Madhya Pradesh
State Action Plan on Climate Change

Briefing Note on the Climate Science of Madhya Pradesh

Climate science not only demonstrates that climate change is taking place, but that its cause is mostly down to human activity. It can also provide responses to the challenges that will ensue. Global and regional climate models project the likely scenarios for the coming decades and century. They are an essential tool for governments to use in climate change vulnerability assessments and inform targeted mitigation and adaptation strategies.

Observed climate

Madhya Pradesh has a subtropical climate with three distinct seasons: winter (December to February), summer (March to May) and the rainy season (June to October).

Temperature – current

In winter, the mean minimum temperature is 10°C, though it can drop as low as 1°C and rise to a mean maximum temperature of 25°C. Summer temperatures fluctuate between a minimum of 22°C and a maximum of 38°C, though it can get very hot with temperatures up to 48°C.

Rainfall – current

Annual average rainfall for the State is 1160 mm, with the heaviest rains in the south eastern parts and decreasing towards the north-west. Most of the rainfall is received from the South Asian monsoon during June to September; which, in Madhya Pradesh, accounts for more than 90% of the total annual rainfall.

Climate projections

What is a climate projection?

To anticipate future climate change, countries need to project how greenhouse gases (GHGs) will change in the future. A range of emissions scenarios has been developed by the Intergovernmental Panel on Climate Change (IPCC) to project the ways in which the global economy might develop. Each scenario uses different assumptions for population and economic growth, energy use and technology.

Climate projections for the 2030s and 2080s have been developed for Madhya Pradesh using data from the Indian Institute of Tropical Meteorology in Pune and PRECIS (Providing Regional Climates for Impacts Studies), a regional climate modelling system devised by the UK's Met Office. PRECIS generates high-resolution climate change information and can be applied in any region of the world. It is used to help countries prepare vulnerability and adaptation assessments under the United Nations Framework Convention on Climate Change (UNFCCC).

In the Vulnerability Assessment for Madhya Pradesh the scenario A1B was used. This assumes a future world of very rapid economic growth, a global population that peaks around mid-century and declines thereafter, and the rapid introduction of new and more efficient technologies.

Such models record changes in the climate during past decades and then project forwards to form a picture of what will happen in coming decades. Therefore, models rely on having reliable data from the past. For example, in Madhya Pradesh, a lack of data for agriculture and some socio-economic indicators is a limitation of the Vulnerability Assessment.

Temperature – future

By the 2030s, the average maximum temperature in Madhya Pradesh is projected to rise 1.8–2.0°C, while the average minimum temperature is projected to be 2.0–2.4°C above what it is today. Overall, it is expected that the eastern half of the State will experience more warming than the western half.

By the 2080s, the average maximum temperature is projected to have risen 3.4–4.4°C with the northern region of the State warming the most. The average minimum temperature is likely to rise by more than 4.4°C across the whole of Madhya Pradesh.

Rainfall – future

Projections of rainfall in Madhya Pradesh for the period 2021–2050 indicate a decrease in winter rainfall from east to west, while more pre-monsoon rain is expected in the south.

During the monsoon period, a slight increase in rainfall is expected across Madhya Pradesh equal to 1.25 times the rainfall observed in the current climate.

Post-monsoon, western parts of Madhya Pradesh are likely to face a decrease in rainfall, while a slight increase in rainfall is projected in most other parts of the State.

By 2100, though, an overall increase in rainfall will affect the south more than the north. Generally, the increase in rainfall during the pre- and post-monsoon periods is projected to be greater than the increase in rainfall during the monsoon itself.

A study by Goswami et al (2006) of observations over 50 years in central India, including Madhya Pradesh, confirms that extreme precipitation events (above 100 mm) are increasing in terms of their intensity and frequency. However, further analysis of the trends in monsoon rainfall is essential as the rains form the main source of water for agriculture and biodiversity in the State.

Projected changes in the climate parameters of Madhya Pradesh

Projected changes in climate	2021–2050	2071–2100
Daily maximum temperatures	1.8–2°C increase	3.4–4.4°C increase
Daily minimum temperatures	2.0–2.4°C increase	>4.4°C increase
Monsoon precipitation	Increase in precipitation by 1.25 times the current observed rainfall in most parts of Madhya Pradesh; no change in Morena, Shivpuri, Gwalior and Bhind; increase in precipitation in eastern parts of Hoshangabad, northern part of Betul, north eastern parts of Betul and southern parts of Sehore	More than 1.35 times increase in precipitation with respect to observed climate in most parts of Madhya Pradesh. With major parts of Hoshangabad and Damoh, Manldla and northern parts of Balaghat experiencing rain in excess of 1.45 times the observed climate now. The extreme northern and western parts of the State will also experience excess rainfall but less than most of the other areas
Winter Precipitation	Decrease in precipitation	Substantial increase in precipitation in central and southwestern parts of Madhya Pradesh, increasing from between 1.45 to 1.85 times

Vulnerability assessment

What is vulnerability?

According to the IPCC, vulnerability is defined as exposure to climate variability and natural disasters, sensitivity to the impacts of that exposure, and capacity to adapt to ongoing and future climatic changes. Vulnerability therefore varies according to physical, social and economic factors; differs across regions, sectors and social groups; and should be used to inform policies, programmes and decisions about adaptation measures.

Such efforts must also recognise that the impacts of climate change will not be felt in isolation, but as a combination of multiple stresses; and, that adaptive capacity and climate resilience can decrease over time, when a population experiences the compounded effects of many climate extremes or natural disasters.

India's vulnerability to climate change

Approximately two-thirds of India's population depends on agriculture and 40% of agricultural land is rain-fed, making people's livelihoods highly susceptible to climate change.

Over time, a changing climate could pose a threat to India's food security. Other sectors, such as forestry, water resources, human health and animal well-being, urban and rural development are equally vulnerable to the impacts of climate change. In addition, unequal social and economic development across the country has resulted in different coping capacities among India's population.

Climate change threatens to undo all the good work around alleviating poverty and ensuring sustainable development that has already taken place in India. The nation's climate change concerns led to the publication of the *National Action Plan on Climate Change* in 2008, which outlined eight 'missions' around adaptation and mitigation.

Madhya Pradesh's vulnerability to climate change

Madhya Pradesh is considered to be highly vulnerable to the effects of climate change. Droughts and floods already occur frequently, with some parts of the State experiencing drought almost every year, impacting people's lives and livelihoods and hampering development efforts.

These natural hazards add to the burdens already felt through poverty, inadequate sanitation and a

lack of safe drinking water. Together, they increase the risk of disease and push people's coping capacities to the limit.

The State's forests and natural resources are also under intense pressure. Forest degradation, loss of biodiversity and the pollution of rivers and wetlands are all being observed, which decrease the natural resilience of ecosystems to climate extremes and natural disasters.

Climate change is introducing additional socio-economic and environmental stresses on top of those already being felt, making Madhya Pradesh particularly vulnerable to its impacts.

Vulnerability assessment

A vulnerability assessment was carried out for Madhya Pradesh to help improve the management of current climate risks, and to respond to future risks. The findings and early trends are currently being reviewed and corroborated.

A set of indicators was chosen, based on the availability of data, to assess the vulnerability of the 50 districts of Madhya Pradesh to climate change (social, economic, agriculture, water resources, forest, climate and health) – see box on 'Business as Usual'. With more time, further indicators will be included to get more refined results.

A Composite Vulnerability Index (CVI) was then formed of these indicators to provide an overall figure that allows for easy comparison by non-specialists. But for a full picture of the State's vulnerability, a series of sub-indices are being identified and used.

Analysis

The socio-economic and environmental indicators were found to differ widely across the districts of Madhya Pradesh. But those ranked highest across the State – in terms of priority and vulnerability – were the social indicators: population growth, percentage of people living below the poverty line, percentage of households with access to sanitation, and the number of people living in slums.

The economic indicators also differed widely. These looked at per capita income, districts' net domestic product and the percentage of the population served per health centre. Lastly, the environmental indicators included the use of fertilisers, crop yield, livestock numbers, frequency of flooding, and annual average rainfall.

'Business as Usual' projections

By 2050...Overall vulnerability of districts increases

- Dindori remains the district with the highest CVI value, with no improvement in its adaptive capacity and almost the same level of sensitivity.
- Bhind moves from a very high to a high CVI value, mainly because other districts become more vulnerable relative to Bhind.
- Sidhi and Panna downgrade slightly from a very high to a high vulnerability index because their level of sensitivity decreases.
- Burhanpur, Chhindwara, Seoni, Narsimhapur and Ujjain move from a moderate to a high vulnerability index, mainly due to increases in the level of sensitivity of these districts.
- Bhopal, Indore, Hoshangabad and Gwalior retain low vulnerability indices mainly due to their high adaptive capacities.

By 2100...Vulnerability rises further towards the end of the century

- Sidhi, Panna and Bhind move from a high to a very high CVI value on account of increases in their level of sensitivity.
- Bhopal, Indore, Hoshangabad and Gwalior retain low vulnerability indices because of their improved adaptive capacity.

By 2100, a total of 15 districts are likely to be in the very high category, compared to 12 in the baseline. There is also expected to be an increase from 22 to 24 in the high category, due to increases in the level of sensitivity.

Baseline results

The results showed that 12 out of 50 districts of Madhya Pradesh are the most vulnerable to climate change, characterised by very high CVI values: Dindori, Anuppur, Shahdol, Ashoknagar, Tikamgarh, Umaria, Singrauli, Sidhi, Morena, Alirajpur, Panna and Bhind. These districts are located in the north and east of the State, with the exception of Alirajpur which is in the south-west.

The southern region of Madhya Pradesh, which contains the three districts of Bhopal, Indore and Hoshangabad, was found to be the least vulnerable

A list of significant variables in order of their importance for each sector

Social	
Population served per health centre (community, primary and sub-health centres)	Adaptive capacity
Percentage of households with access to sanitation facilities	Adaptive capacity
Level of urbanisation	Adaptive capacity
Percentage of households with access to safe drinking water	Adaptive capacity
Density of population	Sensitive
Number of slum dwellers per slum	Sensitive
Percentage of households owning a radio, transistor, television and telephone	Adaptive capacity
Proportion of elderly population aged 65 and above	Sensitive
Proportion of child population in the age group 0–6	Sensitive
Literacy rate	Adaptive capacity
Economic	
Agricultural credit societies per *lakh* of population	Adaptive capacity
Loans disbursed by agricultural credit societies per cultivator	Adaptive capacity
Scheduled commercial banks per *lakh* of population	Adaptive capacity
Agriculture	
Percentage of land holdings below 1 hectare	Sensitive
Fertiliser consumption	Adaptive capacity
Percentage of net irrigated area to geographical area by surface water	Adaptive capacity
Percentage of bio-farming villages in total villages	Adaptive capacity
Percentage share of agricultural and cultivator main workers	Sensitive
Yield of all crops	Adaptive capacity
Water	
Crop water-stress (evapotranspiration/potential evapotranspiration)	Sensitive
Surface water availability	Adaptive capacity
Climate	
Warm nights/days when minimum temperature > 90th percentile	Exposure
Warm days–cool nights/days when maximum temperature > 90th percentile	Exposure
Warm spell duration indicator (annual count of days with at least 6 consecutive days when maximum temperature > 90th percentile)	Exposure
Cool days–cool nights/days when maximum temperature < 10th percentile	Exposure
Cool nights/days when minimum temperature < 10th percentile	Exposure
Flood discharge	Exposure
Extremely wet days–annual total rainfall when rainfall > 99th percentile	Exposure
Health	
Percentage of people having diarrhoea	Sensitive
Index of malaria	Sensitive
Forest	
Percentage of high density forest area to geographical area	Adaptive capacity
NTFP diversity (no. of varieties)	Adaptive capacity
Number of JFM communities	Adaptive capacity

to climate change, along with the district of Gwalior which is located in the north. Households in these districts were found to have high literacy rates, high per capita income and greater access to infrastructure such as schools and health centres. They are characterised by a low CVI.

As expected the indicators showed up some unique characteristics of each district. For example, Indore has a high vulnerability with regard to its water resources, while health and forest vulnerabilities are key issues for Bhopal.

Significant indicators

To provide an even greater level detail, the indicators and index were ranked under the categories: adaptive capacity, sensitivity and exposure.

This Principal Component Analysis (PCA) provides information on which of the indicators are the most important for determining a district's vulnerability. This can help policymakers to decide how to respond and where to invest to reduce vulnerability. Broadly speaking, the higher the district's adaptive capacity, the lower its sensitivity against exposure to climate change.

The results of the PCA for significant indicators are shown in the table on page 5.

The final analysis

This analysis indicates that the north, east, south eastern and south western parts of Madhya Pradesh are the most vulnerable to climate change.

This can be explained by the greater exposure to drought and other extreme events in these areas, declining water availability and degrading forests, as well as relatively low levels of technology and socio-economic and infrastructure development as compared to other areas.

Having assessed the vulnerability of the districts of Madhya Pradesh to climate change, the next step is for the State Departments to implement strategies that reduce vulnerability and adapt to the impacts of climate change. An opportunity exists to build on the Vulnerability Assessment to further refine and enrich the analysis to get a clearer picture of the State's vulnerability and appropriate responses.The results of the current Vulnerability Assessment are being reviewed by subject experts. More indicators are being added so the updated report will be much more refined.

Reference

Goswami, B.N., Venugopal, V., Sengupta, D., Madhusoodanan, M.S. and Xavier, P.K. 2006. Increasing trend of extreme rain events over India in a warming environment. *Science*, 314 (5804): 1442–1445.

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The Madhya Pradesh State Action Plan on Climate Change (SAPCC) has been prepared by the Climate Change Cell, Environmental Planning and Coordination Organisation (EPCO), Housing & Environment Department. Government of Madhya Pradesh. The Plan outlines the strategies required to strengthen development planning and build a more climate-resilient State. It aims to promote the integration of appropriate adaptation/mitigation strategies into the State's development policies and programmes. It is based on secondary data and promotes 'no regret' measures.

In order to share the results of the Madhya Pradesh SAPCC and begin to address climate change concerns through development policies and programmes, the Climate Change Cell of EPCO commissioned a series of policy briefs. CDKN was tasked with producing these, based on the Madhya Pradesh SAPCC, as a Communications Project. This brief is designed to give an overview to stakeholders of the climate science behind the SAPCC. Further information can be found in the full SAPCC, available at http://www.epco.in/pdf/Draft_MP_SAPCC.pdf

Climate & Development Knowledge Network

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