infrastructure

Vulnerability assessment

A vulnerability assessment is the process of identifying, quantifying, and prioritizing (or ranking) the vulnerabilities in a system. Within the range of climate change studies, the most vulnerable are considered to be those who are most exposed to hazard, who possess limited resources to cope, heavily dependent on subsistence activities involving extraction of natural resources, and who have least resilience to climatic shocks (Bohle, Bowling, and Watts 1994). The World Bank funded study on assessment of vulnerability of communities to climatic stress (droughts and floods) addresses two types of vulnerabilities.

- *biophysical vulnerability* (sensitivity of a natural system to an exposure to a hazard) and
- *socio-economic vulnerability* (sensitivity of a human system to an exposure).

Repeated exposure to these climatic stressors can set the vulnerable populations in a vicious cycle of persistent poverty. This concept of 'differential vulnerability' arises from inherent differences in the ability of populations to cope or adapt to the stressors; which is determined by several factors such as availability and distribution of resources across populations, range of available technological options, presence of robust

institutional mechanisms, social capital, human capital, education and awareness (Yohe and Tol 2002).

Methodology

The vulnerability indices were calculated based on district distribution of the assessed climatic risks and impacts due to socio-economical stressors. The indices representing biophysical, social, and technological vulnerability are averaged to produce a final index of adaptive capacity. Higher degrees of adaptive capacity was observed in districts falling in the Indo-Gangetic plains (except Bihar), with lower degrees of adaptive capacity viewed for the interior regions of the country, including districts in Bihar, Rajasthan, Madhya Pradesh, Maharashtra, Andhra Pradesh, and Karnataka.

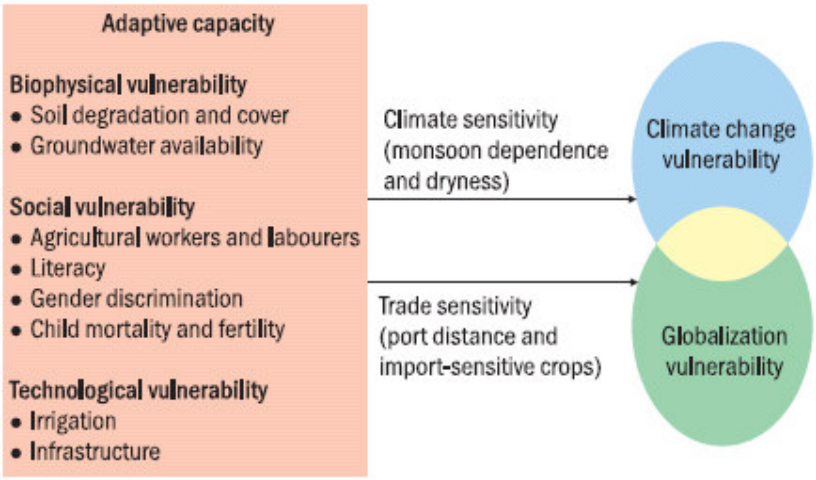

Figure 1 Elements of the vulnerability profile

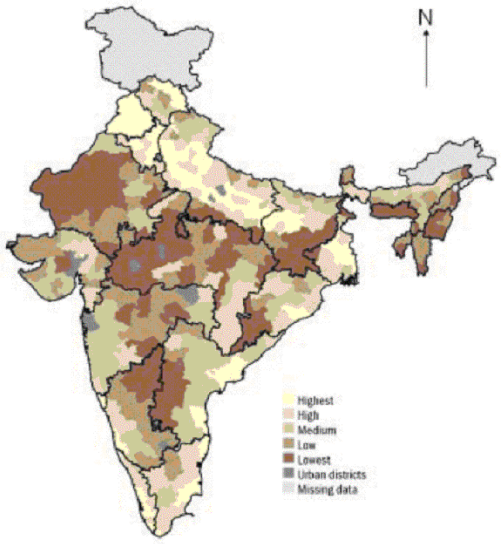

Figure 2 Adaptive capacity profile made by integration of biophysical, social and technological vulnerability profile

Climate change vulnerability

The adaptive capacity index was then incorporated into a more comprehensive climate change vulnerability profile. The sensitivity index was recalculated using the output from the HadRM2 downscaled general circulation model to capture probable shifts in regional climate sensitivity resulting from predicted climate change (Figure 3). It was found that the districts with the highest climate sensitivity under exposure to climate change are not necessarily the most vulnerable, and vice versa. Hence, vulnerability is considered an outcome of both biophysical and social characteristics that influence exposure, sensitivity and adaptive capacity.

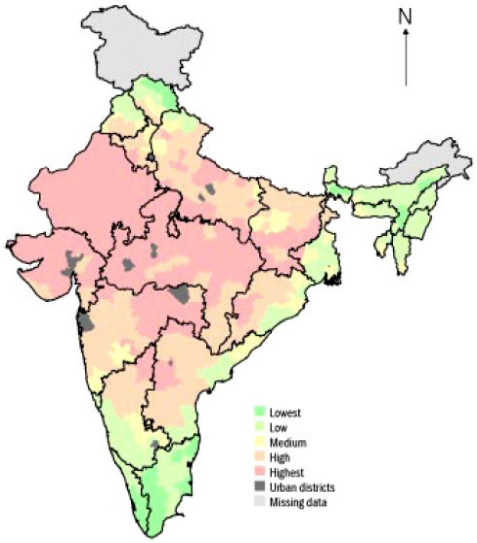

Figure 3 Nation-wide vulnerability index based on double exposure to the climate change impacts on agriculture and globalisation.

SOURCE TERI 2003

Globalization vulnerability

Areas highly vulnerable to globalization include much of Rajasthan and Karnataka, Bihar, Madhya Pradesh, Maharashtra, Gujarat, and Assam.

Secondly, a globalization vulnerability profile (Figure 9) was created for Indian agriculture, that considers the import and export sensitivity of agriculture to trade liberalization measures. Import sensitivity from 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 the value for distance of a district to the closest international port.

Double exposure

Districts in western Rajasthan, southern Gujarat, Madhya Pradesh, Maharashtra, northern Karnataka, northern Andhra Pradesh, and southern Bihar are double exposed.

The climate change and globalization vulnerability profiles were then superimposed to identify districts that are '*double exposed*' (Figure 4) and hence likely to experience negative impacts of both climate change and economic globalization

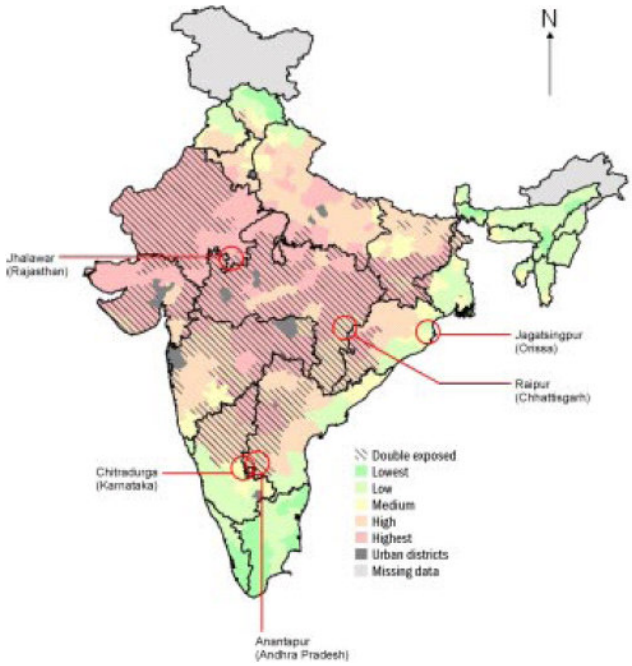

Figure 4 District profile of vulnerability to climate change and globalisation

References

IPCC (Intergovernmental Panel on Climate Change). 2001.
Climate Change 2001: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the *Third Assessment Report* of the IPCC. Cambridge: Cambridge University Press

MoEF (Ministry of Environment and Forests). 2004.
India's Initial National Communication (NATCOM) to the United Nations Framework Convention on Climate Change, Government of India

Noronha L.. 2003.
An approach to assessing vulnerability and coping strategies. In *Environmental Threats, Vulnerability and Adaptation: case studies from India*. New Delhi

TERI. 2003.
Coping with Global Change: vulnerability and adaptation in Indian agriculture.

Yohe G and Tol R S J. 2002.
Indicators for social and economic coping capacity: moving towards a working definition of adaptive capacity.
Global Environmental Change **12**: 25–40.

Bohle H G, Downing T E, and Watts M J. 1994.
Climate change and social vulnerability: towards a sociology and geography of food insecurity.
Global Environmental Change **4**.