



Vulnerability to Climate Change: Adaptation Strategies & Layers of Resilience

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Climate Change Realities and Policy Coherence in SAT India

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Background

Climate change has emerged as a major threat to sustaining livelihoods. There is ample evidence that the occurrence and intensity of drought has increased over the years. The atmospheric temperature is rising significantly at an average rate of 0.01-0.06°C/year in the Indian semi-arid tropics (SAT). In India, the annual mean surface air temperature is projected to rise by 1.7°C to 2.0°C by 2030 (INCCA 2010).

Onset of monsoon, quantum and distribution of rainfall and frequency of occurrence of extreme events such as drought and heat waves, are becoming highly discernible over the years. A decrease in rainy days is likely in most parts of the Indian subcontinent by 2030, affecting productivity and output of Indian agriculture. Declining productivity due to climate change and increased demand for food by a rising population is a challenge.

Over 60% of the districts included under SAT India are highly vulnerable to climate change impacts (ICRISAT c. In press). Any adverse effect of climate change will have a greater impact on people who are most socially and economically marginalized, living in vulnerable localities. ICRISAT conducted the study “Vulnerability to Climate Change: Adaptation Strategies and Layers of Resilience” (2009-2012) funded by the Asian Development Bank (ADB), to assess key changes taking place in climate and identify grassroot level responses as adaptation practices in semi-arid regions of Asia, namely India, Peoples Republic of China (PRC), Sri Lanka, Bangladesh, Pakistan, Thailand and Vietnam.

The situation in India is of grave concern and calls for concerted action.

- ❖ SAT India is home to over 37 percent of the country’s 1.2 billion population. The SAT region constitutes nearly 37% of the total geographical

Global Perspective

The IPCC 4th report (2007) warned Asia of major changes:

- *Rising temperatures will affect crop productivity exacerbating hunger. Global crop productivity is predicted to decline in the coming years if we continue with the current business in the usual way (Fischer et al. 2005). We need strategies to counter productivity losses and ensure food and nutritional security.*
- *Coastal and mega delta regions are at high risk to flooding.*
- *Increasing population pressure on natural resources will increase instances of physical water scarcity.*
- *Decreased precipitation and drought events are likely to increase, affecting over 1.4 billion people.*
- *The FAO (2008) has reported that 2 billion people, representing 40 percent of the population in developing countries, will be affected adversely due to climate change in the future.*
- *Asian countries have also been adversely affected by other natural calamities such as tsunamis, earthquakes, floods, landslides, cyclones, typhoons, hurricanes and droughts.*

area and accounts for nearly 46% of net sown area and 31% of gross irrigated area. The region also accommodates 2/3rd of the livestock population and farming is predominantly rainfed. Even though

the productivity remains low, greatly limited by low and variable rainfall, lack of irrigation and poor soils, the SAT agriculture contrasts sharply with the irrigated Gangetic plains of India. The change in global environment, scarcity of water and degradation of productive resources (land and biodiversity) are threatening to further marginalize agriculture and livelihood in Indian SAT.

- ❖ The Crisis Management Plan of the GOI (2012) presents a disturbing picture¹. The report says that annually 50 million people are exposed to chronic drought. Sixteen percent of India's land area is drought prone and 68% of the land area sown is exposed to drought. Most drought prone areas lie in the arid (19.5%), semi-arid (37%) and sub-humid (21%) areas of the country, occupying 77.6% of the total land of 329 million ha. The Southwest monsoons account for 86% of rainfall occurring in 100-120 days. Thirty three percent of land receives less than 750 mm of rainfall, and is classified as chronically drought prone. Rainfall is erratic in four out of ten years. Per capita water availability is rapidly declining due to population and urban growth, industrialization, cropping intensity and depleting groundwater.
- ❖ There is ample evidence that the occurrence and intensity of drought has increased.
- ❖ As indicated in the first paragraph of the brief, onset of monsoon, quantum and distribution of rainfall and frequency of occurrence of extreme events such as drought and temperature events are becoming highly discernible over the years.
- ❖ It is estimated that 5700 sq. km of coastal area in India will be lost due to 1 m sea level rise, displacing 7.1 million people resulting in significant economic losses.
- ❖ India's contribution to greenhouse gas (GHG) emission is only 4-5% of the global total, and it is estimated that the country's sector wise contribution of GHG emission is 41.7% from its energy and industrial sectors, while a further 17.6% is from its agrarian sector.
- ❖ Any adverse effect of climate change and extreme effects will have a greater impact on people who are socially and economically marginalized, living in vulnerable localities.

Government initiatives for addressing climate change agenda

The Government of India is aware of the challenges ahead and has taken some initiatives to address the climate change impact on agriculture.

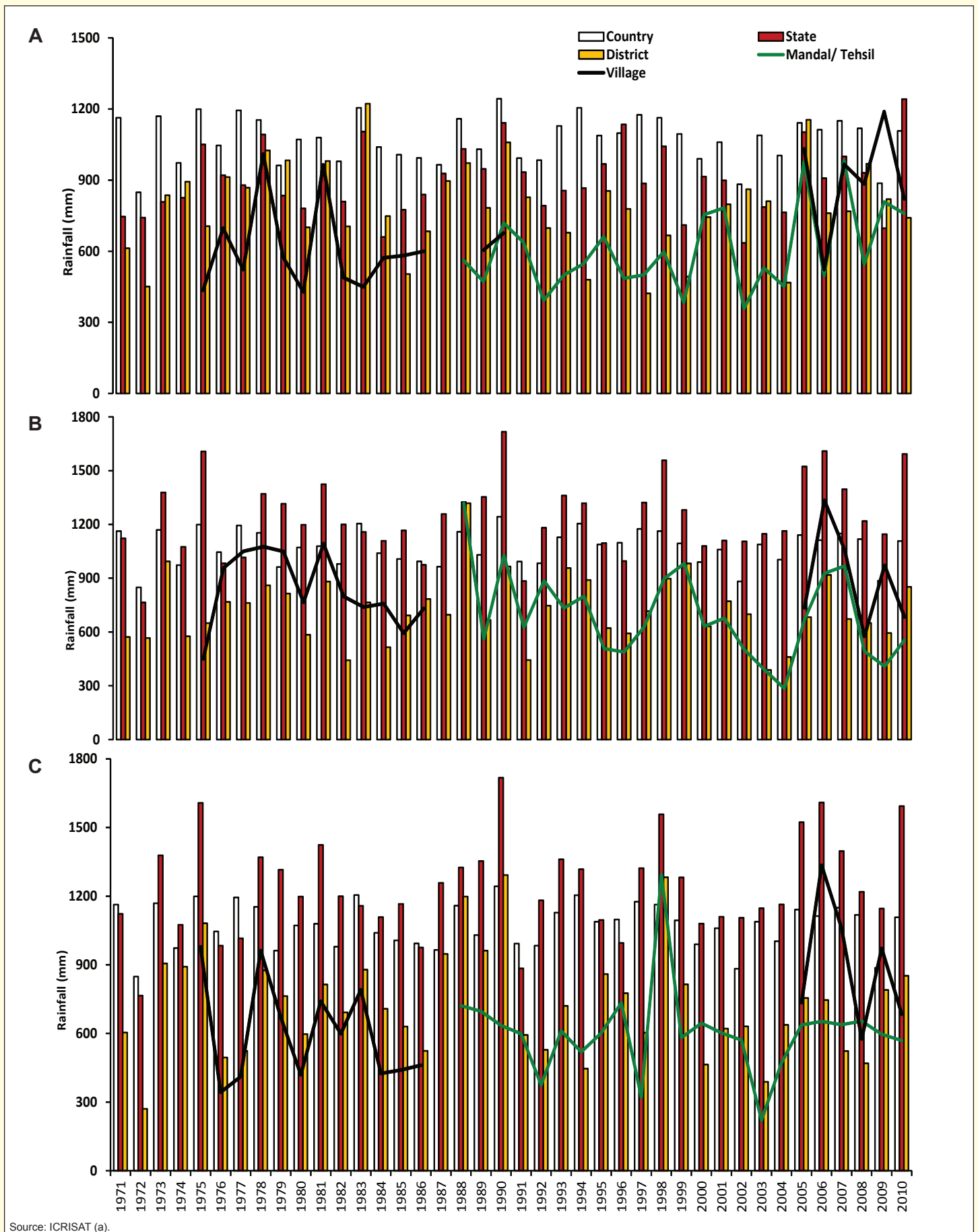
- ❖ The National Action Plan on Climate Change (NAPCC 2008) focuses on agriculture (National mission on sustainable agriculture), and water (National water mission) development along with six other missions. Development of climate resilient crops, expansion of weather insurance mechanisms and agricultural practices and ensuring a 20% improvement in water use efficiency in farming are highlighted.
- ❖ In the 12th national development plan, "Managing the environment and ecology" along with five components directly initiating action against climate change have been addressed. It calls for efficient implementation of NAPCC with effective involvement of the stakeholders.
- ❖ Government of India initiated an ambitious project "National Initiative for Climate Resilient Agriculture (NICRA 2011)" that plans to develop, test, demonstrate, and make available new technologies including cultivars to enable a climate resilient agriculture in India.

Macro-micro realities

The information generated at macro level analysis covers many important contextual issues at the ground level.

- ❖ The economy of India has undergone structural changes over time with the decline in the share of agricultural GDP. Despite a fall in its share from 55.1% in 1950-51 to 15.4% in 2011-12, the importance of agriculture has not lessened for two major reasons; viz., high prevalence of malnutrition and higher dependence of rural workforce on agriculture.
- ❖ Aggregate macro level data is used to develop policies and programs for smallholders. However, they do not consider the diverse contexts at micro levels. Policies and programs developed without adequate consideration to the local context and its variability invariably leads to failure of such interventions.
- ❖ The macro level climatic data analysis masks much variability that exists at meso and village level. Inferences drawn based on macro (national) or state level data cannot be directly applied to the village level. This is clear when the rainfall data is analyzed for trends at national, state, district, mandal and village level (Figure 1).

1. The crisis management plan on drought drawn by Ministry of Agriculture (Department of Agriculture and Cooperation), Government of India.



Source: ICRISAT (a).

Figure 1. Divergence in the observed climate results from macro to micro level (Country \Rightarrow State \Rightarrow District \Rightarrow Mandal/Tehsil \Rightarrow Village) in Indian SAT region A) Aurepalle, AP B) Kanzara & C) Shirapur, Maharashtra, India.

- ❖ The scientific knowledge about climate change, the evidence, analysis and projections remain at the highest academic level of the scientists and professionals. For ascertaining micro level contexts, the data acquisition is more often undertaken with lesser involvement of stakeholders at ground level. Learning from past experience and the generated knowledge has helped generations to survive and adapt to adverse climatic conditions. This vast repository remains with the grassroots people and studies have seldom tried to connect macro and micro inferences.

Disintegrated/district level vulnerability

- ❖ Most of the SAT regions in India are characterized by poor natural resource base and are mostly rain-fed. Vulnerability analysis for climate variability showed that a majority of districts in SAT India come under “very highly vulnerable” to “vulnerable” groups.
- ❖ A set of indicators were considered for components of exposure, sensitivity and adaptive capacity while computing the extent of climate change vulnerability. Micro level insights help to understand the dynamic adjustments that farmers are practicing in response to these changes. However, a major limitation is the non-availability of data on important indicators and a vulnerability assessment methodology.
- ❖ People living in the most vulnerable areas are likely to face severe hardships in extreme weather conditions and their ability to cope effectively with climate change would depend on their capacity as well as the external support system.

The districts of two states – Andhra Pradesh and Maharashtra – were assessed, and ranked according to their level of vulnerability (Figure 2).

- ❖ The majority of districts in these two states are ranked as vulnerable.
- ❖ There is a wide variability in the level of vulnerability among the districts.
- ❖ Over a given period of time, the vulnerability of districts change while the overall situation remains unchanged.

The situation is likely to be the same for the other SAT states and regions.

The intra-state variability in vulnerability and its dynamics are not very well understood by researchers, development practitioners and policy makers. Extensive policy applications may not target the most vulnerable and needy.

Erratic rainfall

Past data analysis show no substantial change in the quantum of rainfall. However, a rise in annual precipitation in the major regions of SAT-India, is predicted (Table 1).

Rainfall variability over the years is the major cause of yield uncertainty and makes rain-fed agriculture one of the risky enterprises in SAT India.

Farmers have to deal with annual and seasonal rainfall variability in quantum and distribution as well as variability in the onset of rainy season.

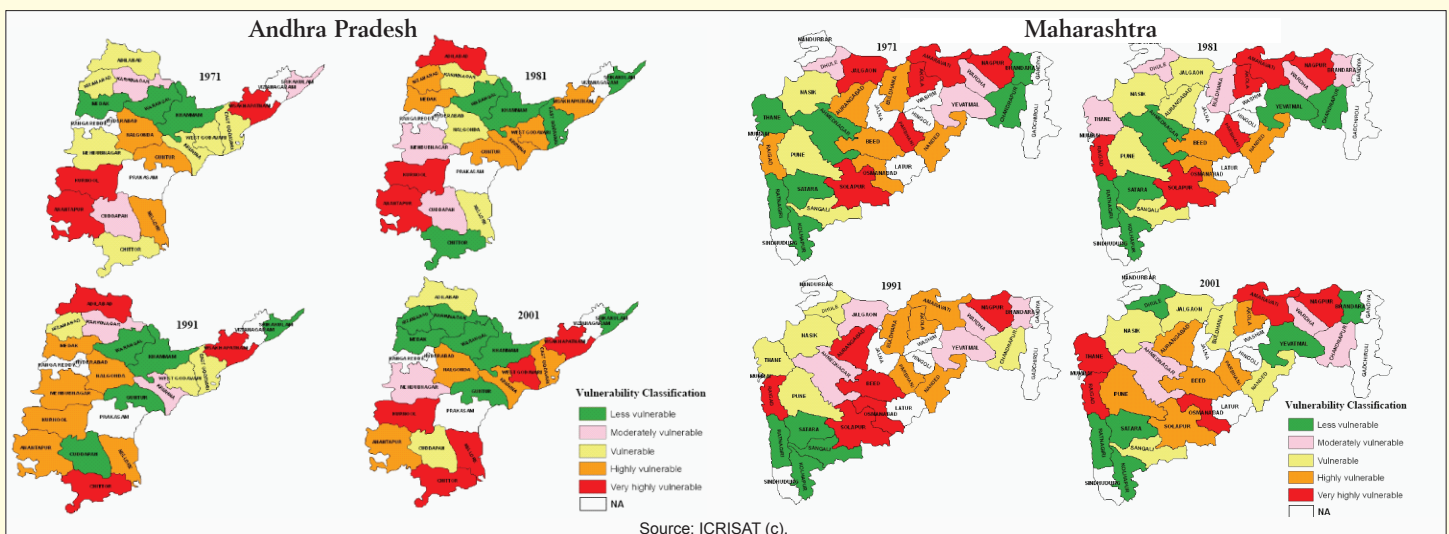


Figure 2. Vulnerability to climate change in the districts of Andhra Pradesh and Maharashtra (1971-2001).

Table 1. Percentage deviation of rainfall and difference in maximum and minimum temperature (°C) from baseline data (1961-1990) during 2021-2050 and 2071-2100 in the selected districts.

Climate	Andhra Pradesh		Maharashtra	
	A	B	A	B
Annual rainfall	8	9.8	10.7	18.9
Southwest season rainfall	5.9	-6.2	12.3	13.4
Annual temperature (Max) (°C)	1.7	3.6	1.8	3.4
Annual temperature (Min) (°C)	2.1	4.5	2.2	4.5

Source: NATCOM (2009); A: 2021-2050; B: 2071-2100.

Increasing drought

A majority of the SAT farmers are likely to face frequent droughts of varied intensity. Spatial variability in the incidence of drought even within each district was identified (Figure 3). Over the years, the frequency of occurrence of drought has increased in the region (Table 2).

Although states may be affected by a severe onset of drought, its intensity and severity varies among different districts.

Long-term analysis showed a decreasing trend in total seasonal rainfall and increased occurrence of heavy rainfall events during the Southwest monsoon season in some parts of SAT India. Deviations from the normal onset of monsoon is being experienced over the years.

Table 2. Frequency of droughts in twenty-year periods (droughts are computed based on long term averages).

Period	Andhra Pradesh		Maharashtra	
	Anantapur	Mahabubnagar	Akola	Solapur
1971-1990	9	5	6	7
1991-2009	8	7	9	11

Source: ICRISAT (a).

Rising temperatures

In SAT India, especially in Andhra Pradesh and Maharashtra long-term climatic analysis undertaken by ICRISAT shows an average rise of 0.02°C per year in annual temperature in the last 40 years. The mean surface air temperature is projected to rise by 1.7-2.0°C by 2030 and 3.4-4.5°C by 2080 from the 1960-1990 base (Table 1). Frequency of occurrence of extreme temperature events are increasing along with the high variability in the length of the growing season.

Future climate and agricultural productivity in SAT India

There exists a considerable yield gap in the SAT region of India. Further productivity loss will continue if climate related deleterious effects are not reversed. According to simulation studies, there can be productivity losses from 5% to 18% from 2030 to 2080 if no effective mitigation measures are undertaken (Figure 4).

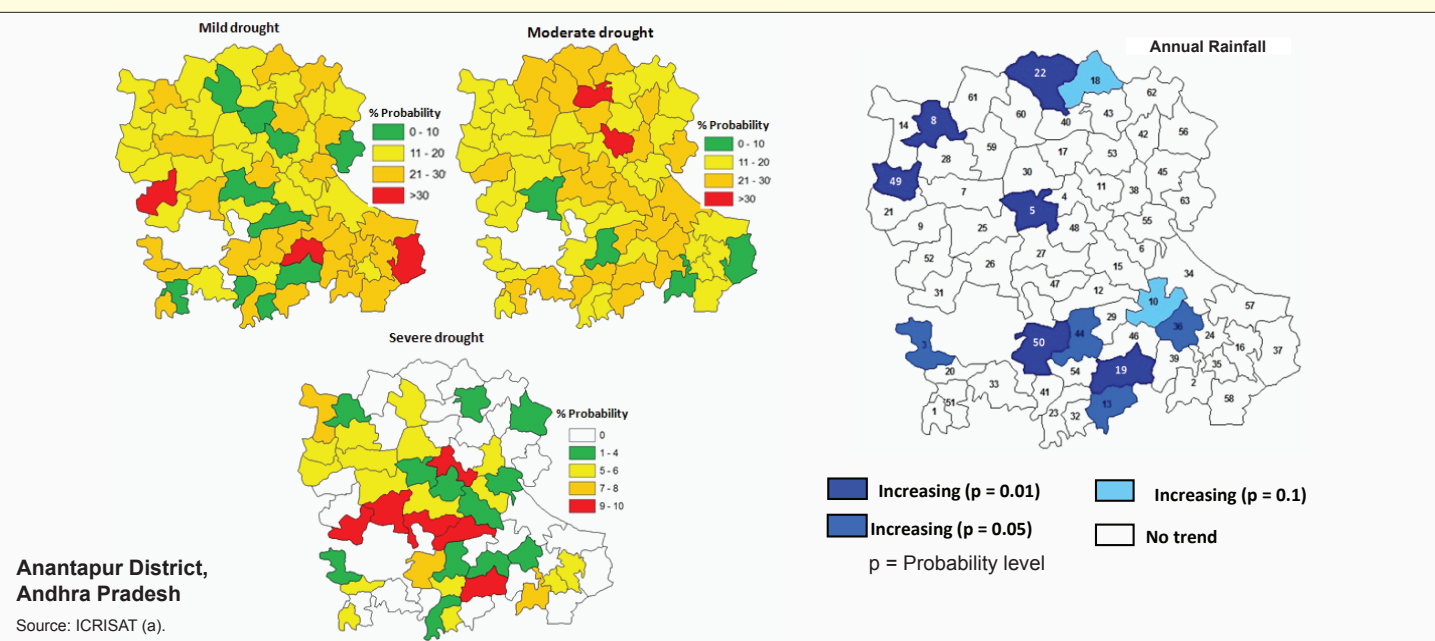


Figure 3. Variability in probability of occurrence of drought and annual rainfall trend in Anantapur District, Andhra Pradesh.

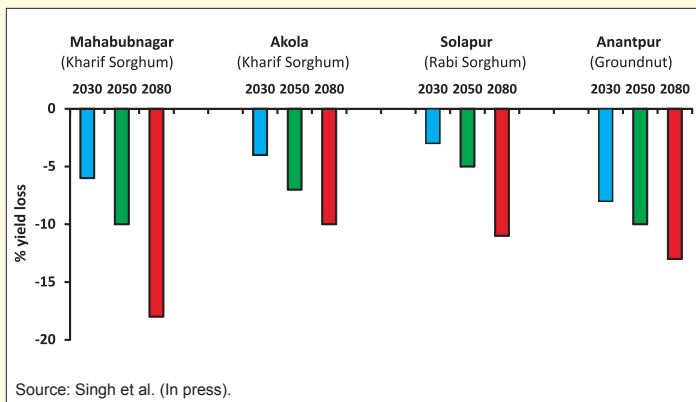


Figure 4. Predicted productivity loss for major crops in Indian SAT (HadCM3-A1B scenario).

Implications

Impact on livelihoods

In future, climate for agriculture will be more uncertain and the risk of rain-fed agriculture will be confounded for the SAT farmers. The frequency of droughts in the semi-arid tropics is high and the resource poor rain-fed farmers are often unable to cope with the effects of these extreme events.

Differential degree of drought together with unpredictable rainfall variability has become common. This situation makes it difficult for the farmer to take pre-emptive decisions, resulting in crop and economic loss. Irrespective of the economic strata of the farming communities, everyone is affected by this sudden change in weather. However, the extent of damage caused will be dependent upon each one's ability to cope with the deleterious effects.

Magnitude of vulnerability

The evidence, although incomplete, is indicative of major changes in the climatic conditions at macro levels. However, this masks the situation and variance at the local level. Greater vulnerability at the local levels implies greater pressure at the state and national level governance systems to respond to prevent the spillover effects such as urban migration, socio-political instability and conflicts, national poverty indicators, increased demands on disaster response systems, depletion of food and fodder production, etc.

Targeting relief mitigatory measures

The analysis provides a methodology as well as insights into the need for targeting relief to those adversely affected by extremes of climate situations so that the efficiency and efficacy of such relief measures are ensured. Blanket policy measures and programs may

reach too many people who may not be in actual need of the support. Gate keeping and power structures at village level may intervene to deflect equitable distribution of state support. There is a need for differentiated packages of benefits based on the actual severity of the situation.

Improving analysis and evidence

The seven-country study along with the more comprehensive data from India has made it clear that there is a need for more micro level studies to understand the spatial differences in climate variabilities, vulnerability, weather patterns, impact and response mechanisms, experiential knowledge, etc. Disaggregating the macro picture to the micro level is essential to diagnose and to ensure targeted interventions to optimize returns to climate change adaptation and mitigation investments.

Further, there is an inadequate knowledge on how climate change will affect the productivity of crops, and other allied sectors and the genotypes required to minimize the effects of productivity losses especially at provincial and village level.

Ongoing policy imperatives

- ❖ At present the major government intervention to assist families affected by drought and other adverse climatic situations is "cash for work".
- ❖ The government has several other livelihood support programs provided through various agencies to enable households to access credit and drought relief.
- ❖ The goods and services provided through free market forces are also available across India. Providing access to these markets is possible at the village level.
- ❖ The National Action Plan on climate change encompasses a range of missions and initiatives, which also includes the strategic knowledge for climate change and sustainable agriculture (NAPCC 2008). Through the initiative, it proposes to ensure an exchange of knowledge and informed research in India.
- ❖ The Indian Council of Agricultural Research (ICAR) has launched a scheme to take up strategic research and technology demonstration on climate resilient agricultural practices and resources. As a part of the project, initiatives are undertaken to collate information on micro level climate variabilities and adaptation strategies.

The policy challenge

Providing relief to millions of people affected by drought, delayed onset of monsoon, rainfall extremes and floods by the government through contingency crop plans, input support, relief employment through MGNREGA, food security and water resource management programs, etc. The relief is provided as macro policy directives and assumed to be uniformly implemented. Our analysis of vulnerability differentiation shows that such assistance may be sub-optimally utilized if it is not targeted and prioritized to ensure that the most vulnerable and needy are benefitted. Many programs supporting the vulnerable regions/sectors are channeled through central and state departments including, state relief/disaster management agency, irrigation and water conservation department, cooperative banks and NGOs with a limited coordination for effective delivery and targeting.

Free markets have limitations in their ability to ensure equitable distribution of market supplies and may contribute to increasing socio-economic inequalities. The demand for 'downstream' research often goes

unrecognized mainly due to the absence of a "voice" at the lower levels of decision making and administrative hierarchy with the beneficiary rights at the bottom of the power structures. Climate change research, developing appropriate knowhow, adaptation, refinement and evaluations, require a long term commitment and consistency, which have not been very forthcoming. Climate change as a contextual factor, is still insufficiently mainstreamed into the national research agenda.

The understanding of the relationship between institutional, infrastructural and technological interventions as effective mitigatory and adaptive strategies requires a re-alignment of institutions and outlook of those engaged. The institution responsible for collection, management and dissemination of information from grassroots to the policy planners and vice versa remains fractured. Hence, for improving coordination efficiency, a multidisciplinary and inter-institutional approach is a dire need to address the challenges of climate change.

Policy Recommendations

Vulnerability Mapping & Prioritization: All regions of India be mapped for the district and mandal level vulnerability, ranked and monitored across time and be made the basis on which relief and mitigatory interventions are provided. The existing database infrastructure need to be expanded to meet the future demands.

Preventive Strategy: The vulnerability assessment be supported by valid scientific forecasting knowhow to develop a robust preventive strategy to mitigate against deleterious effects of climate change. Enriching existing databases and broadening the set of indicators for aptly capturing different facets of vulnerability to climate change and livelihood impacts.

Targeting Relief: Drought and other relief programs of the government must be targeted based on local vulnerability analysis to ensure better results. Differentiated packages of relief must be designed to address the needs of different levels of severity and vulnerability victims. Such targeted programming may be refined and tested in states where the vulnerability assessments have been done. There is also a need to undertake impact assessment and replication.

Local Custodianship: "Climate preparedness" through local "custodianship" be developed through community participation. The required capacity development be provided by the government through the relevant agencies. This may be undertaken as a pilot in the ICRISAT Village Dynamics in South Asia (VDSA) areas and up-scaled with required modifications.

Research on New Genotypes: For the nationally prioritized crops, as well as livestock and fisheries, physiological studies be continued to scientifically estimate effects on productivity due to climate change and develop future genotypes and farming systems.

Knowledge as Public Good: All research information related to climate change, weather forecasting, impact assessments, local adaptation strategies, mitigation programs, and related topics, must be treated as "public good" and be made available to the public in local languages so that there is freedom of access to this vital information on which responsible/responsive citizenship values can be strengthened.

Coordination: An all India climate change support program coordination body be established for effective coordination of programs to avoid local level duplication and waste of efforts and resources.

Building grassroots resiliency – In pursuit of a needed policy environment

The root causes of climate change and erratic weather patterns are beyond the influence and control of villagers. However, the lives of SAT villagers are intimately linked to the deleterious effects of climate change. On the other hand, adaptation occurs at the local level. Building the capacity at various levels enables the rural community to adapt to climate variability and extremes. Improving the existing policy initiatives and the delivery mechanisms of the existing developmental programs to ensure sensitivity to climate variability and extremes is the first step. Policy integration and harmonization to address the needs of farmers with regard to issues at field, farm, social, technological, and institutional levels is important. Policy support must be equity oriented and mainstreamed into the general policy framework while being sensitive to the many layers of constraints faced by farmers.

References

FAO. 2008. Climate Change and Food Security: A Framework Document. Food and Agriculture Organization. <http://www.fao.org/forestry/15538-079b31d45081fe9c3dbc6ff34de4807e4.pdf>

Fischer G, Shah M, Tubiello FN and van Velhuizen H. 2005. Socio-economic and climate change impacts on agriculture: an integrated assessment, 1990-2080. *Philosophical Transactions of The Royal Society of Biological Sciences*. Vol. 360: 2067-2083.

ICRISAT. a. Climatic Trends in India – Agro-climatic analysis. Vulnerability to Climate change: Adaptation strategies and layers of Resilience. Patancheru 502 324, Andhra Pradesh, India: International Crops Research Institute for the Semi-Arid Tropics. (In press).

ICRISAT. b. Farmers' Perception of Climate Change in India: Farm and Village Level Responses and Grassroots Level Insights. Vulnerability to Climate change: Adaptation strategies and layers of Resilience. Patancheru 502 324, Andhra Pradesh, India: International Crops Research Institute for the Semi-Arid Tropics. (In press).

ICRISAT. c. Vulnerability to Climate Change in SAT-India. Vulnerability to Climate change: Adaptation strategies and layers of Resilience. Patancheru 502 324, Andhra Pradesh, India: International Crops Research Institute for the Semi-Arid Tropics. (In Press).

INCCA. 2010. Indian Network for Climate Change Assessment. Report 2. Page 164 in *Climate Change and India: A 4x4 Assessment – A sectoral and Regional Analysis for 2030s*, Ministry of Environment and Forests, Government of India. November 2010.

IPCC. 2007. Climate Change Synthesis Report 2001 Summary for Policy Makers, An Assessment of the Intergovernmental Panel on Climate Change.

NAPCC. 2008. National action plan on climate change. Available from <http://pmindia.nic.in/pg01-52.pdf> (Last accessed on 15 August 2011).

NATCOM. 2009. India's National Communication to UNFCCC. Data Extraction tool for Regional Climate Scenario (PRECIS) for India. Ministry of Environment and Forests, Government of India.

NICRA. 2011. National initiative for climate resilient agriculture. Indian Council of Agricultural Research (ICAR), <http://www.nicra-icar.in/nicrarevised/index.php/en/home> (Accessed in January 2012).

Singh P, Singh NP and Bantilan MCS. Climate change impact and adaptation strategies for improving the productivity of sorghum and groundnut in the four districts of the ADB project. Working Paper. Patancheru 502 324, Andhra Pradesh, India: International Crops Research Institute for the Semi-Arid Tropics (ICRISAT). (In press).

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